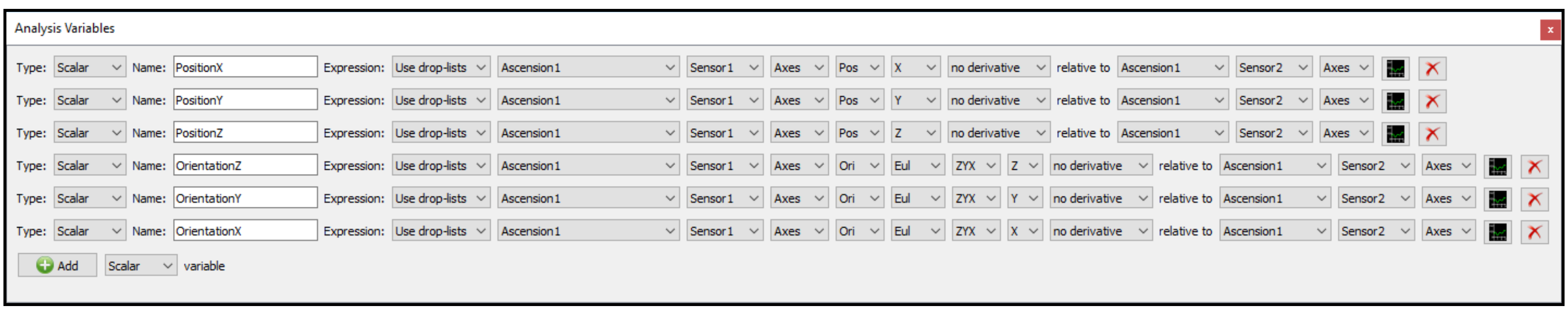
The MotionMonitor xGen Software Guide: Metal Mapping and Distortion Correction

This document reviews the configuration of mapping functions to correct readings from magnetic trackers (Ascension & Polhemus systems) that may have been distorted by environmental conditions. Typically, standard range transmitters do not require mapping as they can often be moved away from sources of distortion.

Prior to performing any type of metal mapping, testing should be performed to determine if environmental distortion exists and the extent that the data capture volume would need to be mapped. To confirm or test for environmental distortion, two sensors can be affixed to a rigid, non-ferrous, rod and then moved through the measurement space. It is recommended to have the sensors directed in the same general orientation as each other, as this will make the relative orientation data easier to evaluate. Since the sensors on the rod are stationary to each other, the reported values will remain stable in the absence of distortion or noise. As the rod is moved through the space, the user can determine the amount of variation from one part of the space to another. If the variation is excessive, it may indicate the need for a metal mapping to recalibrate the space. Please note that the noise is expected to increase as the sensors move farther from the transmitter and that this would not be reason for performing a mapping.

The Analysis Variables displayed in the image below demonstrate how the position and orientation of one sensor can be easily examined relative to another sensor.



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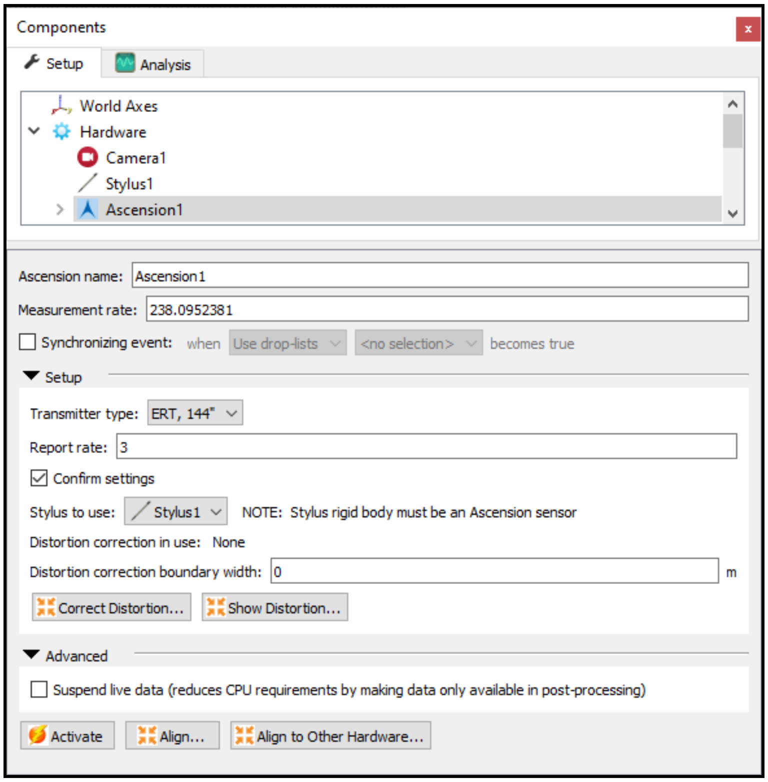
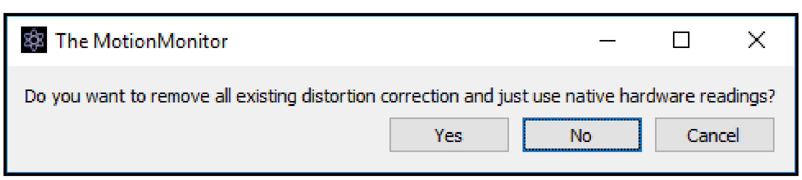
Performing a metal map using the "Grid" method

1. Start The MotionMonitor xGen and go to the Hardware node in the Setup Components window. From the Ascension or Polhemus node, click on the "Correct Distortion" button.

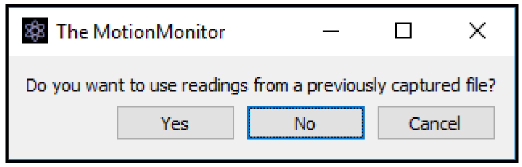


The software will specify whether a metal mapping is currently applied as well as the name of the metal mapping file in use following the "Distortion correction in use" text, as seen in the image above. The "Distortion correction boundary width" setting is not used by the distortion correction metal mapping algorithm. This parameter is only used for mappings created with the "Align to Other Hardware" alignment, which uses a polynomial fitting algorithm and will be reviewed at the end of this document.

