GRADEMETRIX™
Installation Guide, Excavator, 980-8005-XX Series
Revision: A1

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Table of Contents

Chapter 1: Getting Started

Overview

Introduction

Chapter 1 details all the information you need to set up a Case Compact Excavator system (Part Number = 980-8005-10) with all the sensors needed 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, 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 must attach brackets for permanent installations. Prior to welding to the machine be sure to disconnect the IronTwo.

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

- ☐ Slotted screwdriver
- ☐ Phillips screwdriver
- ☐ Adjustable wrench
- ☐ ½" and 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

You will need an instrument that can check if machine components are level and plumb during the calibration procedure. 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 with 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 level 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 the surrounding property. Some steps can be completed prior to getting on the excavator. See Configure and Calibrate 3D Sensors.

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

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

> **Important:** The IronTwo must receive 9 – 36 VDC of input power from the machine (most machines should provide 24 V directly from the battery). **Ground to the machine chassis. Do not ground to the negative terminal of the battery.**

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

Chapter 2: Install Hardware Components

Overview

Introduction

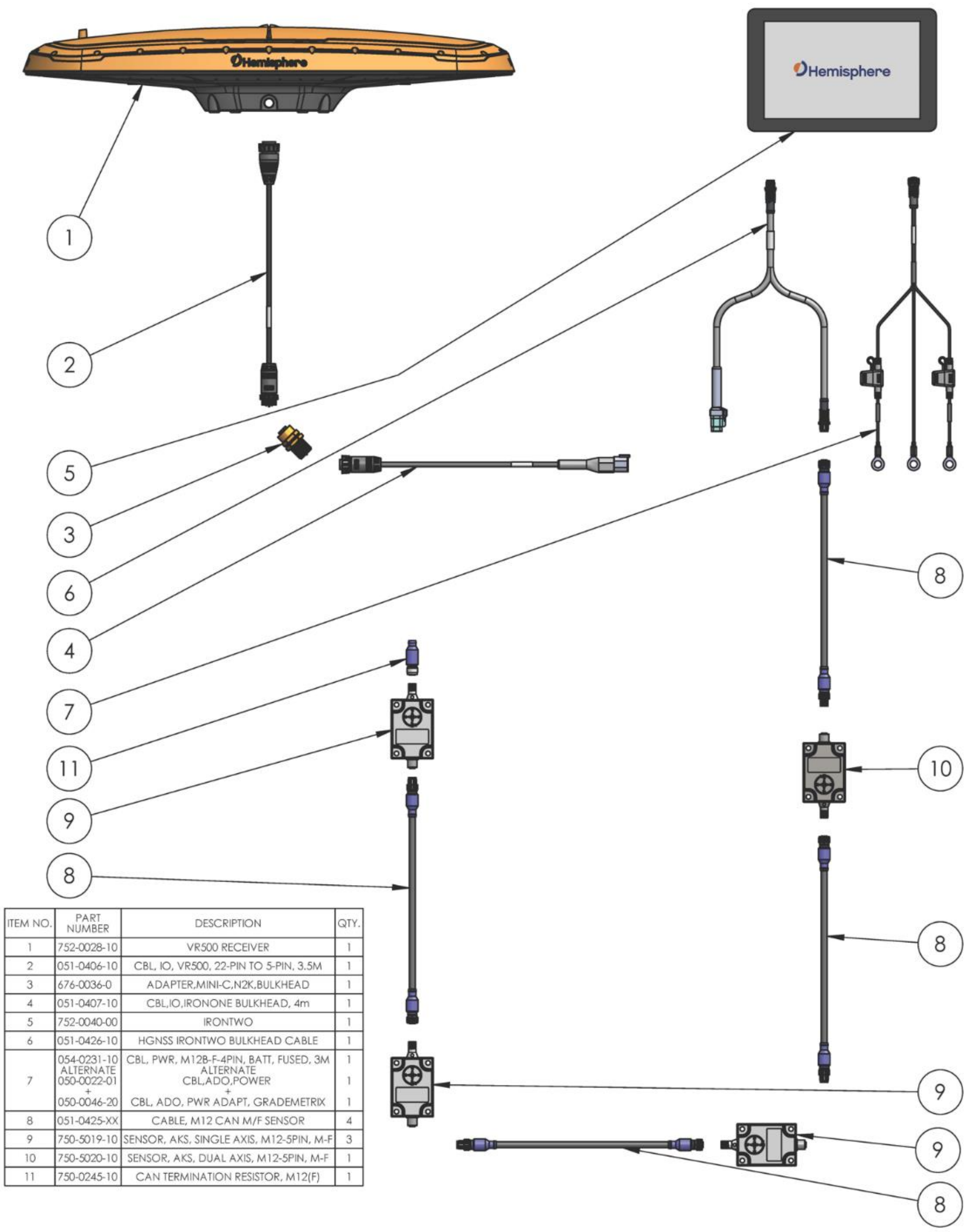
Chapter 2 provides all the information you need to install the hardware components needed for the GradeMetrix compact excavator installation.

Contents

System Components

System components

The receiver, sensors, and IronTwo are each discussed separately. A full system schematic is shown below for reference.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	752-0028-10	VR500 RECEIVER	1
2	051-0406-10	CBL, IO, VR500, 22-PIN TO 5-PIN, 3.5M	1
3	676-0036-0	ADAPTER,MINI-C,N2K,BULKHEAD	1
4	051-0407-10	CBL,IO,IRONONE BULKHEAD, 4m	1
5	752-0040-00	IRONTWO	1
6	051-0426-10	HGNSS IRONTWO BULKHEAD CABLE	1
7	054-0231-10 ALTERNATE 050-0022-01 + 050-0046-20	CBL, PWR, M12B-F-4PIN, BATT, FUSED, 3M ALTERNATE CBL,ADO,POWER + CBL, ADO, PWR ADAPT, GRADEMETRIX	1 1 1
8	051-0425-XX	CABLE, M12 CAN M/F SENSOR	4
9	750-5019-10	SENSOR, AKS, SINGLE AXIS, M12-5PIN, M-F	3
10	750-5020-10	SENSOR, AKS, DUAL AXIS, M12-5PIN, M-F	1
11	750-0245-10	CAN TERMINATION RESISTOR, M12(F)	1

IronTwo Display Installation

Install the IronTwo

The GradeMetrix Excavator Installation Kit comes with the following components:

- IronTwo (P/N: 752-0040-10)

- IronTwo Power Cable (P/N: 050-0022-01 and 050-0046-01)
- IronTwo Flush Mount Kit (P/N: 710-0148-10)

- Magnetic Mounting Base, 48mm, 4-point (604-0086-10)

Continued on next page

Install the IronTwo, continued

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

Table 2-1: Install IronTwo control box

Step	Action
1	Attach the 1.5” RAM ball to the rear of the IronTwo using the included bolts.
2	Install the 1.5” RAM base mount to the magnetic base. **Note:** The RAM swivel mount can be used to adjust the location and viewing angle of the console.
3	Install the magnetic mount using the instructions below.
4	When installing cabling, ensure adequate cable slack is provided, so the IronTwo can swivel on the RAM mount without putting stress on the cables.

To install the components, you must have:
- Philips Screwdriver
- Nut driver

Attach the RAM flush mount to the magnetic base mount. The magnetic base mount can be installed to the windshield. It is important to make sure the IronTwo is placed so that it does not obstruct operator view. Make sure the front windshield can be opened.

To install the RAM magnetic display holder, remove the back four discs (shown below). Place the four discs on the outside of the window. Place the magnetic base on the inside of the window. The magnetic base grips the four discs through the window and holds the mount in place with friction.

Continued on next page

Install the IronTwo, Continued

Warning: When placing the disc on the outside of the window, place the disc against the window in a location that is away from the magnet. Then, slide the disc into place.

The magnetic base is extremely strong. Placing a disc outside the window and directly behind the magnetic base may cause the window to crack due to the initial grab of the magnetic base.

The image below shows an IronTwo attached to the magnetic mount inside of the cab.

Figure 2-1: IronTwo mounted

Continued on next page

IronTwo Display Installation, Continued

Install the IronTwo, Continued

IMPORTANT!
The main power cable (P/N: 050-0022-01, P/N: 050-0046-01 connected) leads should be installed to system power (9-36 +VDC and chassis ground).

Do NOT ground to the negative terminal of the battery; always ground to the machine chassis.

The IronTwo power cable comes with an ignition wire (orange) that can be connected to the switch power. If connected to the switch power, the IronTwo will automatically be turned on after receiving power. Switch power should have 12v or 24v (depending on machine voltage) when the ignition is keyed on and should have 0v when ignition is keyed off. If you do not want to use switch power, connect the ignition to the constant machine voltage power.

The IronTwo bulkhead adapter cable harness (P/N: 051-0426-10) 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 the CAN axial sensors for monitoring boom, stick, and bucket movement.

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

Continued on next page

IronTwo cable schematic

The diagrams below show the cable schematics for P/N: 051-0426-10. The J1 connector plugs into the IronTwo. The J2 connector connects to a CAN cable. The J3 connector connects to the VR500 cable.

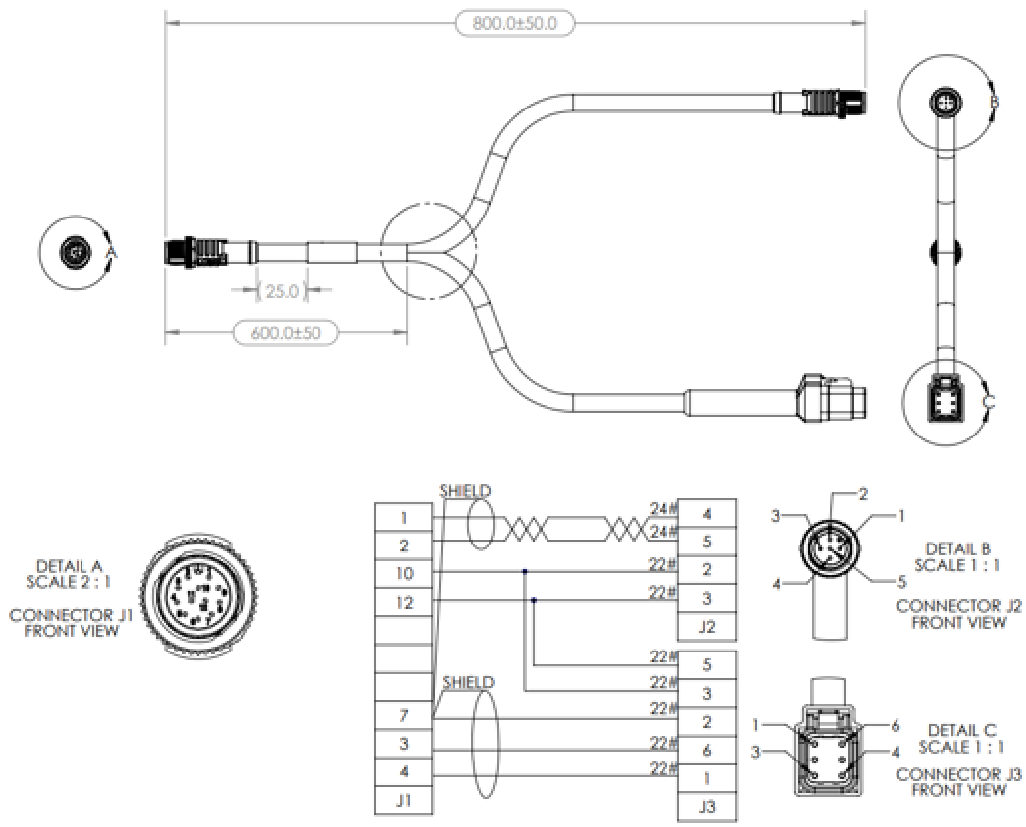


Figure 2-2: Cable schematic for P/N: 051-0426-10

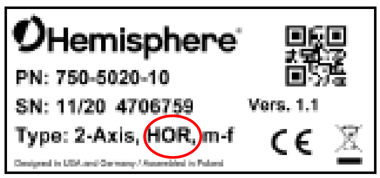
GMS-1 Sensor Installation

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 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 location:

- **Body sensor** – Horizontal slope sensor to measure the pitch and roll of the machine.
- **Boom sensor** - Vertical tilt sensor to measure the angle of the boom.
- **Stick sensor** – Vertical tilt sensor to measure the angle of the stick.
- **Dog-bone sensor** – Vertical tilt sensor mounted on the 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 the hydraulic cable for safety. When possible, welding seams should align with the axis of the machine. This reduces stress. Welds should be more than 75mm (3 inches) from existing welds. Paint surfaces after completion to prevent rust. Before welding, ensure the IronTwo is disconnected, and the machine isolated. This may require removing a battery lead for the battery.

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. These holes do not need to be fully welded. Two stich welds on each side are adequate. After welding the base bracket to the machine, paint the bracket.

Figure 2-3: Base Welded and Painted

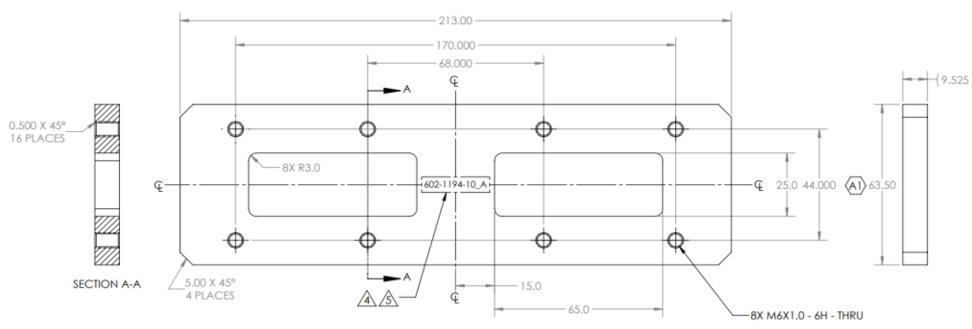


Figure 2-4: Bracket dimensions

Continued on next page

Brackets, Continued

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.

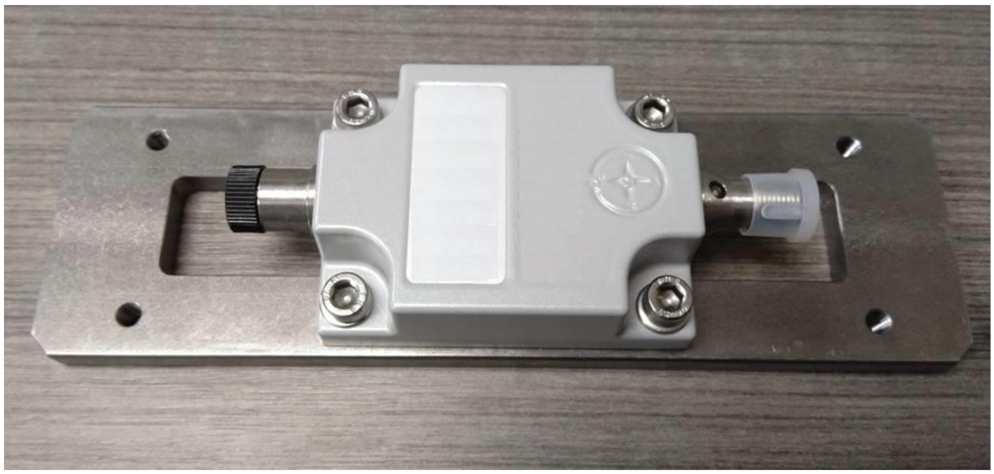


Figure: 2-5: Bracket

Continued on next page

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 2-6) 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.

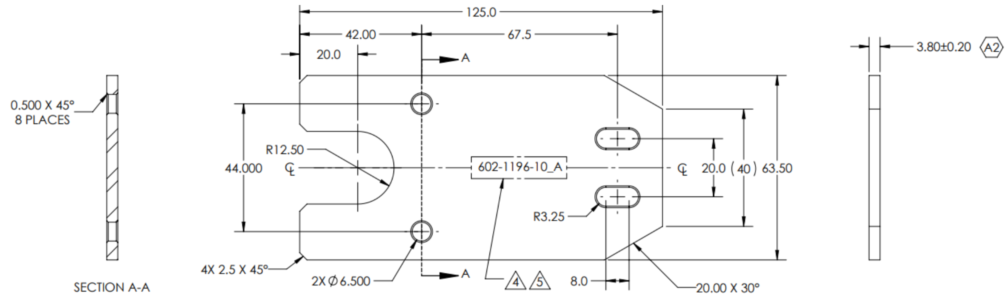


Figure 2-6: P/N: 602-1196-10 strain relief wing

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 by using the provided 14mm M6x1mm screws.

Note: Included are three aluminum covers and one steel cover. Use the steel cover to enclose the dogbone sensor. The other sensors can be covered with aluminum covers.

Note: The flat washer shown must be used, otherwise the screws and spacers threads may protrude beyond the bottom of the welding plate.

