Brx7 Inertial Tilt

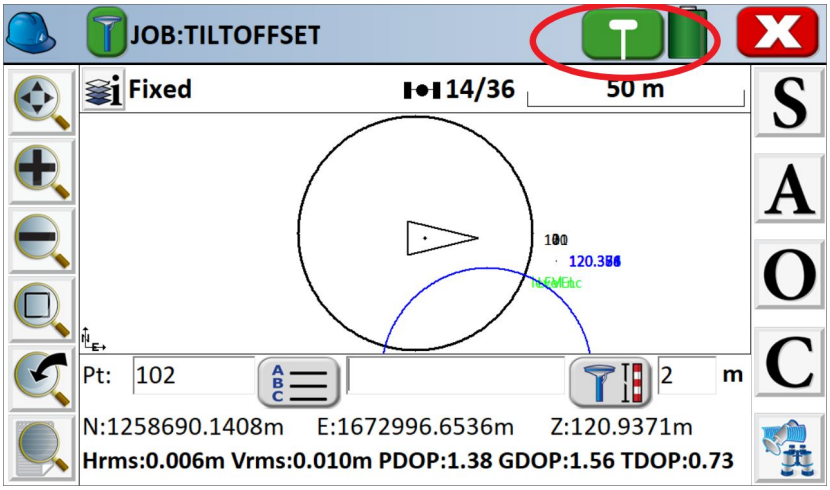
Introduction

The Carlson BRx7 comes equipped with inertial tilt sensors to allow you to view a digital level or even measure positions when the survey pole is at an incline. The software will use the data from the sensors to adjust for the positional error due to the incline and calculate the correct ground position at the tip of the pole.

The new sensor technology auto-initializes in the first few seconds of work to be up and running almost as soon as you get started. This document will give an overview of the system and walk you through required calibrations for first use.

Sensor Status

The inertial sensors in the BRx7 are not sensitive to magnetic noise and do not require a daily calibration for use. The sensors will work any time the receiver has an RTK fix position and is non-static. Once an RTK fix has been achieved, the inertial sensors will be **Initialized** automatically during the first few seconds of movement. The status of the inertial sensors is visible at all times in the top bar of SurvCE/SurvPC, although the behavior of the status icon will depend on whether you are Using A Digital Level or Storing Measurements At An Incline.

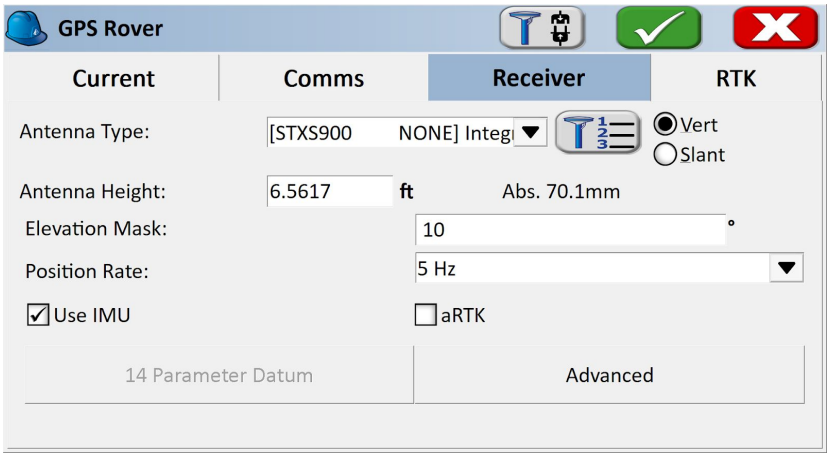


In the image above, the status icon is circled in red. The icon may have the following states:

Icon State	Meaning
	Status: Good The green icon means the sensors are within tolerance and initialized, and measurements will be corrected for tilt if the option is enabled.
	Status: Incline too large This status indicates that the tilt of the pole is outside of the configured tolerance. This is either the incline tolerance or the level tolerance, depending on whether you are Using the Digital Level or Storing Measurements at an incline.
	Status: Uninitialized This icon will appear each day as you start your receiver and before you get an RTK fix. Once a fix is achieved, **Simply move around as normal to automatically initialize the tilt module. Initialization is normally achieved in 5-60 seconds.**
	Status: Motion Excess motion detected. Tilt corrections will not be applied. This error can occur briefly if you are moving the receiver quickly, or in high winds.
	Status: Warning This icon will appear when conditions are not-ideal to use your inertial sensors. In this state, tilt corrections will not be applied, and the software will warn you if you try to measure. This commonly occurs because of low GPS accuracy.