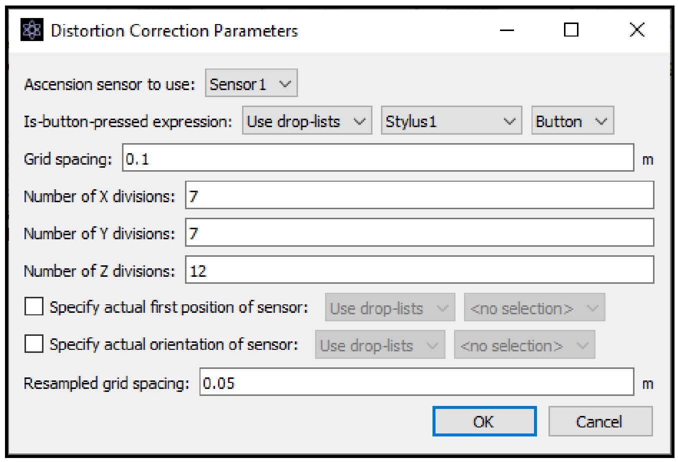
2. Select "No" when asked to remove all existing distortion correction and just use native hardware readings. Selecting "Yes" will clear the current mapping and result in the software going back to using uncorrected sensor position and orientation data. Selecting "Cancel" will exit the process.



3. Select “No” when prompted to use a previously captured mapping file.



4. Specify the distortion correction parameters for the metal map. Select the sensor to use for capturing readings during the process and the Is-button-pressed expression if using a handheld event marker as a remote OK button to advance through the software dialogs. The number of X, Y and Z divisions represent the number of points or layers to take in the mapping. All readings and axis directions are in the transmitter’s default, native, coordinate system. The Grid spacing indicates the spacing between each point.

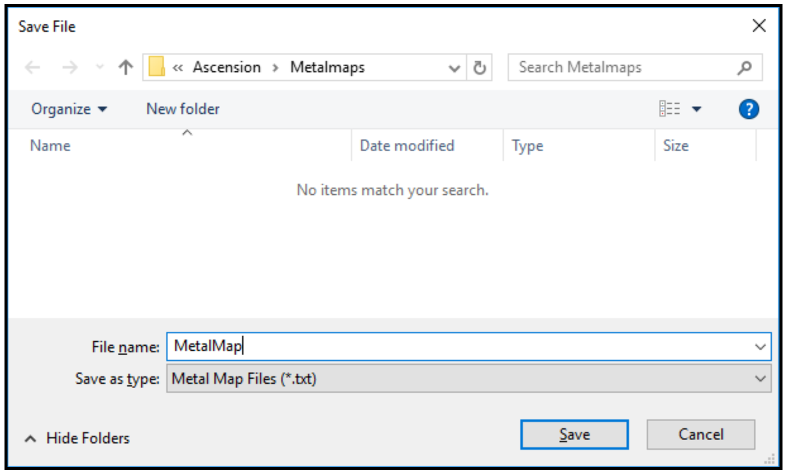


Generally, it is assumed that the closest readings to the transmitter are in undistorted space. However, certain environments may contain a large distortion throughout the volume, even when closer to the transmitter. The “Specify actual first position of sensor” and “Specify actual orientation of sensor” are meant to provide a means to perform a metal mapping when there is significant distortion throughout the capture volume.

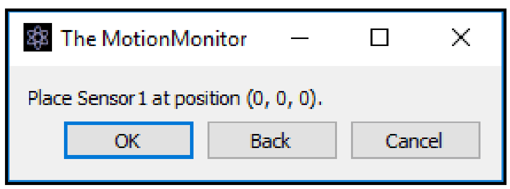
The orientation of the sensor is meant to remain fixed across all the mapping readings, the “Specify actual orientation of sensor” is the orientation of the sensor relative to the transmitter during the mapping process. The orientation of the sensor can be reported as rot(Yaw, Pitch, Roll), where Yaw (Z), Pitch (Y) and Roll (X) are angles relative to the transmitter’s default, native, coordinate system. The “Specify actual first position of sensor” would be the actual position of the first mapping position (reading (0,0,0)). The position can be specified as vec(X, Y, Z), where x, y and z are the X, Y and Z positions reported in meters relative to the transmitter’s default, native, coordinate system. While this might involve some error from the actual measurement of where the first position of the metal mapping grid is (using a ruler or tape measure), it would only be necessary in cases where there is significant distortion, even close to the transmitter. Also, the mapping algorithm is more susceptible to errors in orientation than position, so the orientation field would be more important to specify, and to get correct, than the position. An inaccurate position may only result in an initial shift of where the “origin” of the world is. All positions would be reported relative to that same world axes origin location.

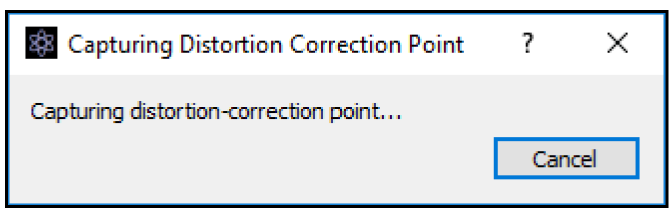
The “Resampled grid spacing” edit field effectively adds additional data points in the mapping correction to the points that are actually digitized. This parameter will be better at reducing absolute errors when it has a smaller value, and better at reducing relative errors when it has a larger value. As a general rule, the best results with this parameter is typically one that is less than the original grid spacing, but it does not need to be significantly less.

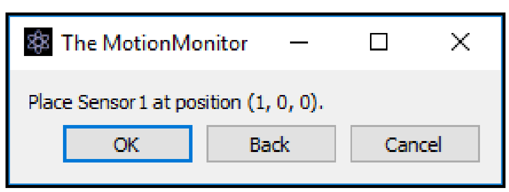
Click “OK” and select a name for the metal map file and to begin the process of capturing points for the metal mapping.



5. The software will then proceed through capturing the points for the metal map as defined in the Distortion Correction Parameters dialog. The readings are taken in order, first on x, then y, then z axes, consistent with that of the transmitter’ default, native, coordinate system.

