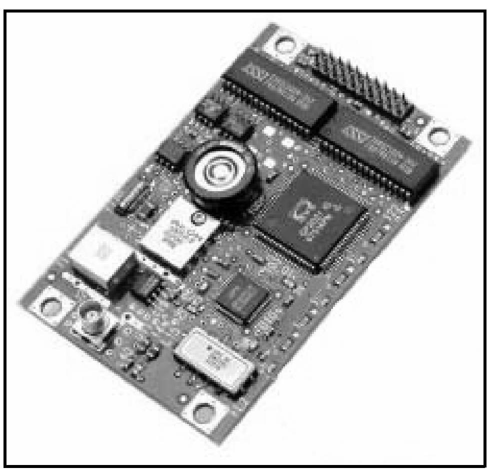
SUPERSTAR

Additional User Information

DRAFT

Specifications are subject to change



SUPERSTAR Additional User Information

Publication Number: OM-20000079
Revision Level: 0B
Revision Date: 2003/07/07

Proprietary Notice

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GPSAntenna™ Series	One (1) Year
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Software Support	One (1) Year

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There are no user serviceable parts in the GPS receiver and no maintenance is required. When the status code indicates that a unit is faulty, replace with another unit and return the faulty unit to NovAtel Inc.

Before shipping any material to NovAtel or Dealer, please obtain a Return Material Authorization (RMA) number by calling NovAtel Customer Service at 1-800-NOVATEL in North America or 1-403-295-4900 elsewhere.

Once you have obtained an RMA number, you will be advised of proper shipping procedures to return any defective product. When returning any product to NovAtel, please return the defective product in the original packaging to avoid shipping damage.

Customer Service

Contact Information

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

NovAtel GPS Hotline:	**1-800-NOVATEL** (North America) 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, ID #99.
2. Log the following data requests to a file on your PC for 30 minutes

Receiver Status, ID# 49	one shot
Ephemeris Data, ID# 22	continuous
Measurement Block, ID# 23	1 Hz
HW/SW Identification, 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 improves basic functionality of the GPS receiver. See also *Appendix F, Updating Receiver Firmware on Page 60*.

If you need further information, please contact NovAtel using one of the methods given above.

Foreword

Congratulations!

Thank you for purchasing a SUPERSTAR receiver. Whether you have purchased a stand alone GPS card, a packaged receiver or a development kit, you will have received other companion documentation.

Scope

This document provides information on the SUPERSTAR GPS OEM board P/N 220-604061-XXX and 245-604061-XXX. The following sections describe functionality, mechanical and electrical characteristics of the SUPERSTAR board. This manual provides the major differences to the *ALLSTAR User's Manual* intended for P/N 220-600944-0XX. There are also additional appendices on timing, measurements and updates.

Chapter 1 Introduction

The SUPERSTAR, see *Figure 1* below, is a breakthrough in low cost and small-size superior quality GPS receivers for embedded applications. The SUPERSTAR is similar to the highly popular ALLSTAR high-end OEM Receiver and has kept the same robust signal tracking and unsurpassed tracking capability under foliage. The SUPERSTAR is the only low cost GPS OEM Receiver on the market offering sub-meter DGPS capability.

The SUPERSTAR is a complete GPS OEM sensor that provides 3D navigation on a single compact board with full differential capability. The SUPERSTAR is a 12-channel GPS receiver that tracks all-in view satellites. It is fully autonomous in the sense that once power is applied, the SUPERSTAR automatically searches, acquires and tracks GPS satellites. When a sufficient number of satellites are tracked with valid measurements, the SUPERSTAR produces 3D position and velocity output with an associated figure-of-merit (FOM). Please refer to *Chapter 2* of the *ALLSTAR User's Guide* for more details on the FOM.

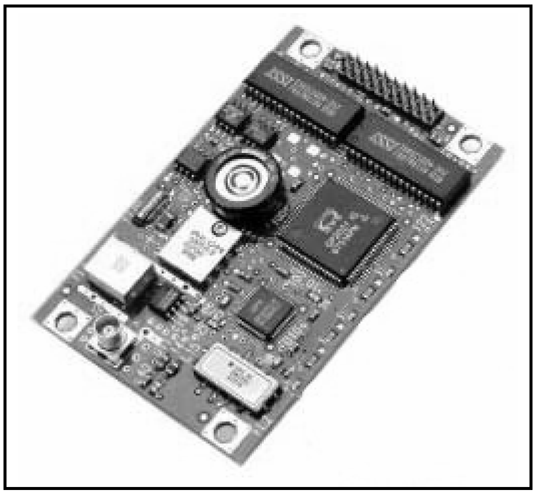


Figure 1: SUPERSTAR

Chapter 2	Installation

2.1 Quick Start

This quick start section provides the basic information you need to setup and begin using your new SUPERSTAR GPS card. For more detailed information on the installation and operation of your receiver, please refer to the user manuals provided.

2.1.1 Additional Equipment Required

Additional user-supplied equipment needed for a basic setup (see also *Figure 2*) is listed below:

A Windows-based PC with an RS-232 DB-9 port

A 5 V power supply capable of providing at least 1.2 W

An enclosure to protect against environmental conditions and RF interference

A wiring harness to provide power to the receiver and access to the data and strobe signals, with one or more DB-9 connectors for serial communication with a PC or other data communications equipment

A straight serial cable

A quality GPS antenna

An antenna RF cable with a BNC female connector at the receiver end

Figure 2: Basic SUPERSTAR Setup

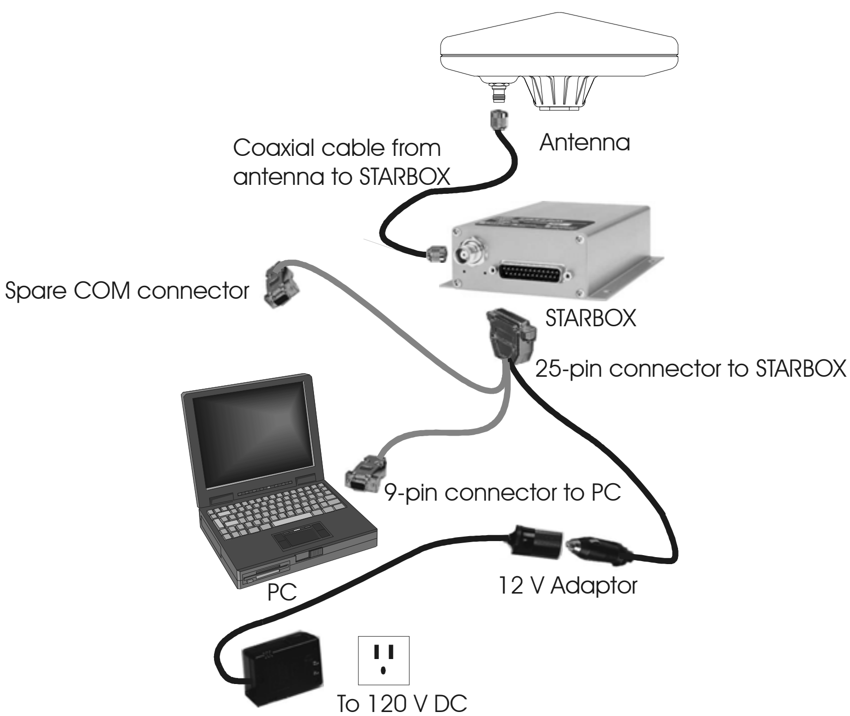


Figure Note:
The SUPERSTAR Development Kit comes with a plastic enclosure or STARBOX, +12dB active GPS antenna, magnetic mount, 6 meter RF cable, DB-9 cable for PC connection, automotive adapter plug and an AC to DC adaptor.

2.1.2 Setting Up Your SUPERSTAR GPS Card

Complete the steps below to connect and power your SUPERSTAR GPS card. Refer to the *ALLSTAR User's Manual* and this manual for more information on steps *1* through *3*.

1. Install the GPS card and the wiring harness in a secure enclosure to reduce environmental exposure and RF interference, making sure to protect against ESD. If you do not take the necessary precautions against ESD, including using an ESD wrist strap, you may damage the card.
2. Mount the GPS antenna on a secure, stable structure with an unobstructed view of the sky.
3. Connect the GPS antenna to the receiver using the antenna RF cable.
4. Connect a serial port on the receiver to a serial port on the PC using a null modem cable.
5. Connect the power supply to the receiver.
6. Plug in and/or turn on the power supply.

2.1.3 Installing StarView

Once the receiver is connected to the PC, antenna, and power supply, install the *StarView* software. The *StarView CD is* supplied with the development kits, otherwise *StarView* is available on our website.

From CD:

1. Start up the PC.
2. Insert the *StarView* CD in the CD-ROM drive of the computer.
3. Install the *StarView* software and follow the steps on the screen. If the setup utility is not automatically accessible when the CD is inserted, select Run from the Start menu and press the Browse button to locate Setup.exe on the CD drive.

From our website:

1. Start up the PC and launch your internet service program.
2. Go to our website and download the *StarView* setup program.
3. Select Run from the Start menu and press the Browse button to locate Setup.exe. The default location is in the C:/Program Files/Starview directory.
4. Click on the OK button to install the *StarView* software and follow the steps on the screen.

2.1.4 Establishing Communication with the Receiver

To open a serial port to communicate with the receiver, complete the following.

1. Launch *StarView* from the *Start* menu folder specified during the installation process. The default location is *Start* | *Programs* | *StarView.*
2. Open the *File/Port* menu and select *Auto Connect.*

🖂 The default baud rate is 9600 baud unless your receiver has the Carrier Phase Output option (19200 baud).

2.1.5 Using StarView

StarView provides access to key information about your receiver and its position. The information is displayed in windows accessed from the *Window* menu. For example, select *Navigation/LLH Solution* from the *Window* menu to display the position of the receiver in LLH (latitude, longitude and height) coordinates. To show details of the GPS satellites being tracked, select *Satellites/Status* from the *Window* menu.