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Brackets, continued

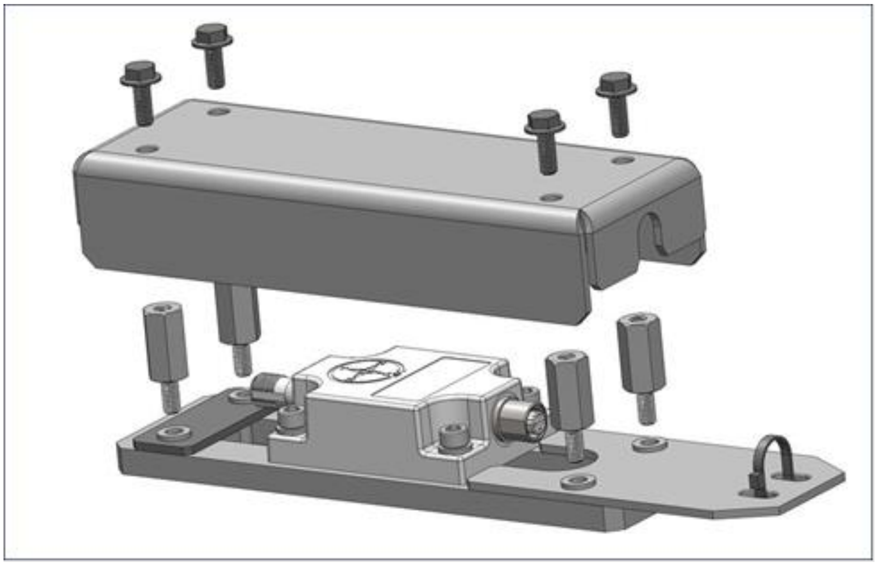

Figure 2-7: Sensor installation assembly view showing dog-bone

The other sensors have two strain relief plates. **Note: The other sensors use the aluminium cover, not the steel cover.**

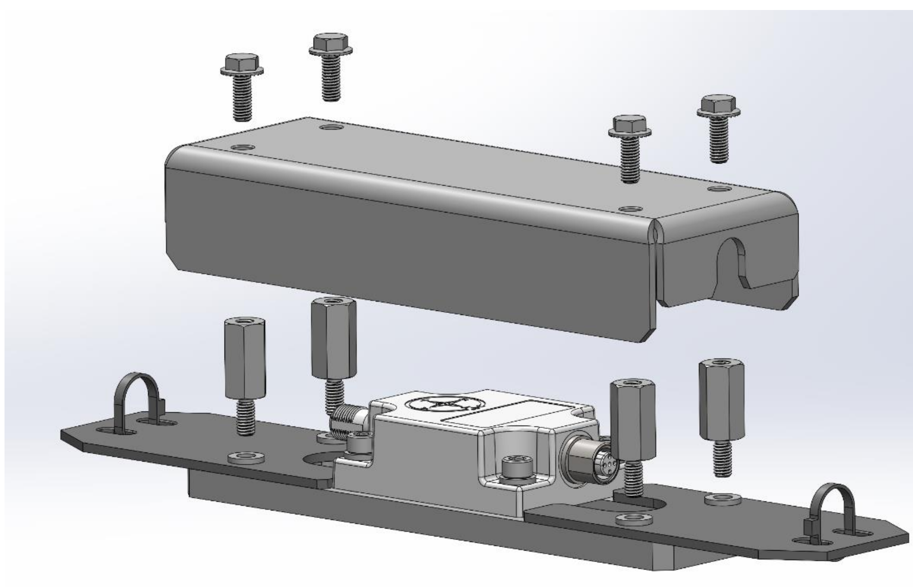

Figure 2-8: Sensor installation assembly view showing chassis, boom, and stick sensors

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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 fully open and fully retract before tacking the bracket onto the dog-bone. If possible, mount the sensor inside of the dog-bone. In the example below, the dogbone is mounted outside, because is not large enough for the sensor to be mounted inside.

You should take extra care to ensure that the bracket and cabling clear the bucket if the bucket is completely open or completely closed. An example is shown below. The cable is shown in the red box. An appropriate amount of cable is used to allow full bucket movement without excessive cable. Take note the dogbone bracket cover remains black to match the dogbone color. The other sensors were painted the “Power Tan” color.

Figure 2-9: Cover and Strain Relief Plates Painted

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

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Mount the dog-bone sensor, Continued

If you are not installing a tilt bucket, use the provided spacer instead of strain relief plate for the side without the cable.

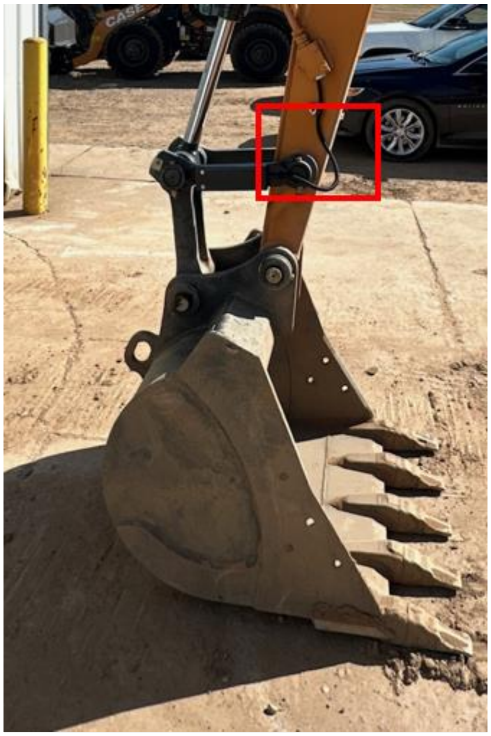

Figure 2-10: Dog-bone sensor

Continued on next page

GMS-1 Sensor Installation 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, excess cable is carefully routed around to run up the 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 2-11: Stick sensor

Note: You are permitted to mount the stick 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 a clear view of the sensors.

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

Continued on next page

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 boom 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 a 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 2-12: 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 the main platform. If you are mounting in a hidden compartment, be sure to note the sensor orientation before bolting any panels back in place.

VR500 Installation

VR500 Installation

First, decide the location you want to mount the receiver. Flip the VR500 over, and you will see an arrow (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 2-2: Mount the VR500

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>
Install the VR500 onto the mounting bracket.

Figure 2-13 shows the VR500 mounting bracket with magnets.

Table 2-3: 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>

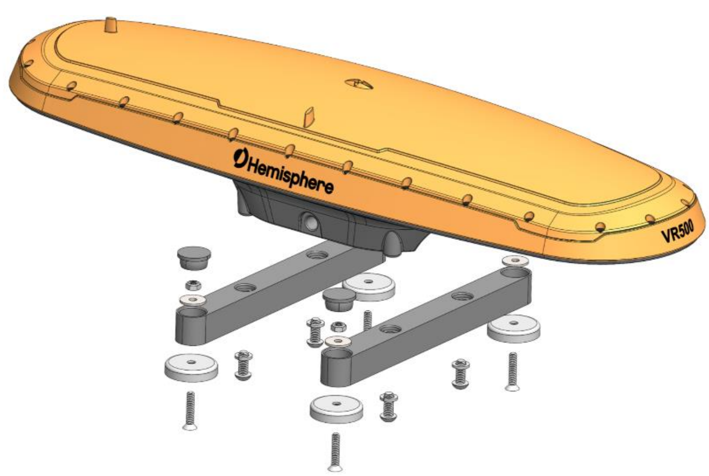

Figure 2-13: VR500 mounting brackets
</td></tr>
</table>

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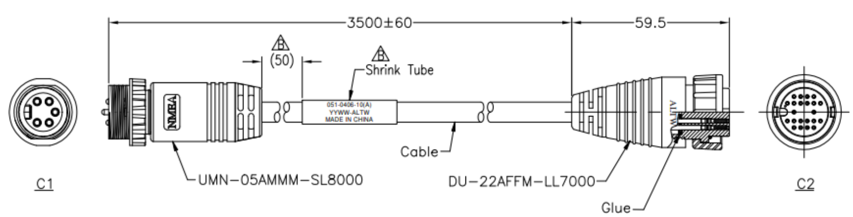
VR500 Installation, Continued

Table 2-2: Mount the VR500 (continued)

Step	Action
2	Find a flat surface on the roof of the machine to mount the receiver. The image below shows a VR500 on the roof of an excavator. 
3	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).  **Figure 2-14: VR500 to bulkhead** 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).

Continued on next page

VR500 Installation, Continued

Table 2-2: Mount the VR500 (continued)

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3
(cont.)</td><td>

Alternatively, there is a supplied bulkhead connector (P/N: 676-0036-0) that can be used to connect the two cables.

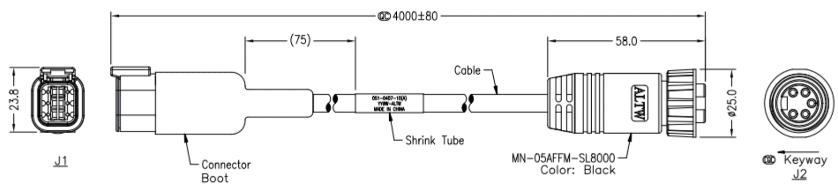


Figure 2-15: VR500 Bulkhead to IronTwo

The photo below shows the VR500 cable run down the back of the machine, secured with p-clamps.

Figure 2-16: VR500 mounted

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.

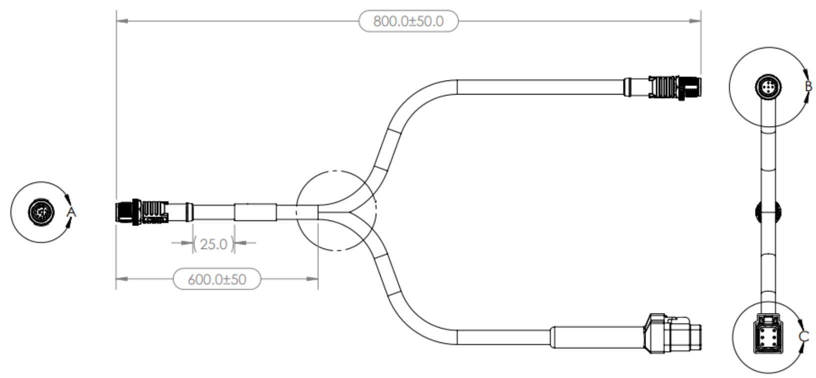
</td></tr>
</table>

Continued on next page

VR500 Installation, Continued

VR500 Installation, Continued

Table 2-2: Mount the VR500 (continued)

Step	Action
4	The VR500 cable (P/N: 051-0407-10) connects to the IronTwo cable (P/N: 051-0426-10) shown below. (See Appendix D Cable Pin-Outs for more information).  **Figure 2-17: Cable 051-0426-10**

Chapter 3: Measure Machine

Overview

Introduction

After entering the machine dimensions in **Equipment Setup**, you will receive a prompt to configure the sensors. These instructions assume that you are measuring a standard excavator.

Contents

Equipment Setup

Equipment setup

Position the excavator on a hard, 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.

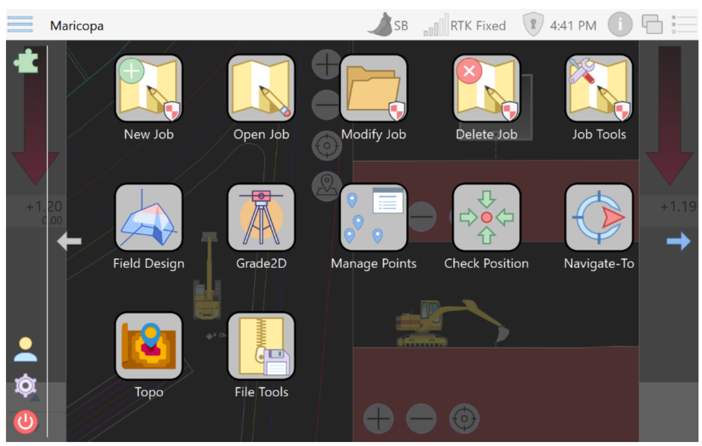
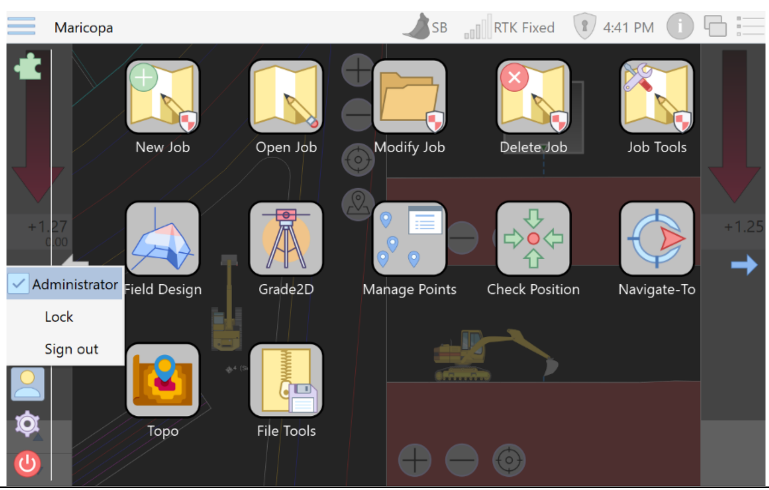
Note: To avoid potential damage to property or nearby individuals, check the surrounding area and confirm it is safe to move and operate the machine.

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.  

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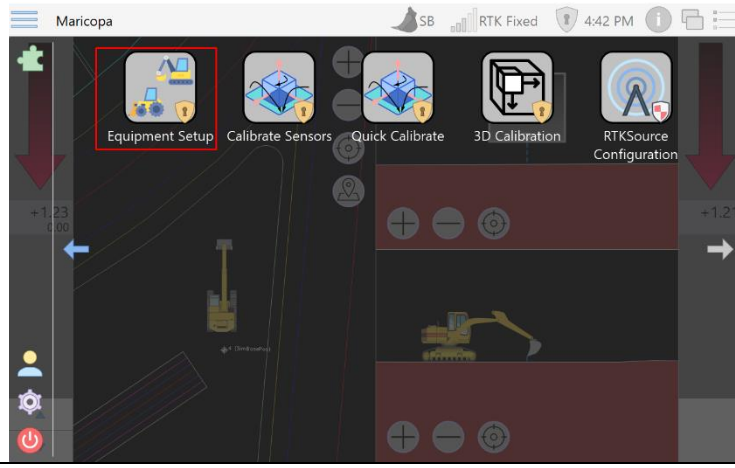
Equipment setup, continued

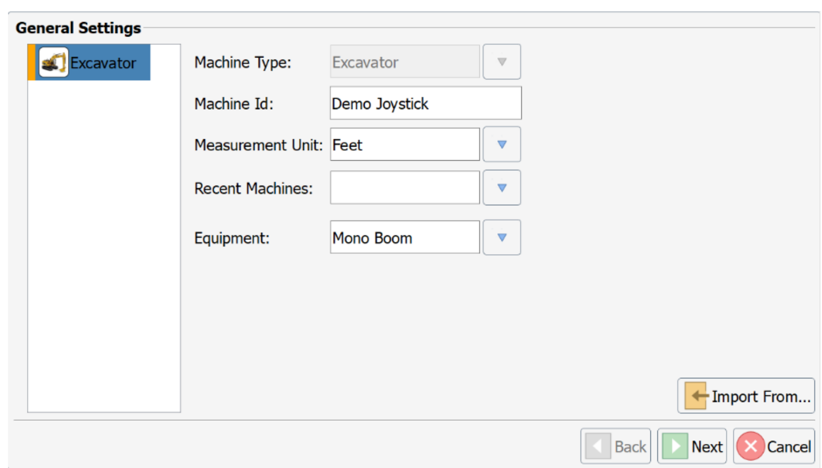
Table 3-1: Set up equipment in GradeMetrix (continued)

Step	Action
2	Scroll to the right (click the blue arrow on the right-hand side). Click the **Equipment Setup** icon. 

Continued on next page

Equipment setup, continued

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

Step	Action
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). The **Equipment** field allows you to select between "Mono Boom" (a standard, single boom excavator), "Multi Boom" (multiple booms, requiring an additional sensor), "Swing Boom," and "Knuckle Boom." This document describes the "Mono Boom." 
4	Click **Next.**

Continued on next page

Equipment Setup, Continued

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 VR500.

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.