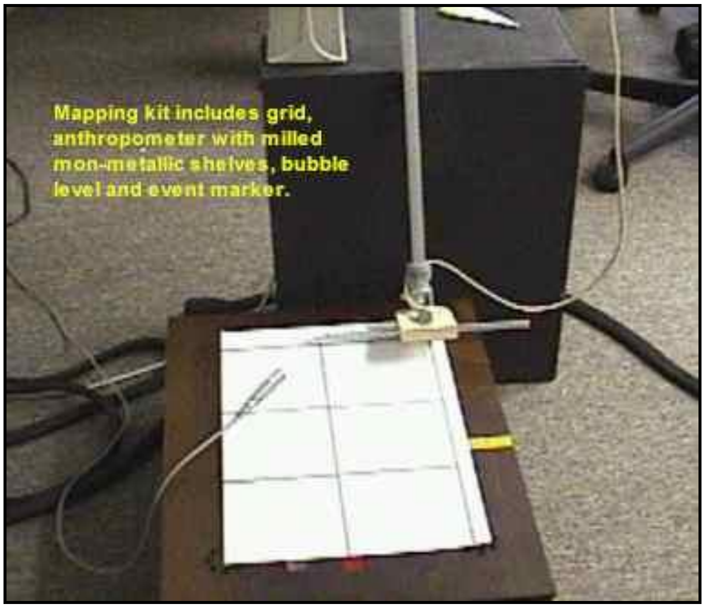




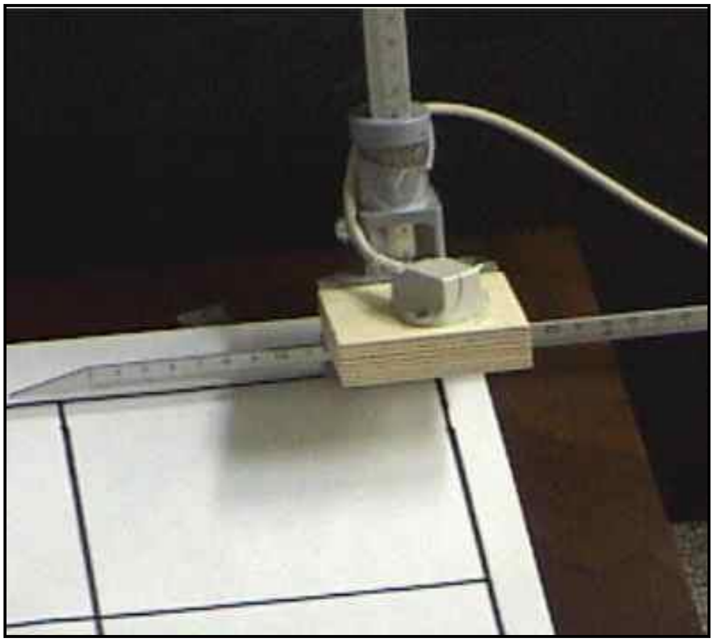


The positioning of the grid should be aligned as best possible with the transmitter’s axes system, as seen in the following sample images.

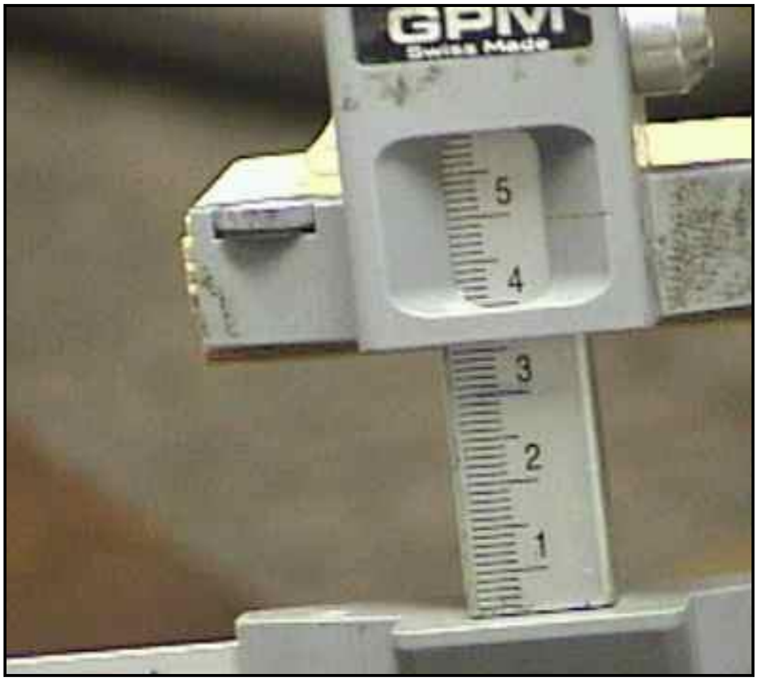
The following images provide a visual representation for how the "grid" method can be performed. This example uses a modified anthropometer, bubble level and grid, as shown here.

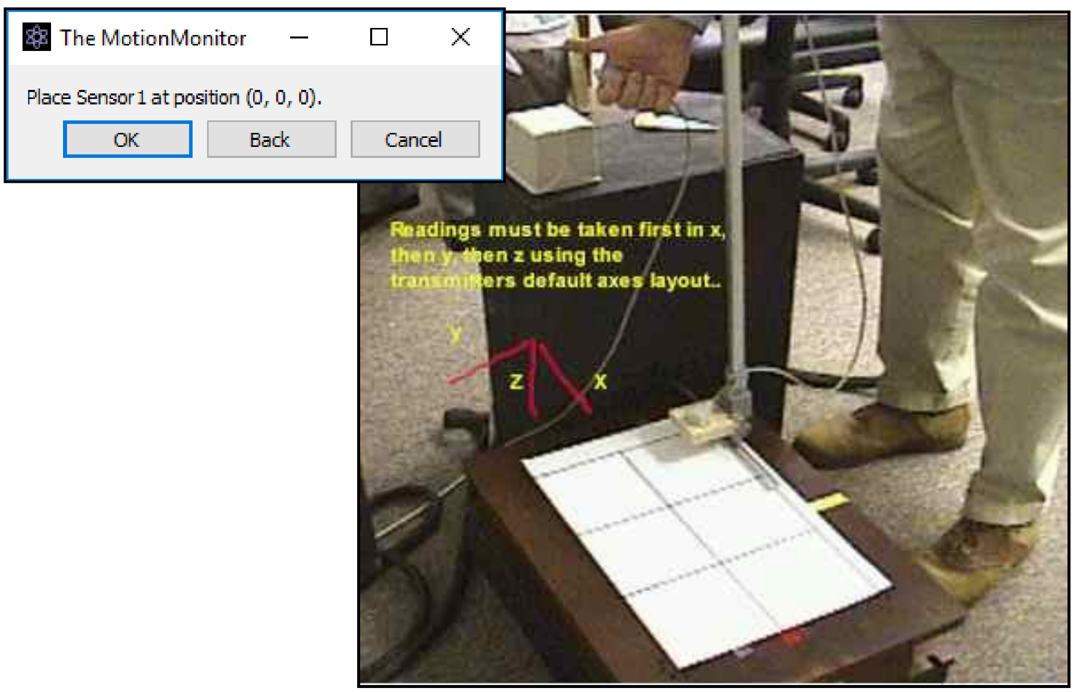


The sensor designated in Distortion Correction Parameters dialog is firmly attached to the milled "slider" shelf on the anthropometer. The sensor orientation does not matter but will need to remain constant throughout the entirety of the mapping process. The grid is then laid out in the measurement space that is to be mapped, using the grid spacing previously specified in the dialog.

