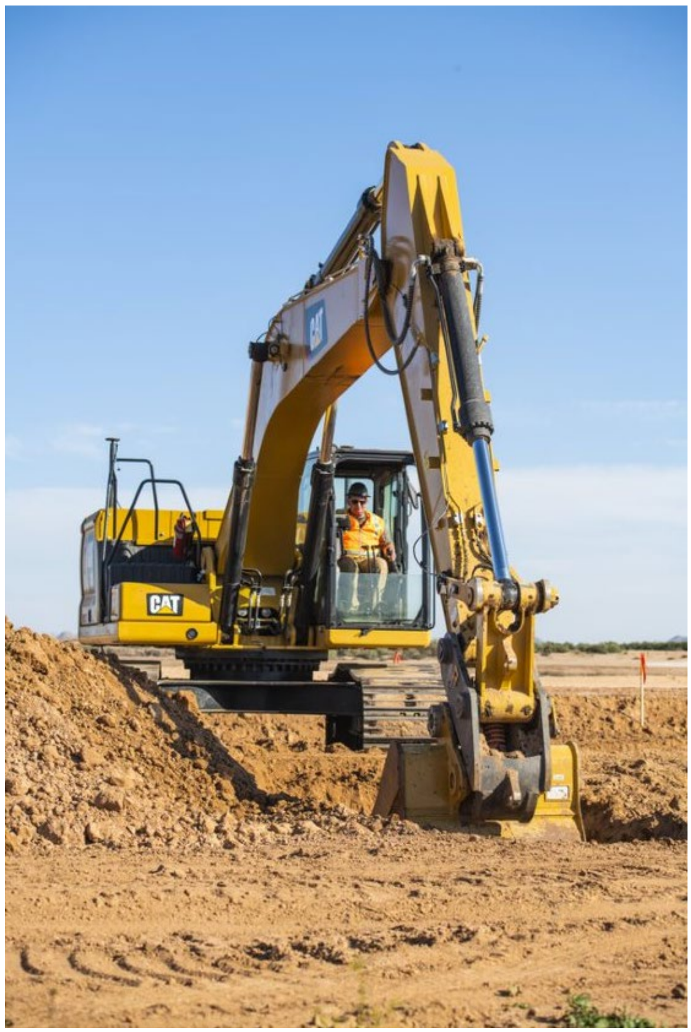
GRADEMETRIX™
EXCAVATOR INSTALLATION GUIDE
Revision: A2



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1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

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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

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2002244539	2002325645
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Table of Contents

Chapter 1: Getting Started

Overview

Introduction

This chapter details all the information you need to set up an excavator system complete with all the sensors for a 3D machine control system.

It is recommended only an experienced service technician perform the installation and configuration of the Hemisphere GradeMetrix™ system.

Contents

Tool List

Tool list

This section lists the tools required and the preparation and power setup necessary to prepare your machine for the GradeMetrix excavator system installation.

A variety of tools are needed to properly set up and install your GradeMetrix excavator system.

Note: A welder is required to attach brackets for permanent installations.

Review the following list and locate these required tools prior to installation:

- ☐ Slotted screwdriver
- ☐ Phillips screwdriver
- ☐ Adjustable wrench
- ☐ ½” & 3/8” ratchet set
- ☐ Inch sockets
- ☐ Metric sockets
- ☐ Cable tie cutters
- ☐ Allen wrench set (inch)
- ☐ Allen wrench set (metric)
- ☐ Torx wrench set
- ☐ Wire stripper / Crimp tool
- ☐ SiteMetrix Base and Rover Kit

An instrument to check level and plumb in certain steps of the calibration procedure is necessary. The installation and calibration shown in this guide is completed without a total station or line transit.

Some recommended tools are:

- ☐ Tape measure
- ☐ Open wheel measuring tape
- ☐ Laser level
- ☐ Plumb bob w/string
- ☐ Magnets for holding string
- ☐ Line level
- ☐ Total station or line transit

Prepare for Installation

Prepare for installation

To prepare for an excavator installation place the excavator on a flat surface. The installation area must be large enough for a machine to rotate 360 degrees with the boom and stick fully extended without risk of injury or damage to surrounding property.

A GNSS base station must be installed (see Appendix C, Set Up a Base Station and Rover) when doing a 3D calibration.

Locate a clean source of power and a safe mounting location for the IronOne control box. Check to ensure the IronOne control box and sensors have power. The GMS-1 sensors are powered through the IronOne and receiver.

Important: The IronOne must receive 7 – 36 VDC of input power from the machine (most machines should provide 24 V directly from the battery).

Note: The IronOne must be installed so that the operator can see the screen. Use care not to place the IronOne in a location that might compromise visibility or block an exit from the cab.

Chapter 2: Install Hardware Components

Overview

Introduction

Chapter 2 provides all the information you need to install the hardware components needed for the GradeMetrix excavator installation.

Contents

IronOne Display Installation

Install the IronOne

The GradeMetrix Excavator Installation Kit comes with the following components:

1) IronOne (P/N: 752-0036-10)
2) IronOne Power Cable (P/N: 710-0210-10)
3) IronOne U-Mount Kit (P/N: 710-0149-10)
4) IronOne Flush Mount Kit (P/N: 710-0148-10)

To install the IronOne, you must have:

1) Philips Screwdriver
2) Nut driver

The IronOne control panel console (P/N: 752-0036-10) and mounting assembly (RAM mount included in the GradeMetrix Excavator Installation Kit) should be installed inside of the cab in a location that does not obstruct the operator's view.

In Figure 2-1, the IronOne is mounted to the firewall on the right side of the cab, so the operator has full view, and the IronOne is on the opposite side of the door.

Figure 2-1: IronOne control box-mounting option #1

Continued on next page

Install the IronOne, continued

Figure 2-2: IronOne control box-mounting option #2

Note: Each machine is different, so some customization may be necessary in any portion of this installation (see Figure 2-1 and Figure 2-2). Some installers may wish to mount the IronOne in a different location or with custom built brackets.

Continued on next page

Install the IronOne, continued

Follow these steps to install the IronOne control box to your machine:

Table 2-1: Install IronOne control box

Step	Action
1	Attach the 1.5" RAM ball to the rear of the IronOne using the included bolts.
2	Install the 1.5" RAM base mount to an unobstructed location in cab for console mounting. **Note:** The RAM swivel mount can be used to adjust the location and viewing angle of the console.
3	Using the IronOne U-Mount Kit, (P/N: 710-0149-10), mount the IronOne to the window rails at the right side of machine cab.
4	Ensure adequate cable slack is provided, so the IronOne can swivel on the RAM mount without putting stress on the cables.

The IronOne power cable runs power to the IronOne console.

The main power cable (P/N: 054-0182-10) connection leads should be installed to system power (9-30 +VDC and chassis ground). Do not ground to the negative terminal of the battery; always ground to the machine chassis**.**

The IronOne bulkhead adapter cable harness (P/N: 710-0210-10) must be installed and routed along the interior side of the cab. Install harness cables away from sharp edges and other areas that could damage cables. The cable provides the following connections for the installation:

- **Serial (1)** – 6-pin Deutsch Connector -Connects to the GNSS receiver
- **CAN (1**) – M12 Connector -Connects to CAN axial sensors for monitoring boom, stick, and bucket movement

Note: When installing cables, ensure you leave enough slack behind the IronOne so the display screen may be moved in any direction and will not place any stress on the cabling.

Continued on next page

IronOne cable schematic

The diagram below shows the cable schematic for P/N: 051-0408-10.
The J1 connector plugs into the IronOne. The J2 connector connects a CAN cable. The J3 connector connects to the VR500 or VR1000 cable.

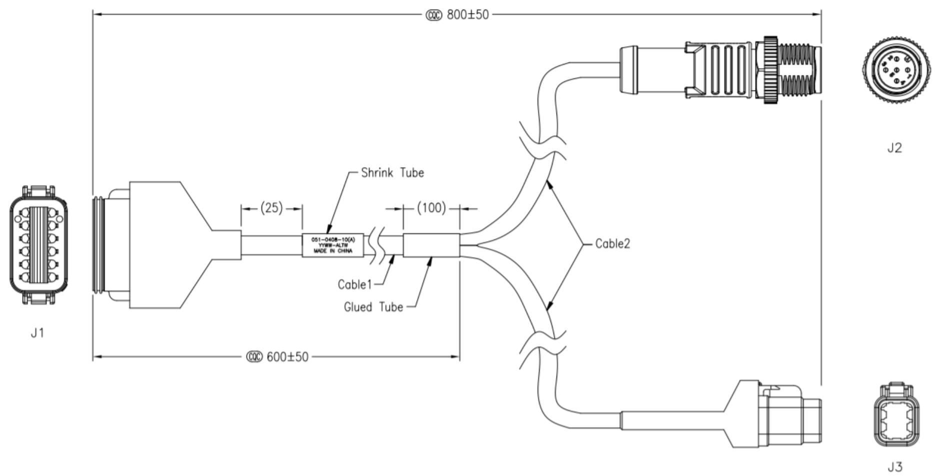


Figure 2-3: Cable schematic for Part Number 054-0182-10

GMS-1 Sensor Installation

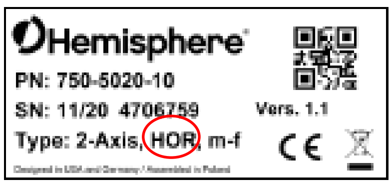
Install the sensors

There are two types of GMS-1 sensors. There is a horizontal sensor (P/N: 750-5020-10) used on the chassis and a vertical sensor (P/N: 750-5019-10) used on the boom, stick, and dog bone. If you purchased a tilt bucket kit, an additional vertical sensor is included for the tilt bucket or tilt hitch.

Important: Take care and ensure the horizontal and vertical sensors are mounted in the correct location.

The labels on the GMS-1 sensors clearly indicate a horizontal or vertical sensor.

Below is a horizontal sensor label.



Below is a vertical sensor label.

The mounting bracket must be welded to the appropriate locations:

- **Body sensor** – Horizontal slope sensor to measure the pitch and roll of machine.
- **Boom sensor** - Vertical tilt sensor to measure angle of boom
- **Stick sensor** – Vertical tilt sensor to measure angle of stick
- **Dog-bone sensor** – Vertical tilt sensor mounted on bucket linkage

Important: Choose safe welding locations for each sensor. Before welding the dog bone sensor, ensure the bracket will clear the stick and bucket if the bucket is opened and/or closed. Boom/stick sensors are ideally mounted behind hydraulic cable for safety.

We recommend mounting the dog bone sensor first, as the extra cable can be easily hidden at the chassis rather than hidden at the stick. Ensure all sensors are mounted on a flat suface and remain parallel throughout the attachment's movement. Do not mount on a tapered surface.

Continued on next page

Install the sensors, continued

Your kit includes five CAN cables. The sizes vary according to the machine size ordered. The five cables are to run from the IronOne to chassis sensor, chassis sensor to boom sensor, boom sensor to stick sensor, and stick sensor to dog bone sensor. All kits include an extra cable.

Additional environmental protection is recommended for CAN cabling, particularly at the bucket end of the machine that is most susceptible to accidental damage. Some options are spiral wrap (hydraulic version), hydraulic hose, fuel hose or corrugated conduit.

The table below lists the cable sizes included with each kit.

Table 2-2: Machine cables

Machine	Description	051-0425-10 2m Cable	051-0425-20 3m Cable	051-0425-30 5m Cable	051-0425-40 10m Cable
980-0077-10	VR500 Excavator	0	2	3	0
980-0078-10	Small	1	2	2	0
980-0078-20	Medium	0	2	3	0
980-0078-30	Large	0	0	4	1

Continued on next page

Brackets

The GMS-1 sensors include a base bracket (P/N: 602-1194-10) that can be welded to the machine. This bracket has two welding holes, so that the bracket can be welded to the machine, hiding the weld. Refer to Figure 2-4 for bracket dimensions.

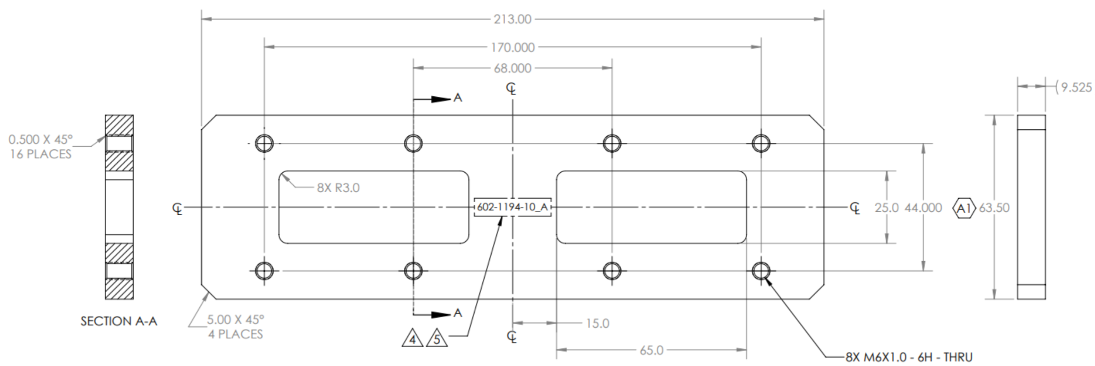


Figure 2-4: Bracket dimensions

After the base bracket has been welded onto the machine, the GMS-1 sensor can be bolted onto the bracket with the provided 20mm M6x1mm screws. The GMS-1 sensors are male/female sensors. The female end always points to the cab, and the male end always points to the bucket.

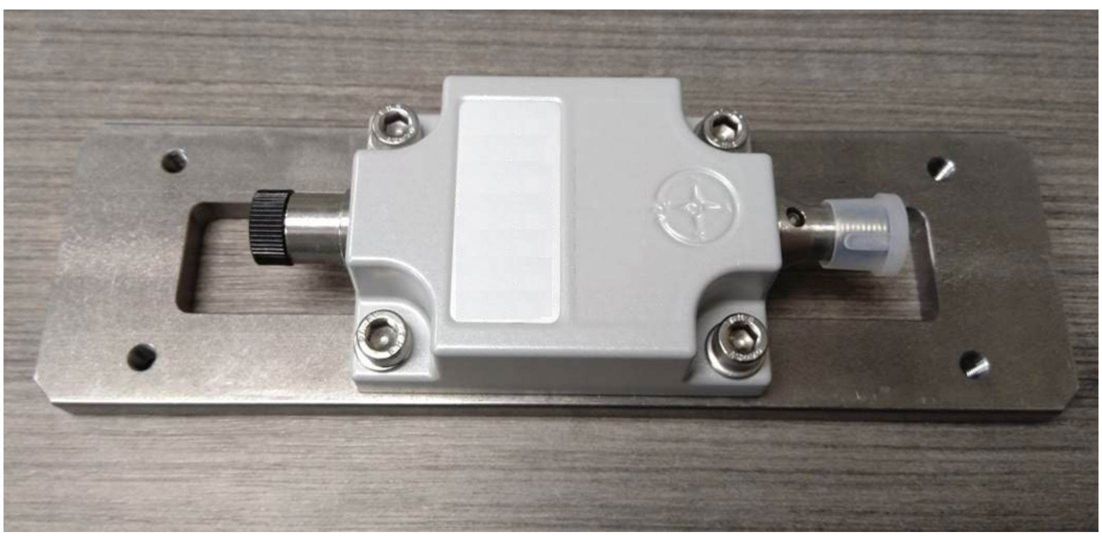


Figure: 2-5: Bracket

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Brackets, continued

The chassis, boom, and stick sensors include two strain relief wings. Screw the strain relief wing onto the bracket (P/N: 602-1196-10) (Figure 2-7) with the provided 14mm M6x1mm screws. The CAN cable can be zip-tied to the strain relief wing.

Figure 2-6 shows the drawing of the P/N: 602-1196-10 strain relief wing.

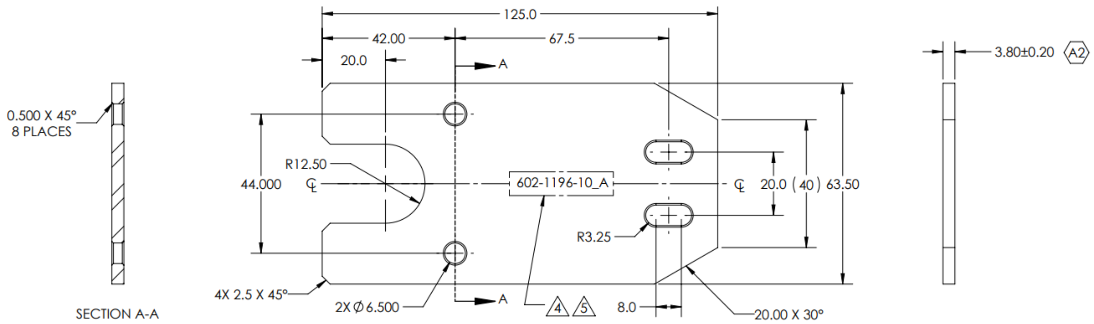

Figure 2-6: P/N: 602-1196-10 strain relief wing

For the dog bone, one strain relief plate and one spacer (P/N: 602-1197-10) is included. The spacer can be attached to the base bracket on the opposite side of the strain relief wing using the provided 14mm M6x1mm screws.

Note: The standoffs are used only in the dog bone installation because a cover placed (not bolted) over the installation.

For the chassis, boom, and stick, use the M6 screws instead of the standoffs, and bolt (P/N: 602-1195-10) the cover onto the installation.

If installing a tilt bucket, the tilt bucket includes an extra strain relief wing. This can be used on the dog bone sensor in place of the spacer, as the terminator will be on the tilt bucket, and not on the dog bone.

Continued on next page

Mount the dog-bone sensor

Most installers choose to start installation with the dog bone sensor. When mounting the sensor on a dog bone, ensure the cable is properly guided and attached. Verify there is enough slack to allow the bucket to be fully opened and fully retracted before tacking the bracket onto the dog bone. If possible, mount the sensor inside of the dog bone.

You should take extra care to ensure that the bracket and cabling clear the bucket with the bucket all the way open and all the way closed.

Note: Excessive cable will result in damage to the cable and the sensor.

If not installing a tilt bucket, use the provided spacer under the terminator.

Figure 2-7: Dog-bone sensor

Continued on next page

Mount the stick sensor

Mount the stick sensor to be visible to the machine operator. Route the cable neatly using the existing hydraulic hose lines. In the image below, the stick sensor is shown protected behind hydraulic hose. The stick angle is the angle from the boom pin to the dog bone pin. You should try to mount the sensor as close to this angle as possible.

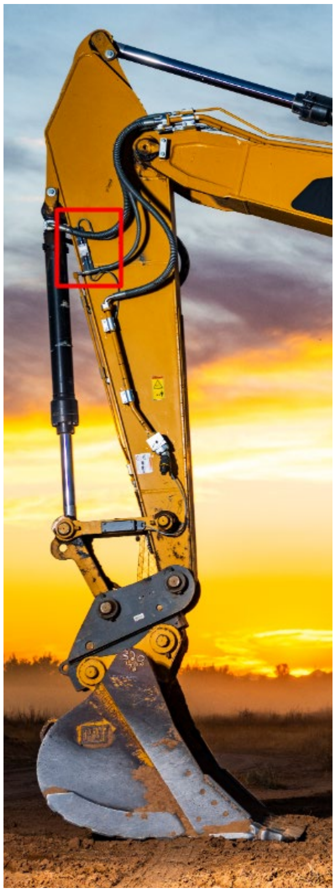

Figure 2-8: Stick sensor

Note: You are permitted to mount the sensor on the left or right (using the correct software configuration). Best practice is to mount the sensor on the left side of the stick, so the operator has clear view of the sensors.

Recommended: *Take care to route the cable to the side of the hydraulic hose – not on the outer or inner bend of the hose.*

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GMS-1 Sensor Installation, Continued

Mount the boom sensor

Mount the boom sensor parallel to the boom center line. Place the sensor in an easily accessible location.

Note: You are permitted to mount the sensor on the left or right of the boom. Best practice is to mount the sensor on the left side of the boom, so the operator has clear view of the sensors. You can also install the boom sensor on the right-hand side for easy access from the access ladder.

Figure 2-9: Boom sensor mounted to boom top showing plate welds

Mount the body sensor

The ideal location to install the body sensor for stability is on the machine platform between the boom lift rams, or as close to the center of the machine as possible, mounted to the turret main frame.

Another option is to install the body sensor inside of the machine compartment on main platform.

If mounting in a hidden compartment be sure to note down the sensor orientation before bolting any panels back in place.

VR500 Installation

VR500 Installation

You will install either a VR1000 or a VR500, but you will not install both. The VR1000 is a GNSS + heading receiver with two external antennas. The VR500 is a GNSS + heading receiver with two internal antennas.

IMPORTANT NOTE: Do not install the VR500 on machines with a reach greater than 4 meters!

First, decide where you want to mount the receiver. If you flip the VR500 over, you will see an arrow (that is on the opposite side of the LED lights). Face the arrow either forward ("pitch" orientation) or face the arrow to the right ("roll" orientation).

Use the following instructions to mount the VR500.

Table 2-3: Mount the VR500

Step	Action
1	Install the VR500 onto the mounting bracket.
2	If welding to a surface plate, (Weld Plate Kit P/N: 710-0158-10), square it center and close to the centerline of cab.
3	If you are using magnetic mounting, (Mag Mount Kit P/N: 710-0157-10) remove the bottom plate and install the magnets directly on the cross bars. **Important: If the antenna mount moves or the antenna location is changed, the 3D calibration must be redone, or the machine will be inaccurate. We recommend permanently marking the exact location for future reference.**

Continued on next page

VR500 Installation, continued

Table 2-3: Mount the VR500 (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>4</td><td>Figure 2-10 shows the VR500 mounting brackets. If you are using a weld-on mount, use the bottom plate.

Do not use the bottom plate if you are using the magnetic mount.

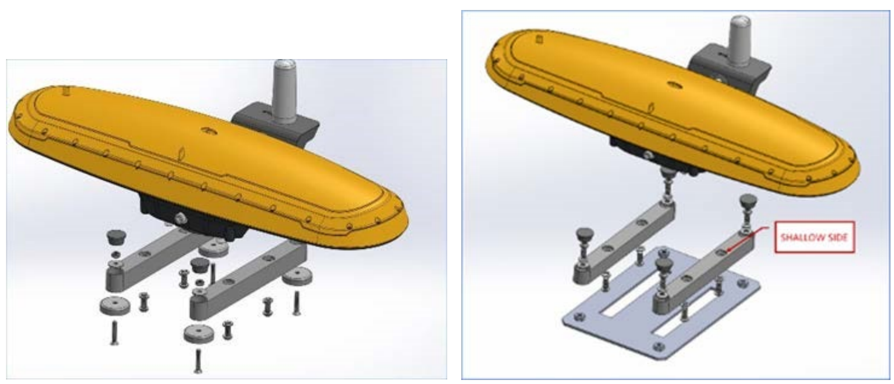
Table 2-4: Permanent mount (P/N: 710-0157-10)
<table>
<tr><th>Part Number</th><th>Description</th></tr>
<tr><td>602-1186-10</td><td>BRACKET, VR500 MC MOUNT</td></tr>
<tr><td>602-1185-10</td><td>PLATE, WELDED, VR500 MC MOUNT</td></tr>
<tr><td>681-1076-10</td><td>PLUG, LDPE, FOR 23.4mm DIA HOLE</td></tr>
<tr><td>675-1342-10</td><td>SCR, BUTTON HEAD, HEX, M8X1.25, 20MM, SS</td></tr>
<tr><td>678-1146-10</td><td>WSHR, FLT, 0.344" ID, 0.75" OD, SS 18-8</td></tr>
<tr><td>678-1145-10</td><td>WSHR, LCK, 8.5mm ID, 14.8mm OD, SS.18-8</td></tr>
</table>


Figure 2-10: VR500 mounting brackets</td></tr>
</table>

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VR500 Installation, continued

Table 2-3: Mount the VR500 (continued)

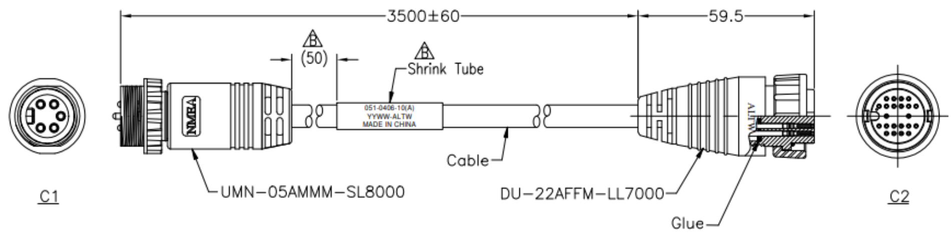
<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>5</td><td>

Table 2-5: Magnet Mount: (P/N: 710-0158-10)

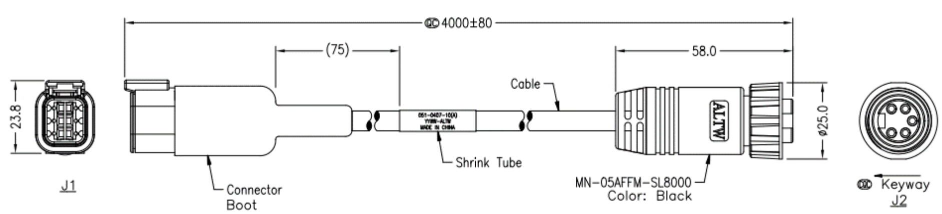
<table>
<tr><th>Part Number</th><th>Description</th></tr>
<tr><td>602-1186-10</td><td>BRACKET, VR500 MC MOUNT</td></tr>
<tr><td>681-1076-10</td><td>PLUG, LDPE, FOR 23.4mm DIA HOLE</td></tr>
<tr><td>675-1342-10</td><td>SCR, BUTTON HEAD, HEX, M8X1.25, 20MM, SS</td></tr>
<tr><td>678-1145-10</td><td>WSHR, LCK, 8.5mm ID, 14.8mm OD, SS.18-8</td></tr>
<tr><td>478-0020-10</td><td>MAGNET, BASE, ENCASED, NEODYMIUM, 1.75"OD, .375"THK</td></tr>
</table>

</td></tr>
<tr><td>6</td><td>

After mounting the VR500, connect the 3.5m cable P/N: 051-0406-10 to the VR500 on the 22-pin side. (See Appendix D Cable Pin-Outs for more information).



