

FARO Tracker Plugin

For compatibility with Geomagic products, see *Geomagic Release Notes for FARO Tracker Plugin*.

Document version A.

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The FARO Laser Tracker X is a portable 3D measurement system which uses laser technology to measure large parts, tooling, and machinery. In real time, it captures the 3D coordinates of a mirrored spherical probe.

The purpose of a Geomagic plugin is to integrate the collection of point data into a Geomagic application, eliminating the need to capture data and load it into the application in separate steps.



Plugins > FARO Tracker activates the interface in Geomagic Studio and Geomagic Qualify to the FARO Laser Tracker X. This menu item is an optional, separately installable feature. If **FARO Tracker** does not already appear on the **Plugins** menu, download the software from support.geomagic.com/downloads and install it according to instructions on the web site.

Turn on the FARO Laser Tracker X *before* activating the plugin.

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Controls and Indicators

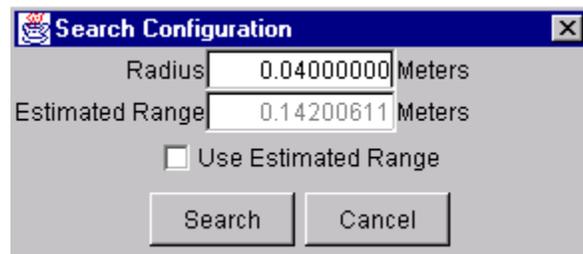
This section details the controls and indicators on the user interface of the plugin.

Recurring Controls and Indicators

The following controls appear on *all* of [The Four Main Dialogs](#).

- **Display Units** group - specifies the units of measure on the object that will be scanned, such as inches or millimeters.
 - **Units** dropdown (inches, millimeters, meters, feet, etc.) - specifies the units of measure.
- **Tracker Controls** group - specifies the units of measure on the object that will be scanned, such as inches or millimeters.

-  **Tracker Pad** icon button - offers Tracker configuration options.
 - **Initialize** button - runs the tracker initialization sequence.
 - **Home** - points the tracker to the TMR of the active target. This button is disabled when the motors are off.
 - **Turn Motors On/Off** button - toggles the state of the motors. It is disabled if the tracker has not been initialized.
 - **Turn Tracking On/Off** button - toggles the tracking state.
 - **Set Backsight** button - toggles the orientation of the tracker. This button is disabled when the motors are off.
 - **Search Target ...** button - search for a target. It has a separate dialog that is used to configure and start the search.



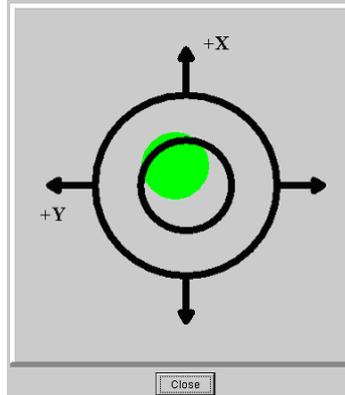
The radius is the maximum radius that the tracker should search for a target at a given range. If the "Use Estimated Range" check box is checked, an estimated range can be entered which the tracker will use for the search. The unit of measure for both values is based on the `-uLength` parameter provided when the application is started. If none is specified, meters is used. This button is disabled if the motors are off.

- **Highlight Beam** button - The highlight beam button has the tracker move the beam in an expanding and contracting spiral so that the user can visually locate the beam. This button is disabled if the motors are off.
- **Drive Beam ...** button - activates a dialog that allows the user to drive the axis of the tracker to a given location using three different methods. This button is disabled if the motors are off.
- **Visual Drive** button - The user clicks on the control pad to start the axis moving. Clicking to the right or left of the crosshair causes the azimuth axis to move to the right or left. Clicking above or below the crosshair moves the zenith axis up or down. The azimuth and zenith locations update as the axis moves.



- **Angular Drive** button - allows the user to specify the azimuth and zenith angles (and optionally a distance) to the target. The "Search..." button provides a convenient way for the user to search for a target once a move has been completed.
- **Manual Drive** button - allows the user to point the tracker by hand to a given azimuth and zenith. The user can toggle the motors on and off. In addition, the "Search..." button provides a convenient way to search for the target once the tracker is pointed and the motors are on.