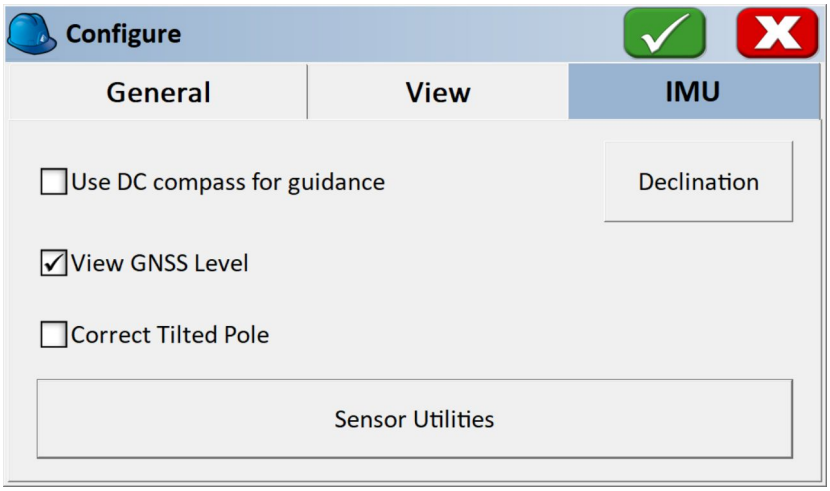
Vertical Pole measurements. Using the Digital Level

To use any IMU feature in SurvCE, it is first necessary to activate the sensors in the receiver. Do this by going to **Equip->GPS Rover**, and checking the box "**Use IMU**" on the Receiver tab.

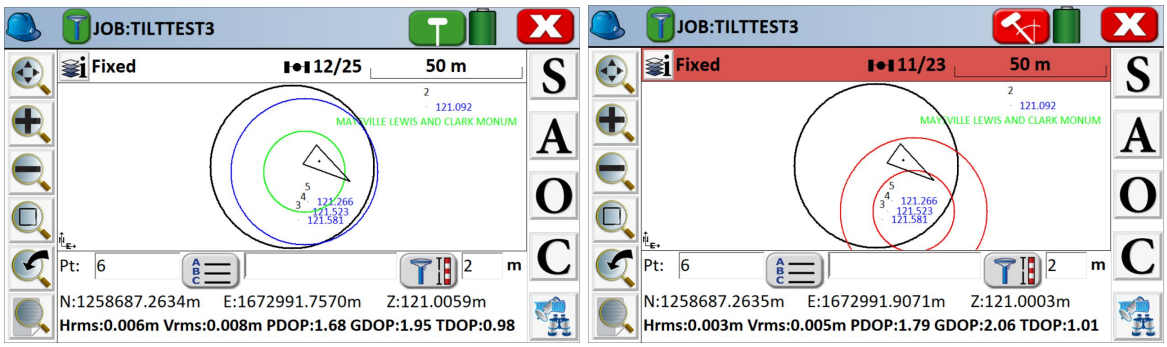


A position rate of 5Hz is encouraged for best experience with the electronic bubble and other sensor features.

Individual IMU features of SurvCE are controlled in **Equip->Configure**, on the IMU tab:



