Hemisphere

875-0375-0

Vector VR500 Smart Antenna

User Guide
Revision: A4
January 4, 2019

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Device Compliance, License and Patents

Device Compliance

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.

This product complies with the essential requirements and other relevant provisions of Directive 2014/53/EU. The declaration of conformity may be consulted at HTTPS://HEMISPHEREGNSS.COM/ABOUT-US/QUALITY-COMMITMENT.

E-Mark Statement: This product is not to be used for driverless/autonomous driving.

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Hemisphere GNSS products may be covered by one or more of the following patents:

Patents			
6111549	6876920	7400956	8000381
6397147	7142956	7429952	8018376
6469663	7162348	7437230	8085196
6501346	7277792	7460942	8102325
6539303	7292185	7689354	8138970
6549091	7292186	7808428	8140223
6711501	7373231	7835832	8174437
6744404	7388539	7885745	8184050
6865465	7400294	7948769	8190337
8214111	8217833	8265826	8271194
8307535	8311696	8334804	RE41358

Australia Patents	
2002244539	2002325645
2004320401	

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Device Compliance, License and Patents, Continued

Notice to Customers	Contact your local dealer for technical assistance. To find the authorized dealer near you: Hemisphere GNSS, Inc 8515 East Anderson Drive Scottsdale, AZ 85255 USA Phone: (480) 348-6380 Fax: (480) 270-5070 PRECISION@HGNSS.COM WWW.HGNSS.COM
Technical Support	If you need to contact Hemisphere GNSS Technical Support: Hemisphere GNSS, Inc. 8515 East Anderson Drive Scottsdale, AZ 85255 USA Phone: (480) 348-6380 Fax: (480) 270-5070 Technical Support
Documentation Feedback	Hemisphere GNSS is committed to the quality and continuous improvement of our products and services. We urge you to provide Hemisphere GNSS with any feedback regarding this guide by opening a support case at the following website: SUPPORT.HGNSS.COM

VR500 Terms & Definitions

Introduction

The following table lists the terms and definitions used in this document.

VR500 Terms & definitions

Term	Definition
1PPS	1 pulse-per-second is a pulse output by the receiver precisely once per second and is used for hardware synchronization.
Activation	Activation refers to a feature added through a one-time purchase. For features that require recurring fees, see Subscription.
Atlas	Atlas is a subscription-based service provided by Hemisphere that enables the VR500 to achieve sub-decimeter accuracy without a base station or datalink.
Base Station	The Base Station is a receiver placed over a familiar point, provides real-time observations, and sends those observations to nearby RTK rovers via UHF radio or the internet.
BeiDou	BeiDou is a Chinese satellite-based navigation system.
DGPS/DGNSS	Differential GPS/GNSS refers to a receiver using Differential Corrections.
Differential Corrections	A method of improving precision of a GNSS rover. Two GNSS receivers placed in a nearby area will have similar error. A base station is placed over a known point. Since the actual position of the base station is known, error can be calculated, and corrections can then be applied to nearby rovers. This differs from RTK.

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VR500 Terms & Definitions, Continued

VR500 Terms & definitions, continued

Term	Definition
Elevation Mask	Elevation Mask is the minimum angle between a satellite and the horizon for the receiver to use that satellite in the solution.
Firmware	Firmware is the software loaded into the receiver that controls the functionality of the receiver and runs the GNSS engine.
GALILEO	Galileo is a global navigation satellite system implemented by the European Union and European Space Agency.
GLONASS	Global Orbiting Navigation Satellite System (GLONASS) is a Global Navigation Satellite System deployed and maintained by Russia.
GNSS	Global Navigation Satellite System (GNSS) is a system that provides autonomous 3D position (latitude, longitude, and altitude) and accurate timing globally by using satellites. Current GNSS providers are: GPS, GLONASS and Galileo.
GPS	Global Positioning System (GPS) is a global navigation satellite system implemented by the United States.
Heading	Heading is the angle between true north and the vector calculated from the primary to secondary antenna.
Heading Bias	Heading Bias is an offset applied to the heading value calculated by the receiver.
Multipath	Multipath occurs when the GNSS signal reaches the antenna by two or more paths. This causes incorrect pseudo-range measurements and leads to less precise GNSS solutions.
NMEA	National Marine Electronics Association (NMEA) is a marine electronics organization that sets standards for communication between marine electronics.

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VR500 Terms & Definitions, Continued

VR500 Terms & definitions, continued

Term	Definition
ROX	ROX is a Hemisphere GNSS propriety RTK message format that can be used as an alternative to RTCM3 when both the base and rover are Hemisphere branded.
RTCM	Radio Technical Commission for Maritime Services (RTCM) is a standard used to define RTK message formats so that receivers from any manufacturer can be used together.
RTK	Real-Time-Kinematic (RTK) is a real-time differential GPS method that provides better accuracy than differential corrections.
SBAS	Satellite Based Augmentation System (SBAS) is a system that provides differential corrections over satellite throughout a wide area or region.
Subscription	A subscription is a feature that is enabled for a limited time. Once the end-date of the subscription has been reached, the feature will turn off until the subscription is renewed.
WAAS	Wide Area Augmentation System (WAAS) is a satellite-based augmentation system (SBAS) that provides free differential corrections over satellite in parts of North America.

Chapter 1: Introduction

Overview

Introduction

This User Guide provides information to help you quickly set up your Vector VR500 GNSS Smart Antenna™. You can download this manual from the Hemisphere GNSS website at WWW.HGNSS.COM.

Contents

Product Overview

Product overview

Based on Eclipse Vector™ GNSS technology, the VR500 (Figure 1-1) is designed for machine control applications that require precise heading and RTK position performance from the Vector VR500 GNSS Smart Antenna.

Featuring an all-in-one Hemisphere GNSS Eclipse Vector-based receiver and two integrally separated antennas, with a baseline of 50.0 cm. The VR500 achieves heading accuracy of up to 0.27º RMS (depending on environmental conditions) and offers robust positioning performance.

Figure 1-1 VR500 Smart Antenna

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The VR500 provides accurate and reliable heading and position information at high update rates by using a high performance GNSS receiver and two antennas for GNSS signal processing.

One antenna is designated as the primary GNSS antenna, and the other antenna is the secondary GNSS antenna. Positions computed by the VR500 are referenced to the phase center of the primary GNSS antenna. Heading data references the Vector formed from the primary GNSS antenna phase center to the secondary GNSS antenna phase center.

The standard model VR500 tracks GPS, GLONASS, Galileo, and BeiDou satellites and Athena RTK.

The VR500 can be upgraded via activations or subscriptions to support Atlas L-band.

Athena RTK

Athena RTK (Real Time Kinematic) technology is available on Eclipse-based GNSS receivers. This is Hemisphere's most advanced RTK processing software and is standard on the VR500.

Athena RTK has the following benefits:

- **Improved Initialization time -** Performing initializations in less than 15 seconds at better than 99.9% of the time
- **Robustness in difficult operating environments -** Extremely high productivity under the most aggressive of geographic and landscape-oriented environments
- **Performance on long baselines -** Industry-leading position stability for long baseline applications

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Product Overview, Continued

Atlas L-band

Atlas L-band is Hemisphere's industry leading correction service, which can be added to the VR500 as a subscription. Atlas L-band has the following benefits:

- **Positioning accuracy -** Competitive positioning accuracies down to 4 cm RMS in certain applications
- **Positioning sustainability -** Cutting edge position quality maintenance in the absence of correction signals, using Hemisphere's patented technology
- **Scalable service levels -** Capable of providing virtually any accuracy, precision and repeatability level in the 4 cm to 50 cm range
- **Convergence time -** Industry-leading convergence times of 10-40 minutes

For more information

For more information about Athena RTK, see:
HTTP://HEMISPHEREGNSS.COM/TECHNOLOGY

For more information about Atlas L-band, see:
HTTP://HEMISPHEREGNSS.COM/ATLAS

Key Features

VR500 key features

Key features of the VR500 include:

- Easy to use all-in-one robust GNSS smart antenna
- High-precision positioning in Athena RTK, Atlas L-band, and SBAS
- Athena technology for improved RTK performance, especially with GLONASS, Galileo, and BeiDou
- Atlas* L-band technology providing highly accurate corrections over the air (*Requires the purchase of a subscription)
- Heave of 30 cm RMS (DGNSS), 10 cm (RTK)
- Pitch and roll < 1° RMS

What's Included in Your Kit

VR500 kit

Table 1-1 lists the parts included with your VR500. The VR500 GNSS Smart Antenna and the power/data cable (accessory item) are the only two required components.

Note: The VR500's parts comply with IEC 60945 Section 4.4: "Exposed to the weather."

VR500 Parts list

Table 1-1 VR500 Parts list

Part No.	Description	Qty
940-3121-10	HGNSS VR500 Receiver	1
752-0028-10	VR500 Receiver	1

All the following items are available for purchase separately from your VR500 receiver:

Part No.	Description	Qty
051-0398-20	Power/data cable, 15m	1
710-0152-10	VR500 22-Pin to 18-Pin Adapter Kit	1
710-0147-10	VR500 External UHF, B/T Kit	1

Firmware Upgrades

Overview

Periodically, Hemisphere GNSS releases firmware upgrades to improve performance, fix bugs, or add new features to a product. To update the firmware on the VR500, choose from one of two options:

1. Download the latest version of Hemisphere GNSS RightArm from the following link: HTTPS://HEMISPHEREGNSS.COM/RESOURCES-SUPPORT/SOFTWARE
2. Use the internal WebUI.

RightArm Updates

Connect the VR500 to a computer over serial. Firmware can be loaded over either serial port. Set the baud rate of the serial port you are using to 19200.

Launch RightArm.

Click the **Connect** button or navigate to Receiver -> Connect.

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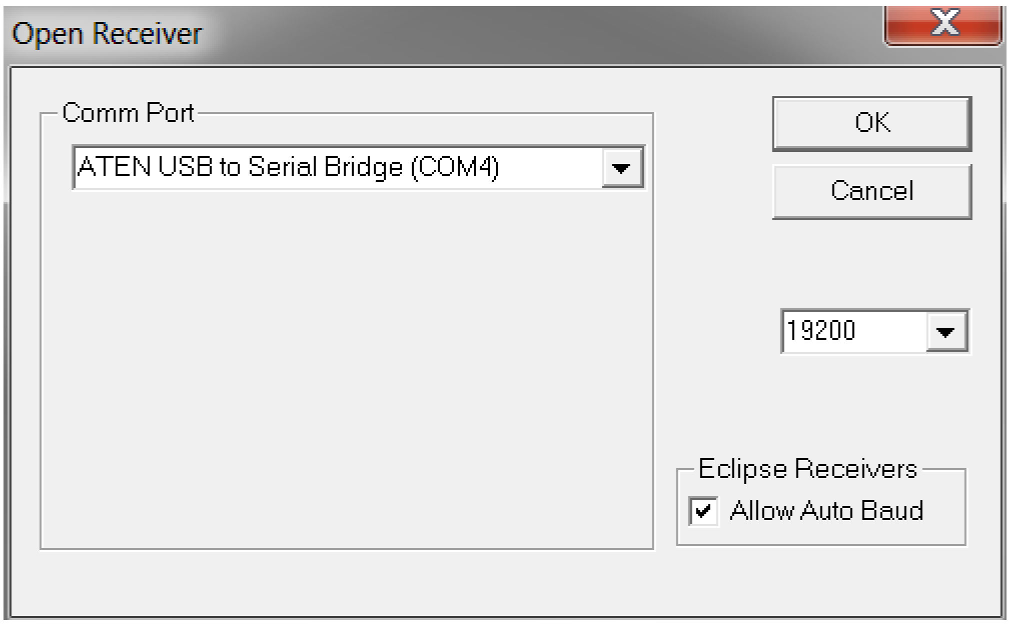
Firmware Upgrades, Continued

RightArm Updates, continued

Choose the COM port connected to the VR500 and click **OK**.



Note: The baud rate of the serial port should be set to 19200 bps. Select **Allow Auto Baud** to change the baud rate during the firmware upgrade for a faster update.

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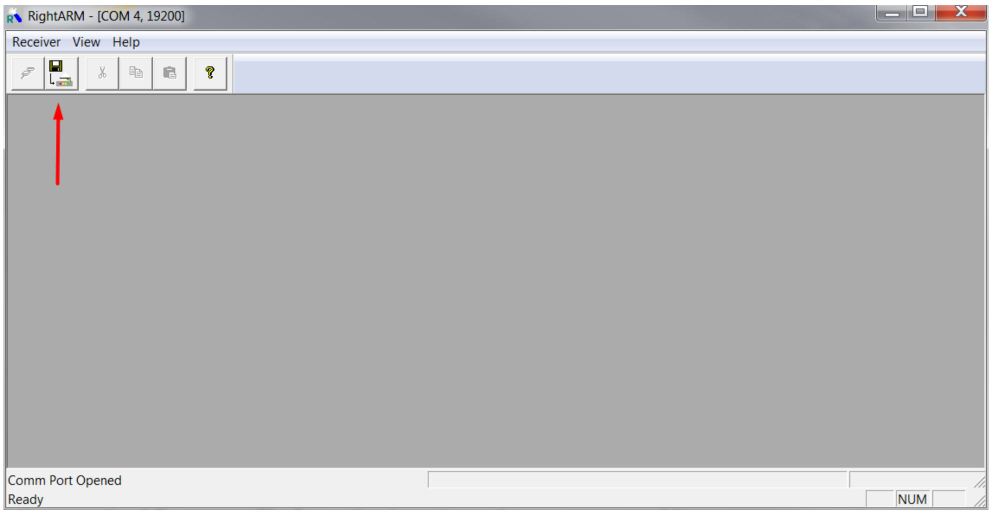
Firmware Upgrades, Continued

RightArm Updates, continued

Click the **Programming** button.



Select a **Program Type**.

The VR500 has two firmware applications, allowing two different versions of GNSS firmware. Hemisphere GNSS suggests loading the new firmware onto both applications.

After the firmware update is completed, check the current GNSS firmware.

If the current firmware is not the same as the newly loaded firmware, the VR500 could be using the other application. You can switch applications by sending the following command:

$JAPP,OTHER.

Choose the Application, and press **Select File** to select the firmware file.