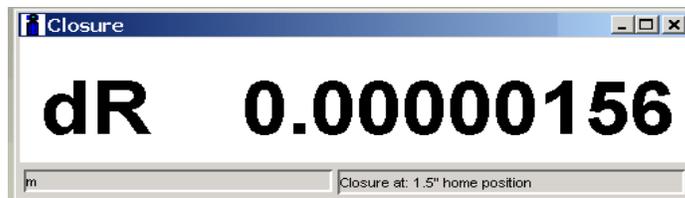
- **Set Distance Mode ...** button - allows a user to choose how the tracker measures the range to the target (Interferometer Only, Interferometer Set By ADM, or ADM Only). If multiple modes of operation are not available for the tracker, the distance measure mode button is disabled. Note that the "ADM Only" choice does not appear for 4000 series trackers.
- **Set Weather Configuration ...** button - allows the user to configure the air pressure, air temperature, and humidity on the tracker. The tracker can be configured to read each value from a sensor, or values can be entered manually.
- **Set Temperature Configuration ...** button - configures alarm parameters for each of eight sensors that may be plugged into the Master Control Unit (MCU).
- **Display Bubble Level ...** button - activates an electronic level that can be used to adjust the tracker so that it is tilted no more than the recommended 1 degree before measuring the level plane.



- **Set Time ...** button - allows setting the date and time in the MCU.
- **Set Distance ...** button - allows setting the distance to the target.
- **Set IP Address ...** button - If the user logged in with factory or administrative privileges, the IP address of the tracker can be changed to any valid IP address. Reboot the tracker after changing the address or mask.
-  **CompIT** icon button - activates an application that performs compensation and interim test procedures.
 - **SelfComp** button - performs self-calibration.
 - **Pointing** button - runs the pointing compensation and interim test procedure.
 - **Level** button - runs the level compensation and interim test procedure.
 - **ADM IT** button - runs the ADM compensation and interim test procedure.
 - **Backsights** button - checks backsight at any location the user chooses.

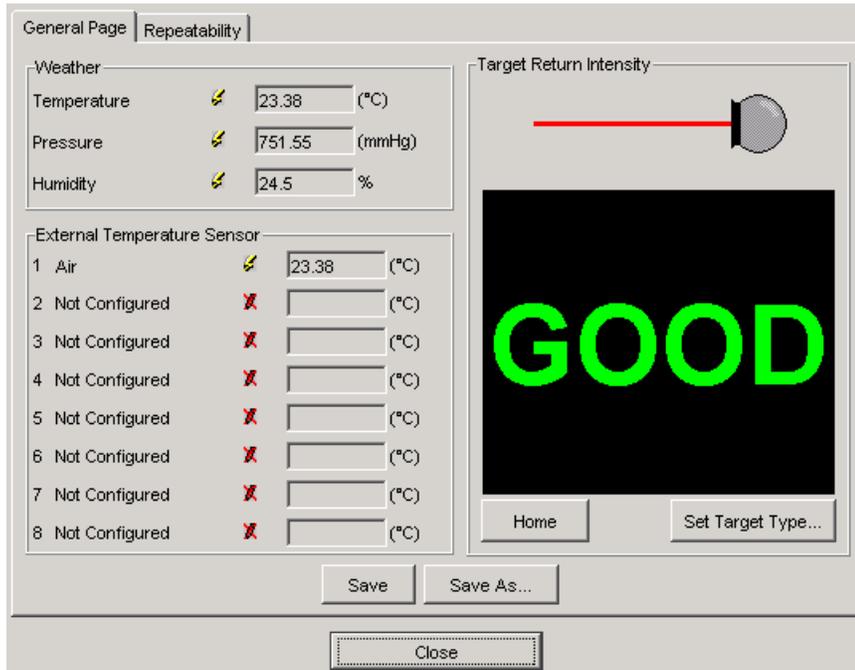
- **Customize** button - changes settings for compensation and interim test.
- **Settings...** button - controls miscellaneous settings.
- **Log** button - shows historical data from past compensation and interim test runs.
- **Exit** button - saves settings and closes the **CompIT** application.

-  **Closure** icon button - activates an application used to check closure at TMR location or against a specific point location. dR is the difference between the distance of TMR read from tracker and the distance measurement of the target if checking closure against TMR. If checking closure against a point, dR will show the difference between the distance measurement of a point and the distance value passed in by user.

