CRESCENT VECTOR OEM INTEGRATOR'S MANUAL

Part Number:	875-0161-000
Date:	December 2005

FCC Notice
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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In order to obtain warranty service, the end purchaser must bring the Product to a CSI Wireless approved dealer, along with the end purchaser's proof of purchase. For any questions regarding warranty service or to obtain information regarding the location of any of CSI Wireless's dealers, contact CSI Wireless at the following address:

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Chapter 1: Quick Start

Receiving Your Shipment

If you find that any of the items are damaged due to shipment, please contact the freight carrier immediately for assistance.

Unpacking Your Crescent Vector

When you unpack your Crescent Vector system, please ensure that it is complete by comparing the parts received against the packing slip. Unless your system has been equipped differently than a standard Crescent OEM system, you should find the following parts in your system:

- One Crescent Vector module (P/N 726-1049-XXX)
- One Crescent Vector OEM Integrator's Manual CD (P/N 132-0132-XXX)

If you have purchased an Evaluation module, you will also receive:

- An Evaluation Enclosure, which includes an additional Crescent Vector module with carrier board (P/N 802-1021-XXX)
- Two CDA3-RTK antennas (P/N 804-0023-XXX)
- Associated cables

Note - If, for some reason, you find a discrepancy between your packing slip and the contents of your shipment, please contact the sales person with which you placed your order immediately.

Configuring the Crescent Vector Module

The Crescent Vector has four communication ports referred to as A, B, C and D. A, B and C are fully independent and may have different message output at different rates. Each of these ports may be configured for external correction input or output binary message information or even RTCM corrections from an outside source. Also, you may configure the output of ports A, B or C through any port A, B or C. Port D is reserved for RTCM differential corrections, and may be used by the SBX-3B board.

NMEA 0183 Message Interface

The Crescent Vector module uses a NMEA 0183 interface for interfacing, which allows you to easily make configuration changes by sending text-type commands to the receiver.

Where appropriate, relevant commands for making the configuration changes are discussed in the following chapters. Chapter 6, however, is devoted to describing the NMEA interface in detail.

BINARY MESSAGE INTERFACE

In addition to the NMEA interface, the Crescent Vector module 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 your application has a requirement for raw measurement data, for instance, this information is available only in a binary format. Consult Chapter 7 for more information on Binary messages.

POCKETMAX PC

Chapter 5 of this manual provides sufficient information on how to communicate to the Crescent Vector Evaluation system with our PocketMAX PC utility. This program allows you to graphically monitor the status and function of the Crescent Vector module, in addition to providing an interface for its control.

We recommend that you gain your initial experience with the Crescent Vector module using this utility and then migrate your work to either a dumb terminal or begin the integration of appropriate commands and messages within your application software.

DEFAULT PARAMETERS

Although presented in the following chapters, this section provides tables that detail the default parameters of the Crescent Vector OEM module.

Note: Any changes you make to the Crescent Vector OEM configuration need to be saved with the $JSAVE NMEA command in order to be present for a subsequent power-cycle.

Table 1-1. Default Application

Application
ATTITUD2

Table 1-2. Default Port Settings

Port	Baud Rate	Data Bits	Parity	Stop Bit	Interface Level
A, B and C	19200	8	None	1	3.3 V CMOS
D	9600	8	None	1	3.3 V CMOS

Note: The data bits, parity, and stop bit are not adjustable. They are fixed with an 8-N-1 configuration.

Table 1-3. Default GPS NMEA Message Output.

Port	GPS NMEA Messages	Update Rate
A, B and C	GGA, GSV, VTG, ZDA, HDT, ROT	1 Hz
D	NONE	N/A

Table 1-4. Default Parameters.

Max DGPS Age	Elevation Mask
1800 seconds	5°

Table 1-5. Available Baud Rates.

Baud Rates
4800
9600
19200
38400
57600

CHAPTER 2: INTRODUCTION

OVERVIEW

This chapter provides a brief introduction to the Crescent Vector module and some of its high-level features. The remaining chapters provide more detailed information on the workings of the product and the integration requirements.

For your convenience, both the GPS and SBAS operation of the Crescent Vector module features automatic operational algorithms. When powered for the first time, the Crescent Vector system will perform a ‘cold start’, which involves acquiring the available GPS satellites in view and the SBAS differential service.

If SBAS is not available in your area, an external source of RTCM SC-104 differential corrections may be used. If you choose to use an external source of correction data, you will need to ensure that the external source supports an eight data bit, no parity, and one stop bit configuration (8-N-1). Additionally, since the Crescent Vector is a low-level module, it will need to receive corrections at a 3.3 V CMOS signal level.

This chapter describes the various modes of operation and features of your Crescent Vector module.

GPS

The GPS engine is always operating, regardless of the DGPS mode of operation. The following sections describe the general operation of the Crescent Vector module.

SATELLITE TRACKING

The Crescent Vector module automatically searches for GPS satellites, acquires the signal, and manages the associated navigation information required for positioning and tracking. This is a hands-free mode of operation. Satellite acquisition quality is described as a signal to noise ratio (SNR). A higher SNR is indicative of better quality signal reception. SNR information is provided by the Crescent Vector through the use of NMEA 0183 data messages available via its multiple serial ports.

HEADING ACCURACY

The Crescent Vector has a heading accuracy of 0.5 degrees 95% with an antenna separation of 0.5 meters. This heading accuracy can be increased with an increased antenna separation, but, with the trade off of slower acquisition and reacquisition times. For more information, please refer to the white paper on the Crescent Vector OEM.

Positioning Accuracy

The Crescent Vector is a sub-meter 95% accurate product under ideal conditions horizontally (minimum error). To determine the positioning performance of the Crescent Vector, Hemisphere GPS gathers a 24-hour data set of positions in order to log the diurnal environmental effects and also to log full GPS constellation changes. Shorter data sets than 24 hours tend to provide more optimistic results.

Keeping in mind that this horizontal performance specification is a real world but ideal scenario test, obstruction of satellites, multipath signals from reflective objects, and operating with poor corrections will detract from the module's ability to provide accurate, reliable positions. Differential performance can also be compromised if the Crescent Vector module is used in a region without sufficient ionospheric coverage. If external corrections are used, the baseline separation between the remote and base station antennas can affect performance.

Since the Crescent Vector will be used in the real world, blockage of the line of sight to SBAS satellites is often inevitable. The COAST function provides solace from obstruction of SBAS services for up to 30 to 40 minutes, depending on the amount of tolerable performance drift.

The estimated positioning precision is accessible through the use of NMEA 0183 command responses as described in Chapter 6 (The GST NMEA data message). As the receiver is not able to determine accuracy with respect to a known location in real time (this is traditionally performed in post-mission analyses), the precision numbers are relative in nature and are only approximates.

Update Rates

The update rate of each NMEA and binary message of the Crescent Vector can be set independently with a maximum that is dependant upon the message type. Some messages have a 1 Hz maximum, for example, while others are 20 Hz. The maximum default rates of the Crescent Vector are 5 Hz position, and 20 Hz heading. Higher position update rates of 10 or 20 Hz are an option and can be obtained at an additional cost.

SBAS

The following sections describe the general operation and performance monitoring of the SBAS demodulator within the Crescent Vector module.

Automatic Tracking

The SBAS demodulator featured within the Crescent Vector will automatically scan and track two SBAS satellite signals, specified by the user by the $JWAASPRN command (defaulted to both WAAS satellites). This automatic tracking allows the user to focus on other aspects of their application rather than ensuring the receiver is tracking SBAS correctly.

The SBAS demodulator features two-channel tracking that provides an enhanced ability to maintain acquisition on a SBAS satellite in regions where more than one satellite is in view. This redundant tracking approach will result in more consistent acquisition of a signal when in an area where signal blockage of either satellite is possible.

SBAS Performance

The performance of the SBAS receiver is described in terms of a bit error rate (BER). SBAS requires a line of sight to the SBAS satellites in order to acquire the signal.

The BER number indicates the number of unsuccessfully decoded symbols in a moving window of 2048 symbols. Due to the use of forward error correction algorithms, one symbol is composed of two bits. The BER value for both SBAS receiver channels is available in the RD1 NMEA data message described in detail in Chapter 6.

A lower BER indicates that data is being successfully decoded with fewer errors, providing more consistent throughput. The bit error rate has a default, no-lock value of 500 or more. As the receiver begins to successfully acquire the signal, it will result in a lower bit error rate. For best operation, this value should be less than 150 and ideally less than 20.

Space-Based Augmentation Systems broadcast an ionospheric map on a periodic basis that may take up to 5 minutes to receive upon startup. The Crescent Vector uses the GPS broadcast ionospheric model until it has downloaded the SBAS map, which can result in lower performance as compared to when the map has been downloaded. This will be the case for any GPS product supporting SBAS services.

Caution: When the map has been downloaded, you may observe a position jump due to the potential difference between the GPS ionospheric model and the ionospheric SBAS map. To minimize the impact of this issue on your use of the Crescent, we may wish to wait up to five minutes before using the Crescent or issue the $JQUERY,GUIDE<CR><LF> message to 'ask' the Crescent if it feels performance will be sufficient for operation.

COAST™ Technology

The Crescent module incorporates Hemisphere GPS COAST technology that allows it to operate with old correction data for up to 30 to 40 minutes or more without significant accuracy degradation. The feature's performance is attributed to sophisticated algorithms that are able to anticipate how errors change during a period of correction loss.

Traditional receiver technology would experience an increasing degradation with increasing age of corrections, resulting in less than adequate performance over a shorter period of time. COAST technology provides more consistent positioning during periods when signal loss occurs, thus bridging the gap to when the signal is reacquired. This means that the Crescent module is more tolerant than competing products to loss of SBAS or externally input RTCM SC-104 corrections.

LOCAL DIFFERENTIAL OPTION

Local differential is a specialized message type that can only be sent between two Crescent-based receivers. One receiver is used as the base station and must remain stationary. It is extremely useful to know the coordinates of the base station position, but averaging the position over several days will also suffice. The second receiver is used as a rover and the messages may be sent either through a cable or over a radio link.

