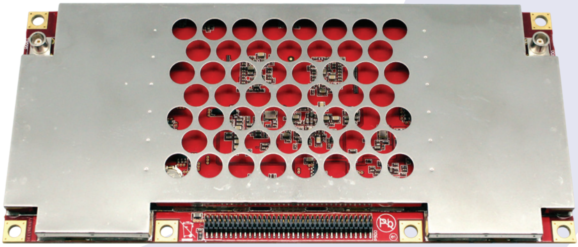

Eclipse Vector H321 OEM Board

Integrator's Guide

Part No. 875-0345-0 Rev. A2

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

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6501346	72777	7460942	8102325	8271194	
6539303	72921	7689354	8138970	8307535	
6549091	72921	7808428	8140223	8311696	
6711501	73732	7835832	8174437	8334804	
6744404	73885	7885745	8184050	RE41358	
6865465	74002	7948769	8190337		

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Notice to Customers

Contact your local dealer for technical assistance. To find the authorized dealer near you:

Hemisphere GNSS, Inc. 8444 N 90th St, Suite 120 Scottsdale, AZ 85258 USA Phone: (480) 348-9919

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Contents

Chapter 1: Introduction

Note: This Integrators Guide does not cover receiver operation, the PocketMax™ utility, or commands and messages (NMEA 0183, NMEA2000® or HGPS proprietary). For information on these subjects refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

This chapter provides an overview of the Eclipse™ Vector™ H321™ OEM board and information on board integration and key features of the board.

Note: Throughout the rest of this manual, the Eclipse Vector H321 OEM board is referred to simply as the H321.

Overview

You can use the H321 for any application needing accurate heading or DGPS or RTK positioning. Fitted with Hemisphere GNSS' patented Eclipse receiver technology, the H321 computes heading and position using two antennas. This design provides precise heading and GPS sub-meter positioning accuracy while stationary. And with integrated SBAS support, you can receive precision guidance anywhere those services are available.

The H321 provides accurate, reliable heading and position information at high update rates. It does this by using a high performance GNSS engine for signal processing.

The one receiver processes information from both the primary GPS antenna and secondary GPS antenna. Positions computed by the H321 are referenced to the phase center of the primary GPS antenna. Heading data references the vector formed from the primary GPS antenna phase center to the secondary GPS antenna phase center.

What's Included

The H321 is available in two configurations:

- H321 OEM board only - designed for integrators who are familiar with H321 board integration
- H321 OEM board and Universal Development Kit - designed for integrators who are new to H321 board integration

  The Universal Development Kit is designed to work with various Hemisphere GNSS OEM boards and includes an enclosure with carrier board, adapter boards, and various cables.

  For more information on the Universal Development Kit visit www.hemispheregnss.com and navigate to the GNSS OEM Board Products page or contact your local dealer.

H321 Integration

Successful integration of the H321 within a system requires electronics expertise that includes:

- Power supply design
- Serial port level translation
- Reasonable radio frequency competency
- An understanding of electromagnetic compatibility
- Circuit design and layout

The Eclipse Vector GNSS engine is a low-level module intended for custom integration with the following general integration requirements:

- Regulated power supply input (3.3 VDC ± 3%) and 1040 mA continuous current
- Low-level serial port (3.3 V CMOS) and USB port communications
- Radio frequency (RF) input to the engine from a pair of GNSS antennas is required to be actively amplified (10 to 40 dB gain)
- GNSS antennas are powered with a separate regulated voltage source up to 15 VDC maximum
- Antenna input impedance is 50 □

H321 Features

Features of the H321 include:

- GNSS engine (3 channels dedicated to SBAS tracking)
- 20 mm horizontal accuracy with RTK 95%
- Raw measurement output (via documented binary messages)
- Position and heading update rates of 20 Hz maximum
- Robust RTK
- Long-range RTK baselines up to 50 km
- Fast reacquisition times
- 10 m heading baseline
- COAST™ technology that provides consistent performance with correction data
- Quick times to first fix
- Four full-duplex serial ports
- Two USB ports (1 USB host and 1 USB device)
- 1 PPS timing output
- Event marker input

Note: For complete specifications of the H321 see Appendix C, “Technical Specifications.”

Configuring the H321

The H321 has four communication ports: A, B, C, and D. Ports A, B, and C are fully independent and can have different messages output at different rates. You can configure each of these ports for external correction input or output binary message information or RTCM corrections from an outside source. You can also configure the output of ports A, B, or C through any of these ports. Configure the baud rates if necessary; the default is 19200 for Ports A, B, and C.

Port D is reserved for RTCM differential corrections and may be used by the Hemisphere GNSS SBX-4™ board.

Configure the supplementary sensors if necessary. The tilt sensor operates by default and the gyro is disabled but it is recommended that all sensors be turned on once installation is complete.

Configure for your mode of differential operation: SBAS, beacon, or external corrections.

NMEA 0183 Message Interface

The H321 uses a NMEA 0183 interface, allowing you to easily make configuration changes by sending text-type commands to the receiver. For more information on NMEA 0183 commands and messages refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

Binary Message Interface

In addition to the NMEA 0183 interface, the H321 also supports a selection of binary messages. There is a wider array of information available through the binary messages, plus binary messages are inherently more efficient with data. If the application has a requirement for raw measurement data, this information is available only in a binary format. For more information on binary messages refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

Using PocketMax to Communicate with the H321

Hemisphere GNSS' PocketMax is a free utility that runs on your PDA or computer and allows you to easily interface with the H321. PocketMax also allows you to:

- Select the internal SBAS or external beacon or RTCM correction sources, if available, and monitor reception
- Configure GPS message output and port settings
- Configure and monitor Vector-related settings
- Record various types of data
- Monitor the H321's status and function

Connect your computer or PDA to the H321 via the COM port and open PocketMax. The menus and tabs within PocketMax allow you to control the H321's settings and monitor its status. PocketMax is available as a free download from the Resources | Software page of the Hemisphere GNSS website at www.hemispheregnss.com.

Chapter 2: Board Overview

Mechanical Layout

Figure 2-1 shows the mechanical layout for the H321. Dimensions are in millimeters (inches).