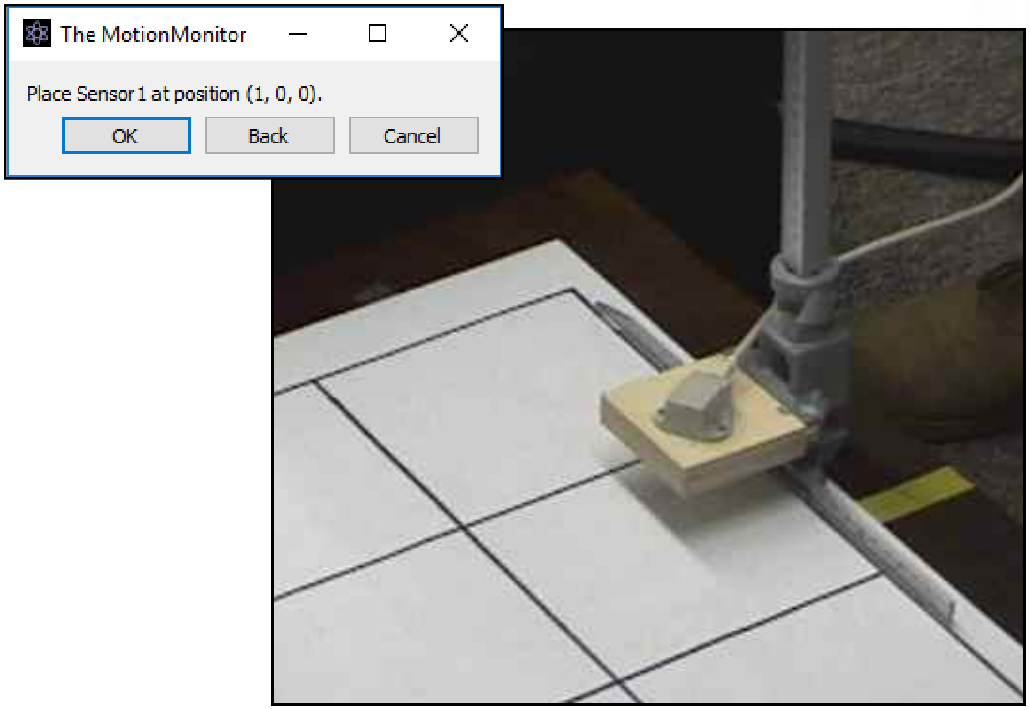


The user should take note of the initial position of the slider. As readings are taken in the upper layers of the grid, it will be necessary to move the slider by the grid spacing previously specified in the dialog.