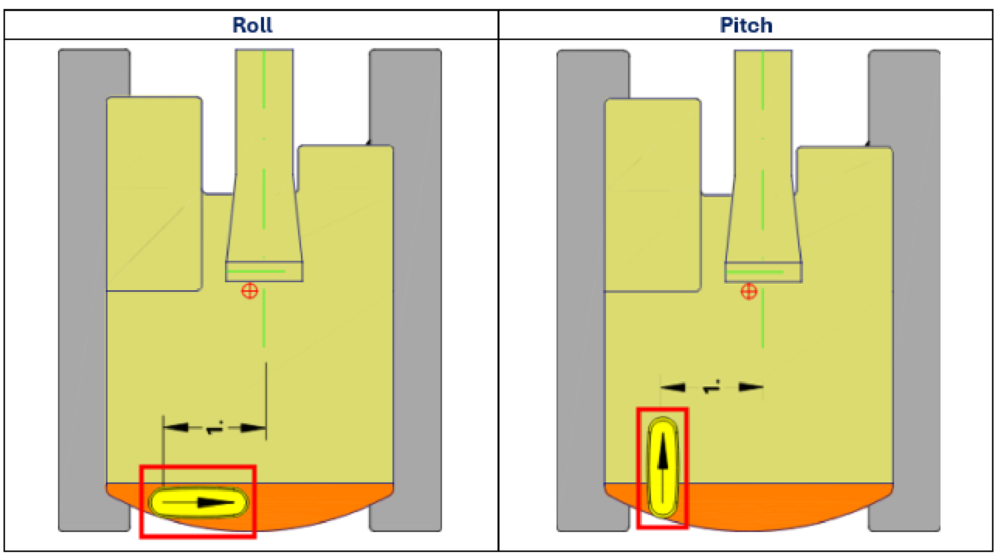
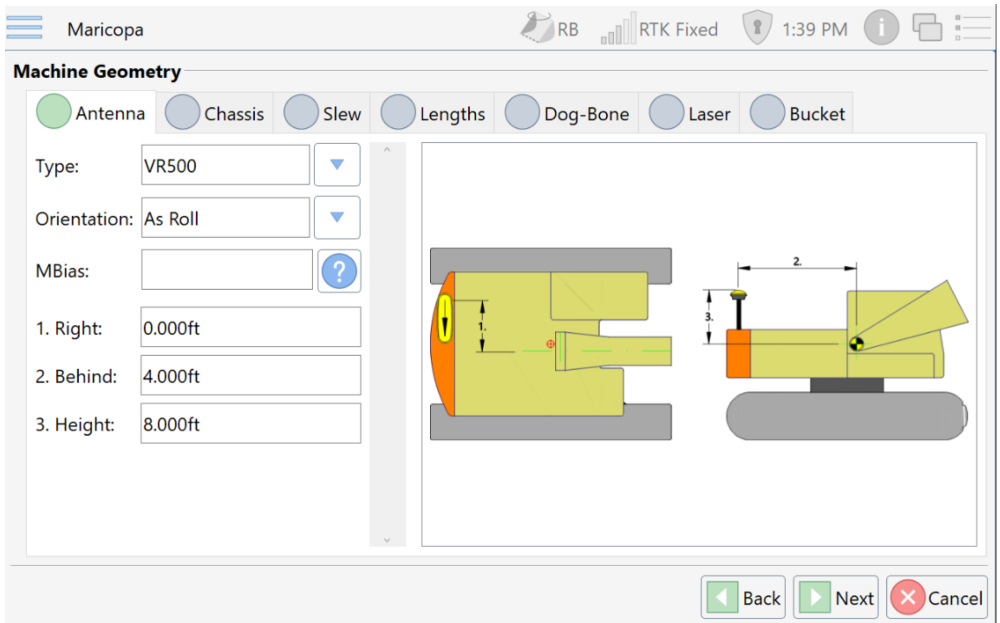


Figure 3-1: Antennas oriented roll and pitch

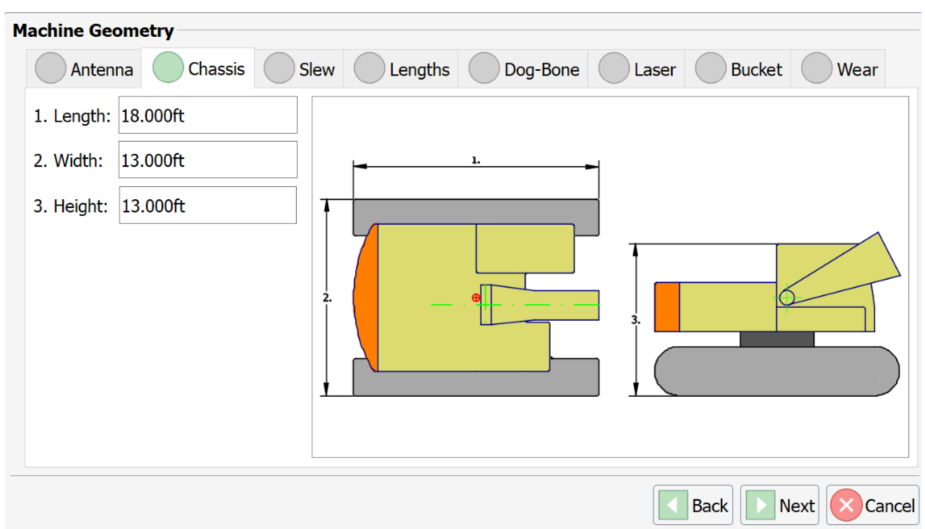
Continued on next page

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 measurements of chassis length, width, and height.

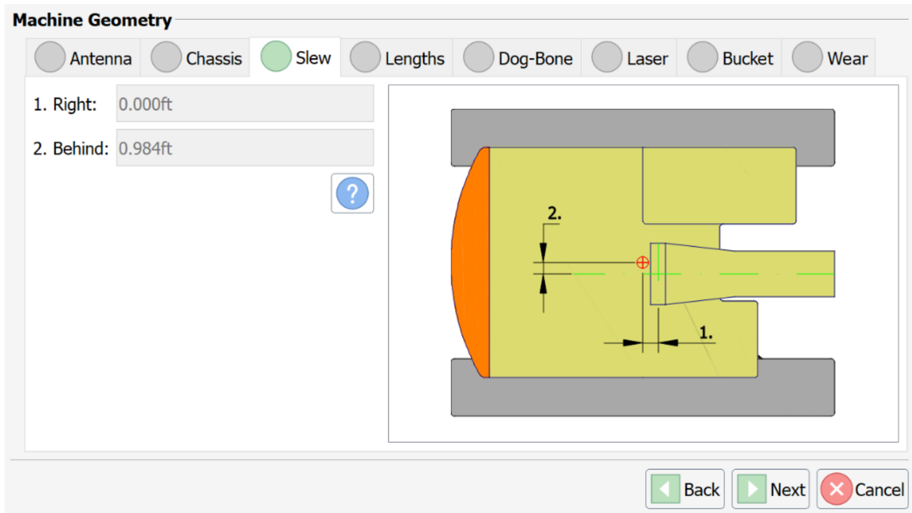
> **Note:** These measurements are for graphical purposes only, millimeter precision is not necessary.

Measurement	Machine Image
Chassis length	
Chassis width	
Chassis height	

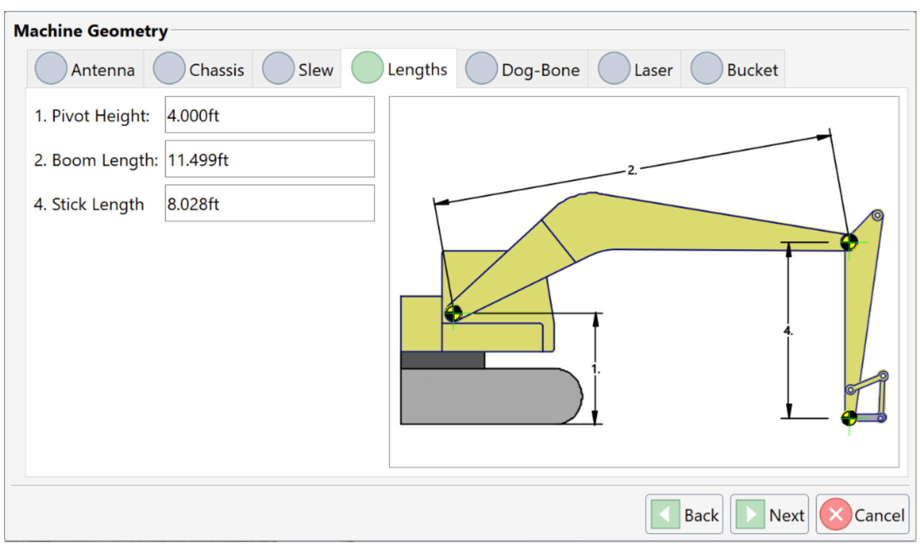
Continued on next page

Measure the machine, continued

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



The **Lengths** tab has fields for pivot height, boom length, and stick length. These measurements are critical for accurate performance. For the 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 the measurement from the boom pin to the stick pin. Take care to precisely measure from the center of the boom pin to the center of the stick pin.

Figure 3-2: Boom Pin to Stick Pin

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

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 to ensure that the tape is parallel to the boom.

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 the bucket pin to ensure the tape is parallel to the stick.

Note: Be careful to measure to the bucket pin instead of to the L1 linkage pin.

Figure 3-3: Stick measurement

Continued on next page

Measure the machine, Continued

The boom pivot height is the height of the boom pin (relative to the bottom of the machine). There are many ways to measure this value. If the machine is completely level (this will not work on a slope), you can use magnets to attach a string line from the boom pin to the stick. Use a line level to level this string. The height of this string above the ground will be the same as the boom pivot height.

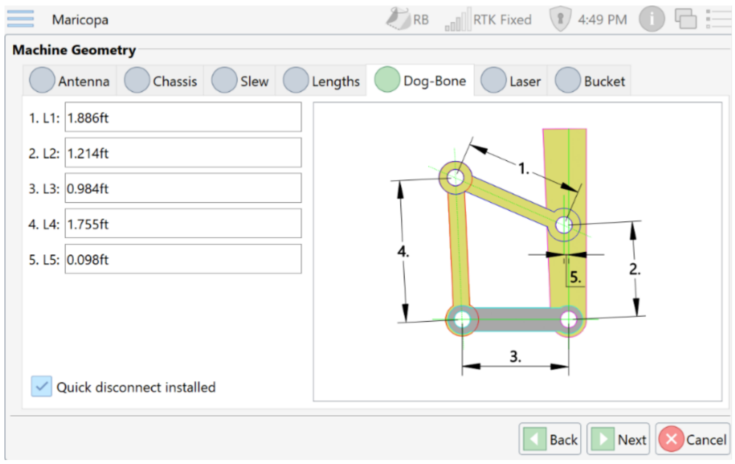
Figure 3-4 Boom Pivot Height

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 per the diagram.

Continued on next page

Measure the machine, continued

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.

The image below shows a string line from the stick pin to bucket pin (using a magnet to secure the line). There is an offset between the string line and the top linkage pin (a red box is around this offset).

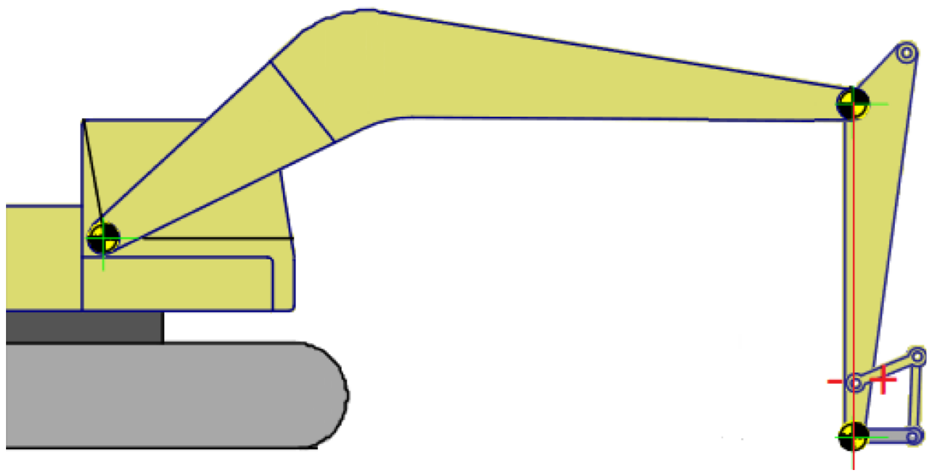


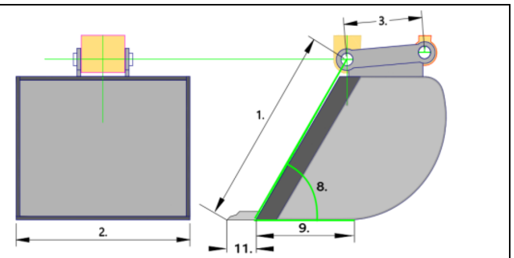
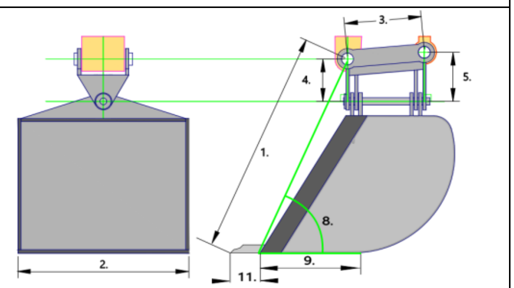
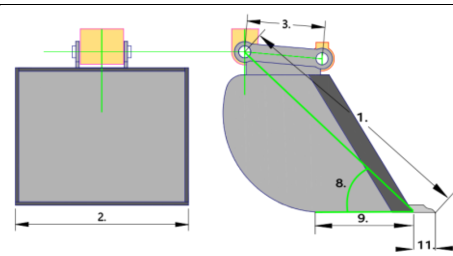
Figure 3-5: String line from stick pin to bucket pin

Continued on next page

Measure the machine, continued

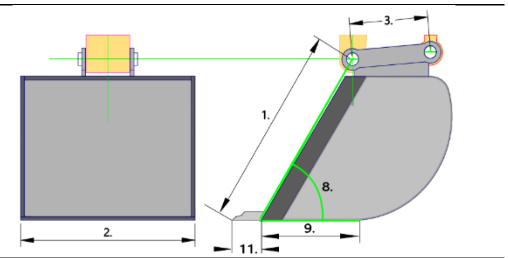
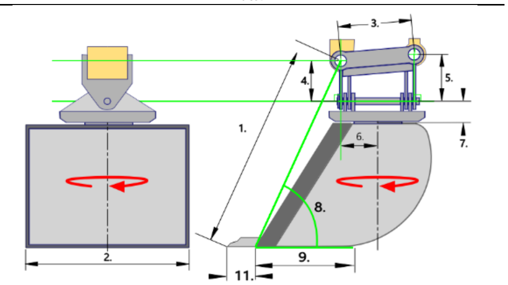
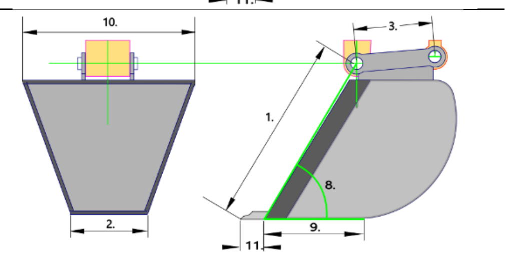
The **Bucket** tab is used to select your bucket type and enter dimensions. Select between a **Standard Bucket**, **Tilting Bucket**, **Shovel Bucket** (reversed bucket with dogbone linkage), **Rotator Bucket**, and **Ditching Bucket**.

Depending on the type of bucket, you will have different measurements. **Note:** Bucket angle (BA) is calculated during calibration. You do not enter this value for any bucket.

<u>Standard Bucket</u> This bucket requires you to enter the bucket width and bucket length. **NOTE:** bucket length should go to the base of the bucket if you are entering teeth length (item 11) for teeth wear calculations.	
<u>Tilting Bucket</u> A tilt bucket requires the additional entry of the measurements from each L3 pivot point to the center of rotation that the bucket tilts around.	
<u>Shovel Bucket</u> The shovel bucket is similar to standard bucket. It has standard bucket linkage but is reversed.	

Continued on next page

Measure the machine, Continued

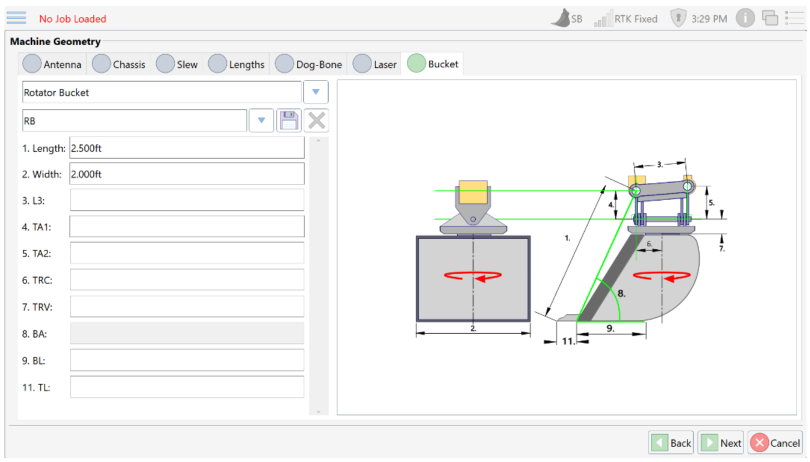
Standard Bucket This bucket requires you to enter the bucket width and bucket length. **NOTE:** bucket length should go to the base of the bucket if you are entering teeth length (item 11) for teeth wear calculations.	
Tilt Rotator The tilt rotator is similar to the tilt bucket, but it also requires you to enter the horizontal (TRC) and vertical (TRV) offset to the point where the bucket rotates around.	
Ditching Bucket The ditching bucket is similar to standard bucket, but the top and bottom of the bucket have different widths.	

Continued on next page

Measure the machine, Continued

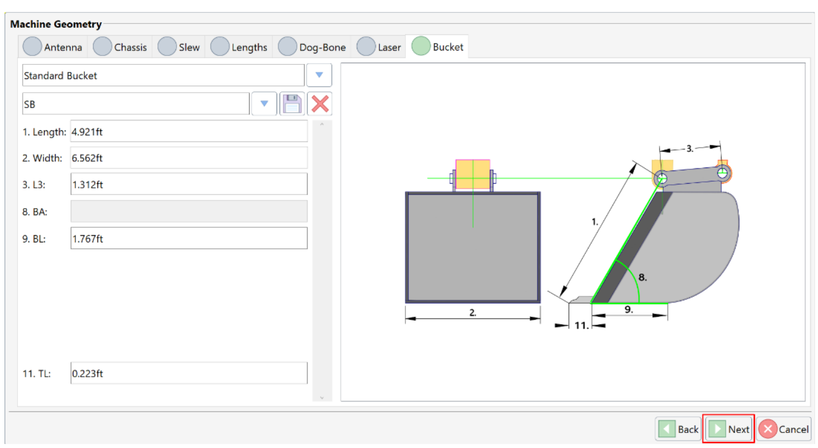
Type a name for this attachment. When typing in the bucket length, measure to the end of the bucket – not including the bucket teeth. Bucket teeth measurements are included in the following tab. Click **Next**.

Note: To **c**onfigure multiple attachments and switch between attachments you must assign each a name.