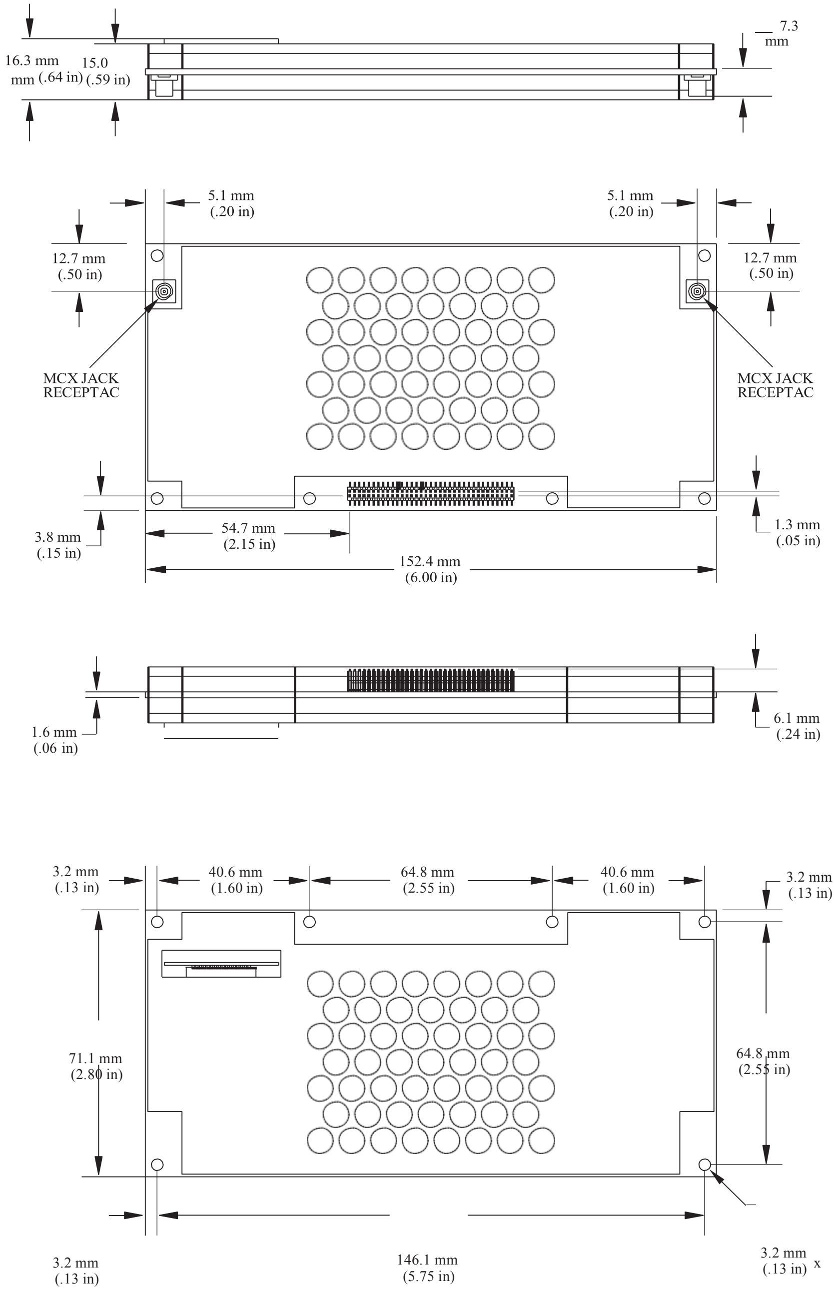

Figure 2-1: H321 mechanical layout

Connectors

Table 2-1 describes the H321's connectors and the mating connectors. You can use different compatible connectors; however, the requirements may be different. The antenna input impedance is 50 Ω.

Table 2-1: H321 connectors

Connector Type	H321 SMT Connector	Mating Connector
RF	MCX, female straight jack Johnson 133-3711-202	MCX, male straight plug Samtec RSP-127824-01
Power/data	70-pin (35x2) male header, 0.05 in (1.27 mm) pitch Samtec FTSH-135-01-L-DV	35x2 female SMT header socket, 0.05 in (1.27 mm) pitch Samtec FLE-135-01-G-DV

Mounting Options

There are two options for mounting the H321:

- Direct Electrical Connection method
- Indirect Electrical Connection (Cable) method

Direct Electrical Connection Method

Place a pair of RF connectors, header connector, and mounting holes on the carrier board and then mount the H321 on the standoffs and RF and header connectors. This method is very cost effective as it does not use cable assemblies to interface the H321.

Note: Be aware of the GNSS RF signals present on the carrier board and ensure the correct standoff height to avoid any flexual stresses on the board when you fasten it down.

The H321 uses a standoff height of 7.9 mm (0.3125 in). With this height there should be no washers between either the standoff and the H321 or the standoff and the carrier board; otherwise, you must make accommodations. You may need to change the standoff height if you select a different header connector.

If you want to use a right angle MCX connector, use a taller header than the Samtec part number suggested in this guide. This will provide clearance to have a right angle cable-mount connector and reduce the complexity by not having the carrier board handle the RF signals. See Table 2-1 on page 7 for H321 connector information.

The mounting holes of the H321 have a standard inner diameter of 3.2 mm (0.125 in).

Indirect Electrical Connection (Cable) Method

The second method is to mount the H321 mechanically so you can connect a ribbon power/data cable to the H321. This requires cable assemblies and there is a reliability factor present with cable assemblies in addition to increased expense.

Header and Pinouts

The H321 uses a dual-row header connector to interface with power, communications, and other signals.

To identify the first header pin orient the board so the diamond is to the upper left of the pins; the first pin is on the left directly below the diamond (see Figure 2-2). The pins are then sequentially numbered per row from top to bottom.

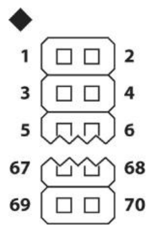

Figure 2-2: H321 header layout

Table 2-2 provides pinout details for the H321 header.

Table 2-2: H321 header pinout descriptions

Pin	Name	Type	Description
1	3.3 V	Power	Receiver power supply, 3.3 V
2	3.3 V	Power	Receiver power supply, 3.3 V
3	3.3 V	Power	Receiver power supply, 3.3 V
4	3.3 V	Power	Receiver power supply, 3.3 V
5	GND	Power	Receiver ground
6	GND	Power	Receiver ground
7	Antenna Pwr	Power	Antenna power, DC, 15 V max
8	Batt Backup	Power	Power, 2.7 to 4.5 V, 500 nA typical
9	n/c	n/c	n/c
10	n/c	n/c	n/c
11	n/c	n/c	n/c
12	Reset	Open collector	Reset, open collector, 3.3 V typical, not required
13	GND	Power	Receiver ground
14	GND	Power	Receiver ground
15	n/c	n/c	n/c
16	USB-DVBS	Input	Device USB bus power monitor
17	Manual Mark	Input	Active low, falling edge, 3.3 V CMOS
18	1 PPS	Output	Active low, falling edge, 3.3 V CMOS
19	Speed Output	Output	0 - 3 V variable clock output

Table 2-2: H321 header pinout descriptions (*continued*)

Pin	Name	Type	Description
20	Speed Ready	Output	Active low, speed valid indicator, 3.3 V CMOS
21	n/c	n/c	n/c
22	USB-PSW (reserved)	Input	Reserved for possible future USB OTG
23	GND	Power	Receiver ground
24	USB-HVBS	Input	Host USB bus power monitor
25	PATX	Output	Port A serial output, 3.3 V CMOS, idle high
26	PARX	Input	Port A serial input, 3.3 V CMOS, idle high
27	PBTX	Output	Port B serial output, 3.3 V CMOS, idle high
28	PBRX	Input	Port B serial input, 3.3 V CMOS, idle high
29	PCTX	Output	Port C serial output, 3.3 V CMOS, idle high
30	PCRX	Input	Port C serial input, 3.3 V CMOS, idle high
31	PDTX	Output	Port D serial output, 3.3 V CMOS, idle high
32	PDRX	Input	Port D serial input, 3.3 V CMOS, idle high
33	n/c	n/c	n/c
34	n/c	n/c	n/c
35	GND	Power	Receiver ground
36	GND	Power	Receiver ground
37	USB HOST+	I/O	USB host data +
38	USB DEV+	I/O	USB device data +
39	USB HOST–	I/O	USB host data -
40	USB DEV–	I/O	USB device data -
41	GND	Power	Receiver ground
42	n/c	n/c	n/c
43	n/c	n/c	n/c
44	n/c	n/c	n/c
45	n/c	n/c	n/c
46	GND	Power	Receiver ground
47	n/c	n/c	n/c
48	n/c	n/c	n/c
49	n/c	n/c	n/c
50	n/c	n/c	n/c
51	GND	Power	Receiver ground
52	n/c	n/c	n/c
53	n/c	n/c	n/c

Table 2-2: H321 header pinout descriptions (*continued)*

Pin	Name	Type	Description
54	n/c	n/c	n/c
55	n/c	n/c	n/c
56	n/c	n/c	n/c
57	Primary GPS Lock	Output	Status indicator, 3.3 V CMOS, active low
58	Secondary GPS Lock	Output	Status indicator, 3.3 V CMOS, active low
59	Diff Lock	Output	Status indicator, 3.3 V CMOS, active low
60	n/c	n/c	n/c
61	DGPS Lock	Output	Status indicator, 3.3 V CMOS, active low
62	Heading Lock	Output	Status indicator, 3.3 V CMOS, active low
63	GND	Power	Receiver ground
64	GND	Power	Receiver ground
65	Analog GND	Power	Receiver ground
66	n/c	n/c	n/c
67	n/c	n/c	n/c
68	Analog GND	Power	Receiver ground
69	Analog GND	Power	Receiver ground
70	n/c	n/c	n/c
Note:	• Pins are not 5 V tolerant. The pin voltage range is 0 to 3.3 VDC, unless otherwise noted. • Leave any data or I/O pins that will not be used unconnected.		