2.1.6 Requesting Messages

The SUPERSTAR GPS card uses a comprehensive command interface. Input messages can be sent to the receiver using the *Xmit Msg* menu in *StarView.*

The following information is important when entering commands:

1. Message requests are only output to the receiver in binary format.
2. You can send a message request using ‘one shot’ or ‘continuos’ by selecting *Xmit Msg/General Message Request.*
3. There is an option in *StarView* to save all messages transmitted by the receiver into a file. Select File/Port/Save Data after you have finished selecting messages in Step #2 above.

The *ALLSTAR User’s Manual* and this manual provide all the available messages and parameters they use.

2.2 Minimum Connections

J1 is the 20-pin connector on the SUPERSTAR, see also *Section A.4, 20 Pin Interface Connector* starting on *Page 37*. The minimum number of connections on J1 required for the system to operate:

Signal Name	J1 Pin #
VCC	2
Ground	10, 13, 16 & 18
TX_No_1	11
RX_No_1	12

If DGPS corrections are required for the application, they may be transmitted to the SUPERSTAR through the Main port or through the Auxiliary port:

Signal Name	J1 Pin #
RX_No_2	15

If an active antenna is used:

Signal Name	J1 Pin #
PREAMP	1

2.2.1 I/O Connector (J1)

The connector shall be a 2mm straight header or right angle 2x10 position connector, PN from one suggested supplier is Samtec part number: TMM-110-03-T-D.

A suggested mating connector could be the Samtec 2mm female connector (part no. TCSD-10-01-N). The cable could also be ordered as one piece (part no. TCSD-10-D-2.00-01-N for a 2î flat cable with a connector at each end). Part no. TCSD-10-S-12.0-01-N has only one connector and is 12 inches long. You could also use a PCB mounted connector (part no. SQT-110-01-L-D[1]).

1. 0.340" long standoffs will be required

⌧ The latest connector specifications can be obtained from Samtec or other equivalent manufacturers.

2.2.2 RF Connector (J2)

The standard RF connector is a straight MCX jack connector. A right angle MCX connector is offered as an option.

Suggested supplier:	Johnson Comp
On-Board connector:	133-3701-211

Interface between SUPERSTAR and customer application:

Suggested Supplier:	Omni Spectra
Supplier part number:	5831-5001-10
or	
Suggested Supplier:	Suhner
Supplier part number:	11MCX-50-2-10C
or	
Suggested Supplier:	Radiall
Supplier part number:	R113082.

The center conductor will provide power for an active antenna (PREAMP signal from J1-1).

2.3 Power Requirements

See also *Appendix A, Technical Specifications*, starting on *Page 33*.

2.3.1 Antenna

The maximum operating voltage for an active antenna supply (PREAMP) is 12 Volts.

2.3.2 Input Voltage

VCC is the main and unique power source for normal operation with a maximum operating voltage of 5.5 Volts.

2.3.3 Memory Back-Up

The SUPERSTAR has a supercap device allowing a warm start, where the receiver has an approximate position, an approximate time and a valid almanac, without the need of an external power supply during a power-off state. VBATT is an external back-up source for the time keeping circuit.

A warm start is available for 1 week typically (25∞C) and 3 days over a more extreme temperature range (-30 to +75∞C). Therefore, VBATT can be used to extend the time retention period.

⌧ An external series diode will be required between J1-3 and the external power source to prevent the supercap from discharging into your circuitry.

2.4 Protocol Selection and Non Volatile Memory

Discrete IOs are available with a SUPERSTAR Development Kit and are useful if you have Application Program Interface (API) software. A summary is shown in *Table 1* below.

Table 1: Use of Discretes

Discrete Name	Development KIT Equivalent Name	Use	Direction
GPIO2	IO1	Navigator	IN/OUT
GPIO3	IO2	SP	IN/OUT
GPIO5	IP1	GPS Data	IN/OUT
GPIO6	IP2	NVM Control	IN/OUT
GPIO7	IP3	Protocol Select	IN/OUT

If you use NMEA, the SUPERSTAR offers you the option of setting the I/O operating mode to NMEA through discrete input levels. Disc_IP2 and Disc_IP3 have the following functions:

Table 2: Discretes IP2 and IP3 functions

Disc_IP3 (Protocol Select)	Disc_IP2 (NVM Control)	Result
OPEN - HI	OPEN - HI	Configuration stored in NVM or Default ROM Configuration if no valid NVM elements
OPEN - HI	GND	Protocol on Port #1: Binary Baud Rate on Port #1: 9600 Other elements: Default ROM Configuration
GND	OPEN - HI	Protocol on Port #1: NMEA Baud Rate on Port #1: 4800 Other elements: Default ROM Configuration if no valid NVM elements
GND	GND	Protocol on Port #1: NMEA Baud Rate on Port #1: 4800 Other elements: Default ROM Configuration

Discrete inputs can also be viewed in byte 26 of *Message ID# 49, Receiver Status Data* (refer to the *ALLSTAR User's Manual*) as follows:

Bit#	Description
0	DISC_IP1
1	DISC_IP2
2	DISC_IP3
3	DISC_IO1
4	DISC_IO2
5	DISC_IO3
6-7	Reserved

2.5 Default Configuration

Below is the SUPERSTAR's default configuration with no valid NVM elements:

Protocol on port #1:	Binary
Baud Rate on port #1:	9600
Protocol on port #2:	RTCM-104
Baud Rate on port #2:	9600
DGPS Correction Timeout:	45 seconds
Default Message List:	
Binary:	Navigation Status User Coordinates (Message ID# 20) @ 1Hz
NMEA:	GGA @ 1Hz
Time Align Mode:	ON

1. Time Align Mode was set to OFF for the ALLSTAR
2. The SUPERSTAR is configured in 1 Hz position, velocity, and time (PVT) mode only.
3. The data contained in NVM is always used if the DISC_IP2 is left unconnected or tied to HI logic.
4. If DISC_IP2 is tied to LO logic, the default ROM configuration will be used and the following parameters will not be read from NVM:

   Position

   Almanac

   Time

   UTC Correction and IONO Parameters

   TCXO Parameters

Chapter 3 Input Messages

This section contains messages that have a difference in the Binary protocol between the ALLSTAR and SUPERSTAR OEM boards.

3.1 Host to Receiver CPU Messages

Table 3: Message Summary

ID	DEFINITION	MESSAGE TYPE	# BYTES
2	Reset Receiver	CM	14
69	Set Timing Parameters	CM	33
80	Set Position/Operating Mode	CM	38
90	Satellite Deselection	CM	18
103	Set Date, Time & GPS Time Alignment Mode	CM	21
113	Request Timing Information	DR	6

LEGEND:

CM: Command Message

DR: Data Request

3.2 Field Types

The following table describes the field types used in the description of messages.

Table 4: Field Types

Type	Binary Size (bytes)	Description
Char	1	The **char** type is an 8-bit integer. Values are in the range -128 to +127. This integer value may be the ASCII code corresponding to the specified character.
UChar	1	The same as Char except that it is not signed. 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.
Hex	n	**Hex** is a packed, fixed length (n) array of bytes in binary but in ASCII or Abbreviated ASCII is converted into 2 character hexadecimal pairs.

3.3 Message Content - Host CPU to Receiver

3.3.1 Reset Receiver ID# 2

This command resets the SUPERSTAR receiver.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section V* of the *ALLSTAR User's Manual*			
5-12		Password UGPS-000 In ASCII format, U character first.	ns	Uchar[8]

3.3.2 Set Timing Parameters ID# 69

This will allow you to set timing parameters for the SUPERSTAR.

Set the timing parameters. If all ones (F..FFh = 1111...11111111 binary) is entered in any field below, the corresponding value will not be modified.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section V* of the *ALLSTAR User's Manual*			
5-8		Cable Delay Set the propagation delay that is induced by the antenna cable. This delay will compensate the 1PPS output so it remains synchronized with the UTC time. Range from -1 to +1 ms	ns	Long
9-12		1PPS Offset Set the offset from the UTC time for the 1PPS signal to be output. Range from 0 to 900 ms	100 ms	Ulong
13-16		1PPS Pulse Width Range from 0 to 65 ms	100 ns	Ulong
17	0	Standard Timing Mode	N/A	Char
	1	One Shot Alignment		
	2	Continuous Alignment		
18	0	1PPS Output continuously	N/A	Char
	1	1PPS Output only when tracking at least one satellite		
	2	1PPS Output only when an alarm is not raised by TRAIM		
	3	Conditions 1 and 2 above		
19		TRAIM Alarm Limit Time solution error threshold at which the alarm limit will be raised. Range from 0 to 2.55 ms 0 indicates no TRAIM is to be performed.	10 ns	Uchar
20-21		Intrinsic delay Range from 0 to 65534 ns 65535 ns indicates no changes.	ns	Uword
22-23		Reserved	N/A	Word
24-27				Long
28-31				Long

3.3.3 Set Operating Mode ID# 80

This command allows you to set the SUPERTSTAR operating mode.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section V* of the *ALLSTAR User's Manual*			
5-12		Password (UGPS-XXX), in ASCII format, U character first, where the command field XXX: 000 - Set User Position (ALLSTAR compatible, see below) R00 - Force to Rover Mode (position not saved) GSP - Get Survey Position BYY - Set Base Position and Base Information SYY - Force to Survey Mode where YY: bytes 11..12 (Station ID and Station Health) bits 0..9 : Station ID (10 bits:1-1023) bits 10..12 : Station Health (as per RTCM-104) bits 13..15: Reserved	N/A	Char [8]
13-20		Interpretation depends on the command field XXX. 000 and BYY: Altitude Ellipsoid SYY: Desired Survey Time R00 and GSP: N/A	m *or* hours	Double
21-28		Interpretation depends on the command field XXX. 000 and BYY: Latitude SYY, R00 and GSP: N/A	radians	Double
29-36		Interpretation depends on the command field XXX. 000 and BYY: Longitude SYY: Desired CEP R00 and GSP: N/A	radians *or* m	Double

Example:

You can set the receiver in static mode by assembling the following message:

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 the static mode is initiated immediately.

✉ **Self-Surveying Mode:** On certain occasions, you may wish to terminate the surveying process. You can do this by using the GSP command as indicated in the message specification above. 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 will then switch to static mode.