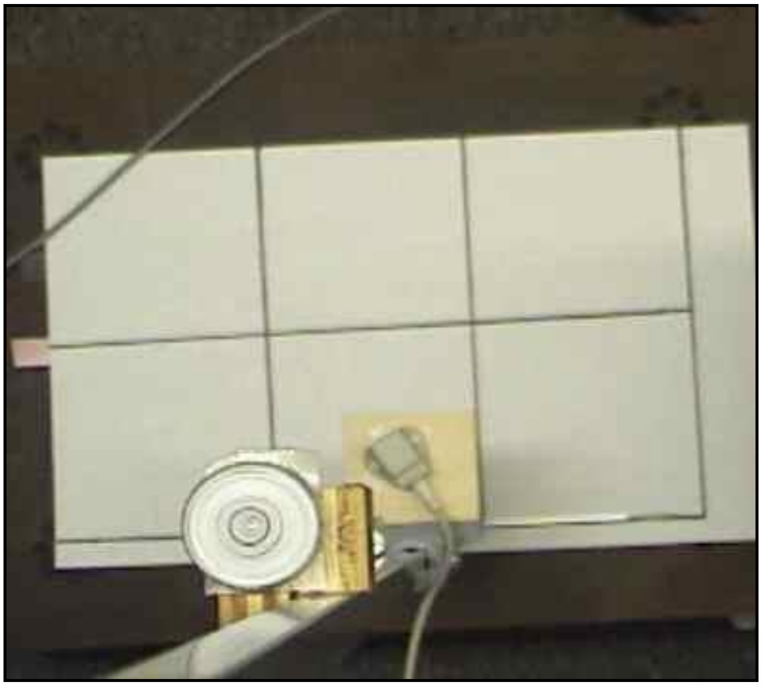




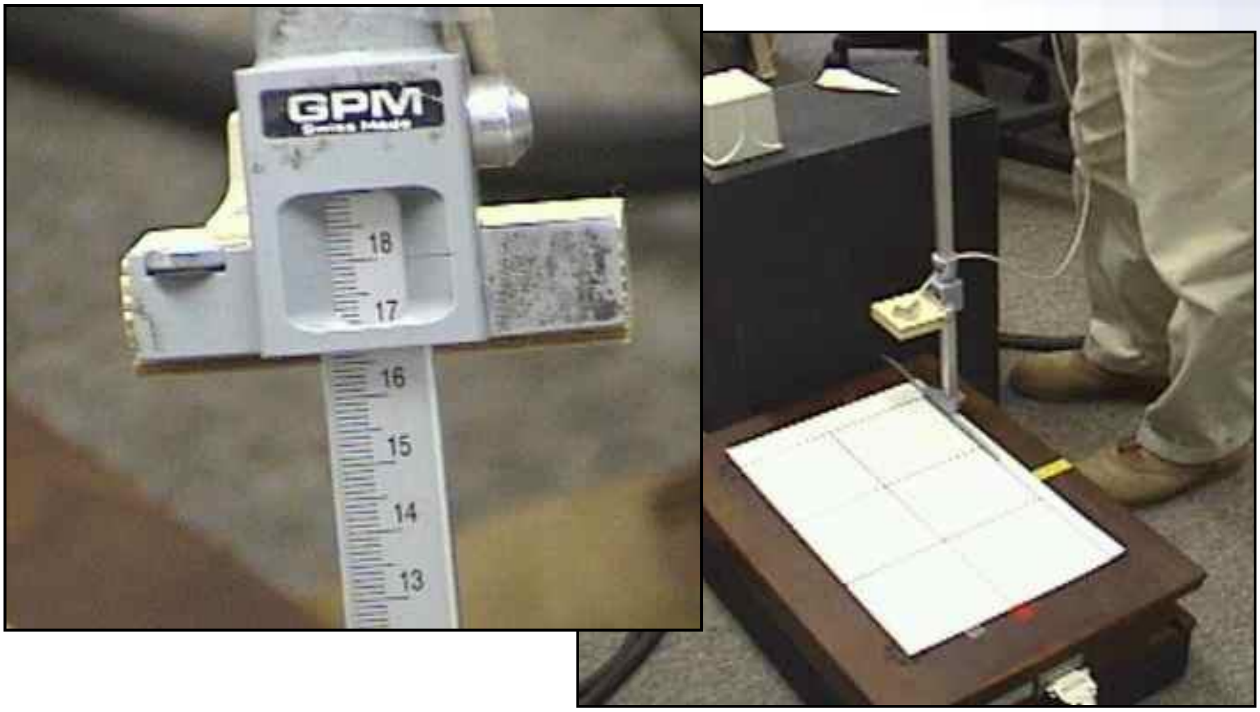
As the anthropometer is moved to successive points in the grid, care must be taken to ensure that the anthropometer is placed in the same relative position and orientation.



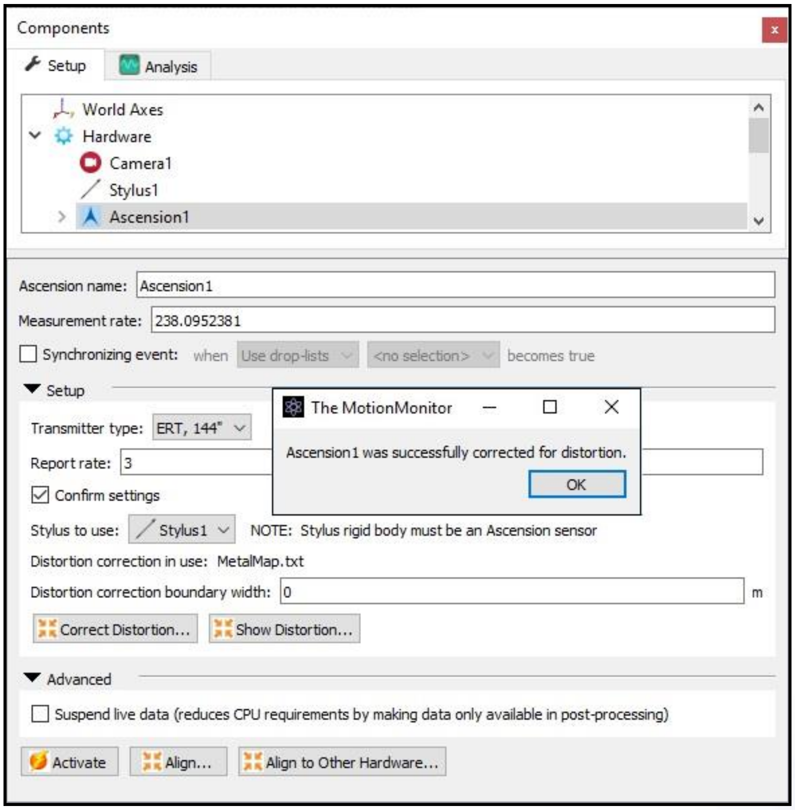
The cross member in the base of the anthropometer should be carefully aligned with the grid; the point on the grid should be accurately positioned at a common point on the anthropometer base. In addition, the bubble level should be observed to ensure that the anthropometer is perfectly vertical.



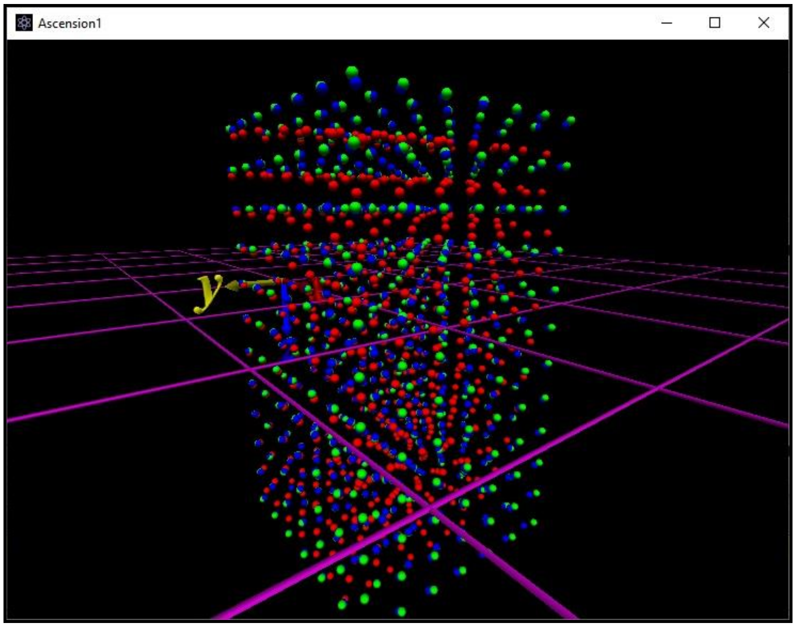
When the layer of x, y points has been recorded, the "slider" should be moved by the spacing specified in the dialog box....



When all the points have been recorded, the Parameter panel for the hardware device now indicates the name of the distortion correction file is in use.