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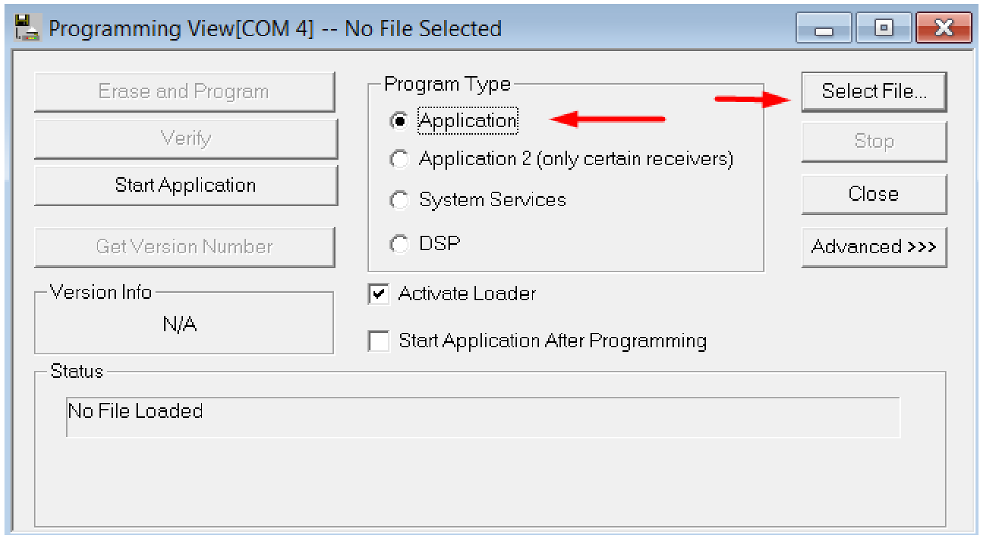
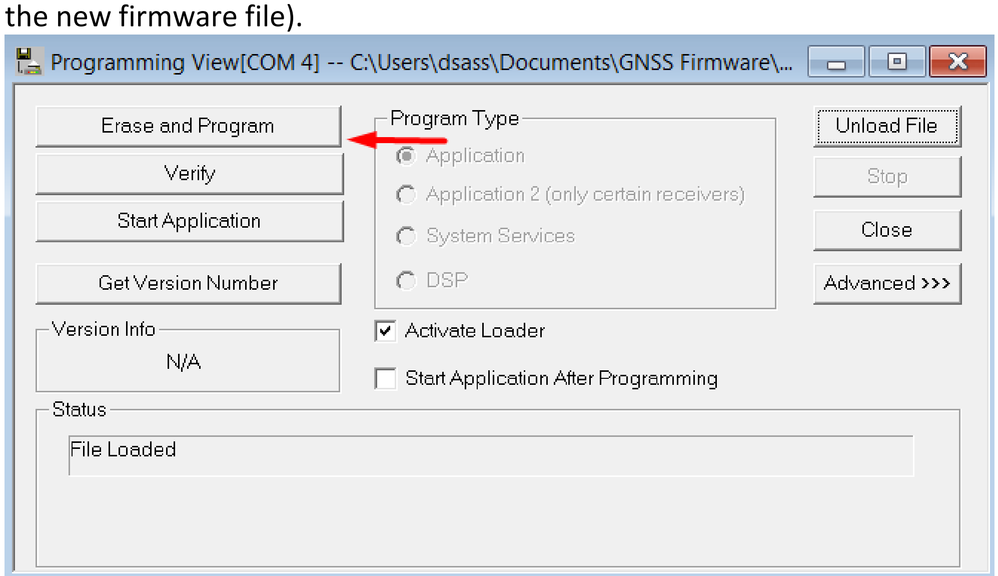
Firmware Upgrades, Continued

RightArm Updates, continued



Choose the firmware, and click **Erase and Program**.

The **Activate Loader** checkbox in the Programming View window is selected. After pressing the Erase and Program button, this checkbox will de-select, and the **Status** field indicates the receiver is in loader mode (ready to receive the new firmware file).



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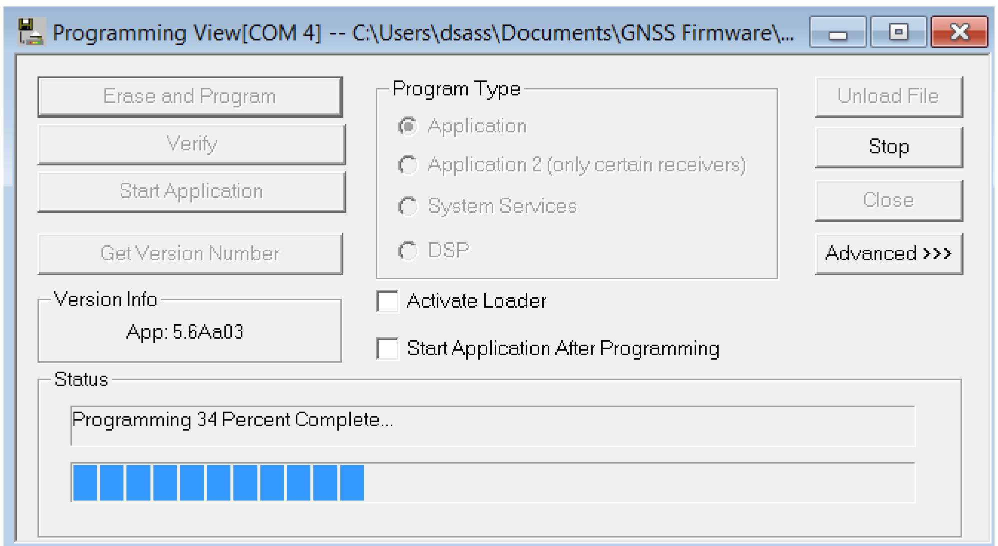
Firmware Upgrades, Continued

RightArm Updates, continued

Note: If the Activate Loader check box remains selected, power the receiver off and on. When the receiver powers back on, the Activate Loader box should be de-selected.

⚠WARNING: Do not interrupt the power supply to the receiver, and do not interrupt the communication link between the PC and the receiver until programming is complete. Failure to do so may cause the receiver to become inoperable and will require factory repair.



Note: After completing the firmware update, Hemisphere GNSS suggests repeating this process for the other application.

Chapter 2: Installing the VR500

Overview

Introduction

This chapter provides instructions on how to mount and install your VR500 receiver.

Contents

Mounting the VR500

Introduction

This section provides information on mounting the VR500 in the optimal location, orientation considerations, environmental considerations, and other mounting options.

GNSS satellite reception

When considering where to mount the VR500, consider the following satellite reception recommendations:

- Ensure there is a clear view of the sky available to the VR500 so the GNSS and L-band satellites are not masked by obstructions that may reduce system performance
- Mount the VR500 in a position in respect to the primary GNSS antenna (located on the end opposite the recessed arrow on the underside of the enclosure)
- Locate any transmitting antennas away from the VR500 by at least a few meters to ensure tracking performance is not compromised
- Ensure cable length is adequate to route into the machine to reach a breakout box or terminal strip
- Do not locate the antenna where environmental conditions exceed those specified in Appendix B, Technical Specifications of this document.

Figure 2-1: Recessed arrow

Continued on next page

Mounting the VR500, Continued

Environmental considerations	Hemisphere Vector Smart Antennas are designed to withstand harsh environmental conditions; however, adhere to the following limits when storing and using the VR500: • Operating temperature: -40°C to +70°C (-40°F to +158°F) • Storage temperature: -40°C to +85°C (-40°F to +185°F) • Humidity: IEC 16750-4:2010 Section 5.6 Humid heat, cyclic test
Mounting orientation	The VR500 outputs heading, pitch, and roll readings regardless of the orientation of the VR500. The relation of the antennas to the machine's axis determines if you need to enter a heading, pitch, or roll bias. The primary antenna is used for positioning and the primary and secondary antennas, working in conjunction, output heading, pitch, and roll values.
Parallel orientation	Installation with the arrow pointing forward orients the VR500 parallel to, and along the centerline of the axis of the machine. **This provides a true heading**. In this orientation: • If you use a gyrocompass and there is a need to align the Vector smart antenna, you can enter a heading bias in the VR500 to calibrate the physical heading to the true heading of the machine. • You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.
Perpendicular orientation	The VR500 can also be installed perpendicular to the centerline of the machine's axis. In this orientation: • Enter a heading bias of +90° if the recessed arrow underneath the receiver is pointing to the left side of the machine, and -90° if the recessed arrow is pointing to the right side of the machine. • Configure the receiver to specify the GNSS smart antenna is measuring the roll axis using the VR500 WebUI. • Enter a roll bias to properly output the pitch and roll values. • You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.

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Mounting the VR500, Continued

Mounting orientation example

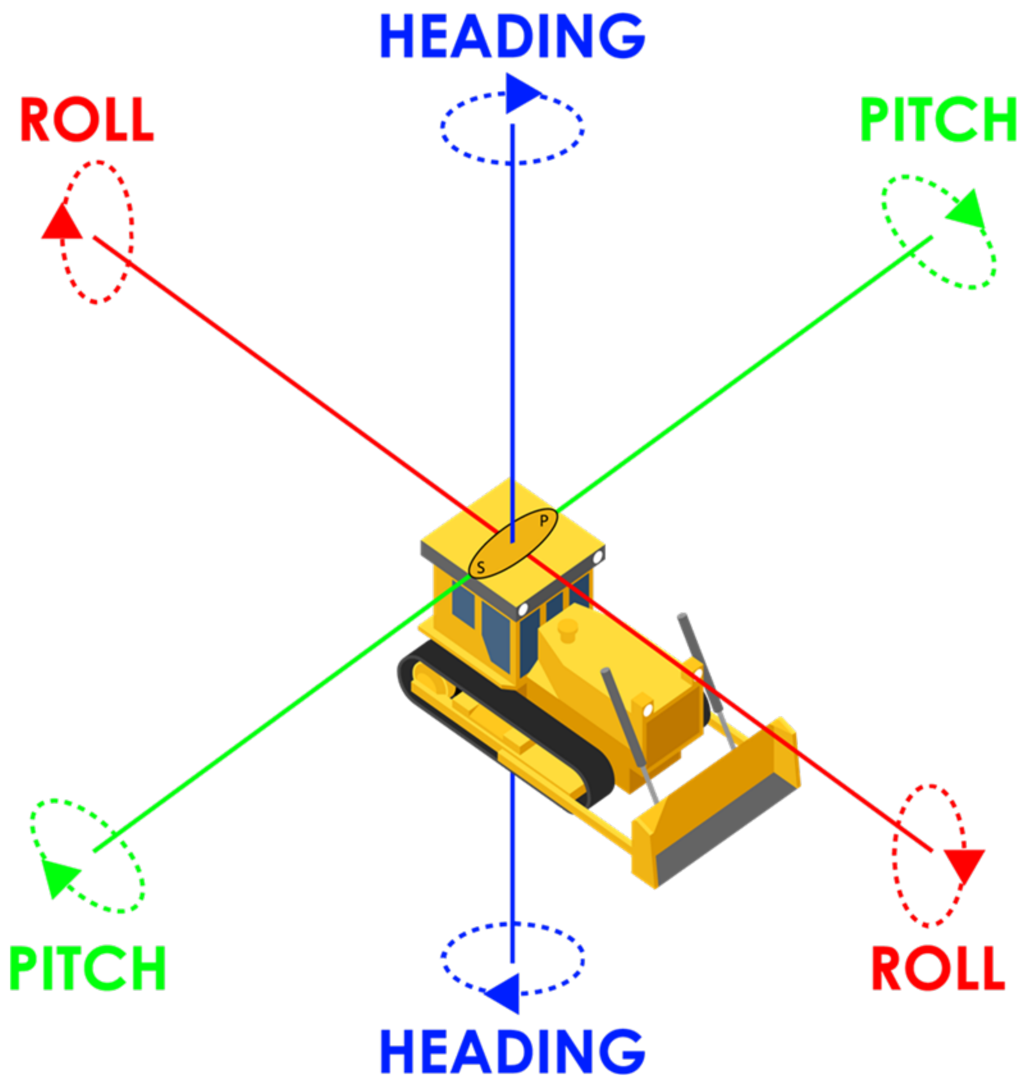

Figure 2-2: Recommended orientation and resulting signs of HPR values

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Mounting the VR500, Continued

Mounting orientation example, continued**Mounting orientation example,**

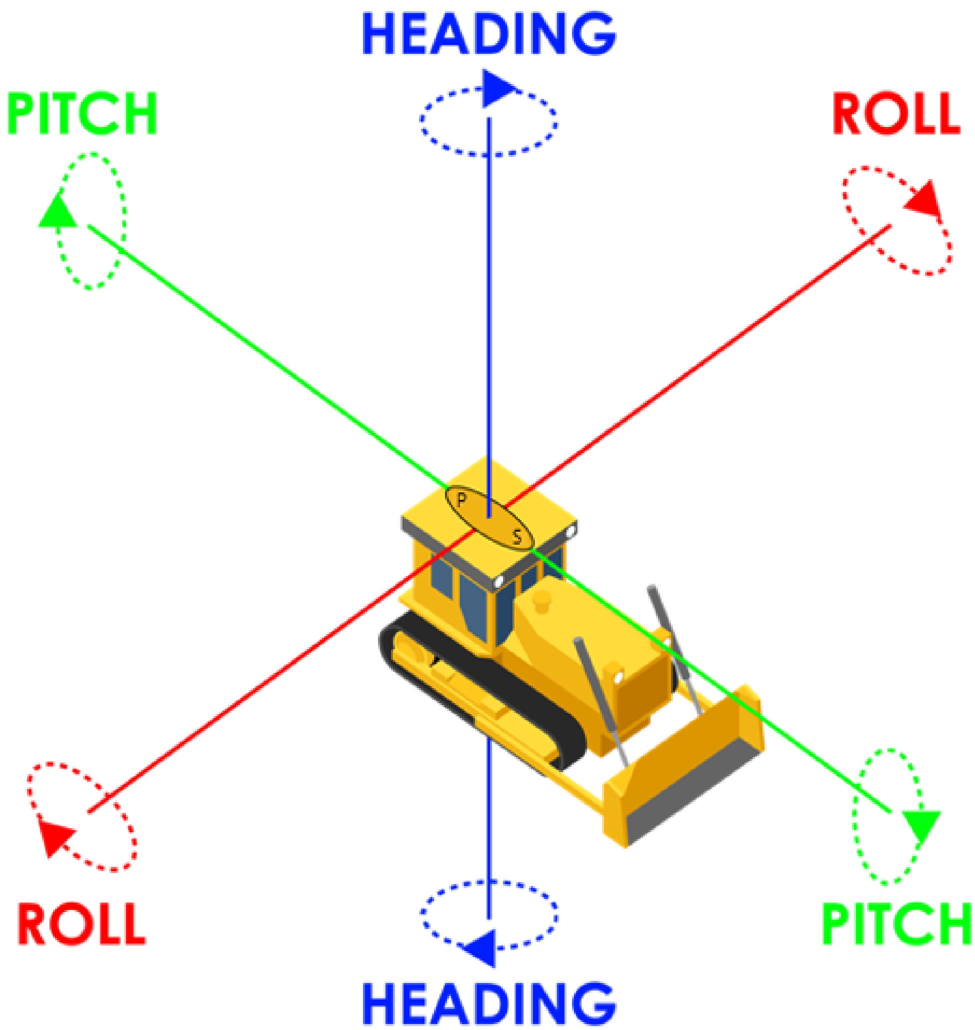

Figure 2-3: Alternate orientation and resulting signs of HPR values

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Mounting the VR500, Continued

Mounting alignment

The top of the VR500 enclosure incorporates sight design features to help you align the enclosure on your machine.