3.3.4 Satellite Deselection ID# 90

This command deselects the desired SVs if the password is valid. The SVs to deselect are indicated in a bitmap form. A 1 in the bitmap specifies that the corresponding SV will be deselected.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section 5* of the *ALLSTAR User's Manual*			
5-12		Password (UGPS-XXX), in ASCII format, U character first where XXX is: 000 - Deselect GPS SV 0G4 or 0G5 - Deselect WAAS SV	N/A	Char[8]
13-14		[000] - GPS SV bit map (bit 0 - SV #1, bit 7 - SV #8) bit map (bit 0 - SV #9, bit 7 - SV #16) [0G5] - SBAS SV (such as WAAS or EGNOS) bit map (bit 0 - SV #129, bit 7 - SV #136) bit map (bit 0 - SV #137, bit 7 - SV #138)	N/A	N/A
15-16		[000] - GPS SV bit map (bit 0 - SV #17, bit 7 - SV #24) bit map (bit 0 - SV #25, bit 7 - SV #32) [0G4] - SBAS SV (such as WAAS or EGNOS) bit map (bit 0 - SV #129, bit 7 - SV #136) bit map (bit 0 - SV #137, bit 7 - SV #138)	N/A	N/A

3.3.5 Set Time ID# 103

This command allows you to set the date, time (UTC) and the GPS Time Alignment mode.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section V* of the *ALLSTAR User's Manual*			
5-12		Password, in ASCII format, U character first UGPS-000: Sets system time to provided date & time if no SV is currently being tracked. UGPS-100: Requests a 1-shot 1PPS output, and sets system time to provided date & time if no SV is currently being tracked.	N/A	Char[8]
13-15		UTC time	h:min:s	Uchar:Uchar:Uchar
16-19		UTC date	dy:mo:yr	Uchar:Uchar:Ushort

3.4 NMEA Protocol Input Messages

Table 5 lists a set of input messages supporting Waypoint Navigation, see *Appendix D, Waypoint Navigation*, starting on *Page 53*. The message contents are described in the *ALLSTAR User's Manual*.

Table 5: List of Input Messages on Primary Communications Port

Message ID	Name	Sentence Length (Maximum) - Characters
000	Configure Primary Port Command	17
001	Initialization Data Command	77
005	Set Output Configuration Command	67
009	Define Waypoint	57
010	Select Active Waypoint	18

Chapter 4 Output Messages

This section contains messages that have a difference in the Binary protocol between the ALLSTAR and SUPERSTAR OEM boards. The NMEA protocol is identical for both products.

4.1 Receiver to Host CPU Messages

Table 6: Message Summary

ID	DEFINITION	MESSAGE TYPE	RATE (/s)	# BYTES
23	Measurement Block	UR/FR	variable	variable
67	SBAS (for example WAAS and EGNOS) Current Message	UR/FR	1	54
68	SBAS Message Status	UR/FR	1	13
113	Precise Timing information	UR/FR	1	65

LEGEND:

FR: First Request

UR: Update Request

4.2 Field Types

Please see *Table 4, Field Types* on *Page 19* for descriptions of the field types used in this manual.

4.3 Binary Message Content - Receiver to Host CPU

4.3.1 Measurement Block ID# 23

This message contains raw data carrier and code, and the parameters required for all applications. The total length of the message is

15 + 11*N Measurement Block + 2

✉ Please also read the *Measurements* appendix starting on *Page 46* of this manual for more details on raw code phase measurements and raw carrier phase measurements.

BYTE	BIT	DESCRIPTION	UNITS	TYPE	OFFSET
1-4	Header, refer to *Section 5* of the *ALLSTAR User's Manual*				0
5		Slew Value	ns	Char	4
6		Reserved	N/A	N/A	5
7		Number of Measurement Blocks		Uchar	6
8..15		Predicted GPS Time This is the time when the measurement samples have been taken at the receiver. Not to be confused with the transmission time.	seconds	Double	7
16	0-5	SV Number	N/A	N/A	15
	6	Reserved			
	7	Toggle at each ephemeris transmission			
17		Signal-to-Noise ratio (SNR). For example, a value of 160 will translate to 40.0 dB/Hz	0.25 dB/Hz	Uchar	16
18..21		Code Phase The correlator will align 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.. 2095103999	1/1024 half chip	Ulong	17

Continued on Page 27

22..25	0-1	Carrier Phase bit 0-1: SUPERSTARs/ALLSTAR Value 0: Ready Value 1: Phase Unlock Value 2: Cycle Slip Detected Value 3: Not Ready bit 0-1: Base RTCM Value 0: Ready Value 1: Carrier not sync Value 2: Phase Unlock Value 3: Bit ambiguity not resolved 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 49*.	N/A	N/A	21
	2-31	Integrated Carrier Phase	cycles	N/A	
26		Cycle_Slip Counter. Raw data and tracking loop slips will be observable in the measurement. The carrier tracking loop has a 180 degrees ambiguity so it is possible to slip by a full cycle or a half cycle. The half cycles will be detected and signalled through the measurements qualifiers (least significant 2 bits of the carrier phase). SUPERSTARs Increment by 1 every time a cycle slip is detected during a 10ms period Base RTCM Loss of Carrier continuity and number of GPS data parity errors	N/A	Uchar	25
27...	Next SV offset = 15 + (#SVs x 11)				
CheckSum			N/A	Hex	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

4.3.2 SBAS Current Message ID# 67

This message is output at a nominal rate of once per second and its length is 50 bytes. It is available to anyone with a SBAS-capable (for example WAAS and EGNOS) receiver model. Bytes 21 - 52 of this message provide the 250 bits SBAS message. The 250-bit message is packed into a 32-byte frame. See also *Section E.2.1, Logging Message ID# 67* starting on *Page 56*.

BYTE	BIT	DESCRIPTION	UNITS	Type
1-4	Header, refer to *Section 5* of the *ALLSTAR User's Manual*			
5..8		Week number	N/A	Ulong
9..16		GPS Time	s	Double
17..20		Reserved	N/A	Ulong
21..52	0-243	SBAS message data field	N/A	char [32]
21..52	244-249	Reserved	N/A	char [32]
CheckSum			N/A	Hex

Example Output:

```
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
99 6C D2 40 80 16 BB 40 0A 00 10 00 A4 08 03 F0
03 B2 12 01 43 BC 30 F0 03 00 00 00 00 00 00 D0
F0 0A 41 00 00 00 00 C6 60 11 9F FD FF C0 00 00
00 00 FB 80 00 A0 9B 56 00 00 00 00 00 00 00 1F
E0 0B B3 28 24 56 00 2B 0E 01 06 F9 55 2E 1A 5E
25 02 00 BC FA 3C 42 00 00 00 00 1A 02 66 27 02
```

Example Header Translated to Decimal: 01 67 188 48

4.3.3 SBAS Message Status ID# 68

This message provides the status of the SBAS (for example WAAS and EGNOS) message and is output at a nominal rate of once per second if your receiver is a SBAS-capable model.

BYTE	BIT	DESCRIPTION	UNITS	TYPE
1-4	Header, refer to *Section 5* of the *ALLSTAR User's Manual*			
5-6		Message count	N/A	Ushort
7		SV Source	N/A	Char
8		SBAS message type	N/A	Char
9-11		Reserved		
CheckSum			N/A	Hex

4.3.4 Precise Timing Information ID# 113

This message allows you to request precise timing information.

The clock bias and drift parameters are computed using the pseudo-range 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. Obviously, when the WAAS 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
1-4	Header, refer to *Section 5* of the *ALLSTAR User's Manual*			
5Ö 8		Cable Delay Value Propagation delay induced by the antenna cable that has been entered using the Set Timing Parameters command ID# 69, see *Page 21*.	ns	Ulong
9Ö 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
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
17		Number of Observations Number of satellites used to compute the clock error	N/A	Uchar
18..19		Mask Angle Elevation angle below which satellite measurements are not used.	0.01 degrees	Uword
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 will revert to 0 after midnight, when the new leap second value has been applied to the UTC time.	s	Char
21		Leap Second Value Offset between the GPS time and the UTC time. It contains only the leap second number. It does NOT contain the fractional part transmitted in the GPS Navigation Message ID#21 (refer to the *ALLSTAR User's Manual*).	s	Char
22..29		Clock Bias Bias between the predicted time and the actual time at the time of the solution.	ns	Double
30..37		Clock Drift Frequency drift of the TCXO at the time of the solution.	ppm	Double
38..41		UTC Date of the 1PPS output.	dy:mo:yr	byte:byte:Word

Continued on Page 30

42..51		UTC Time of the 1PPS output.	hr:min:s	byte:byte:Double
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
56	0-1	Timing Operating Mode 00: Standard 01: One shot alignment 10: Constant alignment		Uchar
	2-3	TRAIM Status 00:Normal 01: Fault Detected 10:Fault Isolated 11:Warning (not enough SVs)		
	4-5	Static Operation Status 00: Successful 01: Warning (TRAIM cannot run) 10: Not Ready (no measurements) 11: Alarm (raised by TRAIM)		
	6	WAAS Processing 0: Inactive 1: Active		
	7	Static Operation 0: Inactive 1: Active		
57..60		TFOM(1Φ) Clock Bias	ns	Long
61		TRAIM Alarm Limit	10 ns	Uchar
62..63		Intrinsic delay	ns	Uword
CheckSum			N/A	Hex

4.4 NMEA Protocol Output Messages

Table 7 lists a set of output messages supporting Waypoint Navigation, see *Appendix D, Waypoint Navigation*, starting on *Page 53*. The message contents are described in *ALLSTAR User's Manual*, except for NMEA ID# 905 which is described in the next section of this document.