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

Measure the machine

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 IronTwo to the 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, as 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.

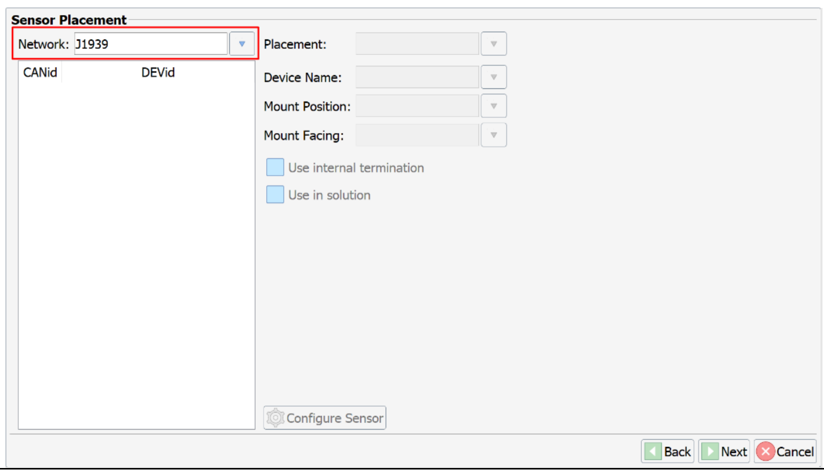
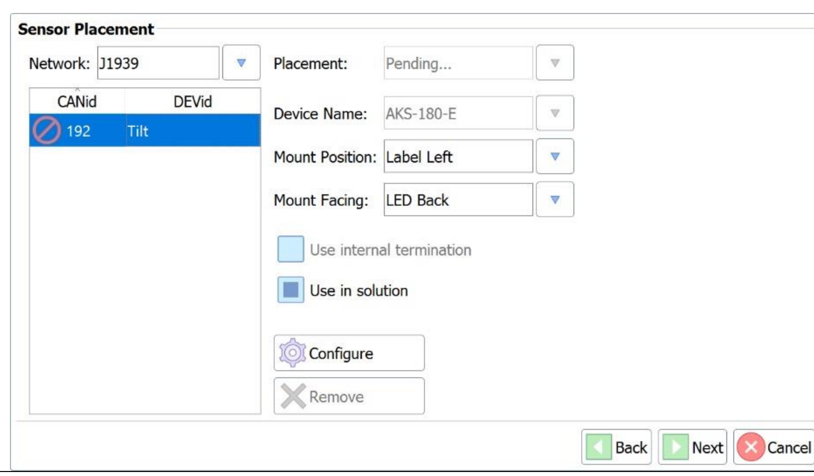
Configure the stick sensor. Reconnect the cable from the stick to dog-bone. At this point, all sensors will be connected (except for tilt bucket). The unidentified sensor is the dog-bone sensor.

Continued on next page

Measure the machine, continued

Use the following steps to set up a sensor.

Table 3-2: Set up sensor network

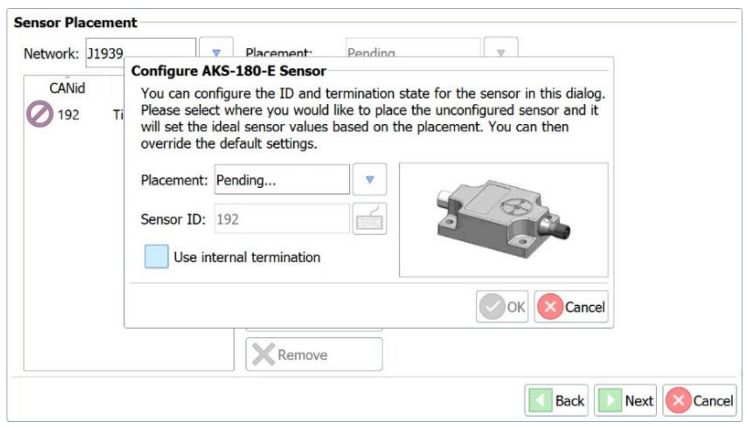
Step	Action
1	Set **Network** to **J1939**. 
2	Click on a **Sensor**, the unconfigured CAN ID is 192. Click **Configure Sensor**. 

Continued on next page

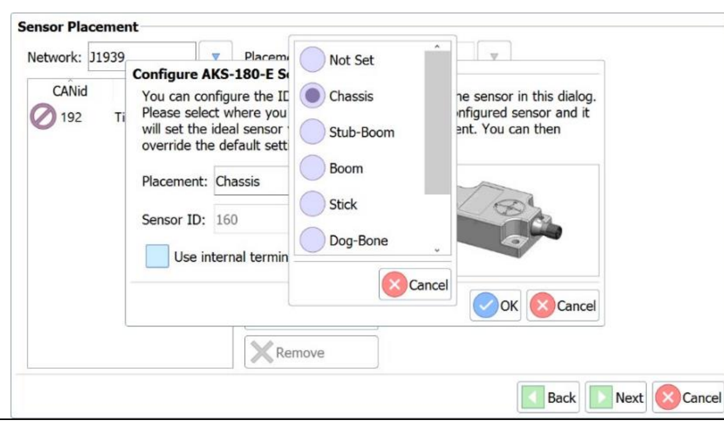
Measure the machine, continued

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

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3</td><td>The configuration 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 except for the dogbone sensor (or tilt bucket sensor, if using a tilt bucket). The Sensor ID field is automatically configured.



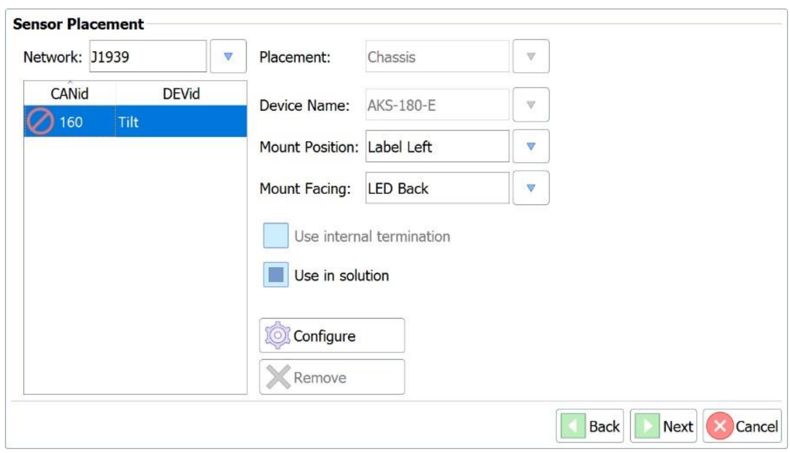
The screen below appears. Select the appropriate placement (Chassis, Boom, etc.).


</td></tr>
<tr><td>4</td><td>Repeat for each sensor.</td></tr>
</table>

Continued on next page

Measure the machine, continued

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

Step	Action
5	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 left. For **Mount Facing**, refer to the LED light. “LED Forward” indicates the LED light is facing the front of the machine. Click to select **Use in solution** and deselect **Use internal termination** since a physical terminator will be installed on the dog-bone sensor.  Refer to your notes for the **Machine ID** you recorded in the Equipment Setup. Click **Finish**.

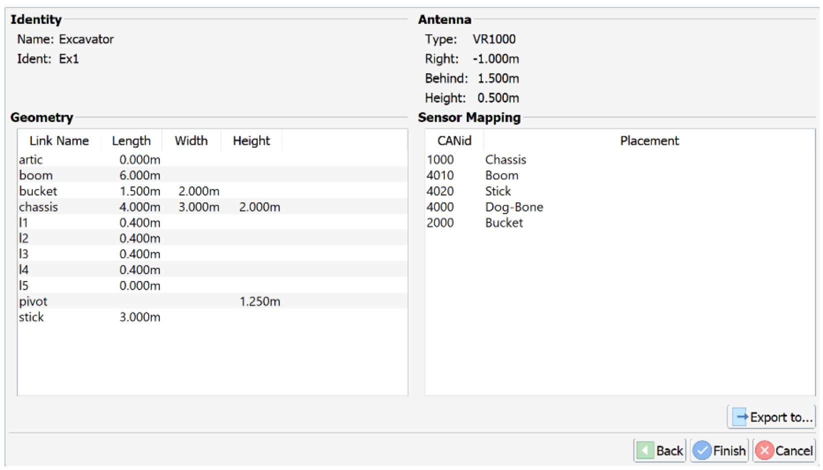
Continued on next page

Equipment Setup, Continued

Measure the machine, continued

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.

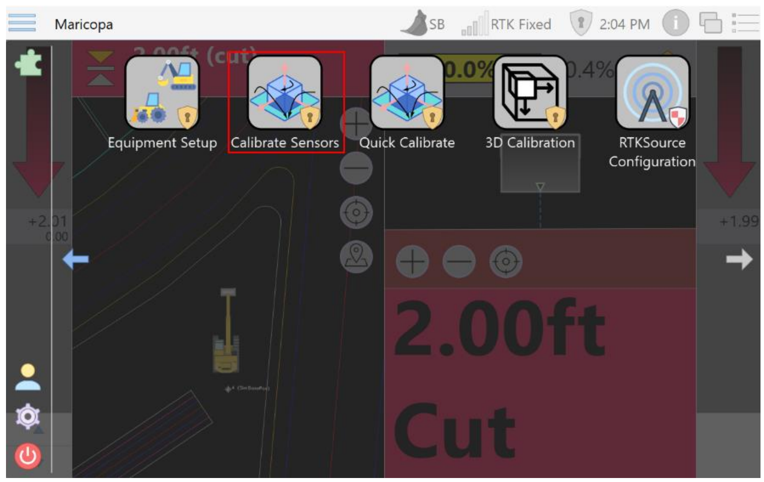
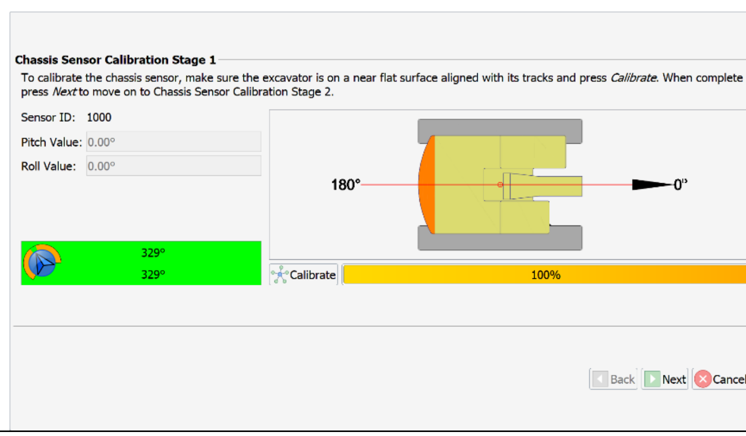


Calibrate Sensors

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 a theodolite. The following calibration was done with a tape, string line, and plumb bob.

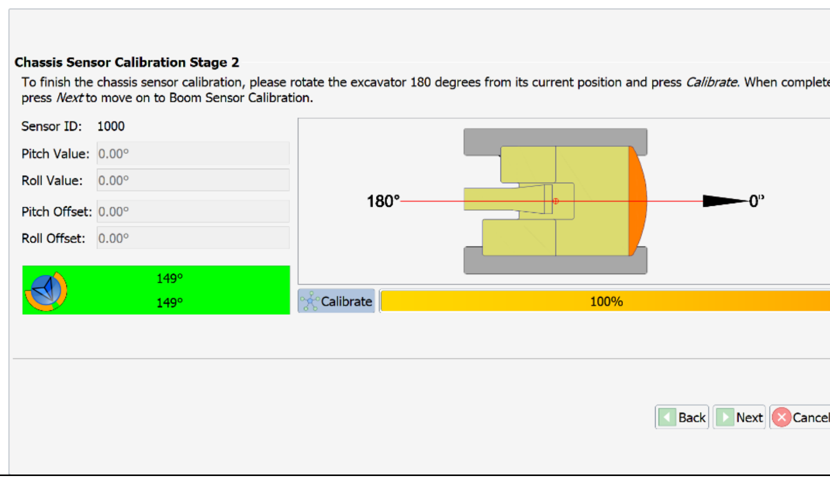
Table 3-3: Calibrate 2D Sensors

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

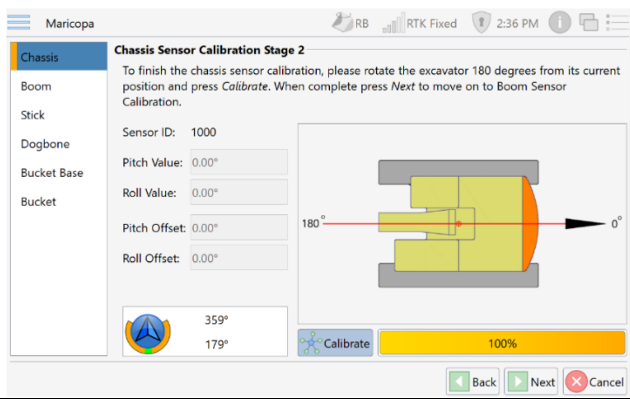
Table 3-3: Calibrate 2D Sensors (continued)

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	Level the boom pin and stick pin using a plumb bob, total station, theodolite, or laser. On many machines, you can use a magnet to attach a string line between the boom pin and the stick pin. The stringline needs to be under some tension. Attach a line level to the string.
5	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. 
6	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). **Note 1:** It is possible that you will not be able to get to 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

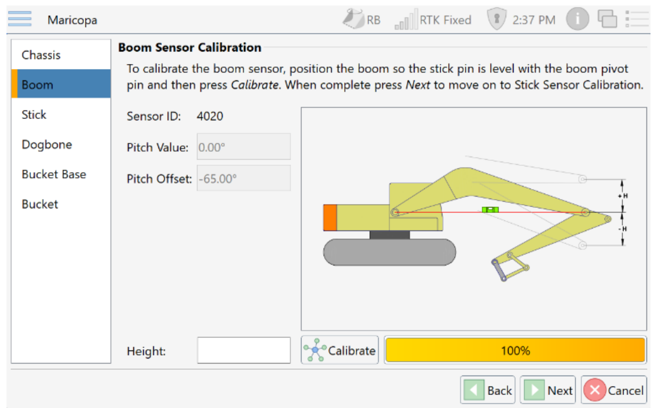
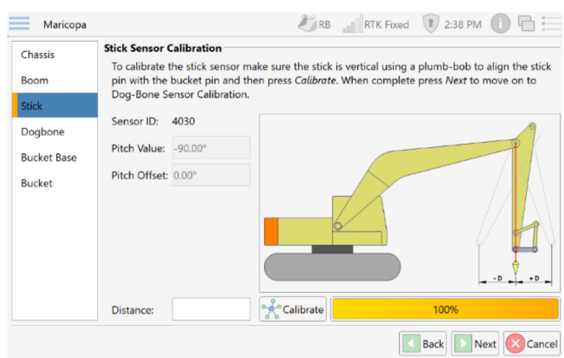
Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
7	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 3-8, the laser level was set up on the door of the engine compartment and level to the boom pin. Setup the laser until it strikes the boom pin (through the engine compartment). Raise or lower the stick until the laser also strikes the stick pin.  **Figure 3-6: Laser level used to calibrate boom**

Continued on next page

Calibrate sensors, continued

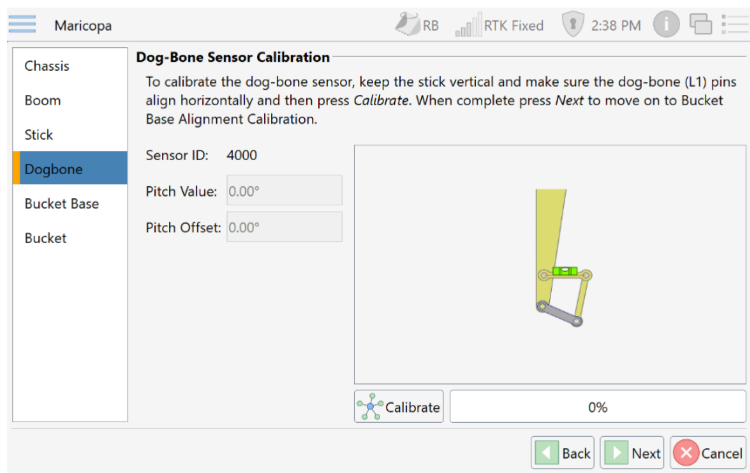
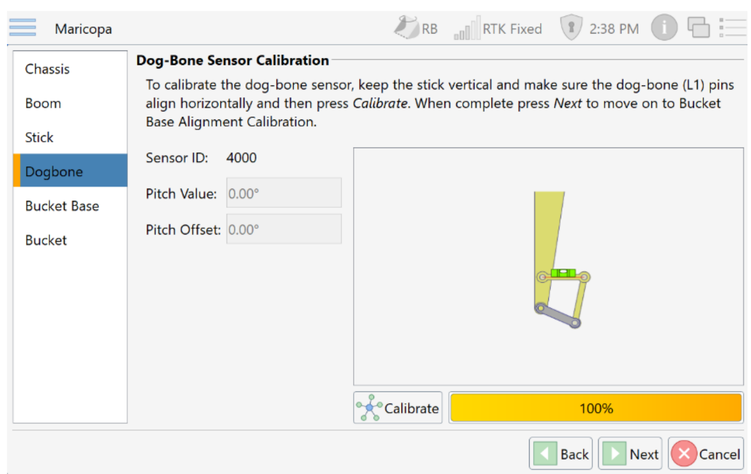
Table 3-3: Calibrate 2D Sensors (continued)

Step	Action
8	Click **Next**. 
9	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.
10	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**.
11	When the string is plumb, click **Calibrate**.  **Note:** You can also use a total station or a theodolite to plumb the stick. Click **Next**.