To use the sights, center the small post on the opposite side of the enclosure from you, within the channel made in the medallion located in the center of the enclosure top as shown in Figure 2-4 and Figure 2-5.

The long sight alignment accuracy (Figure 2-4) is approximately +/- 1°. Short sight alignment accuracy (Figure 2-5) is approximately +/- 2.5°.

Figure 2-4: Long sight alignment

Continued on next page

Mounting alignment, continued

Figure 2-5: Short sight alignment

Mounting options

The VR500 allows for two different mounting options: flush-mount and pole-mount.

1. **Flush-mount**-The bottom of the VR500 contains eight M8-1.25 holes for flush mounting the unit to a flat surface (see Figure 2-7). The eight holes comprise two sets of four holes. Flush mounting does not provide any additional dampening to the receiver.
2. **Pole-mount**-The VR500 can be mounted using a mounting pole.

Note: Hemisphere GNSS does not supply mounting surface hardware or a mounting pole. You must supply the appropriate mounting hardware required to complete VR500 installation.

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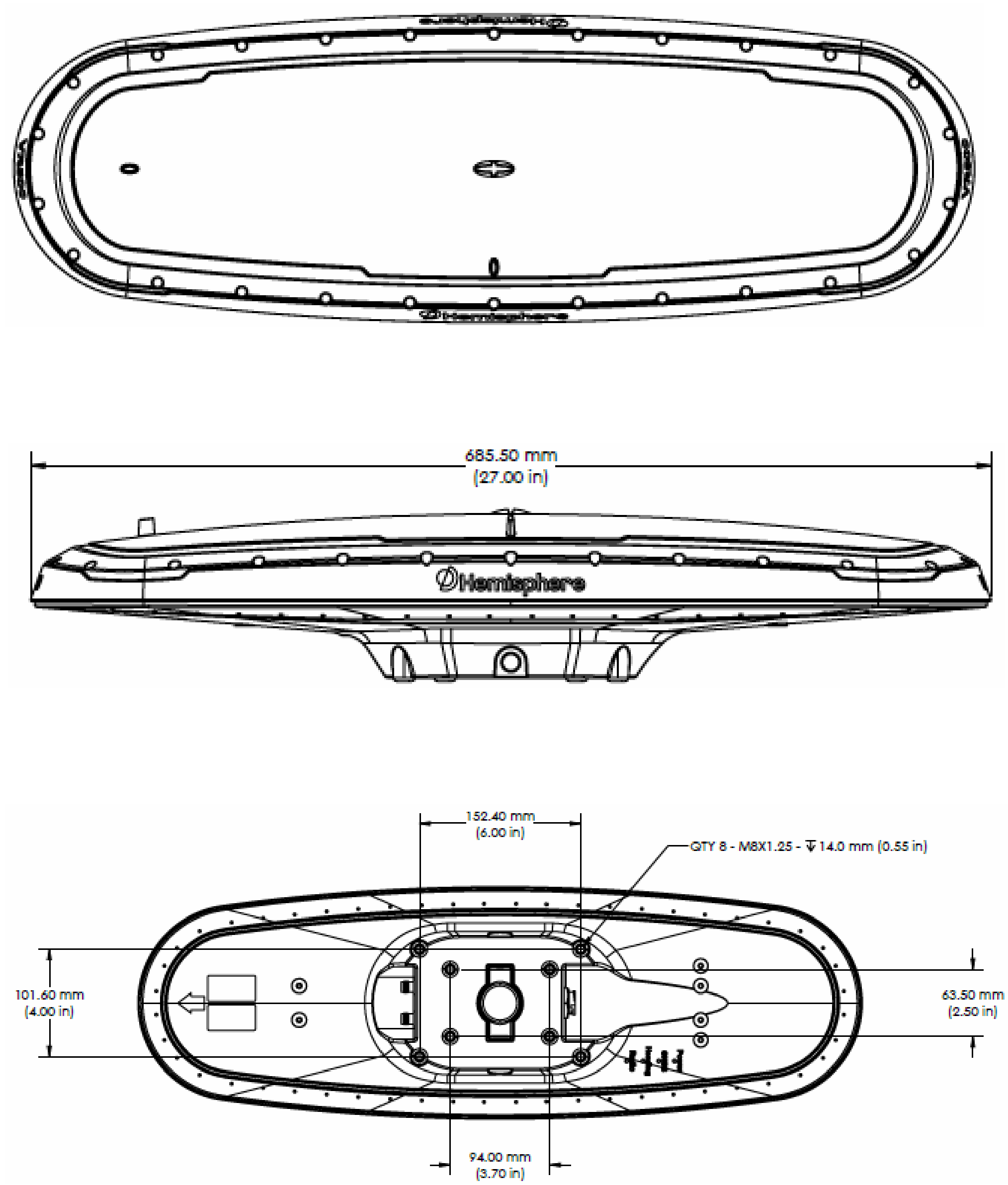
Mounting the VR500, Continued

VR500 dimensions

Figure 2-6 illustrates the physical dimensions of the VR500.



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Mounting the VR500, Continued

VR500 dimensions, continued

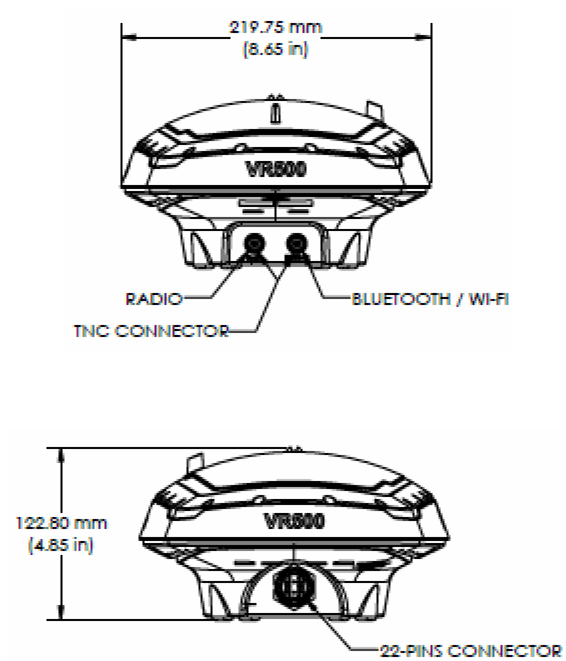

Figure 2-6: VR500 dimensions

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Mounting the VR500, Continued

Power/Data cable considerations

Before mounting the VR500, consider the following regarding power/data cable routing:

Do	Do not
Ensure cable reaches appropriate power source	Run cables in areas of excessive heat
Keep cable away from corrosive chemicals	Run cables through a door or window jams
Connect to a data storage device, computer, or other device that accepts GNSS data	Crimp or excessively bend the cable
Keep cable away from rotating machinery	Place tension on the cable
Remove unwanted slack from the cable at the VR500 end	
Secure along the cable route using plastic wrapping	

⚠WARNING: **Improperly installed cable near machinery can be dangerous.**

Connecting the Serial Power/Data cable

1. Align the cable connector key-way with the VR500 connector key.
2. Rotate the cable ring clockwise until it locks. The locking action is firm; you will feel a positive "click" when it has locked.

Continued on next page

Mounting the VR500, Continued

Flush-mounting the VR500

The bottom of the VR500 contains eight holes (two sets of four holes) for flush-mounting the unit to a flat surface (Figure 2-7).

Figure 2-7: Flush-mounting holes on bottom of VR500

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Mounting the VR500, Continued

Assembly drawing

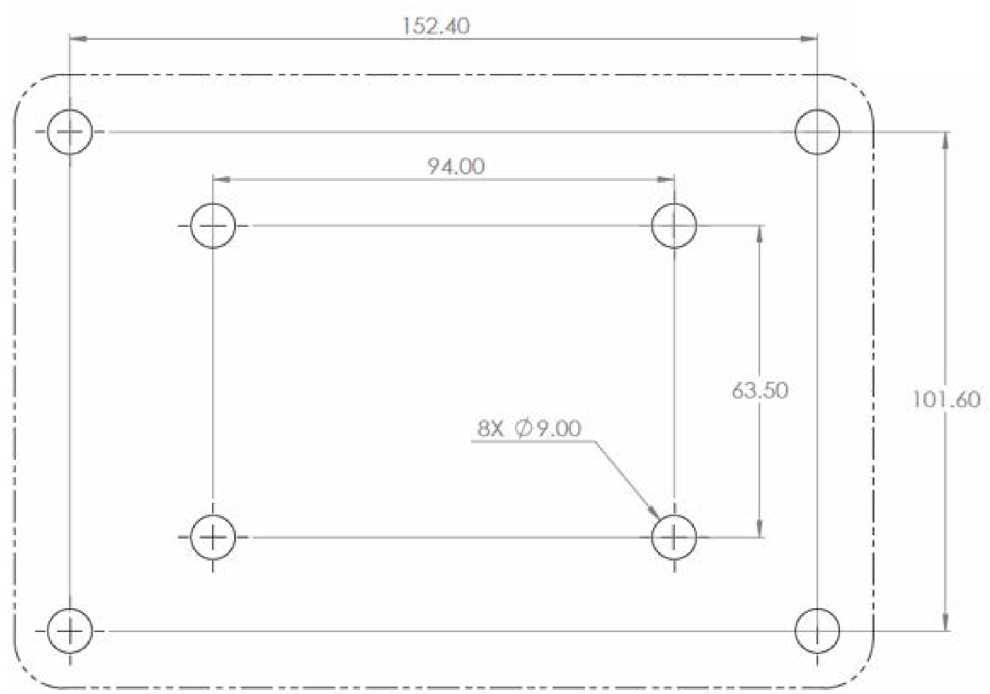
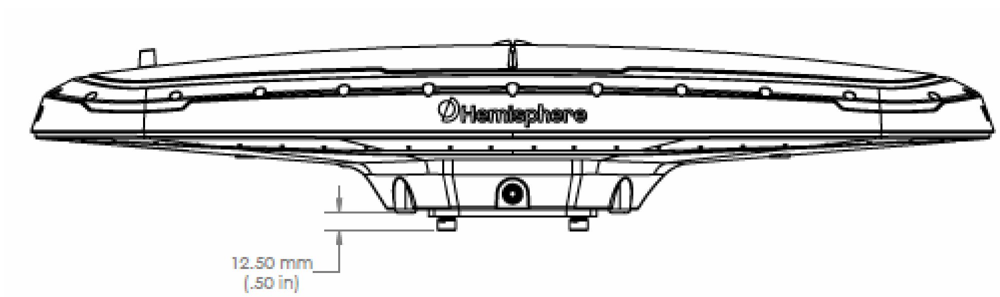


Figure 2-8: Assembly drawing

Pole-mounting the VR500



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Mounting the VR500, Continued

Pole-mounting the VR500, continued

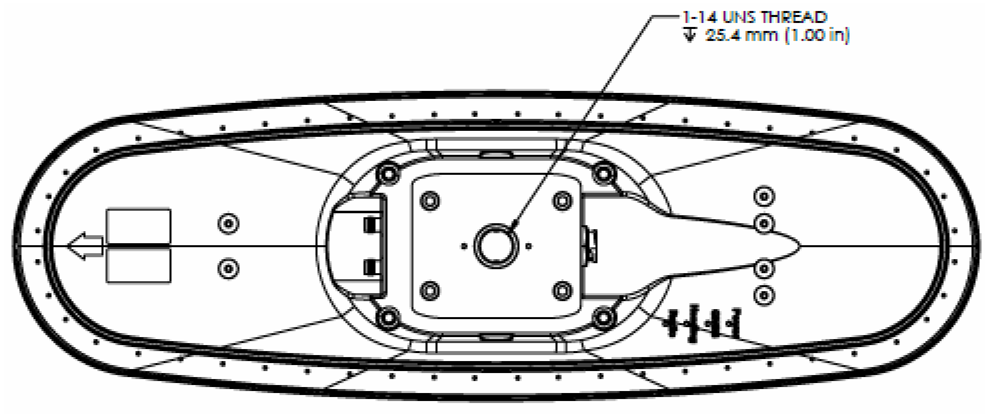


Figure 2-9: Pole-mounting specifications

UHF Radio Antenna

VR500 UHF Radio Antenna

The VR500 has an internal UHF radio for receiving RTK corrections with no need for an external radio or antenna.

If the UHF range needs to be increased, an external antenna can be installed using a TNC connector.

If an external UHF antenna is to be used, it should be mounted to the top of the machine and the coaxial cable should be run safely and securely to the VR500.