The 5-pin connector above can be connected directly to the 5-pin connector on cable P/N: 051-0407-10. (See Appendix D Cable Pin-Outs for more information). Alternatively, there is a supplied bulkhead connector (P/N: 676-0036-0) that can connect these two cables and be drilled through a firewall.

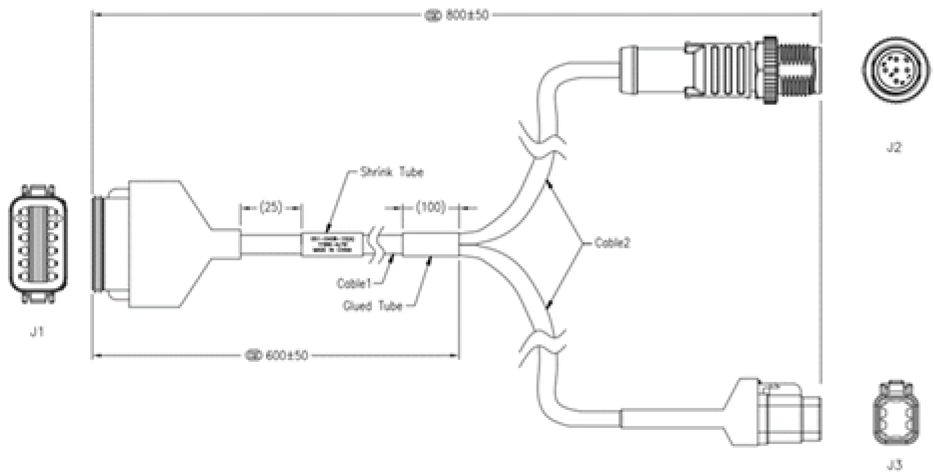


</td></tr>
</table>

Continued on next page

VR500 Installation, continued

Table 2-3: Mount the VR500 (continued)

Step	Action
7	The VR500 cable (P/N: 051-0407-10, shown in Step 6) connects to the IronOne cable (P/N: 051-0408-10) shown below. (See Appendix D Cable Pin-Outs for more information).  **Figure 2-11: IronOne Bulkhead Cable P/N: 051-0408-10**

VR1000 Installation

Overview

You will install either a VR1000 or a VR500, but you will not install both. If installing a VR1000, you must weld the antenna masts to the counterweight of the machine.

Find a safe location to mount the VR1000 (magnets included) and run the coaxial cables from the A46 antennas to the VR1000.

Mount the GNSS antenna

The VR1000 requires the use of two GNSS antennas. One GNSS antenna is used for position and the other antenna is used to provide heading. The VR1000 comes with four magnets (4mm hex bolt with 8mm nut).

The VR1000 will provide an accurate GNSS position and heading. However, as the distance to the bucket teeth increases, a heading error will result in a horizontal error at the teeth of the bucket. Because of this, larger machines can be more susceptible to error (however, this is offset some since larger machines often allow for a larger antenna separation, which reduces heading error).

Antennas should be mounted as high and as far apart from each other as possible. To improve the VR1000 heading accuracy on a larger machine, separate the antennas (up to 10m).

The primary antenna should be mounted on the left side of the machine and the secondary antenna on the right side (roll orientation), or the primary antenna should be mounted in the back of the machine and the secondary antenna in the front (pitch orientation).

The table below is an example of **heading induced error** by antenna separation at 10m.

Table 2-6:-Antenna separation and horizontal error

Antenna Separation	10m	20m	30m
0.5m	3.5cm HRMS	7.0cm HRMS	10.5cm HRMS
1.0m	1.7cm HRMS	3.5cm HRMS	5.2cm HRMS
2.0m	8.73mm HRMS	1.7cm HRMS	2.6cm HRMS
5.0m	3.49mm HRMS	7.0mm HRMS	1.0cm HRMS

Continued on next page

Mount the corrections radio antenna

Mount the radio antenna at the highest point and secure with mounting bolts or a mag mount.

Note 1: The mounting location for RTK antenna can typically be located on top of the cab using a magnet mounted antenna.

Note 2: If receiving RTK over NTRIP, a UHF radio antenna is not necessary.

Figure 2-12: Radio antenna

Continued on next page

Mount the VR1000

Mount the VR1000 in the battery compartnment, or the engine compartment, or behind the seat and as far away from heat sources as possible. The GradeMetrix Excavator Installation Kit contains magnetic mounts so that the VR1000 can be mounted virtually anywhere.

Carefully run the cables into the cab. The GradeMetrix Excavator Installation Kit has a 20’ and 25’ N-Type cable for the two A46 antennas. The cables are color coded for convenience. Connect the WiFi antenna (if necessary) and external UHF radio cable (if necessary).

Note: The power and communication cable must be run into the cab to connect to the IronOne cable. The UHF antenna must be run to the roof of the machine.

Figure 2-13: Mounted VR1000

Continued on next page

Mount the VR1000, continued

Weld masts in a secure location, as far apart from each other as possible. Screw the A46 antennas onto masts and face the N-Type connector in the same direction. If welding to counterweight, some additional sheetwork may be required to spread the load and reduce the risk of cracks.

Note: Be careful not to weld to the engine compartment door, as the door may open and close by.

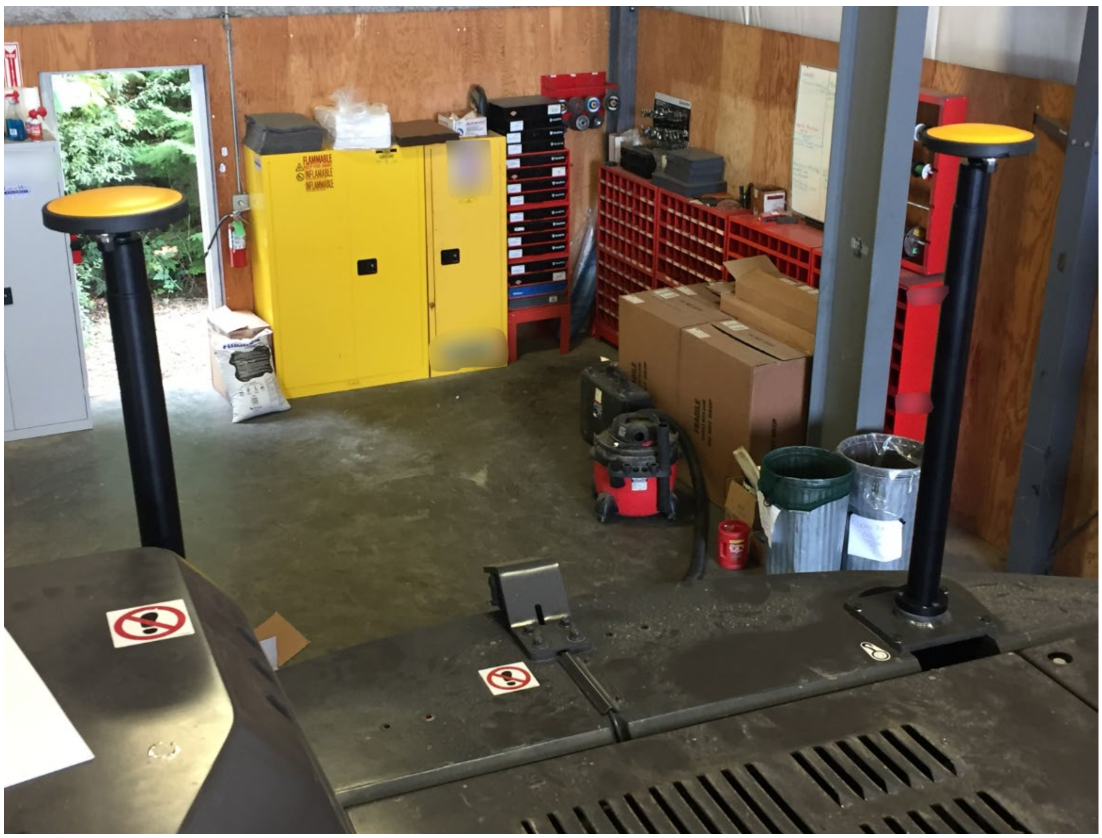


Figure 2-14: Mast mounts

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Running Cables

The IronOne has a bulkhead cable that runs from the IronOne to an M12 male CAN connector and 6-pin Deutsch connector (See Appendix D Cable Pin-Outs for more information).

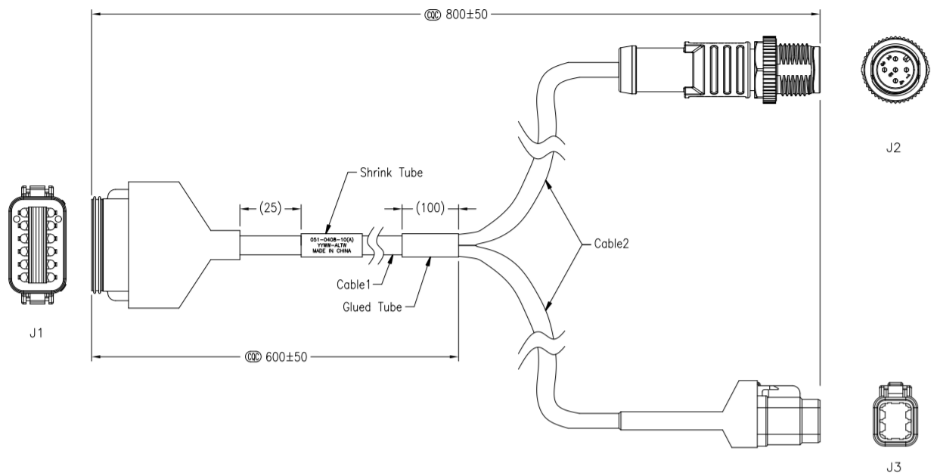

Figure 2-15: J3 Connector

From the 6-pin Deutsch connector (J3 connector in Figure 2-14 above), there is a 5m cable. The J3 connector (shown above) connects to the J2 connector (shown in Figure 2-15 below). The J3 connector below is for using an external UHF radio. We offer the optional 6-pin Deutsch to DB9 cable (P/N: 051-0477-10) as an additional accessory (See Appendix D Cable Pin-Outs for more information).

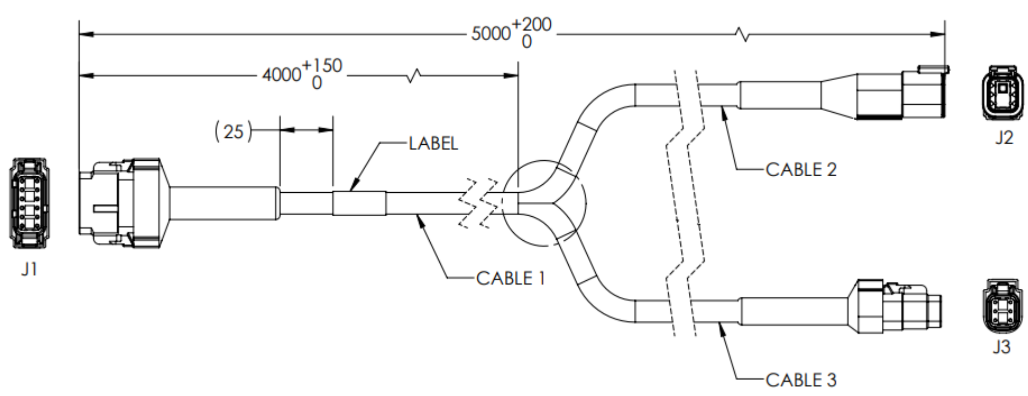

Figure 2-16: J2 Connector

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Running Cables, continued

Finally, connect the J1 connector to the J2 connector. The J1 connector connects to the VR1000. (See Appendix D Cable Pin-Outs for more information).

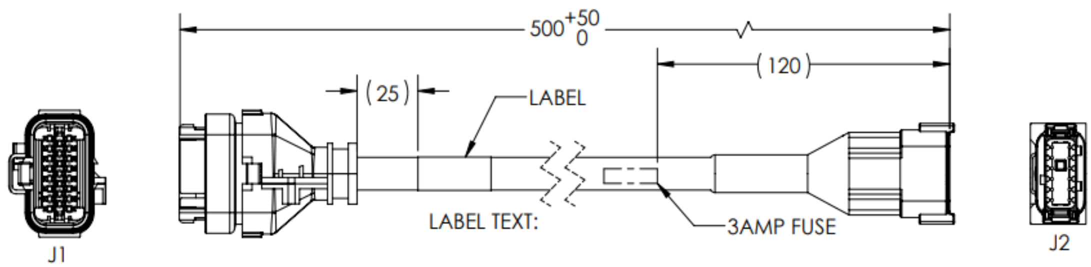


Figure 2-17: J1 Connector

Chapter 3: Measure Machine

Overview

Introduction

After entering the machine dimensions in **Equipment Setup**, you will be prompted to configure the sensors.

Contents

Equipment Setup

Equipment setup

Position the excavator on a flat and level surface. Ensure there is enough area to extend and retract the bucket position and rotation of the machine.

Equipment setup requires accurate measurements of the machine.

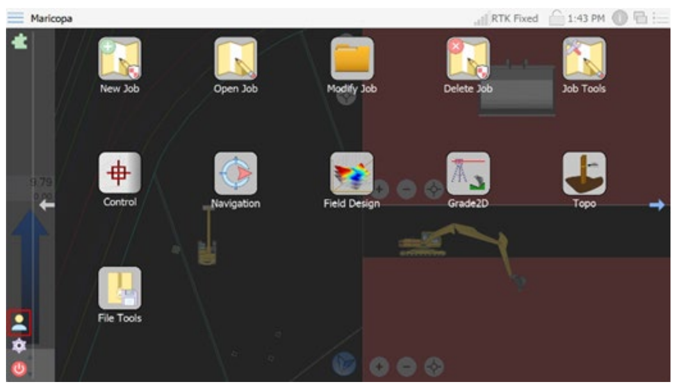
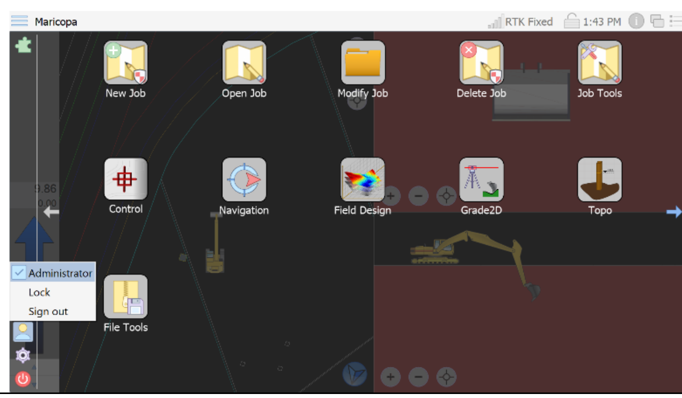
Note: To avoid potential damage to property or nearby individuals, check the surrounding area and confirm it is safe to move and operate the machine.

Continued on next page

Equipment setup, continued

Use the following steps to set up your equipment using GradeMetrix.

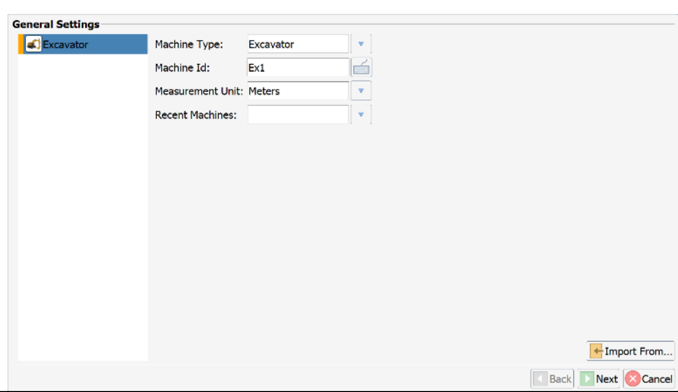
Table 3-1: Set up equipment in GradeMetrix

Step	Action
1	First, log in as **Administrator**. **Note:** An administrator password can be set to prevent unauthorized changes. For details, please see the GradeMetrix User Guide.  

Continued on next page

Equipment setup, continued

Table 3-1: Set up equipment in GradeMetrix (continued)

Step	Action
2	Scroll to the right (clicking the blue arrow on the right-hand side). Click the **Equipment Setup** icon. 
3	Create a **Machine ID**. To create your Machine ID, we suggest using your company's machine number, or use the machine model number. The Machine ID is the reference number you will use to recall your machine. Enter the **Measurement Unit**. **Note:** You can set measurements to either metric or imperial settings. If your job uses imperial units, machine measurements can be taken using the metric settings (providing greater precision). 
4	Click **Next.**

Continued on next page

Measure the machine

When measuring the machine, accurate measurements are critical for correct results. Other measurements are for graphical purposes only and not used in the calculations.

Click the **Antenna** tab. Set **Type** to either VR500 (if a VR500 was installed) or VR1000 (if a VR1000 was installed).

The "Orientation" will display "As Roll" or "As Pitch." If the antennas are installed such that the primary antenna is on the left side of the machine and the secondary antenna is on the right side, you have installed a "Roll" configuration. If the antennas are installed such that the primary antenna is at the back of the machine and the secondary antenna is in front of the primary antenna, you have installed a "Pitch" configuration. The images below show an example of each. The white circles represent the antennas.

Note: In Figure 3-1, the white circles mark the antennas.

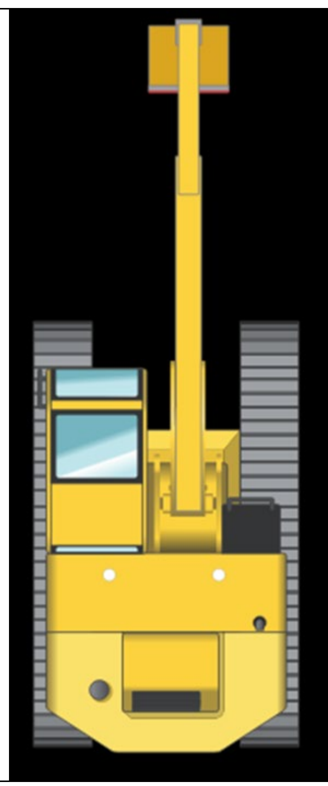
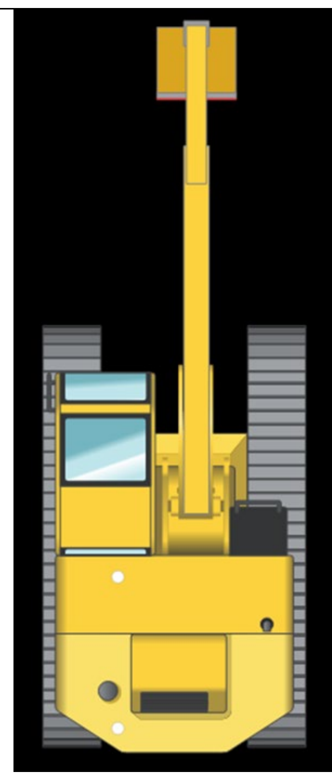
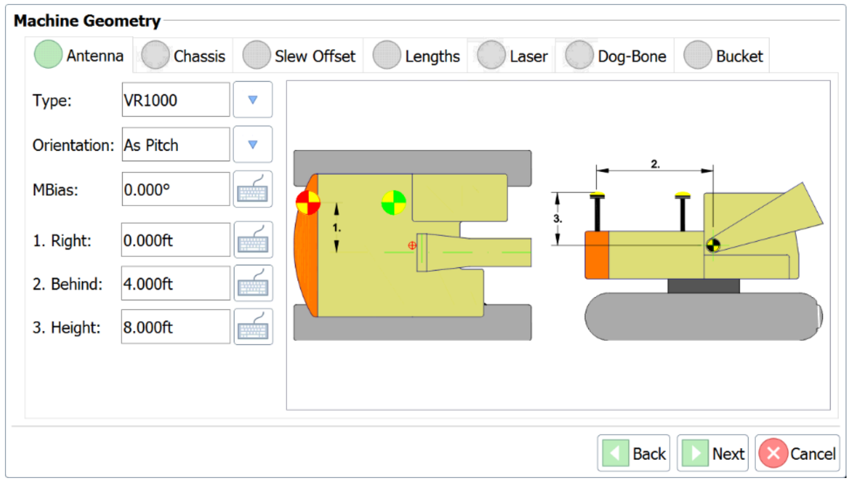
Roll	Pitch
	

Figure 3-1: Antennas oriented roll and pitch

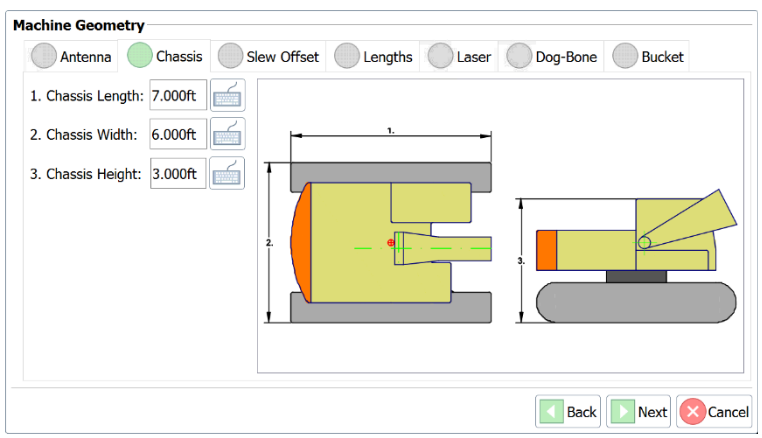
Continued on next page

Measure the machine, continued

Important: MBIAS, right, behind, and height will be automatically populated during the 3D calibration process.



Click the **Chassis** tab. Note the measurements shown below are for example purposes only.



Continued on next page

Measure the machine, continued

The following images show the machine being measured in chassis length, body width, and body height.