Table 7: List of Output Messages on Primary Communications Port

Message ID	Name	Sentence Length (Maximum) - Characters
900	Navigation Status	21
905	User Position ñ UTM Format	45
906	Bearing, Distance & Delta-Elevation to Waypoint	87
907	User Position - MGRS Format	57

4.4.1 User Position in UTM Format ID# 905

Current position in UTM format and UTC time of position.

```
               |
HEADER         |  CONTENTS OF DATA FIELDS
               |
$PMCAG,905     |
               |
               |  ,xx,xxxxxx,xxxxxxx,hhmmss.ss,A*hh<CR><LF>
               |   |  |    |     |      |      |
               |   |  |    |     |      |      Status[1]
               |   |  |    |     |      UTC time of position
               |   |  |    |     Grid northing
               |   |  |    Grid easting
               |   Zone number
```

[1] Status: A = Data Valid ñ Navigation Mode
B = Data Valid ñ Position Initialized
V = Data Invalid

Example:

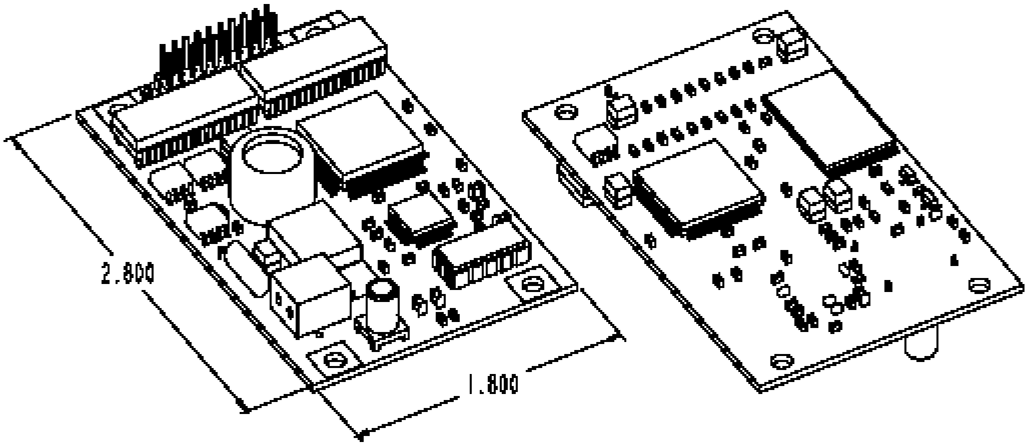
```
$PMCAG,905,18,602090,5038779,141105,A*79<CR><LF>
```

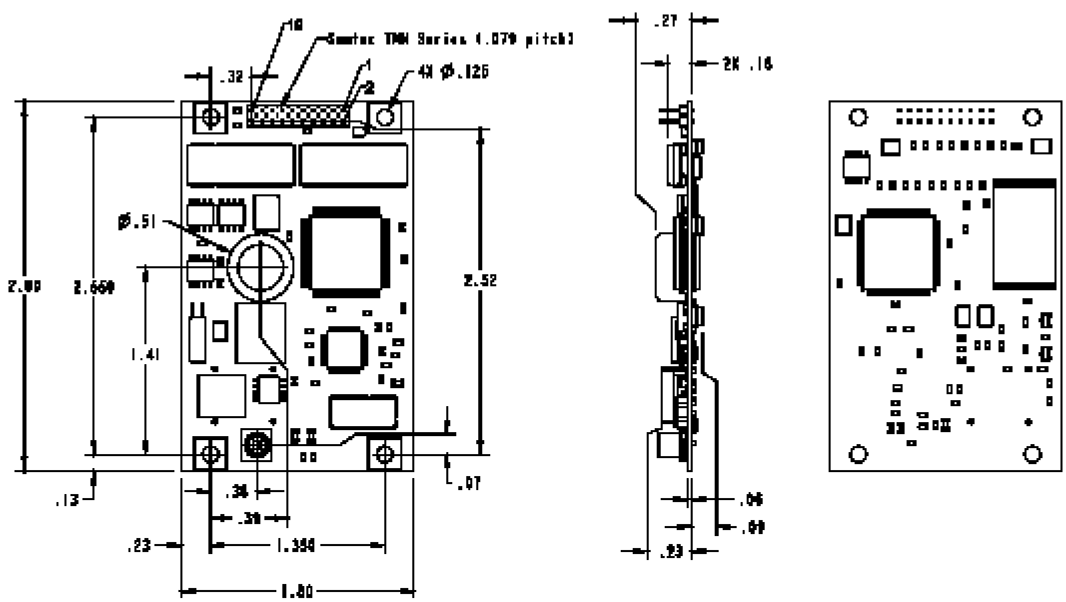
Zone number	-	18
Easting	-	602090
Northing	-	5038779
UTC time	-	14:11:05
Status	-	Valid Data

✉ The position references the receiver's active datum.

Appendix A Technical Specifications

A.1 Dimensions





A.2 SUPERSTAR GPS Card

*GENERAL CHARACTERISTICS**	
12-PARALLEL ì ALL-IN-VIEWî TRACKING	
L1 Frequency:	1,575.42 MHz
Minimum Tracking Sensitivity:	-135 dBm (antenna input level)

PERFORMANCE*	
Position Accuracy:	DGPS <1 m (CEP)
Single Point:	<5 m (CEP)
Time to First Fix:	Hot start: 15 s typical, with current almanac, position, time and ephemeris Warm start: 45 s typical, with current almanac, position and time Cold start: 2 min. typical, no almanac, no position and no time
Signal Re-Acquisition:	< 1 s (typical) (5 s obscuration) < 3 s (typical) (60 min. obscuration)
Dynamics:	
Velocity:	1852 km/h (514 m/s) (limited by US and Canadian export laws)
Acceleration:	4 Gs (39.2 m/s^2)
Jerk:	2 m/s^3
Altitude:	60,000 ft. (18 km)
HARDWARE SPECIFICATIONS*	
Prime Power:	5.0 +10%/-5% VDC INPUT (50-mV p-p ripple maximum) 1.2 W at 5.0 VDC typical with passive antenna
ì Time-Keepingî Power:	2.5 to 4.5 VDC external input <1μA (5V), <0.3μA (3V) Supercap on-board to maintain SRAM and time for warm start
Serial Communications:	2 x RS-232 (TTLlevel) asynchronous data ports; TX1-RX1, TX2-RX2 9,600 baud standard (select from 300 to 19 200 bauds) 3rd and 4th input/output ports (on special version)
Input Messages:	Rx 1: NMEA/Binary Set altitude, position, date and time selectable output messages and rates Rx 2: RTCM SC-104 Message types 1, 2, 9
Output Messages:	Tx 1: NMEA, GGA, GSA, GSV, RMC, VTG, ZDA, GLL plus proprietary messages or Binary All data available on NMEA messages plus channel assignments, ephemeris, Built in Test result (BIT), others, (integrated carrier phase data optional 1 Hz) Tx 2: Spare

Time Mark Output:	L1 pulse/s, aligned with GPS time (± 200 ns typical in absolute mode) (± 50 ns typical in relative mode), with SA imposed Discrete: 3 general purpose input/output lines
PHYSICAL AND ENVIRONMENTAL*	
Dimensions:	1.8" W x 2.8" L x 0.51" H; (46 x 71 x 13 mm)
Weight:	0.05 lb. (22 g)
Operating Temperature:	-30∞C to +75∞C (standard)
Storage Temperature:	-55 to +90∞C
Humidity:	5% to 95% relative humidity, non-condensing to +60∞C
SUPERSTAR DEVELOPMENT KIT*	
Operating Voltage:	10 VDC to 16 VDC
Operating Temperature:	0∞C - 40∞C
Serial Ports:	DB-9 female RS-232 Port 1 INPUT/OUTPUT DB-9 female RS-232 Port 1 DGPS IN
Time Mark:	4 pin right angle header
Power Connector:	2.5 mm male positive center
Antenna Connector:	BNC male with +5V supply for active antenna
3 LEDs:	Power on, time mark DGPS mode
8 DIP Switches:	Various control functions, refer to the full schematic for details.
Accessories included:	A plastic enclosure, including a power regulator, RS-232 driver, 3 LED indicators and a SUPERSTAR receiver. A +12dB active GPS antenna, magnetic mount and 6 meter cable. DB-9 cable for PC connection, automotive adapter plug, AC to DC adaptor.

* Specifications are subject to change without notice

A.3 I/O Electrical Characteristics

Input pins have a valid state during reset and operating mode. No connection is required if the signal is not used in the application.

SIGNAL	Type	Input Lo Max V	Input Hi MIN V	OUTPUT Lo Max V	Output Hi min v	Notes
MASTER_RESET	I	0.5	2.0			(1)(4)
DISC_IP_1, _2, _3 RX_No_1, _2	I	0.8	2.5			(3)(4)(6)
DISC_IO_1, _2	I/O	0.8	2.5	0.4	3.0	lo out≤200μA (3),(5),(8)
TX_No_1, _2	O			0.4	3.0	lo out≤200μA (4)
RX_No_3/ DISC_IO_3	I/O	0.8	2.0	0.4	3.7	lo out≤200μA (3),(4),(8)
TIMEMARK TX_No_3	O			0.4	3.7	lo out≤200μA (7),(8)

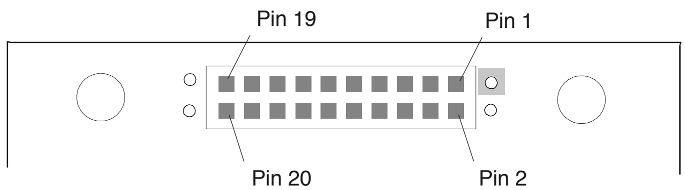
Notes:

1: A LO pulse of 150ns will invoke a master reset to the SUPERSTAR (Max. 1μs rise & fall time)
2: Conditions: 5V +10%/-5% for all limits
3: Maximum input Voltage is 5.5V
4: All pins are in input mode during reset with pull-up resistor
5: All pins are in input mode during reset with pull-down resistor
6: DISC_IP_1 (Programming Ctrl Pin) is in input mode during reset with pull-down resistor
7: All pins are forced to an output logic level 0 during reset state
8: All outputs shall deliver a maximum current of 2mA

A.4 20 Pin Interface Connector

Table *Table 8* shows connector J1 (2X10, 2mm header) on the SUPERSTAR. See also *Appendix A.1, Dimensions*, starting on *Page 33*.