START-UP

When you turn the Crescent on with the Local Differential application running, it will require several commands to initialize the proprietary messages that are sent over the air. These commands are outlined in Chapter 6.

LOCAL DIFFERENTIAL PERFORMANCE

The positioning performance of the Crescent unit in Local Dif mode is dependant upon the environment of the base and rover receivers, the distance between them and the accuracy of the entered coordinates of the base station.

We suggest that you perform your own testing at your location to determine the level of performance that you would expect to see on average. When testing this feature, it's a good idea to look at a lengthy test of 12-24 hours, different environments and monitor performance against a known coordinate. This should be done over a number of days with different states of the ionosphere. You can monitor the energy level of the ionosphere based upon the amount of solar flare activity at the following Web sites:

- iono.jpl.nasa.gov//latest.html
- iono.jpl.nasa.gov//gim_dailymovie.html
- www.spaceweather.com

POST PROCESSING

The Crescent module is able to output raw measurement data for post processing applications. The raw measurement and ephemeris data are contained in the Bin 95 and 96 messages documented in this manual. Both messages must be logged in a binary file.

Depending on your application, you can include site data within the binary file and perform the translation to RINEX yourself.

We make a DOS-based RINEX translator available, however, RINEX has no facility to store station information. Our translator is available by contacting technical support at Hemisphere GPS.

Note: To assist you in your integration of the Crescent, we can equip you with some code snippets to help you incorporate support for the Bin 95 and 96 messages within your software. If this is a need for your application, please contact your representative at Hemisphere and we will assist you further.

EVALUATING CRESCENT VECTOR PERFORMANCE

As mentioned earlier, Hemisphere GPS evaluates performance of the Crescent Vector module with the objective of determining best-case performance in a real-world environment. Our static testing has shown that the Crescent achieves DGPS positioning performance better than one meter 95% of the time.

The qualifier of 95% is a statistical probability. Often you may see manufacturers using a probability of 'rms' or standard deviation. Performance measures with these probabilities are not directly comparable to a 95% measure since they are a lower probability (less than 70% probability).

The following table summarizes the common horizontal statistical probabilities.

Table 2-1. Horizontal Accuracy Probability Statistics.

Accuracy Measure	Probability (%)
Rms (root mean square)	63 to 68
CEP (circular error probability)	50
2drms (twice the distance root mean square)	95 to 98
R95 (95% radius)	95

It's possible to convert from one statistic to another using the following table. Using the value where the 'From' row meets the 'To' column, multiply the accuracy by this conversion value.

Table 2-2. Horizontal Accuracy Statistic Conversions.

		To			
		CEP	**rms**	**R95**	**2drms**
From	**CEP**	1	1.2	2.1	2.4
	rms	0.83	1	1.7	2.0
	R95	0.48	0.59	1	1.2
	2drms	0.42	0.5	0.83	1

For example, if Product A after test results in an accuracy of 90 cm 95% (R95) and you want to compare this to Product B that has a sub-meter horizontal rms specification, select the value from where the 'R95' row and the 'rms' column intersect (to convert to rms).

You will see that this conversion value is 0.59. Multiply the 90 cm accuracy by this conversion factor and the result will be 53 cm rms. If you now compare this to

Product B's specification of sub-meter rms, you can see the first Product A would offer better performance.

To properly evaluate one receiver against another statically, they should be using identical correction input (from an external source) and also share the same antenna using a power splitter (equipped with appropriate DC-blocking of the receivers and a bias-T to externally power the antenna). With this type of setup, the errors in the system are identical with the exception of receiver noise.

Although this is a comparison of the GPS performance qualities of a receiver, it excludes other performance merits of a GPS engine. The dynamic ability of a receiver should be compared in a similar way with the test subjects sharing the same antenna. Unless a receiver is moving, its software filters are not stressed in a similar manner to the final product application. When testing dynamically, a much more accurate reference would need to be used, such as an RTK system so that a 'truth' position per epoch is available.

Further, there are other performance merits of a GPS engine, such as its ability to maintain a lock on GPS and SBAS satellites. In this case, the same GPS antenna should be shared between the receiver test subjects. For the sake of comparing the tracking availability of one receiver to another, no accurate 'truth' system is required, unless performance testing is also to be analyzed. Again, an RTKsystem would be required, however, it's questionable how its performance will fair with environments where there are numerous obstructions, such as foliage. Other methods of providing a truth reference may need to be provided through observation times on surveyed monuments or traversing well-known routes.

If you require assistance in developing a test setup or procedure for evaluating the Crescent, please contact Hemisphere GPS.

Chapter 3: Crescent Vector Module

Understanding the Crescent Vector OEM

The purpose of the Crescent Vector OEM board is to provide accurate, reliable heading and position information at high update rates. To accomplish this task, the Crescent Vector OEM uses a high performance GPS engine for GPS signal processing. The one receiver processes information from both the primary GPS antenna and secondary GPS antenna. Positions computed by the Crescent Vector 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.

Crescent Specifications

Although also presented in Appendix A, the following table lists the various specifications of the Crescent Vector module.

Table 3-1. Crescent Vector Specifications.

Item	Specification
Frequency	1.575 GHz
Channels	Two 12 channel parallel (two 10 channel when tracking SBAS)
Horizontal accuracy	< 0.5 m 95%
Heading accuracy (0.5m antenna separation)	0.5° 95%
Max position update Rate	Up to 20 Hz (upgradeable option)
Max heading update rate	Up to 20 Hz

Serial Interface Specifications (standard cable)	
Item	**Specification**
Serial port interface level	3.3 V CMOS
Port A, B, C and D connector	Via 34-pin header
Port A / B /C available baud rates	4800, 9600, 19200, 38400 and 57600 Baud
Port D baud rate (for SBX module)	9600 (permanent setting)
Output protocols	NMEA 0183, proprietary binary
Input protocol	NMEA 0183
External correction input protocol	RTCM SC-104
Correction output protocol	RTCM SC-104
Raw SBAS data	Available in Bin 80 message

Power Specifications	
Item	**Specification**
Input voltage	3.3 VDC ±3% (3.2 – 3.4 VDC)
Power consumption	1.7 W

Mechanical Characteristics	
Item	**Specification**
Length	109 mm (4.3”)
Width	71 mm (2.8”)

Height	20 mm (0.8”)
Weight	55 g (1.9oz)

Environmental Specifications	
Item	**Specification**
Storage temperature	-40℃ to 85℃
Operating temperature	-30℃ to 70℃
Humidity	95% Non-Condensing

TECHNICAL DRAWING

Figure 3-1 below is a technical drawing for the Crescent Vector OEM board.

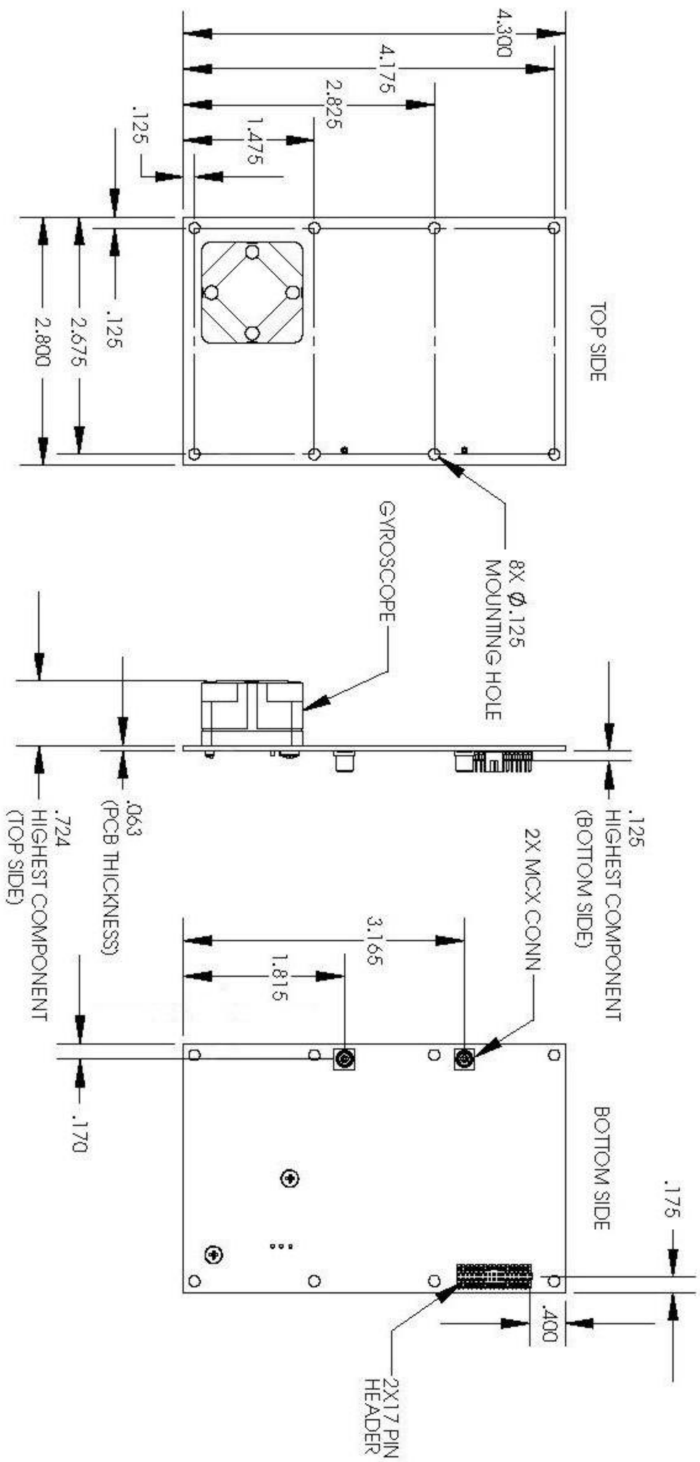

Figure 3-1. Technical Drawing.