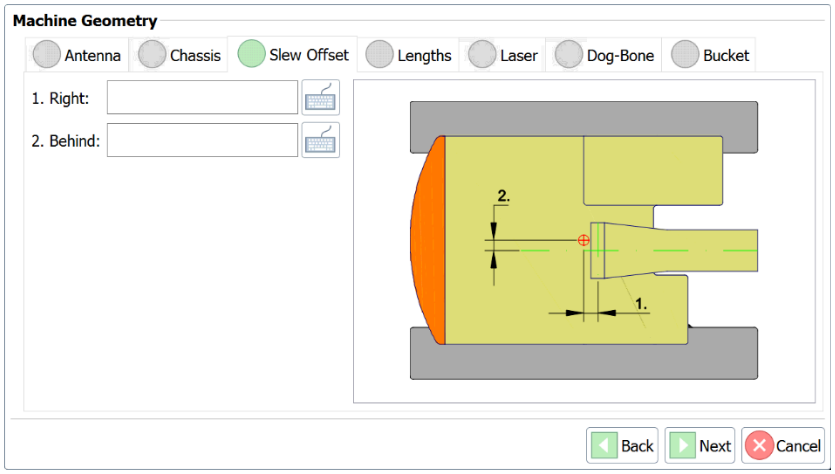
Note: These measurements are for graphical purposes only, millimeter precision is not necessary.

Measurement	Machine Image
Body length	
Body width	
Body height	

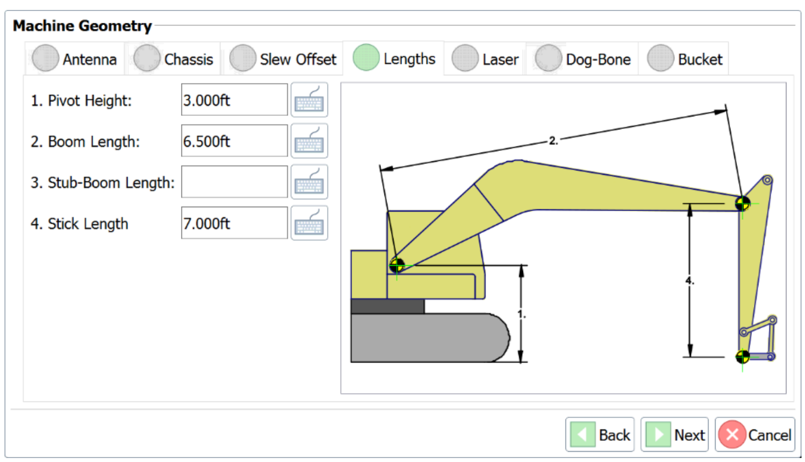
Continued on next page

Measure the machine, continued

Important: The Slew Offset tab information populates automatically during the machine calibration process.



The next tab, **Lengths,** shows the measurements of the machine's pivot points at the pins. These measurements are critical for accurate performance. For best results, measurements should be done with a metric tape measure to millimeter precision. If using feet, use a tape measure with sixteenths (about 1.6mm). A total station can also be used if required (i.e., larger machines).



Continued on next page

Measure the machine, continued

Figure 3-2 shows measuring the boom pin. Take care to precisely measure from the center of the boom pin to the center of the stick pin.

Note: If a single person is doing the calibration, we recommend using a wheel tape and magnet to hold the measuring tape.

One method to measure pivot height, or the height of the boom pin, is to use magnets to set a string line from boom to stick pin and use a line level to level this line. If the machine is on a flat surface and the ground is even, the height of the string line is the height of the boom pin.

Note: Leave the string line to use when calibrating the boom sensor.

Figure 3-2: Measuring the pivot height

Continued on next page

Measure the machine, continued

The boom length is the distance from the boom pin to the stick pin. **Important: Be very precise with this measurement.**

When using a tape measure, ensure the tape is parallel to the boom so that the distance of the boom is accurately measured (versus measuring a slope distance). You can use a ruler (Figure 3-3) to ensure that the tape is parallel to the boom.

Figure 3-3: Measuring the boom pin to stick pin

Continued on next page

Measure the machine, continued

Next, measure the stick length, which is the distance from the stick pin to the bucket pin. You can square a ruler on both the stick and bucket pin to ensure the tape is parallel to the stick.

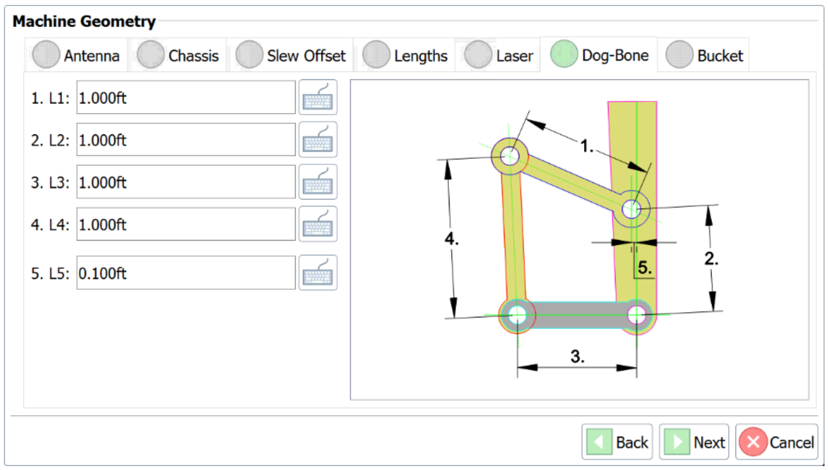
Figure 3-4: Measure stick length

Continued on next page

Measure the machine, continued

Next, enter the dog bone measurements. Click the **Dog Bone** tab.

The **Dog Bone** tab shows the critical measurements of the bucket linkage pivot points at the pins.



The L1-L4 measurements must be measured precisely and entered in per the diagram.

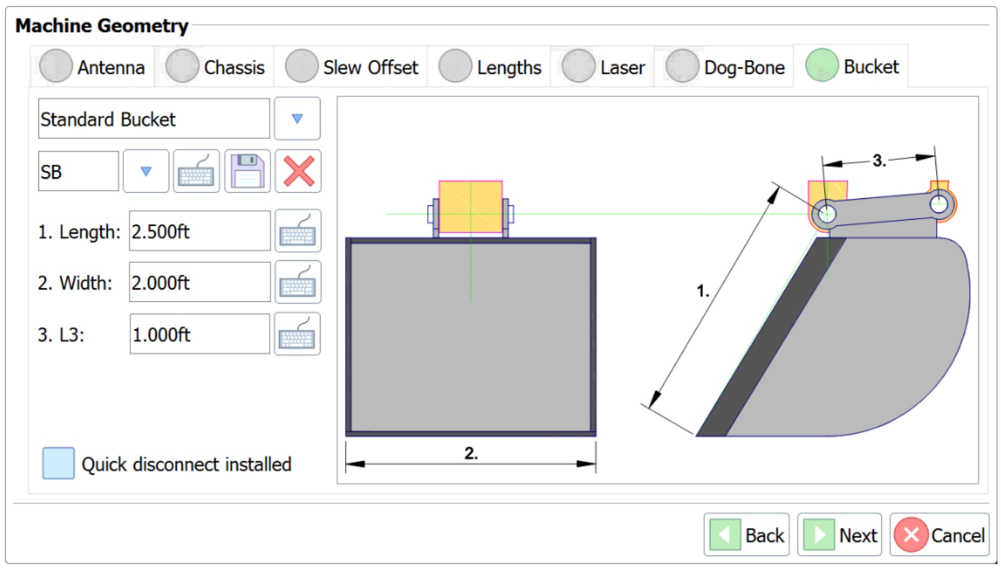
To calculate the L5 offset, run a string line from the stick pin to bucket pin. There will be an offset between the string line and top linkage pin. This measurement must be precisely measured and is the L5 offset.

Continued on next page

Measure the machine, continued

The **Bucket** tab is used to select your bucket type and enter dimensions. Select between a **Standard Bucket**, **Tilted Bucket**, or **Shovel Bucket (reversed bucket with dogbone linkage)**. Enter a name for this attachment. Click **Next**.

Note: Entering a name is required to configure multiple attachments and switch between them.

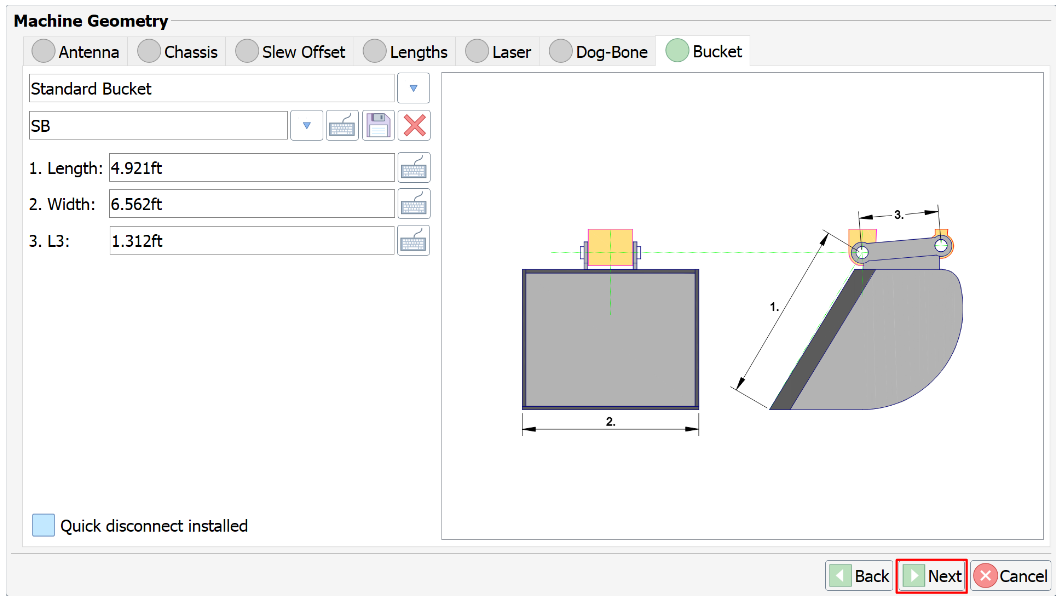


Continued on next page

Set up sensor network

At this point in the calibration process, machine dimensions should have been entered into the software.

The next step is to set up the sensors. After entering machine dimensions, click **Next**.



Continued on next page

Set up sensor network, continued

GMS-1 sensors are shipped with a default CAN ID of 192. Each sensor must be set to a different CAN ID. To set the CAN ID, unplug the CAN cable that runs from the chassis sensor to the boom sensor. Leave the cable connected that runs from the IronOne to connected chassis. This ensures you only have one sensor connected (chassis sensor).

Tip: You can complete this prior to installation (on the bench) and label the sensors.

After configuring the chassis sensor, reconnect the cable to the boom sensor. Then disconnect the cable from the boom sensor to the stick sensor. At this point, only two sensors will be connected. One will be identified as the chassis sensor since it has already been configured that way. The unidentified sensor is the boom sensor.

Configure the boom sensor. Reconnect the cable from the boom to stick. Disconnect the cable from the stick to the dog bone sensor. At this point, only three sensors will be connected. One will be identified as the chassis sensor and another as the boom sensor. The unidentified sensor is the stick sensor.

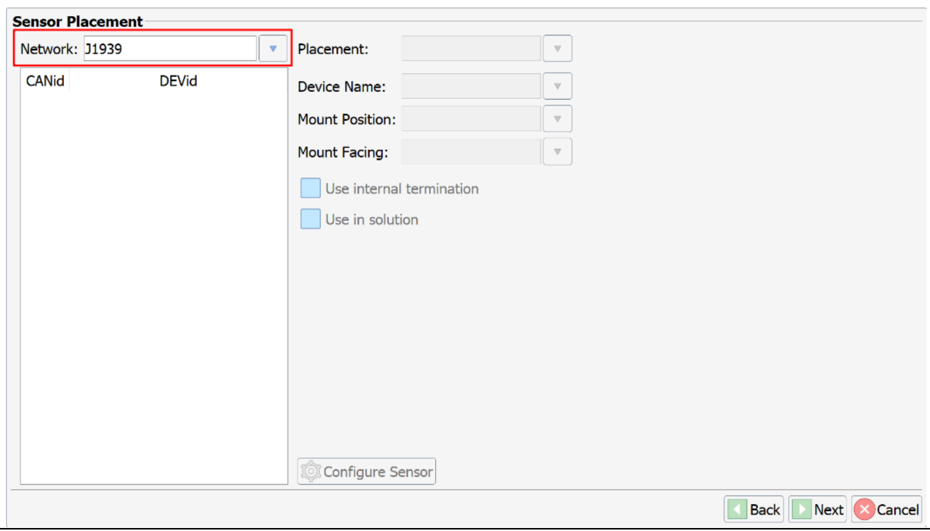
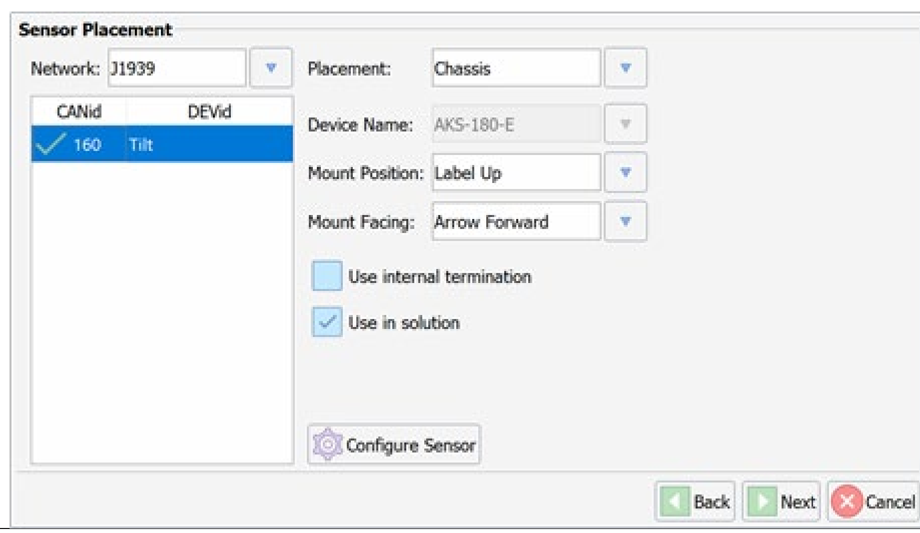
Configure the stick sensor. Reconnect the cable from the stick to dog bone. At this point, all sensors will be connected (except for tilt bucket). The unidentified sensor is the dog bone sensor.

Continued on next page

Set up sensor network, continued

Use the following steps to set up a sensor.

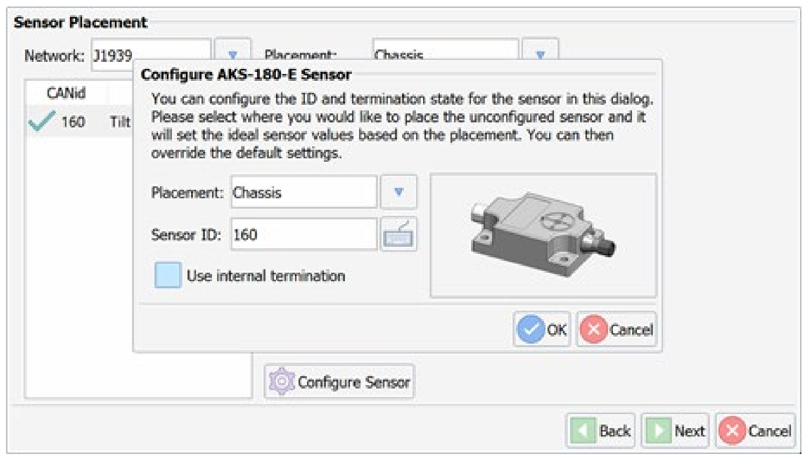
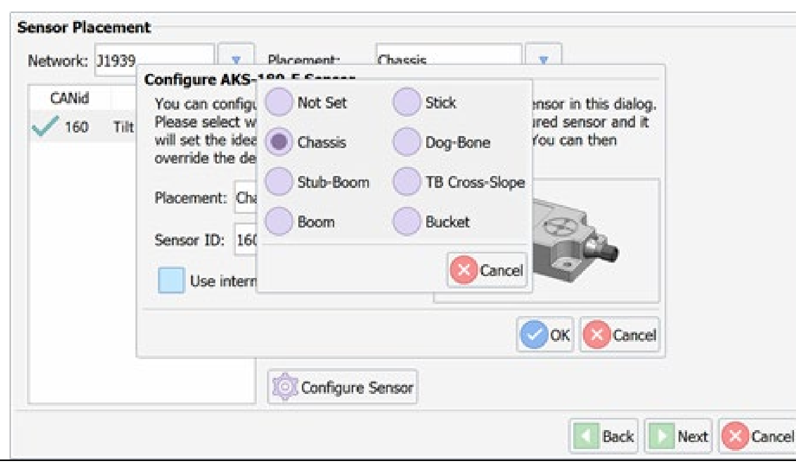
Table 3-2: Set up sensor network

Step	Action
1	Set **Network** to **J1939**. 
2	Click on a **Sensor** (per the instructions above), the unconfigured CAN ID is 192. Click **Configure Sensor**. 

Continued on next page

Set up sensor network, continued

Table 3-2: Set up sensor network (continued)

Step	Action
3	The **Configure AKS-180 E-Sensor** screen displays. Use the drop-down arrow to select **Placement**, or the location the sensor is mounted (i.e. chassis, stick, etc.). The **Use internal termination** option must remain unchecked. The **Sensor ID** field is automatically configured.  The screen below appears. Select the appropriate placement (Chassis, Boom, etc.). 
4	Repeat for each sensor.

Continued on next page

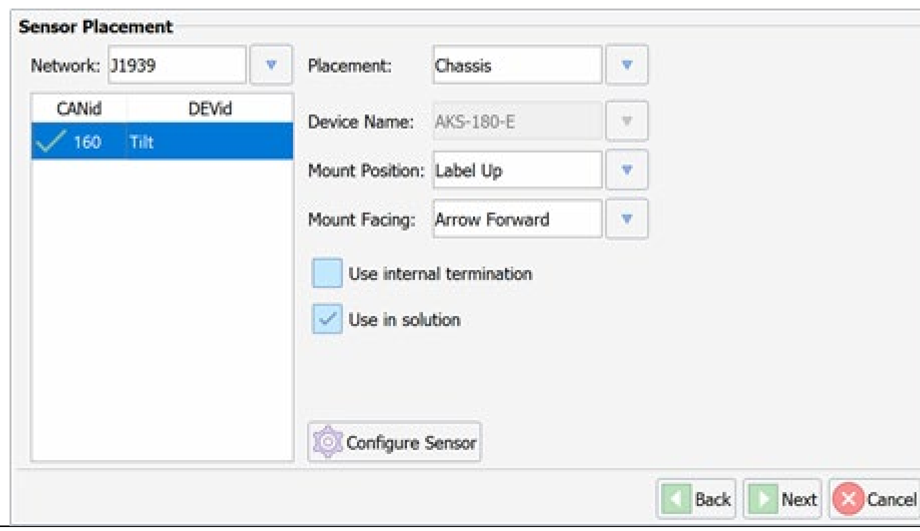
Set up sensor network, continued

Table 3-2: Set up sensor network (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>4</td><td>
Configure the placement of each sensor. **Mount Position** refers to the direction the GMS-1 sensor label is facing. For the chassis, the label is facing up. If you mount the boom/stick/dog bone on the left side of the machine, the label will face up.

For **Mount Facing**, the mount faces the opposite the direction of the LED. For example, with the chassis, if the LED is on the left, “Arrow Right” is the correct mount facing. If the LED is forward facing, the bucket (i.e., boom/stick/dog bone LED), the correct mount facing is “Arrow Back.”

Click to select **Use in solution** and deselect **Use internal termination** since a physical terminator will be installed on the dog bone sensor.



</td></tr>
</table>

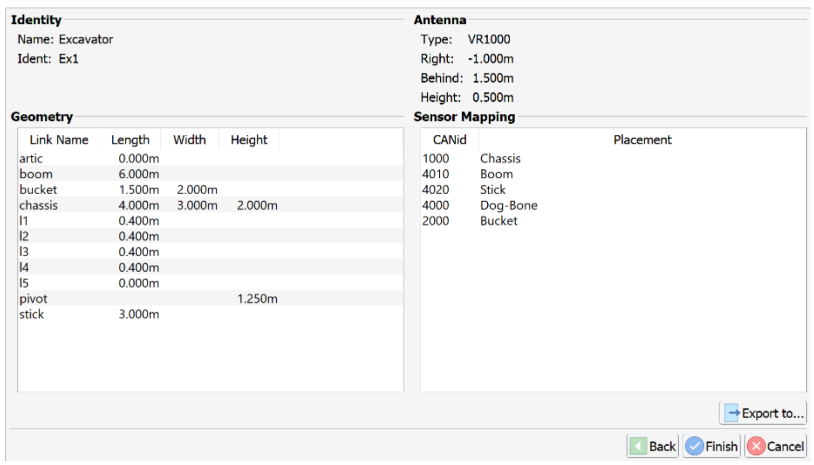
Set up sensor network, continued

Refer to your notes for the **Machine ID** you recorded in the Equipment Setup.

Click **Export to…** to save a copy of the configuration file. This configuration file can be loaded into the software for future use. Please note if the sensors are moved, new measurements will be necessary.

Note: After completing the sensor calibration and/or 3D calibration, return to this dialogue and export the machine file again.

Click **Finish**.

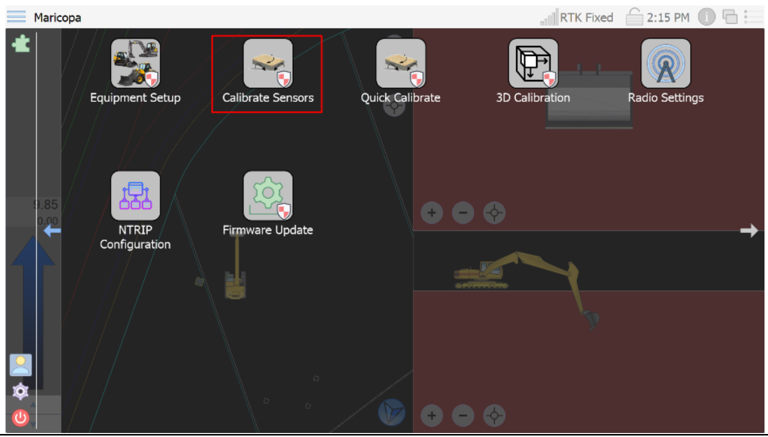
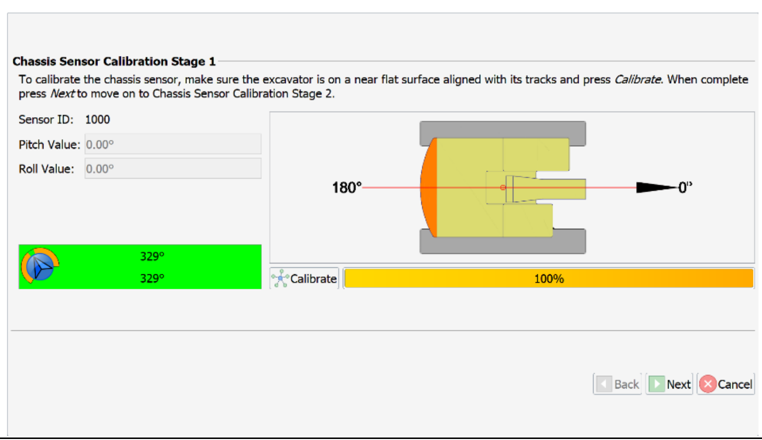


Calibrate Sensors

Calibrate sensors

Use the following steps to calibrate the 2D sensors. You may use any tools you have available, such as a total station or theodolite. The following calibration was done with a tape, string line, and plumb bob.

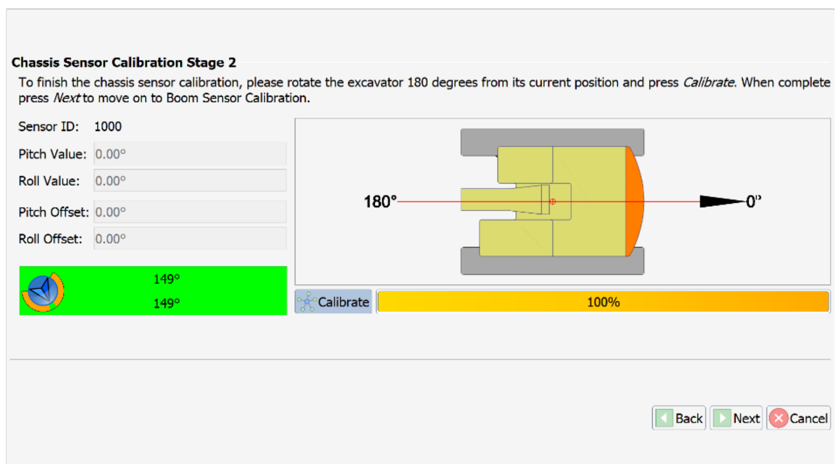
Table 3-3: Calibrate 2D Sensors

Step	Action
1	Go to **Calibrate Sensors**. You must be in **Administrative Mode** to access this routine. 
2	Calibrate the body sensor. Park the machine on a flat surface and click **Calibrate**. 