Table 8: Top View of 20-Pin Connector on the SUPERSTAR



PIN #	Signal Name	Function
1	PREAMP	Power for active antenna (40 mA max)
2	VCC	Primary power (5V +10%/-5%)
3	VBATT	Back-up power for real-time clock device (external series diode required)
4	DISC_IO_3	Programmable discrete I/O expansion pin for special applications
5	MASTER_RESET	Reset input pin (active LO)
6	DISC_IP_1	Reprogramming control input pin (active HI)
7	DISC_IP_3	Protocol select pin (see *Section 2.4* on *Page 17*)
8	DISC_IP_2	NVM control pin (see *Section 2.4* on *Page 17*)
9	DISC_IO_1	Programmable discrete I/O expansion pin for special applications
10	GND	Ground
11	TX_No_1	Serial port TX #1[a]
12	RX_No_1	Serial port RX #1 [a]
13	GND	Ground [a]
14	TX_No_2	Serial port TX #2 [a]
15	RX_No_2	Serial port RX #2 [a]
16	GND	Ground
17	DISC_IO_2	Programmable discrete I/O expansion pin for special applications
18	GND	Ground
19	TIMEMARK	1PPS (1 Pulse Per Second) output
20	Reserved	

a. Low Voltage Transistor Transistor Logic (LVTTL)

Appendix B Timing Engine and Relationships

This appendix familiarizes you with the SUPERSTAR Timing Engine option features. This GPS receiver enables the output of a precise 1PPS (1 Pulse-Per-Second) signal aligned to UTC time, along with related timing data. The Precise Timing feature is a factory-installed option (also known as a config block) on the GPS receiver. Verify that the configuration part number 169-613955-010 is installed within the SUPERSTAR.

This appendix details the use of the SUPERSTAR Timing Engine from a user standpoint, that is, the performance specifications, functional descriptions, and I/O messages.

You may also have the SBAS (for example WAAS and EGNOS) option installed separately on the SUPERSTAR. The SBAS and Precise Timing features are independent from one another, but together yield a more accurate 1PPS alignment and enhanced timing integrity. See also *Appendix E, Satellite-Based Augmentation System*, starting on page 55.

Also, this appendix summarizes 1PPS with Binary, NMEA, and Message ID# 20 timing relationships respectively for the SUPERSTAR.

B.1 The SUPERSTAR Timing Engine

The SUPERSTAR Timing Engine provides an accurate 1PPS timing pulse aligned to UTC for use in precise network synchronization applications. Several timing parameters are configurable; these 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.

This receiver can operate as a standard SUPERSTAR 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. 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:

±30 ns (1σ), or ±60 ns (peak-to-peak using DGPS or WAAS corrections)

B.2 Definitions

This section gives some 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 simply 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, etc.). The intent is to have the clock bias represent the true oscillator’s phase error as accurately as possible. Note that 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’s frequency error. This value is typically computed using the GPS carrier phase measurements.

B.3 Precise Timing Features

In static mode, the receiver uses a known position with the observed measurements (pseudo-ranges and delta-ranges) to derive accurate clock information, that is, the clock bias and clock drift. Set the receiver in static mode using command Message ID# 80 (see *Page 22*), in which the exact position of the receiver antenna must be encoded.

The 1PPS output can be programmed to be offset from the UTC second by a fixed value ranging from 0 to 1 second, in increments of 100 milliseconds. The offset is a positive number only, meaning that the rising edge of the 1PPS is delayed with respect to the UTC second boundary by the desired amount of milliseconds. Also, the pulse width is user-programmable.

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 programmed 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. Refer to *Chapter 3, Input Messages*, starting on *Page 19* for more details.

B.3.1 1PPS Alignment Modes

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

- Constant Alignment: Implements an algorithm that keeps the 1PPS signal aligned on the UTC second boundary.
- 1-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 output the 1PPS signal accordingly. You can request the receiver to redo its one-shot alignment via command Message ID #103. See *Section B.7, Use of 1-Shot Alignment Mode* on *Page 41* for more information on this mode.
- Standard Alignment: This is the default mode for receivers without the Precise Timing configuration block.

B.4 Receiver Self-Surveying

You can request the receiver to initiate a self-survey. 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, please refer to the *ALLSTAR User’s Manual*.

When the surveying process is completed, the associated data is then 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 TRAIM

The receiver implements a Time Receiver Autonomous Integrity Monitor (TRAIM) algorithm.

B.5.1 Alarm Limit and Time Integrity Limit

Two fundamental TRAIM concepts must be accurately defined in order to understand its use:

Alarm Limit (AL): The maximum error in the time estimate that the *you accept to tolerate* in your application. You are advised if the time solution cannot be guaranteed to be accurate within this limit. You must provide this value to the receiver.

Time Integrity Limit (TIL): The level of protection that the time estimator can offer. It defines the *maximum* error that can be induced by one faulty measurement in the estimate without being detected. Beyond this limit, TRAIM detects a fault in the time estimator. This value is computed in real-time based on parameters that prevail at the time.

Therefore, when TIL > AL, an alarm is raised.

Determination of the Alarm Limit cannot be done without prior knowledge of the level of protection that can be offered by the time estimator. The time estimator uses the pseudorange measurements to compute the clock error. These measurements have different error sources: Selective Availability (S/A), ephemeris, ionospheric, tropospheric and thermal noise errors.

When a receiver is tracking the WAAS signal, it extracts ephemeris and ionospheric errors from the message. The errors left in the measurements are residual errors left from tropospheric mismodeling and thermal noise. Hence, you can logically estimate the TIL that can be expected with and without WAAS.

B.5.2 Status Indicators

In order to interpret correctly the status of the time solution, two separate status indicators must be taken into account: the TRAIM solution status (TSS) and the Time Estimator status (TES). These are provided in *Section 4.3.4, Precise Timing Information ID# 113* on *Page 29*.

The Time Estimator status may take one of the values in *Table 9*:

Table 9: Time Estimator Status Conditions

Time Estimator Status (TES)	Condition
OK	All pseudorange residuals passed the detection test.
Fault Detected	A faulty residual has been detected but NOT isolated.
Fault Isolated	A faulty measurement has been detected AND successfully isolated.
Warning	Not enough satellites.

TRAIM provides either one of the status indicators in *Table 10* to you at a given time:

Table 10: TRAIM Solution Status Conditions

TRAIM Solution Status (TSS)	Condition
Successful	Time Estimator Status is set to OK **and** TIL < AL.
Warning	Time Estimator Status is set to WARNING **or** [Time Estimator Status is set to FAULT DETECTED and TIL < AL]
Not Ready	Default value at power up.
Alarm	TIL > AL

Here are some examples of how you can interpret the current setting of both status indicators:

If TSS is set to ALARM and TES is set to OK, it indicates that there are not enough satellites to guarantee the integrity of the clock solution.

If TSS is set to ALARM and TES is set to FAULT DETECTED, it indicates that there is a fault in the measurement set that causes the TIL to be larger than expected. A bad receiver position (programmed via Message ID# 80) may be the cause for such conditions.

If TSS is set to OK and TES is set to FAULT DETECTED, it indicates that a faulty satellite has been detected but the TIL is still below the Alarm Limit. This may occur when there is a slow drift building up in the measurements.

Furthermore, the 1PPS output can be programmed to be disabled when the alarm is raised, in order to enhance timing integrity.

B.6 Receiver Reset Command

You can command the receiver to reset itself using a software command message (see *Section 3.3.1, Reset Receiver ID# 2* on *Page 20*). This causes the receiver to re-initialize its hardware and software, and reacquire the satellites in view. Given the fact that many receivers are installed in remote locations and direct operation of the receiver by maintenance staff is typically not possible, it is imperative that the host application closely monitor the various status indicators, clock errors and residuals output in Message ID# 113 (see *Page 29*) and reset the receiver if necessary.

B.7 Use of 1-Shot Alignment Mode

The purpose of this section is to present the use and behavior of the Timing Engine when it is in 1-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. On the other hand, it is your responsibility to 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 time at which the 1PPS was output (that is, the 1PPS output time) and the time at which it should have been output. For example, if the receiver is programmed to output the 1PPS aligned on the second edge, then the 1PPS residual is in fact the fraction of the 1PPS output time.

Once the external oscillator stabilizes at a perfect 10 MHz frequency, the 1PPS Residual remains constant; it thus represents the actual phase offset. To remove this constant phase offset, you must send a Redo 1-Shot Alignment command to the receiver. It removes this offset from the 1PPS; this is reflected in the reported 1PPS Residual, which is a constant within ±50 ns. If you wish 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 you can remove the reported phase offset from the external oscillator.

Figure 3 on *Page 42* shows a schematic of the configuration to use for a receiver in 1-Shot Alignment mode using a user-steered external oscillator.

.

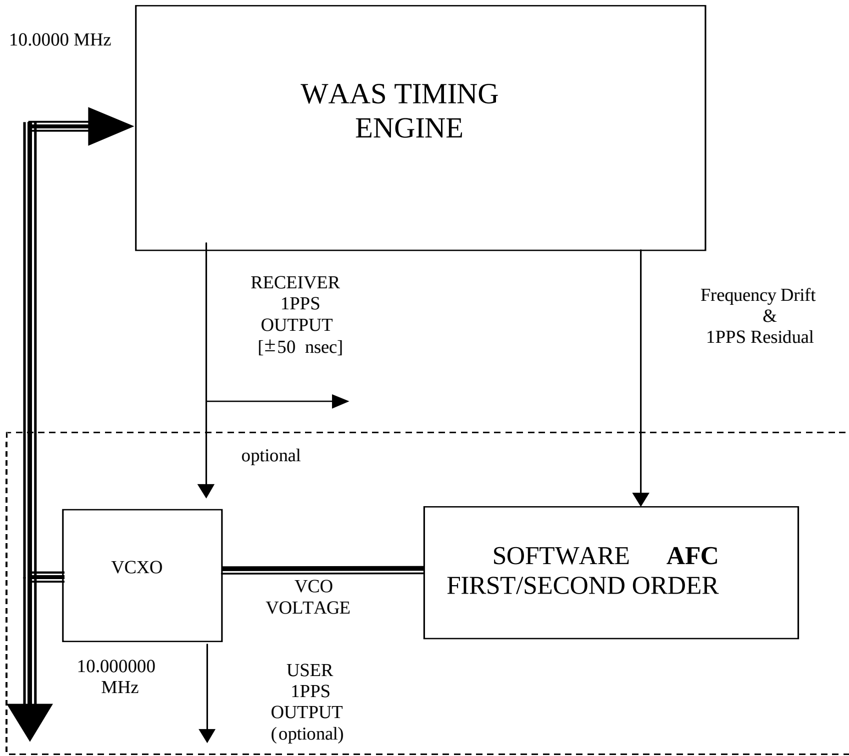


Figure 3: One-Shot Alignment Mode Configuration

B.8 Timing Relationships

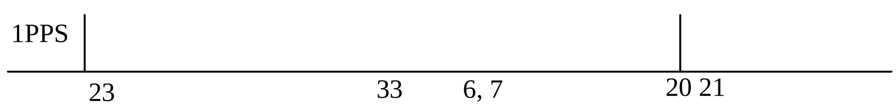
This section summarizes 1PPS with Binary, Message ID# 20, and NMEA timing relationships respectively for the SUPERSTAR.

