KVH® CNS-5000 Continuous Navigation System

User Manual

CNS-5000

CNS-5000 GNSS/IMU Continuous Navigation System User Manual

This manual supports KVH Industries' CNS-5000 GNSS/IMU continuous navigation system. Technical and performance specifications, interface data, installation and configuration guidelines, and a brief troubleshooting guide are included.

This manual uses the following to call attention to important information:

> ***IMPORTANT!***
>
> This is an important notice. Be sure to read these carefully to ensure proper operation and configuration of your system.

NOTE: *Notes contain useful information to get the most out of your system.*

Please direct questions, comments, or suggestions to:

KVH Industries, Inc.
50 Enterprise Center
Middletown, RI 02842 USA
Tel: +1 401 847-3327
Fax: +1 401 849-0045
E-mail: fogsupport@kvh.com
Internet: www.kvh.com

QUALITY CERTIFIED SYSTEM ISO 9001

KVH Part # 54-0914 Rev. A

KVH NASDAQ LISTED

If you have any comments regarding this manual,
please e-mail them to manuals@kvh.com.
Your input is greatly appreciated!

Table of Contents

Chapter 1 - Introduction

This chapter provides a brief overview of the system's capabilities, detailed specifications, an envelope drawing, and a list of references.

Product Description

The CNS-5000 is a strap-down Inertial Navigation System (INS) that seamlessly integrates a KVH fiber optic gyro (FOG)-based Inertial Measurement Unit (IMU) with a highly accurate NovAtel OEM6® Global Navigation Satellite System (GNSS) receiver within a single, easy-to-install enclosure. By combining raw inertial measurements with all available GNSS data, the CNS-5000 provides precise position, velocity, and attitude (roll, pitch, azimuth) information that is far more accurate and reliable than either GNSS or an IMU could provide alone.

Figure 1: CNS-5000

The deep coupling of GNSS and inertial measurements also delivers the following benefits:

- Uninterrupted navigation information when GNSS reception is obstructed or unavailable for short periods, such as when operating in urban settings or heavily wooded areas
- Constrained IMU solution drift by utilizing GNSS carrier phase updates when too few satellites are available for a full GNSS solution
- Dramatically faster GNSS signal reacquisition following a blockage condition
- Faster RTK (real-time kinematic) solution convergence in a differential GNSS configuration
- High-rate (100 Hz) output availability of position, velocity, and attitude solutions for highly dynamic applications

Product Specifications

Figure 2: CNS-5000 Specifications

Attribute	Rating
Performance - Gyros	
Input Limit	±375°/s
Bias Instability (constant temp.)	≤1°/hr-1σ
Bias Offset (room temp.)	±20°/hr max.
Bias Temperature Sensitivity	≤6°/hr-1σ (1°C/minute ramp)
Scale Factor (nominal)	1 ±0.2%
Scale Factor Non-linearity	≤1000 ppm-1σ
Scale Factor Temperature Sensitivity	≤500 ppm-1σ
Angle Random Walk	≤0.0667°/√hr ≤4°/hr/√Hz
Input Axis Misalignment	<8 mrad
Bandwidth (-3 dB)	≥50 Hz
Performance - Accelerometers	
Input Limit	±10 g
Bias Instability (1 year, full environment)	7.5 mg typical 25 mg max.
Bias Instability (room temp.)	≤0.25 mg-1σ
Bias Offset (room temp.)	±5 mg max.
Bias Temperature Sensitivity	≤2 mg/°C (1°C/minute ramp)
Scale Factor Non-linearity	<0.9% of full scale
Scale Factor Temperature Sensitivity	100 ppm/°C typical 250 ppm/°C max. (-40°C to +20°C)
Velocity Random Walk (room temp.)	≤0.23 ft/s/√hr ≤0.12 mg/√Hz
Input Axis Misalignment	<10 mrad
Bandwidth (-3 dB)	≥50 Hz

Electrical	
Input Power	+9 to +18 VDC
Power Consumption	16 W max.
IMU Activation Time	5 secs max.
GNSS Activation Time	20 secs max.
Odometer Power	+9 to +10 VDC, 100 mA max.
Physical	
Dimensions	6.67" L x 6.0" W x 3.5" H (16.94 cm L x 15.24 cm W x 8.89 cm H)
Weight	5.3 lbs (2.4 kg) (max.)
Environmental	
Temperature, Operational	-40°F to +149°F (-40°C to +65°C)
Temperature, Non-operational	-58°F to +176°F (-50°C to +80°C)
Shock, Operational	7 g, 6-10 msec, 1/2 sine
Shock, Non-operational	40 g, 6-10 msec, 1/2 sine
Vibration, Operational	6 g rms, 20-2000 Hz random
Vibration, Non-operational	8 g rms, 20-2000 Hz random
Operating Altitude	-1,000 to 50,000 ft
Humidity	95% non-condensing
Waterproof	MIL-STD-810F, 506.4, Procedure I

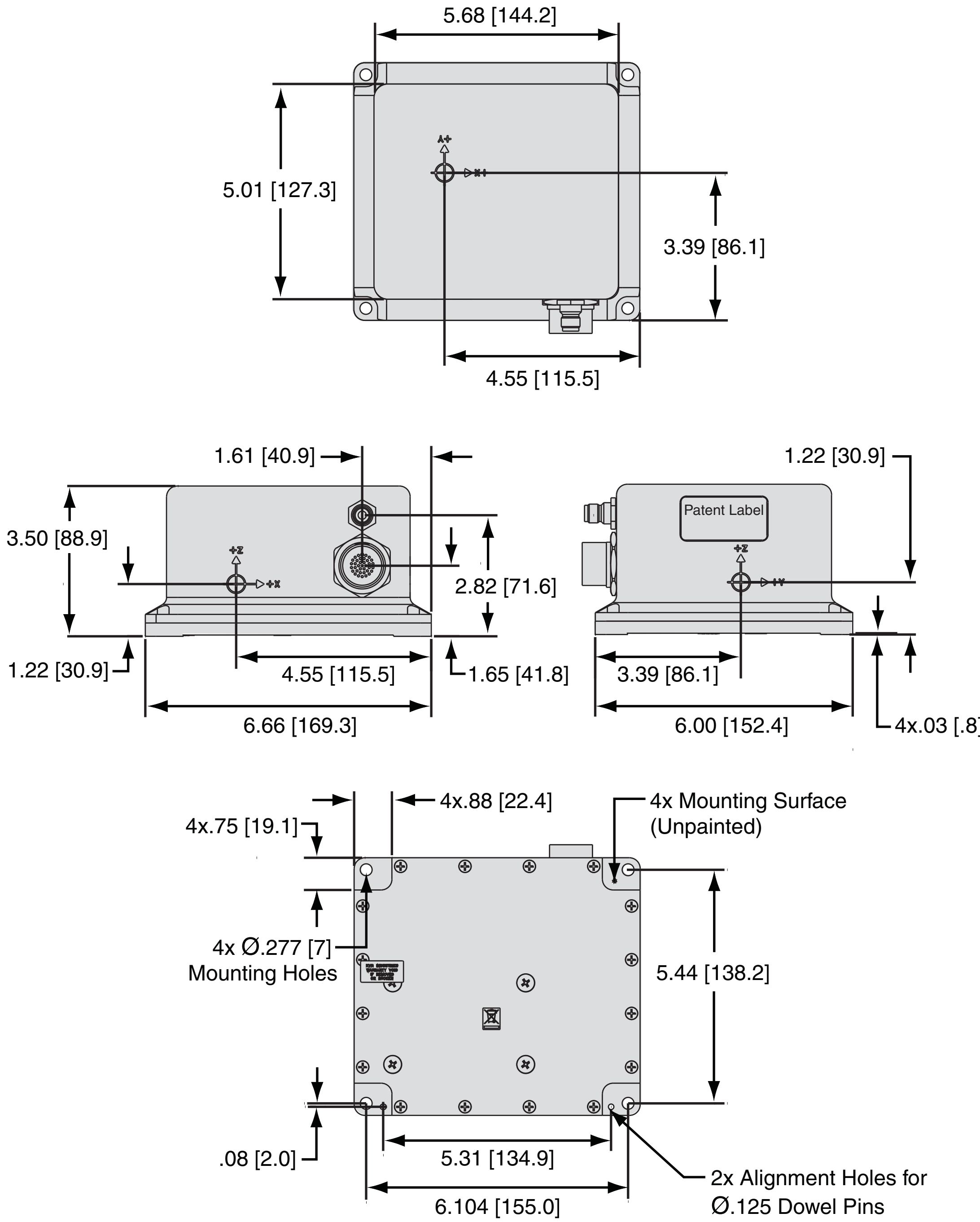
IMPORTANT!

The CNS-5000 is a precision instrument. Handle the unit with care and avoid exposing it to severe static shock.

Figure 3 shows the dimensions, connector placement, and mounting holes of the CNS-5000.

NOTE: *All dimensions are shown in inches [millimeters] format.*

Figure 3: Envelope Drawing



Related Documentation

This manual provides basic installation, configuration, operation, and troubleshooting information. It references the following additional resources for more in-depth information:

Resource	Description
NovAtel SPAN® on OEM6 Firmware Reference Manual (OM-20000144)	Provides detailed descriptions of the commands and logs that are specific to SPAN technology (GNSS + INS) products
NovAtel OEM6 Family Firmware Reference Manual (OM-20000129)	Provides detailed descriptions of the commands and logs that are common to all OEM6 family products *(GNSS receivers with integrated L-band capability)*
NovAtel OEM6 Family Installation and Operation User Manual (OM-20000128)	Provides detailed operation instructions for OEM6 family products
NovAtel Connect™ Help	Provides complete details for the NovAtel Connect software
KVH CNS-5000 Interface Control Drawing (99-0343)	Provides a detailed envelope drawing, I/O pin-outs, and product specifications on one easy-to-scan page

All of the NovAtel manuals listed above are available on the NovAtel website: www.novatel.com/support/firmware-software-and-manuals/product-manuals-and-doc-updates.

The NovAtel Connect Help is accessible from the main menu of the NovAtel Connect user interface (or press F1). You can download the NovAtel Connect software from the NovAtel website: www.novatel.com/support/firmware-software-and-manuals/firmware-software-updates/novatel-connect.

The interface control drawing is available on the KVH website: www.kvh.com/cns5000.

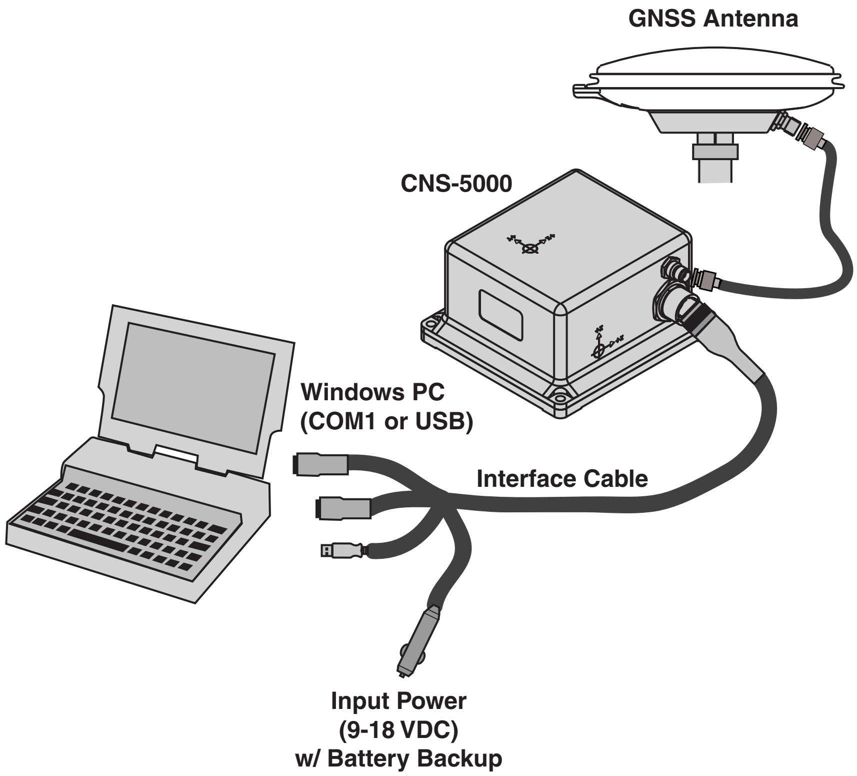
Chapter 2 - Installation

This chapter explains how to install the CNS-5000 in your vehicle. It includes both mounting and wiring information.

Basic Setup

Figure 4 shows the minimum system configuration required to set up the CNS-5000. For more complex configurations, refer to the pin-out information in Figure 17 on page 13.

Figure 4: Basic Wiring Diagram



To complete this basic installation, you will need the following user-supplied components:

- Windows-based PC with a USB or RS-232 DB9 serial port
- 9-18 VDC power supply
- GNSS antenna (see Figure 9 on page 8)
- GNSS antenna cable with a male TNC connector at the end (see Figure 15 on page 12)

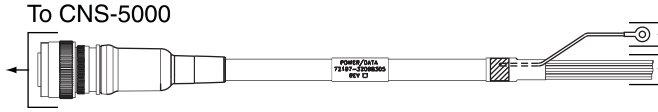
Interface Cables

A 5-ft (1.5 m) interface cable with a mating connector at one end and flying leads at the other is supplied with the CNS-5000. See Figure 5.

IMPORTANT!

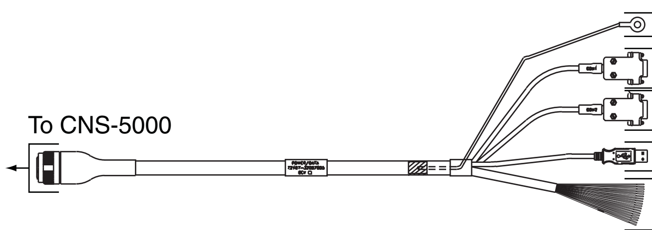
Be sure to snip and insulate any unused wires from the cable to avoid the possibility of a short.