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
3	After the software has averaged the body sensor, click **Next**. Slew the machine 180 degrees. After you have slewed the machine 180 degrees, click **Calibrate**. In the example below, the initial body sensor calibration was done at a heading of 329 degrees, so the machine needs to slew to 180 degrees. The current heading is 149 degrees (the top is your current heading, and the bottom is your target heading). **Note:** If GNSS has not been installed, the heading will not display. 

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
4	Use a magnet to attach a string line between the boom pin and stick pin. Attach a line level to the string. **Note:** Refer to the string line and line level attached from the pivot height measurements.

Continued on next page

Calibrate sensors, continued

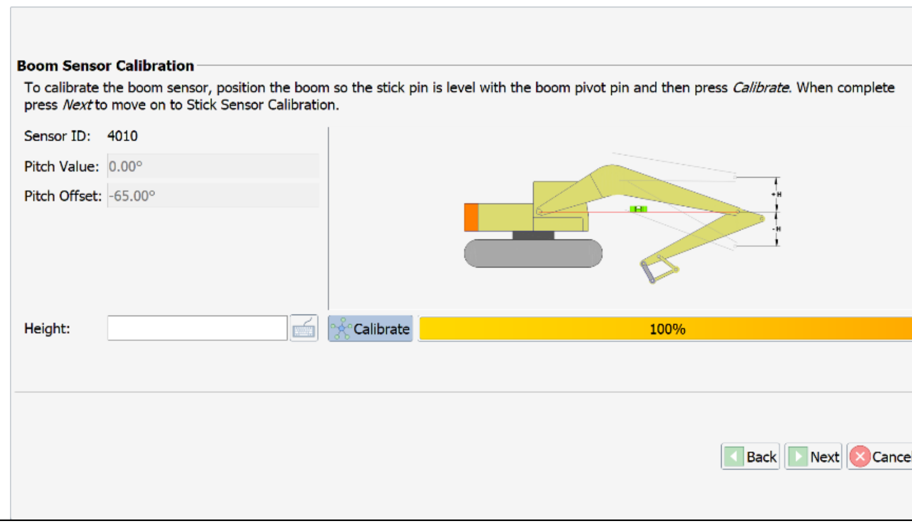
Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
5	Figure 3-7 shows a line level checking that the boom is level. Figure 3-8 shows a string line attached to a magnet placed on the stick pin.  **Figure 3-7: Line level checking boom**  **Figure 3-8: String line attached to magnet on stick pin**

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
6	Look at the current pitch value shown in the calibration software. If the sensor was installed parallel to the line created from the boom to stick pin, the pitch value should be near zero degrees when the line level shows the line is level. 

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
7	When the line level shows that it is completely level, click **Calibrate**. Clicking **Calibrate** informs the software that the sensor line between the boom and stick pins is completely level (i.e., zero degrees). In the image above, the pitch is 0.05 degrees. This represents an offset created from mounting the sensor. Therefore, an offset of 0.05 degrees must be added (see the pitch offset value below). **Note 1:** It is possible that you will not be able to get the boom level. If this is the case, run a string line from the boom pin to below the stick pin. When the string line is level, measure the distance from the string line to the stick pin. Enter this value as the "height" and click **Calibrate**. If the boom is level, omit a value for height.

Continued on next page

Calibrate sensors, continued

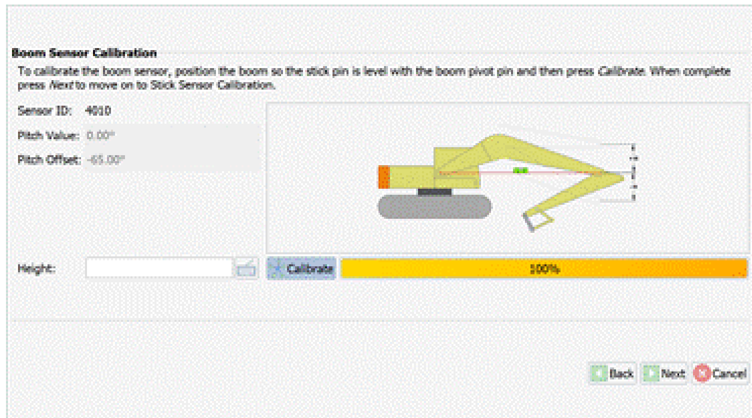
Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
8	You can use other tools such as a laser level to calibrate the boom sensor. Some machines allow you to see the boom pin through the engine compartment. In Figure 3-5, the laser level was set up on the door of the engine compartment and level to the boom pin.  **Figure 3-9: Laser level on door**

Continued on next page

Calibrate sensors, continued

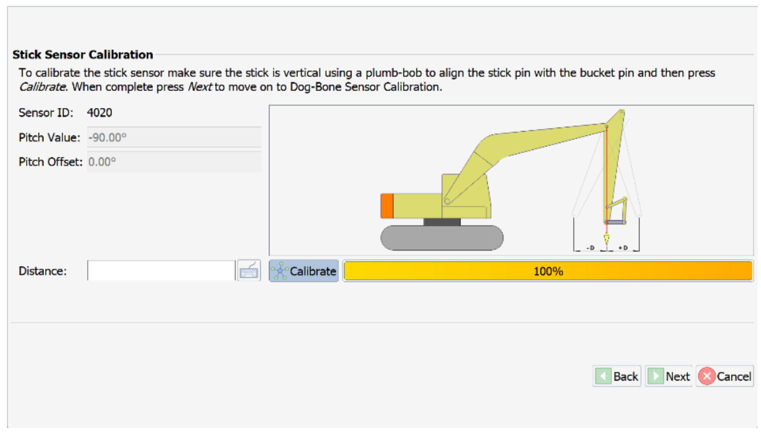
Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
9	Click **Next**. 
10	Use a magnet to attach a string line to the stick pin. Use a plump bob to ensure the string line goes through the exact center of the bucket pin.

Continued on next page

Calibrate sensors, continued

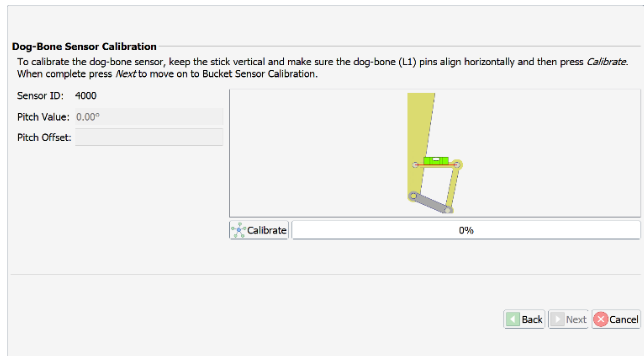
Table 3-3: Calibrate 2D Sensors (continued)

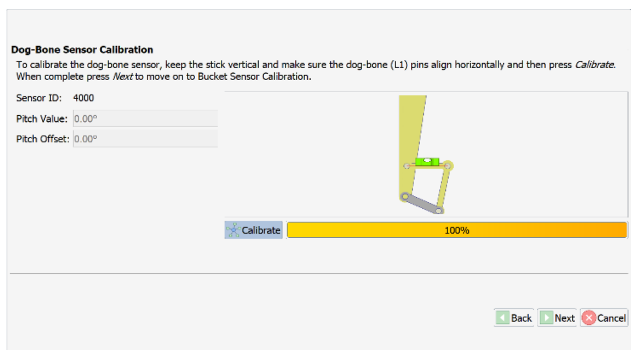
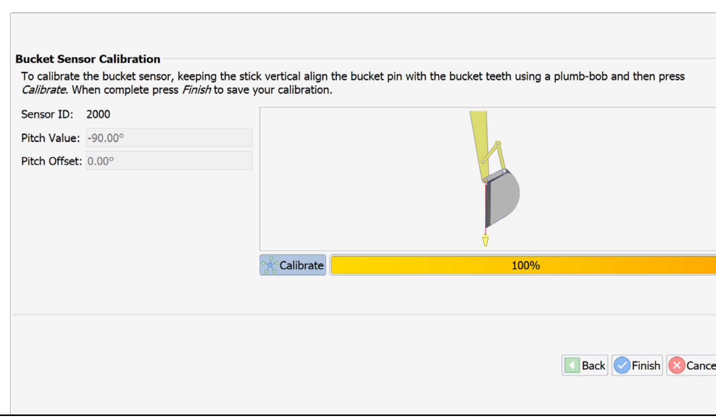
Step	Action
11	If you cannot get the stick plumb, measure the distance from the plumb string line to the bucket pin and enter that distance before pressing **Calibrate**.
12	When the string is plumb, click **Calibrate**.  **Note:** You can also use a total station or theodolite to plumb the stick. Click **Next**.
13	Calibrate the dog bone sensor. Use magnets to place a string line directly over the L1 dog- bone pins.

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

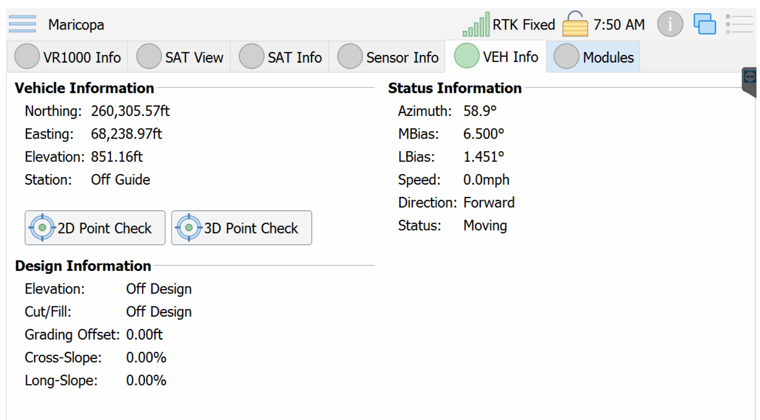
<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>14</td><td>When the string level shows that the line is level, click Calibrate.



</td></tr>
<tr><td>15</td><td>Finally, calibrate the bucket. To do this, drop a plumb bob from the bucket pin (make sure not to use dogbone pin) to the tip of the bucket teeth as shown in the diagram below.

</td></tr>
</table>

Continued on next page

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
16	The sensors are now calibrated. Check the 2D accuracy. **Important: You should only proceed to a 3D calibration if the 2D calibration is accurate.** Go the **Monitor** page. Click **VEH Info**. Click **2D Point Check**. 

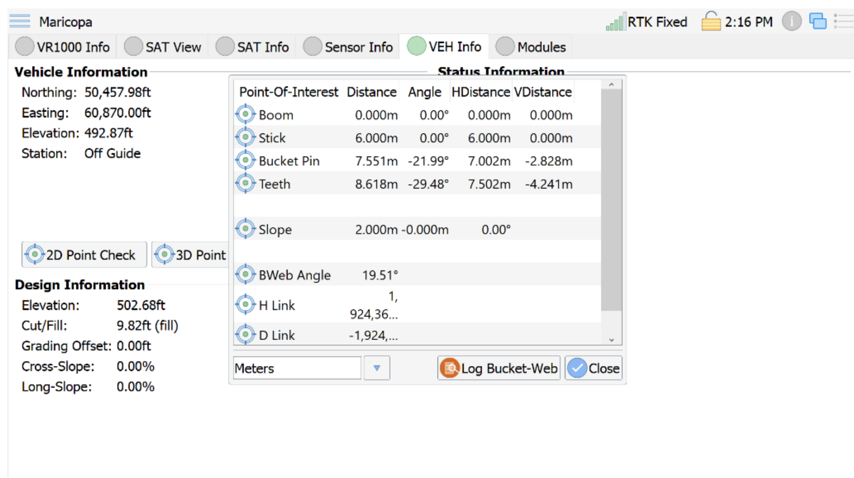
Continued on next page

Calibrate Sensors, Continued

Calibrate sensors, continued

Table 3-3: Calibrate 2D Sensors (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>17</td><td>Use a tape to check the slope distance values from the boom pin to the stick pin, bucket pin, and teeth. The tape should be parallel to the boom at all times (when measuring to teeth, your tape may not be on the center of the bucket).



Note: All measurements are based off the boom pin. Measure from the boom pin and keep the tape parallel to the boom.

Take measurements from the boom pin to the:
• Bucket pin
• Teeth

If the distance from the boom pin to bucket pin is correct, but the distance from the boom pin to teeth is incorrect, there could be a calibration issue with the bucket calibration, dog bone calibration, or an incorrect bucket dimension.

Move the boom, stick, and dog bone into at least ten positions (from fully extended to fully retracted) to ensure that any variation of the orientation or placement the values are correct.</td></tr>
</table>

Chapter 4: 3D Calibration

Overview

Introduction

Chapter 4 contains the instructions you need to configure and calibrate sensors for a 3D calibration.

Contents

Configure and Calibrate 3D Sensors

GPS sensor calibration overview

Before starting the 3D calibration, the following must be completed:

- Check to verify the machine can be safety slewed 360° at full radius without hitting any obstacles.
- Ensure the machine is on level ground, with no greater than ± 0.5° pitch and roll. Check using the sensors diagnostics to confirm the machine is levelled correctly once positioned for testing.
- You must have a completed 2D sensor calibration tested to achieve the correct accuracies (see 2D Calibration).
- You will need a survey rover and data logger configured with the same projection and localization.
- Check the UHF radio link settings are correct for RTK function of machine and GNSS Rover.

Note: It is not necessary to do a site localization for the calibration to function correctly. Simply setup an arbitrary base station and select a UTM zone to match your location. A short base line will increase the accuracy of the calibration.

- Verify that the projection and/or localization match on the rover and machine. Place the rover over the primary antenna on the GNSS to compare Northing, Easting and Height positions data.
- Do not use a separate base station for the machine and survey rover. Do not use an NTRIP service.
- Use tools / magnet makers to mark the measure points on the machine so they are attached correctly and accurately. Start by slewing the house / turret / cab to align with the track base (if not previously completed).
- Rotate the machine on the tracks so that the machine is pointing to WGS north. This can be done by viewing the heading output from the diagnostic screen.

Note: Positioning the excavator to this position will allow safe ingress and egress from the cab in the later stages of the calibration. Enter the 3D calibration menu.

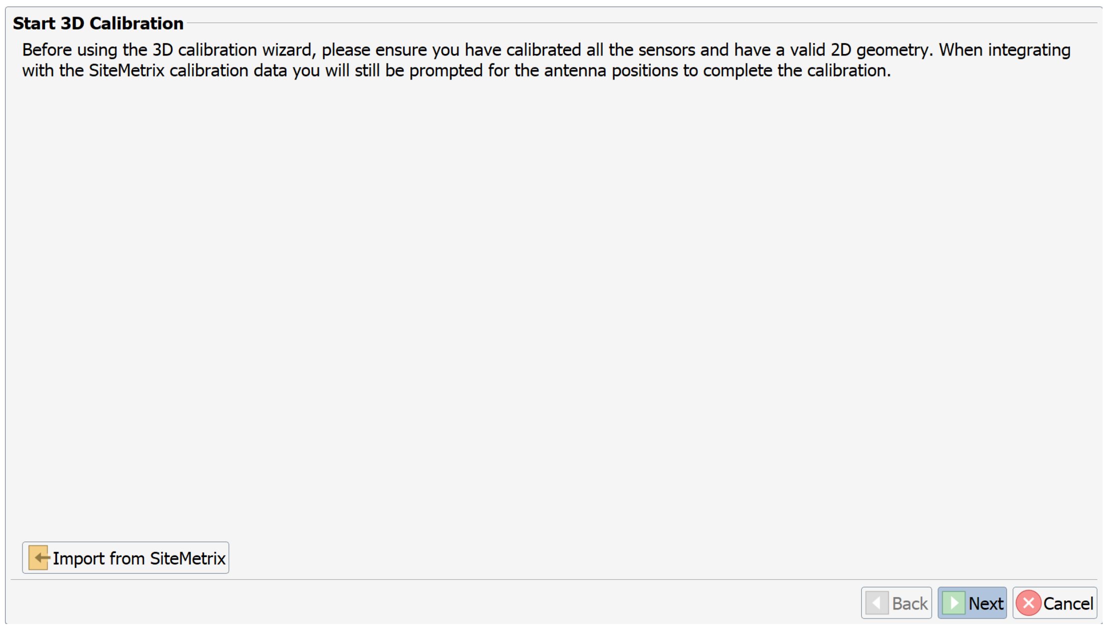
Continued on next page

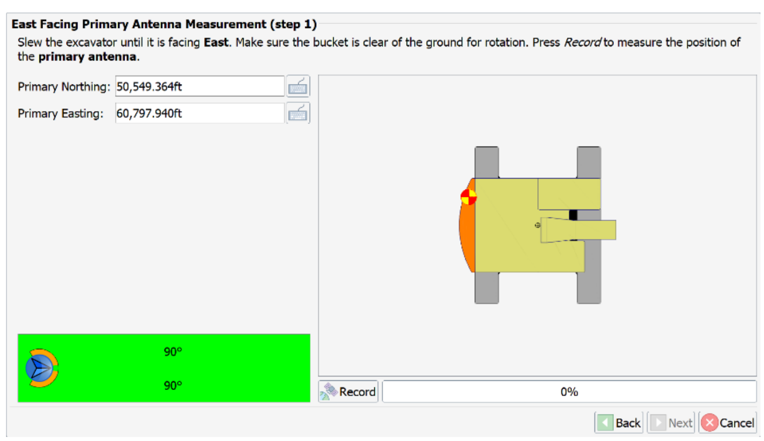
Configure and Calibrate 3D Sensors, Continued

Step 1- GPS calibration

Face the tracks of the machine North. With the bucket lifted off the ground and the boom and stick fully extended, slew the machine until the bucket is facing East. The indicators on the bottom-left of the screen show your target azimuth (90°) and your current azimuth (87 °).

Note: The current azimuth may not be accurate because a heading offset has not yet been calibrated at this point.





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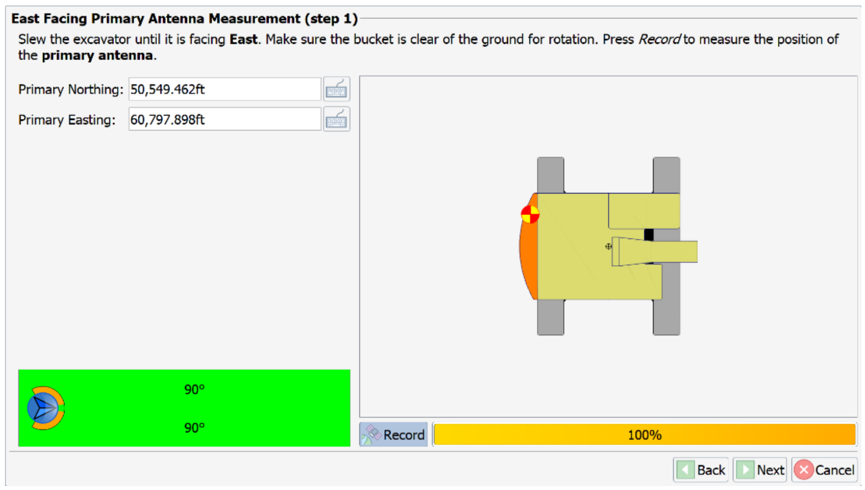
Step 1- GPS calibration, continued

Keep the boom and bucket equipment still to record the **Primary Antenna** location and press the **Record** button.

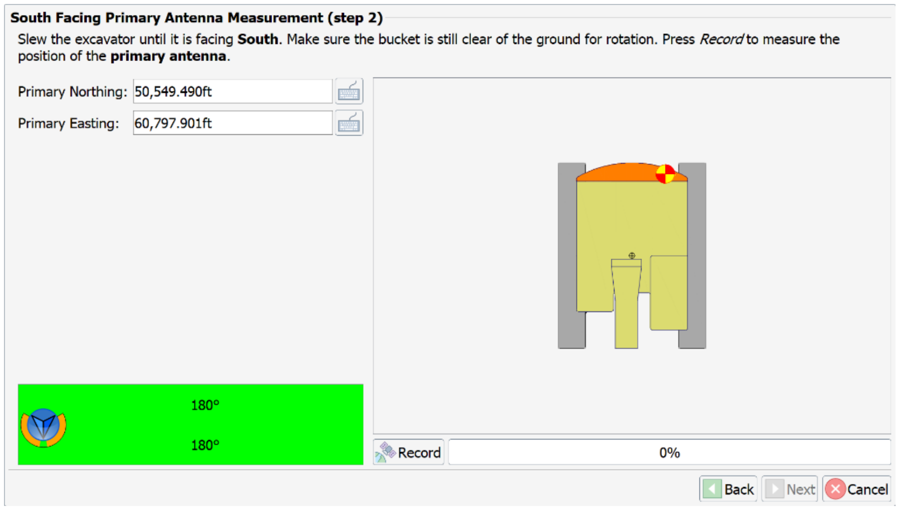
Note: The **Record** button will grayed-out until the turret is has been positioned correctly.



Continued on next page

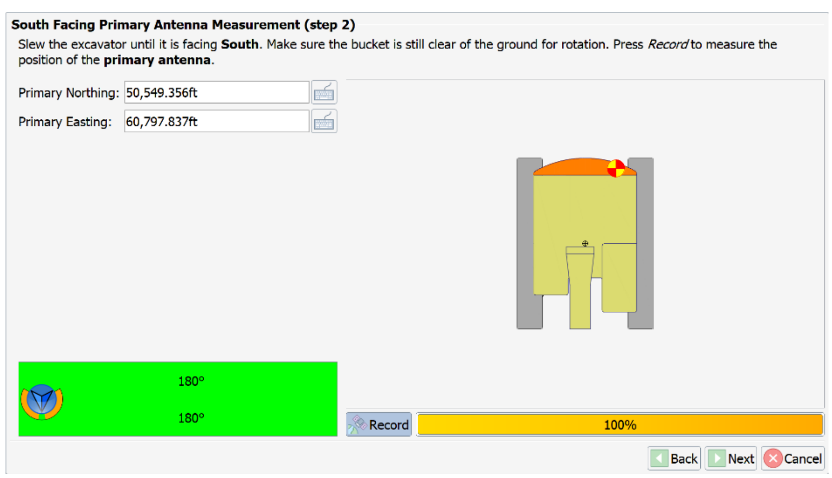
Step 2- GPS calibration

Do not move the tracks, boom, or stick. Carefully slew the machine until the bucket is facing South. The indicators on the bottom-left of the screen show your target azimuth (180°) and your current azimuth (87 °). **Note:** The current azimuth may not be accurate because a heading offset has not yet been calibrated at this point.



Keep the boom and bucket equipment still and record the **Primary Antenna** location using the **Record** button.

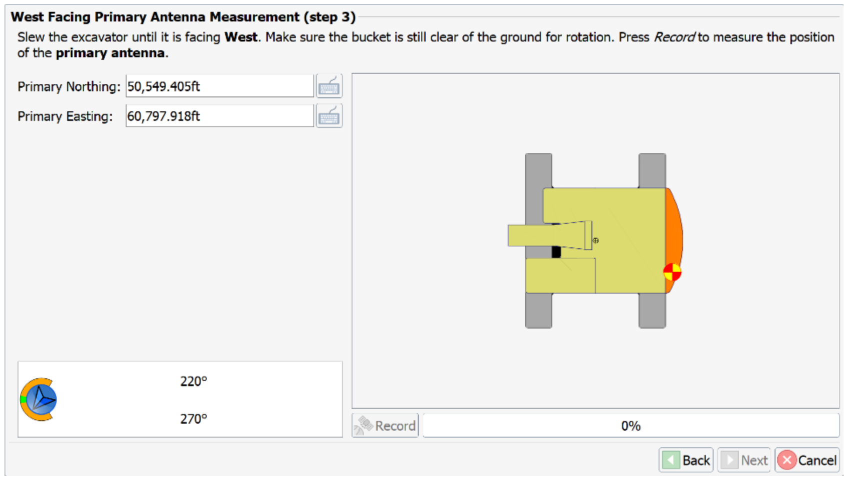
Note: The **Record** button will grayed-out until the turret has been positioned correctly.