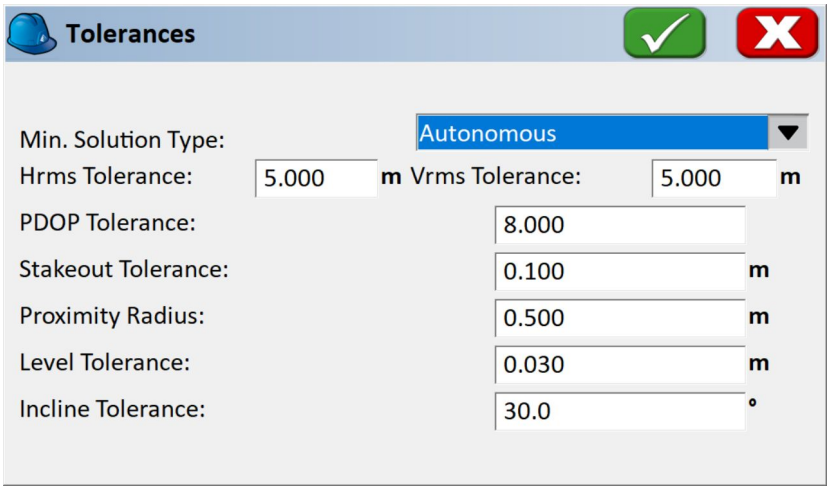
Check the box for **View GNSS Level** to view the GNSS level on the live survey screen. Whenever the "**Correct Tilted Pole**". option gets disabled, the system will NOT compensate the deviations due to incline. This is the INS mode in which the user can fix a leveling tolerance (explained in the next page) and take the advantage of the integrated e-bubble to visualize the pole leveling operation before storing a new reading. A green circle indicates a reading can be stored, and red indicates that the incline of the pole exceeds your user configured level tolerance, and the reading will be blocked.



In the image on the left, the pole is level within tolerance and the measurement can be stored. In the image on the right, the red icon and top bar indicate that tolerance has been exceeded and a warning will be issued if you attempt to store.

Users who wish to stay within level tolerance but do not like the appearance of the digital level can simply turn off **View GNSS Level** in the configure screen. As long as the IMU is enabled in the receiver configuration, SurvCE will still block readings which exceed the level tolerance. For those users, the Green or Red “GPS pole icon” in the top right by the Red X serves as an indicator of whether a reading can be stored at any given moment.

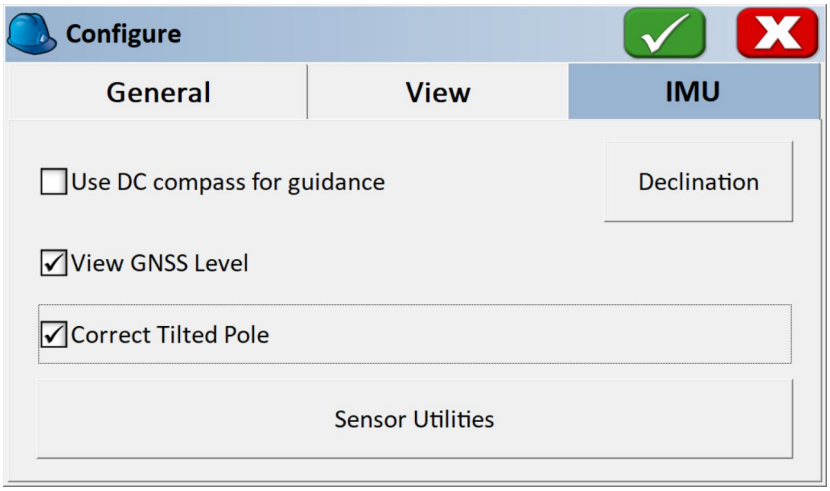
Tolerances can be configured from the main menu under **Equip->Tolerance**.



The **Level Tolerance** defines the amount of error that will be accepted when storing points. The tolerance is defined as the amount of distance error allowable on the ground, and thus is a function of both the incline of the pole and the rod height.