CONNECTORS

The following table details the connectors used by the Crescent Vector module. We have also provided information on the mating connectors. Since your requirements may be different, you are free to choose a different, compatible connector. The antenna input impedance is 50 Ω.

Table 3-2. Crescent Vector Connectors.

Connector	Crescent Vector SMT Connector	Mating Connector
RF	MCX, straight jack (female) (Johnson: 133-3711-201)	MCX, straight plug (male) (AMP: 1061015-1)
Interface	17 x 2 pin header plug (male) 0.050” pitch (Samtec: FTSH-117-01-L-DV)	17 x 2, SMT header socket (female) 0.050” pitch (Samtec: FLE-117-01-G-DV)

CRESCENT VECTOR MOUNTING

There are two methods of mounting the Crescent Vector module. The first is the most cost-effective method since it does not use cable assemblies to interface the module to the integration. We recommend that you place an RF connector, header connector, and mounting holes on your motherboard. The Crescent Vector then mounts on stand-offs and the RF and header connector.

To accomplish this approach, you will, however need to be very contentious with the GPS RF signals present on your motherboard. If you choose to use this method of mounting the Crescent Vector, you will need to consider the correct standoff height so that no flexural stress is placed on the Crescent Vector board mechanically when fastening it down. The Crescent Vector Evaluation Motherboard, with its Johnson RF connector and Samtec header socket, uses a standoff height of 0.3125” (there should not be any washer between either the standoff and the Crescent module or the standoff and the motherboard with this height unless accommodated for). If you choose a different header connector, you may have to change the height of the standoff.

The second method, at the expense of the cost of cable assemblies is to mount the Crescent mechanically such that you can connect a ribbon power/data cable to the module and an internal RF cable assembly. In addition to increased expense, there is a reliability factor present with cable assemblies.

With the approach, it’s simple to accommodate a right angle MCX connector. If you desire a right angle MCX connector for the first approach, in order to reduce the complexity of your motherboard in having it not handle the RF signals, you will need to use a ribbon cable and taller standoffs. This would provide you with clearance to have a right angle cable-mount connector.

The mounting holes of the Crescent module have a standard inner diameter of 0.125”.

Crescent Vector OEM Pin Out

The Crescent Vector OEM module uses a 34-pin (17 pins by 2 rows) header connector for interfacing to power, communications, and other signals. You can identify the first pin of this connector by a small triangular corner on the silk-screen of the header connector footprint. There is also a small diamond symbol next to pin1 and also printed beside the pin is 'P900'. Pin numbering is the conventional row-by-row approach. When you are looking at the board so that the 'P900' is right side up, pin two is beside (to the right) of the first pin. Pin three is below the first pin, and so on.

The following table provides a pin-out description for the Crescent Vector module's 34-pin header connector.

Table 3-3. Crescent Vector Pin-out.

Pin	Signal and Description	Pin	Signal and Description
1	3.3 Volts Input (range: 3.2-3.4VDC)	18	Differential Lock Indicator (Active Low) (1 mA max, active low, 3.3 VDC – optional connection)
2	3.3 Volts Input (range: 3.2-3.4VDC)	19	DGPS Lock Indicator (Active Low) (1 mA max, active low, 3.3 VDC – optional connection)
3	Antenna Power (0 – 15VDC)	20	ARM Boot Select (Active Low) - leave disconnected
4	Backup power input (1.6 - 3.5 VDC, <5 µA consumption)	21	GPIO0
5	USB+	22	Slave GPS lock indicator (Active Low)
6	USB-	23	Auxiliary GPS lock indicator (Active Low)
7	GND	24	Heading Lock indicator (Active Low)
8	GND	25	Speed radar pulse
9	Port A TX	26	Speed radar ready signal
10	Port A RX	27	GND
11	Port B TX	28	GND
12	Port B RX	29	CLK [RESERVED, CSI USE ONLY]
13	Port D TX	30	Alarm - RTC Alarm Output
14	Port D RX	31	Port C TX
15	1 PPS (Active High)	32	Port C RX
16	Manual Mark (Active Low)	33	GPIO4 [PRMUX]
17	GPS Lock Indicator (Active Low) (1 mA max, active low, 3.3 VDC – optional connection)	34	Reset (Active Low) - Input/Output

Note: Any data or I/O pins should be left unconnected if not in use.

Note: The Crescent Vector OEM differs from its predecessor, the Vector OEM, in that it does not have power supply or communication translation; this must be accomplished by a carrier board.

SIGNALS

This section provides more detail on the signals available via the 34-pin header connector.

RF INPUT

The Crescent Vector module is designed to work with active GPS antennas with an LNA gain of 10 to 40 dB. The purpose of this LNA gain above the minimum requirement of 10 dB 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 antenna you choose, your loss budget will likely be lower (a 24 dB gain antenna would have a 14 dB loss budget).

When designing your internal and external cable assemblies, and choosing your RF connectors, please be sure not to exceed your loss budget, otherwise the tracking performance of the Crescent Vector module will be compromised.

COMMUNICATION PORTS

The Crescent Vector module has four communications ports designated Port A, Port B, Port C and Port D. The three main ports are Port A, B and C. The fourth port, Port D is used exclusively for interface to the SBX beacon module or a source of external corrections. This port will not output normal GPS-related NMEA messages.

Communicating into either Port A, B or C, you may establish a virtual connection to the device on Port D using the $JCONN command. Further, you may connect the device on Port A directly to the device on Port B using a derivative of this same command.

As the Crescent Vector serial ports are a 3.3 V CMOS level, you may have to translate this level in order to interface to other devices based upon your product requirements. For example, if you route the Port A / B / C serial ports directly to the outside world, you will likely want to translate to an RS-232-compatible level for communication with PC computers. However, translation of the signal levels is entirely at your discretion based upon your product requirements.

COMMUNICATION PORT D

The exclusive function of Port D is for external correction input to the Crescent Vector. The source of corrections may depend on the geographical use of your final product, market, customer, and positioning performance requirements. Appendix C provides a variety of information on SBAS and as you will see, there is finite coverage of these services. If you wish to market products outside of SBAS coverage, you may want to allow your product to be used with external correction input, or integrate a second source of corrections along with the Crescent Vector, such as the Hemisphere GPS SBX beacon module.

If used, Port D will free up the task of Port A, B or C from being used for external correction input. If you wish to support external correction input when the product is in the field, we recommend that you offer the facility to the user to input corrections on Port A, B or C, and that Port D remain within the integration only.

Note: DGPS corrections are not required for heading accuracies as specified. External corrections will only affect positioning performance.

LED Indicators

There are seven SMT LEDs onboard the Crescent Vector module for indication of power, Master GPS lock, differential lock, DGPS position, Secondary GPS lock, Auxiliary GPS lock (not in use) and heading lock. These LEDs have respective silk-screening of 'PWR', 'M-GPS', 'DIFF', 'DGPS', 'S-GPS', 'A-GPS' (not in use) and 'HDG'.

The signals that drive these LEDs are also available via the 34-pin header connector (excluding a power indication which could drive an LED from somewhere else in the power supply chain). Please refer to the Pin-out table of the Crescent Vector for their pin number. Please note, however, that each of these signal pins can offer only 1 mA of current and are active low. Since 1 mA of current may be inadequate for your application, you may want to transistor-buffer these signals in order to provide more current capacity for acceptable LED luminance.

1 PPS Timing Signal

The one pulse per second (1 PPS) timing signal is used in applications where devices require time synchronization. This signal output is typical of most GPS modules and is not an obligatory feature.

If you have no need for this function, simply do not connect the pin.

The 1 PPS signal is 3.3 V HCMOS active low with rising edge synchronization. The 1 PPS signal is capable of driving a load impedance which is greater than 10 kΩ in parallel with 10 pF.

Event Marker Input

Depending on your application, you may have the need to force a GPS solution at a particular instance, not synchronized with GPS time. Such an application could be to compute the location of a perspective center of a camera being used for a photogrammetric application, where the aircraft moves with considerable speed and an interpolation between two GPS epochs could be unreliable.

If you have no need for this feature, do not connect this pin in your integration.

The Event Marker input is active low 3.3 V HCMOS 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

When connecting the four ground pins of the Crescent Vector module, all four grounds may be connected together (these are not separate analog and digital grounds that require separate attention).

Misc. Pins

The ARM boot select pin should not be connected and is present for Factory use only.

Shielding

Typically, the Crescent Vector does not require shielding for the sake of improving immunity to RF noise incident upon the board and its various devices. You may, however, wish to shield the Crescent Vector from the rest of the integration if you find that it interferes with other devices or systems.

If you are designing a smart antenna based upon the Crescent Vector (the Crescent Vector board and the two GPS antennas in close proximity), you will likely want to shield the Crescent Vector so that it does not interfere with the incoming GPS signals to the antenna.

Chapter 4: Crescent Vector Operation

This chapter introduces the general operational features of the Crescent Vector system, operating modes, and receiver default operating parameters.

Powering the Crescent Vector System

As described in Chapter 2: Introduction, the Crescent Vector is powered by a 3.3 VDC power source. Once appropriate power is connected, the Crescent Vector will be immediately powered.

With the application of power, the Crescent Vector board will proceed through an internal start-up sequence, however it will be ready to communicate immediately.

When installed such that the antenna you are using has an unobstructed view of the sky, the Crescent Vector will provide a position quickly, within approximately 60 seconds. SBAS lock requires approximately 30 seconds to acquire.

Note: It can take up to 5 minutes for a full ionospheric map to be received from SBAS. Optimum accuracy will be obtained once the Crescent Vector is processing corrected positions using complete ionospheric information.

Installation Overview

Due to the inclusion of the tilt sensor and gyro, the Crescent Vector OEM is more complicated to configure than many traditional pieces of GPS equipment. The following list summarizes the primary installation steps and points for consideration to successfully install and configure the Crescent Vector OEM board.