Continued on next page

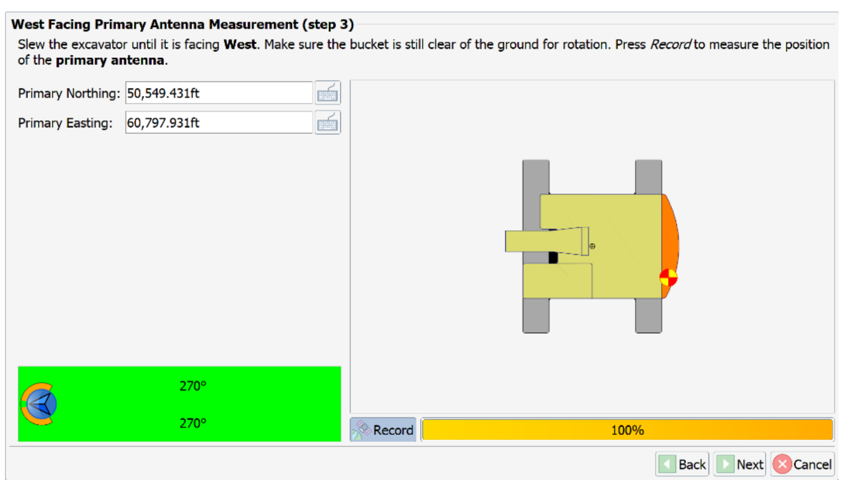
Step 3-GPS calibration

Do not move the tracks, boom, or stick. Carefully slew the machine until the bucket is facing West. The indicators on the bottom-left of the screen show your target azimuth (270°) and your current azimuth (195°). **Note:** The current azimuth may not be accurate because a heading offset has not yet been calibrated at this point.



Keep the boom and bucket equipment still and record the **Primary Antenna** location using the **Record** button.

Note: The **Record** button will grayed-out until the turret has been positioned correctly.



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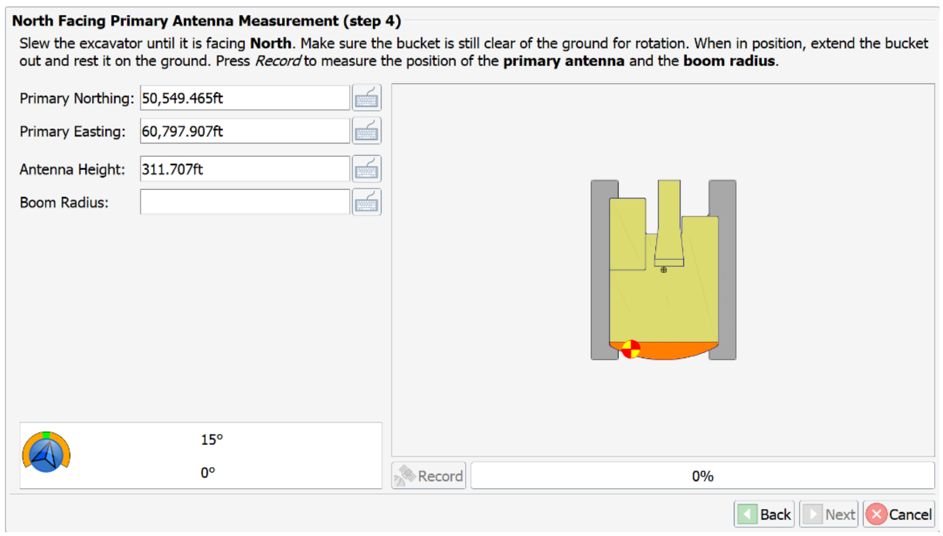
Step 4-GPS calibration

Do not move the tracks, boom, or stick. Carefully slew the machine until the bucket is facing North. The indicators on the bottom-left of the screen show your target azimuth (0°) and your current azimuth (305°). Fully extend the boom and stick and carefully rest the bucket on the ground. This step will calculate the boom radius.

Note: The current azimuth may not be accurate because a heading offset has not yet been calibrated.



Before recording the antenna location, gently rest the bucket and the end of the stick on the ground, trying not to push or move the turret (house) of the machine. This prepares the machine for the next stage of the calibration.

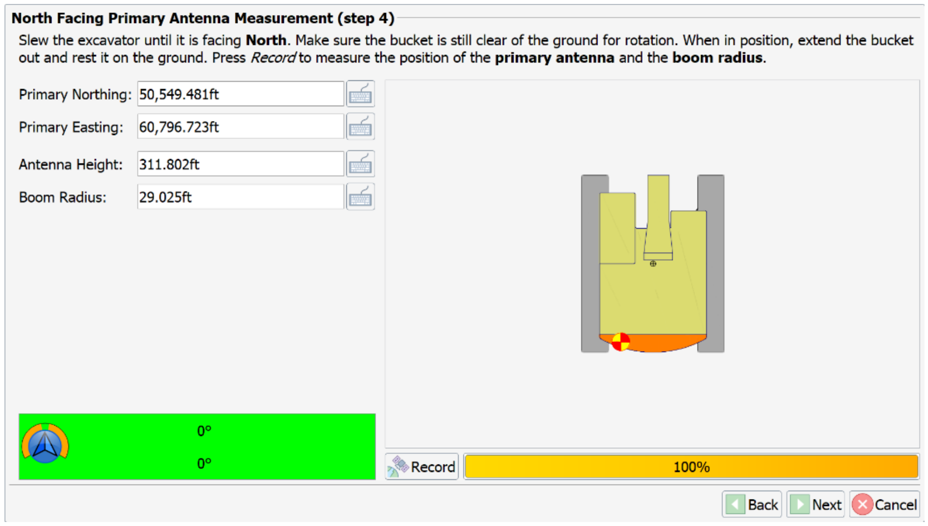
Keep the boom and bucket equipment still and record the **Primary Antenna** location using the **Record** button.

Note: The **Record** button will grayed-out until the turret has been positioned correctly. After recording this position **DO NOT** move the machine. All the following stages require the excavator to stay at this position.

Continued on next page

Step 4-GPS calibration, continued

Warning: If the machine is moved for any reason, return the machine to this position and re-record the position data.



Continued on next page

Step 5-GPS calibration

Continuing with the equipment at the 360° or 0° / North facing position. Place the GNSS rover on the **Secondary Antenna** location and record the Northing and Easting positions.

We recommend unscrewing the **Secondary Antenna** to place the survey rover on this point.

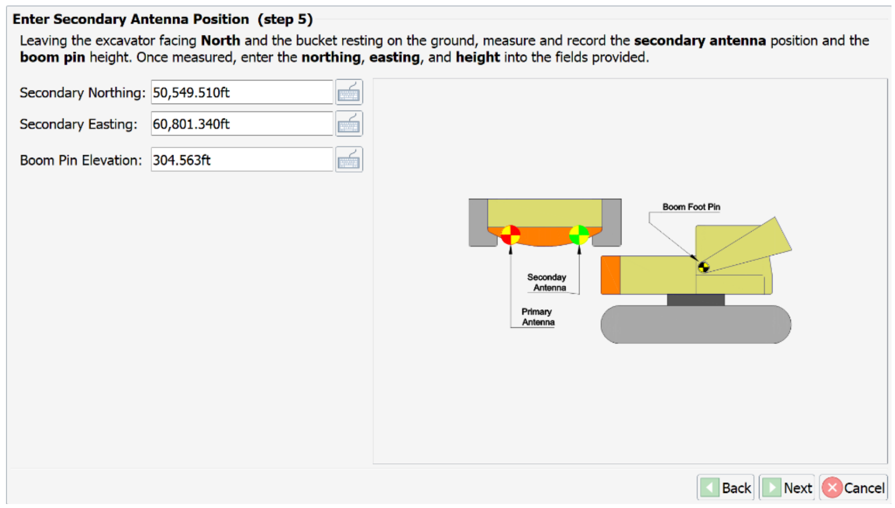
Take the following shots using the GNSS rover and data collection software. Optionally, you can store all shots first and then type them into the software. All shots should be averaged for a minimum of 30 seconds, while monitoring RTK status and HRMS/VRMS values:

1. Secondary Antenna location
2. Boom pin location
3. Center boom
4. Center bucket
5. Left bucket pin
6. Right bucket pin

Continued on next page

Step 5-GPS calibration, continued

> **Note:**-If the moving base is enabled or using a VR500, then there is no need to measure and enter this point, as the calibration will use the Heading and CSEP values from the VR1000 or VR500 units.



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Step 5-GPS calibration, continued

Figure 4-1 shows shooting the boom pin height.

Note: A magnet with a divot (for holding placing the pole) was used to place the pole.

Figure 4-1: Magnet with divot

Continued on next page

Step 5-GPS calibration, continued

The height of the boom foot pin can be measured and entered at this point. Use a GNSS rover to carefully measure then enter this height value. Click **Next**.

Step 6- GPS calibration

Continue with the equipment at the 360° or 0° / North facing position.

Place the GNSS rover on the on or near the boom foot pin on the centerline of the machine. Record this position and enter the **Baseline Northing 1** and **Baseline Easting 1** values for this point.

Note: If possible, use masking tape to mark the centerline and place a round magnet on this line and put the point of the rover pole into the hole at the center of the magnet.

Place the GNSS rover on the on or near the boom bucket pin or the mid-point of the bucket edge on the centerline of the machine.

Continued on next page

Step 6- GPS calibration, continued

Figure 4-2 shows the GNSS rover taking a shot at the middle of boom (for heading calculation offset). A magnet with a divot was placed on the center of the boom. The center of the boom was determined using a tape measure.

Figure 4-2: GNSS rover shot at middle

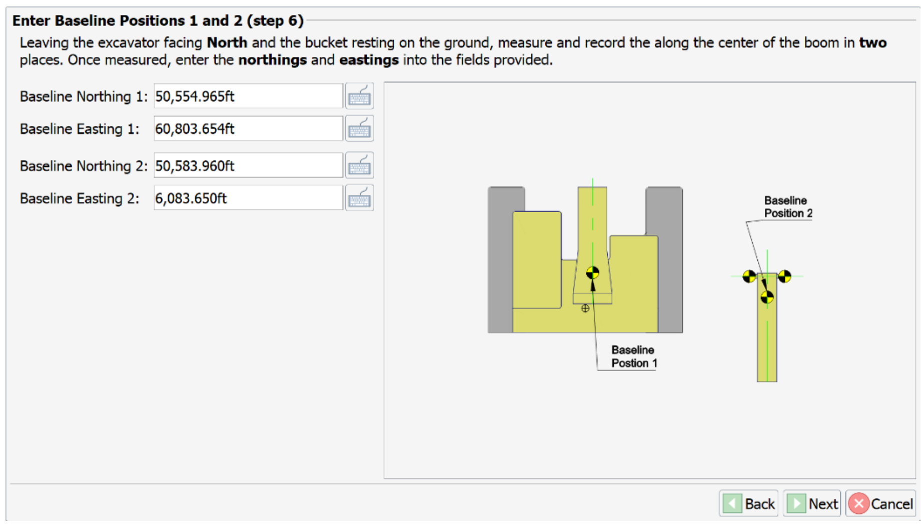
Continued on next page

Step 6- GPS calibration, continued

Record this position and enter the **Baseline Northing 2** and **Baseline Easting 2** values for this point.

Note: Welding chalk may be used to temporally mark the center of the bucket if needed.

Click **Next**.



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Step 7 – GPS calibration

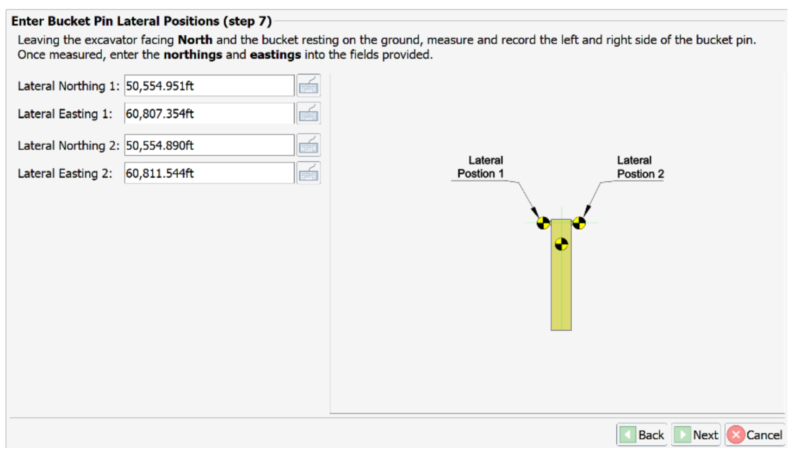
Continuing with the equipment at the 360° or 0° / North facing position. Place the GNSS rover to the Left / West side of bucket pin on the centerline.

Record this position and enter the **Lateral Northing 1** and **Lateral Easting 1** values for this point. Place the GNSS rover to the right / east side of bucket pin on the centerline.

Record this position and enter the **Lateral Northing 1** and **Lateral Easting 1** values for this point.

Note: To measure these points, use a magnet with an eyelet to line the point of the survey pole point to the centerline of the bucket pin for each side of the bucket pin.

Click **Next**.



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Step 8-GPS calibration	The final step calculates the following machine dimensions and angular offsets to finish the 3D calibration of the machine GNSS antennas. Once this is complete, it is required to the test random 3D points to the bucket left or right side to confirm that the 3D calibration is functioning correctly and within the accuracy required. When complete, save the calibration to the current machine file by selecting the **Finish** button.

Appendix A: Troubleshooting

Overview

Introduction

Appendix A offers suggestions to solve common problems.

Contents

Troubleshooting Table A-1 lists common issues and recommendations.

Table A-1: Troubleshooting

Symptom	Possible Solution
Incorrect position	First, check a control point with the machine and the survey rover. If the horizontal or vertical position is off, first consider if it is off by a consistent amount throughout the jobsite, or if the position bust varies throughout the job. if it is consistent, consider the following: • Check your machine measurements/offsets. If any of these are incorrect, your projected position will be off. • Bad localization. Make sure that all points in your localization file have low residuals and/or that the correct coordinate system has been chosen (this can make a significant difference). If there is an inconsistent position bust, check: • Sensor mounting was incorrectly chosen and/or sensor was not calibrated. This is evident if your position is correct when flat, but not if you are on a slope. • If the position at the GPS antenna is correct, but the position bust worsens as you approach the cutting edge, it may be a heading offset error.

Continued on next page

Troubleshooting, continued

Table A-1: Troubleshooting (continued)

Symptom	Possible Solution
No GPS position	1. First, check to see if the VR500 or VR1000 is powered on. 2. If the receiver isn't powered, disconnect the cable and use a multimeter to verify it is receiving power and ground. 3. Check the monitor screen and sky plots to see if there is any data from the receiver. If there is no data, but the receiver is powered, there could be a bad serial connection/mismatched baud rate. 4. If using a VR1000, use a multi-meter to measure the voltage from the primary antenna port. The voltage should be 5V. If it is reading 5V from the receiver, check the other end of the cable (that would plug into the antenna). If there isn't any voltage, it may be a damaged cable or bulkhead connector.

Continued on next page

Troubleshooting, continued

Table A-1: Troubleshooting (continued)

Symptom	Possible Solution
No RTK	1. If using a base station onsite (versus an NTRIP service), first check to verify the base station is turned on. 2. If the base station is turned on and sending RTK out over UHF, check to see if the Tx (or TD on some radios) light is flashing once per second. 3. Verify that the other rovers on the job site are receiving RTK corrections, if available. 4. If it is flashing once per second, check to verify the settings (frequency, bandwidth, forward error corrections, modulation, and protocol) at the base match that of the rover. 6. Check to see if the UHF light at the rover is blinking once per second. If it is, refer to #3. 7. The receiver may be out of UHF range. Consider installing the external UHF antenna (if using a VR500). You may need to install repeaters. See if the RTK corrections work when the machine is closer to the base station. 8. If using NTRIP, check cellular connectivity. One option is to exit GradeMetrix and verify you can go to a website via the browser.
IronOne will not power on	• Check to verify the power cable is connected to machine power. The positive should go to a reliable, clean power source and ground to the chassis of the machine. • Disconnect the cable and refer to the pinout to see if 12V or 24V (depending on machine) is going into the IronOne by using a multi-meter. If the multimeter reads 12V or 24V, then power is confirmed, and the IronOne may need to be serviced. If you don’t have any power, then check your power source, ground, and all fuses.

Continued on next page

Troubleshooting, continued

Table A-1: Troubleshooting (continued)

Symptom	Possible Solution
No heading	• If using a VR1000, you need two external antennas. Use a multi-meter to check the voltage coming out of the N-type connectors Is 5V. If 5V is coming from the receiver, check the other end of the cable (that would plug into the antenna). If there is no voltage, then it is a damaged cable or bulkhead connector. • If using a VR1000, check your MSEP antenna separation measurement. It is the distance, in meters, between the two antennas, and must be accurate to within 2cm.

Appendix B: Technical Specifications

Overview

Introduction

Appendix B contains the technical specifications for the VR500 receiever, the VR1000 GNSS receiver, the IronOne control box, and the GMS-1 sensor.

Contents

VR500 specifications

Table B-1: VR500 Receiver

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 specifications, continued

Table B-1: VR500 Receiver (continued)

Item	Specification
Secondary antenna	GPS L1,L1P,L2C,L2P GLONASS G1,G2 BeiDou B1,B2 Galileo E1,E5b L-band
GPS sensitivity	-142 dBm
SBAS tracking	3-channel, parallel tracking
Update rate	10 Hz standard, and 20 Hz available
Horizontal accuracy	(see sub-table below)
Heading accuracy	0.27° RMS
Pitch/roll accuracy	< 1° RMS
ROT	145°/s maximum
Timing (PPS) accuracy	20 ns
Cold start time	< 60 s typical (no almanac or RTC)
Warm start time	< 30 s typical (almanac and RTC)
Hot start time	< 10 s (almanac, RTC, and position)
Maximum speed	1,850 km/h (999 kts)

Horizontal accuracy:

	RMS (67%)	2DMRS (95%)
RTK[1,2]	8 mm + 1 ppm	15 mm +2 ppm
Atlas®	0.04 m	0.08 m
SBAS (WAAS)[1]	0.3 m	0.6 m
Autonomous, no SA[1]	1.2 m	2.4 m

Continued on next page

VR500 specifications, continued

Table B-1: VR500 Receiver (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	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 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.[3]
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] Under static conditions

VR1000 GNSS receiver

Table B-8: GNSS Receiver

Item	Specification
Receiver Type	GNSS Position & Heading RTK Receiver
Signals Received	GPS, GLONASS, BeiDou, Galileo, QZSS, NavIC (IRNSS) and Atlas®
Channels	1059
GPS Sensitivity	-142 dBm
SBAS Tracking	3-channel, parallel tracking
Update Rate	10 Hz standard, 20 Hz optional
Timing (PPS) Accuracy	20 ns
Rate of Turn	100°/s maximum
Cold Start	40 s (no almanac or RTC)
Warm Start	20 s typical (almanac and RTC)
Hot Start	5 s typical (almanac, RTC and position)
Heading Fix	10 s typical (Hot Start)
Antenna Input Impedance	50 Ω
Maximum Speed	1,850 mph (999 kts)
Maximum Altitude	18,288 m (60,000 ft)
Differential Options	SBAS, Atlas (L-band), RTK

Continued on next page

VR1000 accuracy

Table B-9: Accuracy

Item	Specification	
Positioning	**RMS (67%)**	**2DRMS (95%)**
Autonomous, no SA: [2]	1.2 m	2.5 m
SBAS: [2]	0.25 m	0.5 m
Atlas: [2,3]	0.04 m	0.08 m
RTK: [1]	10 mm + 1 ppm	20 mm + 2 ppm
Heading (RMS)	< 0.2° @ 0.5 m antenna separation < 0.1° @ 1.0 m antenna separation < 0.05° @ 2.0 m antenna separation < 0.02° @ 5.0 m antenna separation < 0.01° @ 10.0 m antenna separation	
Pitch/Roll (RMS)	1°	
Heave (RMS)	30 cm (DGPS) [3],10 cm (RTK) [3]	

VR1000 commun-ications

Table B-10: Communications

Item	Specification
Ports	1x full-duplex RS-232/RS-422, 1x full-duplex RS232, 2x CAN, 1x Ethernet
Baud Rates	4800 - 115200
Radio Interfaces	Bluetooth 2.0 (Class 2), Wi-Fi 2.4 GHz, UHF (400 MHz)
Correction I/O Protocol	Hemisphere GNSS proprietary ROX format RTCM v2.3, RTCM v3.2, CMR[5], CMR+[5]
Data I/O Protocol	NMEA 0183, Hemisphere GNSS binary
Timing Output	PPS, CMOS, active high, rising edge sync, 10kΩ, 10 pF load
Event Marker Input	CMOS, active low, falling edge sync, 10 kΩ, 10pF load

Continued on next page

VR1000 power

Table B11: Power

Item	Specification
Input Voltage	9-36 VDC
Power Consumption	10.8W Maximum (All signals and L-band)
Current Consumption	1.2A Maximum
Power Isolation	No
Reverse Polarity Protection	Yes

VR1000 environmental

Table B-12: 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
Mechanical Shock	50G, 11ms half sine pulse (MIL-STD-810G w/ Change 1 Method 516.7 Procedure 1)
Vibration	7.7 Grms (MIL-STD-810G w/Change 1 Method 514.7 Category 24)
EMC	CE ISO14982/EN13309/ISO13766/IEC60945), Radio Equipment Directive 2014/53/EU, E-Mark, RCM
Enclosure	IP69K

Continued on next page

VR1000 L-band receiver

Table B-13: L-band receiver

Item	Specification
Receiver Type	Single Channel
Channels	1530 to 1560 MHz
Sensitivity	-140 dBm
Channel Spacing	5 kHz
Satellite Selection	Manual or Automatic
Reacquisition Time	15 sec (typical)

VR1000 aiding devices

Table B-14: Aiding devices

Item	Specification
Gyro	Provides smooth heading, fast heading reacquisition and reliable < 0.5° per min heading for periods up to 3 min. when loss of GNSS has occurred [4]
Tilt Sensors	Provide pitch/roll data and assist in fast start-up and reacquisition of heading solution

VR1000 mechanical

Table B-15: Mechanical

Item	Specification
Dimensions No Plate	23.2 L x 16.5 W x 7.9 H (cm) 9.1 L x 6.5 W x 3.1 H (in)
Dimensions with Plate	23.2 L x 21.4 W x 8.3 H (cm) 9.1 L x 8.4 W x 3.3 H (in)
Status Indications (LED)	Power, Primary Antenna, Secondary Antenna, Heading, Quality, Atlas, Bluetooth, Wi-Fi, CAN1, CAN2, Ethernet, Radio
Power/Data Connector	23-pin multi-purpose

Continued on next page

VR1000 footnote references	[1]Depends on multipath environment, number of satellites in view, satellite geometry, no SA, and ionospheric activity [2]Depends on multipath environment, number of satellites in view, WAAS coverage and satellite geometry [3]Requires a subscription [4]Depends on multipath environment, number of satellites in view, satellite geometry, baseline length (for differential services), and ionospheric activity [5]CMR and CMR+ do not cover proprietary messages outside of the typical standard

IronOne

IronOne system

Table B-16: System

Item	Specification
Processor	Intel Atom dual-core CPU E3825 @ 1.33 GHz
Storage	SSD 32GB, RAM 2GB
Operating System	Windows 10

IronOne mechanical

Table B-17: Mechanical

Item	Specification
Dimensions	22.9 L x 16.9 W x 5.2 H (cm) 9.0 L x 6.6 W x 2.0 H (in)
Weight	1.38 kg (3.04 lbs.)
Mount	Adjustable 1.5" RAM ball mount

IronOne environmental

Table B-18: Environmental

Item	Specification
Operating Temperature	-20°C to +70°C (-4°F to 158°F)
Storage Temperature	-40°C to +85°C (-40°F to 185°F)
Operating Humidity	30% ~ 95% (Relative Humidity)
Storage Humidity	45% ~ 80% (Relative Humidity)
Enclosure	IP67
Vibration	EP455 5.15

Continued on next page

IronOne power

Table B-19: Power

Item	Specification
Input Voltage	7 - 36 VDC
Power Consumption	36 W
Current Consumption	3.0 A @ 12 VDC

IronOne screen

Table B-20: Screen

Item	Specification
Display Type	8” TFT-LCD capacitive touchscreen
Size	192.8 mm × 116.9 mm (7.59” × 4.6”)
Resolution	1280 × 720, 16:9
Luminance	750 nit

IronOne input

Table B-21: Input

Item	Specification
Power Button	1× mechanical waterproof button
Function Button	2× mechanical waterproof button
Ignition Input	Yes

Continued on next page

IronOne communication

Table B-22: Communication

Item	Specification
Serial Port	1x RS232×1, 1x RS422/RS485/RS232 (software controlled)
Camera Interface	2× CVBS
USB	1× USB 2.0
Ethernet	10/100
Wi-Fi	IEEE 802.11b/g/n
Cellular	4G LTE
Data I/O Protocol	NMEA 0183

IronOne sensor and multimedia

Table B-23: Sensor and multimedia

Specification
1x 2W Buzzer
1x Headphone Jack

GMS-1 Sensor

GMS-1 sensor measurement range

Table B-24: Measurement range

Item	Specification
Pitch	± 180°
Roll	± 85°

GMS-1 sensor accuracy

Table B-25: Sensor accuracy

Item	Specification
Absolute Accuracy	±0.30°
Resolution	±0.01°
Repeatability	±0.05°
Refresh Rate	20 Hz
Base Sensor Cycle	5ms
Hysteresis	±0.05°

GMS-1 sensor electrical

Table B-26: Electrical

Item	Specification
Supply Voltage	9 – 30 VDC
Current	≤ 65mA @ 10 VDC
EMC Emittance	DIN EN 61000-6-4
EMC Immunity	DIN EN 61000-6-2

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GMS-1 sensor pin-outs

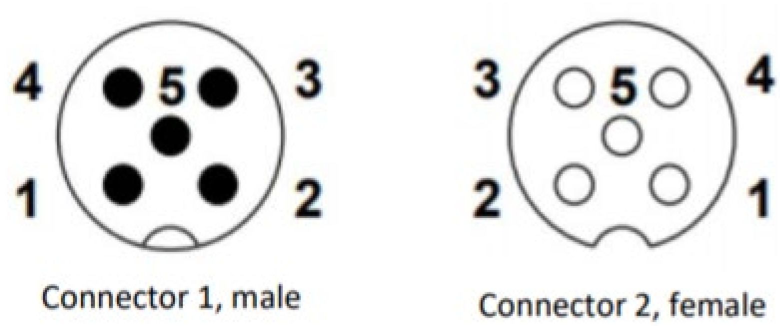


Figure B-1: GMS-1 Sensor pin-out

Table B-27: GMS-1 Sensor pin-out

Signal	Connector	Pin Number
Power Supply	Connector 1	2
GND	Connector 1	3
CAN High	Connector 1	4
CAN Low	Connector 1	5
CAN GND	Connector 1	1
Power Supply	Connector 2	2
GND	Connector 2	3
CAN High	Connector 2	4
CAN Low	Connector 2	5
CAN GND	Connector 2	1

Appendix C: Setup up a Base Station and Rover

Overview

Introduction

To perform a 3D calibration use HGNSS SiteMetrix™ to setup a C631 as the base station and as a rover.