Continued on next page

Calibrate sensors, continued

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

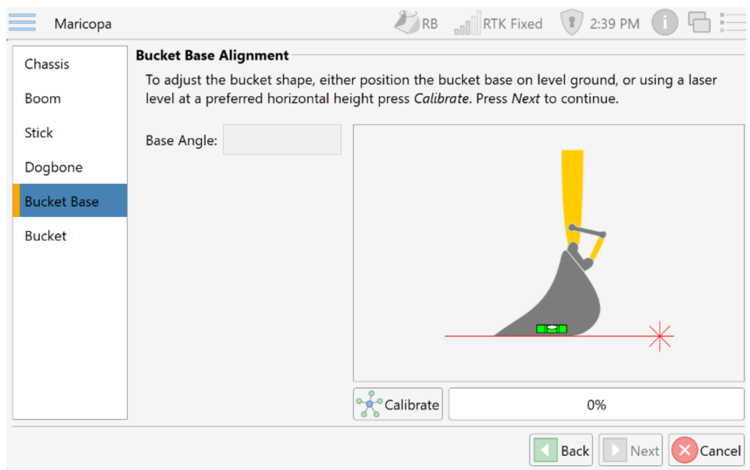
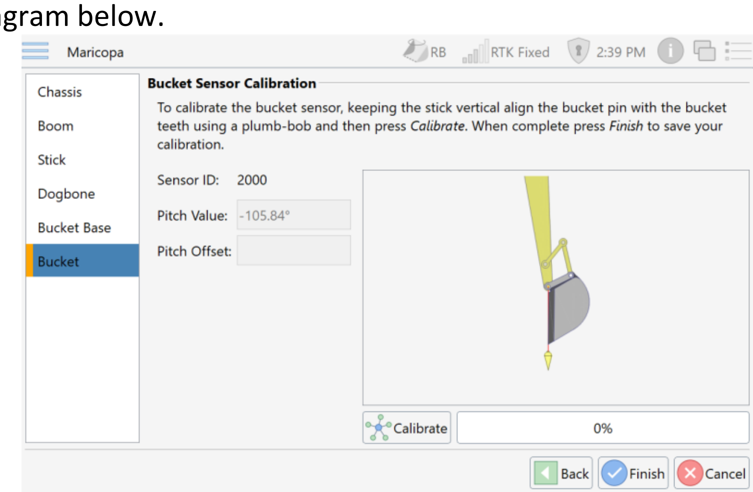
Step	Action
12	Calibrate the dog-bone sensor. Use magnets to place a string line directly over the L1 dog- bone pins.
13	When the string level shows that the line is level, click **Calibrate**.  

Continued on next page

Calibrate Sensors, Continued

Calibrate sensors, continued

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

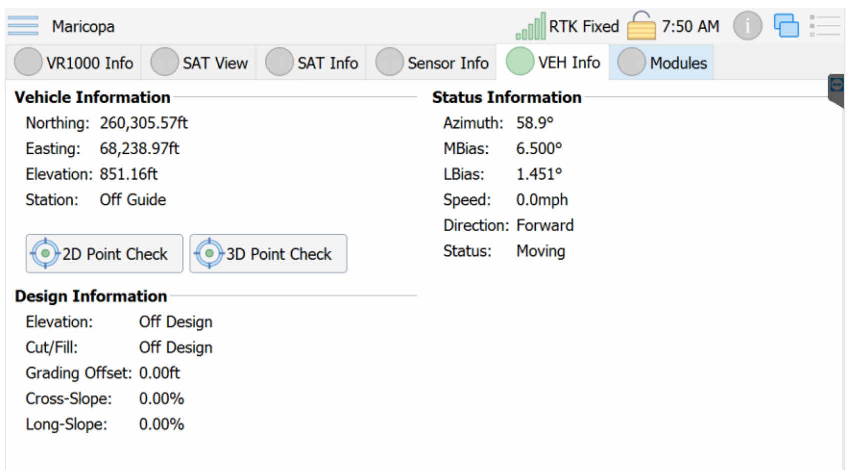
Step	Action
14	Finally, calibrate the bucket. To do this, first place the flat part of the bucket on the ground and click **Calibrate.**  Next, drop a plumb bob from the **bucket pivot pin** (do not use the dogbone pin) to the tip of the bucket teeth as shown in the diagram below. 

Continued on next page

Calibrate sensors, continued

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

Step	Action
15	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 to the **Monitor** page. Click **VEH Info**. Click **2D Point Check**.

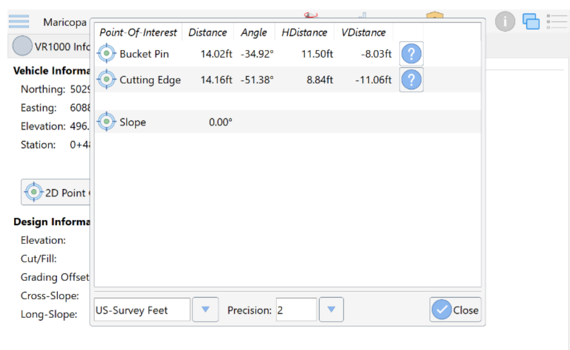


Continued on next page

Calibrate sensors, continued

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

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>16</td><td>Use a tape to check the slope distance values from the boom pin to the cutting edge and the teeth. The tape should always be parallel to the boom. When measuring to teeth, your tape may not be on the center of the bucket. The Slope value shows the cross slope of the cutting edge.



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
• Cutting edge

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 in to at least ten positions (from fully extended to fully retracted) to ensure that any variation of the orientation or placement the values are correct. If using a tilt bucket sensor, make sure the various tilted positions are also used during the test.</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, hard 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 or localization.
- Check the UHF radio link settings are correct for RTK function of the machine and the GNSS Rover.

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

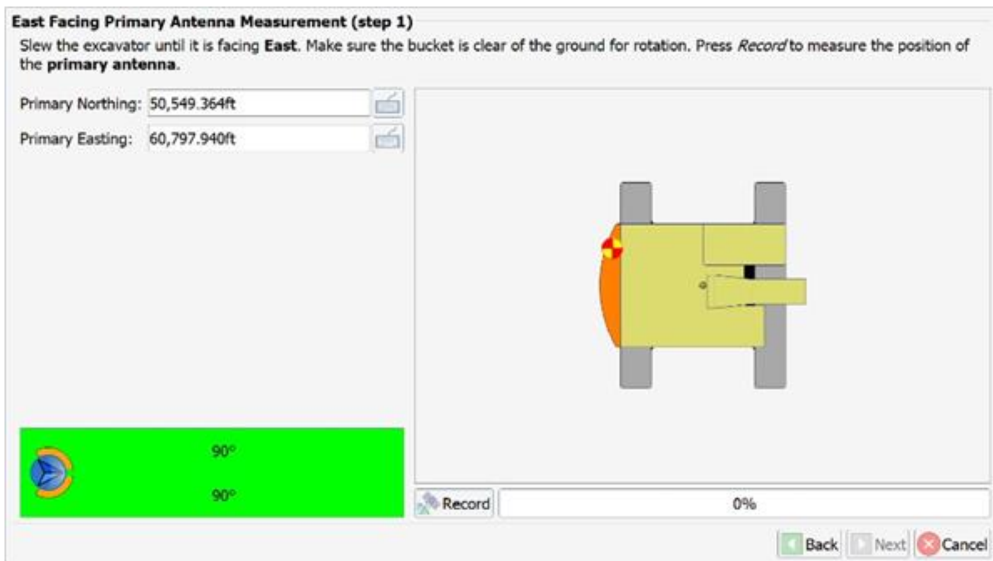
- Verify that the projection and/or localization match on the rover and on the machine. Place the rover over the primary antenna on the GNSS to compare Northing, Easting and Height positions data.
- Do not use a separate base station for the machine and survey rover. Do not use an NTRIP service.
- Use tools / magnet makers to mark the measure points on the machine so they are attached correctly and accurately. Start by slewing the house (body) / 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.

Continued on next page

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.

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



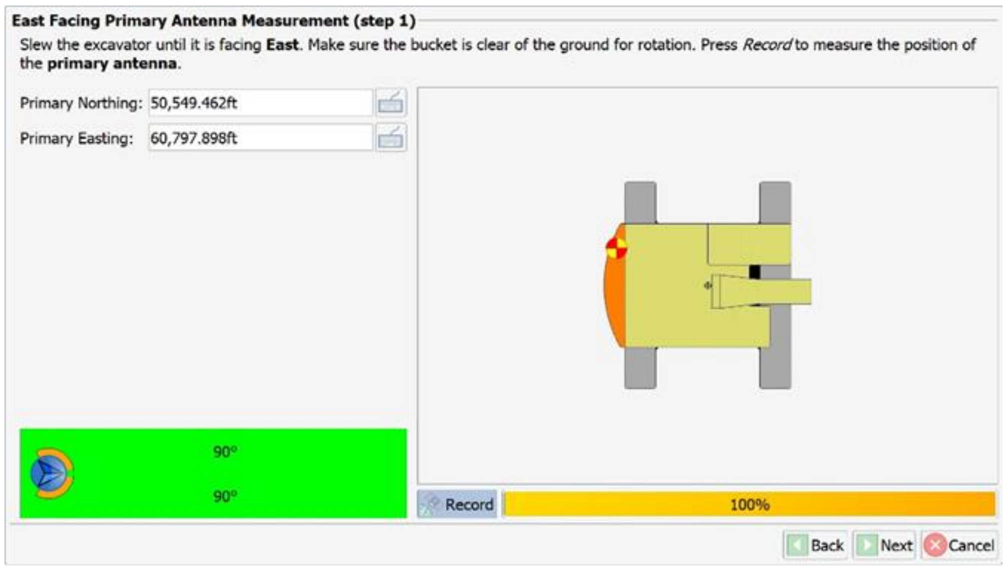
Continued on next page

Configure and Calibrate 3D Sensors, Continued

Step 2- 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 appears gray in color until the turret has been positioned correctly.

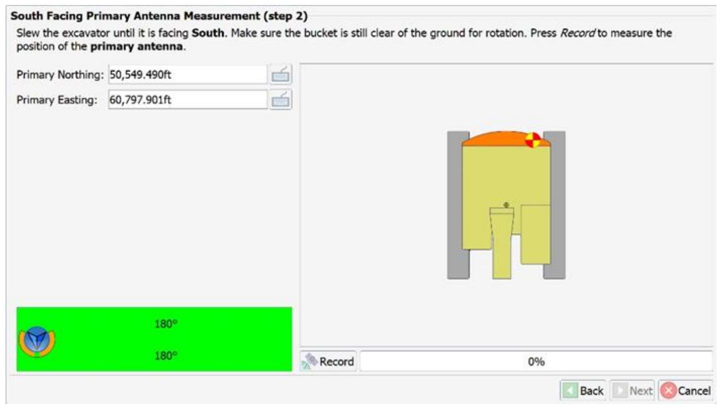


Continued on next page

Step 3- GPS calibration, continued

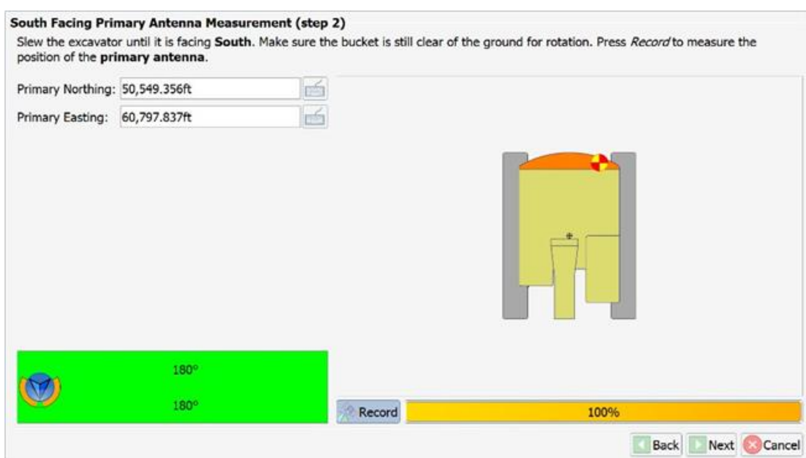
Do not move the tracks, boom, or stick. Carefully slew the machine until the bucket is facing **South**. The indicators on the bottom-left of the screen show your target azimuth (180°) and your current azimuth.

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 is grey in color until the turret has been positioned correctly.

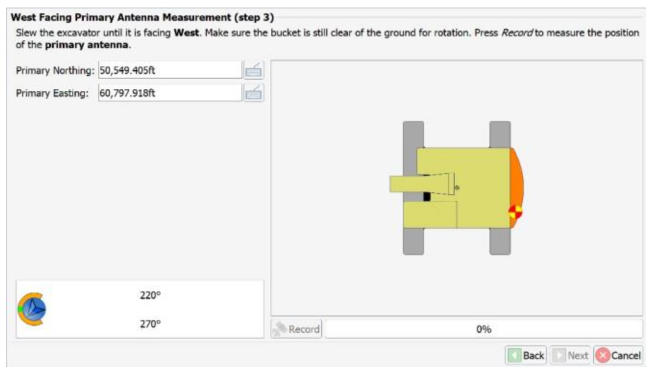


Continued on next page

Step 4-GPS calibration, continued

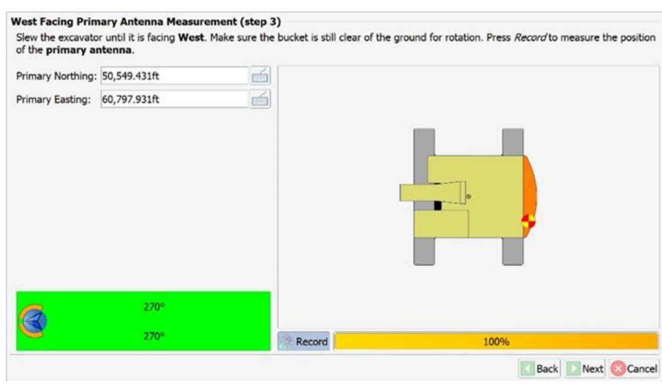
Do not move the tracks, boom, or stick. Carefully slew the machine until the bucket is facing **West**. The indicators on the bottom-left of the screen show your target azimuth (270°) and your current azimuth.

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 is grey in color until the turret has been positioned correctly.

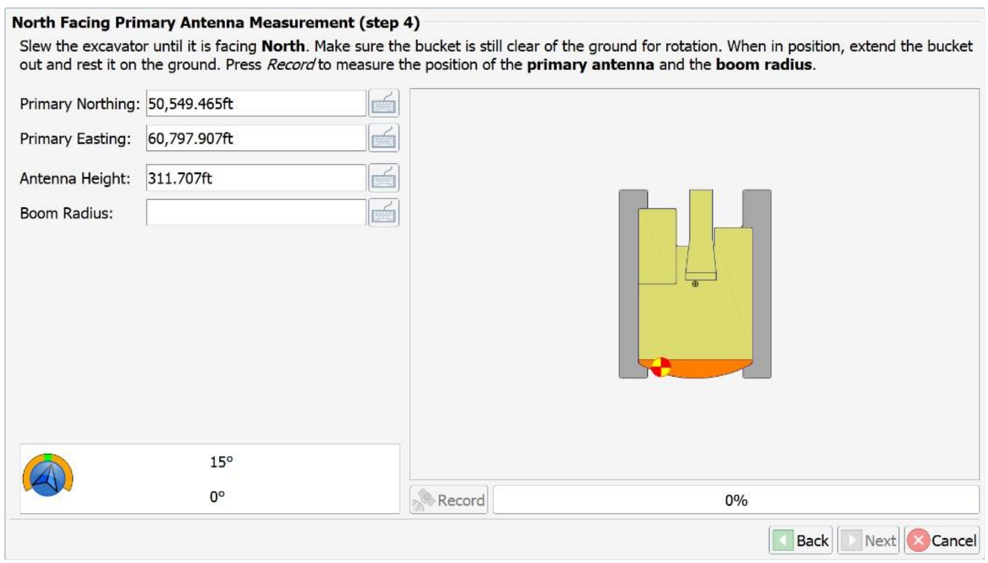


Continued on next page

Step 5-GPS calibration, continued

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. 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 body) of the machine. This prepares the machine for the next stage of calibration.

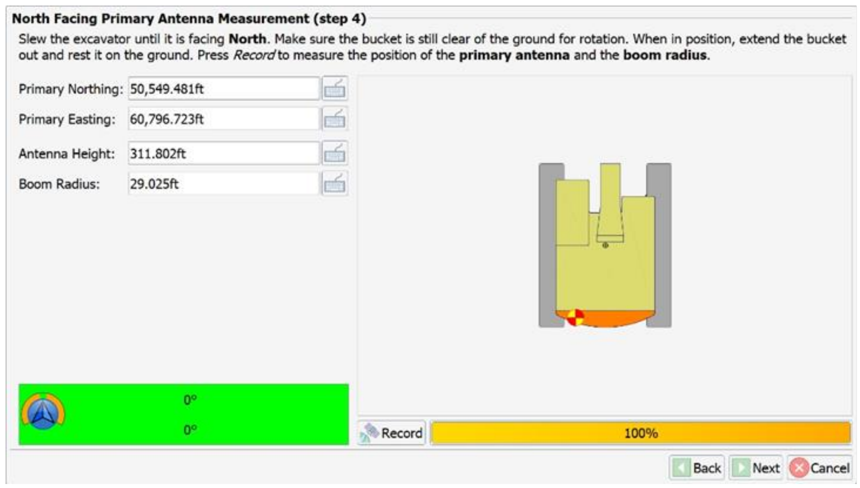
Keep the boom and bucket equipment still and record the **Primary Antenna** location using the **Record** button.