Signals

This section provides information on the signals available via connectors.

RF Input

The H321 is designed to work with active GNSS antennas with an LNA gain range of 10 to 40 dB. The purpose of the range is to accommodate for losses in the cable system. Essentially, there is a maximum cable loss budget of 30 dB for a 40 dB gain antenna. Depending on the chosen antenna, the loss budget will likely be lower (a 24 dB gain antenna would have a 14 dB loss budget).

When designing the internal and external cable assemblies and choosing the RF connectors, do not exceed the loss budget; otherwise, you will compromise the tracking performance of the H321.

Serial Ports

The H321 has four serial communication ports:

- Port A, Port B, Port C - main ports
- Port D - Exclusively used to interface with Hemisphere GNSS' SBX-4 beacon board or an external corrections source. This port will not output normal GPS-related NMEA messages. When communicating into either Port A, B, or C, a virtual connection may be established to the device on Port D using the $JCONN command. See "Communication Port D" below for more information on Port D.

The H321 serial ports' 3.3 V CMOS signal level can be translated to interface with other devices. For example, if serial Ports A, B, and/or C are used to communicate to external devices such as PCs, you must translate the signal level from 3.3 V CMOS to RS-232.

Communication Port D

Port D is exclusively for external DGPS correction input to the H321, such as from Hemisphere GNSS' SBX-4 beacon board.

USB Ports

The H321 has one USB device port and one USB host port, where:

- USB Device port (data communication) shown in Figure 2-3 on page 13 serves as a high speed data communications port, such as for a PC
- USB Host port (data storage) shown in Figure 2-4 on page 14 serves as a data storage port, such as with a USB flash drive

The USB data lines are bi-directional and are differential pairs. The USB data lines should be laid out on printed wire board (PWB) with 90 Ω ±15% differential impedance. The traces should be over a solid continuous ground plane. Maintain parallel traces and symmetry. There shall be no traces or breaks in the ground plane underneath the D+ and D- traces. It is also recommended to leave a minimum 20 mil spacing between USB signals and other signals. Treat the data lines as if they are RF signals.

Relevant Device H321 Pins

USB Device Power Detect	USB–DVBS
USB Device +	USB+ Host
USB Device –	USB– Host

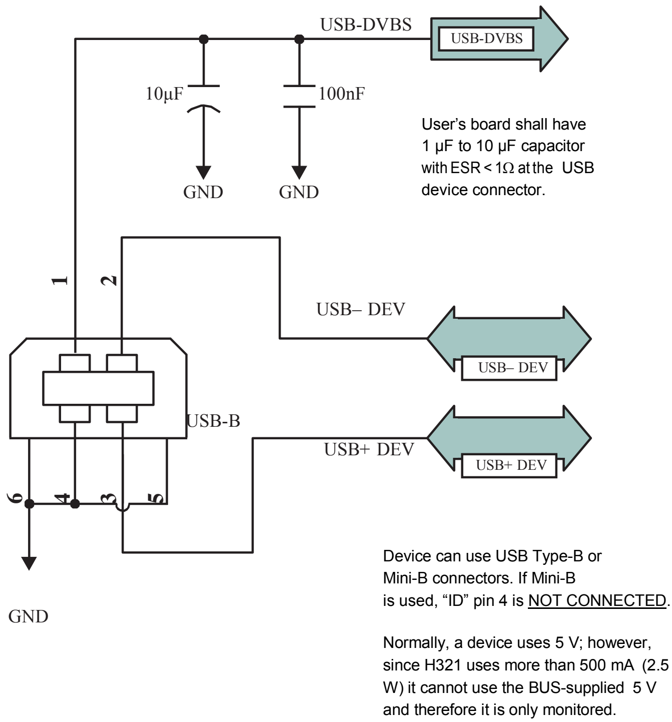

Figure 2-3: H321 USB device design example

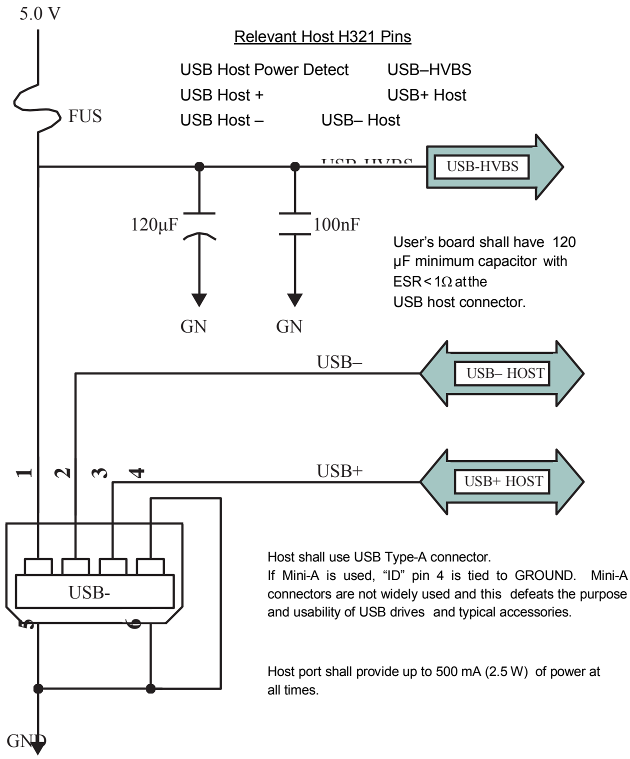

Figure 2-4: H321 USB host design example

LED Indicators

The H321 features the following surface-mounted diagnostic LEDs that indicate board status (see Figure 2-5):

- PWR - Power
- PGPS - Primary GPS lock
- SGPS - Secondary GPS lock
- DIFF - Differential lock
- DGPS - DGPS position
- HDG - Heading lock
- L-BAND - L-band lock

Figure 2-5: Onboard LEDs

With the exception of the power LED the signals that drive the LEDs are available via the header connector. Refer to Table 2-2 on page 9 for pin number descriptions for the H321.

Note: Each signal pin can offer only 1 mA of current and is active low. Since 1 mA of current may be inadequate for the application, you may want to transistor-buffer these signals to provide more current capacity for acceptable LED luminance.

1PPS Timing Signal

The one pulse per second (1 PPS) timing signal is used in applications where devices require time synchronization.

Note: 1 PPS is typical of most GPS boards but not essential to normal receiver operation. Do not connect this pin if you do not need this function.