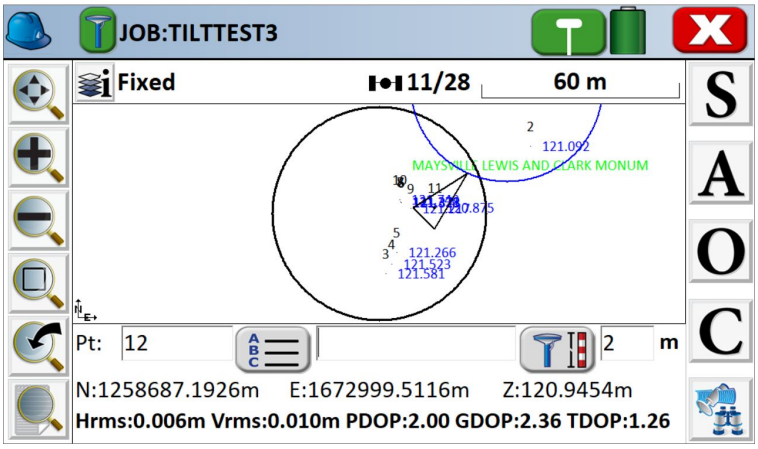
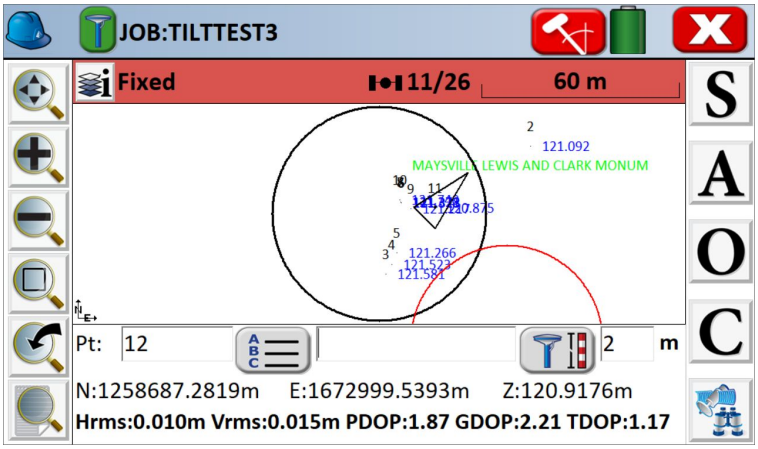
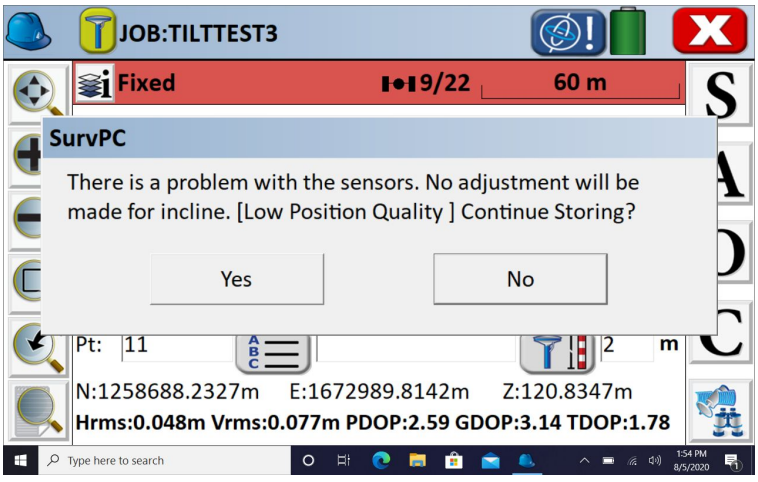
Storing Measurements At An Incline

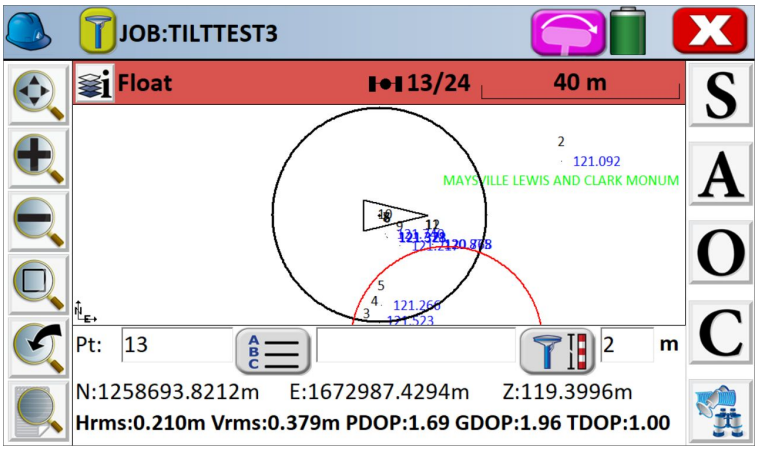
The inertial sensors in the BRx7 also give the software the capability to automatically adjust for positional error due to the incline of the pole. To use this feature, go back to the **Equip->Configure** screen and check the box for "**Correct Tilted Pole**".