Figure 5: Cable with Flying Leads (Supplied with Unit)



An optional 5-ft (1.5 m) interface cable with connectors in place of flying leads is also available. This cable includes a DB9 (female) connector for COM1, a DB9 (male) connector for COM2, and a USB connector (Series A). See Figure 6.

Figure 6: Cable with Connectors (Optional)



The table below lists the part numbers for these two cables.

Figure 7: Interface Cables Available from KVH

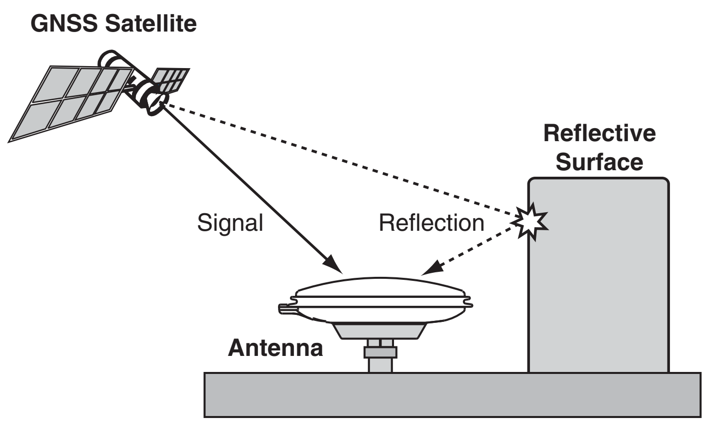
Cable Type	Length	KVH Part #
with Flying Leads	5 ft (1.5 m)	32-0983-05
with Connectors	5 ft (1.5 m)	32-0976-05

Mounting the GNSS Antenna

For maximum positioning precision and accuracy, as well as to minimize the risk of damage, be sure to securely mount the GNSS antenna according to these guidelines:

- Mount the antenna as close as possible to the CNS-5000, and make certain that the distance and relative direction between them remains fixed under all conditions.
- Mount the antenna securely to a stable structure that will not sway or topple.
- Where possible, select a location with a clear view of the sky to the horizon so that satellites can be tracked without obstruction.
- Select a location as far away as possible from RF reflective surfaces, especially those that are above the antenna, to minimize the effect of multipath interference (see Figure 8).

Figure 8: Example of Multipath Interference



Refer to the User Guide that came with the antenna for complete installation details.

KVH offers the following dual-frequency GNSS + L-band antenna models manufactured by NovAtel:

Figure 9: GNSS Antennas Available from KVH

Application	NovAtel Model	KVH Part #
Ground-based	GPS-702L	19-0557
Airborne	ANT-A72GLA4-TW-N	19-0558

Mounting the CNS-5000

Securely mount the CNS-5000 according to these guidelines:

- Mount the CNS-5000 in a fixed location where the distance from the CNS-5000 to the GNSS antenna phase center is constant.
- Ensure the orientation of the CNS-5000 with respect to the vehicle and antenna is constant.
- For attitude output to be meaningful, mount the CNS-5000 such that the positive Z-axis marked on its enclosure points upward and its Y-axis points forward through the front of the vehicle, in the direction of travel (see Figure 10 and Figure 11).

IMPORTANT!

If the CNS-5000 is not mounted precisely with the Z-axis pointing up and the Y-axis pointing forward along the direction of travel, you will need to enter additional configuration commands prior to use. Refer to "Appendix B - Installation Offsets" on page 65.

Figure 10: Output Orientation

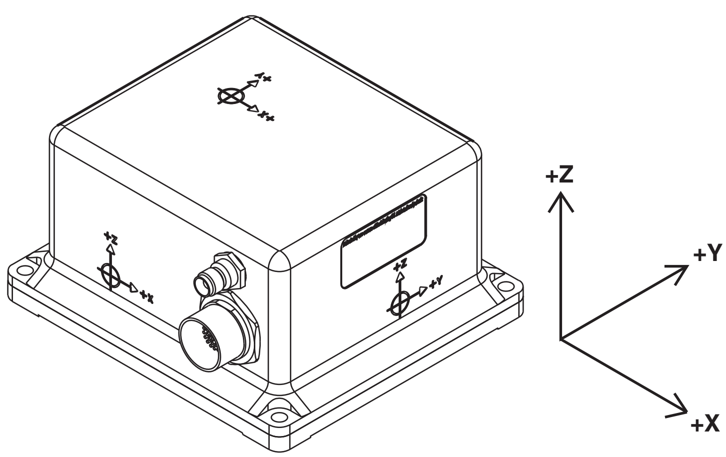
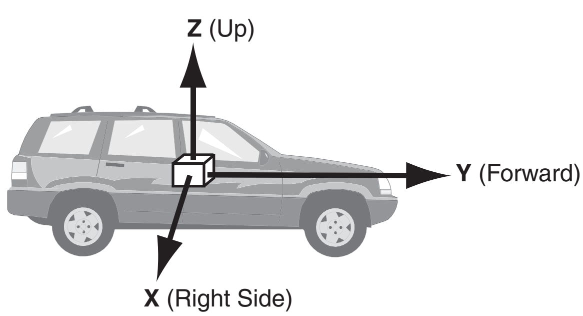
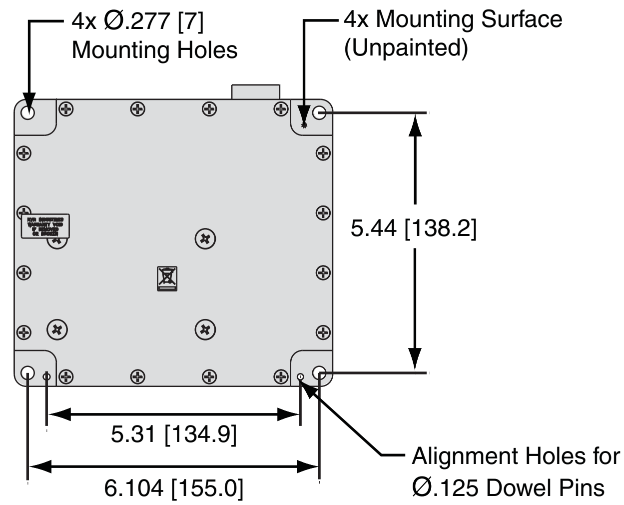


Figure 11: Recommended CNS-5000 Installation Orientation



The CNS-5000 is easily mounted to a structure using the four ∅.277" (∅7 mm) mounting holes on the base of the enclosure (see Figure 12). Two ∅.125" (∅3.175 mm) holes are provided at the front edge of the enclosure for alignment purposes. You may also use the edge of the enclosure itself for alignment.

Figure 12: Mounting Holes (Bottom View)

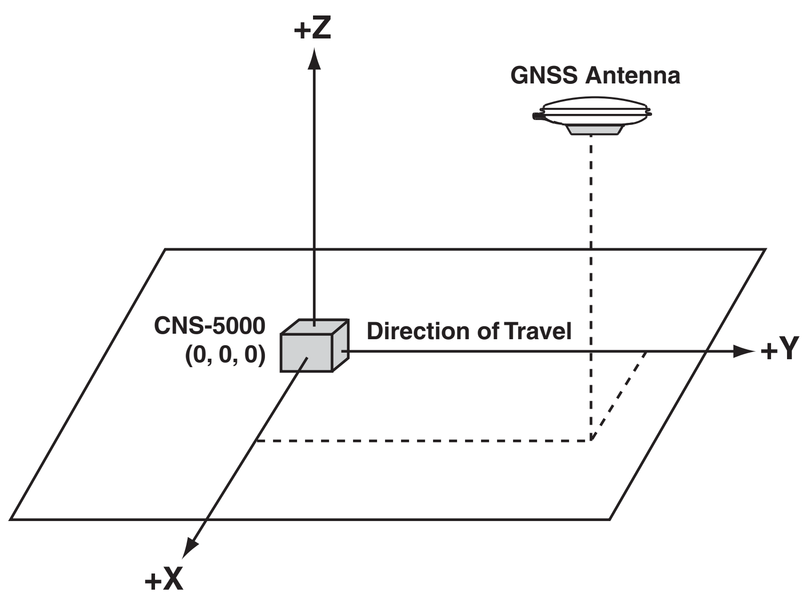


Measuring the Lever Arm Offset Between the GNSS Antenna and the CNS-5000

To configure the CNS-5000 for proper operation, you will need to enter the offset distances between the phase center of the GNSS antenna and each axis of the CNS-5000 (also called the “lever arm offset”). Refer to the antenna’s User Guide to locate the phase center on the antenna. Figure 10 on page 9 shows the markings for the X, Y, and Z axes on the CNS-5000.

NOTE: *The SPAN Alignment Wizard provided with the NovAtel Connect software utility can assist you with these measurements. See* “Using the Wizards for Assisted Setup” on page 21.

Figure 13: Example of Lever Arm Offset



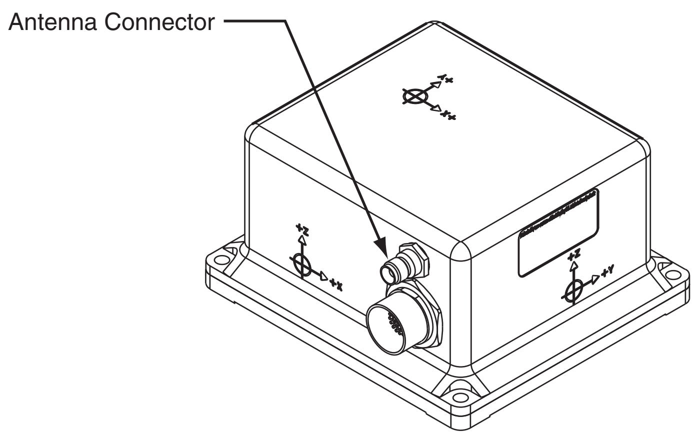
Be sure your measurements are as accurate as possible. A typical RTK GNSS solution is accurate to within a few centimeters. For the integrated CNS-5000 system to provide this level of accuracy, you will need to measure the lever arm offset to within a centimeter. Any offset error shows up directly in the output position. For example, a 10 cm error in recording this offset will result in at least a 10 cm error in the output.

Remember, the offset between the GNSS antenna and CNS-5000 must remain constant in all conditions. So be sure both components are bolted down in one position, perhaps using a custom bracket. If you wish to install the CNS-5000 on a gimbaled mount, see “Variable Lever Arm” on page 22.

Connecting the GNSS Antenna Cable

The CNS-5000 is equipped with a TNC connector (see Figure 14). Connect the GNSS antenna to this connector using a high-quality 50Ω coaxial cable that has a line loss less than 10 dB. The CNS-5000 provides 4.75-5.10 VDC (0-100 mA) LNA operating power to the antenna through this connector.

Figure 14: CNS-5000 Antenna Connector Location



KVH offers the following GNSS antenna cables manufactured by NovAtel:

Figure 15: GNSS Antenna Cables Available from KVH

Cable Length	KVH Part #
16 ft (5 m)	32-0984-05
49 ft (15 m)	32-0984-15
98 ft (30 m)	32-0984-30

Connecting the Interface Cable

The CNS-5000 is equipped with a 37-pin I/O connector of the following type: MIL-DTL-38999 Series 3 (Part Number D38999/24FD35PA). For a suitable mating connector, use part number D38999/26FD35SA. Figure 16 shows the connector location and Figure 17 describes the function of each pin of the I/O connector.

For a basic configuration (shown in Figure 4 on page 6), connect COM1 or the USB cable to your computer. USB drivers are available for download from the NovAtel website. *If you purchased the optional 32-0976-05 cable, the cable is already terminated with the required connectors.*

Figure 16: CNS-5000 I/O Connector Location

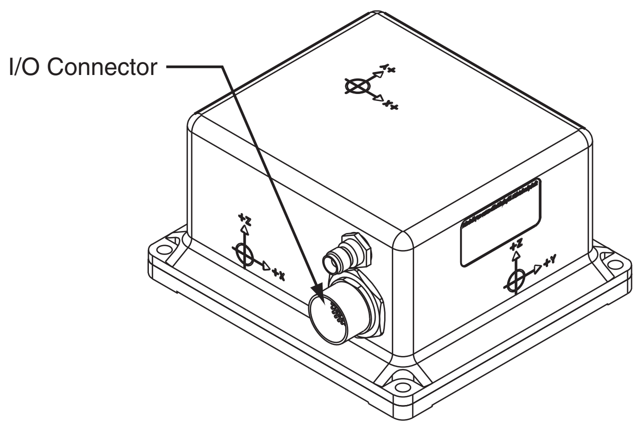


Figure 17: I/O Connector Pins

Pin	Type	Description
1	Power (-)	Power Return
2	Power (+)	9-18 VDC Power Input
3	COM1	RS422 TX+ or RS232 TX from OEM628
4	COM1	RS422 TX- or RS232 RTS from OEM628
5	COM1	RS422 RX+ or RS232 RX to OEM628
6	COM1	RS422 RX- or RS232 CTS to OEM628
7	COM1	RS422 Select In *(tie to pin 8 to select RS422)*
8	COM1	RS422 Select Out *(tie to pin 7 to select RS422)*
9	COM1	Signal Ground
10	USB	D+

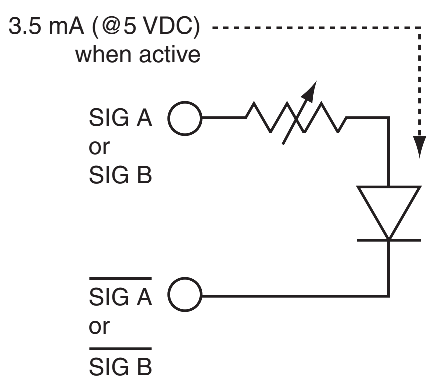
Pin	Type	Description
11	USB	D-
12	USB	Signal Ground
13	Odometer	Odometer Power (9-10 VDC, 100 mA max.)
14	Odometer	Odometer Power Return
15	Odometer	SIGA
16	Odometer	SIGA Inverted
17	Odometer	SIGB
18	Odometer	SIGB Inverted
19	COM2	RS232 TX from OEM628
20	COM2	RS232 RX to OEM628
21	COM2	RS232 RTS from OEM628
22	COM2	RS232 CTS to OEM628
23	-	Reserved for future use
24	-	Reserved for future use
25	COM2	Signal Ground
26	IMU	RS232 TX diagnostics
27	IMU	RS232 RX diagnostics
28	IMU	Signal Ground
29	Strobe	PPS from OEM628
30	Strobe	EVENT1 to OEM628
31	Strobe	Signal Ground
32	CAN Bus	CAN2L (OEM628)
33	CAN Bus	CAN2H (OEM628)
34	CAN Bus	Signal Ground
35	-	Reserved for future use
36	-	Reserved for future use
37	Ground	Chassis Ground

Connecting a Wheel Sensor (Optional)

The CNS-5000 can accept TTL-based input pulses from an external quadrature encoded or pulse and direction wheel sensor. With a wheel sensor connected, the CNS-5000 uses its wheel tick data to compute distance traveled between update intervals (1 Hz), which can be used to constrain free-inertial drift during periods of poor GNSS visibility. The system also contains a state for modeling the circumference of the wheel, as it may change due to hardware changes or environmental conditions.