The 1 PPS signal is 3.3 V CMOS, active low with falling edge synchronization. The 1 PPS signal is capable of driving a load impedance greater than 10 kΩ in parallel with 10 pF. The pulse is approximately 1 ms.

Event Marker Input

A GPS solution may need to be forced at a particular instance, not synchronized with GPS time depending on the application, such as indicating to the GPS receiver when a photo is taken from a camera used for aerial photography.

Note: Event marker input is typical of most GPS boards but not essential to normal receiver operation. Do not connect this pin if you do not need this function.

The event marker input is 3.3 V CMOS, active low with falling edge synchronization. The input impedance and capacitance is higher than 10 kΩ and 10 pF, respectively, with a threshold of lower than 0.7 V required to recognize the input.

Grounds

You must connect all grounds together when connecting the ground pins of the H321. These are not separate analog and digital grounds that require separate attention. Refer to Table 2-2 on page 9 for pinout ground information for the H321.

Speed Radar Output

Note: Speed radar output is not essential to normal receiver operation. Do not connect these pins if you do not need this function.

The following two pins on the H321 relate to the Speed Radar.

- Speed Radar Pulse (pin 19) - Outputs a square wave with 50% duty cycle. The frequency of the square wave varies directly with speed. 97 Hz represents a speed of 1 m/s (3.28 ft/s).
- Speed Radar Ready Signal (pin 20) - Indicates when the speed signal on the 'Speed Radar Pulse' pin is valid. In static situations, such as when the vehicle has stopped, the GPS position may still have slight variations from one moment to the next. During these instances, the signal on the 'Speed Radar Ready Signal' pin is 'high' or +Vcc, indicating the speed coming out of the 'Speed Radar Pulse' pin is erroneous and not truly indicative of the GPS receiver's actual speed. **Therefore, it should not be referred to or be used.** Once the vehicle starts moving again and meets a minimum threshold speed, the output on the 'Speed Radar Ready Signal' pin will go 'low' indicating valid speed information is present on the 'Speed Radar Pulse' pin.

Note: Neither pin 19 nor 20 has any form of isolation or surge protection. If utilizing the Speed Radar Pulse output, Hemisphere GNSS strongly recommends incorporating some form of isolation circuitry into the supporting hardware. Contact Hemisphere GNSS Technical Support for an example of an optically isolated circuit.

Shielding

The H321 is a sensitive instrument. When integrated into an enclosure, the H321 requires shielding from other electronics to ensure optimal operation. The H321 shield design consists of a thin piece of metal with specific diameter holes, preventing harmful interference from penetrating, while still allowing air circulation for cooling.

Receiver Mounting

The H321 is a precision instrument. To ensure optimal operation, consider mounting the receiver in a way to minimize vibration and shock.

When mounting the H321 immediately adjacent to the GPS antenna, Hemisphere GNSS highly recommends shielding the board from the LNA of the antenna. This step can be more complex than some integrators initially estimate. Attempt to confirm the operation in your application as early in the project as possible.

Thermal Concerns

The H321 receiver consumes a few watts of power, which ultimately will generate heat. Since this may raise the ambient temperature inside an enclosure consider managing the heat inside the enclosure to ensure the internal temperature does not exceed the maximum operating temperature for the H321. Some suggestions for heat management are heat sinks, heat conductive foam, or using a small cooling fan possibly using a thermal switch. Air moving over the H321 removes heat very effectively.

Note: Thermal design may only be a concern if the integrated product's maximum design temperature is expected to be close to that of the H321.

Chapter 3: Operation

This chapter provides H321 operation information, such as communicating with the H321, firmware, and configuration defaults.

Note: Install your antenna outdoors so it has a clear view of the entire sky. If you place the antenna indoors near a window, for example, you will likely not track a sufficient number of satellites. With a properly installed antenna the H321 provides a position within approximately 60 sec.

Powering the H321

The H321 is powered by a 3.3 VDC power source. Once you connect appropriate power the H321 is active. Although the H321 proceeds through an internal startup sequence upon application of power, it is ready to communicate immediately.

Communicating with the H321

The H321 features three primary serial ports (Port A, Port B, Port C) that you can configure independently from each other. You can configure the ports for any combination of NMEA 0183, binary, and RTCM SC-104 data. The usual data output is limited to NMEA data messages as these are industry standard.

Note: You may use the three serial ports to separate the different data types and output different rates. If the H321 is required to output different data types simultaneously, ensure data logging and the processing software used can correctly parse the different data from a single stream.

Configuring the H321

You can configure all aspects of H321 operation through any serial port using proprietary commands. These commands are described in detail in the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

You can configure the following:

- Select one of the two firmware applications
- Set communication port baud rates
- Select which messages to output on the serial ports and the update rate of each message
- Set various receiver operating parameters

For a complete lists of commands and messages refer to the Hemisphere GNSS Technical Reference.

To issue commands to the H321 you will need to connect it to a terminal program such as HyperTerminal or either of Hemisphere GNSS' software applications (SLXMon or PocketMax). See "What is the best software tool to use to communicate with the H321 and configure it?" on page 28 for descriptions of HyperTerminal, SLXMon, and PocketMax.

Firmware

The software that runs the H321 is often referred to as firmware since it operates at a low level. You can upgrade the firmware in the field through any serial port as new versions become available.

You can have two firmware applications loaded on the receiver; however, you can only operate one at a time.

The H321 currently ships with the rover RTK application and the base RTK/SBAS application. Refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link) for information on the $JAPP command, which you use to change between the two H321 applications.

Configuring the Data Message Output

The H321 features three primary bi-directional ports (Ports A, B and C) and a differential-only port (Port D). You can configure messages for all ports by sending proprietary commands to the H321 through any port. For a complete list of commands and messages refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

'THIS' Port and the 'OTHER' Port

Both Port A and Port B use the phrases "THIS" and "OTHER" when referring to themselves and each other in NMEA messages.

'THIS' port is the port you are currently connected to for inputting commands. To output data through the same port ('THIS' port) you do not need to specify 'THIS' port. For example, when using Port A to request the GPGGA data message be output at 5 Hz on the same port (Port A), issue the following command:

```
$JASC,GPGGA,5<CR><LF>
```

The 'OTHER' port is either Port A or Port B, whichever one you are not using to issue commands. If you are using Port A to issue commands, then Port B is the 'OTHER' port, and vice versa. To specify the 'OTHER' port for the data output you need to include 'OTHER' in the command. For example, if you use Port A to request the GPGGA data message be output at 5 Hz on Port B, issue the following command:

```
$JASC,GPGGA,5,OTHER<CR><LF>
```

When using Port A or Port B to request message be output on Port C, you must specifically indicate (by name) you want the output on Port C. For example, if you use Port A to request the GPGLL data message be output at 10 Hz on Port C, issue the following command:

```
$JASC,GPGLL,10,PORTC<CR><LF>
```

Saving the H321 Configuration

Each time you change the H321's configuration you may want to save it so you do not have to reconfigure the receiver each time you power it on. To save the configuration, issue the $JSAVE command to the Eclipse using a terminal program such as HyperTerminal or either of Hemisphere GNSS' applications (SLXMon or PocketMax).
The H321 will take approximately five seconds to save the configuration to non- volatile memory and will indicate when the configuration has been saved. Refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link) for more information on the $JSAVE command.

Using Port D for RTCM Input

Port D has been optimized to interface with Hemisphere GNSS' SBX-4 beacon board and operates at 9600 baud (8 data bits, no parity and 1 stop bit – 8-N-1).