Figure 2-10: UHF antenna connections

Ports

Overview	The VR500 offers serial port, CAN, and Ethernet port functionality.
Serial ports	The VR500 has two serial ports: • Port A is full-duplex RS-232 • Port B can be either RS-232 or RS-422 You can receive external differential corrections via either Port A (full-duplex RS-232) or Port B (full-duplex RS-232 or full-duplex RS-422). You can update firmware via Port A or Port B (RS-232). **Note:** The VR500 has maximum baud rate of 115200.
Serial port configuration	You may configure Port A or Port B of the GNSS receiver to output any combination of data. Port A can have a different configuration from Port B in data message output, data rates, and the baud rate of the port, and configure the ports independently based upon your needs. **Note:** For successful communications, use the 8-N-1 protocol and set the baud rate of the VR500's serial ports to match that of the devices to which they are connected. Flow control is not supported.

Selecting Baud Rates and Message Types

Baud Rates & Message Types	When selecting your baud rate and message types, use the following formula to calculate the bits/sec for each message and sum the results to determine the baud rate for your required data throughput. Message output rate * Message length (bytes) * bits in byte = Bits/second (1 character = 1 byte, 8 bits = 1 byte, use 10 bits/byte to account for overhead). For information on message output rates refer to the Hemisphere GNSS Technical Reference Manual.

Connecting the VR500 to External Devices

Recommend-ations for connecting to other devices	When interfacing to other devices, ensure the transmit data output and the signal grounds from the VR500 is connected to the data input of the other device. The RS-422 is a balanced signal with positive and negative signals referenced to ground; ensure you maintain the correct polarity. When connecting the transmit data output positive signal to the receive line of the other device, it should be connected to the receive positive terminal. The negative transmit data signal from the VR500 is then connected to the receive data negative input of the other device. For a list of Hemisphere GNSS commands, please refer to the Hemisphere GNSS Technical Reference Manual. To configure the unit through the WebUI, please refer to Configuring the VR500 using WebUI.
Power/Data cable considerations	The VR500 uses a single 3 m , or 15m (optional) cable for power and data input/ output. The receiver end of the cable is terminated with an environmentally-sealed 22-Pin connection while the opposite end is unterminated and requires field stripping and tinning.

Continued on next page

Connecting the VR500 to External Devices, Continued

Power/Data cable considerations, continued

Depending on the application and installation needs, you may need the optional 15 m cable. However, if you require a longer cable run than 15m, you can bring the cable into a break-out box that incorporates terminal strips, within the machine.

When lengthening the cable keep the following in mind:

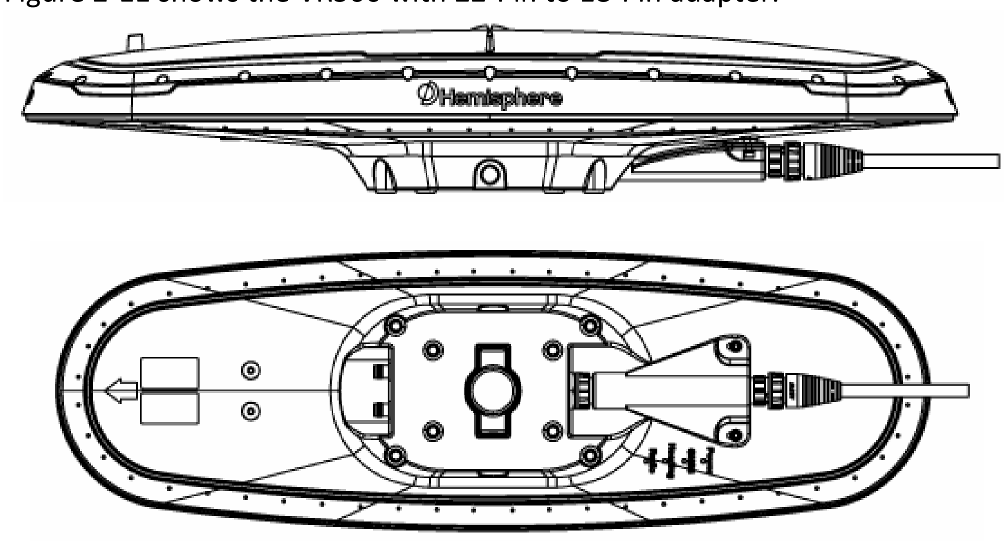
- To lengthen the serial lines inside the machine, use 20-gauge twisted pairs and minimize the additional wire length.
- When lengthening the power input leads to the VR500, ensure the additional voltage drop is small enough that your power system can continue to power the system above the minimum voltage of the system. Wire of 18-gauge or larger should also be used.
- Minimize RS-232 cable length to ensure reliable communication.

VR500 with 22-Pin to 18-Pin adapter

Use the 22-Pin to 18-Pin adapter if you want to use a V320 cable.

Note: Using the adapter will cause you to lose ethernet capability.

Figure 2-11 shows the VR500 with 22-Pin to 18-Pin adapter.



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Connecting the VR500 to External Devices, Continued

VR500 with 22-Pin to 18-Pin adapter, continued

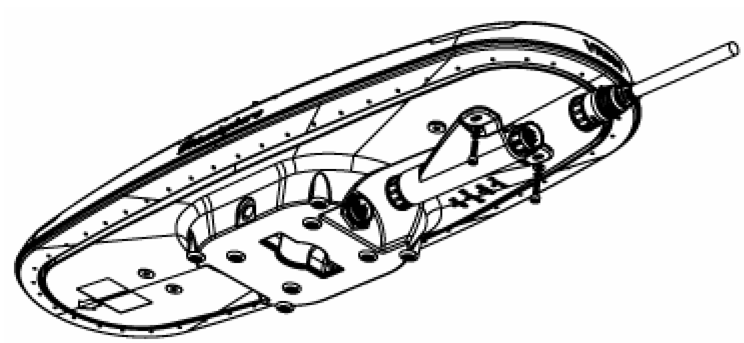

Figure 2-11: VR500 with 22-Pin to 18-Pin adapter

Power/data cable pin-out assignments

Figure 2-12 shows the power/data cable pin-out assignments.

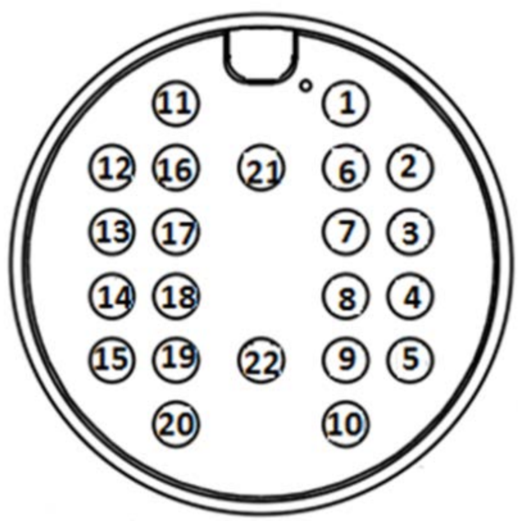

Figure 2-12: VR500 pin-out assignments

Continued on next page

Connecting the VR500 to External Devices, Continued

Power/data cable pin-out specifications

Table 2-1 shows the cable pin-out specifications.

Table 2-1: VR500 pin-out specifications

Pin	Function	Color
1	Power +	Red
2	CAN1 High	Orange-Black stripe
3	CAN1 Low	Yellow Black stripe
4	Port B RS-232 RX/RS-422 A	Orange
5	Port B RS-232 TX/RS-422 Z	Yellow
6	CAN2 High	Green
7	CAN2 Low	Blue
8	Port B RS-422 B	Purple
9	Port B RS-422 Y	Grey
10	1PPS Output	White
11	Port A RS-232 RX	Pink
12	Port A RS-232 TX	Turquoise
13	Signal Ground	Black-White stripe
14	Ethernet TD+	Brown-White stripe
15	Ethernet TD-	Red-White stripe
16	Heading Warning	Orange-White stripe
17	Speed Output	Green-White stripe
18	Ethernet RD+	Blue-White stripe
19	Ethernet RD-	Purple-White stripe
20	Manual Mark Input	Red-Black stripe
21	Power +	Brown
22	Power -	Black

Chapter 3: Understanding the VR500

Overview

Introduction

The GNSS receiver begins tracking satellites when it is powered on. Position and heading accuracy vary depending upon location and environment. Position performance can be improved with RTK or DGNSS.

The following sections provide the steps to configure your VR500 to use Atlas, SBAS, or RTK.

Note: Differential source and RTK status impact only positioning and heave. There is no impact to heading, pitch, or roll.

Contents

Differential and RTK Operation

Differential (DGNSS) and RTK operation

The purpose of differential GNSS (DGNSS) and RTK is to remove the effects of atmospheric errors, timing errors and satellite orbit errors, while enhancing system integrity.

Autonomous positioning capabilities of the VR500 will result in positioning accuracies of 2.5m 95% of the time.

To improve positioning quality, the VR500 can receive DGNSS corrections over SBAS, L-band corrections with Hemisphere GNSS' Atlas L-band technology, or RTK corrections over serial or internal UHF radio.

For more information on the differential services and the associated commands refer to the Hemisphere GNSS Technical Reference Manual.

SBAS Tracking

SBAS tracking

SBAS is a standard feature on the VR500 and does not require an activation or subscription code. The VR500 automatically scans and tracks SBAS signals without the need to tune the receiver.

The VR500 features two-channel tracking that provides an enhanced ability to maintain a lock on an SBAS satellite when more than one satellite is in view.

This redundant tracking approach results in more consistent tracking of an SBAS signal in areas where signal blockage of a satellite is possible.

Note: The VR500 moving base station algorithm uses only GNSS to calculate heading. Differential and RTK corrections are not used in this calculation and will not affect heading accuracy.

Athena RTK

Athena RTK

Athena RTK requires the use of two separate receivers: a stationary base station (primary receiver) that broadcasts corrections over a wireless link to the rover (secondary receiver).

The VR500 can use RTK through either serial port or its internal UHF radio. The receiver uses any RTK message coming in over a serial port if the RTK message type is included in the list of available differential sources.

If you do not know which RTK message type is being sent by the base station, you can include RTCM3, ROX, and CMR.

Including extra differential sources will not affect the receiver if those differential sources are not being received.

After setting the differential source configure the baud rate of the serial port receiving the RTK corrections. Ensure that the serial port configuration of the external device (such as radio or modem) is 8 bits/byte, 1 stop bit, no parity and no flow control.

Connect the external device to the serial port of the VR500. Some cables may require the use of a gender changer and/or null modem adapter. For instructions on configuring the internal UHF radio, please see Configuring the VR500 Using the WebUI.

Atlas L-band

Atlas L-band	Atlas L-band corrections are available worldwide. With Atlas, the positioning accuracy does not degrade as a function of distance to a base station, as the data content is not composed of a single base station's information, but an entire network's information. The VR500 can calculate a position with 4 cm RMS (horizontal) accuracy in an industry-leading time of 20 minutes. To configure the receiver to use Atlas L-band, a subscription must be purchased.

Supported Constellations

GLONASS, Galileo & BeiDou	The VR500 comes standard with all signals and constellations activated. For a heading calculation, GPS, GLONASS, Galileo and BeiDou satellites are used interchangeably, as intersystem biases cancel inside the VR500—this translates into being able to work in more obstructed areas and maintain a GNSS heading solution.

Supplemental Sensors

Overview

The VR500 has an integrated gyro and two tilt sensors, which are enabled by default. Each supplemental sensor may be individually enabled or disabled. Both supplemental sensors are mounted on the printed circuit board inside the VR500.

The sensors act to reduce the RTK search volume, which improves heading startup and reacquisition times. This improves the reliability and accuracy of selecting the correct heading solution by eliminating other possible, erroneous solutions.

The Hemisphere GNSS Technical Reference Manual describes the commands and methodology required to recalibrate, query, or change the sensor status.

Tilt Aiding

The VR500's accelerometers (internal tilt sensors) are factory calibrated and enabled by default and constrains the RTK heading solution beyond the volume associated with a fixed antenna separation.

The VR500 knows the approximate inclination of the secondary antenna with respect to the primary antenna. The search space defined by the tilt sensor is reduced to a horizontal ring on the sphere's surface by reducing the search volume and decreases startup and reacquisition times (see Figure 3-1).

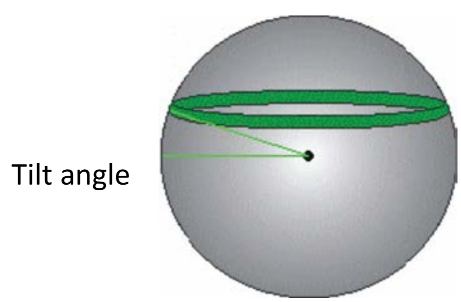

Figure 3-1: VR500 tilt aiding

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Gyro aiding

The VR500's internal gyro reduces the sensor volume for an RTK solution and shortens reacquisition times when a GNSS heading is lost due to blocked satellite signals.

The gyro provides a relative change in angle since the last computed heading, and, when used in conjunction with the tilt sensor, defines the search space as a wedge-shaped location (see Figure 3-2).

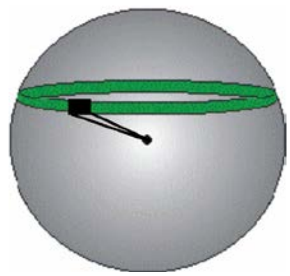


Figure 3-2: VR500 gyro aiding

The gyro aiding accurately smooths the heading output and the rate of turn, and provides an accurate substitute heading for a short period depending on the roll and pitch of the machine (ideally seeing the system through to reacquisition).

The gyro provides an alternate source of heading, accurate to within 1º per minute for up to three minutes, in times of GNSS loss for either antenna. If the outage lasts longer than three minutes, the gyro will have drifted too far and the VR500 begins outputting null fields in the heading output messages. There is no user control over the timeout period of the gyro.

The gyro initializes itself at power up and during initialization, or you can calibrate it as outlined in the Hemisphere GNSS Technical Reference Manual.

For optimal performance, when the gyro is first initializing, ensure the dynamics the gyro experiences during this warm-up period are similar to the regular operating dynamics.

Continued on next page

Supplemental Sensors, Continued

Gyro aiding, continued	With the gyro enabled, it is used to update the post HTAU smoothed heading output from the moving base station RTK GNSS heading computation. If the HTAU value is increased while gyro aiding is enabled, there will be little to no lag in heading output due to vehicle manoeuvres. The Hemisphere GNSS Technical Reference Manual includes information on setting an appropriate HTAU value for the application.