The **Incline Tolerance** in the same tolerance menu of previous page, defines the maximum amount of tilt allowable. Most receivers RTK accuracy starts degrading when tilted more than 30-40 degrees, although the BRx7 does allow tilted corrections up to 60 degrees for extreme cases.

In store points, the icon in the top bar and the appearance of the digital level provide information to you about whether a point can be stored. Please see examples below:

Example 1: The blue digital level bubble indicates that the receiver is not within level tolerance, but the green icon in the top right indicates that a reading can be stored, and the software will account for the incline of the receiver.	
Example 2: The red icon and red top bar indicate that the incline of the receiver exceeds your configured incline tolerance (for example, more than 30 degrees). If the store button is pressed, the software will issue a warning, however, it is still possible to store the measurement and corrections will still be applied.	
Example 3: The blue warning icon indicates that the sensors are in a warning state. This can happen because of low GPS accuracy, being static too long, or excessive shaking of the survey pole. If the store button is pressed, a warning will be issued. A point can still be stored, but no corrections will be applied.	

Example 4: The pink icon indicates that the sensors are uninitialized. Normally this icon only appears briefly as you begin surveying. In this scenario, the receiver has not yet achieved a fix. The sensors will initialize automatically as soon as a fix as achieved and you start moving.	

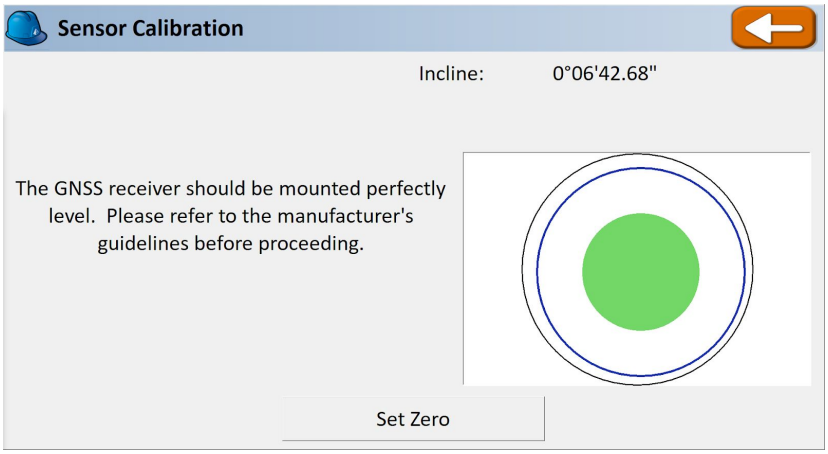
Note that when the icon is green or red, the position in the bottom bar is accounting for the incline of the pole. This can be very useful in stakeout, as directions to the target point can be achieved without careful leveling of the pole

Sensor Utilities

The Sensor Utilities menu is available under GPS Utilities, or directly from the IMU tab. It contains two required calibrations and several tools to help you examine and get comfortable with using the inertial sensors.

Tilt Calibration (Set Hz)

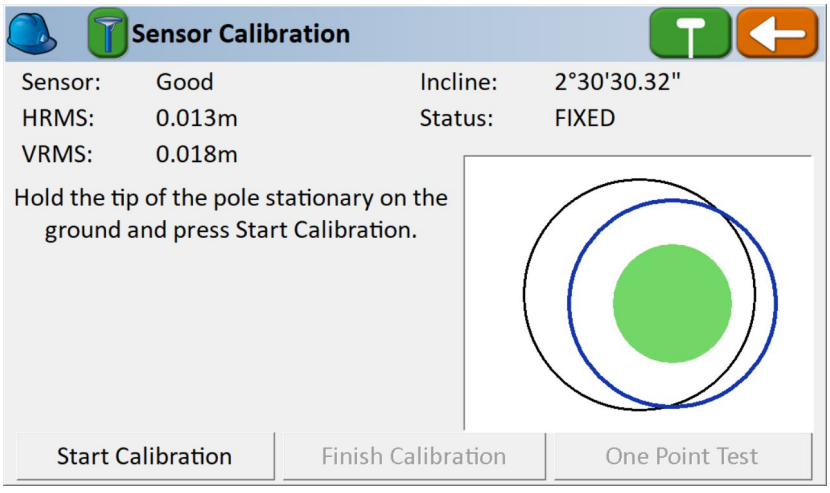
In addition to inertial sensors the BRx7 offers a traditional tilt sensor as a backup. This backup tilt sensor is used when it is not possible to initialize the inertial sensors, such as when the receiver is static for a long period of time or when running in autonomous or DGPS mode. The Tilt Calibration (Set Hz) option is used to calibrate the backup sensors. It is recommended to perform this calibration *indoors* on a level tribrach. Simply level the receiver and press the “Set Zero” button to center the bubble.