Connect your wheel sensor to pins 13-18 of the I/O connector (see Figure 17 on page 13), using Figure 18 as a conceptual guide. The CNS-5000 will power the wheel sensor (9-10 VDC, 100 mA max.) through pins 13 and 14.

Figure 18: Conceptual Electrical Diagram for Wheel Sensor Interface



The wheel sensor must meet the following requirements for compatibility with the CNS-5000:

Figure 19: Wheel Sensor Requirements

Attribute	Rating
Input Range	45 KHz max.
Input Duty Cycle	40-60% symmetric
Active Voltage	≥ 2.5 VDC
Inactive Voltage	≤ 1 VDC
Maximum Input Voltage	50 VDC
Input Current	3.5 mA @ 5 VDC, typical 5 mA @ 50 VDC, max.

Connecting Strobe Signals (Optional)

The CNS-5000 offers input/output strobe signals, enabling it to be part of an interconnected system composed of devices that must be synchronized with each other.

PPS (Pulse Per Second)

The PPS signal on pin 29 of the I/O connector is a synchronization output. The leading edge of the pulse is synchronized to the calculated GNSS time. This pulse can be used to trigger measurements in other devices. For example, you could take temperature and pressure measurements in sync with the GNSS data.

The polarity, period, and pulse width of the PPS output are configurable using the PPSCONTROL command. For details, refer to the NovAtel OEM6 Family Firmware Reference Manual.

Event1 (or Mark1)

The Event1 (or Mark1) signal on pin 30 of the I/O connector is a synchronization input. A pulse greater than 150 ns on the Event1 (or Mark1) input triggers the CNS-5000 to generate certain logs. For example, you could connect an aerial camera such that the CNS-5000 records its position whenever the shutter button is pressed.

Polarity is configurable using the MARKCONTROL command. For details, refer to the NovAtel OEM6 Family Firmware Reference Manual.

Connecting a CAN Bus (Optional)

The CNS-5000 includes a CAN Bus controller that supports physical layer signals and low level messages specified in the appropriate sections of the J1939 and ISO11783 standards. The CAN bus port is available on pins 32-34 of the I/O connector (see Figure 17 on page 13).

NOTE: *Manufacturers can also create messages specific to their application without violating the J1939 and ISO11783 standards. To facilitate manufacturer messages, contact KVH for an Application Program Interface (API).*

Connecting Power

The CNS-5000 requires a 12 VDC (nominal) input voltage. Consider the following guidelines to connect the CNS-5000 to a power supply:

- Be sure to observe the correct polarity when connecting power. Power input pins are located at the I/O connector:
  Pin 1 = Power return, **Pin 2** = +12 VDC

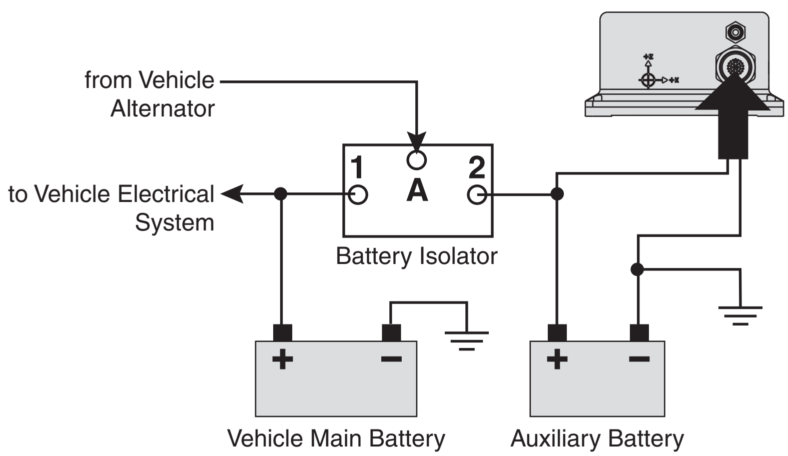
- Ensure the power supply meets minimum specifications (12 VDC nominal, 1.25 amps min.).

IMPORTANT!

Make sure the power supply is monotonic *(does not drop in voltage)* during startup to ensure the CNS-5000 initializes properly.

- If the CNS-5000 is installed on a vehicle, KVH recommends that you install a backup battery between the CNS-5000 and its power supply as a power buffer (see Figure 20). When the engine starts up, power can dip or cut out to ancillary equipment, causing the GNSS receiver and/or IMU to lose lock and calibration settings.

Figure 20: Battery Isolator Installation



- Be sure to connect the interface cable's ground lug to a suitable ground for EMI compliance (see "Interface Cables" on page 7).

- If you are using your own interface cable, be sure to use the appropriate gauge wire to compensate for the voltage drop across the length of the cable. For example, a power cable longer than 7 ft (2.1 m) connecting to a 12 VDC supply should have a wire diameter no smaller than 24 AWG.

The power module within the CNS-5000 filters and regulates the supply voltage, protects against over-voltage, over-current, and high-temperature conditions, and provides automatic reset circuit protection.

Chapter 3 - Configuration

This chapter explains how to communicate with the system, configure it for your particular installation, and enable various sources of correction data.

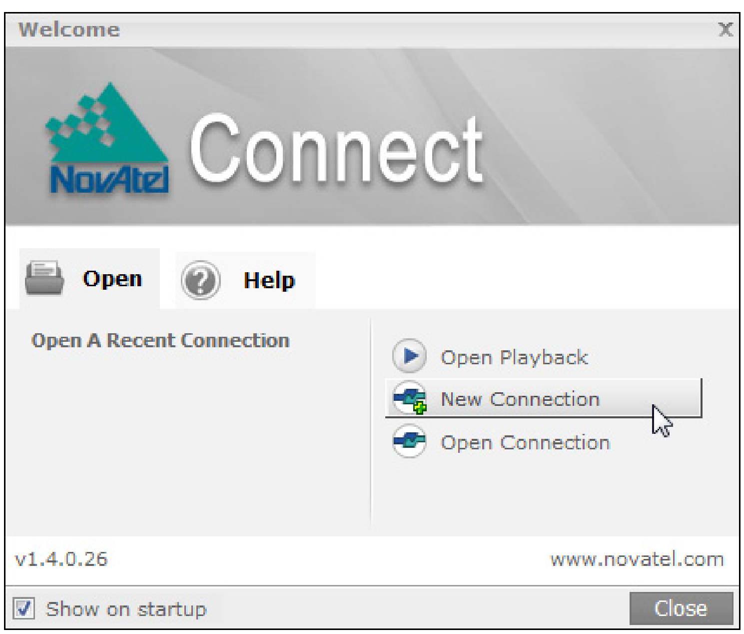
Using NovAtel Connect

The NovAtel Connect PC utilities allow you to connect to and configure the CNS-5000. Download the latest version from the NovAtel website at www.novatel.com/support/firmware-software-and-manuals/firmware-software-updates. (The USB drivers are also available for download). Once you have installed these tools onto your computer, follow these steps to start communicating with the CNS-5000.

NOTE: *You may also use Windows HyperTerminal or other terminal emulator to communicate with the CNS-5000. However, these alternatives are beyond the scope of this manual.*

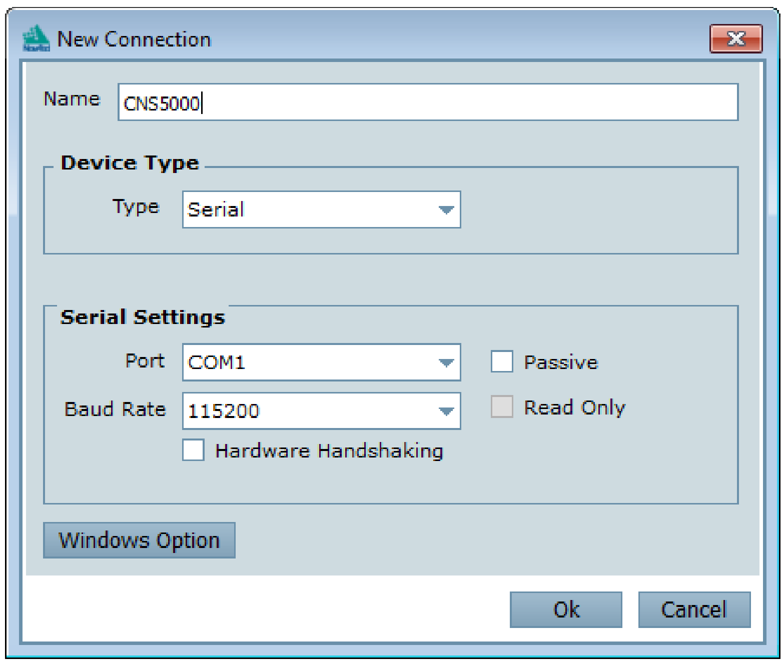
1. Launch NovAtel Connect from the Start menu *(default location is Start > All Programs > NovAtel Connect 1.x.x > NovAtel Connect).*
2. Select **New Connection** from the Welcome window or **Device** menu.

Figure 21: NovAtel Connect Welcome Window



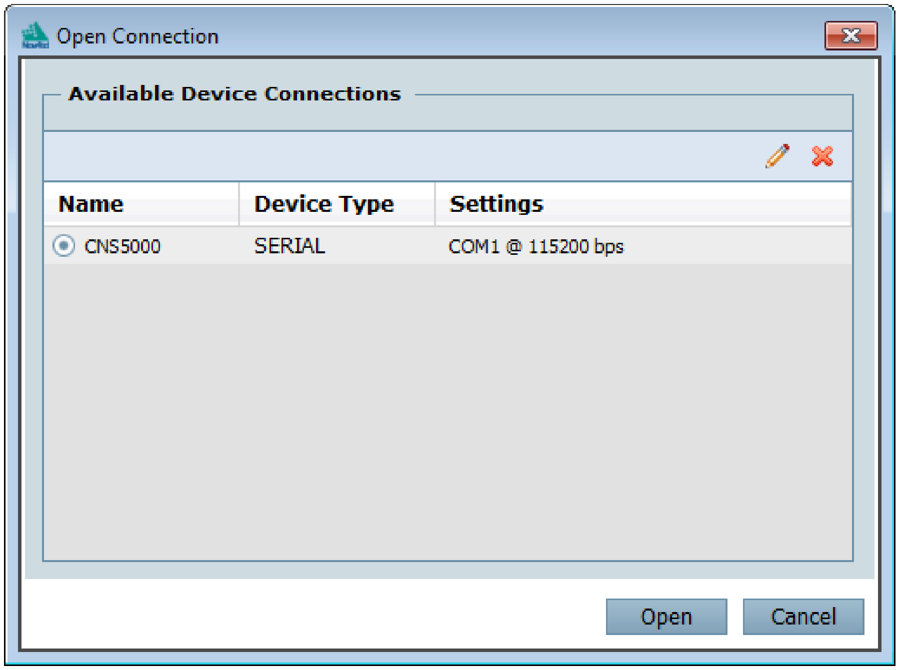
3. Select the following settings then click **OK**:
   - Name: Enter a name for the connection
   - Type: Serial or USB
   - Port: Select the PC port connected to the CNS-5000
   - *(Serial only)* Baud Rate: 115200
   - *(Serial only)* Hardware Handshaking: Unchecked

Figure 22: New Connection Window



4. Select the new configuration in the Open Connection window then select **Open**.

Figure 23: Open Window



5. Wait for NovAtel Connect to establish communications with the CNS-5000. A progress bar is displayed.

6. Once communications have been established, you can control the system's logging to files and ports at the Tools > Logging Control window. You can enter commands at the Console window.

IMPORTANT!

Be sure to save your configuration settings to non-volatile memory (NVM) when you are done. Ensure all windows except Console are closed, then enter the SAVECONFIG command.

Using the Wizards for Assisted Setup

This manual explains how to configure the system by entering commands in the NovAtel Connect Console window. However, NovAtel Connect includes several easy-to-use setup wizards that can walk you through these configuration processes.

SPAN Alignment Wizard:

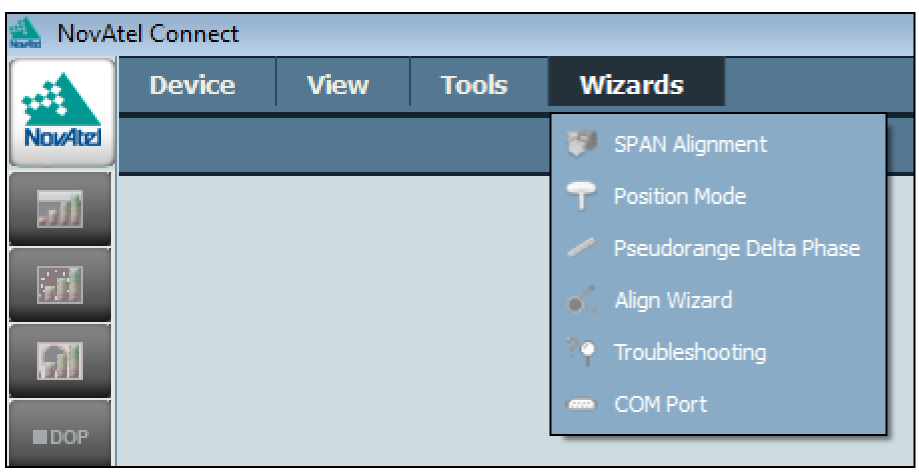
- Set IMU orientation
- Set vehicle to body rotation (VBR)
- Set lever arm offset
- Set inertial data offset
- Select alignment method
- Enter wheel sensor information

Position Mode Wizard:

- Select an SBAS mode
- Select an L-band mode
- Select an RTK (differential GNSS) mode

Wizards are available from the NovAtel Connect Wizards menu. Refer to the NovAtel Connect Help for details.