- Determine how you wish to install the Antenna Array (either along the boat's axis or perpendicular to it - this depends on whether or not you would like to use the second dimension of attitude that the Crescent Vector OEM provides - either pitch or roll). Heading is calculated from the Primary to Secondary antenna, so standard installations usually have the Primary towards the stern and Secondary to the bow of the vessel.
- Choose an Antenna Array location with no structures above its horizon - failure to do so can reduce heading accuracy, startup times, signal reacquisition times, positioning accuracy, and availability of satellite signals from both GPS and SBAS. Make sure the Antenna Array is mounted away from other electronics and antennas (especially active TV antennas) by at least a few feet, preferably more. Keep in mind that the position computed by the Crescent Vector is referenced to the phase center of the primary GPS antenna.
- You may want to install the Antenna Array on the vessel's axis so the resulting position from the primary GPS receiver agrees with the centerline of the vessel. The Crescent Vector does not support a command to translate its position to the vessel centerline if the Antenna Array is not mounted on the centerline.

- Install the Antenna Array in a horizon (as best as can be accomplished - this will provide a foundation for performance success when the internal tilt sensor is used to supplement Crescent Vector operation).
- Connect the primary antenna to the port marked J1000 on the Crescent Vector OEM board, and the secondary to the port identified as J2000.
- You may choose to increase the antenna separation of the Crescent Vector to increase the level of heading accuracy. Increasing the separation beyond the default 0.5 m requires the use of all internal sensors (tilt sensor and gyro). Because of the tradeoff between reliability and accuracy, we recommend no more than a one-meter antenna separation. We have tested the Crescent Vector with a 2.0 m separation, which has yielded a 0.1° heading accuracy 95%. Use of the Crescent Vector with larger than a 2.0 m separation is at your risk.
- Find a quiet location on the vessel from a radio frequency perspective to mount the antennas. This location should ideally have an omni directional view of the horizon and be mounted reasonably high (keeping in mind serviceability).
- Install the Crescent Vector board such that it is horizontal. The Crescent Vector board has an arrow with 'Point towards secondary antenna' written beside it. The board should be installed so that this arrow points along the two antennas towards the secondary antenna. It should be aligned to the Antenna Array to within a few degrees if possible.
- Compensate for any heading offset of the Antenna Array and Crescent Vector OEM, in the Crescent Vector OEM configuration (the default is no compensation)
- Configure the NMEA data message output from the Crescent Vector (by default, Port A, B and C output GGA, VTG, GSV, ZDA, HDT, and ROT at 1 Hz)
- Configure the baud rates if necessary (default is 19,200 for Port A, B and C)
- 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 desired mode of differential operation (either SBAS, beacon, or external corrections)
- If you are using the second dimension of attitude provided by the Crescent Vector OEM (either roll or pitch, depending on the Antenna Array orientation), configure the Crescent Vector OEM appropriately (the default is pitch)
- Compensate for pitch / roll error due to installation, within the Crescent Vector configuration (the default is no compensation)
- If your application does not involve pitching or rolling of more than 10° from horizontal, configuring the Crescent Vector for level operation will reduce startup and reacquisition times significantly
- Configure the Crescent Vector for the correct antenna separation if not the default 0.5 m measure.

⚠ **WARNING!**

Use of the Crescent Vector system with the antenna separation beyond 2.0 m is entirely at your risk. For antenna separations between 0.5 and 2.0 m, all supplemental sensors are required in order to provide a robust heading solution. We recommend that the antenna separation remain equal to or below 1.0 m.

Communicating with the Crescent Vector Module

The Crescent Vector features three primary serial ports that may be configured independently from each other (Ports A, B and C). The ports may be configured for any mixture of NMEA 0183, binary, and RTCM SC-104 data. The usual data output is limited to NMEA data messages since these are industry standard.

Note: If you require different data types to be output from the Crescent Vector simultaneously (such as NMEA and binary or NMEA and RTCM), ensure that the software used for logging and processing of the data has been designed to correctly parse the different data types from the single stream of data. Alternatively, you may also use the three serial ports to separate the different data types and at different output rates.

NMEA 0183 Interface

NMEA 0183 is a communications standard established by the National Marine Electronics Association (NMEA) and provides data definitions for a variety of navigation and related equipment. Such instruments supported include gyrocompasses, Loran receivers, echo sounders, GPS receivers, and more. NMEA functionality is virtually standard on all GPS equipment available. NMEA has an ASCII character format that allows you to read the data via terminal software on the receiving device (if possible). One second of example NMEA data from the Crescent Vector follows:

```
$GPGGA,144049.0,5100.1325,N,11402.2729,W,1,07,1.0,1027.4,M,0,M,,0100*61
$GPVTG,308.88,T,308.88,M,0.04,N,0.08,K*42
$GPGSV,3,1,10,02,73,087,54,04,00,172,39,07,66,202,54,08,23,147,48*79
$GPGSV,3,2,10,09,23,308,54,11,26,055,54,15,00,017,45,21,02,353,45*78
$GPGSV,3,3,10,26,29,257,51,27,10,147,45,,,,,,,,*74
```

Depending on each manufacturer's goals for a product, they may have the need to combine data into custom messages, which allows them to improve communication and programming efficiency. The standard NMEA standard provides for manufacturers to define their own custom, proprietary messages as required. Proprietary NMEA messages are likely to be supported only by the specific manufacturer. In the case of the Crescent Vector, it's likely that you will need to support custom NMEA commands within your application if you wish to have your software configure the unit on-the-fly.

The Crescent Vector supports a variety of standard and proprietary NMEA messages. These messages are used to configure the Crescent Vector and also contain the required information from the Crescent Vector. You may configure a selection of NMEA 0183 data messages on one port at various update rates (each message has a maximum update rate) and a different selection of NMEA 0183 messages with different rates on another port.

Binary Interface

Binary messages may be output from the Crescent Vector simultaneously as NMEA 0183 data. Binary messages have a proprietary definition and would likely require custom software support if you wish to use them. Binary messages are inherently more efficient than NMEA 0183 and would be used when you require maximum communication efficiency. Use of binary messages for most users is not recommended - the NMEA interface allows you to control the operation of the Crescent Vector and also receive most types of information regarding status and positioning information.

Note: If you wish to log binary data, please ensure that your logging software has opened the file as a binary file, otherwise you may lose data.

RTCM SC-104 Protocol

RTCM SC-104 is a standard that defines the data structure for differential correction information for a variety of differential correction applications. It has been developed by the Radio Technical Commission for Maritime services (RTCM) and has become an industry standard for communication of correction information. RTCM is a binary data protocol and is not readable via a terminal program. It appears as 'garbage' data on-screen since it is a binary format and not ASCII text. The following is an example of how the RTCM data appears on-screen:


```
mRMP@PJfeUtNsmMFM{nVtIOTDbA^xGh~kDH`_FdW_yqLRryrDuhcB\@}N`ozbSD
@O^}nrGqkeTlpLLrYpDqAsrLRrQN{zW|uW@H`z]~aGxWYt@I`_FxW_qqLRryrDC
ikA\@Cj]DE]|E@w_mlroMNjkKOsmMFM{PWDwW@HVEbA^xGhLJQH`_F`W_aNsmMF
M[WVLA\@S}amz@ilIuPqx~_IZhTCpLLrYpdP@kOsmMFM[kVDHwVGbA^P{WWuNt_
SW_yMsmMnqdrhcC\@sE^ZfC@}vJmNGAHJVhTCqLRryrdviStW@H_GbA^P{wxu[K
```


RTCM has various levels of detail, however the highest level is the message. RTCM defines numerous messages that contain specific information. The Crescent Vector module processes the C/A code and does not support more advanced methods of differential positioning, such as real-time kinematic (RTK) that uses different RTCM message types. Considering this fact, only certain RTCM messages are important for use with the Crescent Vector:

- Type 1 and Type 9 messages, both of which contain similar information. These two messages contain pseudorange corrections and range rate corrections to each GPS satellite.
- The Type 2 message contains delta differential corrections that are used when the remote receiver is using a different satellite navigation message than used by the base station.
- The Type 5 message contains GPS constellation health information used for improving tracking performance of a GPS receiver
- The Type 6 message contains null information, and is broadcast so that a beacon receiver demodulating the data from the broadcast does not lose lock when the beacon station has no new data to transmit.

Note: RTCM is a local area data standard. This means that when positioning with an external source of corrections or outputting corrections from the Crescent Vector to another GPS receiver, performance will degrade as a function of distance from the base station. The additional degradation will depend on the difference in observed orbit and ionospheric errors between the reference station and the remote unit – typically an additional 1 m error per 100 miles. This error is often seen as a bias in positioning, resulting in a position offset. The scatter of the receiver is likely to remain close to constant.

The RTCM SC-104 data output by the Crescent Vector is converted from the RTCA SC-159 data broadcast by SBAS networks.

Appendix B - Resources contains the contact information should you wish to purchase a copy of the RTCM SC-104 specification.

Configuring the Crescent Vector

All aspects of Crescent Vector operation may be configured through any serial port with the use of NMEA 0183 commands. These commands are described in Chapter 6. The following items are user-configurable:

- Selecting the differential source (SBAS or external RTCM)
- Setting the baud rate of both communication ports
- Choosing which NMEA data messages to output on the serial ports and the update rate of each message
- Setting the maximum differential age cut-off
- Setting the satellite elevation angle cut-off mask

Firmware

The software that runs the Crescent Vector is often referred to as firmware since it operates at a low level. The type of firmware within the Crescent Vector is for the processor. This type of firmware may be upgraded in the field through Port A as new revisions become available. The version of firmware installed on the Crescent Vector may be determined through the $JI command.

Configuring the Data Message Output

The Crescent Vector features three primary bi-directional ports referred to as A, B and C(in addition to its differential-only Port D). GPS data messages for all three ports are easily configured by sending NMEA commands to the Crescent Vector module through all of its communication ports (the output of Port B can be configured through A, for instance and vice versa). The $JASC NMEA message discussed in Chapter 6 in details allows you to turn messages on and off as you require.