Note: It is not necessary to set the base station up over a known coordinate or to localize with this base station if the VR1000 and C631 rover are both receiving RTK from the same base station.

Set the C631 base station up in wide open sky near the machine, so a short baseline RTK solution will provide greater accuracy and a better localization.

Contents

Configure C631 Base Station

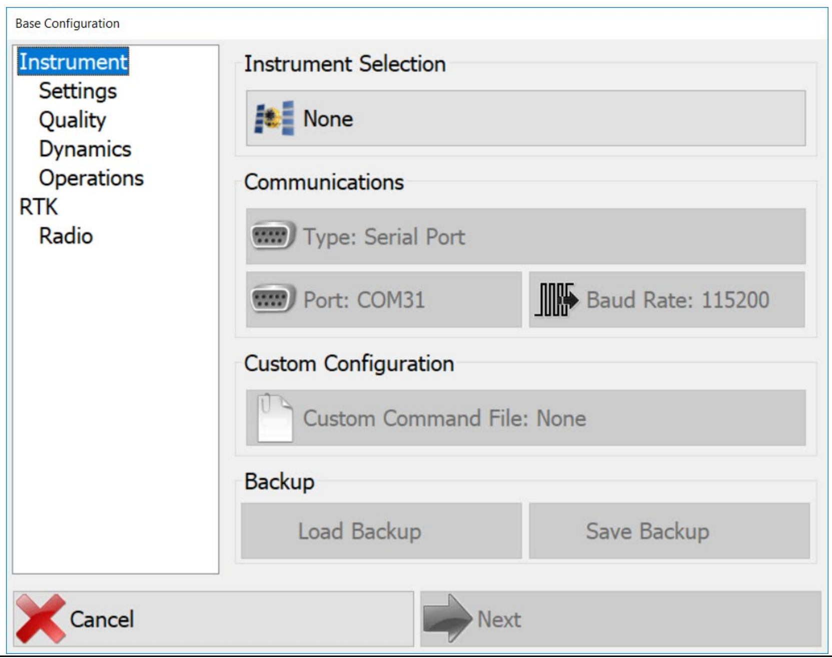
Overview

This section explains how to set up the base station needed for performing a 3D calibration.

Configure C631 Base Station

Use the following steps to configure the C631 base station for your 3D calibration routine.

Table C-1: Configure C631 Base Station

Step	Action
1	Click **Tools -> Advanced Tools -> Configure Base**. The first time you enter the software the dialogue an instrument will not be selected. 

Continued on next page

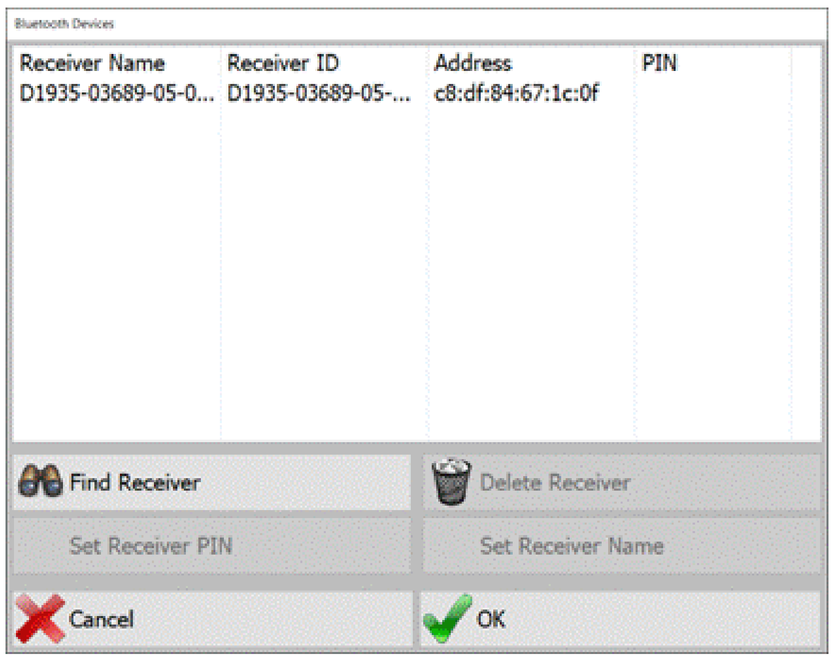
Configure C631 Base Station, continued

Table C-1: Configure C631 Base Station (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>2</td><td>
Select an instrument. Scroll over to the Hemisphere tab and select C631.

For communications, change Type to Bluetooth. Click Remote Device: None.

The following dialogue appears. Click Find Receiver to allow the software to search for nearby Bluetooth devices.



Note: Multiple devices (laptops, cell phones, etc.) may appear on this list because the software searches for all nearby Bluetooth devices.
</td></tr>
</table>

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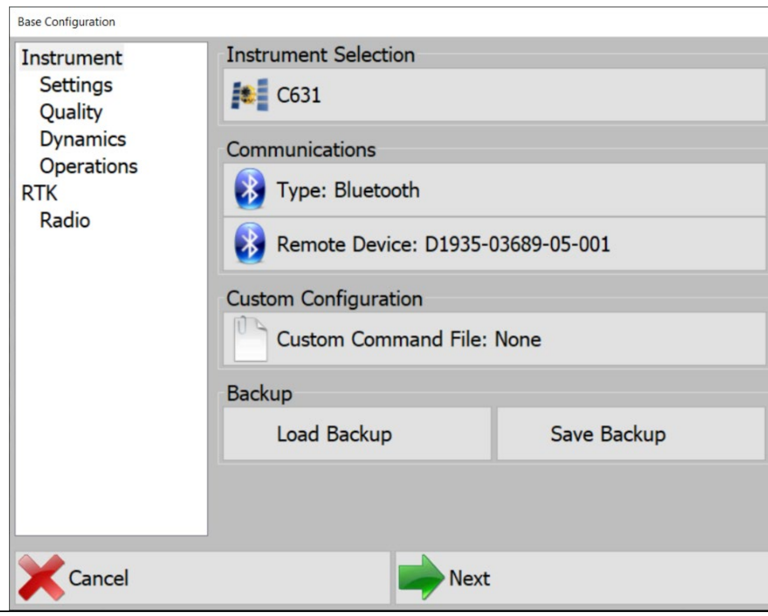
Configure C631 Base Station, continued

Table C-1: Configure C631 Base Station (continued)

Step	Action
3	Locate the C631 serial number. After the C631 displays in the list, click to highlight and press **OK**. The C631 displays under **Instrument Selection**. 

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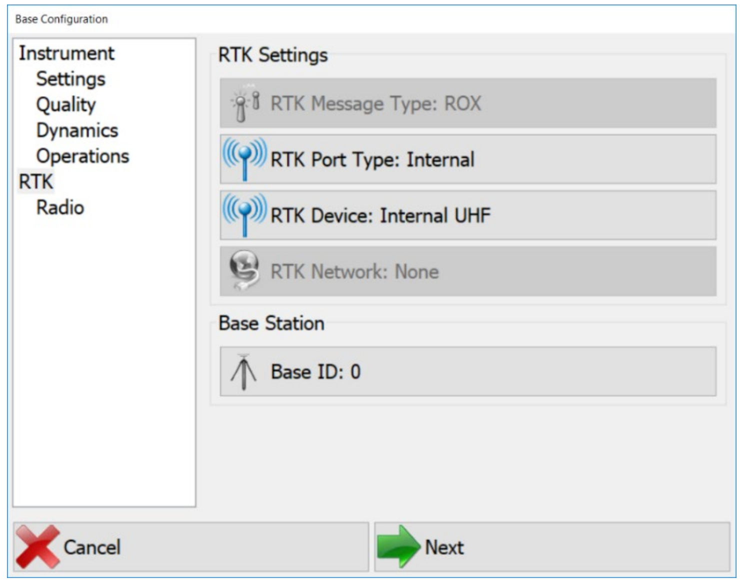
Configure C631 Base Station, Continued

Configure C631 Base Station, , continued

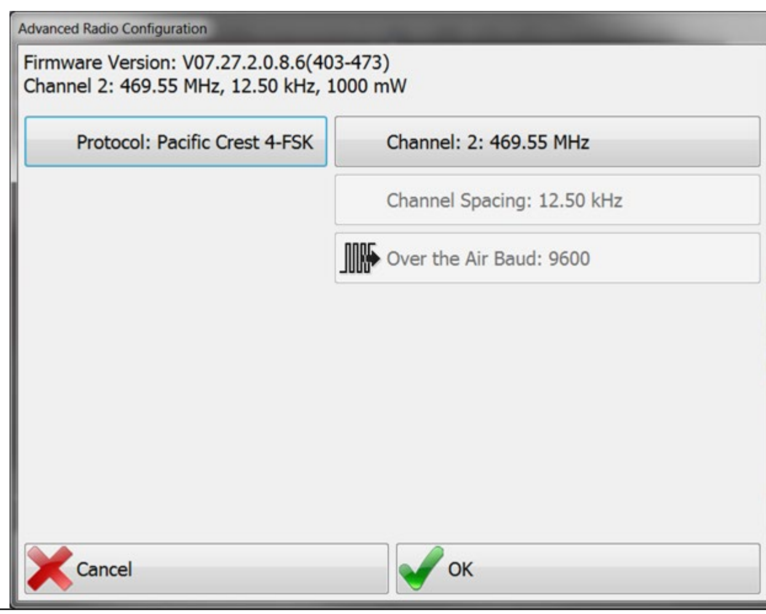
Table C-1: Configure C631 Base Station (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>4</td><td>

Click **RTK**. Set **RTK Port Type** to **Internal** and **RTK Device** to **Internal UHF**.



Click **Radio -> Advanced Configuration**.



</td></tr>
</table>

Continued on next page

Configure C631 Base Station , continued

Table C-1: Configure C631 Base Station (continued)

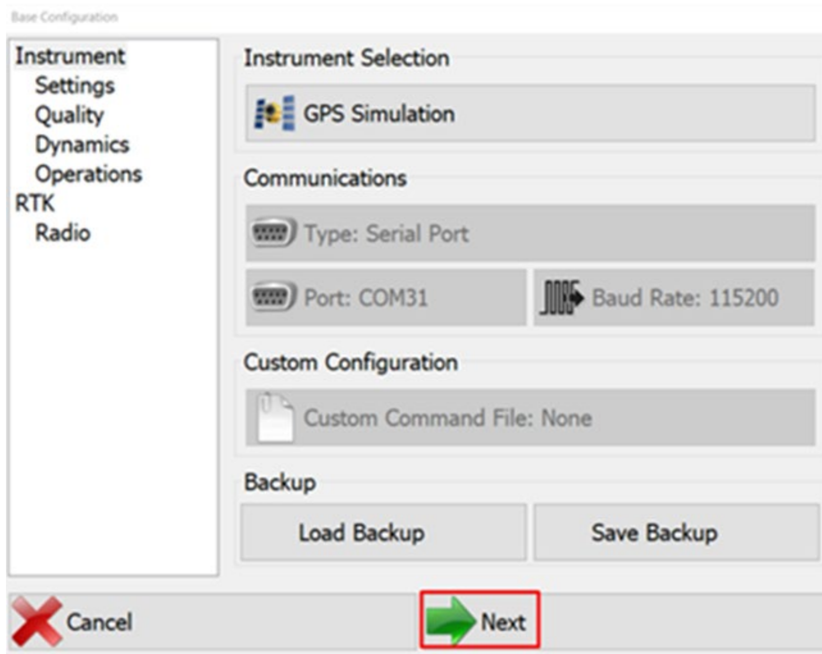
Step	Action
5	Select the protocol and channel. **WARNING:** You cannot enter channels into the UHF radio. This must be done by a certified HGNSS dealer. If you do not have the correct UHF frequency, please contact your local dealer to request a channel table. The channel table provides the channels you can use and the channel spacing for each channel configured by your dealer depending upon the licensing and regulations of your geographic region.
6	The available protocol depends on the channel spacing of the channel you are on. If the channel you are on is set for 25.0 KHz channel spacing, then only wideband protocols are shown. For the definition of each protocol, please see the chart below:

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

Continued on next page

Configure C631 Base Station , continued

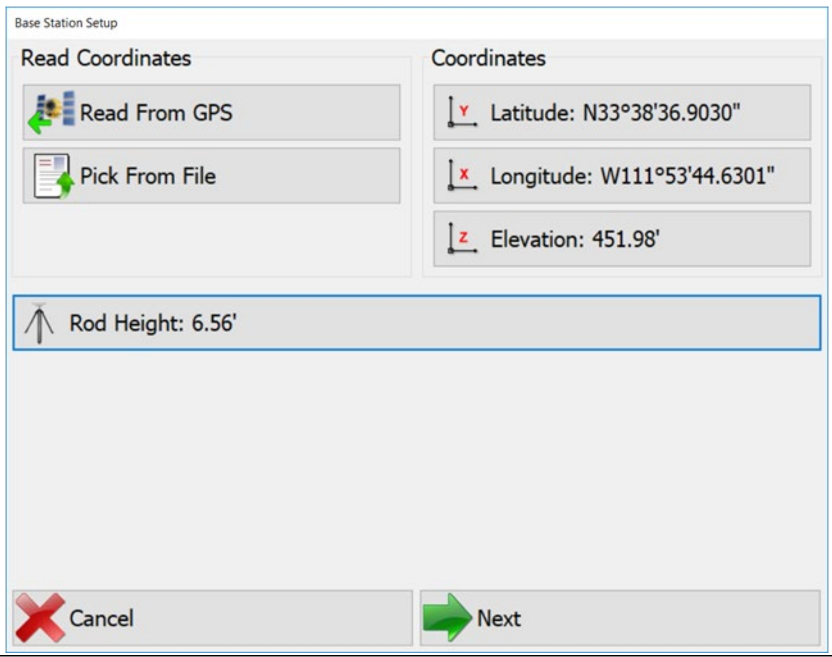
Table C-1: Configure C631 Base Station (continued)

Step	Action
7	Click **Next**. 

Continued on next page

Configure C631 Base Station , continued

Table C-1: Configure C631 Base Station (continued)

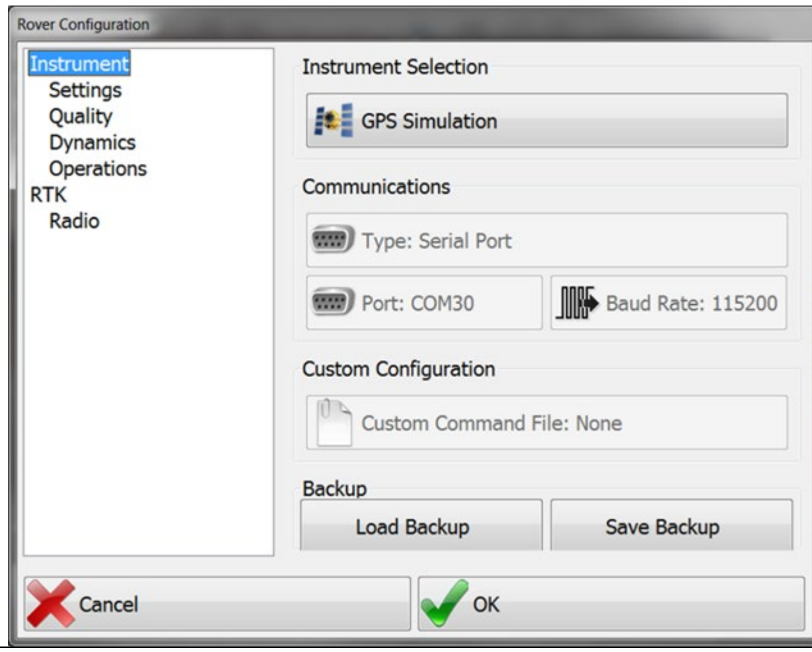
Step	Action
8	The base station coordinates must be entered. Click **Read From GPS**. You can use your current GPS position. **Note:** There is no need to enter a known control point installation. Rod height is optional and only for the calibration. 

Configure C631 Rover

Configure the C631 Rover

Use the following steps to configure the C631 Rover for your 3D calibration routine.

Table C-2: Configure the C631 Rover

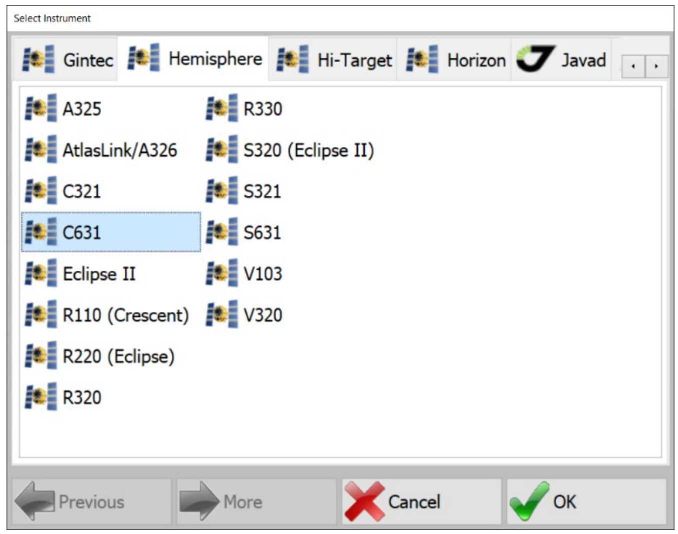
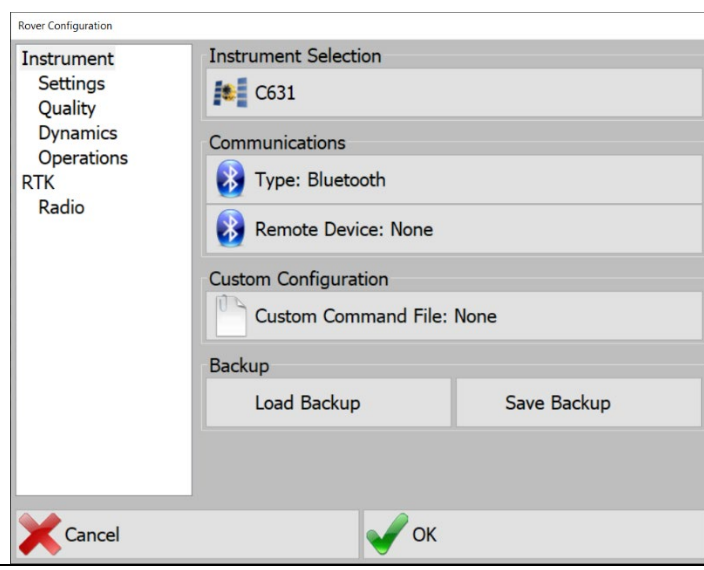
Step	Action
1	Open SiteMetrix and connect to the C631. Click **Tools -> Advanced Tools -> Configure Rover**. The first time you use the software, the following dialogue appears. 

Continued on next page

Configure C631 Rover, Continued

Configure the C631 Rover, continued

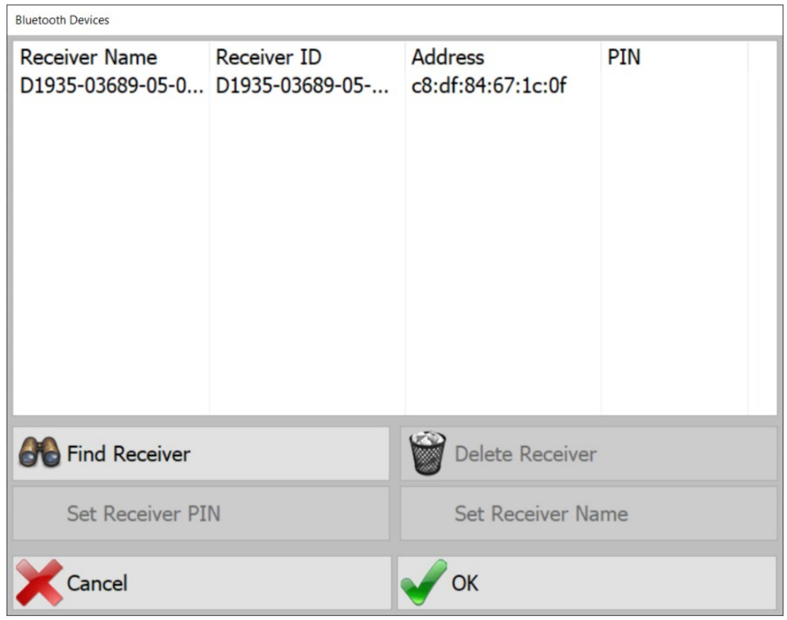
Table C-2: Configure the C631 Rover (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>2</td><td>Click the button under Instrument Selection. Scroll over to the Hemisphere tab and select C631.

</td></tr>
<tr><td>3</td><td>Most applications will require the user to connect to the C631 with Bluetooth. Click Type: Serial Port and toggle to Type: Bluetooth.