☒ Be careful doing any substitution between receivers. Depending on the receiver type and software version, message transmissions begin following a 1PPS pulse or just after the next 1PPS pulse.

Table 11: 1PPS and Binary Messages

Message[a]	Beginning of Messages (reference to 1PPS rising edge)	Transmission Duration (approximate)
ID 23	15 ms (may be pushed by preceding message)	150 ms
ID 33	500 ms (always)	100 ms
ID 6,7	700 ms (always)	280 ms
ID 20	915 ms (always)	115 ms
ID 21	915 ms (may be pushed by preceding message)	130 ms

a.With software 169-614174-VAR



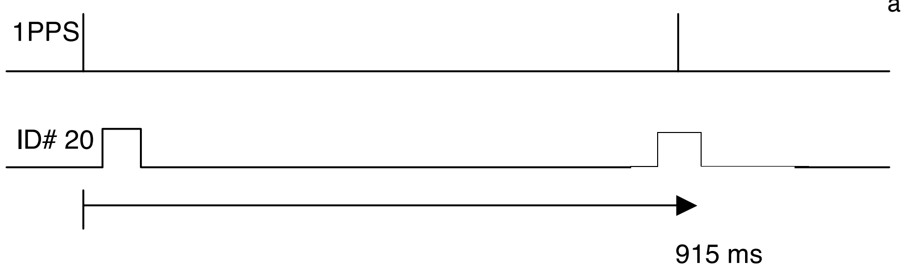
As you can see in *Table 11*, Message ID# 23 is output at the beginning of the GPS second (where the measurements are taken) and Message ID# 21 is output at the end of the GPS second (when the solution is done computing). Depending on the port baud rate, Message ID# 21 can end up being transmitted after the following time mark. The time mark indicates the moment the measurements are taken. The predicted time used to tag the Message ID# 23 is the GPS time at the time this set of measurements was taken. It is called a predicted time because it has not been corrected for a clock bias that is only known when the solution is computed.

Table 12: 1PPS and Timing Binary Messages

Message[a]	Beginning of Messages (reference to 1PPS rising edge)	Transmission Duration (approximate)
ID 20	350 ms	115 ms
ID 113	350 ms (may be pushed by preceding message)	100 ms

a.With software 169-614333-VAR

Table 13: 1PPS and Message ID# 20 [a]



a.With software 169-614174-B08

Message ID# 20 begins 915 ms after the 1PPS signal. The transmission duration is approximately 115 ms.

Table 14: 1PPS and NMEA Messages

MESSAGE[a]	Beginning of messages (reference to 1PPS rising edge)	Transmission duration (approximate)
GGA	815 ms	100 ms
GLL	915 ms	70 ms
GSA	400 ms	70 ms
GSV	300 ms	100 ms
VTG	720 ms	50 ms
ZDA	0 ms	60 ms

a.With software 169-614174-VAR

Appendix C Measurements

This appendix explains in detail, for advanced users, the processing of the raw carrier and code phase measurements of the SUPERSTAR. Basically, GPS receivers provide 2 types of raw measurements: raw code phase measurements and 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 TIC.

Raw measurements are provided in Message ID# 23. The structure of Message ID #23 is provided in *Chapter 4* on *Page 26*. Details on the integrated carrier phase output by this message are given later in *Section C.4* on *Page 49*.

C.1 Measurements Concepts

C.1.1 Time Aligned and Not Aligned Concept

The aligned concept refers to the ability of the receiver to steer the measurement TIC.

Numerous clock steering schemes can be implemented. Some receivers directly steer the TCXO frequency. Other receivers adjust the phase of the measurement TIC sporadically when the clock bias exceeds a threshold. The phase of the sampler is modified at that time and the clock bias is adjusted accordingly.

In the SUPERSTAR, the clock steering is performed as described below. When the Time Aligned capability is active, the receiver steers the measurement TIC 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 that, the fractional seconds of the time tag, the clock bias and the clock drift are used to steer the measurement TIC so that it occurs at the one second epoch. This way, receivers take their measurements simultaneously. The steering occurs at each second.

For most applications, it is required to have the solution (and raw measurements) on the one-second epoch. Therefore, the receiver should be set in Aligned Mode. For applications where it is not required to have the solution on the one-second epoch, the receiver can be operated in Not Aligned Mode. You must know the operating mode when you use the raw data in post processing.

Whether in Aligned Mode or Not Aligned Mode, the carrier phase and code phase measurements are taken at the same time. The SUPERSTAR receiver operates by default in Aligned Mode. You can use binary command ID# 103 (Set Date Time / Alignment Mode) to set the steering on or off. The selected mode is then activated at the next power up and it is saved in Non Volatile Memory (NVM).

C.1.2 Doppler Concept

The GPS data is modulated by a 1.57542 GHz carrier, see *Figure 4* and *Figure 5* on *Page 47*. 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 that we output is the integrated carrier in 1024th of cycles 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 4: Modulated GPS Data (Doppler Present)

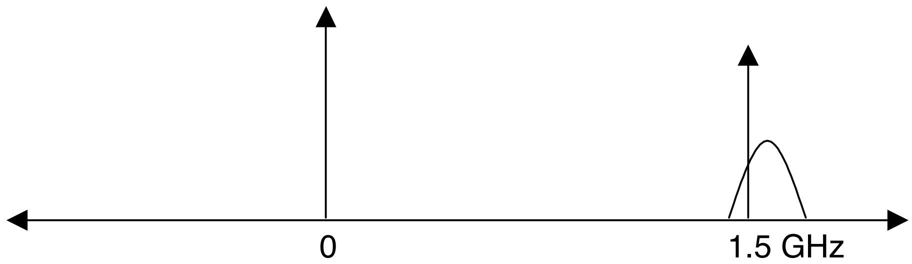
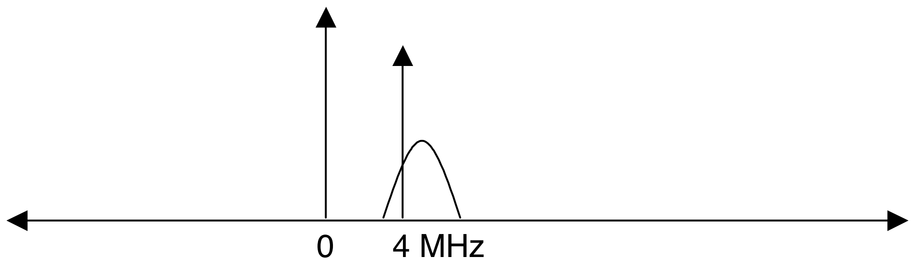


Figure 5: Demodulated GPS Data (Doppler Present)



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 measurement by the measurement period:

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

for a measurement period of 0.999999.

If the time is not aligned, the ICP are accumulated for 1 s - 1 µs + Clock Drift. The nominal number of cycles is computed for 1 s - 1 µs so if the TCXO does not drift, ICP = integrated cycles over 0.999999 s due to doppler. If the TCXO drifts, the measurement period is affected by the clock drift and the measured ICP contains a clock drift component in addition to the doppler.

If the time is aligned, 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 + 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 TIC by reaching the TIC count in advance or with a delay depending on the drift direction. Time alignment compensates this effect by increasing or decreasing the measurement period by delaying or advancing the occurrence of the TIC interrupt based on the predicted clock drift.

Because the measurement TIC 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 15 on *Page 48* summarizes the effect of the clock drift on the measurement period (time) and the code and carrier phases.

Table 15: Clock Drift (CD) Effects

Measurement	Time Not Aligned	Time Aligned
Time	The measurement period varies in the range [0.999999-Clock Drift, 0.999999+Clock Drift] If CD = 0 then the period = 0.999999 If CD = +1 µs / 1s then the period = 1 s	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 effect present due to the measurement period which is influenced by the clock drift	CD has only a little effect.
Carrier	CD effect present due to the measurement period which is influenced by the clock drift. The ICP output has the nominal cycles removed for a period of 0.999999. The ICP contains the clock drift.	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 TIC. The time tag (identification of the Measurement TIC) of that TIC is reported in Message ID# 23. The pseudoranges are computed using the relation below:

$$\begin{aligned} &\rho_i = \left[PredictedTime_i - Floor(PredictedTime_i)\right] - CodePhase_i / (CodePhaseUnitPeriod) \\ &if\ \ \rho_i < 0 \\ &\quad \rho_i += 1 \\ &\rho_i = \rho_i * C \end{aligned}$$

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 SUPERSTAR steers the measurement TIC continuously.

C.3 Carrier Phase Measurements

Raw carrier phase measurements (ϕ) are output as Integrated Carrier Phase (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 bits 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 should 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 are used to derive a quantity ICP (Integrated Carrier Phase). 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 16* below.