To configure the H321 to use Port D, issue the following command:

```
$JDIFF,BEACON<CR><LF>
```

To return to using SBAS as the correction source, send the following command to the H321:

```
$JDIFF,WAAS<CR><LF>
```

For a complete list of commands and messages refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

Configuration Defaults

Below is the standard configuration for the H321. For more information on these commands refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link).

```
$JOFF,PORTA
$JOFF,PORTB
$JOFF,PORTD

$JAGE,2700
$JLIMIT,10
$JMASK,5
$JNP,5
$JWAASPRN,AUTO
$JDIFF,WAAS
$JPOS,51.0,-114.0
$JSMOOTH,LONG
$JTAU,COG,0.00
$JTAU,SPEED,0.00
$JAIR,AUTO
$JALT,NEVER

$JATT,HTAU,0.1
$JATT,HRTAU,2.0
$JATT,COGTAU,0.0
$JATT,MSEP,1.0
$JATT,GYROAID,YES
$JATT,TILTAID,YES
$JATT,LEVEL,NO
$JATT,EXACT,NO
$JATT,HIGHMP,YES
$JATT,FLIPBRD,NO
$JATT,HBIAS,0.0
$JATT,NEGTILT,NO
$JATT,NMEAHE,0
$JATT,PBIAS,0.0
$JATT,PTAU,0.5
$JATT,ROLL,NO
$JATT,SPDTAU,0.0

$JBAUD,19200,PORTA
$JASC,GPGGA,1,PORTA
$JASC,GPHDT,10,PORTA
$JASC,GPROT,10,PORTA
$JASC,GPHPR,1,PORTA

$JBAUD,19200,PORTB
$JASC,GPGGA,1,PORTB
$JASC,GPHDT,10,PORTB
$JASC,GPROT,10,PORTB
$JASC,GPHPR,1,PORTB

$JSAVE
```

Appendix A: Frequently Asked Questions

Integration

Power, Communication, and Configuration

GPS Reception and Performance

SBAS Reception and Performance

External Corrections

Installation

Support and Repair

Integration

Do I need to use the 1 PPS and event marker?

No, these are not necessary for H321 operation.

What should I do with the 1 PPS signal if I do not want to use it?

This signal will be strobing at 1 Hz, so it should not be connected.

What should I do with the manual mark input if I am not going to use it?

Do not connect the pin because this signal is active low.

Do I need to use the lock indicators?

No, these are present for applications where it is desirable to have an LED visible to the user. These signals need to be transistor-buffered, as these lines can only offer 1 mA. Depending on the product and the application, LEDs can be very useful to the end user. These signals are active low.

Do I need to use a shield-can for the H321?

Not necessarily...but you may need to if there are RF interference issues, such as if the H321 interferes with other devices. A shield-can would be a good start in terms of investigating the benefit. If you are designing a smart antenna system, one is likely needed. Hemisphere GNSS recommends that you always conduct an RF prescan when integrating OEM boards.

If my company wishes to integrate this product, what type of engineering resources will I need to do this successfully?

Hemisphere GNSS recommends you have sufficient engineering resources with the appropriate skills in and understanding of the following:

- Electronic design (including power supplies and level translation)
- RF implications of working with GPS equipment
- Circuit design and layout
- Mechanical design and layout

What type of assistance can I expect from Hemisphere GNSS when integrating the H321?

Integration of a GPS board has such benefits as:

- Lower system cost
- Improved branding (rather than relabeling an existing product)
- Better control of system design

As an integrator, you are responsible for ensuring that the correct resources are in place to complete the integration. Hemisphere GNSS will provide reasonable assistance; however, Hemisphere GNSS does not have dedicated engineering resources for in-depth integration support. Hemisphere GNSS will do its best to provide support as necessary, but you should expect to have reasonable expertise to use this Integrators Guide.

Power, Communication, and Configuration

My H321 system does not appear to be communicating. What do I do?

This could be one of a few issues:

- Examine the H321 cables and connectors for signs of damage or offset.
- Ensure the H321 system is properly powered with the correct voltage.
- Ensure there is a good connection to the power supply since it is required to terminate the power input with the connector.
- Check the documentation of the receiving device, if not a PC, to ensure the transmit line from the H321 is connected to the receive line of the other device. Also, ensure the signal grounds are connected.
- If the H321 is connected to a custom or special device, ensure the serial connection to it does not have any incompatible signal lines present that prevent proper communication.
- Make sure the baud rate of the H321 matches the other device. The other device must also support an 8 data bit, 1 stop bit, no parity port configuration (8-N-1). Some devices support different settings that may be user configurable. Ensure the settings match.
- Consult the troubleshooting section of the other device's documentation to determine if there may be a problem with the equipment.

Am I able to configure two serial ports with different baud rates?

Yes, all ports are independent. Example: set one port to 4800 and another port to 19200.

Am I able to have the H321 output different NMEA messages through multiple ports?

Yes, different NMEA messages can be sent to the serial ports you choose. These NMEA messages may also be at different update rates.

A high enough baud rate is needed to transmit the data; otherwise, some data may not be sent.

How can I determine the current configuration of the H321?

The $JSHOW command will request the configuration information from the H321. The response will be similar to:

```
$>JSHOW,BAUD,19200
$>JSHOW,BIN,1,5.0
$>JSHOW,BAUD,4800,OTHER
$>JSHOW,ASC,GPGGA,1.0,OTHER
$>JSHOW,ASC,GPVTG,1.0,OTHER
$>JSHOW,ASC,GPGSA,1.0,OTHER
```

How can I be sure the configuration will be saved for the subsequent power cycle?

Query the receiver to make sure the current configuration is correct by issuing a $JSHOW command. If not, make the necessary changes and reissue the $JSHOW command. Once the current configuration is acceptable, issue a $JSAVE command and wait for the receiver to indicate the save is complete. Do not power off the receiver until the "save complete" message appears.

How do I change the baud rate of a port from that port?

Connect at the current baud rate of the H321 port and then issue a $JBAUD command to change the port baud rate to the desired rate. Now change the baud rate in your application to the desired rate.

What is the best software tool to use to communicate with the H321 and configure it?

Hemisphere GNSS uses three different software applications:

- HyperTerminal™ - Available on all Windows® 95, 98, ME, and XP. This tool allows you to configure the H321 by directly typing commands into the terminal window. The output from the H321 is simultaneously shown. When using HyperTerminal, ensure it is configured to use the correct PC communication port and baud rate, and that the local echo feature is on (to see what is being typed).
- SLXMon - Available at www.hemispheregnss.com. This application is a very useful tool for graphically viewing tracking performance and position accuracy, and for recording data. It can also configure message output and port settings. SLXMon runs on Windows 95 or higher.
- PocketMax - Available at www.hemispheregnss.com. Similar to SLXMon, you can use this application to graphically view tracking performance and position accuracy, record data, and configure message output and port settings. PocketMax runs on multiple Windows platforms using the Windows .NET framework.

GPS Reception and Performance

How do I know what the H321 is doing?

The H321 supports standard NMEA data messages. The $GPGSV and Bin99 data messages contain satellite tracking and SNR information. If available, the computed position is contained in the $GPGGA message. Additionally, the H321 has surface-mounted status LEDs that indicate receiver status.

Do I have to be careful when using the H321 to ensure it tracks properly?

For best performance, the H321’s antenna must have a clear view of the sky for satellite tracking. The H321 can tolerate a certain amount of signal blockage because redundant satellites are often available. Only four satellites are required for a position; however, the more satellites that are used, the greater the positioning accuracy.

SBAS Reception and Performance

How do I know if the H321 has acquired an SBAS signal?