Note: The **Record** button will be grey in color until the turret has been positioned correctly. After recording this position **DO NOT** move the machine. All the following stages require the excavator to remain in this position.

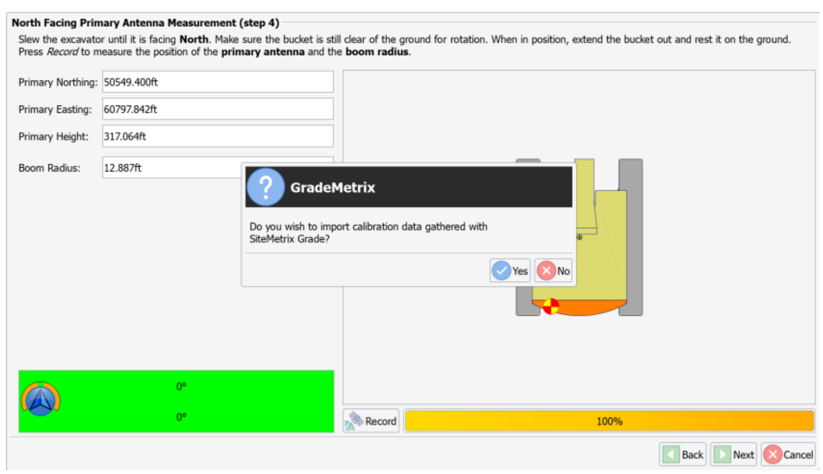
Continued on next page

Step 5-GPS calibration, continued

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



A prompt displays asking if you are going to import calibration data from SiteMetrix Grade. If you click **No**, you will manually type in the coordinates collected in the section. If you select **Yes**, you can save these coordinates to a file, and upload them after proceeding with the steps below.



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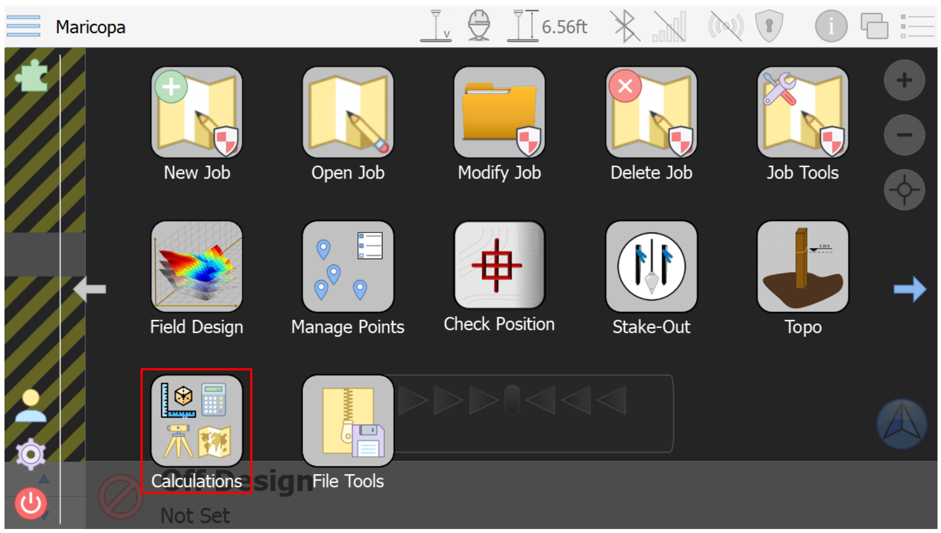
Step 6-GPS calibration, continued

Connect to your C631 rover (see Appendix C, section C-2).

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.

Go to **Calculations**.

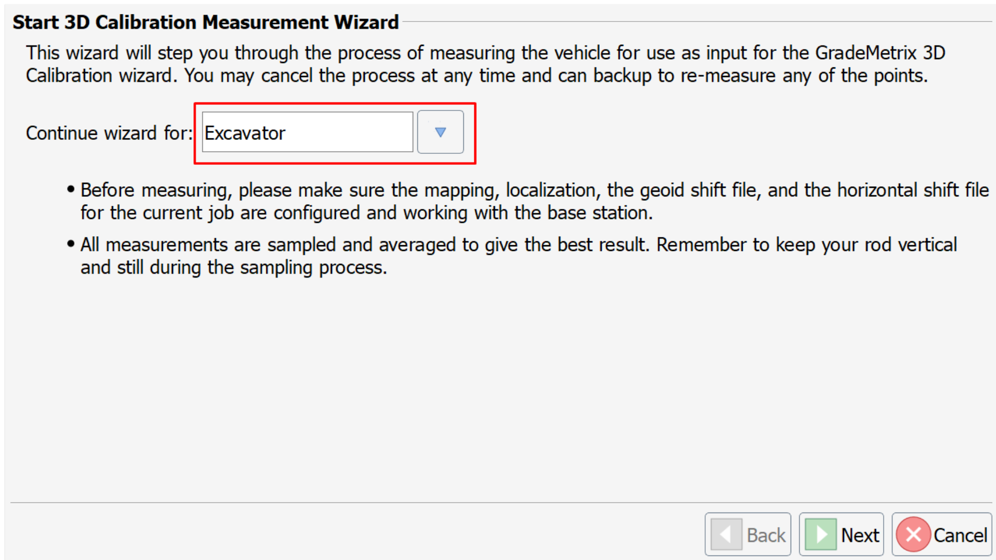


Click **Vehicle Calibration Wizard**.

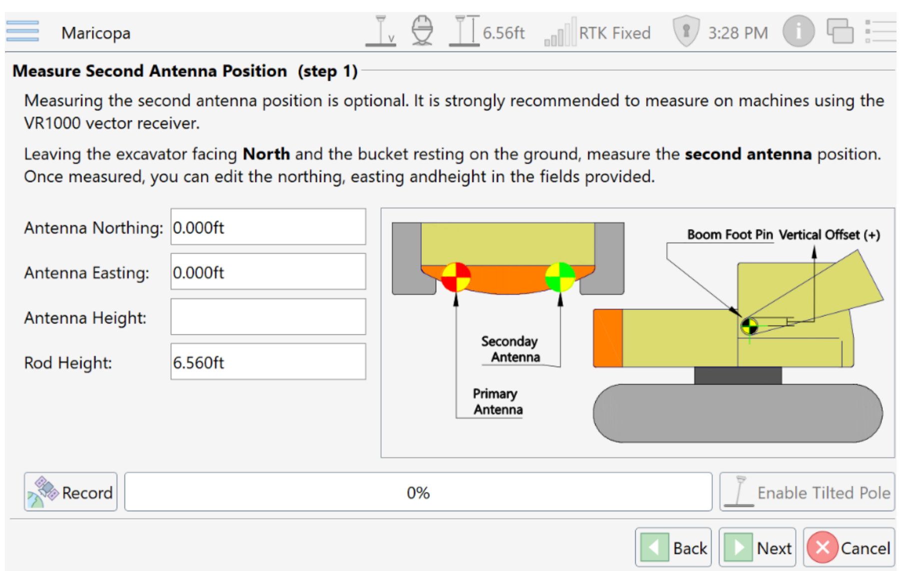
Continued on next page

Step 7-GPS calibration continued

Select **Excavator**.



There is no need to measure the secondary antenna position when using a VR500. Therefore, leave these fields blank and click **Next**.



Continued on next page

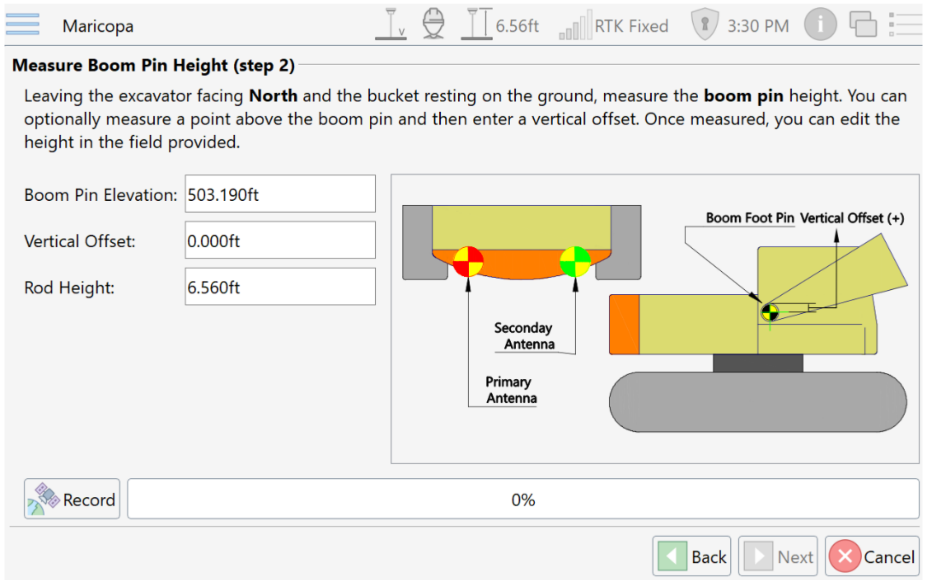
Step 7-GPS calibration, continued

In the next window, measure **Boom Pin Elevatio**n. Use your C631 to measure the height of the boom pin, right at the center of the pin. For this value, only elevation is required.

The elevation must be of the center of the boom pin. In the image below, this is the bottom red line. It may be easier to use a rover to measure on top of the boom pin (the top red line). If you measure here, measure the vertical offset (the blue line) and enter that into the **Vertical Offset** field.

Continued on next page

Step 7-GPS calibration,, Continued



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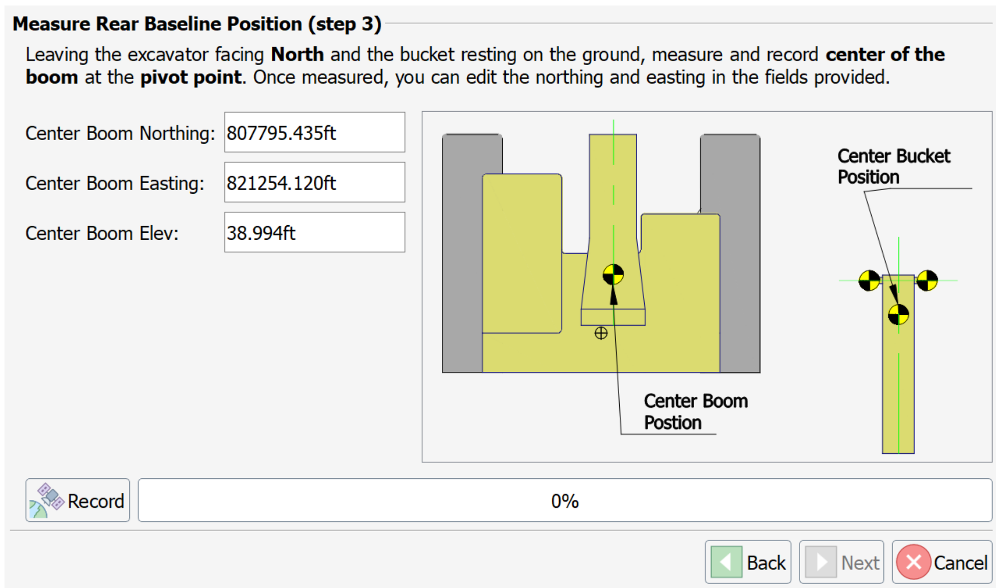
Step 8- GPS Calibration, continued

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

Next, record the center of the boom.



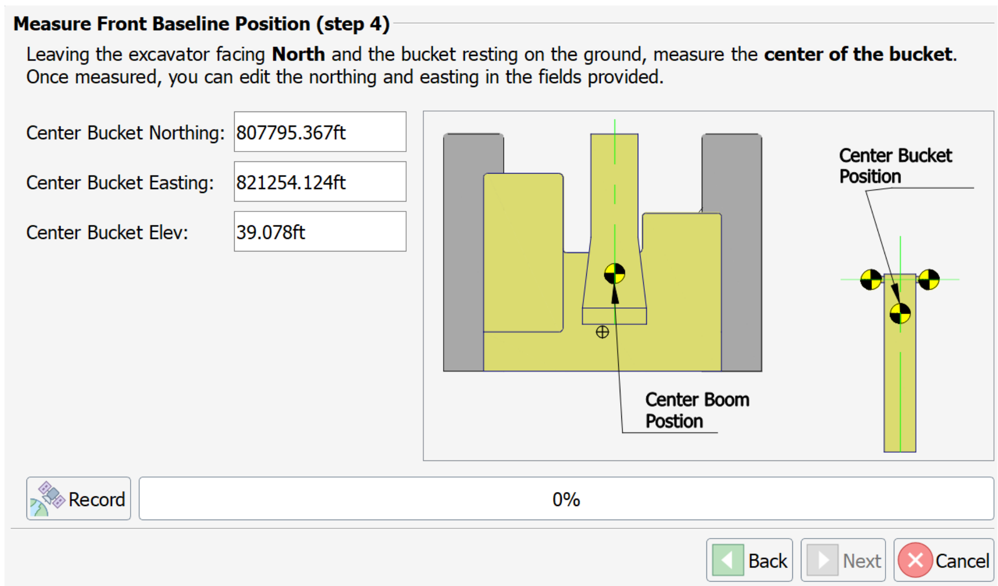
Place the GNSS rover on or near the boom foot pin on the centerline of the machine. This measurement is only used for heading offset and horizontal antenna offset. Elevation does not matter. What is very important is that the position of the measurement is directly over the centerline of the boom.

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.

Continued on next page

Step 8- GPS Calibration, continued

Place the GNSS rover on the mid-point of the bucket edge on the centerline of the machine. Like the previous measurement, elevation does not matter. This needs to be directly over the centerline of the boom/bucket so that a correct heading offset can be calculated.



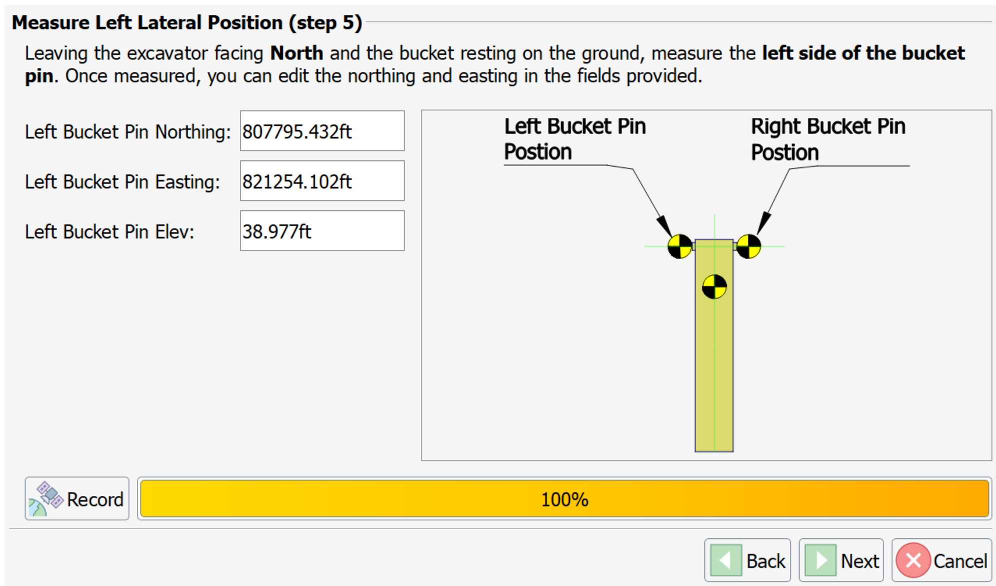
Note: Welding chalk may be used to temporally mark the center of the bucket if needed.

Click **Next**.

Continued on next page

Step 9 – GPS calibration, continued

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.

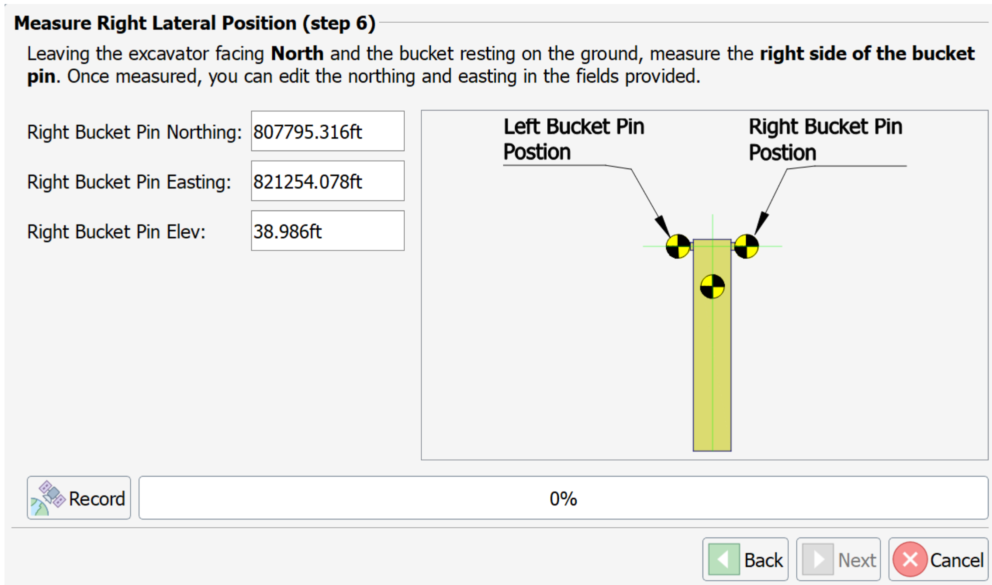


Continued on next page

Configure and Calibrate 3D Sensors, Continued

Step 9 – GPS calibration, continued,continued

Place the GNSS rover to the **Right / East** side of the bucket pin on the centerline.