Time Constants

Overview

The VR500 incorporates user-configurable time constants that can provide a degree of smoothing to the heading, pitch, Rate-of-Turn (ROT), Course-over-Ground (COG), and speed measurements.

You can adjust these parameters depending on the expected dynamics of the machine. For example, increasing the time is reasonable if the machine is very large and is not able to turn quickly or would not pitch quickly. The resulting values would have reduced “noise,” resulting in consistent values with time. If the machine is quick and nimble, increasing this value can create a lag in measurements.

Formulas for determining the level of smoothing are located in the Hemisphere GNSS Technical Reference Manual. If you are unsure how to set this value, it is best to be conservative and leave it at the default setting.

Heading

Use the $JATT,HTAU command to adjust the level of responsiveness of the true heading measurement provided in the $GPHDT message. The default value of this constant is 0.1 seconds of smoothing when the gyro is enabled. The gyro is enabled by default but can be disabled.

By disabling the gyro, the equivalent default value of the heading time constant would be 0.5 seconds of smoothing. This is not automatic, and therefore it must be manually entered.

Increasing the time constant increases, the level of heading smoothing and increases lag.

Pitch

Use the $JATT,PTAU command 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 increases the level of pitch smoothing and increases lag.

Continued on next page

Time Constants, Continued

Rate-of-Turn (ROT)	Use the $JATT,HRTAU command to adjust the level of responsiveness of the ROT measurement provided in the $GPROT message. The default value of this constant is 2.0 seconds of smoothing. Increasing the time constant increases the level of ROT smoothing.
Course-Over-Ground (COG)	Use the $JATT,COGTAU command 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 increases the level of COG smoothing. COG is computed using only the primary GNSS antenna and its accuracy depends upon the speed of the machine (noise is proportional to 1/speed). This value is invalid when the machine is stationary.
Speed	Use the $JATT,SPDTAU command 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 increases the level of speed measurement smoothing.

Chapter 4: Operating the VR500

Overview

Introduction

The chapter includes information about powering and configuring your VR500 receiver.

Contents

Powering the Receiver On/Off

Power the receiver on/off	The VR500 powers on when it receives clean power with an input voltage of 9 to 32 VDC via the power cable. The supplied power should be continuous and clean for best performance. Refer to Appendix B for the power specifications of the VR500. ⚠WARNING: **Do not apply a voltage higher than 32 VDC. This will damage the receiver and void the warranty. Also, do not attempt to operate the VR500 with the fuse bypassed as this will void the warranty.** The VR500 features reverse polarity protection to prevent damage if the power leads are accidentally reversed. Although the VR500 proceeds through an internal startup sequence when you apply power, it will be ready to communicate immediately. Initial startup may take 5 to 15 minutes depending on the location. Subsequent startups will output a valid position within 1 to 5 minutes depending on the location and time since the last startup. The VR500 may take up to 5 minutes to receive a full ionospheric map from SBAS. Optimum accuracy is obtained once the VR500 is processing corrected positions using complete ionospheric information.
Electrical isolation	The VR500's power supply is isolated from the communication lines and the enclosure isolates the electronics mechanically from the machine (preventing machine hull electrolysis).

LED Indicators

Overview

The VR500 has four LED lights located bottom of the unit. Table 4-1 below describes each LED indicator.

Figure 4-1: VR500 LED

Table 4-1: LED indicators

Indicator	Description/Function
Power	Solid red light when receiver is powered on
GNSS	Solid amber light when the primary antenna is tracking four or more satellites
Heading	Indicates the Vector has calculated a heading value
Radio	Blinks each time an RTK message is received over UHF

Configuring the VR500 Using the WebUI

Overview

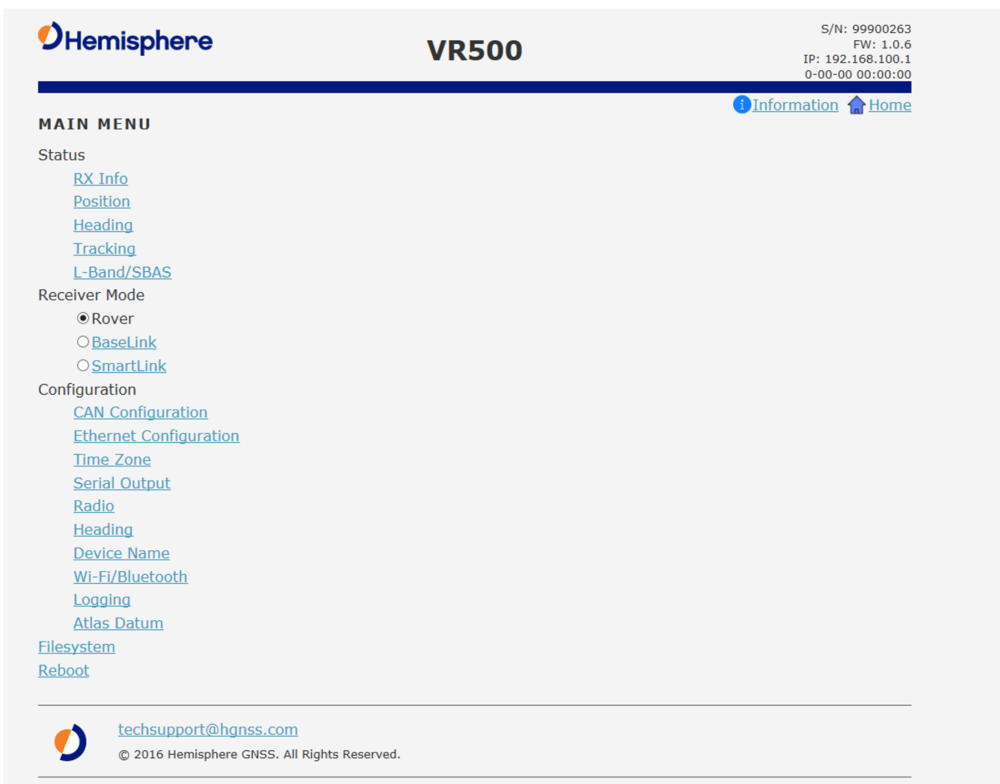
The VR500 is equipped with an onboard WebUI.

First, connect the Bluetooth/WiFi antenna to the connector. The receiver displays as an available Wi-Fi device in your available networks. Connect the tablet or PC to the VR500's WiFi.

To log in use the password: hgnss1234

Open a web browser window and type the following IP address: 192.168.100.1

The VR500 Main Menu displays.



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Configuring the VR500 Using the WebUI, Continued

Status

You can configure RX Info, Position, Heading, Tracking, L-band and SBAS.

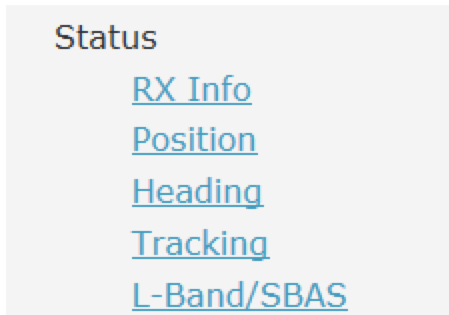


Table 4-2: Status links

Link	Description
RX Info	Serial number of the board, firmware versions, and subscriptions
Position	Position, accuracy, HDOP, number of satellites used, and differential/RTK status
Heading	Heading, COG, the offset between heading and COG, ROT, yaw, pitch, roll, heave and speed
Tracking	Sky plot and SNRs of signals tracked
L-band/SBAS	Manually tune the antenna to track a specific L-band satellite or to set the receiver up to automatically select the correct SBAS satellite

Continued on next page

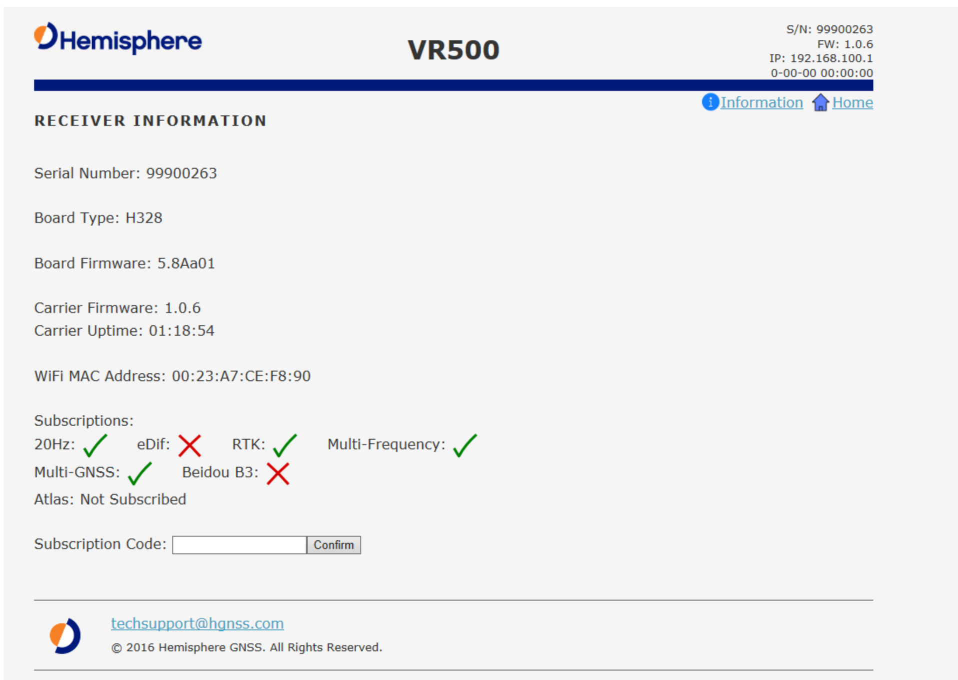
Configuring the VR500 Using the WebUI, Continued

RX info

The Serial Number, Board Type, Carrier Firmware (for both GNSS and carrier board), Carrier Uptime, WiFi MAC Address, and your Subscriptions are displayed.

Activated items have a green check mark.

Important: If you have purchased an activation or subscription, use the field at the bottom of the screen to type the Subscription Code, and click ***Confirm***.



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Configuring the VR500 Using the WebUI, Continued

Position

Position and time are displayed at the top of the screen. In the example below, the Time Zone is set to UTC-10, Honolulu time.

To change the Time Zone, go to the main page and click **Time Zone**. Please note this does not affect UTC time in NMEA output.

An estimate of your 3D (and 2D) position accuracy is given in both RMS and 2DRMS.

HDOP-Horizontal Dilution of Precision
Satellites Used-Number of satellites used

Solution Type-Fixed, Float, etc.
Differential Source-Atlas, RTK, etc.
Age of Differential-RTK latency

Continued on next page

Configuring the VR500 Using the WebUI, Continued

Heading

The **Heading Information** screen displays the following data:

Term	Definition
Compass rose	the difference between heading and COG
Heading	the direction of the vector created from the primary to secondary antenna. Heading is measured using true north
COG	the direction the machine is moving
YAW	the difference between COG and heading
Pitch	angle between the front and back of the machine
Roll	angle between the left and right side of the machine
Heave	the upward movement of the ground
Speed	speed of machine in km/h

-

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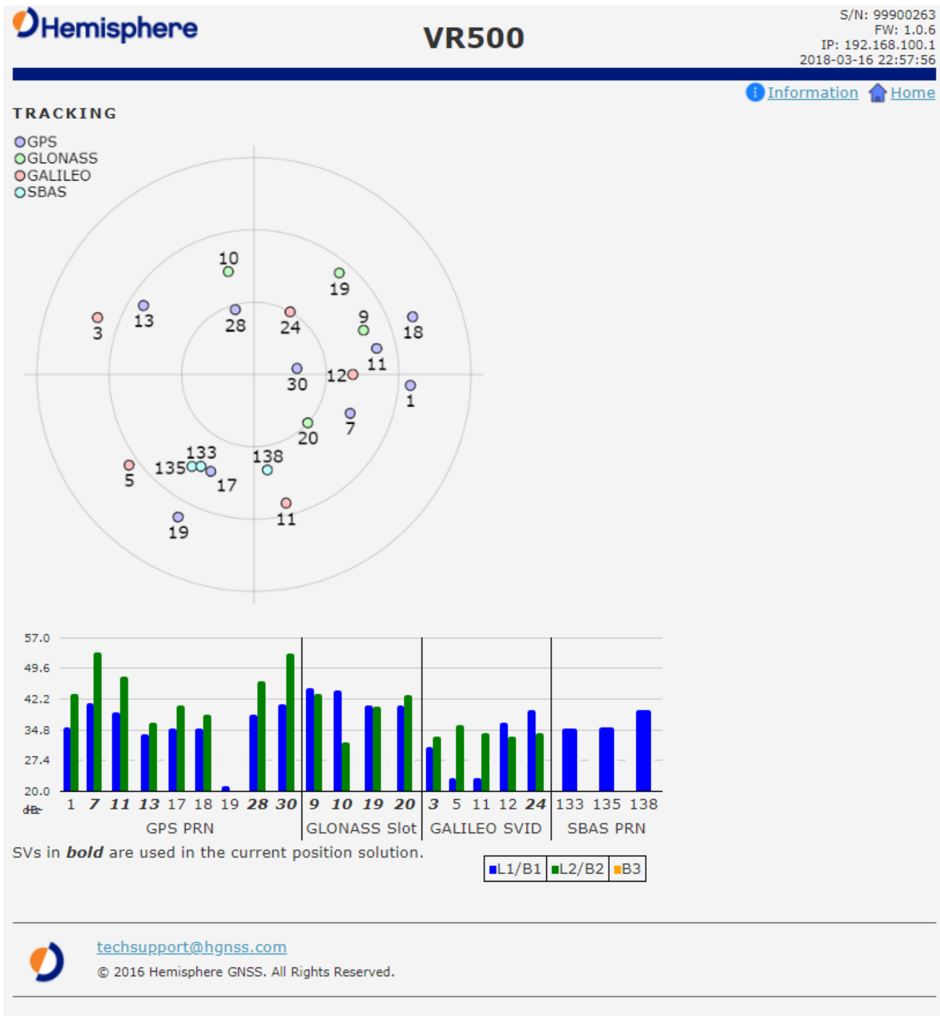
Tracking

The Sky Plot shows the azimuth, elevation, and SNR values of all tracked satellites.



