Purpose

The purpose of this manual is to act as a starting point for new users of the 3-Space Mini Bluetooth Sensor, and to offer tips on how to operate it in a way that ensures it acts as desired.

Overview

The 3-Space Mini Bluetooth Sensor is an Attitude and Heading Reference System which uses a 3-axis accelerometer, gyroscope, and compass to determine which way it is facing (its orientation) relative to some reference orientation. A reference orientation can be manually set, but if not it will use the direction of gravity as down, the direction of north as forward, and the cross product of gravity by north as right. The sensor can send orientation data to a PC using a USB or Bluetooth connection. It can also use this connection to send any of the other data it provides, like acceleration data, and to allow its parameters to be modified. For a complete listing of these parameters/data and the commands that are used to access them, see the Protocol Reference in the User's Guide document. The sensor can communicate in two modes:

- ASCII mode, which is good for using with a terminal, as it takes and returns data in a human readable form
- Binary mode, which is good for using from a programming language and when speed is important, as it takes and returns smaller, fixed length pieces of data

Once again, for further detail, see the aforementioned documents.
Run the latest 3-Space Sensor installer, which can be found at https://yostlabs.com/yost-labs-3-space-sensor-software-suite/. This will install the drivers needed to use the 3-Space Sensor, as well as the 3-Space Suite, a program which displays the current orientation of the sensor graphically and offers a UI to many of the options the sensor offers. It also offers a terminal mode in which you may interface with the sensor using text-based commands.

Once these have been installed, plug the 3-Space Mini Bluetooth Sensor into one of your computer's USB ports. Make sure that the charging LED on the sensor turns red. Turn the sensor on by flipping the switch on the side towards the side of the sensor with the mini USB port.

On Windows 10, if you have already installed the 3-Space Sensor Suite, the drivers for the USB connection should be automatically installed in the background, with a message appearing in the bottom right status bar area letting you know when the drivers begin installing and when installation has completed.
On Windows 7, if the computer recognizes it, the “Found New Hardware Wizard” will appear. Select “No, not this time” and then “Install the software automatically”. Two more “Found New Hardware Wizards” will appear, select the same options on these. After a moment the installation should finish.

We may now check to ensure the 3-Space Sensor is working. The easiest way to do this is to run the 3-Space Suite. Upon running this program, there will be a list of COM ports in the lower left hand corner.
Select the COM port from the list which corresponds to your sensor. If you are unsure as to which port corresponds to your sensor, look to see if one of them is labeled with your type of sensor. Alternately, you can check the list of COM ports with your sensor unplugged, and then recheck the list once you have plugged it in. If a new port appears, this corresponds to your sensor. Once you have chosen your COM port, the suite will attempt to connect to it.
Sensor Calibration

Run the 3-Space Suite, and select your COM port from the list. You should see a model of the sensor that rotates along with the actual sensor.

The sensors are calibrated at the factory, but due to changes in environment, the sensor may need to be recalibrated at the application site. Move the sensor around and see if its orientation in the real world matches the one rendered on screen. If it does not match, calibration may be needed.

Basic Calibration

- **Auto Calibrate Gyros:** The gyroscope needs to be calibrated while the sensor is stationary so it can get an idea of what readings correspond to no motion. Hold the sensor still and press the Calibrate Gyros button. Continue to hold the sensor still for a second after that, and gyroscope calibration will be complete.

- **Tare:** Following this, the sensor most likely needs to be tared. Taring sets a certain sensor orientation as the “zero” point. This is always represented on screen by the sensor with its top(button side) up and the cord facing directly towards you. Therefore, to put the sensor in an appropriate taring position, you should make sure the physical sensor has its top up and its cord facing directly towards you. You will probably also want to place it on a flat surface to help line it up. Once you have it in the proper position, press the Tare button in the suite. The command will finish immediately, so you may begin moving the sensor around after that. The movement of the on-screen sensor should now much more closely match that of the real sensor.

Commit Your Settings

Once you have the sensor properly calibrated, you will want to save your changes so you don't have to make them again every time you plug in your sensor. To commit your settings to the sensor's non-volatile memory, press the Commit Settings button. Be sure to do this each time you make changes you want to keep. If you decide later that you want to return to the original settings and try again, use the Restore Factory Settings menu option. This will return all settings to their original states, though this change will also not be saved unless you commit it.

Dealing with Small Errors

You may find that while the on-screen orientation may be close to the actual sensor's orientation, in some places it will still have a small error(this is easiest to see when holding it so any edge is flat against a surface and another edge is facing the screen). There are several methods for correcting this:
• **Perform sphere calibration:** The Suite provides a wizard that allows users to perform a calibration similar to the one performed at the factory. Go the Sensor menu and select Calibration and then Run Sphere Calibration Wizard. The following window will appear:

![Sphere Calibration Wizard](image1)

Rotating the sensor will cause the sphere to rotate as well. The cyan and yellow arrows will paint their colors on the sphere wherever they touch. Any area they both paint will turn green. The goal of this wizard is to more or less turn the entire sphere green. The reason for this is that if both of these arrows have touched the entire sphere, this is a good sign that the data set that has been collected from the sensor provides a decent representation of all possible values. Another good metric is that the estimated density has dropped to around 30 to 60. Once you are satisfied that the sphere is decently filled in, hit Finish and new calibration parameters will be calculated for your sensor. Make sure to commit the new settings if they seem to help.