This Port and the Other Port

The NMEA interface for Port A and B both use 'This' and 'Other' terminology. When interfacing to either port for the sake of turning data messages on or off, the port that is being communicated with is referred to as 'This' port. If you wish to turn a data message on or off, on the opposite port to which you are communicating, the opposite port is referred to as the 'Other' port.

For example, if you are communicating with the Crescent Vector Port B, and wish to turn the GPGGA message on at an update rate of 5 Hz on Port A, the following command would be used.

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

If you wish to turn the GPGGA message on at 5 Hz on Port B, you would issue the following command.

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

When turning a message on or off on 'This' port, you do not need to indicate 'This' at the end of the message. In contrast, when turning messages on or off on Port C from Port A or Port B, you must use the following procedure. For example, if you are communicating with the Crescent Vector on Port A and wish to turn on the GLL NMEA message at 10 Hz on Port C, the following command would be used.

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

As with Port A and B, if you are communicating directly with Port C, you do not need to indicate anything at the end of the message. Consult Chapter 6 for more information on NMEA messages.

Saving the Crescent Vector Configuration

Each time that you change the configuration of the Crescent Vector, you may wish to save the new configuration so the receiver does not have to be reconfigured again for the next power cycle.

To save the settings, issue the $JSAVE command and the receiver will record the current configuration to non-volatile memory. The Crescent Vector will let you know when the save process has been completed, which will take approximately five seconds.

Using Port D for RTCM Input

The Crescent Vector has a port that's been designed to accommodate externally supplied corrections input according to the RTCM SC-104 protocol. Port D provides this functionality although it's been fixed to operate at a baud rate of 9600 (8 data bits, no parity, and 1 stop bit – 8-N-1).

To use Port D of the Crescent Vector for correction input you must set the Crescent Vector to operate in beacon differential mode using the following command:

$JDIFF,BEACON<CR><LF>

This command was designed to 'turn on' Port D differential operation in our products since many use the Hemisphere GPS SBX beacon module, interfaced to Port D.

Although the following RTCM SC-104 message types don't all contain differential data, the Crescent Vector is compatible with them.

- Type 1
- Type 2
- Type 3
- Type 5
- Type 6
- Type 7
- Type 9
- Type 16

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

$JDIFF,WAAS<CR><LF>

You will find detailed information on NMEA commands and messages supported by the Crescent Vector in the Programming Manual, available for download from the CSI Wireless website.

CHAPTER 5: POCKETMAX & POCKETMAX PC

Hemisphere GPS offers configuration utilities designed for use with Hemisphere's SLX, SX-1 and Crescent based products, including the Crescent Vector OEM. As these utilities were not designed specifically for any one product alone, they support features not offered by every product, such as tracking of the OmniSTAR differential service and display of our Vector product's true heading, however, the interface may be used for all I/O operations.

PocketMAX is a configuration program designed for PDAs with Windows PocketPC software that runs on PocketPC 2000, 2002 and 2003 platforms. PocketMAX PC runs on laptop and PC computers running the Microsoft Windows 95 or higher operating system.

PocketMAX PC runs on any PC with Windows 95, 98, or NT 4.0+ (Windows 2000, Windows XP). Screen resolution of 800x600 or greater is recommended. You must connect one of the receiver's serial ports to a COM port on your computer. The current versions of PocketMAX and PocketMAX PC, as well as their associated user manuals are available for download from our website at:

http://www.csi-wireless.com/products/software.php

The following figure is an example screen capture from this utility.

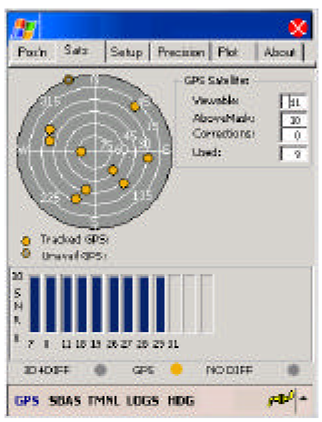

Figure 5-1 PocketMAX PC Screen Capture

Note: It is important to note that when you are using PocketMAX or PocketMAX PC, the program is doing many operations behind the scenes. This includes modifying the data output from the serial port as the program requires, which is screen dependant. When you close PocketMAX, it will give you a message confirming the current settings. It will then ask you if you want to proceed and save these settings or go back and change them. Once you have the settings configured properly, it is imperative to let the program close completely before you disconnect or power down the receiver. This may take up to 10 seconds. If this is not performed, the receiver will not be configured according to any settings you may have specified, and can output a mixture of binary and NMEA data.

Chapter 6: Crescent Vector Commands

This section details the various settings that relate to the GPS heading aspect of the Crescent Vector OEM heading system. For a comprehensive list of all commands that can be used with the Crescent Vector, please refer to the CSI Programming Manual, available for download from our website at:

http://www.csi-wireless.com/products/documents/ProgrammingManual_011.pdf

The following table summarizes the commands detailed in this section.

Table 6-1 GPS Heading Commands

Message	Description
TILTAID	Command to turn on tilt aiding and query the current feature status
TILTCAL	Command to calibrate tilt aiding and query the current feature status
GYROAID	Command to turn on gyro aiding and query the current feature status and query the current feature status
LEVEL	Command to turn on level operation and query the current feature status
CSEP	Query to retrieve the current separation between GPS antennas
MSEP	Command to manually set the GPS antenna separation and query the current setting
HTAU	Command to set the heading time constant and to query the current setting
PTAU	Command to set the pitch time constant and to query the current setting
HRTAU	Command to set the rate of turn time constant and to query the current setting
JTAU,COG	Command to set the course over ground time constant and to query the current setting
JTAU,SPEED	Command to set the speed time constant and to query the current setting
HBIAS	Command to set the heading bias and to query the current setting
PBIAS	Command to set the pitch bias and to query the current setting
NEGTILT	Command to turn on the negative tilt feature and to query the current setting
ROLL	Command to configure the Crescent Vector for roll or pitch output
SEARCH	Command to force a new RTK heading search
FLIPBRD	Command to allow upside down installation
SUMMARY	Query to show the current configuration of the Crescent Vector
HELP	Query to show the available commands for GPS heading operation and status

$JATT,TILTAID

The Crescent Vector's internal tilt sensor (accelerometer) is enabled by default and constrains the RTK heading solution to reduce startup and reacquisition times. Since this sensor resides inside the Crescent Vector, the receiver enclosure must be installed in a horizontal plane, as must the Antenna Array.

To turn the tilt-aiding feature off, use the following command.

$JATT,TILTAID,NO<CR><LF>

You may turn this feature back on with the following command.

$JATT,TILTAID,YES,<CR><LF>

To query the Crescent Vector for the current status of this feature, issue the following command.

$JATT,TILTAID<CR><LF>

Note: If you choose to increase the antenna separation of your Crescent Vector OEM beyond the default 0.5 m length, use of tilt aiding is required.

$JATT,TILTCAL

The tilt sensor of the Crescent Vector can be calibrated in the field; however the Crescent Vector enclosure must be horizontal when performing the calibration. To calibrate the Crescent Vector's internal tilt sensor, issue the following command.

$JATT,TILTCAL<CR><LF>

The calibration process takes about two seconds to complete. The calibration is automatically saved to memory for subsequent power cycles.

$JATT,GYROAID

The Crescent Vector's internal gyro is shipped off by default, and it offers two benefits. It will shorten reacquisition times when a GPS heading is lost, due to obstruction of satellite signals, by reducing the search volume required for solution of the RTK. It will also provide an accurate substitute heading for a short period (depending on the roll and pitch of the vessel) ideally seeing the system through to reacquisition. This is why we highly recommend you turn the gyro aiding on.

Exceeding rates of 90 degrees per second is not recommended since the gyro cannot measure rates beyond this point. This is a new recommendation since we now use gyro measurements to get a heading rate measurement.

To turn on the gyro-aiding feature, use the following command.

$JATT,GYROAID,YES<CR><LF>

If you wish to turn this feature off, use the following command.

$JATT,GYROAID,NO<CR><LF>

If you wish to request the status of this message, send the following command.

$JATT,GYROAID<CR><LF>

Every time the Crescent Vector is powered, the gyro goes through a 'warm-up' procedure. This warm up calibrates the gyro to a point where it is operational to its fullest potential. The gyro will automatically warm up by itself over the span of several minutes. This 'self-calibration' is the equivalent to performing the procedure below. You may wish to follow this procedure if you need the gyro fully calibrated at a certain time.

When your Crescent Vector unit is installed, apply power and wait several minutes until it has acquired a GPS signal and it is computing heading. Ensure that the gyro-aiding feature is on by issuing a $JATT,GYROAID<CR><LF> command. Then, slowly spin the unit for one minute at a rate of no more than 15 degrees per second. Then, let it sit stationary for four minutes. Your Crescent Vector's gyro is now fully calibrated. Since this setting cannot be saved, this procedure must be performed every time the Crescent Vector's power is cycled.

$JATT,LEVEL

This command is used to invoke the level operation mode of the Crescent Vector. If your application will not involve the system tilting more than ±10° maximum, then you may choose to use this mode of operation. The benefit of using level operation is increased robustness and faster acquisition times of the RTK heading solution. By default, this feature is turned off. The command to turn this feature on follows.

$JATT,LEVEL,YES<CR><LF>

To turn this feature off, issue the following command.

$JATT,LEVEL,NO<CR><LF>

To determine the current status of this message, issue the following command.

$JATT,LEVEL<CR><LF>

$JATT,CSEP

This command polls the Crescent Vector for the current separation between antennas, as solved for by the attitude algorithms. It has the following format.

$JATT,CSEP<CR><LF>

The Crescent Vector will reply with the following.

$JATT,x,CSEP

Where 'x' is the antenna separation in m.

$JATT,MSEP

This command is used to manually enter a custom separation between antennas (must be accurate to within one to two centimeters). Using the new center-to-center measurement, send the following command to the Crescent Vector.

$JATT,MSEP,sep<CR><LF>

Where 'sep' is the measured antenna separation entered in meters.

To show the current antenna separation, issue the following command.