The H321 outputs the $RD1 message that contains the SBAS bit error rate (BER) for each SBAS channel. The BER value describes the rate of errors received from SBAS. Ideally, this should be zero. However, the H321 performs well up to 150 BER. The SLXMon and PocketMax utilities provide this information without needing to use NMEA commands.

How do I know if the H321 is offering a differentially-corrected or RTK-corrected position?

The H321 outputs the $GPGGA message as the main positioning data message. This message contains a quality fix value that describes the GPS status. If this value is 2, the position is differentially corrected; if this value is 4 or 5, the position is RTK-corrected. The SLXMon and PocketMax utilities provide this information without needing to use NMEA commands.

How do I select an SBAS satellite?

By default the H321 will automatically attempt to track the appropriate SBAS satellites. If multiple satellites are available, the one with the lowest BER value is selected to be used to decode the corrections.

You can manually select which SBAS satellites to track (refer to the Hemisphere GNSS Technical Reference—go to www.hemispheregnss.com/resources and click the GPS Reference Guide link—for more information); however, this is not recommended.

Should I be concerned if the H321 is frequently losing lock on SBAS due to obstructions or low satellite elevation angles at my geographic location?

No, provided that the receiver is receiving a full set of corrections relatively often. Using COAST technology, the H321 is able to perform well for 40 minutes or more with aging correction data. Similar to DGPS corrections, accuracy degrades over time and distance. To obtain a full set of corrections the H321 antenna receives the ionospheric map over a period of a few minutes. This is the minimum amount of time required to get a full set of corrections for SBAS operation. After this, the receiver can coast until the next set of corrections have been received.

Accuracy is a function of correction age and current ionospheric activity, which will increase in the coming years.

Do I need a dual frequency antenna for SBAS?

Hemisphere GNSS recommends using a dual frequency antenna with the H321. While some receiver function is possible with an L1-only antenna, full receiver performance will only be realized with a dual frequency antenna.

External Corrections

My H321 system does not appear to be using DGPS or RTK corrections from an external correction source. What could be the problem?

This could be due to a number of factors. To isolate the issue:

- Make sure DGPS corrections are RTCM v2.3 protocol.
- Make sure RTK corrections are either ROX, RTCM v3, CMR, or CMR+ protocol.
- Verify the baud rates used by the H321 match that of the external correction source.
- The external correction should be using an 8 data bit, no parity, 1 stop bit (8-N-1) serial port configuration.
- Inspect the cable connection to ensure there is no damage.
- Check the pinout information for the cables to ensure the transmit line of the external correction source is connected to the receive line of the H321 serial port and that the signal grounds are connected.
- Make sure the H321 has been set to receive external corrections by issuing the $JDIFF command. Refer to the Hemisphere GNSS Technical Reference (go to www.hemispheregnss.com/resources and click the GPS Reference Guide link) for more information.

Installation

Does it matter where I mount the H321's antenna?

Yes, the mounting location must provide a clear view of the sky for satellite tracking. Additionally, the position that it computes is based on the center of the antenna. It should be placed in the location for which the user would like a position. Often antennas are mounted on the centerline of a vehicle or on a pole-mount for georeference.

How will the antenna selection and mounting affect H321 performance?

For best results select a multipath-resistant antenna. Ensure the antenna tracks all the available signals for the receiver.

Mount the antenna:

- With the best possible view of the sky
- In a location with the lowest possible multipath

Using a magnetic mount for the antenna will not affect performance.

Support and Repair

How do I solve a problem I cannot isolate?

Hemisphere GNSS recommends contacting the dealer first. With their experience with this product, and other products from Hemisphere GNSS, they should be able to help isolate a problem. If the issue is beyond the capability or experience of the dealer, Hemisphere GNSS Technical Support is available from 8:00 AM to 5:00 PM Mountain Standard Time, Monday through Friday.

See "Technical Support" on page ii (just before the Contents page) for Technical Support contact information.

What do I do if I cannot resolve a problem after trying to diagnose it myself?

Contact your dealer to see if they have any information that may help to solve the problem. They may be able to provide some in-person assistance. If this is not viable or does not solve the problem, Hemisphere GNSS Technical Support is available from 8:00 AM to 5:00 PM Mountain Standard Time, Monday through Friday.

See "Technical Support" on page ii (just before the Contents page) for Technical Support contact information.

Can I contact Hemisphere GNSS Technical Support directly regarding technical problems?

Yes, however, Hemisphere GNSS recommends speaking to the dealer first as they would be the local support. They may be able to solve the problem quickly, due to their closer location and experience with our equipment.

Appendix B: Troubleshooting

Table B-1 provides a list of issues with possible solutions to help you troubleshoot anomalous H321 operation. Refer to Appendix C, “Technical Specifications” if necessary.

Table B-1: Troubleshooting

Issue	Possible Solution
What do I do initially if I have a problem with the operation of the H321?	Try to isolate the source of the problem. Problems are likely to fall within one of the following categories: • Power, communication, and configuration • GNSS reception and performance • Beacon reception and performance • SBAS reception and performance • External corrections • Installation • Shielding and isolating interference It is important to review each category in detail to eliminate it as a problem.
Receiver fails to power	• Verify polarity of power leads • Check 1.0 A in-line power cable fuse connection • Check integrity of power cable connections • Check power input voltage • Check current restrictions imposed by power source (minimum available should be > 1.0 A)
No data from the H321 1. No communication 2. No valid data	• (1) Check receiver power status (this may be done with an ammeter) • (2) Verify the H321 is locked to a valid DGPS signal (this can often be done on the receiving device or by using SLXMon) • (2) Verify the H321 is locked to GPS satellites (this can often be done on the receiving device or by using SLXMon) • (2) Check integrity and connectivity of power and data cable connections
Random binary data from the H321	• Verify the RCTM or Bin messages are not being accidentally output (send a $JSHOW command) • Verify the baud rate settings of H321 and remote device match • Potentially, the volume of data requested to be output by the Eclipse could be higher than the current baud rate supports. Try using 19200 or higher for the baud rate for all devices

Table B-1: Troubleshooting

Issue	Possible Solution
No GPS lock	• Check integrity of antenna cable • Verify antenna’s view of the sky • Verify the lock status and signal to noise ratio (SNR) of GPS satellites (this can often be done on the receiving device or by using SLXMon)
No SBAS	• Check integrity of antenna cable • Verify antenna’s view of the sky, especially toward SBAS satellites, south in the northern hemisphere • Verify the bit error rate and lock status of SBAS satellites (this can often be done on the receiving device or by using SLXMon - monitor BER value)
No DGPS position in external RTCM mode	• Verify the baud rate (BER) of the RTCM input port matches the baud rate of the external source • Verify the pinout between the RTCM source and the RTCM input port (the ‘ground’ pin and pinout must be connected, and the ‘transmit’ from the source must connect to the ‘receiver’ of the RTCM input port).
Non-DGPS output	• Verify H321 SBAS and lock status (or external source is locked)

Appendix C: Technical Specifications

Table C-1 through Table C-6 provide GNSS sensor, L-band, communication, power, environmental, and mechanical specifications of the H321.