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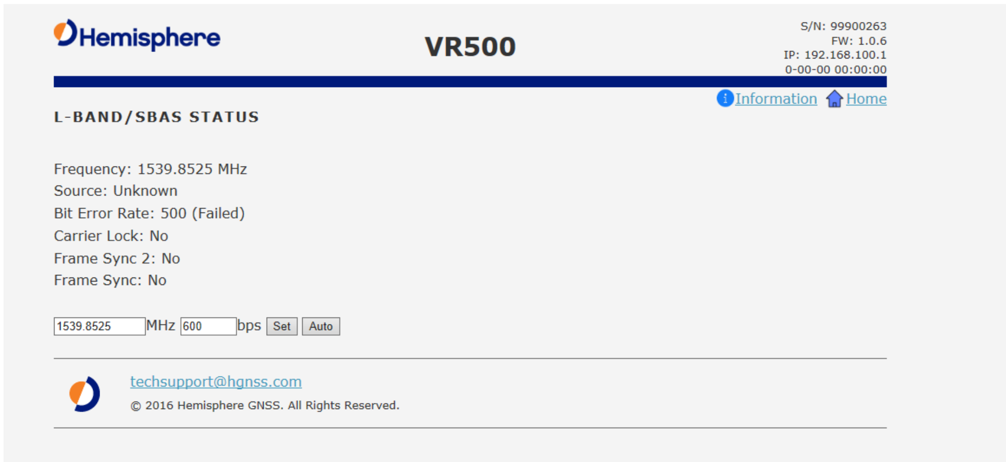
Configuring the VR500 Using the WebUI, Continued

L-band/SBAS

You can manually configure the frequency and bandwidth of the L-band satellite you wish to track, or simply click the **Auto** button and let the receiver track automatically.



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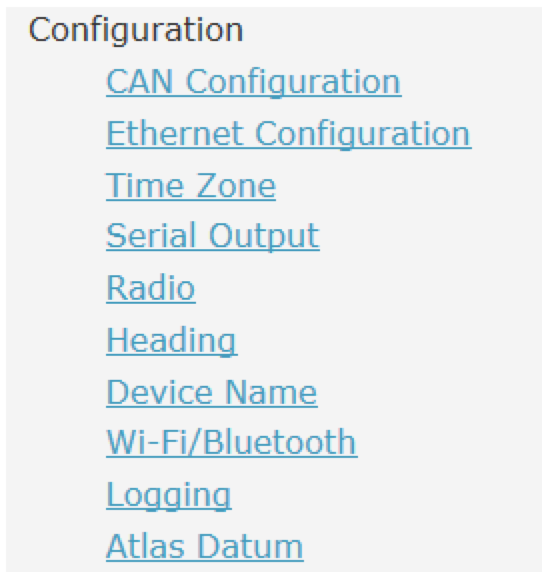
Configuring the VR500 Using the WebUI, Continued

Configuration overview

You can configure the following using the VR500 WebUI:

- CANbus
- Ethernet
- Time zone
- Serial port baud rate and output
- Radio
- Heading constants
- Device name
- WiFi Bluetooth settings
- Logging options
- Atlas Datum



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Radio

Use Radio to configure the internal UHF radio (protocol, frequency, etc.). The Radio Configuration defaults to a no-frequency setting.

Use the drop-down arrows to select pre-configured channels. Each channel has an associated frequency, and bandwidth.

Select a protocol (see Table 4-4 Radio Mode). The list of available protocols is dependent upon the bandwidth of your channel. For example, if the bandwidth of the channel you are using is 12.5KHz, Trimtalk 2 will not display.

To add new channels, obtain and load a .ucf file from your dealer using the **Upload Config File** button. Choose a channel and select the protocol. For Satel protocol, you may turn FEC OFF/ON.

Continued on next page

Configuring the VR500 Using the WebUI, Continued

Radio, continued

Use the following table to configure Radio settings. You may configure any settings in the blue boxes.

Table 4-4: Radio mode

Radio Mode	Link Rate	Spacing	Modulation	Scrambling	FEC
Trimtalk 1	4800 bps	12.5 kHz	GMSK	On	Off
Trimtalk 2	9600 bps	25 kHz			
PC1	9600 bps	25 kHz	GMSK	On	On
PC5	4800 bps	12.5 kHz			
PCC-4FSK	9600 bps	12.5 kHz	4FSK	On	On
	19200 bps	25 kHz			
Satel 3AS	9600 bps	12.5 kHz	4FSK	On	Off
					On
	19200 bps	25 kHz			Off
					On

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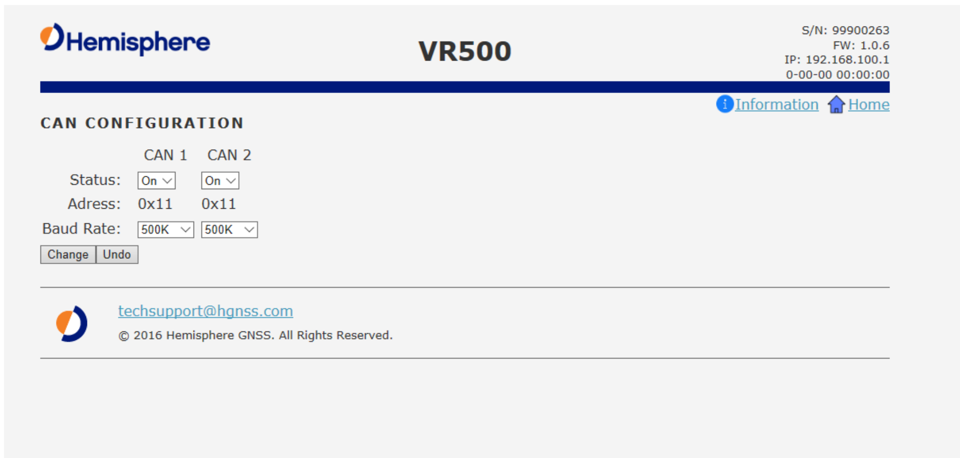
Configuring the VR500 Using the WebUI, Continued

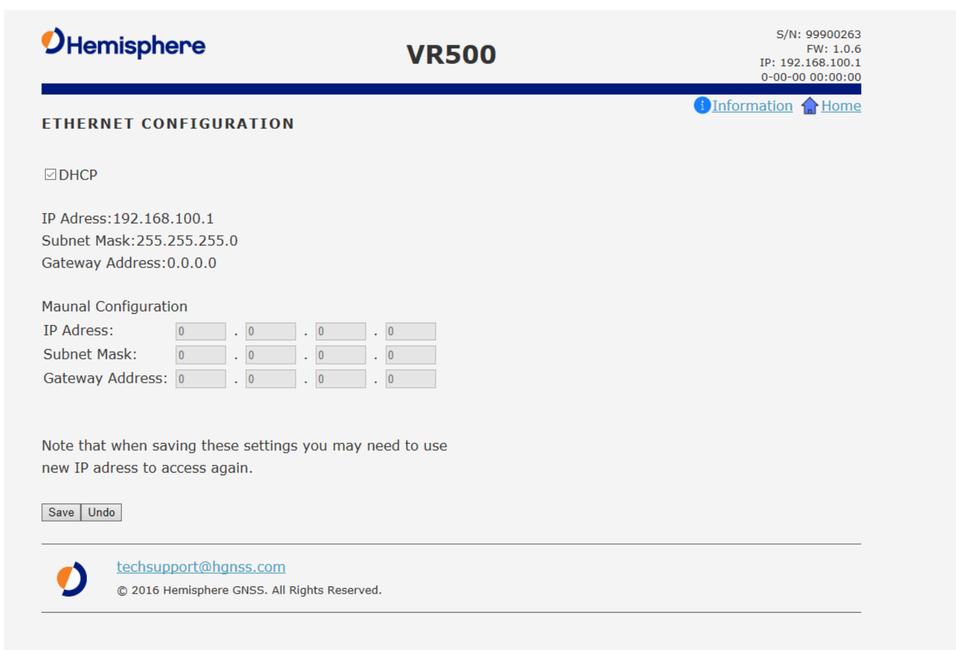
CAN

Turn ON/OFF CAN and select the baud rate (250 kbps or 500 kbps).



Ethernet

Use the VR500 WebUI to configure the Ethernet connection.



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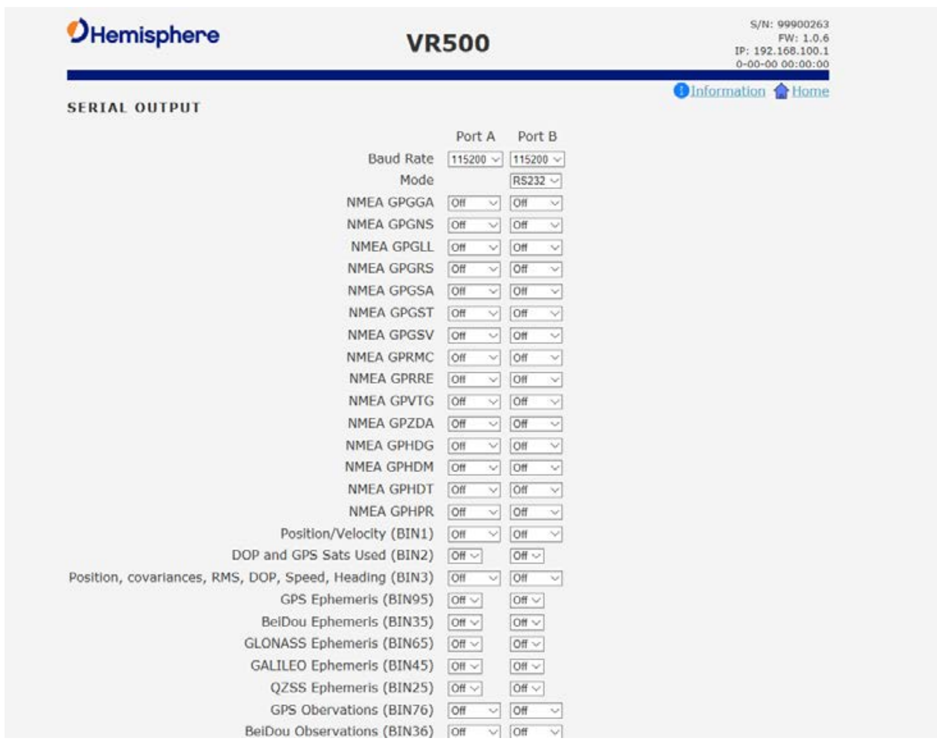
Configuring the VR500 Using the WebUI, Continued

Serial Output

Use Serial Output to configure the baud rate of each serial port (PortA and PortB and turn off/on specific NMEA 0183 messages and proprietary Hemisphere BIN messages.

You can also change Port B from RS232 to RS422 and RS422 to RS232 reciprocally.

Configure the baud rates of the serial ports and click **Change**.



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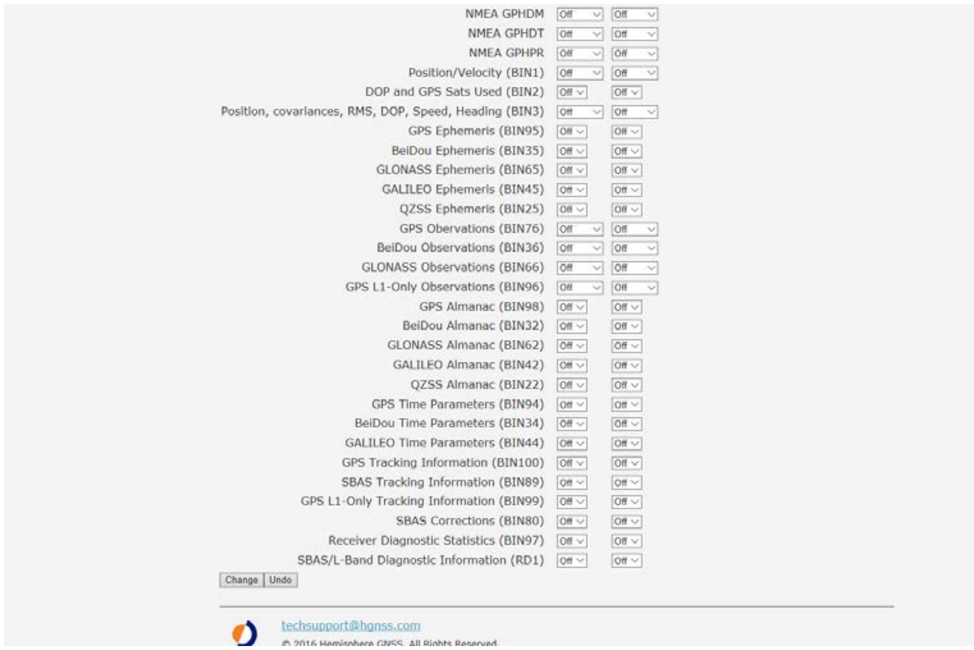
Configuring the VR500 Using the WebUI, Continued

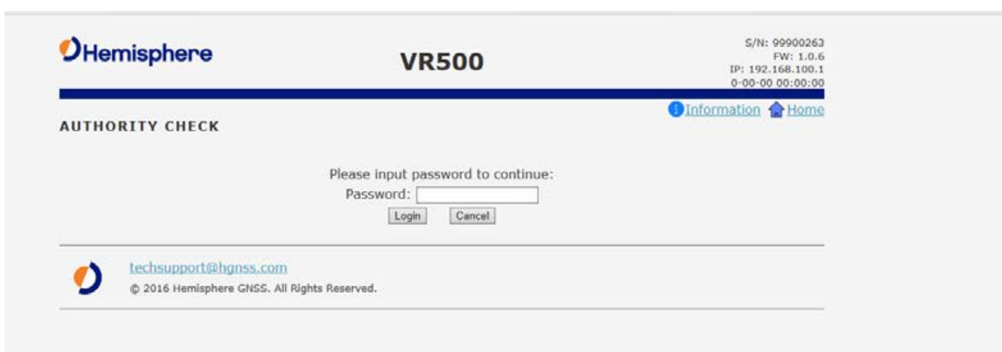
Serial Output, continued



Heading

Authorized users may change the Heading configuration.

Under the **Configuration** menu, click **Heading**. If you are an authorized user, type the Hemisphere GNSS provided password, and click **Login**.