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.

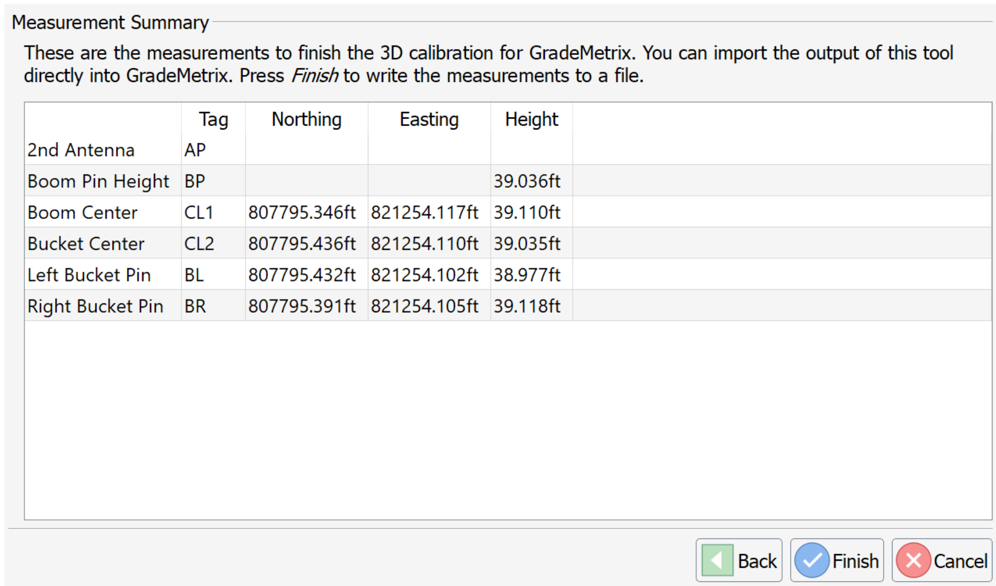
Click **Next**.

Continued on next page

Configure and Calibrate 3D Sensors, Continued

Step 10-GPS calibration, continued

The points you collected are shown. Click **Finish**. Insert a USB thumb drive into the HT20 to save the calibration file.


Measurement Summary

These are the measurements to finish the 3D calibration for GradeMetrix. You can import the output of this tool directly into GradeMetrix. Press *Finish* to write the measurements to a file.

	Tag	Northing	Easting	Height
2nd Antenna	AP			
Boom Pin Height	BP			39.036ft
Boom Center	CL1	807795.346ft	821254.117ft	39.110ft
Bucket Center	CL2	807795.436ft	821254.110ft	39.035ft
Left Bucket Pin	BL	807795.432ft	821254.102ft	38.977ft
Right Bucket Pin	BR	807795.391ft	821254.105ft	39.118ft

Back Finish Cancel

Import this file into GradeMetrix (see Step 5, GPS Calibration).

The last 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 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

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. Ensure 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 is not 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 4.5v to 5.5v. If the voltage does not measure 4.5v-5.5.5v value, check the other end of the cable (plugged into the antenna). If there is not 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.
IronTwo will not power on	• Check to verify the power cable is connected to machine power. The positive should connect 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 IronTwo by using a multi-meter. If the multimeter reads 12V or 24V, then power is confirmed, and the IronTwo may need to be serviced. If you do not have power, 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 4.5 - 5.5v. If more than 5.5v is coming from the receiver, check the other end of the cable (plugged 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 receiver, the IronTwo control box, and the GMS-1 sensor.

Contents

VR500 GNSS Receiver

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 specifications, continued

Table B-1: VR500 Receiver (continued)

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

Continued on next page

VR500 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

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

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 GNSS Receiver, Continued

VR500 :-L-band sensors

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: VR500aiding 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

IronTwo

IronTwo system

Table B-8: IronTwo System

Item	Specification
Processor	Intel® Celeron N3350
System Memory	DDR3L 1600 SO-DIMM 4GB
Storage	M.2 SSD 64GB
Operating System	Ubuntu 18.04 or Windows

IronTwo mechanical

Table B-9: IronTwo Mechanical

Item	Specification
Dimensions	263.28 L x 171 H x 35.7 W (mm)
Mount	RAM Mount (38.1 x 30 mm) 4x M5-0.8 x 10 mm Philips screws provided

IronTwo environmental

Table B-10: IronTwo Environmental

Item	Specification
Operating Temperature	-20°C to +60°C
Operating Humidity	30% ~ 90% (Non-condensing)
Enclosure	IP65

Continued on next page

IronTwo power

Table B-11: IronTwo Power

Item	Specification
Input Voltage	9 - 36 VDC

IronTwo screen

Table B-12: IronTwo Screen

Item	Specification
Display Type	10.1" TFT edge-to-edge projective capacitive multi-touch screen
Brightness	700 cd/m
Resolution	1920 x 1200, widescreen
Contrast Ratio	800:1
Max Colors	16.7M (8-bit)

IronTwo communication

Table B-13: IronTwo Communication

Item	Specification
COM Port	2× RS232
USB Port	2× USB 2.0
SD Slot	1× MicroSD
Ethernet	2× 10/100 LAN
CANBUS	2× CANBUS
WiFi	802.11 a/b/g/n/ac (Up to 867 Mbps data rate)
Bluetooth	Bluetooth 4.1
Cellular	4G LTE

IronTwo sensor and multimedia

Table B-14: IronTwo Sensor and multimedia

Specification
1x 1W Speaker

GMS-1 Sensor

GMS-1 sensor measurement range

Table B-15: GMS-1 Measurement range

Item	Specification
Pitch	± 180°
Roll	± 85°

GMS-1 sensor accuracy

Table B-16: GMS-1 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-17: GMS-1 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, Continued

GMS-1 sensor pin-outs

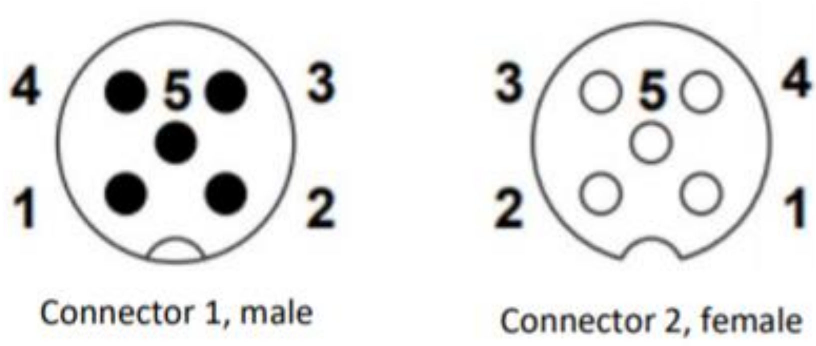


Figure B-1: GMS-1 Sensor pin-out

Table B-18: 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: Set up a Base Station and Rover

Overview

Introduction

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 VR500 and C631 rover are both receiving RTK from the same base station.

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

Contents

Configure C631 Base Station

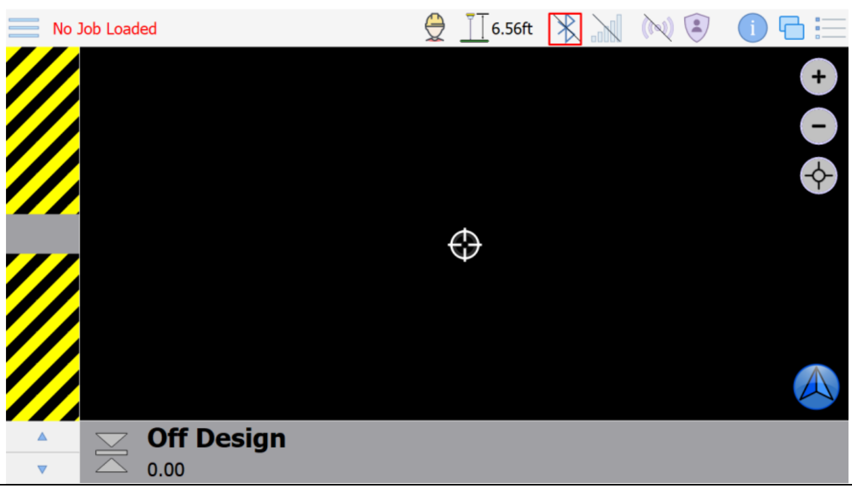
Overview

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	To configure your C631 as a base station, open **SiteMetrix Grade**. Click the **Bluetooth** icon. 

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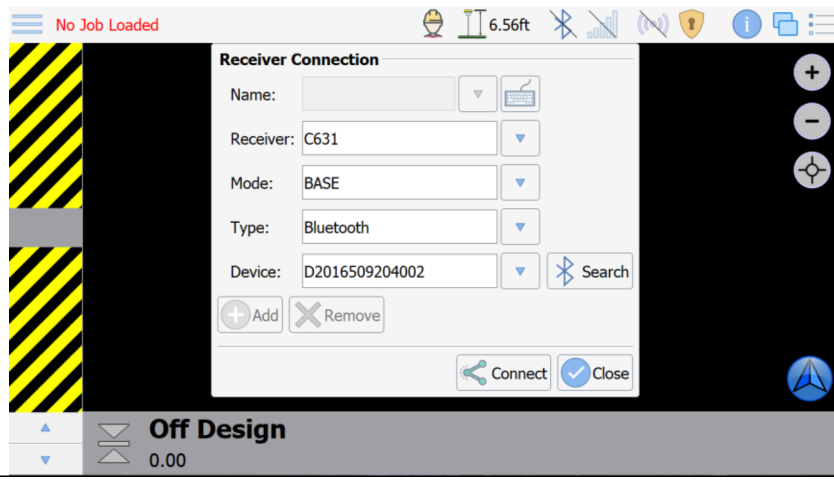
Configure C631 Base Station, Continued

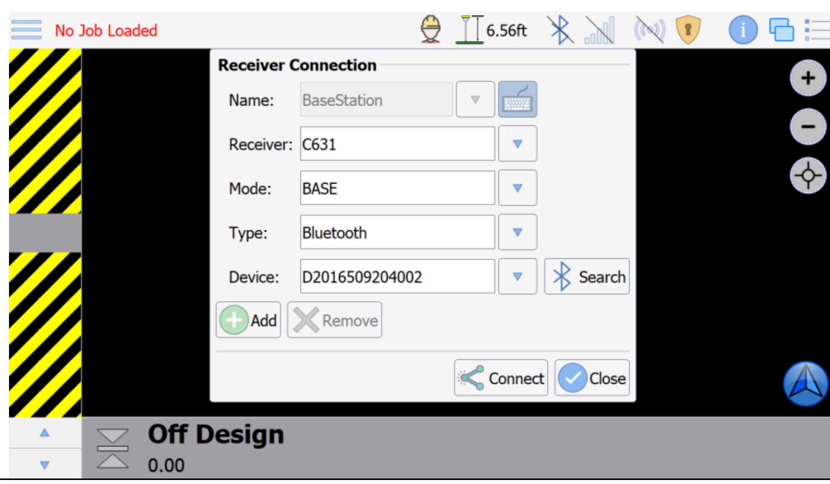
Configure C631 Base Station, continued

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

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>2</td><td>Click Search. The HT20 tablet will search for devices. The Bluetooth ID is the serial number of the C631 Smart Antenna. Set Mode to BASE.



</td></tr>
<tr><td>3</td><td>Click on the keypad to enter a name for this receiver. This is an optional step, but is useful for easily distinguishing between your base and rover without memorizing the Bluetooth ID.



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

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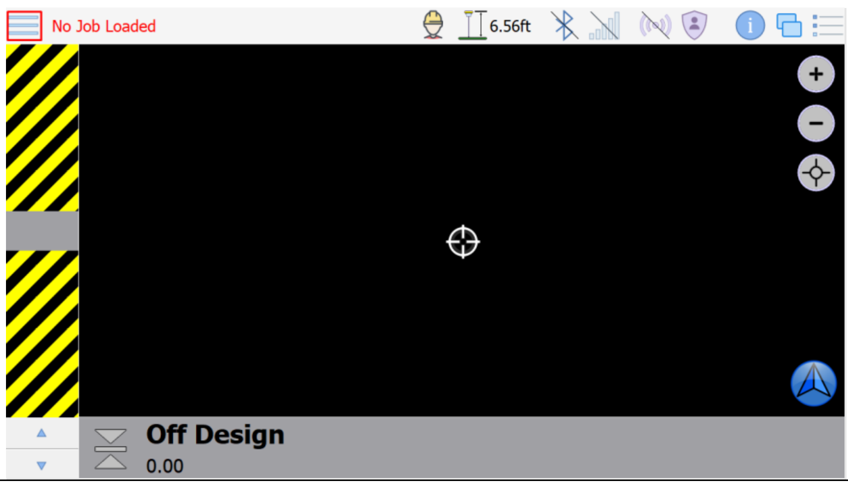
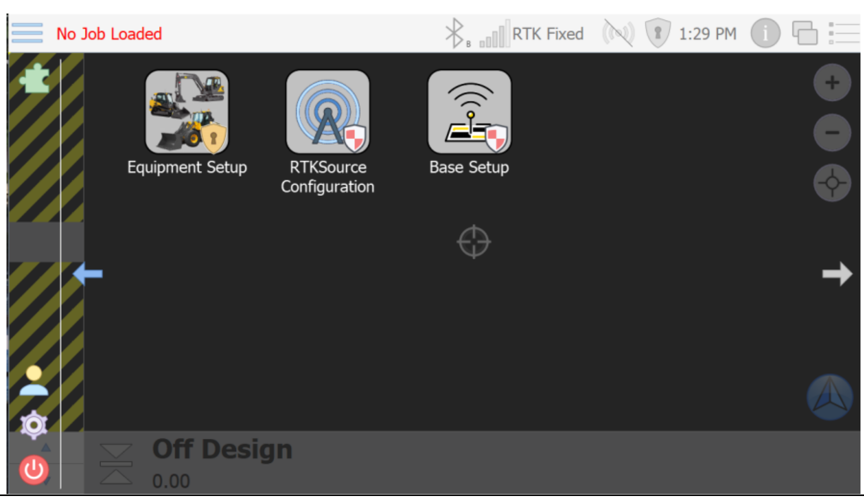
Configure C631 Base Station, continued

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

Step	Action
4	Click **Add** to save this receiver to the database. Click **Connect**. After SiteMetrix Grade has finished connecting, the dialogue automatically closes. Click the three bars on the top left of the screen to enter the menu. 
5	Scroll to the right by clicking on the right-arrow. Click **Base Setup**. 

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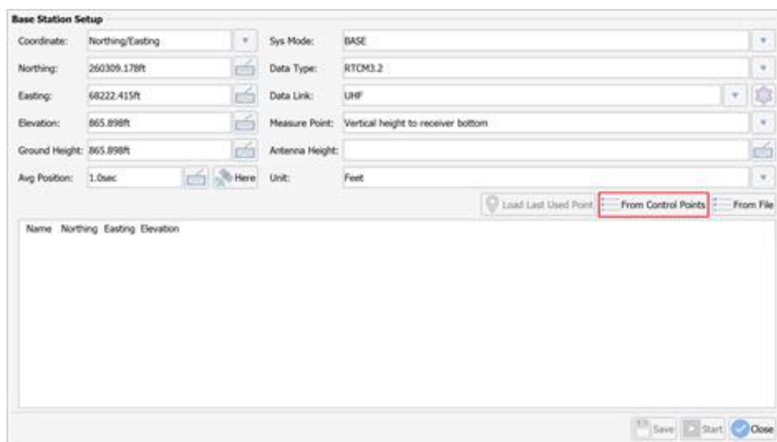
Configure C631 Base Station, continued

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

Step	Action
6	The Base Station Dialogue has multiple options: **Coordinate:** Can be set to geodetic (latitude/longitude) or local coordinates (if a localization is entered). This is the coordinate that the base station is occupying. **Latitude, Longitude, Height**: The geodetic coordinate of your base station. If **Coordinate** is set to **Northing/Easting**, you can enter a local coordinate. If a localization file is loaded, you have the option to load a point **From Control Points**. 