Table C-1: GNSS sensor specifications

Item	Specification
Receiver type	Triple GNSS (GPS/GLONASS/BeiDou) RTK
Channels	12 L1CA GPS 12 L1P GPS 12 L2P GPS (with subscription code) 12 L2C GPS (with subscription code) 12 L1 GLONASS (with subscription code) 12 L2 GLONASS (with subscription code) 12 L1 BeiDou (with subscription code) 12 L2 BeiDou (with subscription code) 3 SBAS or 3 additional L1CA GPS 1 L-Band SBAS
GPS sensitivity	-142 dBm
SBAS tracking	3-channel, parallel tracking
Update rate	10 Hz standard, 20 Hz available
Horizontal accuracy	RMS (67%) / 2DRMS (95%) RTK[1,2]: 10 mm + 1 ppm / 20 mm + 2 ppm L-band high precision services[2,3]: 0.08 m / 0.16 m SBAS (WAAS)[2]: 0.25 m / 0.50 m Autonomous, no SA[2]: 1.2 m / 2.5 m
Heading accuracy	< 0.17º rms @ 0.5 m antenna separation < 0.09º rms @ 1.0 m antenna separation < 0.04º rms @ 2.0 m antenna separation < 0.02º rms @ 5.0 m antenna separation < 0.01º rms @ 10.0 m antenna separation
Pitch/roll accuracy	< 1º rms
Heave accuracy	30 cm rms (DGPS)[4] 5 cm rms (RTK)[4]
Timing (1PPS) accuracy	20 ns
Rate of turn	100º/s maximum
Cold start time	< 40 s typical (no almanac or RTC)
Warm start time	< 20 s typical (almanac and RTC)
Hot start time	< 5 s (almanac, RTC, and position)
Heading fix	< 10 s typical (hot start)
Maximum speed	1,850 kph (999 kts)
Maximum altitude	18,288 m (60,000 ft)

Table C-2: L-band sensor specifications

Item	Description
Sensitivity	-130 dBm
Channel spacing	7.5 KHz
Satellite selection	Manual and Automatic
Reacquisition time	15 seconds (typical)
Rejection	15 kHz spacing > 30 dB 300 kHz spacing > 60 dB
Processor	DSP for demodulation and protocol decoding module provides processing for differential algorithms
Command support	Reports L-band region and satellite information Allows input and status of L-band subscription, bit error rate (BER) output for reception quality indication and manual frequency tuning.

Table C-3: Communication specifications

Item	Description
Serial ports	4 full-duplex 3.3 V CMOS (3 main serial ports, 1 differential-only port)
USB ports	1 USB host, 1 USB device
Baud rates	4800 - 115200
Data I/O protocol	NMEA 0183, Crescent binary[5]
Correction I/O protocol	RTCM SC-104, RTCM v2.3 (DGPS), RTCM v3 (RTK), CMR, CMR+[6]
Timing output	1 PPS CMOS, active low, falling edge sync, 10 kΩ, 10 pF load
Event marker input	CMOS, active low, falling edge sync, 10 kΩ, 10 pF load
Heading warning I/O (Heading Lock)	Pin 62 (see Table 2-2 on page 9 for more information)

Table C-4: Power specifications

Item	Specification
Input voltage	3.3 VDC +/- 5%
Power consumption	< 3.2 W at 3.3 V (L1/L2 GPS/GLONASS/BeiDou) < 3.9 W at 3.3 V (L1/L2 GPS/GLONASS/BeiDou; L-band)
Current consumption	< 970 mA at 3.3 V (L1/L2 GPS/GLONASS/BeiDou) < 1180 mA at 3.3 V (L1/L2 GPS/GLONASS/BeiDou; L-band)
Antenna voltage input	15 VDC maximum
Antenna short circuit protection	Yes
Antenna gain input range	10 to 40 dB
Antenna input impedance	50 Ω

Table C-5: Environmental specifications

Item	Specification
Operating temperature	-40°C to +85°C (-40°F to +185°F)
Storage temperature	-40°C to +85°C (-40°F to +185°F)
Humidity	95% non-condensing (when installed in an enclosure)

Table C-6: Mechanical specifications

Item	Description
Dimensions	152.4 L x 71.1 W x 16.3 H mm (6.00 L x 2.80 W x 0.64 H in)
Weight	.105 kg (3.70 oz.)
Status indication (LED)	Power, Primary and Secondary GPS lock, Differential lock, DGPS position, Heading, RTK lock, L-band lock
Power/data connector	70-pin male header, 0.05” (1.27 mm) pitch
Antenna connector	MCX, female, straight

[1] Depends on multipath environment, number of satellites in view, satellite geometry, baseline length (for local services), and ionospheric activity.

[2] Depends on multipath environment, number of satellites in view, satellite geometry and ionospheric activity.

[3] Requires an L-band subscription.

[4] Based on a 40-second time constant.

[5] Hemisphere GNSS proprietary.

[6] Receive only, does not transmit this format.

Index

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19. INFRINGEMENT. If use of the Software may be enjoined due to a claim of infringement by a third party then, at its sole discretion and expense, Hemisphere may do one of the following: (a) negotiate a license or other agreement so that the Product is no longer subject to such a potential claim, (b) modify the Product so that it becomes non-infringing, provided such modification can be accomplished without materially affecting the performance and functionality of the Product, (c) replace the Software, or the Product, with non-infringing software, or product, of equal or better performance and quality, or (d) if none of the foregoing can be done on a commercially reasonable basis, terminate this license and Licensee shall stop using the Product and Hemisphere shall refund the price paid by Licensee less an amount on account of amortization, calculated on a straight-line basis over a deemed useful life of three (3) years.

    The foregoing sets out the entire liability of Hemisphere and the sole obligations of Hemisphere to Licensee in respect of any claim that the Software or its use infringes any third party rights.

20. INDEMNIFICATION. Except in relation to an infringement action, Licensee shall indemnify and hold Hemisphere harmless from any and all claims, damages, losses, liabilities, costs and expenses (including reasonable fees of lawyers and other professionals) arising out of or in connection with Licensee's use of the Product, whether direct or indirect, including without limiting the foregoing, loss of data, loss of profit or business interruption.

21. TERMINATION. Licensee may terminate this Agreement at any time without cause. Hemisphere may terminate this Agreement on 30 days notice to Licensee if Licensee fails to materially comply with each provision of this Agreement unless such default is cured within the 30 days. Any such termination by a party shall be in addition to and without prejudice to such rights and remedies as may be available, including injunction and other equitable remedies. Upon receipt by Licensee of written notice of termination from Hemisphere or termination by Licensee, Licensee shall at the end of any notice period (a) cease using the Software; and (b) return to Hemisphere (or destroy and provide a certificate of a Senior Officer attesting to such destruction) the Software and all related material and any magnetic or optical media provided to Licensee. The provisions of Sections 6), 7), 8), 9), 10), 15), 21), 26) and 27) herein shall survive the expiration or termination of this Agreement for any reason.

22. **EXPORT RESTRICTIONS**. Licensee agrees that Licensee will comply with all export control legislation of Canada, the United States, Australia and any other applicable country's laws and regulations, whether under the Arms Export Control Act, the International Traffic in Arms Regulations, the Export Administration Regulations, the regulations of the United States Departments of Commerce, State, and Treasury, or otherwise as well as the export control legislation of all other countries.

23. **PRODUCT COMPONENTS.** The Product may contain third party components. Those third party components may be subject to additional terms and conditions. Licensee is required to agree to those terms and conditions in order to use the Product.

24. **FORCE MAJEURE EVENT.** Neither party will have the right to claim damages as a result of the other's inability to perform or any delay in performance due to unforeseeable circumstances beyond its reasonable control, such as labor disputes, strikes, lockouts, war, riot, insurrection, epidemic, Internet virus attack, Internet failure, supplier failure, act of God, or governmental action not the fault of the non-performing party.