$JATT,MSEP<CR><LF>

$JATT,HTAU

The heading time constant allows you to adjust the level of responsiveness of the true heading measurement provided in the $HEHDT message. The default value of this constant is 2.0 seconds of smoothing when the gyro is enabled. The gyro by default is enabled, but can be turned off. By turning the gyro off, the equivalent default value of the heading time constant would be 0.5 seconds of smoothing. This is not done automatically, and therefore must be entered manually by the user. Increasing the time constant will increase the level of heading smoothing.

The following command is used to adjust the heading time constant.

$JATT,HTAU,htau<CR><LF>

Where 'htau' is the new time constant that falls within the range of 0.0 to 3600.0 seconds.

Depending on the expected dynamics of the vessel, you may wish to adjust this parameter. For instance, if the vessel is very large and is not able to turn quickly, increasing this time is reasonable. The resulting heading would have reduced 'noise', resulting in consistent values with time. However, artificially increasing this value such that it does not agree with a more dynamic vessel could create a lag in the heading measurement with higher rates of turn. A convenient formula for determining what the level of smoothing follows for when the gyro is in use. If you are unsure on how to set this value, it's best to be conservative and leave it at the default setting.

htau (in seconds) = 40 / maximum rate of turn (in °/s) – gyro ON

htau (in seconds) = 10 / maximum rate of turn (in °/s) – gyro OFF

You may query the Crescent Vector for the current heading time constant by issuing the same command without an argument.

$JATT,HTAU<CR><LF>

Note: If you are unsure of the best value for this setting, it's best to be conservative and leave it at the default setting of 2.0 seconds when the gyro is on and at 0.5 seconds when the gyro is off.

$JATT,PTAU

The pitch time constant allows you to adjust the level of responsiveness of the pitch measurement provided in the $PSAT,HPR message. The default value of this constant is 0.5 seconds of smoothing. Increasing the time constant will increase the level of pitch smoothing.

The following command is used to adjust the pitch time constant.

$JATT,PTAU,ptau<CR><LF>

Where 'ptau' is the new time constant that falls within the range of 0.0 to 3600.0 seconds.

Depending on the expected dynamics of the vessel, you may wish to adjust this parameter. For instance, if the vessel is very large and is not able to pitch quickly, increasing this time is reasonable. The resulting pitch would have reduced 'noise', resulting in consistent values with time. However, artificially increasing this value such that it does not agree with a more dynamic vessel could create a lag in the pitch measurement. A convenient formula for determining what the level of smoothing follows. If you are unsure on how to set this value, it's best to be conservative and leave it at the default setting.

ptau (in seconds) = 10 / maximum rate of pitch (in °/s)

You may query the Crescent Vector OEM for the current pitch time constant by issuing the same command without an argument.

$JATT,PTAU<CR><LF>

Note: If you are unsure of the best value for this setting, it's best to be conservative and leave it at the default setting of 0.5 seconds.

$JATT,HRTAU

The heading rate time constant allows you to adjust the level of responsiveness of the rate of heading change measurement provided in the $HEROT message. The default value of this constant is 2.0 seconds of smoothing. Increasing the time constant will increase the level of heading smoothing.

The following command is used to adjust the heading time constant.

$JATT,HRTAU,hrtau<CR><LF>

Where 'hrtau' is the new time constant that falls within the range of 0.0 to 3600.0 seconds.

Depending on the expected dynamics of the vessel, you may wish to adjust this parameter. For instance, if the vessel is very large and is not able to turn quickly, increasing this time is reasonable. The resulting heading would have reduced 'noise', resulting in consistent values with time. However, artificially increasing this value such that it does not agree with a more dynamic vessel could create a lag in the rate of heading change measurement with higher rates of turn. A convenient formula for determining what the level of smoothing follows. If you are unsure on how to set this value, it's best to be conservative and leave it at the default setting.

hrtau (in seconds) = 10 / maximum rate of the rate of turn (in °/s2)

You may query the Crescent Vector for the current heading rate time constant by issuing the same command without an argument.

$JATT,HRTAU<CR><LF>

Note: If you are unsure of the best value for this setting, it's best to be conservative and leave it at the default setting of 2.0 seconds.

$JTAU,COG

The course over ground (COG) time constant allows you to adjust the level of responsiveness of the COG measurement provided in the $GPVTG message. The default value of this constant is 0.0 seconds of smoothing. Increasing the time constant will increase the level of COG smoothing.

The following command is used to adjust the COG time constant.

$JTAU,COG,tau<CR><LF>

Where 'tau' is the new time constant that falls within the range of 0.0 to 200.0 seconds.

The setting of this value depends upon the expected dynamics of the Crescent. If the Crescent will be in a highly dynamic environment, this value should be set to a lower value since the filtering window would be shorter, resulting in a more responsive measurement. However, if the receiver will be in a largely static environment, this value can be increased to reduce measurement noise. The following formula provides some guidance on how to set this value. If you are unsure what is the best value for this setting, it's best to be conservative and leave it at the default setting.

tau (in seconds) = 10 / maximum rate of change of course (in °/s)

You may query the Crescent for the current course over ground time constant by issuing the same command without an argument.

$JTAU,COG<CR><LF>

Note: If you are unsure of the best value for this setting, it's best to be conservative and leave it at the default setting of 0.0 seconds.

$JTAU,SPEED

The speed time constant allows you to adjust the level of responsiveness of the speed measurement provided in the $GPVTG message. The default value of this parameter is 0.0 seconds of smoothing. Increasing the time constant will increase the level of speed measurement smoothing.

The following command is used to adjust the speed time constant.

$JTAU,SPEED,tau<CR><LF>

Where 'tau' is the new time constant that falls within the range of 0.0 to 200.0 seconds.

The setting of this value depends upon the expected dynamics of the receiver. If the Crescent will be in a highly dynamic environment, this value should be set to a lower value since the filtering window would be shorter, resulting in a more responsive measurement. However, if the receiver will be in a largely static environment, this value can be increased to reduce measurement noise. The following formula provides some guidance on how to set this value initially, however, we recommend that you test how the revised value works in practice. If you are unsure what is the best value for this setting, it's best to be conservative and leave it at the default setting.

tau (in seconds) = 10 / maximum acceleration (in m/s2)

You may query the Crescent for the current speed time constant by issuing the same command without an argument.

$JTAU,SPEED<CR><LF>

Note: If you are unsure of the best value for this setting, it's best to be conservative and leave it at the default setting of 0.0 seconds.

$JATT,HBIAS

You may adjust the heading output from the Crescent Vector in order to calibrate the true heading of the Antenna Array to reflect the true heading of the vessel using the following command.

$JATT,HBIAS,x<CR><LF>

Where x is a bias that will be added to the Crescent Vector's heading, in degrees. The acceptable range for the heading bias is -180.0° to 180.0°. The default value of this feature is 0.0°.

To determine what the current heading compensation angle is, send the following message to the Crescent Vector.

$JATT,HBIAS<CR><LF>

$JATT,PBIAS

You may adjust the pitch / roll output from the Crescent Vector in order to calibrate the measurement if the Antenna Array is not installed in a horizontal plane. The following NMEA message allows to you to calibrate the pitch / roll reading from the Crescent Vector.

$JATT,PBIAS,x<CR><LF>

Where x is a bias that will be added to the Crescent Vector's pitch / roll measure, in degrees. The acceptable range for the pitch bias is -15.0° to 15.0°. The default value of this feature is 0.0°.

To determine what the current pitch compensation angle is, send the following message to the Crescent Vector.

$JATT,PBIAS<CR><LF>

Note: The pitch / roll bias is added after the negation of the pitch / roll measurement (if so invoked with the $JATT,NEGTILT command).

$JATT,NEGTILT

When the secondary GPS antenna is below the primary GPS antenna, the angle from the horizon at the primary GPS antenna to the secondary GPS antenna is considered negative.

Depending on your convention for positive and negative pitch / roll, you may wish to change the sign (either positive or negative) of the pitch / roll. To do this, issue the following command.

$JATT,NEGTILT,YES<CR><LF>

To return the sign of the pitch / roll measurement to its original value, issue the following command.

$JATT,NEGTILT,NO<CR><LF>

To query the Crescent Vector for the current state of this feature, issue the following command.

$JATT,NEGTILT<CR><LF>

$JATT,ROLL

If you wish to get the roll measurement, you will need to install the Antenna Array perpendicular to the vessel's axis, and send the following command to the Crescent Vector.

$JATT,ROLL,YES<CR><LF>

If you wish to return the Crescent Vector to its default mode of producing the pitch measurement, issue the following command.

$JATT,ROLL,NO<CR><LF>

You may query the Crescent Vector for the current roll / pitch status with the following command.

$JATT,ROLL<CR><LF>

$JATT,SEARCH

You may force the Crescent Vector to reject the current RTK heading solution, and have it begin a new search with the following command.

$JATT,SEARCH<CR><LF>

Note: The SEARCH function will not work if the GYROAID feature has been enabled. In this case power must be cycled to the receiver to have a new RTK solution computed.

$JATT,FLIPBRD

This new command was added to allow for the Crescent Vector OEM board to be installed upside down. This command should only be used with the Vector Sensor and the Crescent Vector OEM board, since flipping the OEM board doesn't affect the antenna array, which needs to remain facing upwards. When using this command, the board needs to be flipped about roll, so that the front still faces the front of the vessel. To turn this 'upside down' feature on, use the following command.

$JATT,FLIPBRD,YES<CR><LF>

If you wish to return the Crescent Vector to its default mode of being right side up, issue the following command.

$JATT,FLIPBRD,NO<CR><LF>

You may query the Crescent Vector for the current flip status with the following command.

$JATT,FLIPBRD<CR><LF>

$JATT,SUMMARY

This command is used to receive a summary of the current Crescent Vector settings. This command has the following format.

$JATT,SUMMARY<CR><LF>

The response has the following format.

$>JATT,SUMMARY,htau,hrtau,ptau,ctau,spdtau,hbias,pbias,hexflag<CR><LF>

An example of the response to this message follows.