Figure 24: Wizards Menu



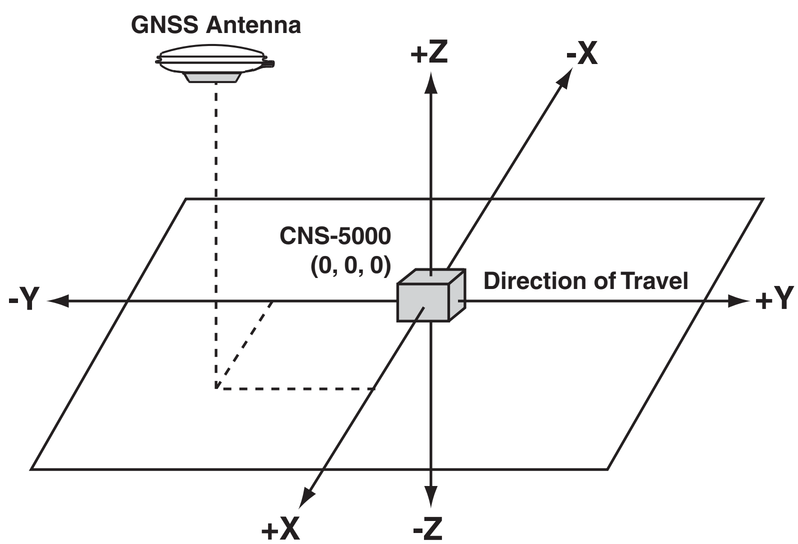
Setting the Lever Arm Offset

At the NovAtel Connect Console window, enter the following command to enter the offset values you measured in "Measuring the Lever Arm Offset Between the GNSS Antenna and the CNS-5000" on page 11. All units are in meters.

SETIMUTOANTOFFSET x_offset y_offset z_offset [x_stdev] [y_stdev] [z_stdev]

Example:
SETIMUTOANTOFFSET 0.54 -0.32 1.20
In this example, you measured a 54 cm X-axis offset, a -32 cm Y-axis offset, and a 120 cm Z-axis offset.

Figure 25: Example of a Lever Arm Offset



The optional standard deviation fields allow you to account for any possible errors in your measurements. For example, if you think your "x_offset" measurement might be off by a centimeter, you would enter 0.01 in the [x_stdev] field.

Variable Lever Arm

The GNSS antenna and CNS-5000 must be rigidly fixed to the vehicle to ensure a constant offset. However, the CNS-5000 offers a variable lever arm function to support applications in which the CNS-5000 is installed on a gimbaled mount. To use this function, the device upon which the CNS-5000 is mounted must be able to send its gimbal rotation angles to the system, allowing it to recalculate the lever arm at the rate they are received. Refer to the NovAtel SPAN on OEM6 Firmware Reference Manual for details.

Setting the Inertial Data Offset

Inertial data logs (such as INSPVA) output position and velocity data at the CNS-5000's center of navigation. If you wish to move this data's reference point to a different location on the vehicle, enter the following command to shift the data by a specified distance with respect to the CNS-5000's frame axes. All units are in meters.

SETINSOFFSET x_offset y_offset z_offset

Example:
SETINSOFFSET 0.15 0.15 0.25
In this example, position and velocity data are offset 15 cm along the X-axis, 15 cm along the Y-axis, and 25 cm along the Z-axis.

Selecting a Positioning Mode

By default, the CNS-5000 operates in Single-Point mode. However, the CNS-5000 can accept a variety of correction data to enhance the system's accuracy. This section explains how to enable these various modes.

If the CNS-5000 is receiving correction data from multiple sources, RTK data will be preferred over OmniSTAR L-band, and OmniSTAR L-band data will be preferred over SBAS. To specify a particular source, use the PSRDIFFSOURCE command. For details about this command, refer to the OEM6 Family Firmware Reference Manual. For details about the various correction sources, refer to the NovAtel OEM6 Family Installation and Operation User Manual.

Enabling SBAS Positioning

A Satellite-Based Augmentation System (SBAS) is a type of geo-stationary satellite system that improves the accuracy, integrity, and availability of GNSS signals. For example:

- **WAAS** - Wide Area Augmentation System - Covers North America
- **EGNOS** - European Geo-Stationary Navigation Overlay System - Covers Europe
- **MSAS** - MTSAT Satellite-Based Augmentation System - Covers Japan

The CNS-5000 can automatically track the SBAS that is operating in the region and apply corrections from the service. To enable SBAS positioning, enter the command below.

```
SBASCONTROL ENABLE
```

To disable SBAS positioning, enter **SBASCONTROL DISABLE**.

NOTE: *You can also specify which particular SBAS system to use. Refer to the NovAtel OEM6 Family Firmware Reference Manual for details.*

Enabling L-Band Positioning

L-band corrections allow you to achieve sub-meter accuracy. The CNS-5000 can receive L-band correction data from the OmniSTAR service, which covers most of the world's land masses. OmniSTAR requires a subscription fee by geographic area and offers three levels of service: VBS, XP, or HP (visit www.omnistar.com for details).

To enable the L-band mode, enter the command below to set the service's base station communication parameters (frequency and data rate). You can enter the frequency in Hz (10 digits) or kHz (7 digits). A value entered in Hz is rounded to the nearest 500 Hz. A frequency/ data rate chart is available at www.omnistar.com.

ASSIGNLBAND OMNISTAR frequency baud

Example:
ASSIGNLBAND OMNISTAR 1536782 1200
In this example, you would enable OmniSTAR service with a frequency of 1536.7820 MHz and a baud rate of 1200.

The following commands also relate to L-band positioning:

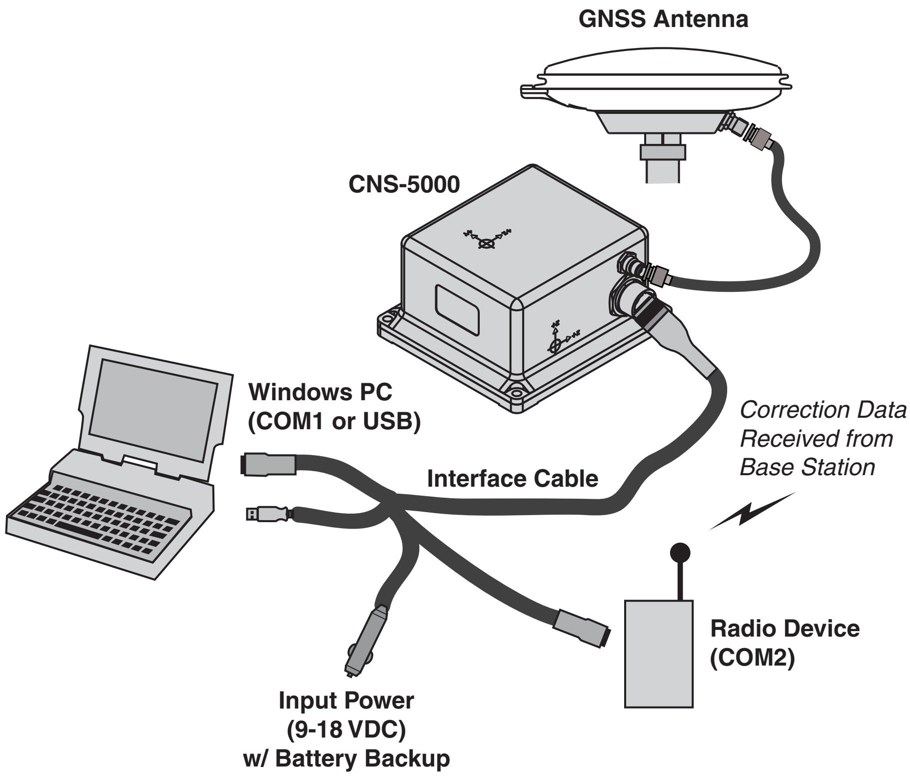
- **LOG LBANDINFO** - View the configuration information for the L-band signal. The fifth field (six-digit number between 700000-799999) is the OmniSTAR serial number; you will need to provide this number to activate OmniSTAR service.
- **LOG LBANDSTAT** - View the status of the L-band signal, to confirm it is being tracked. For example, the fifth field should be 00c2 if you are receiving OmniSTAR HP.
- **ASSIGNLBAND IDLE** - Disable L-band positioning

For details about these commands, refer to the NovAtel OEM6 Family Firmware Reference Manual.

Enabling RTK Positioning (Differential GNSS)

In an RTK (real-time kinematic) positioning configuration, a stationary base station in the local area at a known location transmits GNSS correction data to the rover station to improve its position accuracy. To set up an RTK configuration, you will need to establish a radio data link between the base station and the rover. A user-supplied radio device may be connected to the COM2 port of the CNS-5000 (pins 19-25 of the I/O connector) for this purpose (see Figure 17 on page 13).

Figure 26: Example of an RTK Configuration (CNS-5000 Installed on Rover)



The CNS-5000 is compatible with the following RTK correction messages:

- RTCA
- RTCM V2.3
- RTCM V3
- CMR
- CMR+

For details on configuring the system for these messages, refer to the NovAtel OEM6 Family Installation and Operation User Manual.

Integrating Wheel Sensor (Odometer) Data

If you connected a wheel sensor to the CNS-5000 (see "Connecting a Wheel Sensor (Optional)" on page 15), you may enter your wheel sensor's specific parameters into the system to give the INS filter a good starting point for the wheel size scale factor, as well as an indication of the expected accuracy of the wheel data. Enter the SETWHEELPARAMETERS command below:

SETWHEELPARAMETERS ticks circ spacing

Field	**Description**
ticks	Number of ticks per revolution [1-10000]
circ	Wheel cirumference (m) [0.1-100] Default = 1.96 m
spacing	Spacing of ticks, or resolution of the wheel sensor (m) [0.001-1000]

Example:
SETWHEELPARAMETERS 58 1.96 0.025

The ticks and wheel circumference data are used with the estimated scale factor to determine distance traveled. The spacing data is used to weight the wheel sensor measurement.

NOTE: *To view the output wheel sensor data, request the TIMEDWHEELDATA log. Refer to the NovAtel SPAN on OEM6 Firmware Reference Manual for details.*

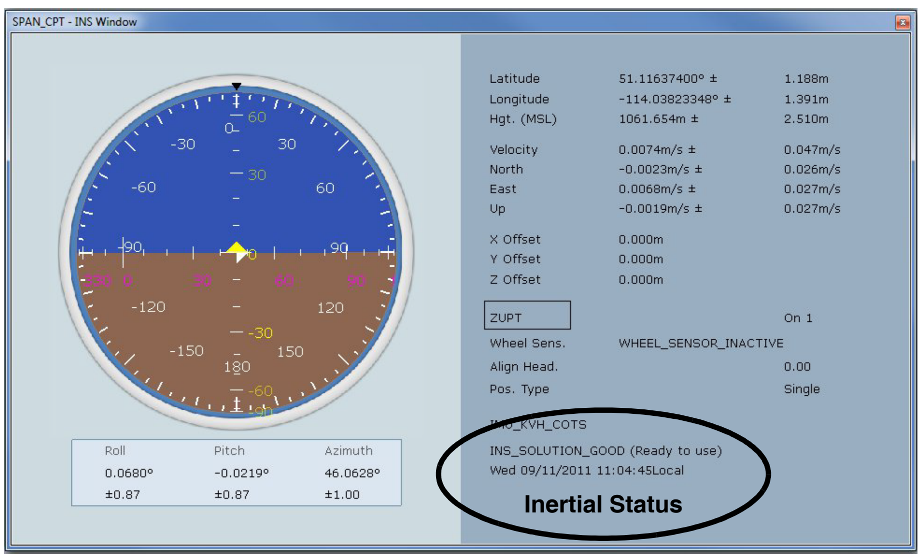
Chapter 4 - Operation

This chapter explains how to interpret the system's inertial status messages, select an alignment mode, and collect data for both real-time and post-processing applications.

Viewing Status Information

You can use the NovAtel Connect program to monitor CNS-5000 data in real time. It offers several data views, including the INS window shown in Figure 27. For details about this window, and all other available windows, refer to the NovAtel Connect Help file.

Figure 27: NovAtel Connect INS Window



The dial is a graphical display of the roll, pitch, and azimuth values, indicated by an arrow on each axis. In addition to position, velocity, offset, ZUPT (zero velocity update), and attitude (roll, pitch, azimuth) information, the INS window displays the current status of the inertial solution (see Figure 28 on page 29 for details).