Table 16: 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 Whole cycle counter bit is clear. Then, the receiver starts the accumulation of the cycle and continues accumulation until loss of power has been detected. The bit can be asserted when the receiver has detected parity error while demodulating and assembling the GPS word. This status is latched over 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 phasor motion is determined to have exceeded a threshold in the one-second interval, the FR bit of the measurement status is asserted.

In the SUPERSTAR, the WC and FR status bits are swapped as described in the *ALLSTAR User's Manual* (e.g. Status = 1, Phase unlock).

C.5 Coherence Between Pseudoranges and ICP

Unless you want to further smooth pseudoranges measurement with carrier phase, there is no need to obtain coherent measurement. 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 both aligned and not aligned mode, the first difference of ICP and pseudorange differs for the ionospheric differential that is causing 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 in the pseudoranges measurements. 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 TIC 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:

$$\rho_i(m) = [PTime_i - Floor(PTime_i)] - (CodePhase_i / 2095104000)$$
$$if\ \ \rho_i < 0$$
$$\rho_i += 1$$
$$\rho_i = \rho_i * C$$
$$where\ C\ is\ the\ speed\ of\ light$$

Equation 6

These equations reconstructs 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 a measurement period different than 0.999999 s. The Slew value is the number of 175 ns corrections that were applied on the measurements TIC 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 non-coherency constant is the same for all satellites and therefore drop out of the equation. You can use *Equation 2* on *Page 49* to unwrap the ICP measurement.

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

To account for the true measurement period, the measurements have to be adjusted 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.

$$
\begin{aligned}
&\rho_i = \left[PredictedTime_i - Floor(PredictedTime_i)\right] - CodePhase_i / (CodePhaseUnitPeriod) \\
&if \;\; \rho_i < 0 \\
&\quad \rho_i += 1 \\
&\rho_i = \rho_i * C
\end{aligned}
$$

Equation 9

The Carrier phase measurements must be modified to match the 1 s code phase measurements. The following equations does the job.

$$
\begin{aligned}
&ICP_k(cycles) = RawICP_0 + \sum_{i=1}^{k} (\Delta ICP_i + TrunkCorrection - TimeCorrection_i - ClockDrift_i * c / Lambda)) \\
&where \\
&\Delta ICP = (RawICP_i - RawICP_{i-1}) \\
&TimeCorrection_i = Slew_i * f_{IF} * 175e-9 \\
&f_{IF} = 1405396.825 Hz \\
&ClockDrift_i = 175e-9 * Slew_i - NominalDrift - (PredictedTime_i - PredictedTime_{i-1} - 1.0) \\
&NominalDrift = 1e-6
\end{aligned}
$$

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 also applicable for 1 Hz measurements only since the slew is required. The slew is output only once a second.

Note that the slew is used to remove the clock drift element. The clock drift can be computed externally and then removed. Doing that would allow you to work with any rate of measurements, both aligned or not aligned.

Appendix D Waypoint Navigation

The purpose of this appendix is to familiarize you with the SUPERSTAR Waypoint Navigation feature. Waypoint Navigation is a factory-installed option (also known as a config block) on your GPS receiver. Verify that you have configuration part number 169-613955-009 installed within the SUPERSTAR.

The Waypoint Navigation feature requires the use of the NMEA protocol. An explanation of the supported NMEA protocol and field definitions is provided in the *ALLSTAR User's Manual* to assist you in understanding the Waypoint Navigation option.

For further details on the NMEA message structure and formats, please refer to NMEA 0183 specification (available from NMEA executive office Tel. 252-638-2626; Fax. 252-638-4885; internet: www.nmea.org).

D.1 Start-up in NMEA Protocol Mode

To setup the I/O operating mode to NMEA protocol:

Apply ground to the DISC_IP_3 signal (connector J1, pin 7) of the SUPERSTAR.

D.2 Waypoints

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

A database containing a maximum of 100 waypoints can be maintained within the receiver. Waypoint entry, retrieval and editing is accomplished via defined input/output messages. Waypoint positions are in the Military Grid Reference System (MGRS) and Universal Transversal Mercator (UTM) co-ordinate system formats. A waypoint is defined by an identifier number and an 8 character name.

D.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 SUPERSTAR by sending a series of "*Define Waypoint*" messages (NMEA ID# 009). 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). The SUPERSTAR 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.

3. **Current Status**

   The SUPERSTAR transmits navigation status and the current user position in both UTM and MGRS formats. These messages are defined by NMEA message ID#s 900, 905 and 907 respectively.

Appendix E Satellite-Based Augmentation System

A Satellite-Based Augmentation System (SBAS) is a type of geo-stationary satellite system (for example WAAS and EGNOS) 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 card is only able to receive corrections from an SBAS satellite if it has the SBAS option installed. It may also have the the SUPERSTAR Timing Engine option installed. They are independent from one another, but together yield a more accurate 1PPS alignment and enhanced timing integrity. See also *Appendix B, Timing Engine and Relationships*, starting on page 38.

In *StarView*, the terms WAAS and GIC are used to include all SBAS satellites.

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

As shown in *Figure 6, The SBAS Concept* on *Page 56*, 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 the SMART Antenna 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 via 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 - e.g. 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.

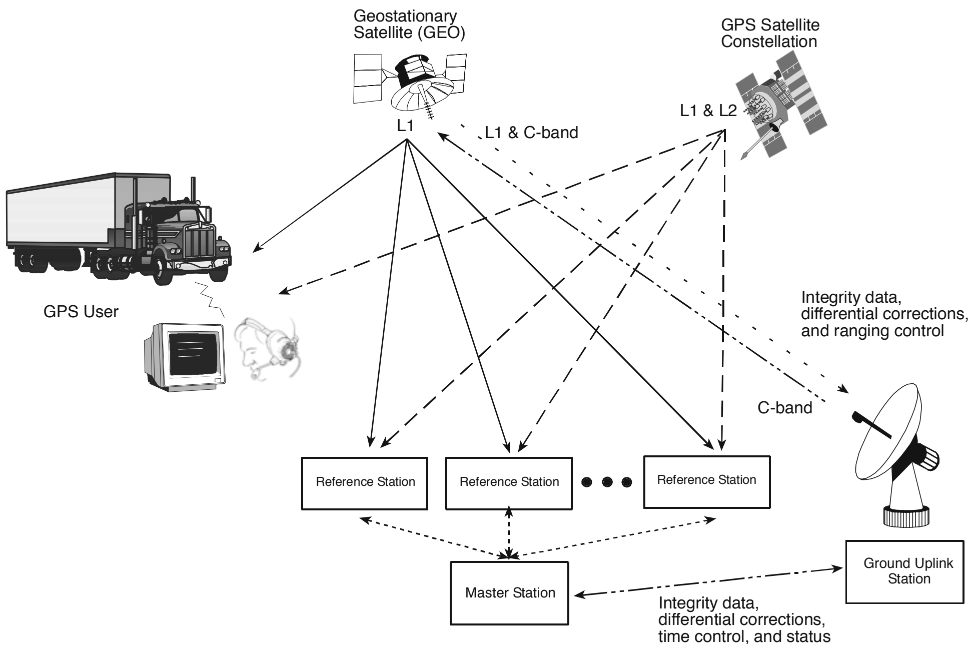


Figure 6: The SBAS Concept

E.1 SBAS Receiver

Many models of the NovAtel receivers are equipped with an SBAS (for example WAAS and EGNOS) option. The ability to simultaneously track two SBAS satellites, and incorporate the SBAS corrections into the position, is available in many models.

These models can output the SBAS data in log format (Message ID#s 67 and 68), and can incorporate these corrections to generate differential-quality position solutions. Standard SBAS data messages are analyzed based on RTCA standard DO-229B Change 1 Minimum Operational Performance Standards for GPS/WAAS airborne equipment.

A SBAS-capable receiver will permit anyone within the area of coverage to take advantage of its benefits.

E.2 SBAS Messages

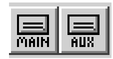
Two SBAS-specific messages are available if you have a SBAS-capable model. Details of Message ID#s 67 and 68 can be found in *Chapter 4, Output Messages* starting on *Page 28*. You will find more on message structure and other message descriptions in the *ALLSTAR User's Manual*.

E.2.1 Logging Message ID# 67

To get the raw SBAS data out of the receiver, you must explicitly request Message ID# 67 through *StarView* as follows:

1. Select Xmit Msg | General Message Request from the main menu
2. Enter 67 (Raw SBAS Message) and select Continuous in the Request I/O Message dialog box
3. Select Window | Messages | Received Messages from the main menu. Watch the Message ID# 67 count incrementing.

4. Select one of the Log Incoming Data icons, shown below, to log all incoming messages:



   The application will request a filename where you want to store data. The filename is then echoed in the bottom of the main *StarView* Window.

5. Click on the icon again to stop the logging of data.

The program *cget67.exe* is a 32-bit console application that extracts Message ID# 67 and formats it into an ASCII format as follows:

```
480790.00 3 530D1FFDFFDFFFF79FFDFFFF75FFDFFC09BCF5FFDFFFBB8FB87B84FB83BE2B80
480791.00  63 9AFC00000000000000000000000000000000000000000000000000001C877740
480792.00  24 C663F69FFDFFC0000000013B8000A09B120000000000000001FE00BEB03BB7980
480793.00  62 53FAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA8EC0ED00
480794.00   0 9A021FFC1ABFCDFFDFFDFFF8F9FFDFFC01C1D5FFFFFB8FBBB93B94F9268619C0
480795.00  25 C6668B000000000000000000002F80800000000000000000000000000028925E40
480796.00   3 530E1FFDFFDFFFFA9FFDFFFF05FFDFFC08FD11FFDFFFBB8FB87B84FB864AC580
480797.00  63 9AFC00000000000000000000000000000000000000000000000000001C877740
480798.00  24 C663F19FFDFFC0000000013B800080800000000000000000000000002BDEB
```

where, for example:

480790.00 is the GPS Time

3 is the SBAS Message Type

and the rest is the 250-bit SBAS message packed into a 32-byte frame and the 6 MSB are set to zero

E.3 SV Deselection

StarView allows you to deselect GPS and SBAS system satellites. Select Tool Settings | Deselect | SVs from the main menu and the SV Deselection dialog will appear as seen in *Figure 7* below.