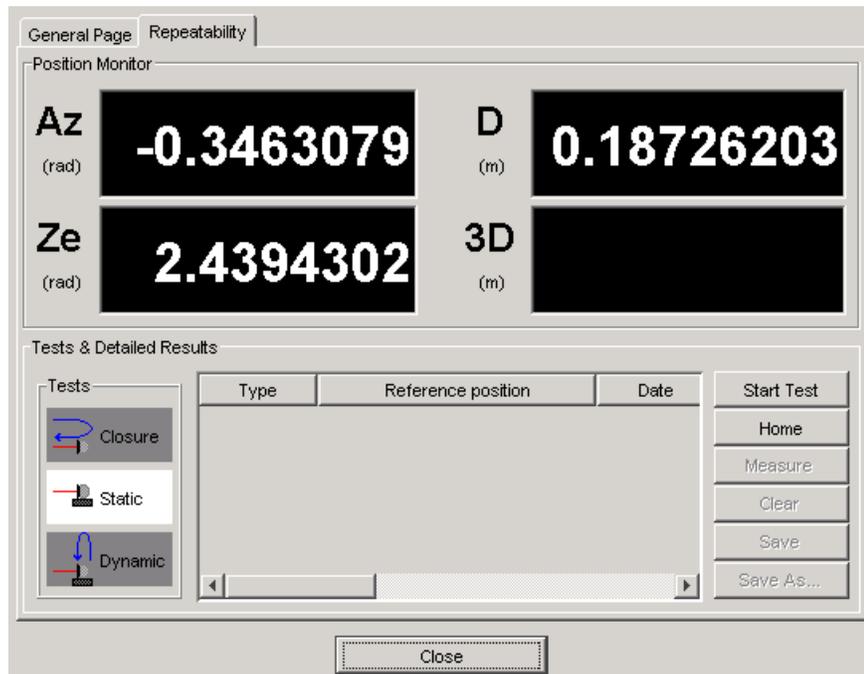


-  **Operational Checks** icon button - There are two tabs behind the Operational Checks button, "General Page" and "Repeatability".
 - **General Page** tab - The SMR return power, PWM value and the external temperature sensor information are displayed to the user. For a 4xxx tracker laser intensity checks (PSD values, dark level values) can also be performed. The General page looks as shown below. The meaning of the symbols that appear next to each of the weather and temperature sensor fields is as follows. The lightning bolt implies automatic (i.e. the value is read from the tracker), while a yellow pencil indicates that the value is set manually. A red pencil with a strike across implies that the status of the

information is an error status (for external temperature sensors, it implies that the sensors are not plugged in).

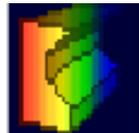


- **Repeatability** tab - lets the user test the static and dynamic repeatability of the tracker at various locations in the work volume. Also the closure checks at various points in the work volume can be checked through this page. The Repeatability page looks as shown below for a FARO tracker (the data is in red color indicating that the beam is broken).



- **Target Type** dropdown (a list of target ball descriptions) - specifies the target-ball that is in use.
- **Use Nest** checkbox - specifies whether a nest is connected to the target ball. If so, the following fields are applicable.
 - **Nest Offset** decimal field - specifies the length of the shaft on the nest tool.
 - **Nest Shank** decimal field - specifies the width of the shaft on the nest tool.
- **Scanning Options** group - controls behavior of the tracker during data collection.
 - **Samples per Point** integer field - specifies the number of laser samples that are averaged to yield the location of a single point. This setting applies to all **Data Collection Methods**.
 - **Collection Technique** group - specifies the conditions under which the Tracker collects each point.
 -  **Single Point** radio button - specifies that each press of the **Enter** key causes the collection of a single data point.
 -  **Time** radio button and **Interval** decimal field - The tracker collects a point at a periodic interval, given in fractions of a second.
 -  **Distance** radio button and **Interval** decimal field - The tracker collects a point when the target ball has moved a distance from the previous point.
 -  **Stabilized Laser** radio button - The tracker collects a point when the target ball has been almost motionless (not moved more than **Distance Tolerance**) during a specified **Stabilization Time** period.
 - **Distance Tolerance** decimal field - the distance element of "almost motionless".
 - **Stabilization Time(s)** decimal field - the time element of "almost motionless".