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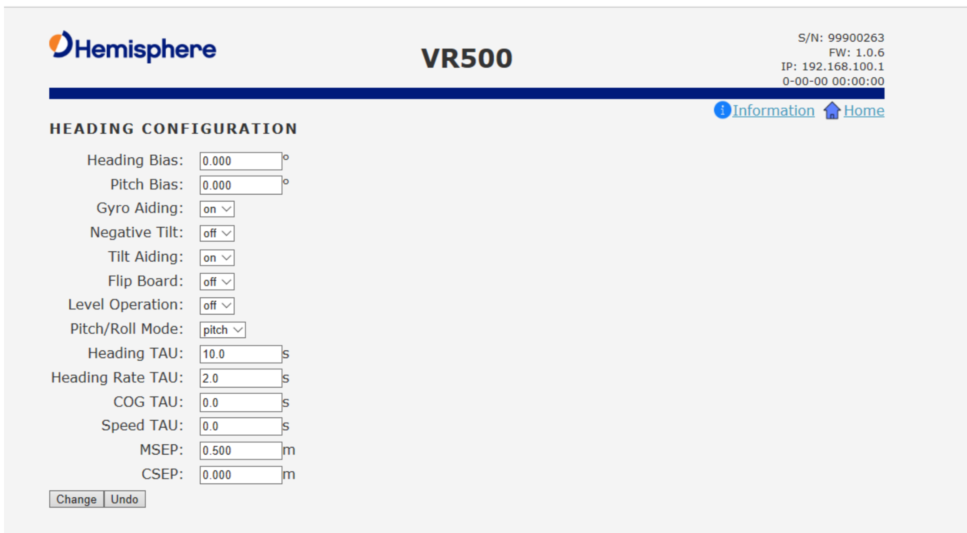
Configuring the VR500 Using the WebUI, Continued

Heading, continued

Note: Default settings can be changed to set the time constants to smooth heading, Course-over-Ground (COG), and speed measurements.

Various heading settings can also be configured.

Click the box of the desired setting and type the configuration setting values.



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Heading, continued

Table 4-5: Heading configurations

Time Constant	Description
Heading Bias	Add a bias to the heading value the receiver outputs. Range: -180 – +180
Pitch Bias	Add a bias to the pitch value the receiver outputs. If the receiver is in "roll" mode, this will add a bias to the roll instead. Range: -15 – +15
Gyro Aiding	Gyro aiding enables the use of the internal gyro sensor and allows for the continuous output of heading for up to three minutes during a GNSS outage. Gyro aiding improves the reacquisition time when GNSS heading is lost because of an obstruction in GNSS signal.
Negative Tilt	Change the sign of the pitch/roll measurement.
Tilt Aiding	Turn OFF or ON tilt aiding. When on, the sensors are used to reduce the RTK search volume – improving heading startup and reacquisition times.
Flip Board	N/A
Pitch/Roll Mode	If the antennas are mounted such that they model pitch, set to PITCH. If the antennas are mounted such that they model roll), set to ROLL. **Note:** If your HBIAS is -90 or +90, this will be set to ROLL. If your HBIAS is 0 or 180, set this to PITCH.

Continued on next page

Heading, continued

Table 4-5: Heading configurations (continued)

Time Constant	Description
HTAU (Heading)	Adjust the responsiveness to true heading. If the machine is large and unable to turn quickly, increase this value. For longer baselines (10 m) HTAU should be between 0.1 and 0.5, since the gyro introduces noise. **Default value:** 0.1 s with gyro enabled Range: 0.0 to 60 s **Formula:** htau (s) = 40 / max rate of turn (°/s) *with gyro ON* htau (s) = 10 / max rate of turn (°/s) *with gyro OFF*
HRTAU (Rate of Turn)	Adjust the responsiveness to the rate of heading change. If the machine is large and unable to turn quickly, increase this value. **Default value:** 2.0 s with gyro enabled Range: 0.0 to 60 s **Formula:** hrtau (s) = 10 / max rate of the rate of turn (°/s^2)

Continued on next page

Heading, continued

Table 4-5: Heading configurations (continued)

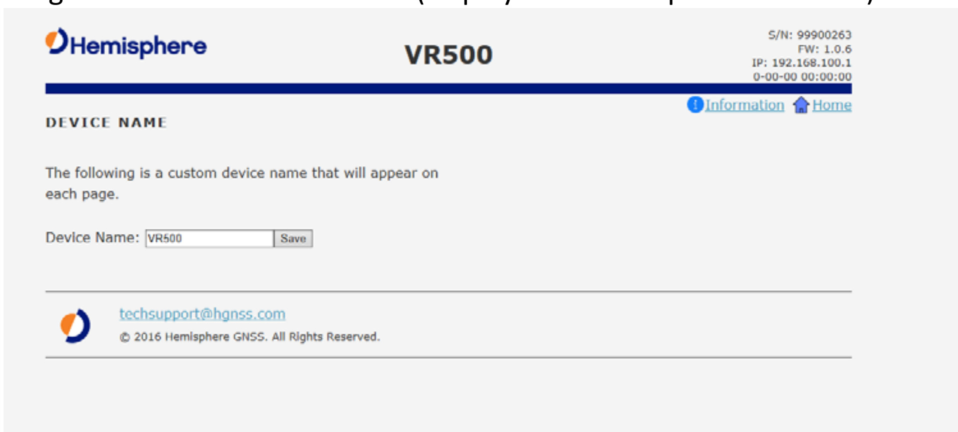
Time Constant	Description
COGTAU (Course Over Ground)	Adjust the responsiveness to the course over ground measurement. If the machine is small and dynamic, leave this value at 0.0 s to be conservative. If the machine is large and resistant to motion, increase this value. **Default value:** 0.0 s Range: 0.0 to 60 s **Formula:** cogtau (s) = 10 / max rate of change of course (°/sec)
SPDTAU (Speed)	Adjust the responsiveness to speed. If the machine is small and dynamic, leave this value at 0.0 s to be conservative. If the machine is large and resistant to motion, increase this value. **Default value:** 0.0 s Range: 0.0 to 60 s **Formula:** spdtau (s) = 10 / max acceleration (m/s^2)
CSEP	This is the antenna separation calculated by the receiver. Ensure the CSEP value is within 0.2 of 0.5 (within two cm of 50 cm). **Note:** If CSEP value is "0" the receiver is unable to calculate the separation between the primary and secondary antennas.

Continued on next page

Configuring the VR500 Using the WebUI, Continued

Device name

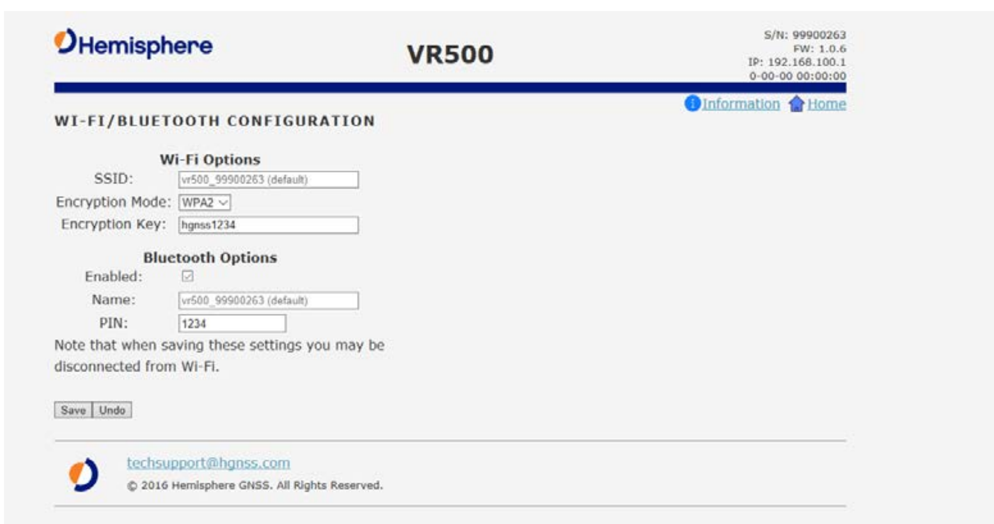
Change the name of the receiver (displayed at the top of the WebUI).



Wi-Fi Bluetooth configuration

Configure the WiFi access name, encryption mode, and encryption key of the VR500 in the WiFi/Bluetooth configuration settings. Click to enable Bluetooth options and type the PIN of the VR500.

Note: The VR500 internal filesystem cannot be accessed when Bluetooth is enabled. To access the internal filesystem, disable Bluetooth.



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Configuring the VR500 Using the WebUI, Continued

Logging Log data to the internal memory of the VR500 or download a previously saved log.

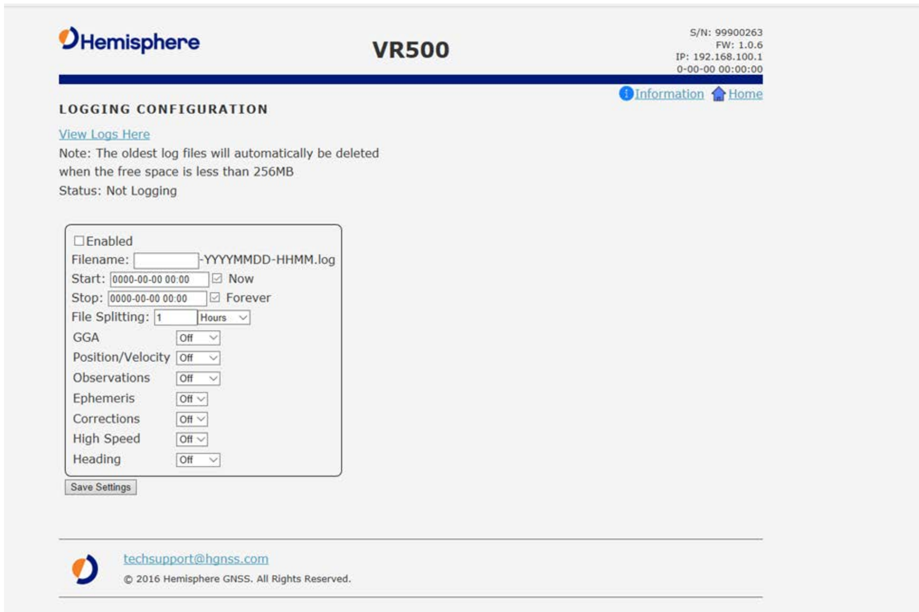


Table 4-6: Logging configuration

Field	Description
Enabled checkbox	Click to enable logging. Each time the VR500 is powered on, logging begins with the specified settings.
Filename	Choose a filename. All filenames automatically have an appended date and timestamp.
Start/Stop	Set a time to start and a time to stop logging.
Now/Forever	Select the logs to start logging now, or to log indefinitely (until shut off).

Continued on next page

Logging, continued

Table 4-6: Logging configuration (continued)

Field	Description
File Splitting	Automatically closes a file and restarts a new file after a period of time. Use file splitting to decrease file sizes or to prevent the loss of a file resulting in the loss of all data
GGA	Turn on GGA message logging at 0.2Hz, 1Hz, 10Hz, or 20HZ. **Note:** 10Hz and 20Hz are only available with activations (some kits may come with 10Hz or 20Hz included).
Position Velocity	Log the position and velocity of the receiver at 0.2Hz, 1Hz, 10Hz, or 20HZ. **Note:** 10Hz and 20Hz are only available with activations (some kits may come with 10Hz or 20Hz included).
Observations* *This feature is only available if you have a "Raw" activation on the receiver.	Log raw GNSS observations at 0.2Hz, 1Hz, 10Hz, or 20HZ. **Note:** 10Hz and 20Hz are only available with activations (some kits may come with 10Hz or 20Hz included).

Continued on next page

Logging, continued

Table 4-6: Logging configuration (continued)

Field	Description
Ephemeris* *This feature is only available if you have a "Raw" activation on the receiver.	Log raw GNSS ephemeris messages at 0.2Hz, 1Hz, 10Hz, or 20HZ. **Note:** 10Hz and 20Hz are only available with activations (some kits may come with 10Hz or 20Hz included).
Corrections	Log the correction messages coming into the receiver.
High Speed	High Speed logs diagnostic data. **Note:** Selecting that dropdown option forces the GGA, "corrections" and "ephemeris" options on.
Heading	Heading logs the following messages: • GPHDT • GPHDM • GPHDG • HPR • BIN3

To stop logging, de-select the **Enabled** button and press **Save Settings**.

⚠WARNING:
If you power off the receiver without properly closing a log, the log file will become corrupted.

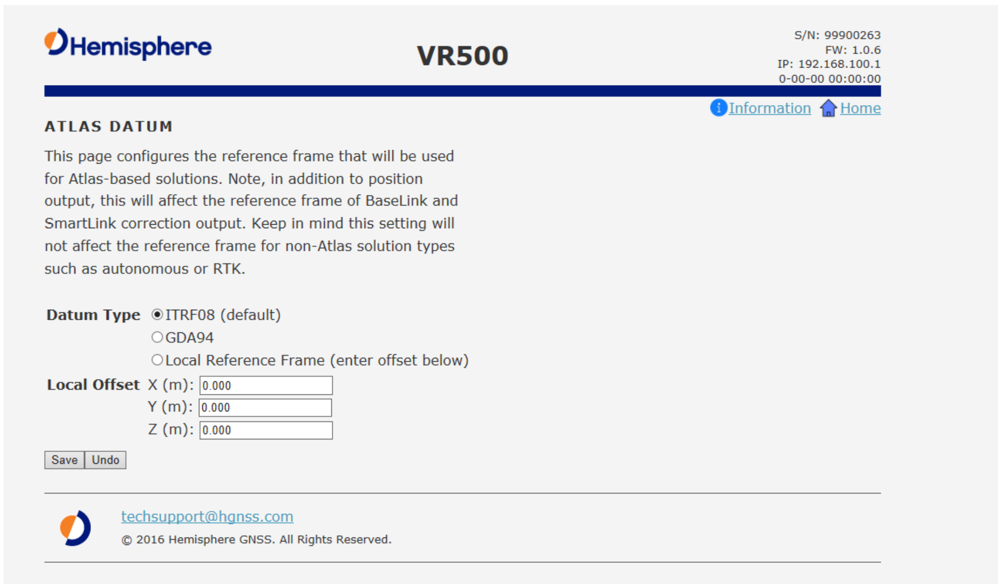
Continued on next page

Configuring the VR500 Using the WebUI, Continued

Atlas Datum

If using Atlas (**not RTK**), datum defaults to ITRF08.