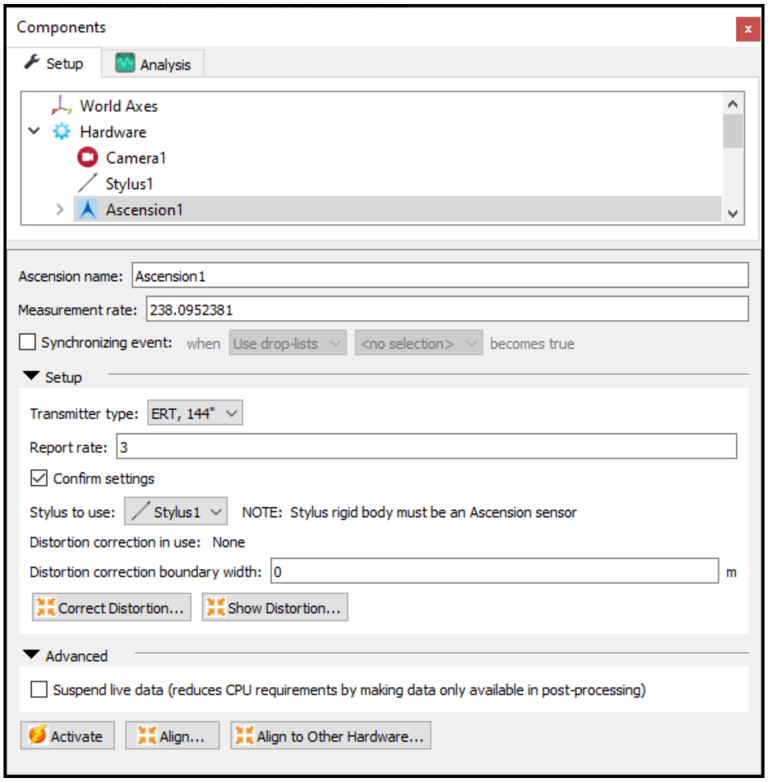


6. Click on the “Show Distortion” button for a visual representation of your metal mapping correction in an interactive 3D Animation window. An example of a metal mapping distortion correction is displayed below. The Green dots represent the actual positions for the grid. The Red dots represent the raw positions that were captured. The Blue dots represent the corrected readings for the sensor data.



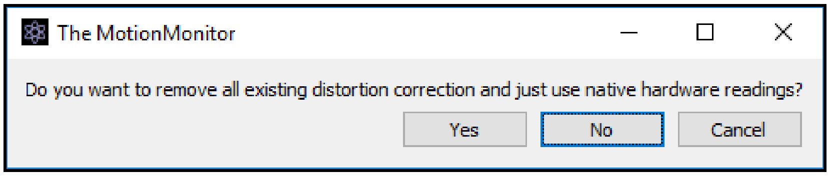
Loading an existing metal map file

1. Start The MotionMonitor xGen and go to the Hardware node in the Setup Components window. From the Ascension or Polhemus node, click on the "Correct Distortion" button.

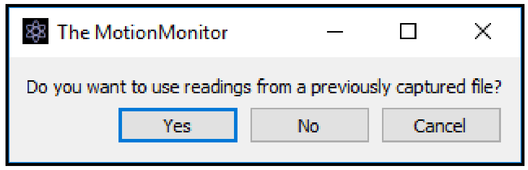


The software will specify whether a metal mapping is currently applied as well as the name of the metal mapping file in use following the "Distortion correction in use" text, as seen in the image above. The "Distortion correction boundary width" setting is not used by the distortion correction metal mapping algorithm. This parameter is only used for mappings created with the "Align to Other Hardware" alignment, which uses a polynomial fitting algorithm and will be reviewed at the end of this document.

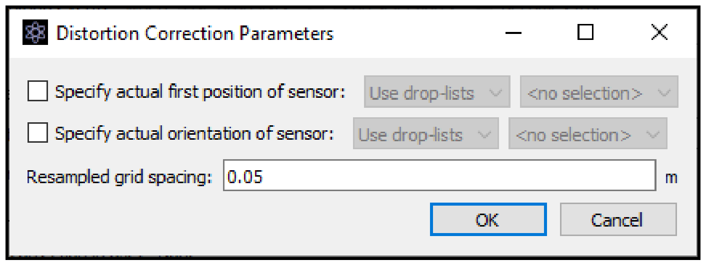
2. Select "No" when asked to remove all existing distortion correction and just use native hardware readings. Selecting "Yes" will clear the current mapping and result in the software going back to using uncorrected sensor position and orientation data. Selecting "Cancel" will exit the process.



3. Select “Yes” when prompted to use a previously captured mapping file.



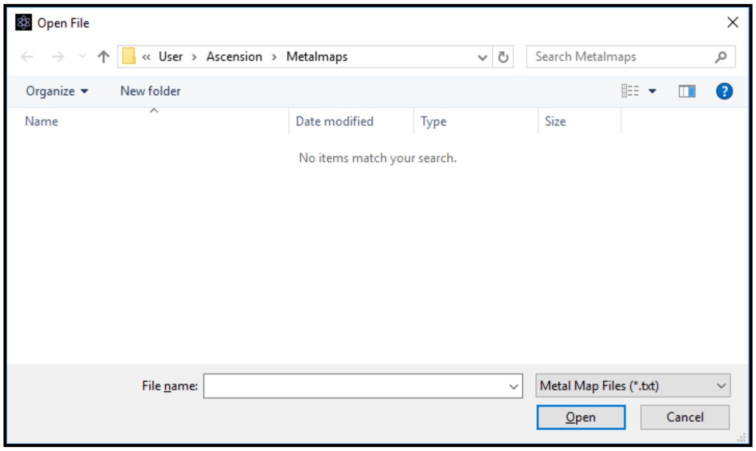
The Distortion Correction Parameters dialog provides the option for enabling the “Specify actual orientation of sensor” and “Specify actual first position of sensor” and to set the “Resampled grid spacing”.