$>JATT,SUMMARY,TAU:H=0.50,HR=2.00,COG=0.00,SPD=0.00,BIAS:H=0.00,P=0.0
0,FLAG_HEX:GN- RMTL=01

Field	Description
htau	This data field provides the current heading time constant in seconds
hrtau	This data field provides the current heading rate time constant in seconds
ptau	This data field provides the current pitch time constant in seconds.
cogtau	This data field provides the current course over ground time constant in seconds
spdtau	This data field provides the current speed time constant in seconds
hbias	This data field gives the current heading bias in degrees
pbias	This data field gives the current pitch / roll bias in degrees
hexflag	This field is a hex code that summarizes the heading feature status and is described in the following table

Flag	Value	
	Feature On	Feature Off
Gyro aiding	02	0
Negative tilt	01	0
Roll	08	0
Tilt aiding	02	0
Level	01	0

The 'GN-RMTL' field is two separate hex flags, 'GN' and 'RMTL'. The 'GN' value is determined by computing the sum of the gyro aiding and negative tilt values, depending if they are on or off. If the feature is on, their value is included in the sum. If the feature is off, it has a value of zero when computing the sum. The value of RMTL is computed in the same fashion but by adding the values of roll, tilt aiding, and level operation.

For example, if gyro aiding, roll, and tilt aiding features were each on, the values of 'GN' and 'RMTL' would be the following:

GN = hex (02 + 0) = hex (02) = 2

RMTL = hex (08 + 02) = hex (10) = A

'GN-RMTL' = 2A

The following tables summarize the possible feature configurations for the first GN character and the second RMTL character.

GN Value	Gyro Aiding	Negative Tilt
0	Off	Off
1	Off	**On**
2	**On**	Off
3	**On**	**On**

RMTL Value	Roll	Tilt Aiding	Level
0	Off	Off	Off
1	Off	Off	**On**
2	Off	**On**	Off
3	Off	**On**	**On**
8	**On**	Off	Off
9	**On**	Off	**On**
A	**On**	**On**	Off
B	**On**	**On**	**On**

$JATT,HELP

The Crescent Vector supports a command that you can use to get a short list of the supported commands if you find yourself in the field without documentation.

This command has the following format.

$JATT,HELP<CR><LF>

The response to this command will be the following.

$>JATT,HELP,CSEP,MSEP,EXACT,LEVEL,HTAU,HRTAU,HBIASPBIAS,NEGTILT,ROLL,TILTAID,TILTCAL,MAGAID,MAGCAL,MAGCLR,GYROAID,COGTAU,SPDTAU,SEARCH,SUMMARY

Chapter 7: Crescent Vector Evaluation System

This chapter describes the Crescent Vector Evaluation system as a complete integrated product.

The Crescent Vector Evaluation system is composed primary of the following subassemblies:

- An Evaluation Enclosure
- An Evaluation Motherboard
- A Crescent Vector OEM module
- Antennas
- Associated cables

This chapter provides detailed information that describes the interface of the Evaluation system, its specifications, and its requirements.

Cable Interface

The Crescent Vector Evaluation enclosure requires power, data, and antenna cable interfaces. The following figure shows the various connections located on the rear panel of the Crescent Vector Evaluation enclosure.

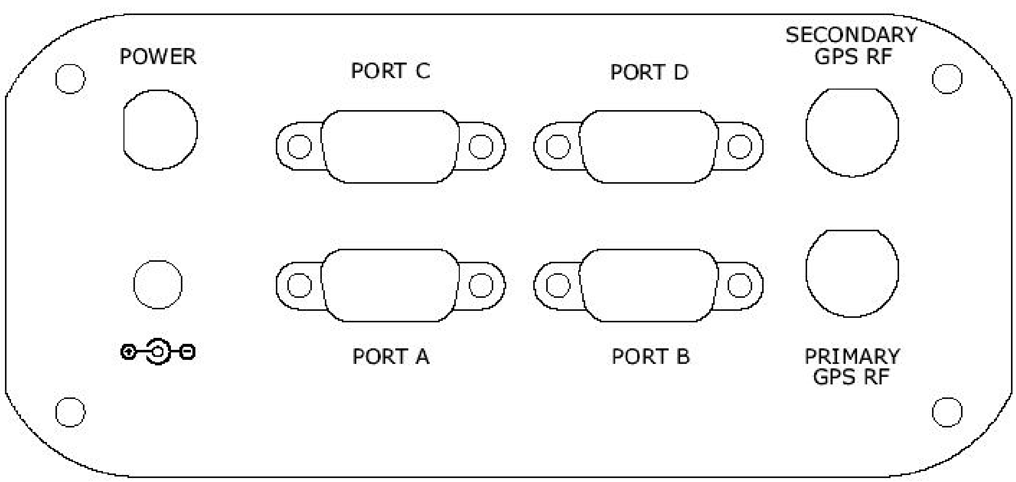

Figure 7-1 Cable Interface

Routing and Securing the Cable

When choosing a route for Evaluation system cables.

- Avoid running cables in areas of excessive heat
- Keep antenna cables away from corrosive chemicals

- Do not run the extension cable through door or window jams
- Keep the cable away from rotating machinery
- Do not bend excessively or crimp the extension cable
- Be careful not to apply tension to the cable
- Remove unwanted slack from the cable at the opposite end to the antenna
- Secure the cable route using plastic tie wraps

> ⚠ **WARNING!**
>
> **Improperly installed cables near machinery can be dangerous.**

Environmental Requirements

The equipment supplied with this Evaluation system has specific environmental limits that you should ensure are met when storing and using the system.

The Evaluation Enclosure and Crescent Vector module are designed to be stored between -40°C and +85°C. The operating temperature range is -30°C and +70°C. Both the Enclosure with internal motherboard the Crescent Vector module are specified to operate with humidity up to 95% non-condensing.

The antennas are designed to operate in an outdoor environment with 100% relative humidity, condensing.

Power Requirements

There are three ways to power the Crescent Vector Evaluation Enclosure. The first is via a power cable that interfaces to the enclosure's 'POWER' connector. This system accepts an input voltage between 5 and 18 VDC. The second method is through the 2.1 mm IDC power connector. The center of the connector is positive, as is indicated on the back panel of the unit. This input also accepts from 5 – 18 VDC. The third method is through the USB port located on the front panel of the unit. For best performance, the supplied power should be continuous and clean. Please note that only one source of power can be connected at one time. The following table details the power specifications of the Crescent Vector Evaluation system.

Table 7-1 Power Requirements

Input Voltage	Input Current	Input Power
5 to 18 VDC	250 mA @ 12 VDC (no antenna)	<3 W Nominal (no antenna)

> ⚠ **WARNING!**
>
> **Connecting more than one source of power at a time can seriously damage the unit and will void the warranty.**

Powering the Crescent Vector Evaluation System

The first step to powering the Crescent Vector Evaluation system is to terminate the power leads of the power cable, connect the IDC connector or connect the USB. There are a variety of power connectors and terminals on the market from which to choose if you are terminating the power cable yourself, depending on your specific requirements. We suggest that a weather-tight connection and connector be used if the connection will be located outside or if it will be part of a portable system.

⚠ **WARNING!**

Do not apply a voltage higher than 18 VDC as this will damage the receiver and void the warranty.

To turn on the Crescent Vector Evaluation system:

- Connect the red wire of the cable's power input to DC positive (+).
- Connect the black wire of the cable's power input to DC negative (-).

The Crescent Vector Evaluation Motherboard features reverse polarity protection to prevent damage if the power leads are accidentally reversed.

A 1.0 A fast-blow fuse, situated in-line of the power input of the extension cable and protects the Crescent Vector receiver from power surges. The fuse container should remain accessible after installation.

The Crescent Vector Evaluation system will start when an acceptable voltage is applied to the power leads of the extension cable. Be careful not to provide a voltage higher than the input range as this could damage the system.

⚠ **WARNING!**

Do not operate the Crescent Vector Evaluation system with the fuse bypassed. Such a modification will void the product warranty.

Serial Port Interface

The four serial ports of the Crescent Vector Evaluation motherboard are compatible with the RS-232C interface level to communicate with external data loggers, navigation systems, PC computers, PDAs and other devices. These serial ports are accessible via the rear panel of the Evaluation Enclosure and have Port A, Port B, Port C and Port D labels.

You may use any of the ports A, B or C for operation of the system, however Port A should be used for firmware updates. Port D has been designed exclusively as an external correction input port, however, either Port A, B or C may be used for the input of external differential corrections, if needed.

The following three tables provide the pin assignments for all three ports.

Table 7-2 Port A Pin-out, RS-232C Interface Level

Pin	Signal	Description
2	TXD	NMEA 0183, binary, and RTCM output
3	RXD	NMEA 0183, binary, and RTCM input
5	Sig. Ground	Signal return

Table 7-3 Port B Port Pin-out, RS-232C Interface Level

Pin	Signal	Description
2	TXD	NMEA 0183, binary, and RTCM output
3	RXD	NMEA 0183, binary, and RTCM Input
5	Sig. Ground	Signal Return

Table 7-4 Port C Port Pin-out, RS-232C Interface Level

Pin	Signal	Description
2	TXD	NMEA 0183, binary, and RTCM output
3	RXD	NMEA 0183, binary, and RTCM Input
5	Sig. Ground	Signal Return

Table 7-5 Port D Port Pin-out, RS-232C Interface Level

Pin	Signal	Description
2	TXD	CSI Proprietary
3	RXD	RTCM Input
5	Sig. Ground	Signal Return

Note: Port D is to be used exclusively for external RTCM input to the Crescent Vector from a source such as a beacon receiver. This port operates permanently at 9600 baud with an 8 data bit, no parity, and 1 stop bit configuration. The presence of Port D does not, however, preclude you from using Port A, B or C for correction input.

Figure 7-2 displays the numbering scheme for extension cable's DB9 socket connectors (female). The associated numbering for the plug connector (male) is a mirror reflection of scheme showed in this figure.