The Four Main Dialogs

			
Hardware Alignment Dialog	Features And Datums Dialog	Scanning Dialog	Real-Time 3D Comparison Dialog

HARDWARE ALIGNMENT DIALOG



- **Hardware Alignment** icon button - Alignment is the synchronization of the coordinate system of a reference object with the coordinate system of the tracker and test object, such that the coordinates of incoming data points can be correctly compared to points on the reference object. This button activates controls and indicators for the alignment process. Every scan must be performed with respect to a known spatial orientation (also called a "coordinate system", imprecisely called an "alignment"). The spatial orientation remains in effect on subsequent scans and the next time Geomagic Studio or Qualify is started.
 - **Display Units** group - see [Recurring Controls and Indicators](#) on page 2.
 - **Tracker Controls** group - see [Recurring Controls and Indicators](#) on page 2.

Define an orientation by one of the following methods.

-  **Last Test Model Alignment** button (selectable only when an object has been designated in the Model Manager as the Test object, or when a Feature/Datum object is present in the Model Manager) - specifies that the spatial orientation is based on the scheme of an existing object. In Geomagic *Qualify*, use the orientation of the currently designated Test object. If no Test object exists, use the spatial orientation of the Feature/Datum object. If this is Geomagic *Studio*, use the spatial orientation of the Feature/Datum object. (See [Example of "Last Test Model Alignment" with Geomagic Qualify](#) on page 27.)

-  **Load Transform** button - allows the user to select a .tfm or .xal file that defines a spatial orientation.
-  **Use CSYS** button - sets the spatial orientation (also called Coordinate SYStem) to the tracker default, where the laser "eye" is the origin.
-  **3-2-1 Alignment** button - Allows the user to establish spatial orientation by defining the position of the X, Y, and Z planes. See [3-2-1 Alignment](#) on page 13.
-  **"Move Device" Wizard** is a specialized procedure for aligning the multiple scans of an object that is larger than the reach of the tracker. It involves the probing of reference points, moving the object or the tracker itself, and probing of the same reference points to re-establish bearings. This section presents two buttons that are the entry point to the "Move Device" feature. See [Move Device](#) on page 20.
- **Transformation Matrix** - is a representation of the transformation that will be applied to all incoming data. This is not in human-readable form, but a change in the values confirms that an alignment technique has been successful.

```
[ 1.0000, 0.0000, 0.0000, 0.0000, ]
[ 0.0000, 1.0000, 0.0000, 0.0000, ]
[ 0.0000, 0.0000, 1.0000, 0.0000, ]
[ 0.0000, 0.0000, 0.0000, 1.0000, ]
```

- **Show Coords** button - presents the current XYZ coordinates of the tracker ball.

FEATURES AND DATUMS DIALOG

-  **Features And Datums** icon button - allows the creation of datums and features. For detailed procedures, see [Datum and Feature Creation](#) on page 16.
 - **Display Units** group - see [Recurring Controls and Indicators](#) on page 2.

- **Tracker Controls** group - see [Recurring Controls and Indicators](#) on page 2.
- **Object Name** field and **Reset** button - indicates the name of the object that will be stored in the Geomagic Model Manager. Names are of the form Scan 1, Scan 2, Scan 3, **Reset** restores the numeric part to 1.
- **Datum/Feature Type** group - specifies the kind of datum or feature that will be defined by use of the tracker ball. A datum or feature can be defined even if no scan data exists yet. If no scan data yet exists, an "empty" point object called Datums/Features is created in the Model Manager and the new datum and feature sub-objects are stored under it.

The datum types are: *plane*, *axis*, *point*, and *point target*.
The feature types are *circle*, *slot*, *rectangle*, and *line*.
For complete definitions, see the online help in the Geomagic product at Tools > Datums > Create Datums.
- **Input Method** group - (applicable with some of the Datum types) specifies the method by which you will use the probe to define the datum. A datum can be defined even if no scan data exists yet. If no scan data yet exists, an "empty" point object called Datums/Features is created in the Model Manager and the new datum and feature sub-objects are stored under it. The Input Methods are:
 - **Cylinder** (for the *axis datum*) - the user is instructed to click six or more points on the surface of the cylinder
 - **Cone** (for the *axis datum*) - the user is instructed to click six or more points on the surface of the cone
 - **Surface Point** (for the *point datum* and *point target datum*) - the user is instructed to probe three points to define a plane, then one point on the surface of that plane.
 - **Best Fit Centroid** (for the *point datum* and *point target datum*) - the user is instructed to select three or more points to define a plane. The defined point is at the best-fit center of this collection.
 - **Sphere** (for the *point datum*) - the user is instructed to select four or more points on the sphere surface. The defined point is at the center of this sphere.
 - **Single Point** (for the *point datum*) - the user is instructed to probe one point. The defined point is at the center of the probe.
 - **Show Instructions** checkbox - specifies whether the user interface presents a sentence explaining how to define the datum or feature given the Datum/Feature Type and the Method Input that is chosen.
 - **Instructions** (if requested by the **Show Instructions** checkbox) - presents a sentence explaining how to define the datum or feature given the Datum/Feature Type and the Method Input that is chosen.