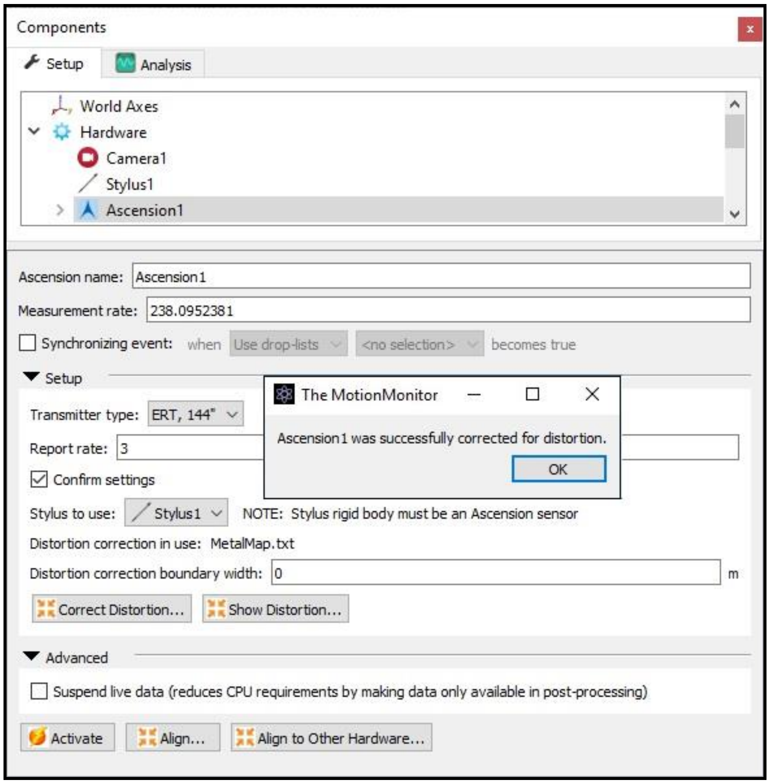
As described previously, it is assumed that the closest readings to the transmitter are in undistorted space. However, certain environments may contain a large distortion throughout the volume, even when closer to the transmitter. The “Specify actual first position of sensor” and “Specify actual orientation of sensor” are meant to provide a means to perform a metal mapping when there is significant distortion throughout the volume. The orientation of the sensor is meant to remain fixed across all the mapping readings, the “Specify actual orientation of sensor” is the orientation of the sensor relative to the transmitter during the mapping process. The orientation of the sensor can be reported as rot(Yaw, Pitch, Roll), where Yaw (Z), Pitch (Y) and Roll (X) are angles relative to the transmitter’s default, native, coordinate system The “Specify actual first position of sensor” would be the actual position of the first mapping position (reading (0,0,0)). The position can be specified as vec(X, Y, Z), where x, y and z are the X, Y and Z Scalar positions reported in meters relative to the transmitter’s default, native, coordinate system. While this might involve some error from the actual measurement of where the first position of the metal mapping grid is (using a ruler or tape measure), it would only be necessary in cases where there is significant distortion, even close to the transmitter. The mapping algorithm is more susceptible to errors in orientation than position, so the orientation field would be more important to specify than the position. An inaccurate position may only result in an initial shift of where the “origin” of the world is. All positions would be reported relative to that same world axes location.

The “Resampled grid spacing” edit field effectively adds additional data points in the mapping correction to the points that are actually digitized. This parameter will be better at reducing absolute errors when it has a smaller value, and better at reducing relative errors when it has a larger value. As a general rule, the best results with this parameter is typically one that is less than the original grid spacing, but it does not need to be significantly less.

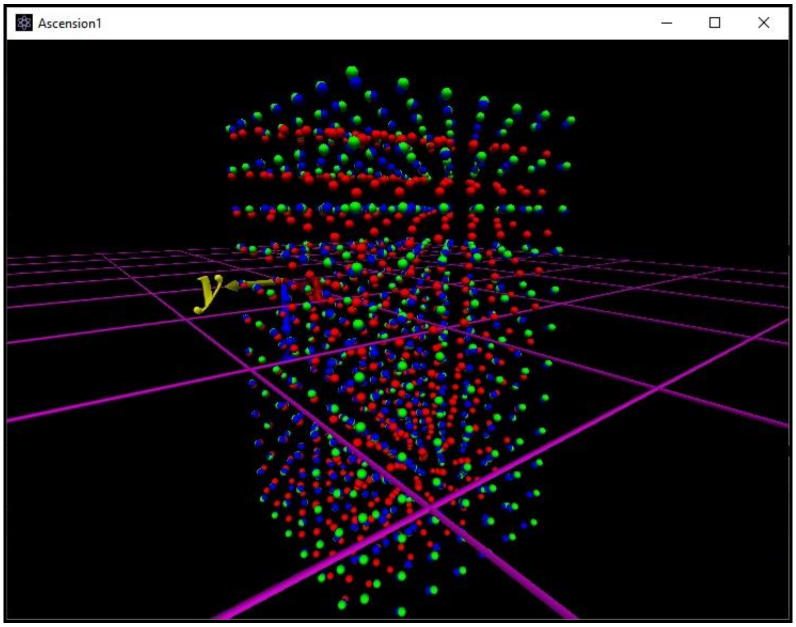
Select a name for the metal map file. Each metal map is unique to the transmitter position/orientation and environmental sources of distortion. Note: Mapping files generated using The MotionMonitor Classic can also be selected here.



The Parameter panel for the hardware device now indicates which distortion correction file is in use.



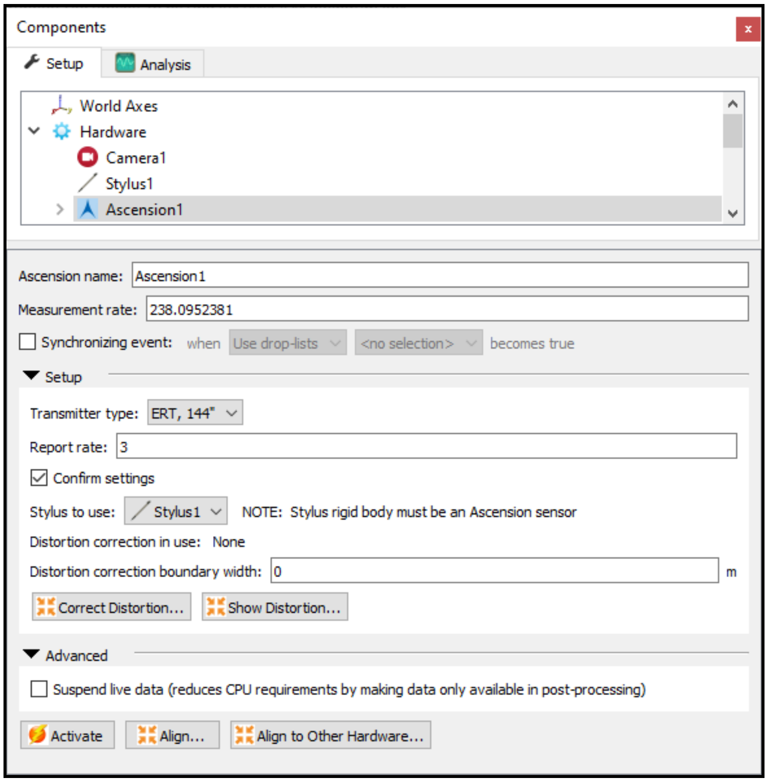
3. Click on the “Show Distortion” button for a visual representation of your metal mapping correction in an interactive 3D Animation window. An example of a metal mapping distortion correction is displayed below. The Green dots represent the actual positions for the grid. The Red dots represent the raw positions that were captured. The Blue dots represent the corrected readings for the sensor data.