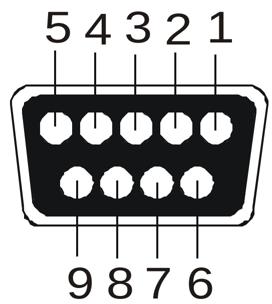

Figure 7-2 DB9 Socket Numbering

Note: For successful communications, the baud rate of the Crescent Vector serial ports must be set to match that of the devices to which they are connected. Please refer to the Programming Manual for the command to change the baud rate.

Factory Default Parameters

The following table shows the application (firmware) present within the Crescent Vector engine.

Table 7-6 Firmware Applications

Application
ATTITUD2

The following table outlines the default communication parameters of the Crescent Vector Evaluation system.

Table 7-7 Default Port Settings

Port	Baud Rate	Data Bits	Parity	Stop Bit	Interface Level
A, B, and C	19200	8	None	1	RS-232C

Note: The RS-232C interface level is that of the Evaluation Motherboard and not the Crescent Vector, which uses a CMOS level. Port D operates permanently at 9600 baud.

Table 7-8 Default GPS NMEA Message Output

Port	GPS NMEA Messages	Update Rate
A,B,C	GGA, GSV, VTG, ZDA, HDT, ROT	1 Hz

Table 7-9 Default Parameters

Max DGPS Age	Elevation Mask
1800 seconds	5°

Note: Any changes you make to the Crescent Vector configuration need to be saved with the $JSAVE NMEA command in order to be present for a subsequent power-cycle.

LED Indicators

The Crescent Vector motherboard features surface-mounted diagnostic LEDs that provide a quick indication of module status. These LEDs are routed to through-hole mounted LEDs visible through windows in the front panel display.

The ten diagnostic LEDs visible from the front panel of the Evaluation Enclosure provide the following functionality:

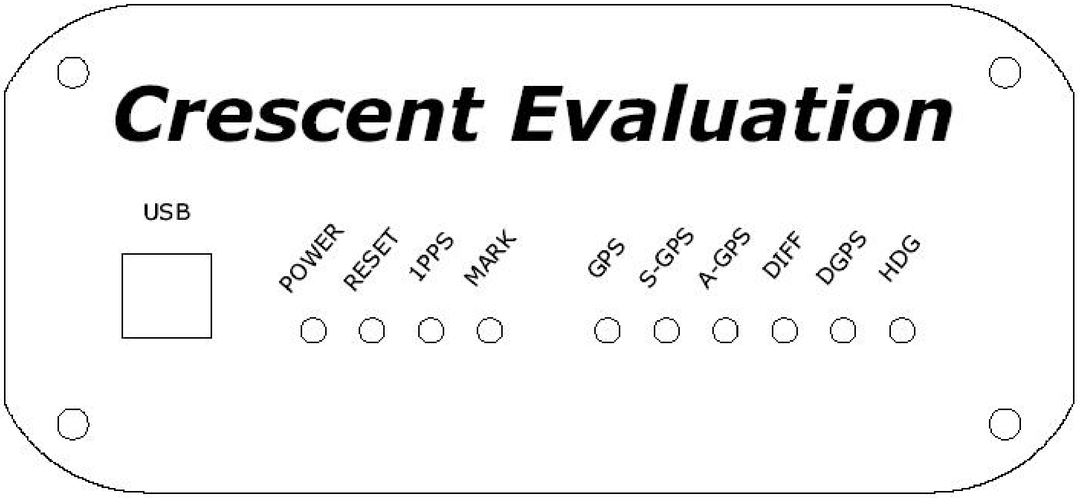

Figure 7-3 Crescent Vector Evaluation Front Panel

Table 7-10 LED Indicator Definition

LED	Color	Function
POWER	Red	Power indicator – when the Crescent Vector is powered within the Evaluation enclosure, this LED will illuminate
RESET	Green	Reset indicator – when the reset button is pressed, this LED will illuminate. The LED should also flash upon powerup. Note: the button to initiate reset is inside the enclosure and we highly recommend using ESD protection when opening the evaluation enclosure.
1PPS	Blue	Timing signal: 1 pulse per second – this LED will strobe once per second once a GPS lock has been attained
MARK	Red	Mark indicator – upon releasing the mark button, the manual mark is initiated and the LED will illuminate. Note: the button to initiate manual mark is inside the enclosure and we highly recommend using ESD protection when opening the evaluation enclosure.
GPS	Yellow	Primary GPS lock indicator –Once the Crescent Vector achieves a solid GPS lock on the primary antenna, this LED will remain illuminated. If this LED continues to blink, it could be an indication of a receiver hardware failure.
S-GPS	Yellow	Secondary GPS lock indicator – Once the Crescent Vector achieves a solid GPS lock on the secondary antenna, this LED will remain illuminated. If this LED continues to blink, it could be an indication of a receiver hardware failure.
A-GPS	Yellow	This indicator is not used in this application.
DIFF	Yellow	Differential lock indicator – this indicator will illuminate continuously when the Crescent Vector has achieved a solid SBAS lock with better than a 150 bit error rate (BER) or when it is successfully receiving externally input RTCM corrections. If the SBAS BER is higher than 150 but the receiver is still locked, this LED will blink, showing that lock is marginal.
DGPS	Green	DGPS position indicator – this LED will illuminate when the receiver has achieved a differential position and the psuedorange residuals are below that set with the $JLIMIT command. The default value is a psuedorange residual of better than 10.0 meters. If the residual value is worse than the current threshold, the green DGPS LED will blink indicating that differential mode has been attained but that the residual has not yet met the threshold.
HDG	Blue	Heading lock indicator – this indicator will illuminate continuously when the Crescent Vector has achieved a solid heading lock. If this LED continues to blink, it could be an indication of a receiver hardware failure.

Chapter 8: Troubleshooting

Use the following checklist to troubleshoot anomalous Crescent Vector receiver operation. Table 8-1 provides a problem symptom, followed by a list of possible solutions.

Table 8-1 Troubleshooting

Symptom	Possible Solution
Receiver fails to power	• Verify polarity of power leads • Check integrity of power cable connections • Check power input voltage (8 to 40 VDC) • Check current restrictions imposed by power source (minimum available should be > 1.0 A)
No data from Vector OEM	• Check receiver power status LED to ensure that the receiver is powered • Verify that Vector OEM is locked to a valid DGPS signal through the LEDs or with the use with PocketMAX running on a PC) • Verify that Vector OEM is locked to GPS satellites (this can often be done on the receiving device or with PocketMAX PC) • Check integrity and connectivity of power and data cable connections
Random data from Vector OEM	• Verify that the RTCM or the Bin95 and Bin96 messages are not being output accidentally (send a $JSHOW command) • Verify baud rate settings of Vector OEM and remote device match correctly • Potentially, the volume of data requested to be output by the Vector OEM could be higher than the current baud rate supports. Try using 38,400 as the baud rate for all devices or reduce the amount of data being output
No GPS lock	• Check integrity of antenna cable • Verify antennas have unobstructed view of sky • Verify the lock status of GPS satellites (this can often be done through the board's LEDs or with the use of PocketMAX PC)
No SBAS lock	• Check antenna connections • Verify antennas have unobstructed view of sky • Verify the lock status of SBAS satellites (this can often be done through the board's LEDs or with the use of PocketMAX PC - monitor BER value) • There is only differential positioning enabled for the Primary receiver, and the Secondary should only have GPS position
No beacon lock	• Check beacon antenna connected to J410 port • Verify that the receiver is tuned to the correct frequency and bit rate • Ensure that beacon signal coverage is expected in your area • There is only differential positioning enabled for the Primary receiver, and the Secondary should only have GPS position
No DGPS position in external RTCM mode	• Verify that the baud rate of the RTCM input port matches the baud rate of the external source • Verify the pin-out between the RTCM source and the RTCM input port (transmit from the source must go to receive of the RTCM input port and

	grounds must be connected) • There is only differential positioning enabled for the Primary receiver and RTCM corrections should be input to the Primary receiver (either Port A or B) • Ensure corrections are being transmitted to the correct port. Using the $JDIFF,OTHER command on Primary Port A will cause the receiver to expect the corrections to be input through Primary Port B
Non-differential GPS output	• Verify SBAS and beacon lock status (or external source is locked) • Confirm baud rates match an external source correctly • Issue a $JDIFF<CR><LF> command and see if the expected differential mode is in fact the current mode • There is only differential positioning enabled for the Primary receiver, and the Secondary should only have GPS position
No heading or incorrect heading values	• Ensure that the antennas are connected to the proper ports. J1000 and J2000 are for the Primary and Secondary antennas, while J410 is for an optional beacon antenna connection • Heading is from Primary to Secondary antenna, so the Secondary antenna should be towards the bow, and Primary towards the stern • Use the heading output from the Primary receiver (either through Port A or B) and not from the Secondary receiver • Check the measurement of the antenna separation. The Measured (MSEP) and Calculated (CSEP) values are in metres, and should agree to within 1 centimetre. CSEP will continuously change, so you should average this reading over a few minutes to obtain an approximate value • Check CSEP value is fairly constant without varying more than 1 cm. Larger variations may indicate a high multipath environment and require moving the antenna locations • Reduce antenna separation – we recommend that the separation between the antennas remain below 2 metres for accurate and timely heading reading output • $JATT,SEARCH command forces the Vector to acquire a new heading solution. This should also be used after entering a new MSEP value • Disable MAGAID – this feature requires precise calibration, and if improperly performed this will affect heading output. This sensor requires recalibration each time anything in the magnetic environment changes • Enable GYROAID as this will give heading for up to 3 minutes in times of GPS signal loss • Enable TILTAID to reduce heading search times • Check the applications on the Primary and Secondary receivers using the $JAPP query. The Primary receiver should answer $JAPP,ATTITUDM,ATTITUDM and the Secondary will respond with $JAPP,ATTITUDS,ATTITUDS • Monitor the number of satellites and SNR values for both antennas. At least 3 satellites should have SNR values above 20 • Antenna connectors should both be facing in the same direction