25. **FORUM FOR DISPUTES**. The parties agree that the courts located in Calgary, Alberta, Canada and the courts of appeal there from will have exclusive jurisdiction to resolve any disputes between Licensee and Hemisphere concerning this Agreement or Licensee's use or inability to use the Software and the parties hereby irrevocably agree to attorn to the jurisdiction of those courts. Notwithstanding the foregoing, either party may apply to any court of competent jurisdiction for injunctive relief.

26. **APPLICABLE LAW**. This Agreement shall be governed by the laws of the Province of Alberta, Canada, exclusive of any of its choice of law and conflicts of law jurisprudence.

27. **CISG.** The United Nations Convention on Contracts for the International Sale of Goods will not apply to this Agreement or any transaction hereunder.

28. **GENERAL.** This is the entire agreement between Licensee and Hemisphere relating to the Product and Licensee's use of the same, and supersedes all prior, collateral or contemporaneous oral or written representations, warranties or agreements regarding the same. No amendment to or modification of this Agreement will be binding unless in writing and signed by duly authorized representatives of the parties. Any and all terms and conditions set out in any correspondence between the parties or set out in a purchase order which are different from or in addition to the terms and conditions set forth herein, shall have no application and no written notice of same shall be required. In the event that one or more of the provisions of this Agreement is found to be illegal or unenforceable, this Agreement shall not be rendered inoperative but the remaining provisions shall continue in full force and effect.

Warranty Notice

COVERED PRODUCTS: This warranty covers all products manufactured by Hemisphere GNSS and purchased by the end purchaser (the "Products"), unless otherwise specifically and expressly agreed in writing by Hemisphere GNSS.

LIMITED WARRANTY: Hemisphere GNSS warrants solely to the end purchaser of the Products, subject to the exclusions and procedures set forth below, that the Products sold to such end purchaser and its internal components shall be free, under normal use and maintenance, from defects in materials, and workmanship and will substantially conform to Hemisphere GNSS's applicable specifications for the Product, for a period of 12 months from delivery of such Product to such end purchaser (the "Warranty Period"). Repairs and replacement components for the Products are warranted, subject to the exclusions and procedures set forth below, to be free, under normal use and maintenance, from defects in material and workmanship, and will substantially conform to Hemisphere GNSS's applicable specifications for the Product, for 90 days from performance or delivery, or for the balance of the original Warranty Period, whichever is greater.

EXCLUSION OF ALL OTHER WARRANTIES. The LIMITED WARRANTY shall apply only if the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Hemisphere GNSS's relevant User's Manual and Specifications, AND the Product is not modified or misused. The Product is provided "AS IS" and the implied warranties of MERCHANTABILITY and FITNESS FOR A PARTICULAR PURPOSE and ALL OTHER WARRANTIES,
express, implied or arising by statute, by course of dealing or by trade usage, in connection with the design, sale, installation, service or use of any products or any component thereof, are EXCLUDED from this transaction and shall not apply to the Product. The LIMITED WARRANTY is IN LIEU OF any other warranty, express or implied, including but not limited to, any warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE, title, and non-infringement.

LIMITATION OF REMEDIES. The purchaser's EXCLUSIVE REMEDY against Hemisphere GNSS shall be, at Hemisphere GNSS's option, the repair or replacement of any defective Product or components thereof. The purchaser shall notify Hemisphere GNSS or a Hemisphere GNSS's approved service center immediately of any defect. Repairs shall be made through a Hemisphere GNSS approved service center only. Repair, modification or service of Hemisphere GNSS products by any party other than a Hemisphere GNSS approved service center shall render this warranty null and void. The remedy in this paragraph shall only be applied in the event that the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Hemisphere GNSS's relevant User's Manual and Specifications, AND the Product is not modified or misused. NO OTHER REMEDY (INCLUDING, BUT NOT LIMITED TO, SPECIAL, INDIRECT, INCIDENTAL, CONSEQUENTIAL OR CONTINGENT DAMAGES FOR LOST PROFITS, LOST SALES, INJURY TO PERSON OR PROPERTY, OR ANY OTHER INCIDENTAL OR CONSEQUENTIAL LOSS) SHALL BE AVAILABLE TO PURCHASER, even if
Hemisphere GNSS has been advised of the possibility of such damages. Without limiting the foregoing, Hemisphere GNSS shall not be liable for any damages of any kind resulting from installation, use, quality, performance or accuracy of any Product.

HEMISPHERE IS NOT RESPONSIBLE FOR PURCHASER'S NEGLIGENCE OR UNAUTHORIZED USES OF THE PRODUCT. IN NO EVENT SHALL HEMISPHERE GNSS BE IN ANY WAY RESPONSIBLE FOR ANY DAMAGES RESULTING FROM PURCHASER'S OWN NEGLIGENCE, OR FROM OPERATION OF THE PRODUCT IN ANY WAY OTHER THAN AS SPECIFIED IN HEMISPHERE GNSS'S RELEVANT USER'S MANUAL AND SPECIFICATIONS. Hemisphere GNSS is NOT
RESPONSIBLE for defects or performance problems resulting from (1) misuse, abuse, improper installation, neglect of Product; (2) the utilization of the Product with hardware or software products, information, data, systems, interfaces or devices not made, supplied or specified by Hemisphere GNSS; (3) the operation of the Product under any specification other than, or in addition to, the specifications set forth in Hemisphere GNSS's relevant User's Manual and Specifications; (4) damage caused by accident or natural events, such as lightning (or other electrical discharge) or fresh/salt water immersion of Product; (5) damage occurring in transit; (6) normal wear and tear; or (7) the operation or failure of operation of any satellite-based positioning system or differential correction service; or the availability or performance of any satellite-based positioning signal or differential correction signal.

THE PURCHASER IS RESPONSIBLE FOR OPERATING THE VEHICLE SAFELY. The purchaser is solely responsible for the safe operation of the vehicle used in connection with the Product, and for maintaining proper system control settings. UNSAFE DRIVING OR SYSTEM CONTROL SETTINGS CAN RESULT IN PROPERTY DAMAGE, INJURY, OR DEATH.
The purchaser is solely responsible for his/her safety and for the safety of others. The purchaser is solely responsible for maintaining control of the automated steering system at all times. THE PURCHASER IS SOLELY RESPONSIBLE FOR ENSURING THE PRODUCT IS PROPERLY AND CORRECTLY INSTALLED, CONFIGURED, INTERFACED, MAINTAINED, STORED, AND OPERATED IN ACCORDANCE WITH HEMISPHERE GNSS'S RELEVANT USER'S MANUAL AND
SPECIFICATIONS. Hemisphere GNSS does not warrant or guarantee the positioning and navigation precision or accuracy obtained when using Products. Products are not intended for primary navigation or for use in safety of life applications. The potential accuracy of Products as stated in Hemisphere GNSS literature and/or Product specifications serves to provide only an estimate of achievable accuracy based on performance specifications provided by the satellite service operator (i.e. US Department of Defense in the case of GPS) and differential correction service provider. Hemisphere GNSS reserves the right to modify Products without any obligation to notify, supply or install any improvements or alterations to existing Products.

GOVERNING LAW. This agreement and any disputes relating to, concerning or based upon the Product shall be governed by and interpreted in accordance with the laws of the State of Arizona.

OBTAINING WARRANTY SERVICE. In order to obtain warranty service, the end purchaser must bring the Product to a Hemisphere GNSS approved service center along with the end purchaser's proof of purchase. Hemisphere GNSS does not warrant claims asserted after the end of the warranty period. For any questions regarding warranty service or to obtain information regarding the location of any of Hemisphere GNSS approved service center, contact Hemisphere GNSS at the following address:

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