Distortion correction with hybrid hardware configuration

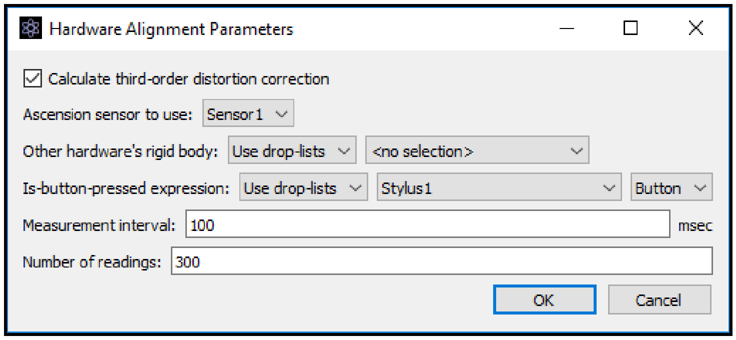
If capturing passive or active optical camera data with an electromagnetic system (Ascension or Polhemus) a dynamic distortion correction can be performed by taking simultaneous readings from a sensor or rigid body from each hardware device when the sensors are affixed to a rigid, non-ferrous, object and then moved through the measurement space.

1. Start The MotionMonitor xGen and go to the Hardware node in the Setup Components window. From the Ascension or Polhemus node, click on the "Align to Other Hardware" button.

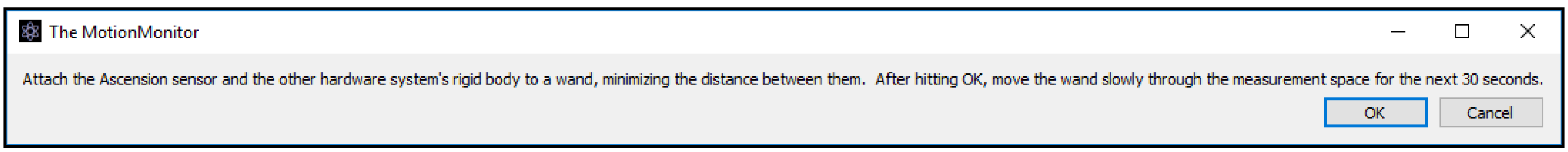


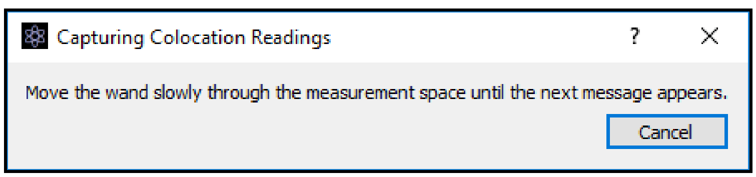
The "Distortion correction boundary width" setting is a polynomial fitting algorithm that determines the thickness of the region surrounding the mapped area where the degree of distortion correction will taper off to zero when "Align to Other Hardware" alignment is used.

2. Specify the parameters in the Hardware Alignment Parameters. For the distortion correction to be performed, enable the "Calculate third-order distortion correction" otherwise the hardware devices coordinate systems will only be aligned. Specify the electromagnetic sensor to use along with the other hardware's sensor or 6DoF rigid body to be used and the Is-button-pressed expression if using a handheld event marker as a remote OK button to advance through the software dialogs. The Measurement interval and Number of readings edit fields will determine how often the readings are captured and the number of readings to include in the distortion correction, respectively. Click "OK" to proceed.

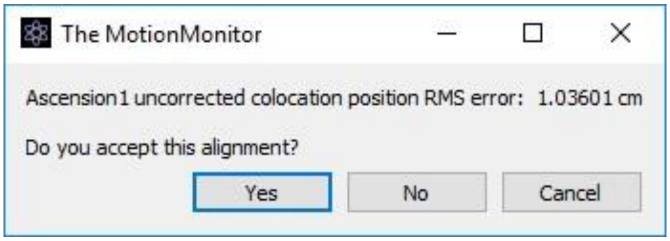


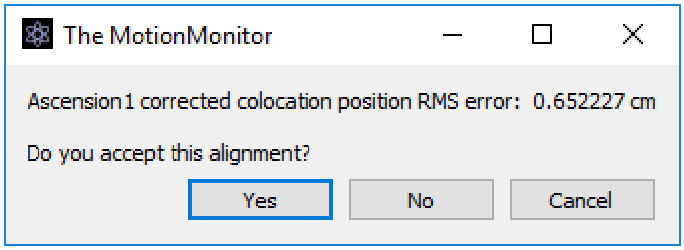
3. After ensuring that the sensors from both hardware systems are attached to the same rigid object, click "OK" to proceed with the capturing of the distortion correction points.

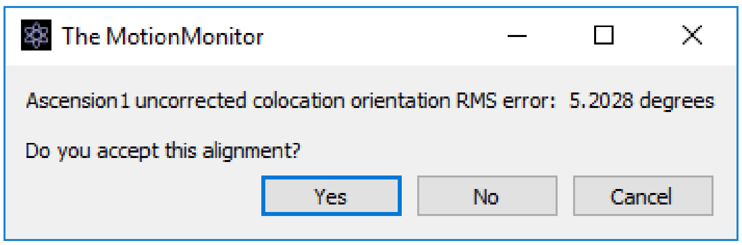


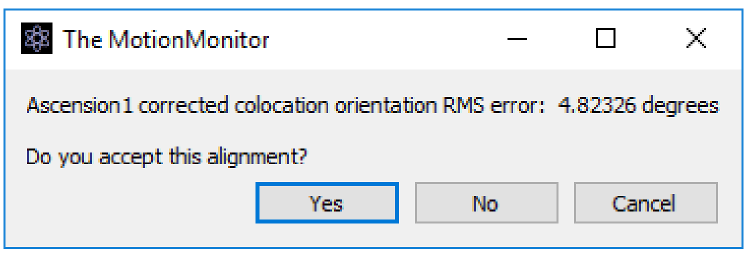


4. After capturing the distortion correction readings, the software will report the pre and post position RMS errors followed by the pre and post and orientation RMS errors.









5. If accepted, this distortion correction will be applied to the electromagnetic hardware data.