Figure 28: Inertial Status Field

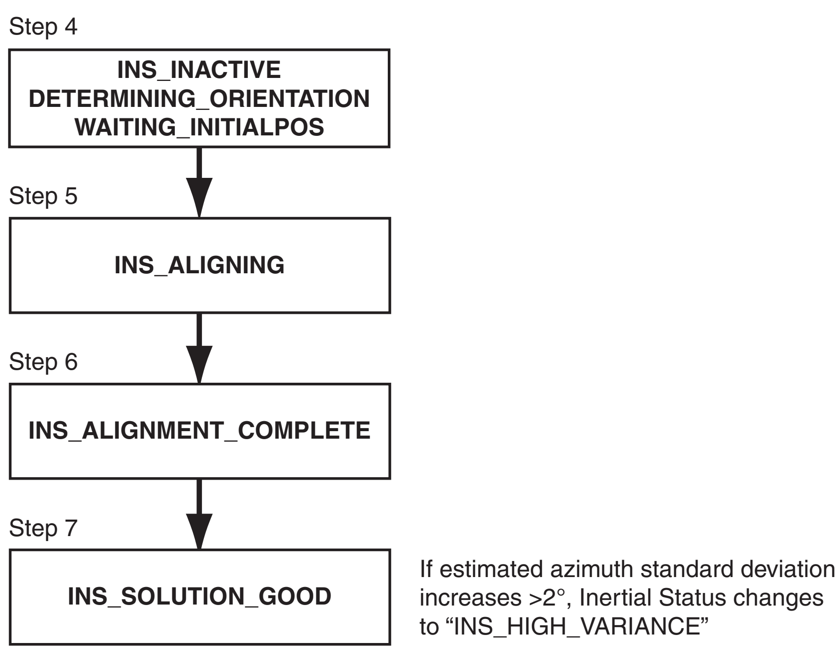
Inertial Status	Definition
INS_INACTIVE [Binary 0]	IMU logs are present, but the alignment routine has not yet started.
INS_ALIGNING [Binary 1]	In Alignment mode. You may move the vehicle to initiate the kinematic alignment or enter a SETINITAZIMUTH or SETINITATTITUDE command (see "Alignment" on page 31).
INS_HIGH_VARIANCE [Binary 2]	The inertial solution is valid, but the azimuth solution uncertainty has exceeded 2°. This may occur when GNSS data is unavailable.
INS_SOLUTION_GOOD [Binary 3]	In Navigation mode. The inertial solution is good.
INS_SOLUTION_FREE [Binary 6]	In Navigation mode, but the GNSS solution is erroneous, probably due to limited satellite availability or multipath interference. The INS filter will reject the GNSS position until its quality improves.
INS_ALIGNMENT_COMPLETE [Binary 7]	In Navigation mode, but not enough vehicle dynamics have been experienced to bring the unit within specifications.
DETERMINING_ORIENTATION [Binary 8]	The INS filter is determining the IMU axis that is aligned with gravity.
WAITING_INITIALPOS [Binary 9]	The INS filter has determined the IMU orientation and is awaiting an initial position estimate to begin the alignment process.

System Startup

When power is first applied to the CNS-5000, the following sequence of events occurs:

1. **To begin, the GNSS antenna must be connected and have a clear view of the sky.** The first satellites are then tracked and "coarse time" is solved.
2. Enough satellites are tracked to compute a position.
3. Receiver "fine time" is solved; the time onboard the CNS-5000 is accurate enough to begin timing IMU measurements.
4. Raw IMU measurements begin to be timed by the receiver and are available to the INS filter. They are also available in the RAWIMUS log (see "RAWIMUS - Raw IMU Data" on page 55).
5. The inertial alignment routine starts. By default, the system performs a kinematic alignment once the vehicle starts moving. Or you may initiate a coarse or manual alignment (see "Alignment" on page 31 for details).
6. Alignment is completed. The system transitions to navigation mode.
7. The solution is refined using updates from GNSS. Once the system is operating within specifications, and after some vehicle movement, the estimated azimuth standard deviation drops below 2°.

Figure 29: Inertial Status Startup Sequence



Alignment

Since the CNS-5000 does not have position, velocity, or attitude information upon startup, its IMU requires an initial attitude estimate to begin navigation. This process is called system alignment. Three options are available:

- Kinematic (Moving) Alignment - *default*
- Coarse Alignment
- Manual Alignment

Kinematic Alignment

In a kinematic alignment, the CNS-5000 uses GNSS velocity direction to align the attitude of the IMU with the vehicle's direction of travel.

IMPORTANT!

If the CNS-5000 is not oriented as recommended in "Mounting the CNS-5000" on page 9, be sure to enter the appropriate offset commands as described in "Appendix B - Installation Offsets" on page 65. The accuracy of the kinematic alignment depends largely upon the precision of these commands.

NOTE: *This alignment routine is best suited for ground-based vehicles in which the direction of travel is coincident with the forward axis of the vehicle, and vehicle roll is close to zero. Kinematic alignment might not be suitable for certain marine or airborne applications in which direction of travel differs from the forward axis of the vehicle, due to factors such as crab angle.*

Kinematic alignment begins automatically once Inertial Status indicates "INS_ALIGNING" and the vehicle begins moving at a speed greater than 2.5 mph (4 km/hr) (1.15 m/s). The accuracy of the resulting estimated initial attitude will depend on the dynamics of the vehicle. However, after some vehicle motion (stops, starts, and turns), the attitude solution will converge and accuracy will improve.

Coarse Alignment

In a coarse alignment, the CNS-5000 uses gyro and accelerometer measurements averaged over a period of time to estimate the pitch and roll of the IMU, and it uses the estimated azimuth that you enter manually into the system.

Coarse alignment begins once Inertial Status indicates "INS_ALIGNING" and the vehicle remains stationary for approximately one minute. To complete the coarse alignment, enter the SETINITAZIMUTH command below:

SETINITAZIMUTH azimuth az_stdev

Example:
SETINITAZIMUTH 90 10
In this example, initial azimuth is set to 90°, meaning the CNS-5000 system's Y-axis is pointing due East, within a standard deviation of 10°.

NOTE: *The azimuth angle you enter is relative to the CNS-5000 frame. If you mounted the unit such that the marked Z-axis is not pointing up, you will need to enter the azimuth with respect to the transformed axis from the SETIMUORIENTATION command. See* "Setting the IMU Orientation" on page 65 *for details.*

The accuracy of the initial attitude will depend on the duration of the stationary period and the accuracy of the azimuth you entered. Therefore, if you are unsure which standard deviation to enter, use a larger deviation. After some vehicle motion (stops, starts, and turns), the attitude solution will converge and accuracy will improve.

Manual Alignment

In a manual alignment, you manually enter the pitch, roll, and azimuth (heading) into the system. The CNS-5000 will immediately use this data for alignment. **Be sure your input values are precise for maximum accuracy.** If you are unsure which standard deviation to enter for an angle, err on the side of a larger deviation.

Enter the SETINITATTITUDE command below:

SETINITATTITUDE pitch roll azimuth pitch_stdev roll_stdev az_stdev

Example:
SETINITATTITUDE 0 0 90 5 5 5
In this example, initial pitch and roll are set to 0°, with a standard deviation of 5° for both. This means the CNS-5000 is mounted very close to level with respect to the local gravity field. The azimuth is set to 90° within a standard deviation of 5°.

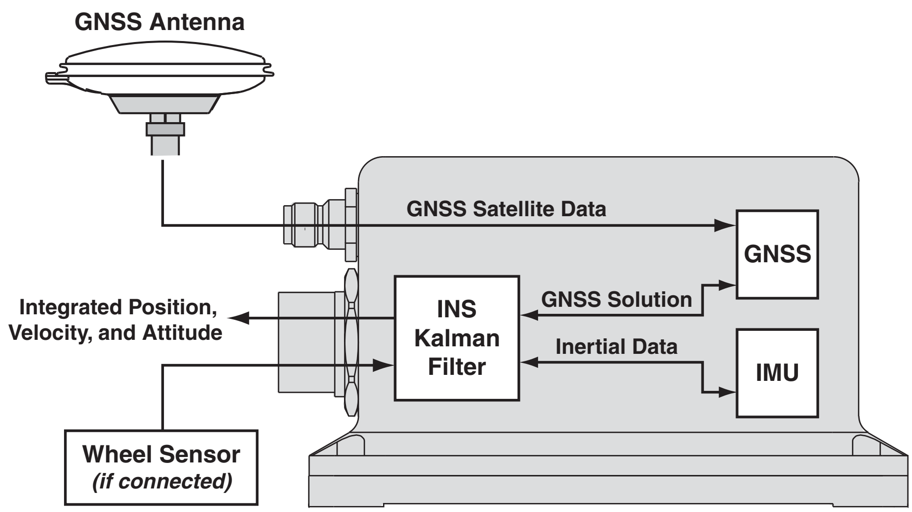
NOTE: *The angles you enter are relative to the CNS-5000 frame. If you mounted the unit such that the marked Z-axis is not pointing up, you will need to enter the angles with respect to the transformed axes from the SETIMUORIENTATION command. See* "Setting the IMU Orientation" on page 65 *for details.*

Navigation Mode

Once the alignment routine has successfully completed, the CNS-5000 enters navigation mode.

In navigation mode, the CNS-5000 computes the navigation solution by accumulating velocity and rotation increments from the IMU to generate position, velocity, and attitude. It models system errors by using a Kalman filter. The GNSS solution, phase observations, and automatic zero velocity updates (ZUPTs) provide updates to the Kalman filter. If a wheel sensor is connected to the system, wheel displacement updates are also incorporated.

Figure 30: Computing the Navigation Solution



Following alignment, the attitude is coarsely defined, especially in heading. Vehicle dynamics, specifically turns, stops, and starts, allow the system to observe the heading error and allows the heading accuracy to converge. Once convergence is complete, the Inertial Status field changes to INS_SOLUTION_GOOD. (Whenever heading solution uncertainty exceeds 2°, the Inertial Status field reverts to INS_HIGH_VARIANCE until accuracy is restored.)

Azimuth Sources

The CNS-5000 uses two methods to calculate the azimuth:

- **Course Over Ground** – Determined using the position delta between two GNSS or INS position solutions. This method is most advantageous in aerial or marine environments where the actual direction of travel may not match the forward axis of the aircraft/boat due to winds or currents. (This effect is known as the crab angle.) It is also a great way to compute the offset if another means of computing the vehicle azimuth is available.

> ***IMPORTANT!***
>
> Course Over Ground does not work when the vehicle is stationary, as any position difference is due to position error, making the computed azimuth meaningless.

- **Inertial Azimuth** – Computed by the INS filter, which uses the sensors in the IMU to calculate the azimuth of the IMU.

Course Over Ground is available in several velocity logs, while Inertial Azimuth is provided in most INS logs (see Figure 31). For details on the INSPVA log, see "INSPVA - Inertial Position, Velocity, and Attitude" on page 51. For details on all other logs, refer to the NovAtel SPAN on OEM6 Firmware Reference Manual and the NovAtel OEM6 Family Firmware Reference Manual.

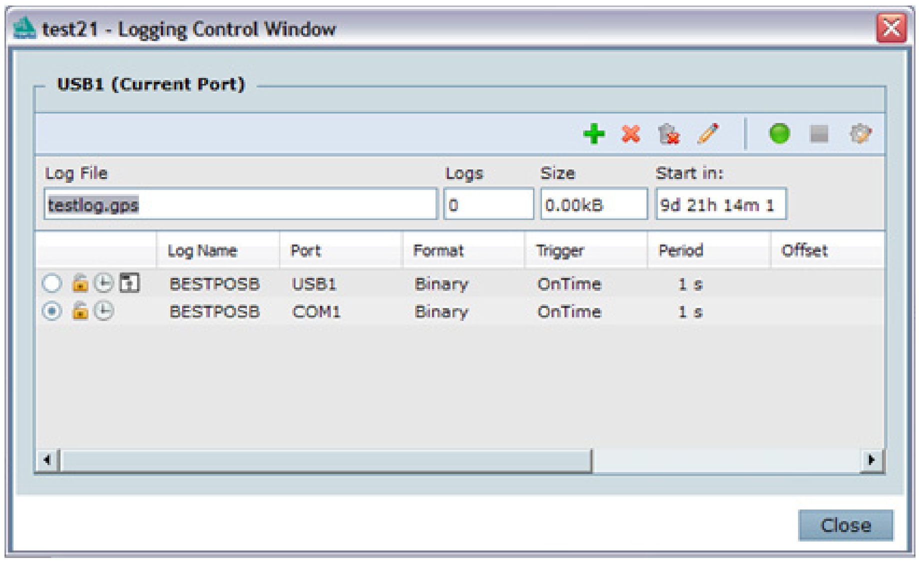
Figure 31: Logs with Azimuth Data

Log	**Format**	**Azimuth Source**
INSPVA/INSPVAS/INSPVAX	NovAtel	Inertial
INSATT/INSATTS/INSATTX	NovAtel	Inertial
PASHR	NMEA	Inertial
INSSPD	NovAtel	Course Over Ground *(using INS solution only)*
BESTVEL	NovAtel	Course Over Ground *(using best solution, either GNSS or INS)*
GPVTG	NMEA	Course Over Ground *(using best solution, either GNSS or INS)*

Collecting Data

The CNS-5000 can generate many different types of data logs, available in ASCII or binary format. These logs can either be saved to a file or exported to a COM or USB port (for processing by user-supplied software). To set up your desired logging scheme, you can either use the NovAtel Connect Logging Control window (see Figure 32) or enter commands via the Console port.

Figure 32: NovAtel Connect Logging Control Window



There are well over 100 logs to choose from. However, KVH recommends the following:

- **INSPVA** - This log reports the inertial position, velocity, and attitude (pitch, roll, and azimuth), as well as inertial status.
- **INSUPDATE** - This log indicates the inertial updates that were performed in the INS filter during the last epoch. It also provides a wheel sensor status indicator.
- **BESTGNSSPOS** - This log contains the best available GNSS position without IMU data factored in. It also provides several status indicators, including differential age.
- **RXSTATUS** - Reports the status of the GNSS receiver component, including any error conditions.
- **RAWIMUS** - Reports the status of the IMU and provides the measurements from the gyros and accelerometers with respect to the CNS-5000 frame.

For more information about these logs, see "Appendix A - Data Logs" on page 43.

To select a log, enter the LOG command below:

LOG [port] message [trigger [period]]

Field	Description
port	The port if you wish to export the log (COM2 or USB1, for example)
message	Title of the desired log By default, the log message is output in abbreviated ASCII format. To select ASCII or binary format: **ASCII**: Append an "A" to the log title **Binary**: Append a "B" to the log title
trigger	The desired output frequency: • ONNEW - Outputs when the message is updated • ONCHANGED - Outputs when the message is changed • ONTIME - Outputs on a time interval, defined in the "period" field • ONNEXT - Outputs only the next message • ONCE - Outputs only the current message • ONMARK - Outputs when a pulse is detected on the Event1 input
period	The log period (in seconds) for the ONTIME trigger Valid periods are 0.01 (100 Hz), 0.02 (50 Hz), 0.05, 0.1, 0.2, 0.25, 0.5, 1, and any integer

Example:
LOG INSPVAA ONTIME 0.02
In this example, the position, velocity, and attitude will output at the rate of 50 Hz in ASCII format.