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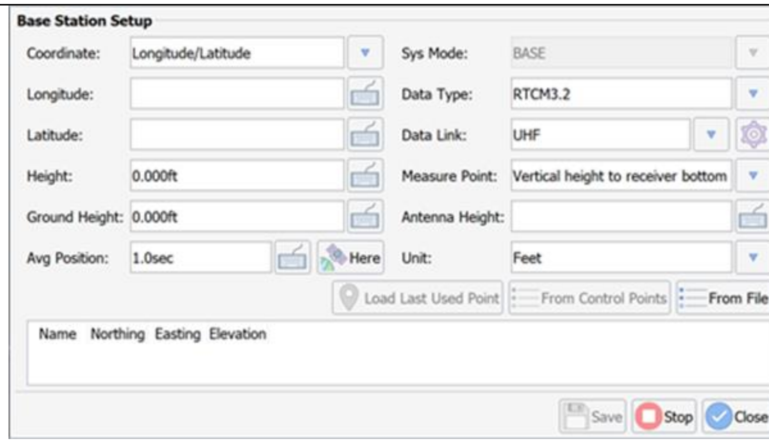
Configure C631 Base Station, Continued

Configure C631 Base Station, continued

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

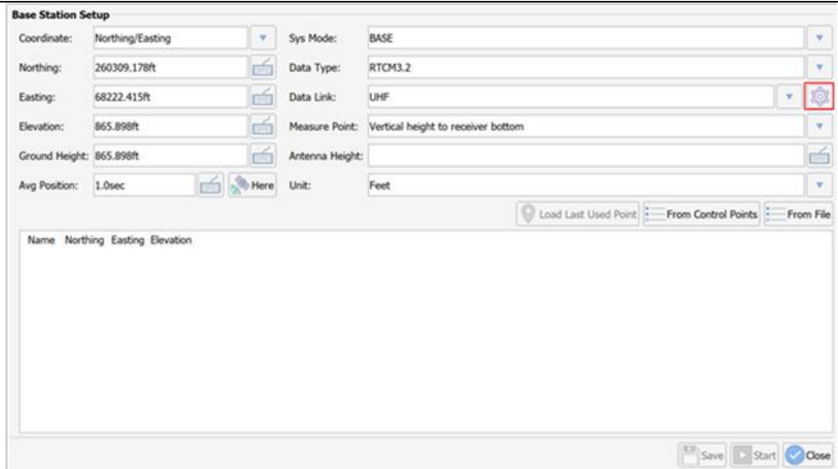
Step	Action
7	 If using UHF, you will see the Channel table. You can select from one of your pre-loaded UHF radio channels*, the protocol, FEC, and Scrambling. *Channel tables can be provided by a certified Hemisphere GNSS dealer.
8	**Ground Height**: refers to the elevation of the monument the C631 is being set up over (if applicable). The C631 height will be higher than the monument height if the C631 is installed onto a tripod. **Data Type**: RTK message format the C631 will transmit. ROX or RTCM 3.2 are suggested for best performance. **Data Link**: The medium which RTK message are transmitted (NETWORK for using the C631's internal GSM modem to send the RTK messages over NTRIP or TCP/IP, UHF for broadcasting over the internal UHF radio, or EXT for outputting over the 5-pin serial port to an external radio).

Continued on next page

Configure C631 Base Station, Continued

Configure C631 Base Station, continued

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

Step	Action
9	 

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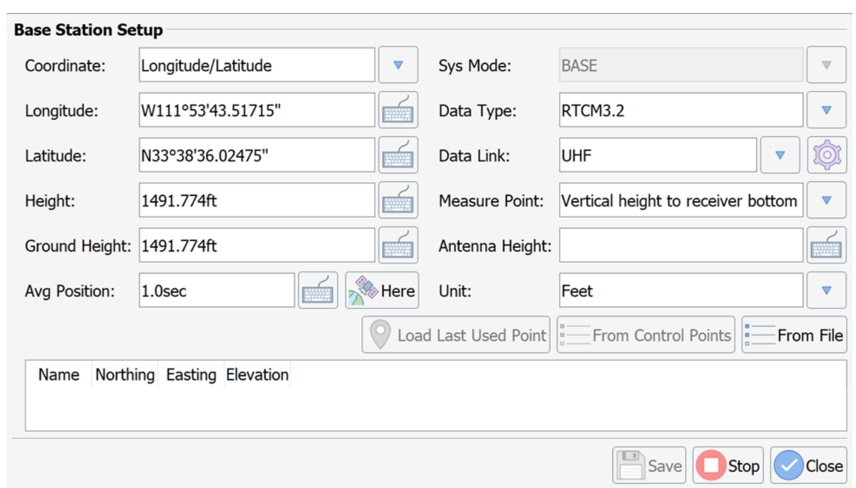
Configure C631 Base Station, continued

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

Step	Action
10	If using a Network, you are given the option to select from **TCP Server** or **NTRIP Server**. Enter the APN, APN username, APN password, IP, Port, username (if applicable), password (if applicable), and mountpoint (if applicable). If using EXT, enter the baud rate of the external device. **Measure Point:** Defines where “antenna height” is measured to. Vertical height to receiver bottom is a measurement to the base of the C631. Slant height is a measurement to the triangle above the model name on the lip of the enclosure. L1 phase center is used for setting up a base station over an arbitrary point. **Antenna Height:** Measures the height of the pole, tripod, etc. Use this measurement in conjunction with **Measure Point** – which defines where the measurement is to. **Unit:** Meters, U.S. Survey Feet, International Feet. Click **Save** to save base station settings. 

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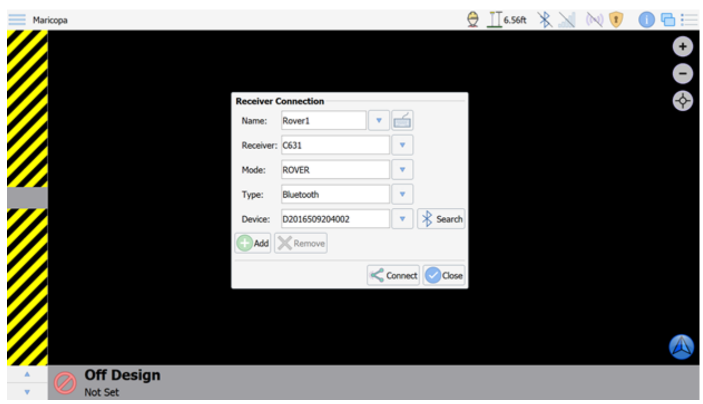
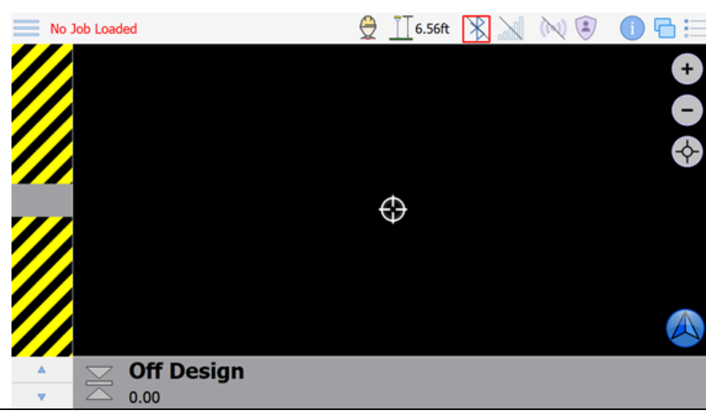
Configure C631 Rover

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	To connect to a rover, click the **Bluetooth** icon on the top toolbar in **SiteMetrix Grade**. Click **Search**. The HT20 tablet will search for devices. The **Bluetooth ID** is the serial number of the C631 Smart Antenna. Set **Mode** to **ROVER**.
2	Click the keypad to enter a name for this receiver. This is an optional step, but is useful for easily distinguishing between your base and rover without memorizing the **Bluetooth ID**.  

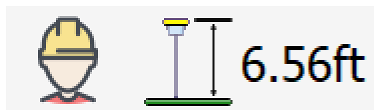
Continued on next page

Configure C631 Rover, Continued

Configure the C631 Rover, continued

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

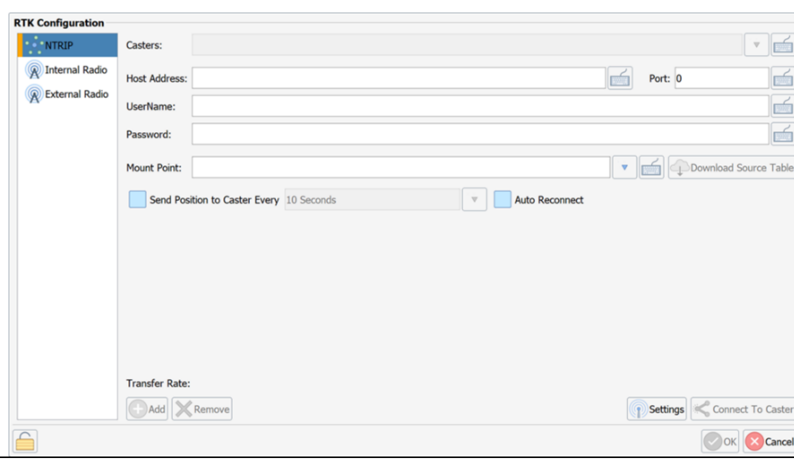
<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3</td><td>Click Add to save this receiver to the database. Click Connect. After SiteMetrix Grade has finished connecting, the dialogue automatically closes.

The top toolbar will show one of the following icons:
1) 

2) 

If the truck (option two) is visible, click on the truck to change to a Man Rover. Click on the pole height icon to the right to adjust pole height (6.56 feet, or 2 meters, in the example above).</td></tr>
<tr><td>4</td><td>Click the three bars on the top-left of the screen to enter the menu. Scroll to the right and click the RTK Configuration icon:


Within this menu, you can adjust RTK Settings. For a full description, please see the SiteMetrix Grade user manual.


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

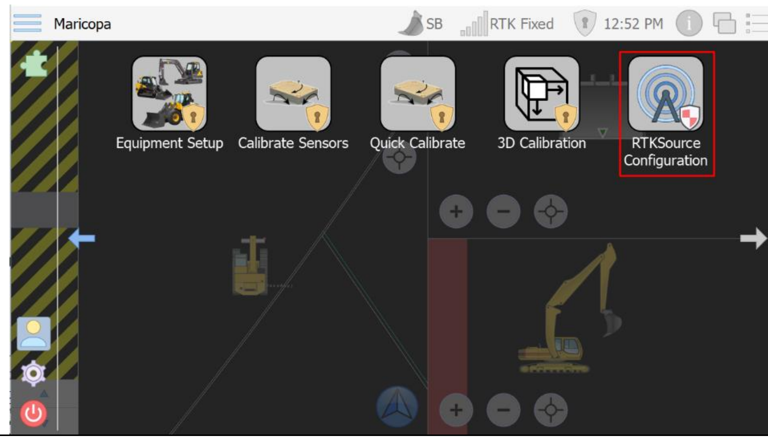
Configure VR500 Radio

Configure VR500 radio

Use the following steps to configure the VR500 radio for your 3D calibration routine.

Table C-3: Configure VR500 radio

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Click RTK Source Configuration.



</td></tr>
<tr><td>2</td><td>Select a channel that is configured to the same frequency as the C631 base station (if you do not have this frequency located, contact your Hemisphere GNSS representative for a channel table).

Select the correct protocol per the chart provided below. The fields in blue are configurable.
<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</td><td>12.5 kHz</td><td>GMSK</td><td>OFF</td><td>OFF</td></tr>
<tr><td>Trimtalk 2</td><td>9600</td><td>25.0 kHz</td><td>GMSK</td><td>OFF</td><td>OFF</td></tr>
<tr><td rowspan="4">PacCrest 4FKS</td><td rowspan="2">9600</td><td rowspan="2">12.5 kHz</td><td rowspan="2">4FSK</td><td>ON</td><td>ON</td></tr>
<tr><td>OFF</td><td>OFF</td></tr>
<tr><td rowspan="2">19200</td><td rowspan="2">25.0 kHz</td><td rowspan="2">4FSK</td><td>ON</td><td>ON</td></tr>
<tr><td>OFF</td><td>OFF</td></tr>
<tr><td rowspan="4">PacCrest GMSK</td><td rowspan="2">4800</td><td rowspan="2">12.5 kHz</td><td rowspan="2">GMSK</td><td>ON</td><td>ON</td></tr>
<tr><td>OFF</td><td>OFF</td></tr>
<tr><td rowspan="2">9600</td><td rowspan="2">25.0 kHz</td><td rowspan="2">GMSK</td><td>ON</td><td>ON</td></tr>
<tr><td>OFF</td><td>OFF</td></tr>
<tr><td rowspan="4">Satel</td><td rowspan="2">9600</td><td rowspan="2">12.5 kHz</td><td rowspan="2">4FSK</td><td rowspan="2">ON</td><td>ON</td></tr>
<tr><td>OFF</td></tr>
<tr><td rowspan="2">19200</td><td rowspan="2">25.0 kHz</td><td rowspan="2">4FSK</td><td rowspan="2">ON</td><td>ON</td></tr>
<tr><td>OFF</td></tr>
</table>
</td></tr>
</table>

Continued on next page

Appendix D: Cable Pin-Outs

Overview

Introduction

Appendix D contains the cable pin-outs used for installation of the GradeMetrix system.

VR500 Cables

P/N: 051-0406-10

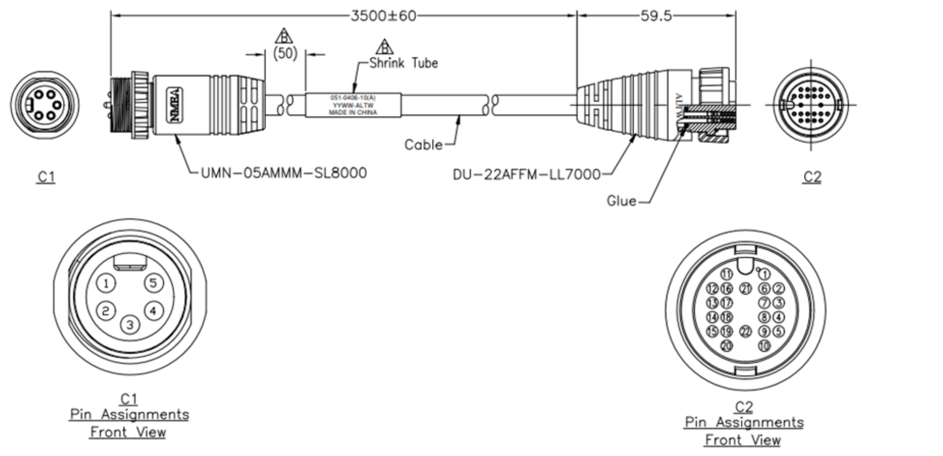


Figure D-1: P/N: 051-0406-10

Table D-1: P/N: 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

Continued on next page

Part Number:
051-0407-10

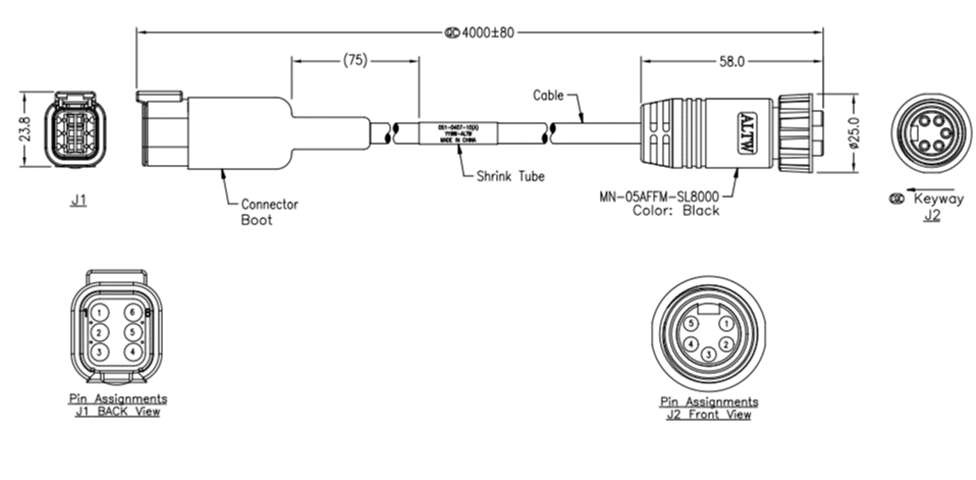


Figure D-2: P/N: 051-0407-10

Table D-2: P/N: 051-0407-10 Pin-Outs

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

Continued on next page

Part Number
051-0426-10

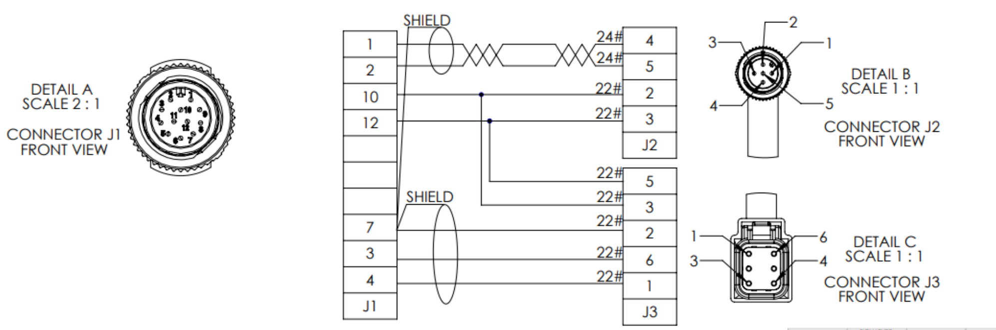


Figure D-3: P/N: 051-0426-10

Table D-3: P/N: 051-0426-10

J1	J2	J3	Signal
1	4		CAN High
2	5		CAN Low
3		6	IronTwo RS232 Rx
4		1	IronTwo RS232 Tx
7		2	Signal Ground
10	2	3	Power+
12	3	5	Power Ground

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Table D-5: Excavator Schematic R232 and Power, IronTwo - VR500

051-0426-10 J1 (IronTwo)	051-0426-10 J3	051-0407-10 J2	051-0406-10 J2	VR500
3	6	2	12	VR500 Tx (IronTwo RS232 Rx)
4	1	3	11	VR500 Rx (IronTwo RS232 Tx)
7	2	5	13	Signal Ground
10	3	1	21	Power+
12	5	4	22	Power Ground

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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:

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

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