</td></tr>
</table>

Continued on next page

Configure the C631 Rover, continued

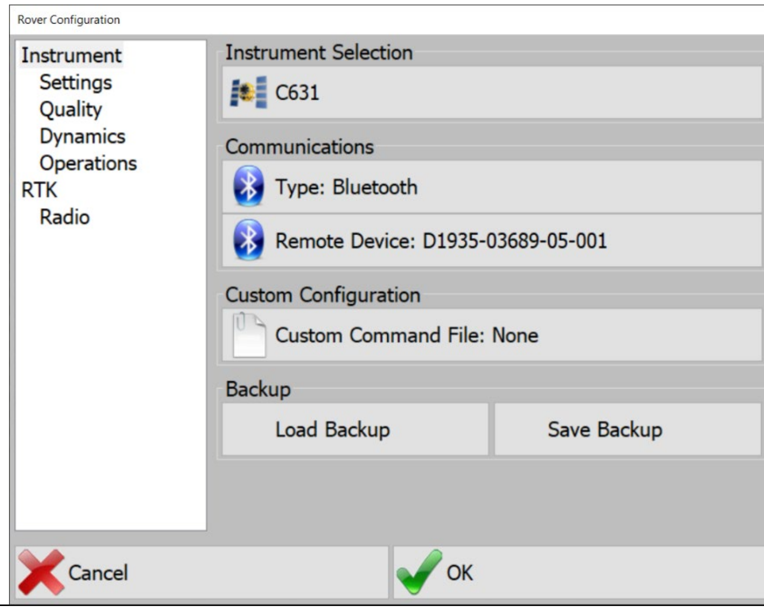
Table C-2: Configure the C631 Rover (continued)

Step	Action
4	Click **Remote Device: None.** The following dialogue appears.  Click **Find Receiver** and the software will search for nearby Bluetooth devices. **Note:** Multiple devices (laptops, cell phones, etc.) may appear on this list because the software searches for all nearby Bluetooth devices.

Continued on next page

Configure the C631 Rover, continued

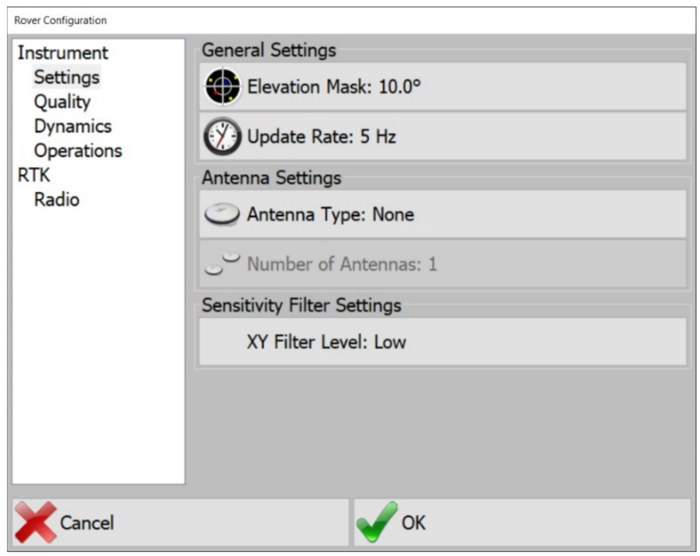
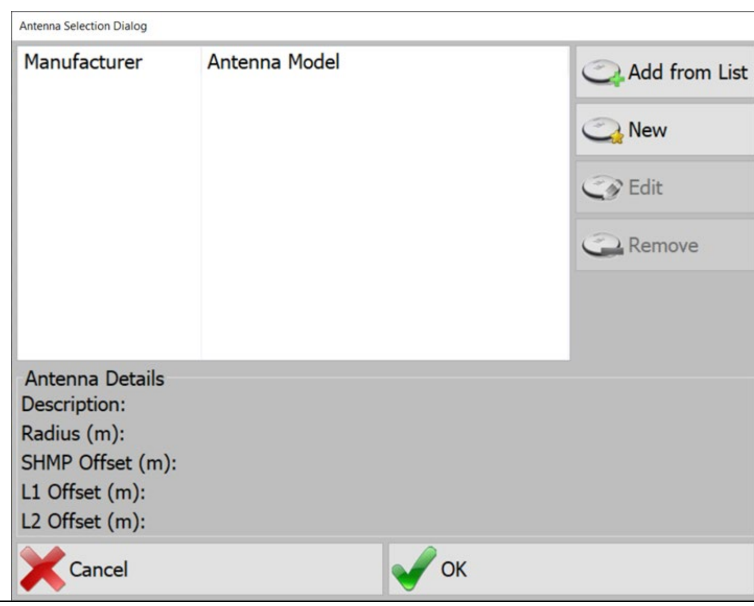
Table C-2: Configure the C631 Rover (continued)

Step	Action
5	Click to highlight the C631 serial number and click **OK**. 

Continued on next page

Configure the C631 Rover, continued

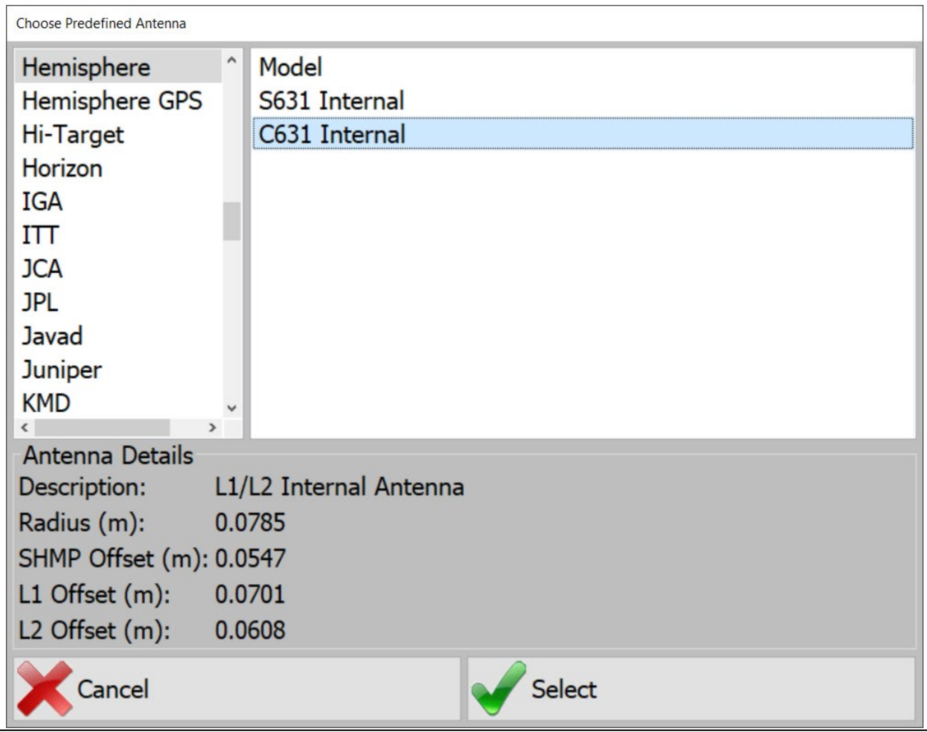
Table C-2: Configure the C631 Rover (continued)

Step	Action
6	Click **Settings**. Set **Update Rate** to **5Hz**.  Click **Antenna Type: None**. 

Continued on next page

Configure the C631 Rover, continued

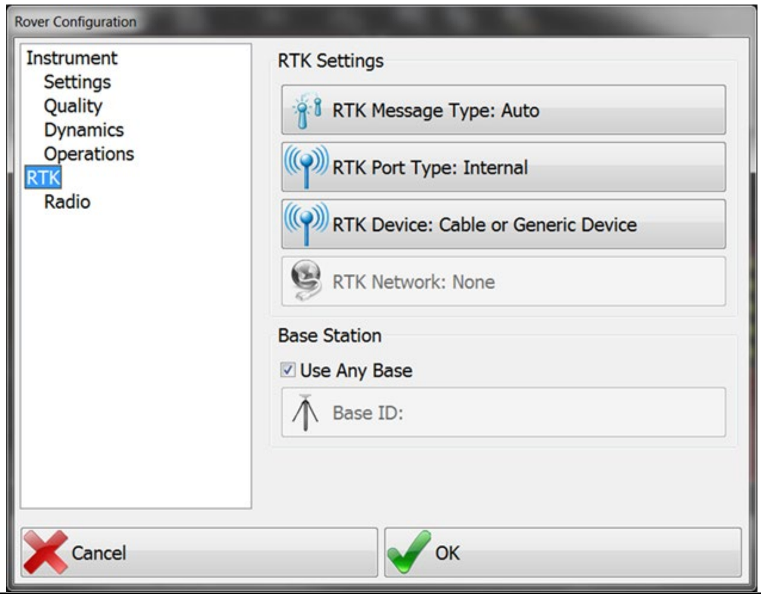
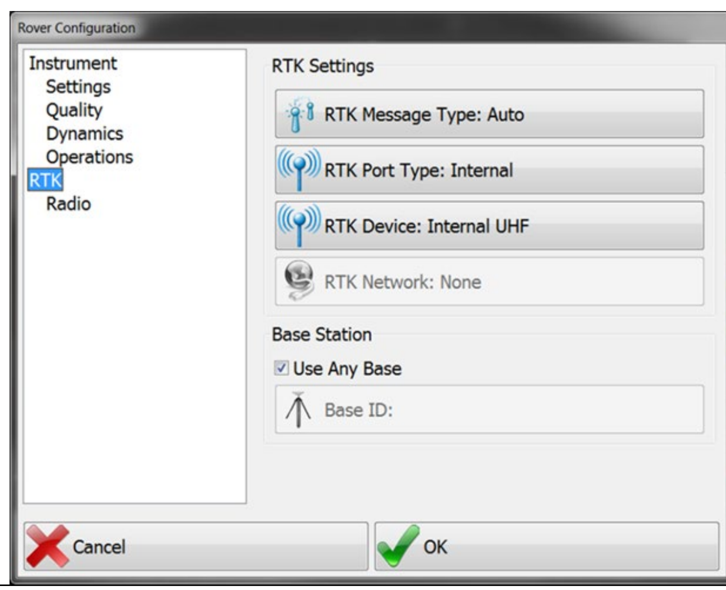
Table C-2: Configure the C631 Rover (continued)

Step	Action
6 (cont.)	Click **Add from List**. Scroll down to **Hemisphere** and select **C631 Internal**. 

Continued on next page

Configure the C631 Rover, continued

Table C-2: Configure the C631 Rover (continued)

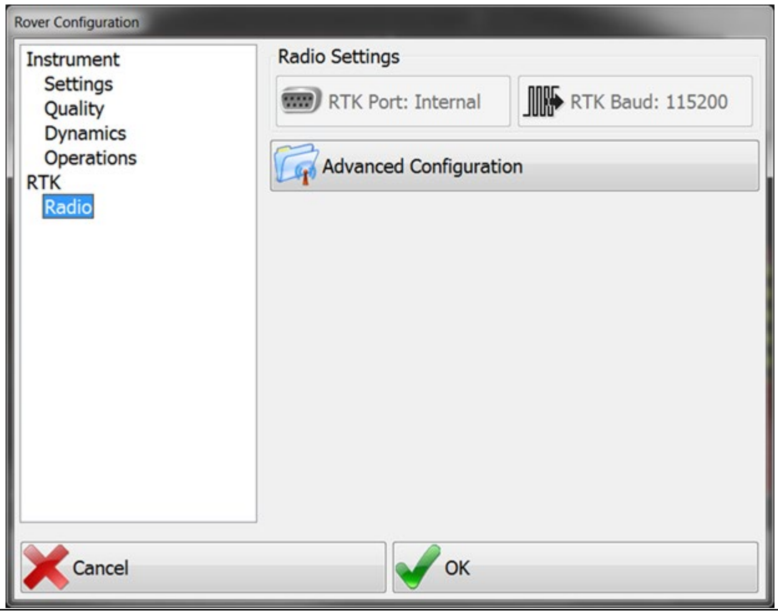
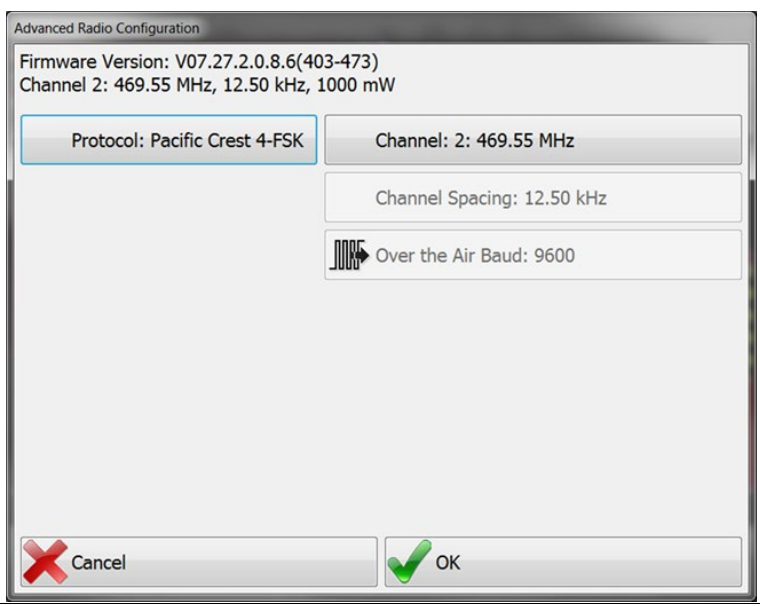
Step	Action
7	Click **RTK**. 
8	To use the internal UHF radio, click **RTK**. Set **RTK Port Type: Internal**. Set **RTK Device: Internal UHF**. 

Continued on next page

Configure C631 Rover, Continued

Configure the C631 Rover, continued

Table C-2: Configure the C631 Rover (continued)

Step	Action
9	Click **Radio**. 
10	Click **Advanced Configuration**. 

Continued on next page

Configure the C631 Rover, continued

Table C-2: Configure the C631 Rover (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>11</td><td>Select the protocol and channel.

WARNING: You cannot enter channels into the UHF radio. This must be done by a certified HGNSS dealer. If you do not have the correct UHF frequency, please contact your local dealer for a channel table. The channel table provides the channels you can use and the channel spacing for each channel configured by your dealer depending on the licensing and regulations of your geographic region.</td></tr>
<tr><td>12</td><td>The available protocol is dependent upon the channel spacing of the channel you are on. If the channel you are on is set for 25.0 KHz channel spacing, then only wideband protocols are shown. For the definition of each protocol, please see the chart below:

<table>
<tr><th>Radio Mode</th><th>Link Rate</th><th>Spacing</th><th>Modulation</th><th>Scrambling</th><th>FEC</th></tr>
<tr><td>Trimtalk 1</td><td>4800 bps</td><td>12.5 kHz</td><td rowspan="2">GMSK</td><td rowspan="2">On</td><td rowspan="2">Off</td></tr>
<tr><td>Trimtalk 2</td><td>9600 bps</td><td>25 kHz</td></tr>
<tr><td>PC1</td><td>9600 bps</td><td>25 kHz</td><td rowspan="2">GMSK</td><td rowspan="2">On</td><td rowspan="2">On</td></tr>
<tr><td>PC5</td><td>4800 bps</td><td>12.5 kHz</td></tr>
<tr><td rowspan="2">PCC-4FSK</td><td>9600 bps</td><td>12.5 kHz</td><td rowspan="2">4FSK</td><td rowspan="2">On</td><td rowspan="2">On</td></tr>
<tr><td>19200 bps</td><td>25 kHz</td></tr>
<tr><td rowspan="4">Satel 3AS</td><td rowspan="2">9600 bps</td><td rowspan="2">12.5 kHz</td><td rowspan="4">4FSK</td><td rowspan="4">On</td><td>Off</td></tr>
<tr><td>On</td></tr>
<tr><td rowspan="2">19200 bps</td><td rowspan="2">25 kHz</td><td>Off</td></tr>
<tr><td>On</td></tr>
</table></td></tr>
<tr><td>13</td><td>Click OK. Your C631 is configured for UHF radio.

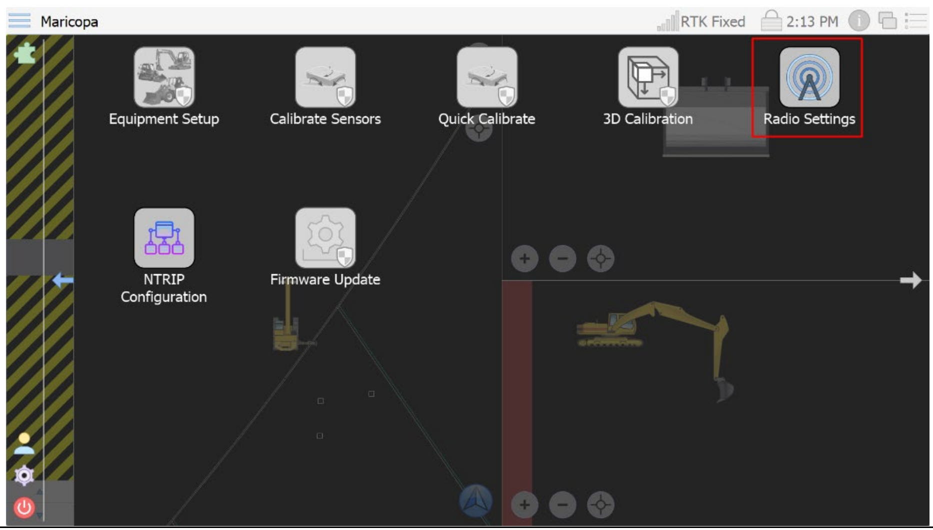
WARNING: If you are not receiving RTK corrections, please check to ensure the UHF antenna is secured into the UHF slow (not the GSM antenna slot) and check to verify the settings of the base UHF match the settings of the C631 UHF.</td></tr>
</table>

Configure VR1000 or VR500 Radio

Configure VR1000 radio

Use the following steps to configure the VR1000 radio for your 3D calibration routine.

Table C-3: Configure VR1000 radio

Step	Action
1	Click **Radio Settings**. 

Continued on next page

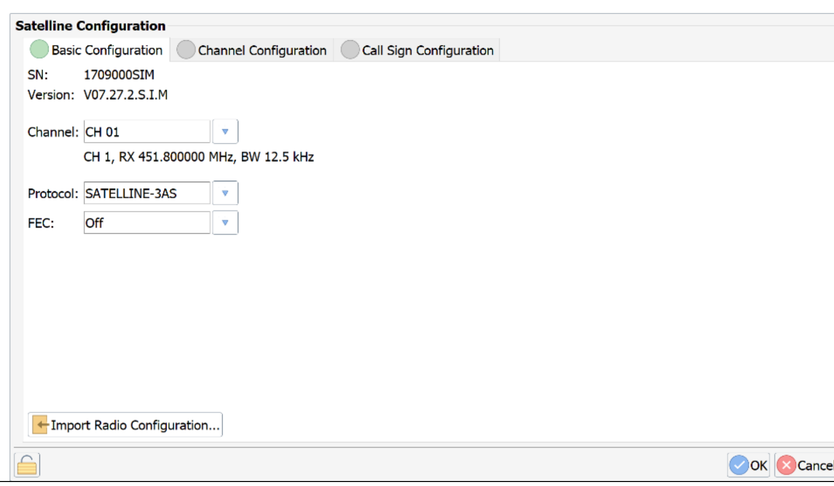
Configure VR1000 or VR500 Radio, Continued

Configure VR1000 radio, continued

Table C-3: Configure VR1000 radio (continued)

Step	Action
2	Select a channel that is configured to the same frequency as the C631 base station (if you don't have this frequency located, contact your Hemisphere GNSS representative for a channel table). Select the correct protocol per the chart provided below.

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



Appendix D: Cable Pin-Outs

Overview

Introduction

Appendix D contains the cable pin-outs used for installation of the VR500 and the VR1000 receivers.

Contents

Part Number 051-0419-10

P/N: 051-0419-10

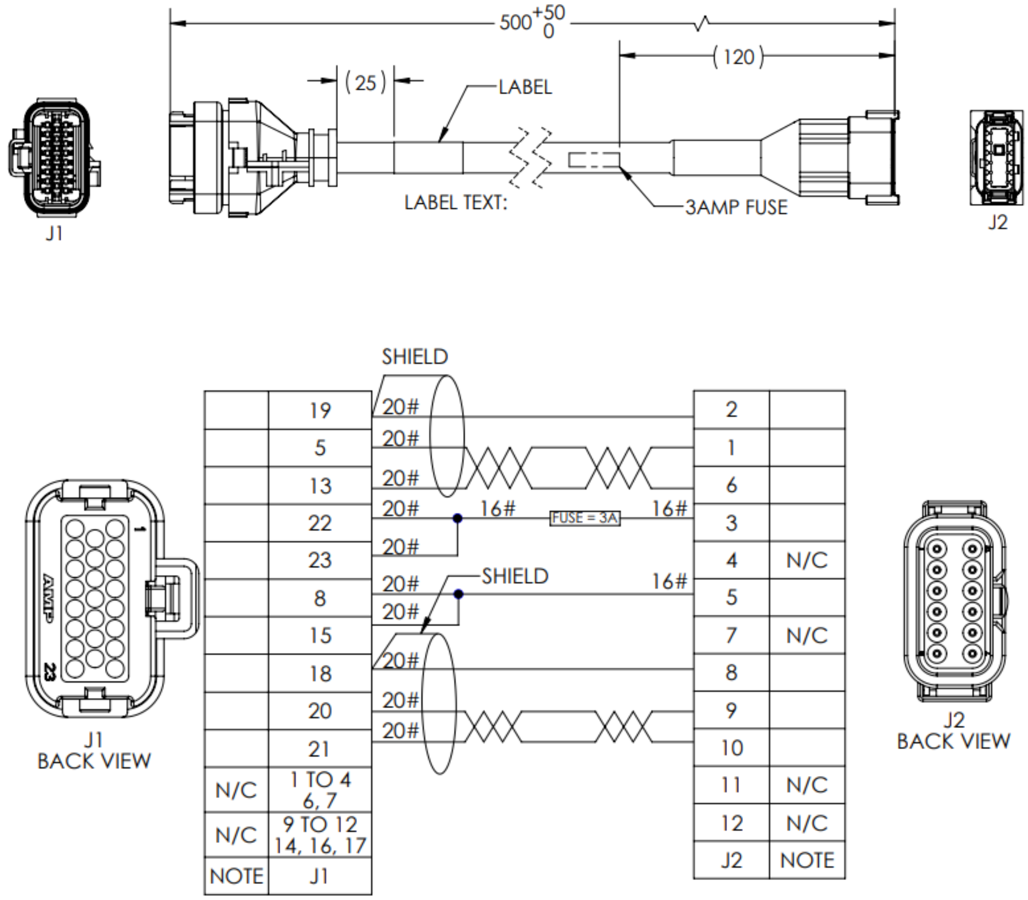


Figure D-1: Part Number: 051-0419-10

Table D-1: Part Number: 051-0419-10 Pin-Outs

J1	J2	Signal
5	1	VR1000 Port A RS232 Rx
8	5	Power Ground
13	6	VR1000 Port A RS232 Tx
15	5	Power Ground
18	8	Signal Ground
19	2	Signal Ground
20	9	VR1000 Port B RS232 Tx
21	10	VR1000 Port B RS232 Rx
22	3	Power Positive
23	3	Power Positive

Part Number 051-0420-10

P/N: 051-0420-10

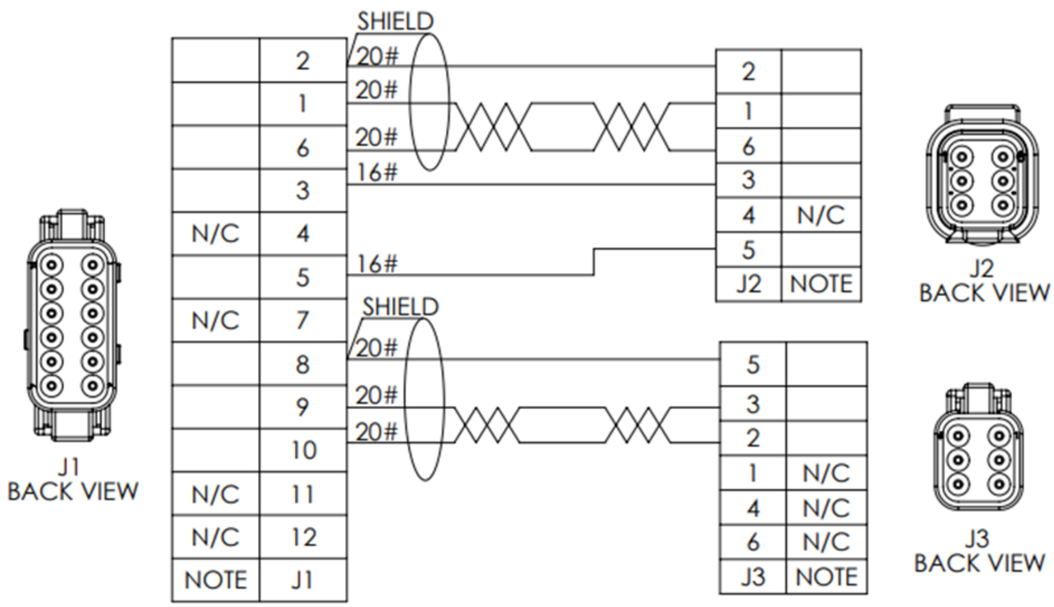


Figure D-2: Part Number: 051-0420-10

Table D-2: Part Number: 051-0420-10 Pin-Outs

J1	J2	J3	Signal
1	1	NC	VR1000 Port A RS232 Rx
2	2	NC	Signal Ground
3	3	NC	Power Positive
4	NC	NC	
5	5	NC	Power Ground
6	6	NC	VR1000 Port A RS232 Tx
7	NC	NC	
8	NC	5	Signal Ground
9	NC	3	VR1000 Port B RS232 Tx
10	NC	2	VR1000 Port B RS232 Tx
11	NC	NC	
12	NC	NC	