Consider the following guidelines when setting up your desired logs:

- The inertial solution is available up to the rate of 100 Hz. However, only one log can be output at this high rate at one time. All other logs are limited to a maximum rate of 50 Hz. The highest rate you can request GNSS logs (such as BESTGNSSPOS) is 5 Hz.

- Disable your PC's hibernate or standby modes. You will lose data if one of these modes occurs during a logging session.

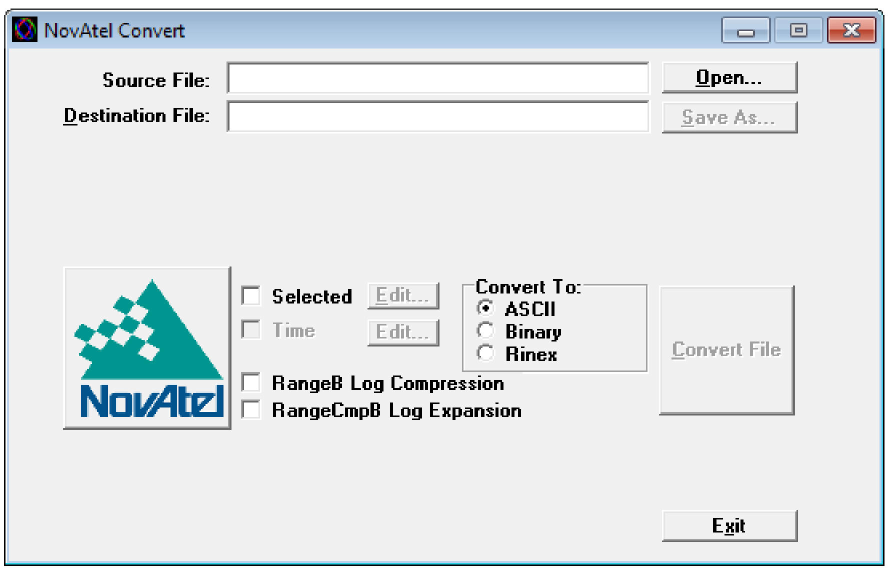
Using the Convert Utility to Convert Between ASCII and Binary

When you installed NovAtel Connect on your computer, you also installed NovAtel's Convert utility. This software tool allows you to easily perform the following conversions:

- ASCII to Binary
- Binary to ASCII
- Short-header ASCII to Short-header Binary
- Short-header Binary to Short-header ASCII

Convert can also perform RINEX (Receiver-Independent Exchange) conversions to/from ASCII or binary.

Figure 33: Convert Utility



In addition to data conversions, you can use the Convert utility to screen particular logs out of large data files in either ASCII or binary format.

For complete details about the Convert software, refer to the NovAtel OEM6 Family Installation and Operation User Manual.

Post-Processing Data

Certain applications, such as survey operations, do not require real-time navigation information from the CNS-5000. For such operations, you may calculate the position, velocity, or attitude solution post-mission, resulting in a much more robust and accurate solution than is possible in real time. Processing raw data in both forward and reverse directions significantly improves the results.

To generate a solution by post-processing, you need to collect the following data logs from base and rover stations simultaneously:

From the Base:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONCHANGED
- GLOEPHEMERISB ONCHANGED *(if using GLONASS)*

From the Rover:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONCHANGED
- GLOEPHEMERISB ONCHANGED *(if using GLONASS)*
- RAWIMUSXB ONNEW
- IMUTOANTOFFSETSB ONCHANGED
- VEHICLEBODYROTATIONB ONCHANGED

IMPORTANT!

A USB connection (not serial) is required if your post-processing application requires 100 Hz IMU data.

The CNS-5000 data output is compatible with Inertial Explorer® post-processing software from NovAtel's Waypoint® Products Group. Visit www.novatel.com for details.

Chapter 5 - Troubleshooting

This chapter explains how to diagnose basic problems, as well as how to contact KVH Technical Support.

IMPORTANT!

The CNS-5000 is supplied as a sealed unit. Breaking the QA seals voids the warranty and may violate the contract under which the unit was supplied. The warranty does not apply if the unit has been damaged by misuse or as the result of service or modification other than by KVH Industries.

Basic Diagnostics

The table below provides simple solutions to the most basic problems.

Figure 34: Basic Troubleshooting

Problem	Solution
Power is applied to the unit, but it is not making any sound.	This is normal. The CNS-5000 uses fiber optic gyros, not ring laser or mechanical gyros.
The unit does not power up.	Check the input power supply. 12 VDC (nominal) is best for stable performance. The supply should also output at least 16 W over the entire operating temperature range. If the power supply is OK, check the power cable and wiring. Also make sure the input current does not exceed 5 amps (at 23°C) on startup. *(The CNS-5000 over-current interrupt will reset after a few seconds of cooling.)*
Accelerometer measurements in the RAWIMUS log are zero and the IMU status shows one or all accelerometers are invalid.	Ensure the power supply is monotonic (does not drop in voltage) during startup of the CNS-5000.
The GNSS receiver is unable to calculate a position.	Ensure the GNSS antenna is connected to the system and has an unobstructed view of the sky in all directions.

Problem	Solution
The INS solution status is "INS_INACTIVE" and INS logs are not available.	The INS alignment routine does not begin until the system has solved for time, which requires a GNSS antenna and a clear view of GNSS satellites. Check the time status in the standard header of any GNSS log, such as BESTGNSSPOS. Time is solved when time status reaches "FINESTEERING."
No data is being logged.	Check your COM port configuration (e.g., in NovAtel Connect's Logging Control window) and check the interface wiring.
Random data is being output, or binary data is streaming.	Ensure the CNS-5000 and the communication software (NovAtel Connect) are set to the same baud rate (default is 115200 bps).
RTK positioning mode (differential GNSS) is not working properly.	Check the radio link between rover and base station and check the COM2 port wiring.
CPU or port buffers are becoming overloaded or overrun.	Reduce the quantity or data rate of selected logs.

For more advanced troubleshooting information, refer to the NovAtel OEM6 Family Installation and Operation User Manual.

In addition, the following data logs provide system status information:

Figure 35: Status Information Available in Data Logs

Status Information	Data Log
GNSS receiver status	RXSTATUS - see page 57
IMU status	RAWIMUS - see page 55
Wheel sensor status	INSUPDATE - see page 53

Resetting the System to Factory Default Settings

If you performed basic troubleshooting, and verified your connections and configuration, but the CNS-5000 is still not providing any data, or is providing only random data, you may try resetting the system to its factory default settings.

Enter the FRESET command below:

```
FRESET
```

This command clears all data stored in non-volatile memory, including the almanac, ephemeris, and any user-specific configurations. Therefore, you will need to reconfigure the system as explained in "Chapter 3 - Configuration" on page 18.

For complete details about the FRESET command, including variations for resetting only certain parameters, refer to the NovAtel SPAN on OEM6 Firmware Reference Manual.

Technical Support

For technical support, please e-mail your question or a description of your problem to fogsupport@kvh.com.

Appendix A - Data Logs

This appendix provides overviews of the following data logs:

- **BESTGNSSPOS**
- **INSPVA**
- **INSUPDATE**
- **RAWIMUS**
- **RXSTATUS**

For details on using the LOG command to request one of these logs, see "Collecting Data" on page 36.

Log Structure

All data logs are available in any of the following three formats:

Figure 36: Log Formats

Format	Description
ASCII	Data is readable by both the user and a computer *(append "A" to the log command)*
Abbreviated ASCII	Data is formatted in ASCII and arranged in an easy-to-understand layout *(default)*
Binary	Data is readable only by a computer; its compactness is ideal for high data rate applications *(append "B" to the log command)*

In addition, each individual log is characterized by one of the following output types:

Figure 37: Log Types

Type	Description
Synchronous	Data is generated on a regular schedule
Asynchronous	Data is generated at irregular intervals
Polled	Data is generated on demand

For complete details about logs and their standard structure, refer to the NovAtel SPAN on OEM6 Firmware Reference Manual and OEM6 Family Firmware Reference Manual.

Short Headers

Certain ASCII and binary logs offer an alternate short header option, which significantly reduces their storage and baud rate requirements, particularly when running a log at the maximum rate of 100 Hz. Short header logs are identified by an appended "S" to their log title (for example: "RAWIMU**S**"). The tables in Figure 38 and Figure 39 show the structure of these short headers. For details on standard headers, refer to the NovAtel SPAN on OEM6 Firmware Reference Manual.

Figure 38: Structure of ASCII Short Header

Field #	**Description**	**Type**
1	"%" sync character	Char
2	Log name	Char
3	GNSS week number	Ushort
4	Milliseconds from beginning of GNSS week	Ulong

Figure 39: Structure of Binary Short Header

Field #	**Description**	**Type**	**Binary Bytes**	**Binary Offset**
1	Hex 0xAA	Char	1	0
2	Hex 0x44	Char	1	1
3	Hex 0x13	Char	1	2
4	Message length, excluding header and CRC	Uchar	1	3
5	Message ID number of the log	Ushort	2	4
6	GNSS week number	Ushort	2	6
7	Milliseconds from beginning of GNSS week	Ulong	4	8

Log Message Termination

ASCII logs end with a hexadecimal number preceded by an asterisk and followed by a carriage return and line feed, such as *1234ABCD[CR][LF]. This value is a 32-bit CRC (cyclic redundancy check) of all bytes in the log, excluding "#", "%", and "*" indentifiers. Binary logs end with a CRC without the carriage return and line feed.

BESTGNSSPOS - Best GNSS Position

This log records the best available GNSS position (without IMU data) computed by the CNS-5000's internal GNSS receiver. It also provides various status indicators, including differential age. Differential age can help predict anomalous behavior brought about by outages in differential corrections; a differential age of "0" indicates that no differential correction was used.

NOTE: *BESTGNSSPOS always outputs positions at the antenna phase center.*

If the system is operating in RTK mode, this log reflects the latest low-latency solution for up to 60 seconds after reception of the last base station observations. After this 60-second period, the position reverts to the best solution available; the degradation in accuracy is reflected in the standard deviation fields. If the system is not operating in an RTK mode, pseudorange differential solutions continue for the time period specified by the PSRDIFFTIMEOUT command (refer to the NovAtel OEM6 Family Firmware Reference Manual).

Message ID: 1429
Log Type: Synchronous
Recommended Command: LOG BESTGNSSPOSA ONTIME 1
ASCII Example:

```
#BESTGNSSPOSA,COM1,0,62.5,FINESTEERING,1036,484878.000,00000
028,63e2,0;
SOL_COMPUTED,SINGLE,51.11629893124,-114.03820302746,
1052.3434,-16.271287293,61,19.6934,13.1515,23.8561,"",
0.0,60.000,10,10,0,0,0,0,0,0*1051ada9
```

Figure 40: Structure of BESTGNSSPOS Log

Field #	Description	Type	Binary Bytes	Binary Offset
1	Header	-	H	0
2	Solution status (see page 47)	Enum	4	H
3	Position type (see page 48)	Enum	4	H+4
4	Latitude	Double	8	H+8
5	Longitude	Double	8	H+16
6	Height above mean sea level	Double	8	H+24

Field #	Description	Type	Binary Bytes	Binary Offset
7	Undulation	Float	4	H+32
8	Datum ID *(refer to the NovAtel SPAN on OEM6 Firmware Reference Manual)*	Enum	4	H+36
9	Latitude standard deviation	Float	4	H+40
10	Longitude standard deviation	Float	4	H+44
11	Height standard deviation	Float	4	H+48
12	Base station ID	Char[4]	4	H+52
13	Differential age	Float	4	H+56
14	Solution age in seconds	Float	4	H+60
15	Number of observations tracked	Uchar	1	H+64
16	Number of satellite solutions used in computation	Uchar	1	H+65
17	Number of GPS and GLONASS L1 ranges above the RTK mask angle	Uchar	1	H+66
18	Number of GPS and GLONASS L2 ranges above the RTK mask angle	Uchar	1	H+67
19	Reserved	Uchar	1	H+68
20	Reserved	Uchar	1	H+69
21	Reserved	Uchar	1	H+70
22	Reserved	Uchar	1	H+71
23	32-bit CRC- *ASCII and binary only*	Hex	4	H+88
24	[CR][LF] - *ASCII only*	-	-	-

Solution Status Field

The table below defines the indications for "Solution Status."

Figure 41: Solution Status Indications

Binary	ASCII	Description
0	SOL_COMPUTED	Solution computed
1	INSUFFICIENT_OBS	Insufficient observations
2	NO_CONVERGENCE	No convergence
3	SINGULARITY	Singularity at parameters matrix
4	COV_TRACE	Covariance trace exceeds max. (trace > 1000 m)
5	TEST_DIST	Test distance exceeded (max. of 3 rejections if distance > 10 km)
6	COLD_START	Not yet converged from cold start
7	V_H_LIMIT	Height or velocity limits exceeded *(in accordance with COCOM export licensing restrictions)*
8	VARIANCE	Variance exceeds limits
9	RESIDUALS	Residuals are too large
10	DELTA_POS	Delta position is too large
11	NEGATIVE_VAR	Negative variance
12-17	Reserved	
18	PENDING	When a FIX POSITION command is entered, GNSS receiver computes its own position and determines if the fixed position is valid [a]

Binary	ASCII	Description
19	INVALID_FIX	Fixed position, entered with FIX POSITION command, is invalid

a PENDING implies not enough satellites are being tracked to verify if the FIX POSITION entered into the receiver is valid. The receiver needs to track two or more GNSS satellites to perform this check. Under normal conditions, PENDING should be seen for a few seconds on power-up before the GNSS receiver locks onto the first few satellites. If the antenna is obstructed (or not plugged in) and the FIX POSITION command was entered, then PENDING may display indefinitely.