• **Perform Gradient Descent Calibration:** The sphere calibration is excellent for fixing overall sensor error, but sometimes magnetic effects can twist orientation readings in a way that requires a more specific solution. In cases where after sphere calibration some orientations still are off, gradient descent calibration is the recommended solution. Gradient descent calibration is layered on top of sphere calibration, so both can be used in unison. This also means that if you reperform sphere calibration, you should also reperform gradient descent calibration if you would like to continue using it. To perform gradient descent calibration, go the Sensor menu and select Calibration and then Run Gradient Descent Calibration Wizard.

![Gradient Descent Wizard](image2)
• A small picture of the sensor will appear, indicating a certain orientation you should be placing your sensor in. Place the sensor in that orientation and hit the Next button. When you press the Next button, the picture will move on to the next orientation, and so on until it has guided you through all the orientations. After this has been done, check the orientation to see if the error still exists.

• **Turn on continual auto-reference vector mode:** In its default state, the sensor will automatically calculate the compass reference vector when it starts up. However, it can be set to continually recalculate this, allowing it to adjust the reference vector on the fly. To set up this mode, click the Single Auto Continual radio button. Note that in this mode, the accelerometer reference vector is always (0,1,0).

### Advanced Calibration

• **Smoothing out the results:** If you would like the orientation coming out of the sensor to be smooth at the expense of responding quickly, you can set up a running average. Choose the Settings option from the Advanced menu. On this screen you will see a field labeled Running Average Percent under each of the components and the orientation.

![Running Average Percent](image)

When this is 0, no smoothing will be done. It can be as much as 97, which indicates that 97% of each orientation is composed of averaged previous orientations. At 97% the orientation will be very smooth, but will respond more slowly. Experiment with this value to find the right combination of response and smoothness. Be sure to hit Save for your changes to take effect. (Note that hitting Save will not commit the changes to non-volatile memory, it will only cause them to take effect for the current session. To keep the changes, commit them as described above.)

• **Oversampling:** The same settings window contains an oversampling setting. This value can be between 1 and 10, where 1 means only one sample is taken per orientation calculation, and 10 means 10 samples are taken per calculation. A higher value for this will cause orientations to be calculated more slowly, but will also reduce noise. Experiment with this value if you need to reduce sensor noise, and be sure to commit the setting afterward if it is suitable.
Windows 10 Basic Startup Instructions (Bluetooth)

Ensure that your computer has a Bluetooth receiver installed. Make sure the 3-Space Sensor has power either through a USB connection or through its battery. The following steps for connection come from Windows 19's built in Bluetooth device installation dialogs, but other systems should have similar processes.

**Step 1)** Click on the Start Menu button and click the small gear icon to open the Windows Settings Menu and then select **Devices**.

**Step 2)** Select **Bluetooth & other devices**, if it's not initially open and then select “Add Bluetooth or other device”
Step 2) Select **Bluetooth** in the “Add a device” window. On the next window, look for the device with the name “**YostLabsMBT**”.

Step 3) After a moment, a pairing dialog will appear. Enter the sensor's pairing code – **1234** – to finish the device connection process.
Step 4) After adding the device, select “Devices and Printers” on the right hand side.

Double click on the “YostLabsMBT” device
This window will list the COM port which was assigned for the serial link to this sensor. In this case, it is COM14. Remember what your COM port is listed as.
Step 7) Return to the 3-Space Suite and select the indicated COM port from the COM port list. If it is not present, hit the Refresh button and try again.

You should now be connected to the sensor over Bluetooth in the Suite. It should move around normally and allow for calibration as if it were wired.
Windows 7 Basic Startup Instructions (Bluetooth)

Ensure that your computer has a Bluetooth receiver installed. Make sure the 3-Space Sensor has power either through a USB connection or through its battery. The following steps for connection come from Windows 7’s built in Bluetooth device installation dialog windows, but other systems should have similar processes.

**Step 1)** Bring up the Devices and Printers page, which can be accessed from the Start Menu or Control Panel. Select the “Add a device” option in the upper left.

![Add a device window](image1)

**Step 2)** A list of nearby devices will appear. The sensor's name will contain the phrase “3space” in it. Select the one named as such.

![Add a device window](image2)
Step 3) After a moment, a pairing dialog will appear. Say you want to enter a pairing code.

Step 4) Enter the sensor's pairing code, 1234.
Step 5) A dialog will appear indicating that the device has been installed successfully. Balloons will also appear in the bottom right corner indicating drivers are being installed.

![Add a device dialog](image1.png)

Step 6) Figure out which COM port is associated with your device. Click on the Bluetooth icon in your tray and select **Show Bluetooth Devices**. The following screen should appear.

![Bluetooth Devices](image2.png)
Right click on the sensor device and select **Properties**. Navigate to the Hardware tab on the resulting window.

This window will list the COM port which was assigned for the serial link to this sensor. In this case, it is COM59. Remember what your COM port is listed as.
**Step 7**) Return to the 3-Space Suite and select the indicated COM port from the COM port list. If it is not present, hit the Refresh button and try again.

You should now be connected to the sensor over Bluetooth in the Suite. It should move around normally and allow for calibration as if it were wired.