Part Number 051-0408-10

P/N: 051-0408-10

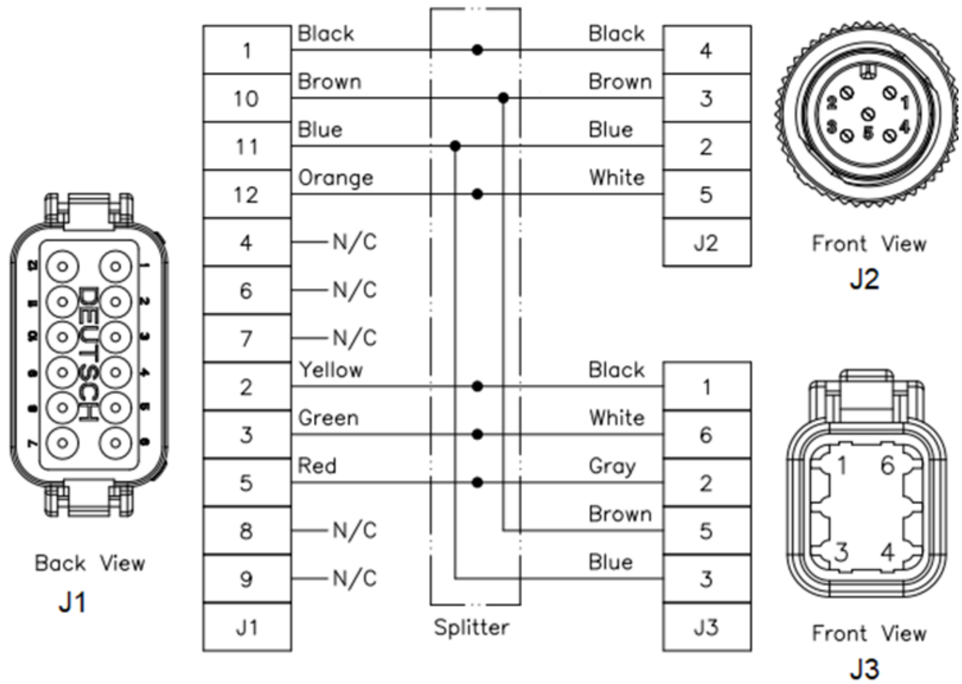


Figure D-3: Part Number: 051-0408-10

Table D-3: Part Number: 051-0408-10 Pin-Outs

J1	J2	J3	Signal
1	4		CAN High
2		1	IronOne RS232 Tx
3		6	IronOne RS232 Rx
4			
5		2	Signal Ground
6			
7			
8			
9			
10	3	5	Power Ground
11	2	3	12V+ Out
12	5		CAN Low

VR500 Installation Schematic

Table D-4: Excavator Schematic-R232 and Power, IronOne -VR500

051-0408-10 J1	051-0408-10 J3	051-0407-10 J1	051-0407-10 J2	051-0406-10 J2	Signal
1					CAN High
2	1	1	3	11	IronOne RS232 Tx/V500 Rx
3	6	6	2	12	IronOne RS232 Rx/VR500 Tx
4					
5	2	2	5	13	Signal Ground
6					
7					
8					
9					
10	5	5	4	22	Power Ground
11	3	3	1	21	12V+ Out
12					CAN Low

VR100 Installation Schematic

Table D-5: Excavator Schematic-R232 and Power, IronOne -VR1000

051-0408-10 J1	051-0408-10 J3	051-0420-10 J2	051-0420-10 J1	051-0419-10 J1	Signal
1					CAN High
2	1	1	1	5	IronOne RS232 Tx/VR1000 Rx
3	6	6	6	13	IronOne RS232 Rx/VR1000 Tx
4					
5	2	2	2	19	Signal Ground
6					
7					
8					
9					
10	5	5	5	15	Power Ground
11	3	3	3	23	12V+ Out
12					CAN Low

Part Number 051-0477-10 (Optional Accessory)

P/N: 051-0477-10

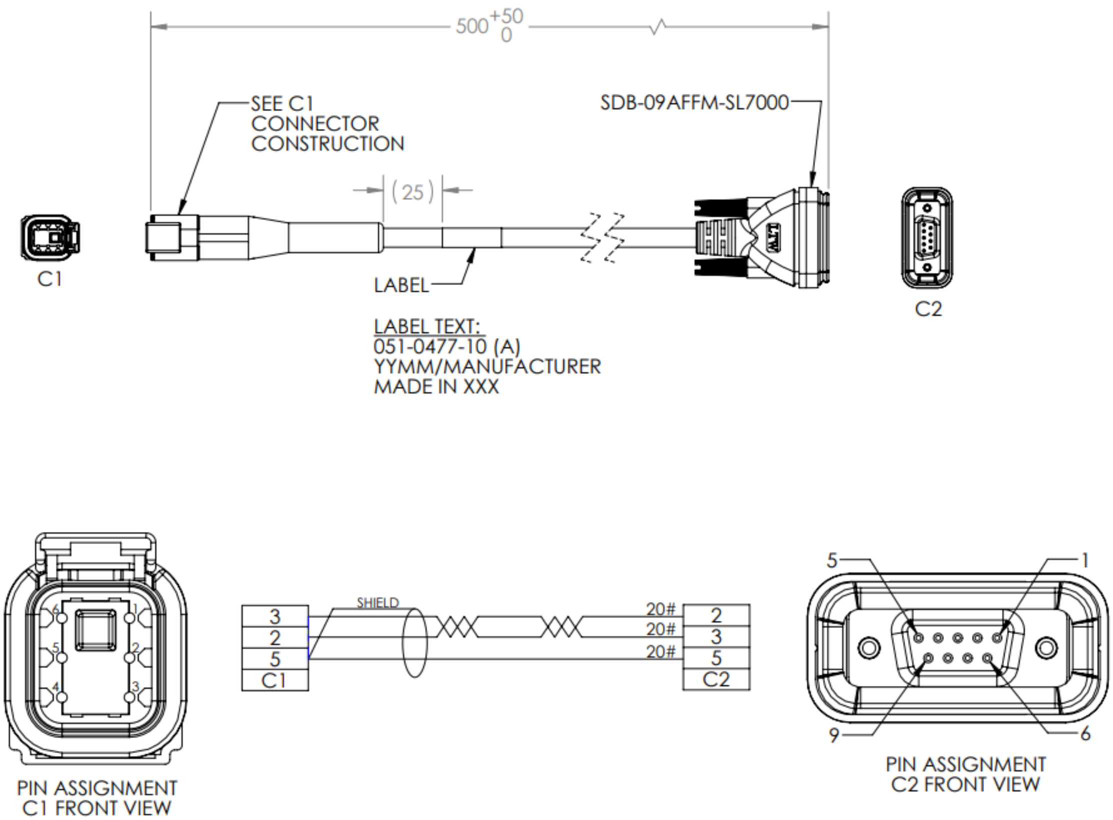


Figure D-4: Part Number: 051-0477-10

Table D-6: **Part Number: 051-0477-10**

C1	C2	Signal
2	2	VR1000 Port B RS232 Rx
3	3	VR1000 Port B RS232 Tx
5	5	Signal Ground

Part Number 051-0406-10

P/N: 051-0406-10

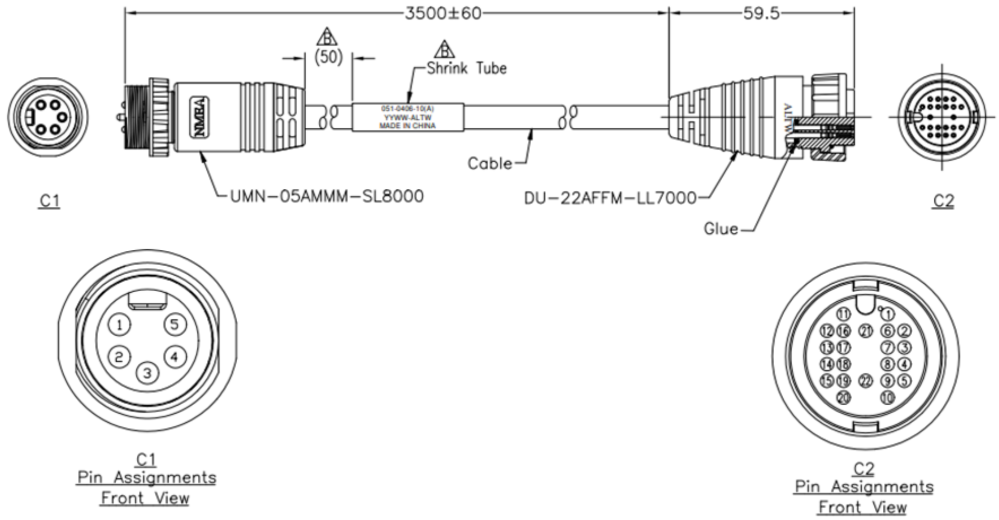


Figure D-5: Part Number: 051-0406-10

Table D-7: Part Number: 051-0406-10 Pin-Outs

C1	C2	Signal
1	21	Power+
2	12	VR500 Port A RS232 Tx
3	11	VR500 Port A RS232 Rx
4	22	Power-
5	13	Signal Ground

Part Number 051-0407-10

P/N: 051-0407-10

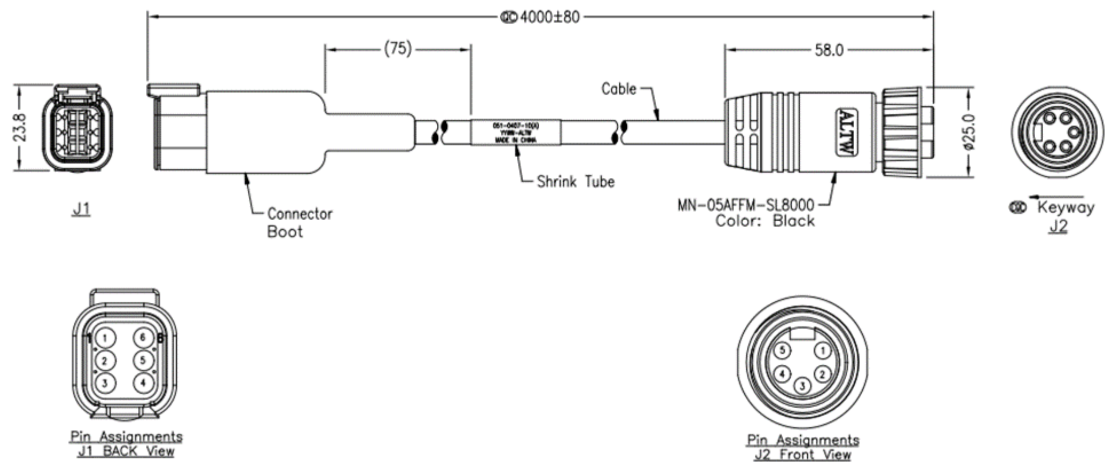


Figure D-6: Part Number: 051-0407-10

Table D-8: Part Number: 051-0407-10 Pin-Outs

J1	J2	Signal
1	3	VR500 Port A RS232 Rx
2	5	Signal Ground
3	1	Power-
4		
5	4	Power+
6	2	VR500 Port A RS232 Tx

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2. **LICENSEE REMEDIES.** In all cases which involve a failure of the Software to conform in any material respect to the documentation during the Warranty Period or a breach of a warranty, Hemisphere's sole obligation and liability, and Licensee's sole and exclusive remedy, is for Hemisphere, at Hemisphere's option, to (a) repair the Software, (b) replace the Software with software conforming to the documentation, or (c) if Hemisphere is unable, on a reasonable commercial basis, to repair the Software or to replace the Software with conforming software within ninety (90) days, to terminate this Agreement and thereafter Licensee shall cease using the Software. Hemisphere will also issue a refund for the price paid by Licensee less an amount on account of amortization, calculated on a straight-line basis over a deemed useful life of three (3) years.
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5. BASIS OF BARGAIN. Licensee agrees and acknowledges that Hemisphere has set its prices and the parties have entered into this Agreement in reliance on the limited warranties, warranty disclaimers and limitations of liability set forth herein, that the same reflect an agreed-to allocation of risk between the parties (including the risk that a remedy may fail of its essential purpose and cause consequential loss), and that the same forms an essential basis of the bargain between the parties. Licensee agrees and acknowledges that Hemisphere would not have been able to sell the Product at the amount charged on an economic basis without such limitations.
6. PROPRIETARY RIGHTS INDEMNITY. Hemisphere shall indemnify, defend and hold harmless Licensee from and against any and all actions, claims, demands, proceedings, liabilities, direct damages, judgments, settlements, fines, penalties, costs and expenses, including royalties and attorneys' fees and related costs, in connection with or arising out of any actual infringement of any third party patent, copyright or other intellectual property right by the Software or by its use, in accordance with this Agreement and documentation, PROVIDED THAT: (a) Hemisphere has the right to assume full control over any action, claim, demand or proceeding, (b) Licensee shall promptly notify Hemisphere of any such action, claim, demand, or proceeding, and (c) Licensee shall give Hemisphere such reasonable assistance and tangible material as is reasonably available to Licensee for the defense of the action, claim, demand or proceeding. Licensee shall not settle or compromise any of same for which Hemisphere has agreed to assume responsibility without Hemisphere's prior written consent. Licensee may, at its sole cost and expense, retain separate counsel from the counsel utilized or retained by Hemisphere. 19. INFRINGEMENT. If use of the Software may be enjoined due to a claim of infringement by a third party then, at its sole discretion and expense, Hemisphere may do one of the following: (a) negotiate a license or other agreement so that the Product is no longer subject to such a potential claim, (b) modify the Product so that it becomes non- infringing, provided such modification can be accomplished without materially affecting the performance and functionality of the Product,

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End User license agreement, continued

c) replace the Software, or the Product, with non-infringing software, or product, of equal or better performance and quality, or (d) if none of the foregoing can be done on a commercially reasonable basis, terminate this license and Licensee shall stop using the Product and Hemisphere shall refund the price paid by Licensee less an amount on account of amortization, calculated on a straight-line basis over a deemed useful life of three (3) years.

5. The foregoing sets out the entire liability of Hemisphere and the sole obligations of Hemisphere to Licensee in respect of any claim that the Software or its use infringes any third party rights.
6. INDEMNIFICATION. Except in relation to an infringement action, Licensee shall indemnify and hold Hemisphere harmless from any and all claims, damages, losses, liabilities, costs and expenses (including reasonable fees of lawyers and other professionals) arising out of or in connection with Licensee's use of the Product, whether direct or indirect, including without limiting the foregoing, loss of data, loss of profit or business interruption. TERMINATION. Licensee may terminate this Agreement at any time without cause. Hemisphere may terminate this Agreement on 30 days notice to Licensee if Licensee fails to materially comply with each provision of this Agreement unless such default is cured within the 30 days. Any such termination by a party shall be in addition to and without prejudice to such rights and remedies as may be available, including injunction and other equitable remedies. Upon receipt by Licensee of written notice of termination from Hemisphere or termination by Licensee, Licensee shall at the end of any notice period (a) cease using the Software; and (b) return to Hemisphere (or destroy and provide a certificate of a Senior Officer attesting to such destruction) the Software and all related material and any magnetic or optical media provided to Licensee. The provisions of Sections 6), 7), 8), 9), 10), 15), 21), 26) and 27) herein shall survive the expiration or termination of this Agreement for any reason.
7. **EXPORT RESTRICTIONS**. Licensee agrees that Licensee will comply with all export control legislation of Canada, the United States, Australia and any other applicable country's laws and regulations, whether under the Arms Export Control Act, the International Traffic in Arms Regulations, the Export Administration Regulations, the regulations of the United States Departments of Commerce, State, and Treasury, or otherwise as well as the export control legislation of all other countries.
8. **PRODUCT COMPONENTS.** The Product may contain third party components. Those third party components may be subject to additional terms and conditions. Licensee is required to agree to those terms and conditions in order to use the Product.
9. **FORCE MAJEURE EVENT.** Neither party will have the right to claim damages as a result of the other's inability to perform or any delay in performance due to unforeseeable circumstances beyond its reasonable control, such as labor disputes, strikes, lockouts, war, riot, insurrection, epidemic, Internet virus attack, Internet failure, supplier failure, act of God, or governmental action not the fault of the non-performing party.
10. **FORUM FOR DISPUTES**. The parties agree that the courts located in Calgary, Alberta, Canada and the courts of appeal there from will have exclusive jurisdiction to resolve any disputes between Licensee and Hemisphere concerning this Agreement or Licensee's use or inability to use the Software and the parties hereby irrevocably agree to attorn to the jurisdiction of those courts. Notwithstanding the foregoing, either party may apply to any court of competent jurisdiction for injunctive relief.
11. **APPLICABLE LAW**. This Agreement shall be governed by the laws of the Province of Alberta, Canada, exclusive of any of its choice of law and conflicts of law jurisprudence.
12. **CISG.** The United Nations Convention on Contracts for the International Sale of Goods will not apply to this Agreement or any transaction hereunder.

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

Warranty Notice

Warranty notice

COVERED PRODUCTS: This warranty covers all products manufactured by Hemisphere GNSS and purchased by the end purchaser (the "Products"), unless otherwise specifically and expressly agreed in writing by Hemisphere GNSS.
LIMITED WARRANTY: Hemisphere GNSS warrants solely to the end purchaser of the Products, subject to the exclusions and procedures set forth below, that the Products sold to such end purchaser and its internal components shall be free, under normal use and maintenance, from defects in materials, and workmanship and will substantially conform to Hemisphere GNSS's applicable specifications for the Product, for a period of 12 months from delivery of such Product to such end purchaser (the "Warranty Period"). Repairs and replacement components for the Products are warranted, subject to the exclusions and procedures set forth below, to be free, under normal use and maintenance, from defects in material and workmanship, and will substantially conform to Hemisphere GNSS's applicable specifications for the Product, for 90 days from performance or delivery, or for the balance of the original Warranty Period, whichever is greater.
EXCLUSION OF ALL OTHER WARRANTIES. The LIMITED WARRANTY shall apply only if the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Hemisphere GNSS relevant User's Manual and Specifications, AND the Product is not modified or misused. The Product is provided "AS IS" and the implied warranties of MERCHANTABILITY and FITNESS FOR A PARTICULAR PURPOSE and ALL OTHER WARRANTIES,
express, implied or arising by statute, by course of dealing or by trade usage, in connection with the design, sale, installation, service or use of any products or any component thereof, are EXCLUDED from this transaction and shall not apply to the Product. The LIMITED WARRANTY is IN LIEU OF any other warranty, express or implied, including but not limited to, any warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE, title, and non-infringement.
LIMITATION OF REMEDIES. The purchaser's EXCLUSIVE REMEDY against Hemisphere GNSS shall be, at Hemisphere GNSS's option, the repair or replacement of any defective Product or components thereof. The purchaser shall notify Hemisphere GNSS or a Hemisphere GNSS's approved service center immediately of any defect. Repairs shall be made through a Hemisphere GNSS approved service center only. Repair, modification or service of Hemisphere GNSS products by any party other than a Hemisphere GNSS approved service center shall render this warranty null and void. The remedy in this paragraph shall only be applied in the event that the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Hemisphere GNSS's relevant User's Manual and Specifications, AND the Product is not modified or misused. NO OTHER REMEDY (INCLUDING, BUT NOT LIMITED TO, SPECIAL, INDIRECT, INCIDENTAL, CONSEQUENTIAL OR CONTINGENT DAMAGES FOR LOST PROFITS, LOST SALES, INJURY TO PERSON OR PROPERTY, OR ANY OTHER INCIDENTAL OR CONSEQUENTIAL LOSS) SHALL BE AVAILABLE
TO PURCHASER, even if Hemisphere GNSS has been advised of the possibility of such damages. Without limiting the foregoing, Hemisphere GNSS shall not be liable for any damages of any kind resulting from installation, use, quality, performance or accuracy of any Product.
HEMISPHERE IS NOT RESPONSIBLE FOR PURCHASER'S NEGLIGENCE OR UNAUTHORIZED USES OF THE PRODUCT. IN NO EVENT SHALL Hemisphere GNSS BE IN ANY WAY RESPONSIBLE FOR ANY DAMAGES RESULTING FROM PURCHASER'S OWN NEGLIGENCE, OR FROM OPERATION OF THE PRODUCT IN ANY WAY OTHER THAN AS SPECIFIED IN Hemisphere GNSS's RELEVANT USER'S MANUAL AND SPECIFICATIONS. Hemisphere GNSS is NOT
RESPONSIBLE for defects or performance problems resulting from (1) misuse, abuse, improper installation, neglect of Product; (2) the utilization of the Product with hardware or software products, information, data, systems, interfaces or devices not made, supplied or specified by Hemisphere GNSS; (3) the operation of the Product under any specification other than, or in addition to, the specifications set forth in Hemisphere GNSS's relevant User's Manual and Specifications; (4) damage caused by accident or natural events, such as lightning (or other electrical discharge) or fresh/ salt water immersion of Product; (5) damage occurring in transit; (6) normal wear and tear; or (7) the operation or failure of operation of any satellite-based positioning system or differential correction service; or the availability or performance of any satellite-based positioning signal or differential correction signal.
THE PURCHASER IS RESPONSIBLE FOR OPERATING THE VEHICLE SAFELY. The purchaser is solely responsible for the safe operation of the vehicle used in connection with the Product, and for maintaining proper system control settings. UNSAFE DRIVING OR SYSTEM CONTROL SETTINGS CAN RESULT IN PROPERTY DAMAGE, INJURY, OR DEATH.

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Warranty notice, continued

The purchaser is solely responsible for his/her safety and for the safety of others. The purchaser is solely responsible for maintaining control of the automated steering system at all times. THE PURCHASER IS SOLELY RESPONSIBLE FOR ENSURING THE PRODUCT IS PROPERLY AND CORRECTLY INSTALLED, CONFIGURED, INTERFACED, MAINTAINED, STORED, AND OPERATED IN ACCORDANCE WITH Hemisphere GNSS's RELEVANT USER'S MANUAL AND SPECIFICATIONS. Hemisphere GNSS does not warrant or guarantee the positioning and navigation precision or accuracy obtained when using Products. Products are not intended for primary navigation or for use in safety of life applications. The potential accuracy of Products as stated in Hemisphere GNSS literature and/or Product specifications serves to provide only an estimate of achievable accuracy based on performance specifications provided by the satellite service operator (i.e. US Department of Defense in the case of GPS and differential correction service provider. Hemisphere GNSS reserves the right to modify Products without any obligation to notify, supply or install any improvements or alterations to existing Products.
GOVERNING LAW. This agreement and any disputes relating to, concerning or based upon the Product shall be governed by and interpreted in accordance with the laws of the State of Arizona.
OBTAINING WARRANTY SERVICE. In order to obtain warranty service, the end purchaser must bring the Product to a Hemisphere GNSS approved service center along with the end purchaser's proof of purchase. Hemisphere GNSS does not warrant claims asserted after the end of the warranty period. For any questions regarding warranty service or to obtain information regarding the location of any of Hemisphere GNSS approved service center, contact Hemisphere GNSS at the following address:

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