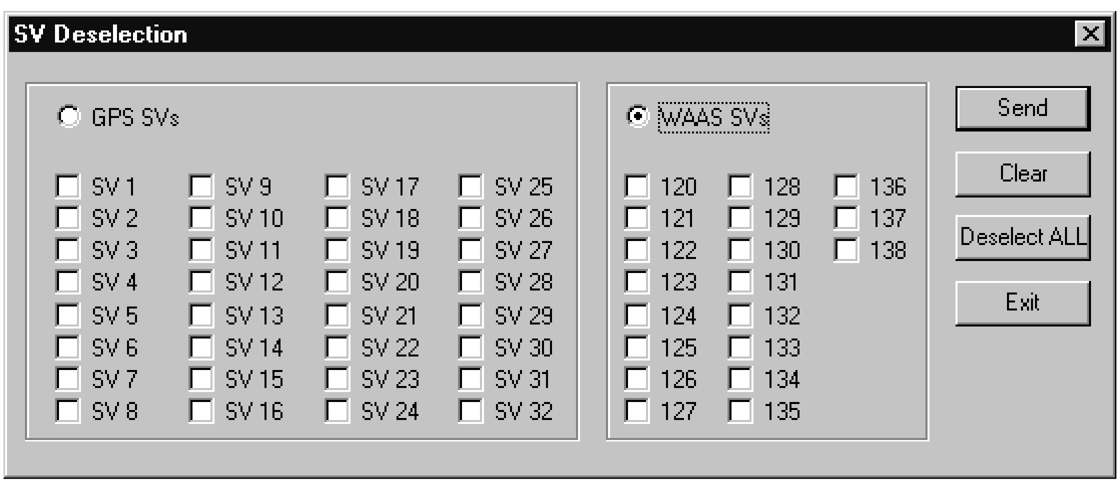


Figure 7: SV Deselection

To track one SBAS satellite in particular, do the following:

1. Select WAAS SVs
2. Select the SBAS satellite that you wish to track by deselecting all the others. This insures that the receiver will search for a satellites that is known to be operating and thus ensure quick acquisition/ reacquisition of the active SBAS satellite.

🖂 By default, if you select WAAS SVs alone, the unit is only searching for satellite PRNs 120, 122 and 134.

E.4 StarView SBAS Message Status

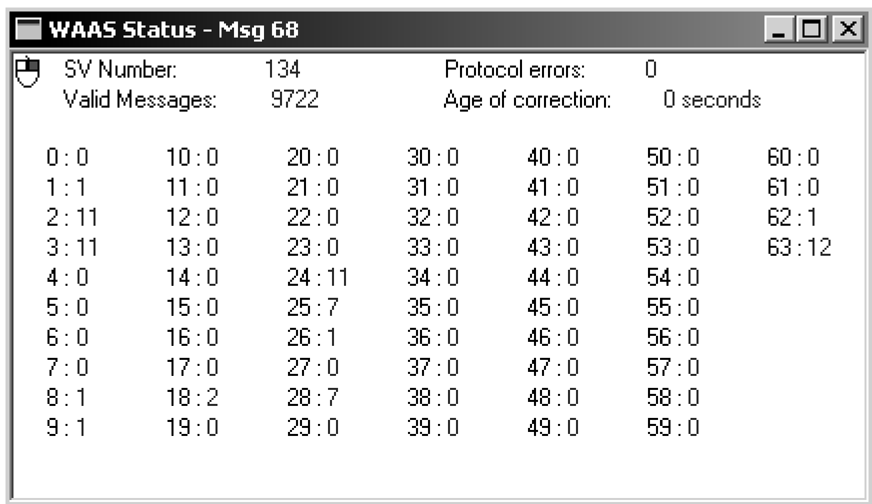


Figure 8: SBAS Status

The WAAS Status window, see *Figure 8*, shows you 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.

E.5 SBAS Satellite ID

Table 17: SBAS Satellite Identification

SV#	Description
120	AOR-E: Atlantic Ocean Region (E15)
121	Not allocated
122	AOR-W: Atlantic Ocean Region (W55)
134	POR: Pacific Ocean Region (E178)

Figure 9 on *Page 59* shows the coverage of two WAAS satellites (PRN 134 - yellow and PRN 122 - red):

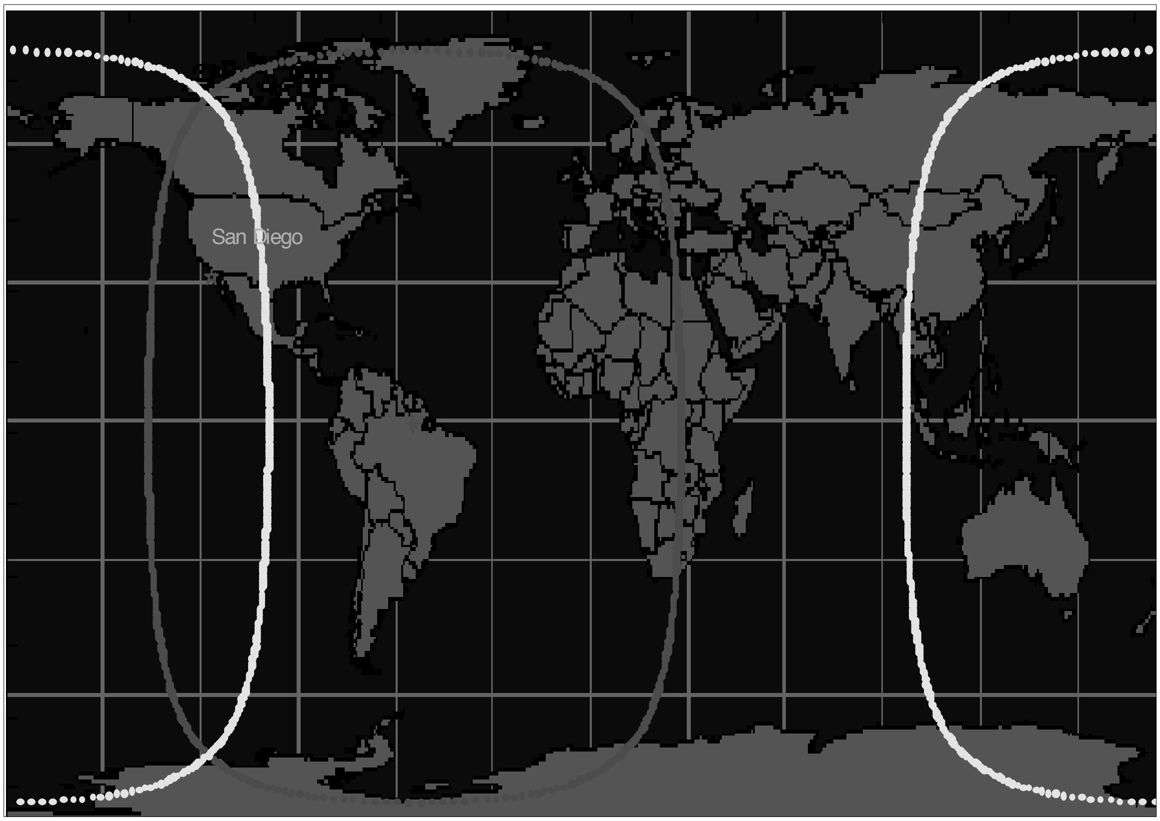


Figure 9: WAAS Coverage

Appendix F Updating Receiver Firmware

This appendix will explain how to update the receiver's firmware from a binary file using the programming utility.

F.1 Introduction

GPS receivers have their firmware stored in flash memory and therefore you can update its content in the field. This feature increases tremendously the receiver's flexibility allowing you to always use the latest version of the firmware, thus, continuously improving the receiver's capability.

F.2 Description

For the purpose of the explanation, we will consider that the firmware name is *filename* and that the programming utility name is *prog*.

The programming utility is a DOS based command line utility which, once invoked with the proper parameters, will update the receiver's firmware. Although it is DOS based, it can be used on computer using Windows 95 and higher or Windows NT operating system.

Usually, the programming utility and the firmware binary file will be provided to the customer in zip files. Therefore, those files must be unzipped before proceeding with the firmware update.

If you invoke *prog* without any parameters or with a missing parameter, a pop-up menu will appear.

The programming utility requires four parameters to perform the update task. The first one must be the firmware binary filename. The second is the port of the PC used to communicate with the receiver. The third one is the communication protocol used (binary or NMEA). Finally for the fourth and fifth parameters, you need to supply the synchronization speed (the actual speed of the GPS receiver) and the programming speed (communication speed used while programming the board).

```
PROG FILENAME PORT PROTOCOL SYNC PROGRAMMING
```

Table 18: Updating Parameters

Parameter	Possible Value
filename	any valid filename in the 8.3 DOS standard
port	Any number representing a valid port number installed on the PC. e.g. 1 for COM1, 3 for COM3,...
protocol	Used to indicate the current protocol used by the GPS receiver. 0: Binary protocol 1: NMEA protocol
sync	Current speed used by the GPS receiver. Any standard speed between 300 and 115200.
programming	Speed used to transmit information to the GPS receiver. Any standard speed between 300 and 115200.

F.2.1 Example

The following command line would used prog.exe to update the GPS receiver's firmware, using the binary file called 614174.007. The receiver is in binary mode at 9600 bps and we want to transmit the data at 115600 bps. COM4 of the PC is used. Therefore you would enter the following line:

```
PROG 614174.007 4 0 9600 115200
```

F.3 Troubleshooting

F.3.1 Firmware Partially Erased or Invalid

If, upon powering up the receiver, the following message is displayed at 9600 bps:

```
BAD OPERATIONAL JUMPING IN PROGRAMMING MODE
```

then, you have to use the same command again with the synchronization speed set to 9600 bps for the SUPERSTAR or SUPERSTAR II receivers and to 19200 for the ALLSTAR receiver. The remaining parameters are according to your setup.

Please refer to the *ALLSTAR* manual (*Appendix F*) for details on how to hard program the receiver.

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