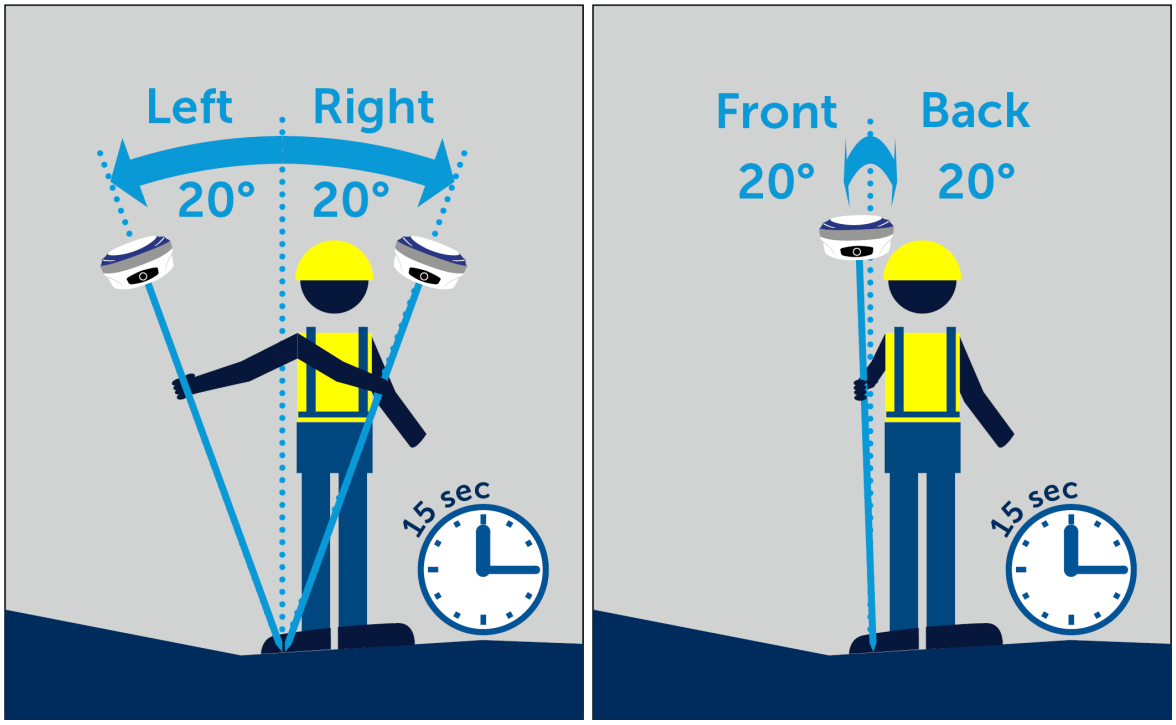
This calibration does not normally need to be repeated except in the case of drastic temperature change (> 40 degrees).

IMU Pole Calibration

IMU Pole calibration must be performed the first time you use your system. The pole-calibration trains the sensors to compensate for the mechanical imperfections and unique geometry of the physical pole in use. This calibration only needs to be performed once, and need not be repeated unless you change to a new or different survey pole (raising and lowering the height of the pole is okay). The calibration is not geographically dependent. To perform this calibration, press the Pole Calibration button inside of Sensor Utilities. Before beginning the calibration, you must be RTK fixed, within Initialized Sensors. In the image below, the GNSS Status is “FIXED” and the Sensor status is Good, meaning calibration can be performed.