You can change Datum Type to GDA94 or enter custom reference frame offsets.



Filesystem

The filesystem can be used to download log files that have been previously stored onto the VR500, or the filesystem can be used to upgrade both GNSS firmware or carrier board firmware.

Note: The filesystem cannot be used when Bluetooth is enabled. If Bluetooth is enabled, an option will be given to disable Bluetooth.

Continued on next page

Filesystem, continued

After Bluetooth is disabled, the filesystem displays. Any log files stored on the receiver will be available for download.

To upgrade firmware, click **Choose File**, select the GNSS or carrier board firmware, and press "Upload."

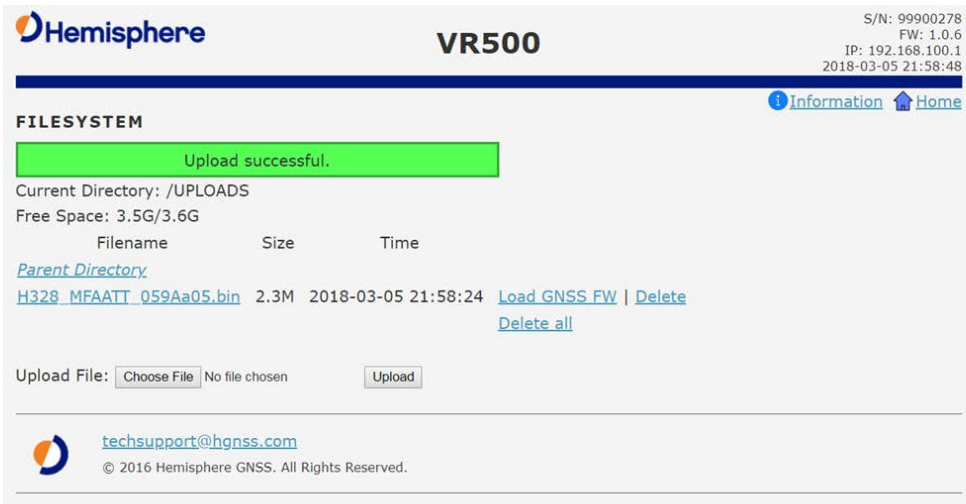
Continued on next page

Configuring the VR500 Using the WebUI, Continued

Filesystem, continued

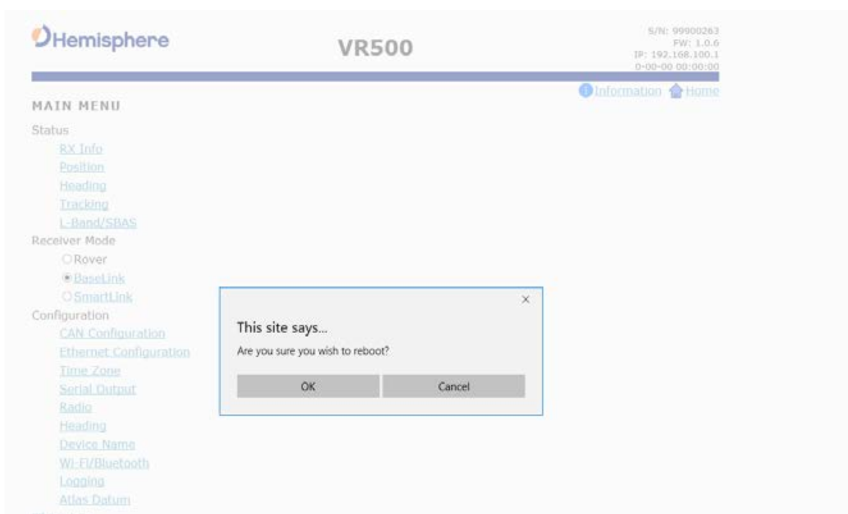
After the file is uploaded, the list of files display.

Click **Load GNSS FW** or **Load Carrier FW**. When the FW is complete, click **Delete**.



Reboot

Click **OK** to hard-boot the receiver.



Appendix A: Troubleshooting

Overview

Introduction

Appendix A provides troubleshooting for common problems.

Contents

Troubleshooting

Appendix A troubleshooting

Table A-1: VR500 Troubleshooting

Symptom	Possible Solution
Receiver fails to power on	• Check to see if the power LED is lit • Verify polarity of power leads • Check integrity of power cable connectors • Check power input voltage (9 to 32 VDC) • Check the voltage from the connector at the end of the cable • Check current restrictions imposed by power source (minimum available should be > 1.0 A)
No data from VR500	• Check receiver power status to ensure the receiver is powered on • Verify desired messages are activated (using PocketMax4, the WebUI, or $JSHOW command in any terminal program) • Ensure the baud rate of the VR500 matches that of the receiving device • Check integrity and connectivity of power and data cable connections
Random data from VR500	• Verify that RTCM or binary messages are not being output (use the WebUI to see which messages are turned on) • Ensure the baud rate of the VR500 matches that of the remote device • Ensure the requested throughput does not exceed the amount of data allowed by the baud rate of the COM port
No GNSS lock	• Verify the VR500 has a clear view of the sky • Use PocketMax4 or the WebUI to see how many satellites are in view and the SNR values

Continued on next page

Appendix A troubleshooting, continued

Table A-1: VR500 Troubleshooting (continued)

Symptom	Possible Solution
No heading or incorrect heading value	• Check CSEP value is constant without varying more than 1 cm (0.39 in)—larger variations may indicate a high multipath environment and require moving the receiver location • $JATT,SEARCH command forces the VR500 to acquire a new heading solution (unless gyro is enabled) • Enable GYROAID to provide heading for up to three minutes during GNSS signal loss • Enable TILTAID to reduce heading search times • Monitor the number of satellites and SNR values for both antennas within PocketMax—at least four satellites should have strong SNR values • The VR500 calculates heading from the primary to secondary GNSS antenna (the secondary antenna has an arrow underneath). Ensure via the WebUI or PocketMax4 there is not a heading bias added to the heading solution
VR500 will not go RTK fixed	• Check to see if the UHF indicator is blinking. If it is not blinking, check to see if the UHF base radio is transmitting data • Ensure the frequency and settings (modulation, protocol, channel spacing, forward error corrections, and scrambling) of the base radio match the VR500 radio • Check other VR500 receivers in the same area are going RTK Fixed. If they are not, the area may not have UHF coverage. Check if the VR500 works closer to the base radio. Installation of a repeater may be necessary • An external UHF radio antenna may be installed to improve UHF performance

Continued on next page

Appendix A troubleshooting, continued

Table A-1: VR500 Troubleshooting (continued)

Symptom	Possible Solution
VR500 will not go RTK fixed (continued)	• Check the RTK latency. If the VR500 remains in RTK Float, but the latency keeps climbing, this usually indicates the radio settings are correct, but the environment is poor (or lacks adequate UHF coverage) . If the RTK latency is consistently 1, but the VR500 stays RTK Float, ensure the VR500 has an RTK activation.
Constellations	• If the VR500 is not using satellites from a specific constellation (such as Galileo or BeiDou), verify the base station supports those constellations. Only satellites used at the base station can be used at the rover. • Check the WebUI for multi-GNSS activation.
Atlas Corrections Are Not Working	• Check your subscription end-date in the WebUI. • Use the L-band tab to check the frequency and bandwidth of the tracked satellite. We suggest pressing **Auto** to use your position to automatically tune to the correct frequency for your region.

Appendix B: Technical Specifications

Technical Specifications

Introduction

Appendix B provides the VR500 technical specifications and the VR500 certification information.

Contents

VR500 Technical Specifications

VR500 sensor specifications

Table B-1: VR500 Sensor

Item	Specification
Receiver type	GPS, GLONASS, BeiDou, Galileo and RTK with carrier phase and L-band dual antenna
Channels	744
Satellites	12 L1CA GPS 12 L1P GPS 12 L2P GPS 12 L2C GPS 15 L5 GPS 12 G1 GLONASS 12 G2 GLONASS 12 G3 GLONASS 22 B1 BeiDou 22 B2 BeiDou 14 B3 BeiDou 12 Galileo E1 12 Galileo E5a 12 Galileo E5b 3 SBAS or 3 additional L1CA GPS 2 L-band
Primary antenna	GPS L1,L1P,L2C,L2P,L5 GLONASS G1,G2,Pcode BeiDou B1,B2,B3 Galileo E1,E5a,E5b L-band

Continued on next page

VR500 Technical Specifications, Continued

VR500 sensor specifications specifications, continued

Table B-1: VR500 Sensor (continued)

<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Secondary antenna</td><td>GPS L1,L1P,L2C,L2P
GLONASS G1,G2
BeiDou B1,B2
Galileo E1,E5b
L-band</td></tr>
<tr><td>GPS sensitivity</td><td>-142 dBm</td></tr>
<tr><td>SBAS tracking</td><td>3-channel, parallel tracking</td></tr>
<tr><td>Update rate</td><td>10 Hz standard, and 20 Hz available</td></tr>
<tr><td>Horizontal accuracy</td><td><table>
<tr><th></th><th>RMS (67%)</th><th>2DMRS (95%)</th></tr>
<tr><td>RTK[1,2]</td><td>8 mm + 1 ppm</td><td>15 mm +2 ppm</td></tr>
<tr><td>Atlas</td><td>0.04 m</td><td>0.08 m</td></tr>
<tr><td>SBAS (WAAS)[1]</td><td>0.3 m</td><td>0.6 m</td></tr>
<tr><td>Autonomous, no SA[1]</td><td>1.2 m</td><td>2.4 m</td></tr>
</table></td></tr>
<tr><td>Heading accuracy</td><td>0.27° RMS</td></tr>
<tr><td>Pitch/roll accuracy</td><td>< 1° RMS</td></tr>
<tr><td>ROT</td><td>145°/s maximum</td></tr>
<tr><td>Timing (1PPS) accuracy</td><td>20 ns</td></tr>
<tr><td>Cold start time</td><td>< 60 s typical (no almanac or RTC)</td></tr>
<tr><td>Warm start time</td><td>< 30 s typical (almanac and RTC)</td></tr>
<tr><td>Hot start time</td><td>< 10 s (almanac, RTC, and position)</td></tr>
<tr><td>Maximum speed</td><td>1,850 km/h (999 kts)</td></tr>
</table>

Continued on next page

VR500 Technical Specifications, Continued

VR500 sensor specifications, continued

Table B-1: VR500 Sensor (continued)

Item	Specification
Maximum altitude	18,288 m (60,000 ft)
Differential options	SBAS, Autonomous, External RTCM v2.3, RTK v3, L-band (Atlas), and DGPS
Antenna LNA gain input	10 to 40 dB

VR500 communication specifications

Table B-2: VR500 Communication

Item	Specification
Serial ports	3x full-duplex UART's 2x 3.3V CMOS 1x RS-232
CAN	2 CAN ports NMEA2000, ISO-11783
Baud rates	4800 - 115200
Data I/O protocol	NMEA 0183, CAN, Hemisphere GNSS binary
Correction I/O protocol	Hemisphere GNSS' ROX, RTCM v2.3 (DGPS), RTCM v3 (RTK), CMR, CMR+3, and Atlas
Timing output	1 PPS CMOS, active high, rising edge sync, 10 kΩ, 10 pF load
Event marker input	CMOS, active low, falling edge sync, 10 kΩ 10 pF load
Ethernet	1x 10/100 base-T

VR500 power specifications

Table B-3: VR500 Power

Item	Specification
Input voltage	9-32 VDC
Power consumption	10.8W Maximum (All signals and L-band)
Current consumption	1.2A Maximum

Continued on next page

VR500 environmental specifications

Table B-4: VR500 Environmental

Item	Specification
Operating temperature	-40°C to +70°C (-40°F to +158°F)
Storage temperature	-40°C to +85°C (-40°F to +185°F)
Humidity	95% non-condensing (when installed in an enclosure)
Shock and vibration	50Gs, 11ms half sine pulse, 10 shocks in each direction and axis, total 60 shocks Operational IEC 60068-2-29 MIL-STD-810G Vibration Sine: 30.6Grms MIL-STD-810G SAE J1211 ISO 16750-3:2007 Vibration Random: 5.96Grms IEC 60068-2-64 MIL-STD- 202F
EMC[4]	CE (ISO 14982 Emissions and Immunity) FCC Part 15, Subpart B CISPR22

VR500 mechanical specifications

Table B-5: VR500 Mechanical

Item	Specification
Dimensions	68.6 L x 22 W x 12.3 H cm
Weight	3.9 kg
Status indication	Power, GNSS, Heading, Radio
Power/Data connector	22-Pin environmentally sealed

Continued on next page

VR500 Technical Specifications, Continued

VR500 L-band sensor specifications

Table B-6: VR500 L-band sensor

Item	Specification
Receiver type	Single Channel
Channels	1525 to 1560 MHz
Sensitivity	140 dBm
Channel spacing	5.0 kHz
Satellite selection	Manual and Automatic
Reacquisition time	15 seconds (typical)

VR500 aiding device specifications

Table B-7: VR aiding device

Device	Description
Gyro	Provides smooth heading, fast heading reacquisition, and reliable < 3° heading for periods up to 3 minutes when loss of GPS has occurred.[4]
Tilt sensor	Provide pitch and roll data and assist in fast startup and reacquisition of heading solution.

[1] Depends on multi-path environment, number of satellites in view, satellite geometry, and ionospheric activity

[2] Depends also on baseline length

[3] Receive only, does not transmit this format

[4] Under static conditions

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Hemisphere GNSS
8515 E. Anderson Drive Scottsdale, AZ 85255, USA
Phone: +1-480-348-6380
Fax: +1-480-270-5070
TECHSUPPORT@HREGNSS.COM WWW.HGNSS.COM

Hemisphere GNSS Inc.
8515 East Anderson Drive, Suite A
Scottsdale, Arizona, US 85255
Phone: 480-348-6380
Fax: 480-270-5070
PRECISION@HGNSS.COM
WWW.HGNSS.COM