Position Type Field

The table below defines the indications for "Position Type."

Figure 42: Position or Velocity Type Indications

Binary	ASCII	Description
0	NONE	No solution
1	FIXEDPOS	Position has been fixed by the FIX POSITION command or by position averaging
2	FIXEDHEIGHT	Position has been fixed by the FIX HEIGHT, or FIX AUTO, command or by position averaging
3	Reserved	
4	FLOATCONV	Solution from floating point carrier phase ambiguities
5	WIDELANE	Solution from wide-lane ambiguities
6	NARROWLANE	Solution from narrow-lane ambiguities
7	Reserved	
8	DOPPLER_VELOCITY	Velocity computed using instantaneous Doppler

Binary	ASCII	Description
9-15	Reserved	
16	SINGLE	Single point position
17	PSRDIFF	Pseudorange differential solution
18	WAAS	Solution calculated using corrections from an SBAS
19	PROPOGATED	Propagated by a Kalman filter without new observations
20	OMNISTAR	OmniSTAR VBS position (L1 sub-meter) [a]
21-31	Reserved	
32	L1_FLOAT	Floating L1 ambiguity solution
33	IONOFREE_FLOAT	Floating ionospheric-free ambiguity solution
34	NARROW_FLOAT	Floating narrow-lane ambiguity solution
48	L1_INT	Integer L1 ambiguity solution
49	WIDE_INT	Integer wide-lane ambiguity solution
50	NARROW_INT	Integer narrow-lane ambiguity solution
51	RTK_DIRECT_INS	RTK status where the RTK filter is directly initialized from the INS filter [b]
52	INS	INS calculated position corrected for the antenna [b]
53	INS_PSRSP	INS pseudorange single point solution - no DGPS corrections [b]

Binary	ASCII	Description
54	INS_PSRDIFF	INS pseudorange differential solution [b]
55	INS_RTKFLOAT	INS RTK floating point ambiguities solution [b]
56	INS_RTKFIXED	INS RTK fixed ambiguities solution [b]
57	INS_OMNISTAR	INS OmniSTAR VBS position (L1 sub-meter) [a]
58	INS_OMNISTAR_HP	INS OmniSTAR high precision solution [a]
59	INS_OMNISTAR_XP	INS OmniSTAR extra precision solution [a]
64	OMNISTAR_HP	OmniSTAR high precision [a]
65	OMNISTAR_XP	OmniSTAR extra precision [a]
66	Reserved	

a In addition to a GNSS antenna with L-band capability, a subscription to the OmniSTAR service is required.

b These types appear in GNSS position logs such as BESTPOS. Refer to the NovAtel SPAN on OEM6 Firmware Reference Manual.

INSPVA - Inertial Position, Velocity, and Attitude

This log records the inertial position, velocity, and attitude with respect to the CNS-5000 frame. (The attitude can be output in the vehicle frame. See “Setting the Angular Offsets Between the Vehicle and the CNS-5000” on page 67 for details.)

NOTE: *The data are relative to the CNS-5000 frame. If you mounted the unit such that the marked Z-axis is not pointing up, the output will be with respect to the transformed axes from the SETIMUORIENTATION command.* *See* “Setting the IMU Orientation” on page 65 *for details.*

Message ID: 507
Log Type: Synchronous
Recommended Command: LOG INSPVAA ONTIME 1
ASCII Example:

```
#INSPVAA,COM1,0,31.0,FINESTEERING,1264,144088.000,00040000,
5615,1541;
1264,144088.002284950,51.116827527,-114.037738908,
401.191547167,354.846489850,108.429407241,-10.837482850,
1.116219952,-3.476059035, 7.372686190,INS_ALIGNMENT_COMPLETE
*af719fd9
```

Figure 43: Structure of INSPVA Log

Field #	Description	Type	Binary Bytes	Binary Offset
1	Header	-	H	0
2	GNSS week	Ulong	4	H
3	Seconds from week start	Double	8	H+4
4	Latitude (WGS84)	Double	8	H+12
5	Longitude (WGS84)	Double	8	H+20
6	Ellipsoidal Height (WGS84) [m]	Double	8	H+28
7	Velocity in northerly direction *(negative value = southernly direction)* [m/s]	Double	8	H+36
8	Velocity in easterly direction *(negative value = westerly direction)* [m/s]	Double	8	H+44

Field #	Description	Type	Binary Bytes	Binary Offset
9	Velocity in upward direction [m/s]	Double	8	H+52
10	Roll - Right-handed rotation from local level around Y-axis in degrees	Double	8	H+60
11	Pitch - Right-handed rotation from local level around X-axis in degrees	Double	8	H+68
12	Azimuth - Left-handed rotation around Z-axis in degrees clockwise from North	Double	8	H+76
13	Inertial status (see page 29)	Enum	4	H+84
14	32-bit CRC	Hex	4	H+88
15	[CR][LF] - *ASCII only*	-	-	-

INSUPDATE - Inertial Update Information

This log records the most recent inertial update information. Specifically, it denotes which updates were performed in the Kalman filter during the last update epoch. It also indicates the status of the wheel sensor, if one is connected.

Message ID: 757
Log Type: Asynchronous
Recommended Command: LOG INSUPDATEA ONCHANGED
ASCII Example:

```
#INSUPDATEA,UNKNOWN,0,32.5,FINESTEERING,1379,339642.042,0004
0040,3670,2431;
SINGLE,0,6,0,FALSE,WHEEL_SENSOR_UNSYNCED,0*fb5df08b
```

Figure 44: Structure of INSUPDATE Log

Field #	Description	Type	Binary Bytes	Binary Offset
1	Header	-	H	0
2	GNSS solution type used for the last update (see "Position Type Field" on page 48)	Enum	4	H
3	Reserved	Integer	4	H+4
4	Number of raw phase observations used in the last update	Integer	4	H+8
5	Reserved	Integer	4	H+12
6	Zupt flag - A zero velocity update was performed during the last update (0 = False; 1 = True)	Boolean	2	H+16
7	Wheel status (see page 54)	Ulong	4	H+18
8	Status of the heading update during the last INS filter update (see page 54)	Enum	4	H+22
9	32-bit CRC - *ASCII, binary, and short binary only*	Hex	4	H+26
10	[CR][LF] - *ASCII only*	-	-	-

Wheel Status Field

The table below lists the indications for “Wheel Status.”

Figure 45: Wheel Status Indications

Binary	ASCII
0	INACTIVE
1	ACTIVE
2	USED
3	UNSYNCED
4	BAD_MISC
5	HIGH_ROTATION

Heading Update Field

The table below lists the indications for “Heading Update.”

Figure 46: Heading Update Indications

Binary	ASCII	Description
0	INACTIVE	Heading update was not available.
1	ACTIVE	Heading updates are running, but the epoch is not used as an update. When all other rejection criteria pass, a heading update will still only be applied once every 5 seconds (20 seconds if stationary).
2	USED	The update for that epoch was taken.
3	HIGH_STD_DEV	The standard deviation of the update failed a 3 sigma check against the inertial standard deviation (azimuth checked only).
4	HIGH_ROTATION	The last 1 second recorded a turn of over 5 degrees/second.
5	BAD_MISC	The difference between the ALIGN heading and INS heading failed a 3 sigma check with the inertial standard deviation.

RAWIMUS - Raw IMU Data

This log reports the status of the IMU and records the measurements from the accelerometers and gyros with respect to the CNS-5000 enclosure frame, regardless of its mounting orientation.

NOTE: *The "S" in the RAWIMUS log title indicates a short header, which minimizes its data storage and baud rate requirements.*

Message ID: 325
Log Type: Asynchronous
Recommended Command: LOG RAWIMUSA ONNEW
ASCII Example:

```
%RAWIMUSA,1105,425384.180;
1105,425384.156166800,00000077,43088060,430312,-3033352,
-132863,186983,823*5aa97065
```

NOTE: *The RAWIMUS log is only available with the ONNEW or ONCHANGED trigger.*

Figure 47: Structure of RAWIMUS Log

Field #	Description	Type	Binary Bytes	Binary Offset
1	Header	-	H	0
2	GNSS week	ULong	4	H
3	Seconds from week start	Double	8	H+4
4	IMU status (see page 56)	Long	4	H+12
5	Change in accel. velocity count along the Z-axis [a]	Long	4	H+16
6	- (Change in accel. velocity count along the Y-axis) [a,b]	Long	4	H+20
7	Change in accel. velocity count along the X-axis [a]	Long	4	H+24
8	Change in gyro angle count around the Z-axis, right-handed [c]	Long	4	H+28
9	- (Change in gyro angle count around the Y-axis), right-handed [b,c]	Long	4	H+32

Field #	Description	Type	Binary Bytes	Binary Offset
10	Change in gyro angle count around the X-axis, right-handed [c]	Long	4	H+36
11	32-bit CRC- *ASCII, binary, and short binary only*	Hex	4	H+40
12	[CR][LF] - *ASCII only*	-	-	-

a Change in velocity (acceleration) scale factor = $0.05/2^{15}$ m/s/LSB. Multiply this scale factor by the value in this field to calculate the velocity increments in m/s.
b A negative value indicates the output is along the positive Y-axis marked on the CNS-5000. A positive value indicates the change is in the opposite direction to the Y-axis direction marked on the CNS-5000.
c Change in angle (gyro) scale factor = 0.1 rad/LSB. Multiply this scale factor by the value in this field to calculate the angle increments in radians.

IMU Status

The table below defines the indications for "IMU Status." An ASCII value of "00000077" is normal.

Figure 48: IMU Status Indications

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N0	0	0x00000001	Gyro X status	Invalid	Valid
	1	0x00000002	Gyro Y status	Invalid	Valid
	2	0x00000004	Gyro Z status	Invalid	Valid
	3	Unused - Set to zero			
N1	4	0x00000010	Accelerometer X status	Invalid	Valid
	5	0x00000020	Accelerometer Y status	Invalid	Valid
	6	0x00000040	Accelerometer Z status	Invalid	Valid
	7	Unused - Set to zero			
N2-N7	8-31	Unused			

RXSTATUS - GNSS Receiver Status

This log reports various status parameters for the internal GNSS receiver.

Message ID: 93
Log Type: Asynchronous
Recommended Command: LOG RXSTATUSA ONCHANGED
ASCII Example:

```
#RXSTATUSA,COM1,0,43.5,FINESTEERING,1337,407250.846,00000000
,643c,1984;
00000000,4,00000000,00000000,00000000,00000000,00000083,
00000008,00000000,00000000,00000000,00000000,00000000,
00000000,00000000,00000000,00000000,00000000*ba27dfae
```

Figure 49: Structure of RXSTATUS Log

Field #	Description	Type	Binary Bytes	Binary Offset
1	Header	-	H	0
2	Receiver error (see page 59); A value of zero = no errors	ULong	4	H
3	Number of status codes, including receiver status	ULong	4	H+4
4	Receiver status (see page 61)	ULong	4	H+8
5	Receiver status priority mask [a]	ULong	4	H+12
6	Receiver status event set mask [a]	ULong	4	H+16
7	Receiver status event clear mask [a]	Ulong	4	H+20
8	Auxiliary 1 status (see page 63)	Ulong	4	H+24
9	Auxiliary 1 status priority mask [a]	ULong	4	H+28
10	Auxiliary 1 status event set mask [a]	ULong	4	H+32

Field #	Description	Type	Binary Bytes	Binary Offset
11	Auxiliary 1 status event clear mask [a]	ULong	4	H+36
12	Auxiliary 2 status (see page 64)	ULong	4	H+40
13	Auxiliary 2 status priority mask [a]	ULong	4	H+44
14	Auxiliary 2 status event set mask [a]	ULong	4	H+48
15	Auxiliary 2 status event clear mask [a]	ULong	4	H+52
16	Auxiliary 3 status (see page 64)	ULong	4	H+56
17	Auxiliary 3 status priority mask [a]	ULong	4	H+60
18	Auxiliary 3 status event set mask [a]	ULong	4	H+64
19	Auxiliary 3 status event clear mask [a]	ULong	4	H+68
20...	Next status code offset = H + 8 + (# stats x 16)	-	-	-
varies	32-bit CRC- *ASCII and binary only*	Hex	4	H+8+ (#stats x64)
varies	[CR][LF] - *ASCII only*	-	-	-

a You can set these values using the STATUSCONFIG command. For details, refer to the NovAtel OEM6 Family Firmware Reference Manual.

Receiver Error Field

The table below defines the indications for “Receiver Error.”

Figure 50: Receiver Error Indications

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N0	0	0x00000001	Dynamic Random Access Memory (DRAM) status [a]	OK	Error
	1	0x00000002	Invalid firmware	OK	Error
	2	0x00000004	ROM status	OK	Error
	3	Reserved			
N1	4	0x00000010	Electronic Serial Number (ESN) access status	OK	Error
	5	0x00000020	Authorization code status	OK	Error
	6	0x00000040	Reserved		
	7	0x00000080	Supply voltage status	OK	Error
N2	8	0x00000100	Reserved		
	9	0x00000200	Temperature status (as compared against acceptable limits)	OK	Error
	10	0x00000400	MINOS5 status	OK	Error
	11	0x00000800	PLL RF1 hardware status - L1	OK	Error
N3	12	0x00001000	PLL RF2 hardware status - L2	OK	Error
	13	0x00002000	Reserved		
	14	0x00004000	Reserved		
	15	0x00008000	NVM status	OK	Error
N4	16	0x00010000	Software resource limit	OK	Error
	17	0x00020000	Model not valid for this receiver	OK	Error
	18	0x00040000	Reserved		
	19	0x00080000			

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N5	20	0x00100000	Remote loading has begun	No	Yes
	21	0x00200000	Export restriction	OK	Error
	22	0x00400000	Safe Mode	OK	Error
	23	0x00800000	Reserved		
N6	24	0x01000000			
	25	0x02000000			
	26	0x04000000			
	27	0x08000000			
N7	28	0x10000000			
	29	0x20000000			
	30	0x40000000			
	31	0x80000000	Component hardware failure	OK	Error

a RAM failure on an OEM6 card may also be indicated by a flashing red LED.