Hold the tip of the survey pole stationary on the ground and press “Start Calibration.” Without moving the tip of the pole, tilt the survey pole left to right for 15 seconds, tilting roughly 20 degrees each way. After about 15 seconds, without spinning the pole in your hand, start moving the pole from front to back, again roughly 20 degrees in each direction, for 15 seconds. Once complete, press the “Finish Calibration” button.

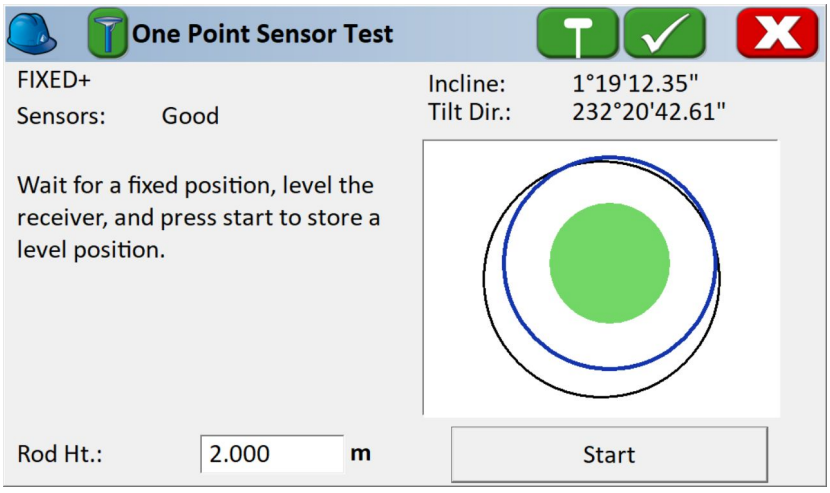


Pole Calibration Tips And Tricks

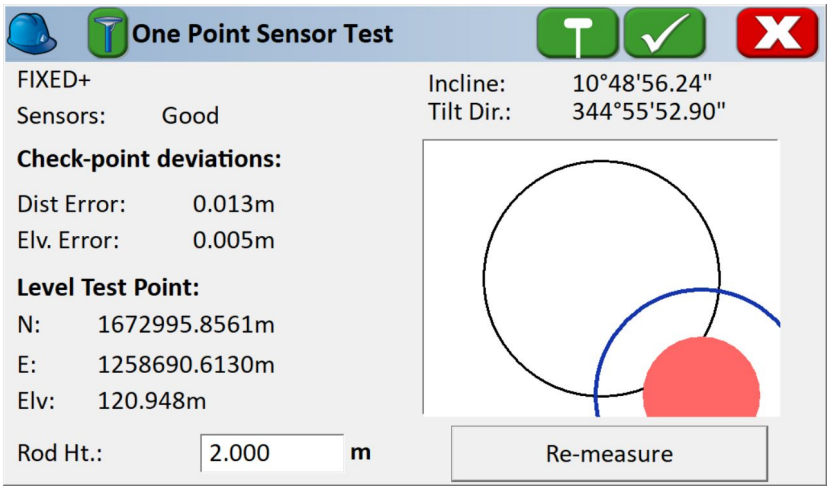
- Prior to starting the pole calibration, make sure the receiver is mounted tightly and securely on the pole (no looseness in connection or mechanical parts).
- It is important to select a secure location on the ground to prevent the pole from slipping during calibration. A conventional survey marker or nail (with an indentation for pole tip) is ideal.
- Pole calibration accuracy is dependent on the quality of the GNSS Solution. For best results:
    - Set up in an open area free of buildings, fences, power lines, or trees that might cause multipath.
    - Use a short baseline (< 3 miles). A short and direct connection to the base normally provides better accuracy than a network solution.
    - Use Surefix if possible.
- Always recalibrate when you switch to a new pole, even if the pole is the same model. Each pole should be considered unique in terms of calibration.

One Point Test

The One Point Test routine is the ideal way to test and get comfortable with the sensor functionality on your receiver. The test allows you to measure a level (uncorrected) center point, and then tilt the receiver in various directions to examine the quality of the tilted pole correction.



The one point test should only be used when the GPS is Fixed (or Surefixed) and sensors are Good (initialized). Place the tip of the pole on the ground, level the pole, and press Start. Three level positions will be measured and averaged.