Receiver Status Field

The table below defines the indications for “Receiver Status.”

Figure 51: Receiver Status Indications

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N0	0	0x00000001	Error flag (see page 59)	No error	Error
	1	0x00000002	Temperature status	OK	Warning
	2	0x00000004	Voltage supply status	OK	Warning
	3	0x00000008	Antenna power status	Powered	Not powered
N1	4	0x00000010	LNA failure	OK	Failure
	5	0x00000020	Antenna open [a]	OK	Open
	6	0x00000040	Antenna shorted [a]	OK	Shorted
	7	0x00000080	CPU overload [a]	OK	Overload
N2	8	0x00000100	COM1 buffer overrun	OK	Overrun
	9	0x00000200	COM2 buffer overrun	OK	Overrun
	10	0x00000400	COM3 buffer overrun	OK	Overrun
	11	0x00000800	Link overrun [b]	OK	Overrun
N3	12	0x00001000	Reserved		
	13	0x00002000	Aux transmit overrun	OK	Overrun
	14	0x00004000	AGC out of range [c]	OK	Out of range
	15	0x00008000	Reserved		
N4	16	0x00010000	Reserved		
	17	0x00020000			
	18	0x00040000	Almanac/UTC known	Valid	Invalid
	19	0x00080000	Position solution	Valid	Invalid

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N5	20	0x00100000	Position fixed	Not fixed	Fixed
	21	0x00200000	Clock steering status	Enabled	Disabled
	22	0x00400000	Clock model	Valid	Invalid
	23	0x00800000	External oscillator lock	Unlocked	Locked
N6	24	0x01000000	Software resource	OK	Warning
	25	0x02000000	Reserved		
	26	0x04000000			
	27	0x08000000			
N7	28	0x10000000	Reserved		
	29	0x20000000	Auxiliary 3 status event	No event	Event
	30	0x40000000	Auxiliary 2 status event	No event	Event
	31	0x80000000	Auxiliary 1 status event	No event	Event

a This flag is only available on certain products.

b This flag indicates whether any of the USB, ICOM, NCOM, or XCOM ports are overrun. See the auxiliary status field for the specific port for which the buffer is overrun.

c This flag indicates if any of the RF AGCs are out of the range as indicated in Figure 52 on page 63.

Auxiliary 1 Status Field

The table below defines the indications for “Auxiliary 1 Status.”

Figure 52: Auxiliary 1 Status Indications

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N0	0	0x00000001	Reserved		
	1	0x00000002			
	2	0x00000004			
	3	0x00000008	Position averaging	Off	On
N1	4	0x00000010	Reserved		
	5	0x00000020			
	6	0x00000040			
	7	0x00000080	USB connection status	Connected	Not connected
N2	8	0x00000100	USB1 buffer overrun	OK	Overrun
	9	0x00000200	USB2 buffer overrun	OK	Overrun
	10	0x00000400	USB3 buffer overrun	OK	Overrun
	11	0x00000800	Reserved		
N3	12	0x00001000	Profile activation bit	OK	Error
	13	0x00002000	Reserved		
	14	0x00004000	RF1 AGC out of range	OK	Out of range
	15	0x00008000	RF2 AGC out of range	OK	Out of range
N4	16	0x00010000	RF3 AGC out of range	OK	Out of range
	17	0x00020000	Reserved		
	18	0x00040000	Ethernet connection	OK	Not connected
	19	0x00080000	ICOM1 buffer overrun	OK	Overrun

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N5	20	0x00100000	ICOM2 buffer overrun	OK	Overrun
	21	0x00200000	ICOM3 buffer overrun	OK	Overrun
	22	0x00400000	NCOM1 buffer overrun	OK	Overrun
	23	0x00800000	NCOM2 buffer overrun	OK	Overrun
N6	24	0x01000000	NCOM3 buffer overrun	OK	Overrun
	25	0x02000000	XCOM1 buffer overrun	OK	Overrun
	26	0x04000000	XCOM2 buffer overrun	OK	Overrun
	27	0x08000000	XCOM3 buffer overrun	OK	Overrun
N7	28	0x10000000	Reserved		
	29	0x20000000			
	30	0x40000000			
	31	0x80000000			

Auxiliary 2 or 3 Status Fields

The table below defines the indications for “Auxiliary 2 Status” or “Auxiliary 3 Status.”

Figure 53: Auxiliary 2 or 3 Status Indications

Nibble #	Bit #	Mask	Description	Bit=0	Bit=1
N0	0	0x00000001	Reserved		

Appendix B - Installation Offsets

If the CNS-5000 is not installed exactly as recommended in "Mounting the CNS-5000" on page 9, with the Z-axis pointing up and the Y-axis pointing forward along the direction of travel, follow the steps in this section to enter the appropriate offset commands into the system.

NOTE: *You can enter these offsets easily using NovAtel Connect's SPAN Alignment Wizard (select it from the Wizards menu). The wizard includes a graphical aid to help you visualize the angular rotations.*

Setting the IMU Orientation

By default, the CNS-5000 is configured for the following orientation:

- Z-axis pointing up
- Y-axis pointing forward
- X-axis pointing to the right side

Axes are marked on the outside of the enclosure. If the CNS-5000 is not mounted in this manner, you will need to enter the command below to specify which axis is aligned with gravity.

SETIMUORIENTATION switch

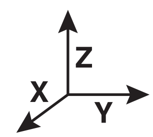
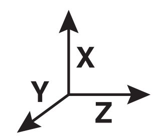
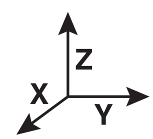
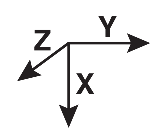
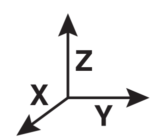
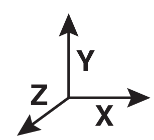
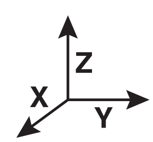
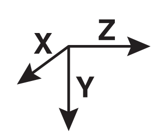
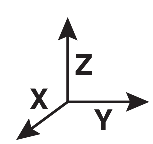
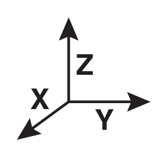
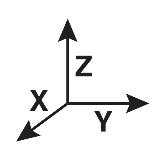
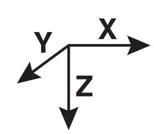
Switch	Description
1	X-axis pointing UP
2	X-axis pointing DOWN
3	Y-axis pointing UP
4	Y-axis pointing DOWN
5	Z-axis pointing UP *(default)*
6	Z-axis pointing DOWN

Example:
SETIMUORIENTATION 1
In this example, the CNS-5000's X-axis is pointing up.

Once you have entered this command, be sure to save the configuration. Ensure all NovAtel Connect windows, other than the Console, are closed. Then enter the SAVECONFIG command.

In accordance with the selected SETIMUORIENTATION switch, the CNS-5000 will map frame axes to the following axes marked on the outside of the CNS-5000 enclosure:

Figure 54: SETIMUORIENTATION Axes Mapping

Switch Map	CNS-5000 Frame Axes	CNS-5000 Frame	Physically Marked Axes	CNS-5000 Enclosure Frame
1	X		Y	
	Y		Z	
	Z		X	
2	X		Z	
	Y		Y	
	Z		-X	
3	X		Z	
	Y		X	
	Z		Y	
4	X		X	
	Y		Z	
	Z		-Y	
5 *(default)*	X		X	
	Y		Y	
	Z		Z	
6	X		Y	
	Y		X	
	Z		-Z	

NOTE: *The data in the RAWIMUS log is never mapped. The axes in the RAWIMUS log always refer to the axes marked on the outside of the physical enclosure.*

Setting the Angular Offsets Between the Vehicle and the CNS-5000

If the CNS-5000 if not precisely aligned with the orientation of the vehicle (within ±10°), you need to set the approximate offset angles between the vehicle (direction of travel) and the CNS-5000 (direction the unit is pointing) to ensure a good kinematic alignment. Enter the VEHICLEBODYROTATION command below. Enter all values in degrees.

VEHICLEBODYROTATION X Y Z

In addition, if you want the output attitude of the CNS-5000 (such as that reported in the INSPVA log) to match the vehicle's attitude, you then need to enter the APPLYVEHICLEBODYROTATION command below to apply the angular offsets to the output attitude data.

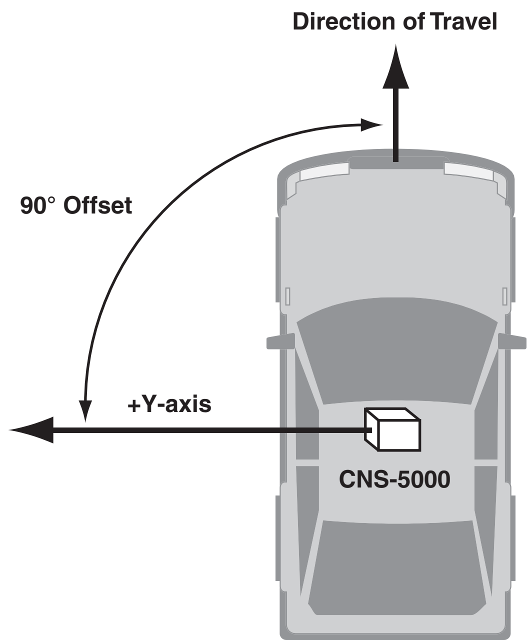
APPLYVEHICLEBODYROTATION ENABLE

NOTE: *Even if the CNS-5000 is aligned within ±10° to the vehicle's orientation, you may wish to enter the precise offsets using these commands. The more accurate the offsets, the more closely the output attitude will match the vehicle's.*

Refer to the example on the following page.

Example:
VEHICLEBODYROTATION 0 0 90
APPLYVEHICLEBODYROTATION ENABLE
In this example, the Y-axis of the CNS-5000 is pointing 90° to the left of the vehicle's direction of travel. The angle is positive because the rotation is about the vehicle's Z-axis and follows the right-hand rule for sign correction.

Figure 55: Example of Offset Between the Vehicle and the CNS-5000



This command is most often used for installations in which the unit's cable connectors need to face a direction other than the rear of the vehicle. In the example, the cables would connect to the right (passenger) side of the unit.

NOTE: *If you are unable to determine the offset angles yourself, you can perform an RVB calibration instead to allow the system to calculate the offsets automatically (RTK GNSS required). For details, refer to the NovAtel SPAN on OEM6 Firmware Reference Manual.*

Appendix C - Patents

One or more of the following U.S. patents protect the technology in KVH fiber optic gyros*:

KVH Patent Numbers	
5,444,534	6,441,779
5,481,358	6,466,596
5,512,904	6,542,651
5,552,887	6,594,020
5,739,944	6,718,097
5,768,462	6,763,153
6,041,149	6,836,334
6,134,356	6,856,300
6,351,310 B1	6,864,347
6,370,289 B1	6,891,622
6,429,939	7,120,323

One or more of the following U.S. patents protect the technology in NovAtel products*:

NovAtel Patent Numbers	
5,101,416	6,243,409 B1
5,390,207	6,664,923 B1
5,414,729	6,721,657 B2
5,495,499	6,750,816 B1
5,736,961	7,193,559 B2
5,809,064	7,738,536 B2
6,184,822 B1	7,738,606 B2
6,608,998 B1	7,346,452
6,728,637 B2	7,885,317 B2
6,922,167 B2	

**Additional patents pending*

KVH Industries Limited Warranty
CNS-5000

LIMITED WARRANTY ON HARDWARE

KVH Industries, Inc. warrants the Continuous Navigation System purchased against defects in materials and workmanship for a period of ONE (1) year from the date of original retail purchase by the original purchaser. If you discover a defect, KVH will, at its option, repair, replace or refund the purchase price of the product at no charge to you, provided you return it during the warranty period, transportation charges prepaid, to the factory direct.

Please attach your name, address, telephone number, a description of the problem and a copy of the bill of sale or sales receipt as proof of date of original retail purchase, to each product returned to warranty service.

This Limited Warranty does not apply if the product has been damaged by accident, abuse, misuse, or misapplication or has been modified without the written permission of KVH; if any KVH serial number has been removed or defaced; or if any factory-sealed part of the system has been opened without authorization.

THE EXPRESS WARRANTIES SET FORTH ABOVE ARE THE ONLY WARRANTIES GIVEN BY KVH WITH RESPECT TO ANY PRODUCT FURNISHED HEREUNDER; KVH MAKES NO OTHER WARRANTIES, EXPRESS, IMPLIED OR ARISING BY CUSTOM OR TRADE USAGE, AND SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. SAID EXPRESS WARRANTIES SHALL NOT BE ENLARGED OR OTHERWISE AFFECTED BY TECHNICAL OR OTHER ADVICE OR SERVICE PROVIDED BY KVH IN CONNECTION WITH ANY PRODUCT.

KVH's liability in contract, tort or otherwise arising out of or in connection with any product shall not exceed the price paid for the product. **IN NO EVENT SHALL KVH BE LIABLE FOR SPECIAL, PUNITIVE, INCIDENTAL, TORT OR CONSEQUENTIAL DAMAGES OR LOST PROFITS OR GOODWILL (INCLUDING ANY DAMAGES RESULTING FROM LOSS OF USE, DELAY IN DELIVERY OR OTHERWISE) ARISING OUT OF OR IN CONNECTION WITH THE PERFORMANCE OR USE OR POSSESSION OF ANY PRODUCT, OR ANY OTHER OBLIGATIONS RELATING TO THE PRODUCT, EVEN IF KVH HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.**

If any implied warranty, including implied warranties of merchantability and fitness for a particular purpose, cannot be excluded under applicable law, then such implied warranty shall be limited in duration to ONE (1) YEAR from the date of the original retail purchase of this product by the original purchaser.

Some states do not allow the exclusion or limitation of implied warranties or liability for incidental or consequential damages, so the above limitations may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

CNS5000_cover

KVH Industries, Inc.
50 Enterprise Center • Middletown, RI 02842-5279 • U.S.A.
Phone: +1 401 847-3327 • Fax: +1 401 849-0045 • E-mail: info@kvh.com • Internet: www.kvh.com