Without moving the tip of the pole, tilt the head of the receiver to observe the quality of the corrections. In the image above, the receiver is inclined at an angle of roughly 11 degrees, and the calculated position is 1.3cm horizontally from the measured center point. Elevation error is 5mm. The deviations will update as you maneuver the receiver, and the center point can be re-measured at any time.

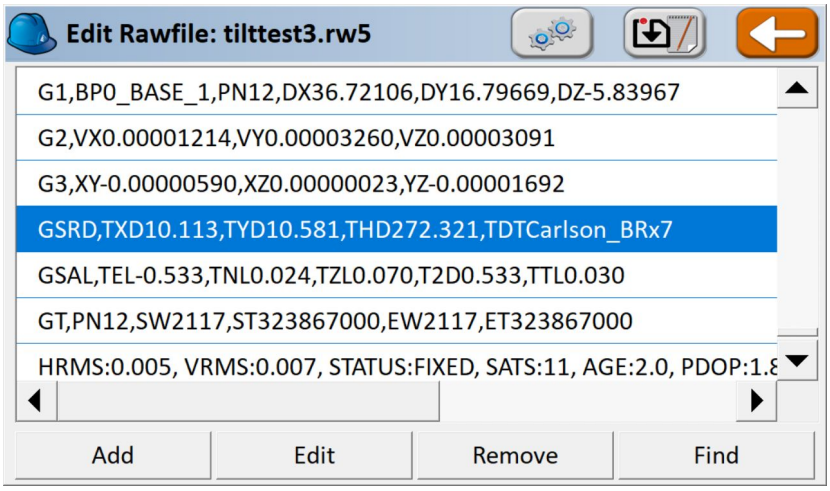
Using the **One Point Test** can help field crews understand the limitations of their receiver. Very bad results in this screen could indicate that pole calibration needs to be repeated.

Verify E-Bubble

The Verify E-Bubble routine can be used to perform an extra quality check on your ebubble calibration. The test can be performed indoors or outdoors, but requires that the receiver be set up a tribrach which should be sitting on a stable tripod or table. The tribrach should be as level as possible, although perfect leveling is not required. The two-step process will sample measurements from the ebubble, then ask you to spin the receiver 180 degrees to repeat the sampling. By averaging the results for the X and Y axis, the routine can give a final report on the deviations from level as well as linear deviation assuming a 2 meter pole.

RW5 File Records

When IMU is enabled, tilt records will appear in the RW5 file.



The records are defined as follows, and can be reprocessed using Carlson Desktop Products or in SurvCE.

Raw Data Record:

Header	Description	Units and format
--GSRD	**GNSS Sensors Raw Data, direct readings**	
TXD	Tilt X reading, tilt axis perpendicular to GNSS panel	pos/neg degrees (-90 to 90), 3 decimals
TYD	Tilt Y reading, tilt axis parallel to GNSS panel	pos/neg degrees (-90 to 90), 3 decimals
THD	Compass reading	positive degrees (0-360), 3 decimals
TDT	Tilt Sensor built in device type_brand_model	Free text (GNSS unit, datacollector, etc)

Computed Deviations In Linear Units (In Digital Level Mode -- No corrections applied):

Header	Description	Units and format
--GSRL	**GNSS Sensors Relative Linear deviations**	
TXL	Tilt X relative linear distance to point	pos/neg meter/feet, 3 decimals
TYL	Tilt Y relative linear distance to point	pos/neg meter/feet, 3 decimals
T2D	Tilt 2D distance to pole point	positive meter/feet, 3 decimals
TTL	Tilt tolerance in linear units	positive meter/feet, 3 decimals

Computed Deviations in Linear Units (Corrections Applied):

Header	Description	Units and format
--GSAL	**GNSS Sensors Absolute Linear deviations**	
TEL	Tilt X Easting linear distance to point	pos/neg meter/feet, 3 decimals
TNL	Tilt Y Northing linear distance to point	pos/neg meter/feet, 3 decimals
TZL	Tilt Z Elevation linear distance to point	pos/neg meter/feet, 3 decimals
T2D	Tilt 2D distance to pole point	positive meter/feet, 3 decimals
TTL	Tilt tolerance in linear units	positive meter/feet, 3 decimals