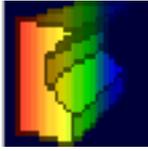
- **Show Information** checkbox - specifies whether the user interface presents the following details about the just-created datum or feature:
 - **Feature Information** group - The following fields are populated when appropriate for the datum or feature that is being detailed:
 - Feature - the name of this feature.
 - Radius - the radius of this feature, if applicable.
 - Length - the length of this feature, if applicable.
 - Width - the width of this feature, if applicable.
 - Center X - the center of this feature on the X axis.
 - Center Y - the center of this feature on the Y axis.
 - Center Z - the center of this feature on the Z axis.

SCANNING DIALOG



- **Scanning** icon button - Scanning is the process of collecting data points from a physical part.
 - **Display Units** group - see [Recurring Controls and Indicators](#) on page 2.
 - **Tracker Controls** group - see [Recurring Controls and Indicators](#) on page 2.
 - **Object Name** field and **Reset** button - indicates the name of the object that will be stored in the Geomagic Model Manager. Names are of the form Scan 1, Scan 2, Scan 3, **Reset** restores the numeric part to 1.
-  **Start Capture** icon button - begins the data capture process.
- **Data Options** - affect the appearance of collected data *after* the plugin is closed.
 - **Merge Scan Passes** checkbox - specifies whether to perform a point merge on all individual scan passes created during the current session of the plugin. The result will be one point object in the Model Manager.
 - **Sampling** checkbox - specifies whether to perform uniform sampling (a reduction of point density) on the resulting point cloud at the end of a scan pass.
 - **Spacing** - specifies the spacing parameter used by the Uniform Sample operation.

REAL-TIME 3D COMPARISON DIALOG



- **Real-Time 3D Comparison** icon button (visible in Geomagic Qualify, not Geomagic Studio) - Real-Time 3D Comparison is a scanning method during which the deviations between scanned points and a reference object are graphically illustrated in real time. This button activates the laser scanner in a mode that performs real-time 3D comparison of the scanned object to a reference object.
 - **Scanner Controls** group - is identical to the “**Scanner Controls** group” under the **Laser Capture** icon button, detailed on 11.
 - **Initialize** button - initializes the comparison process by creating an empty Result object in the Geomagic Model Manager.
-  **Start Compare** icon button - begins the data comparison process by passing control to the scanning device.
- **Objects** group -
 - **Reference** - indicates the name of the object in the Geomagic Model Manager that is designated as the Reference object.
 - **Scan** - indicates that the test object is the “New Object” that is being scanned.
- **Max. Deviation** field - indicates the greatest difference between corresponding reference and test points to allow in the test data. Points beyond this deviation are not included in the test data set.
- **Display** group - controls various aspects of the graphical display:
 - **Test Object** checkbox - specifies whether to display the raw test data points during the data capture process.
 - Color radio buttons - specifies the one attribute that will be colored in the Viewing Area:
 - **Color Reference** - color will appear on the reference object.
 - **Color Test Points** - color will appear on test points.
 - **Color Deviations** - color will appear on whisker lines that extend between test points and the reference object.
 - **Edit Spectrum** checkbox - allows modification of the color coding scheme of the deviation map in the Viewing Area.
- **Statistics** checkbox - specifies whether to include the following indicators:
 - **Maximum Distances** - indicates the maximum distance between any two corresponding points on the test and reference objects.
 - **Average Distances** - indicates the average deviation between corresponding points on the test and reference objects.
 - **Standard Deviation** - indicates the standard deviation between corresponding points on the test and reference objects.

The **OK** and **Cancel** buttons described here apply to all of [The Four Main Dialogs](#).

- **OK** button -
 - For the **Hardware Alignment** function - saves the currently configured alignment. The same alignment will be in effect the next time this plugin is started.
 - For the **Features And Datums** function - saves datums and features into the Model Manager in an “empty” point object called Datums/Features, or, if data was collected with the **Laser** function, as datum and feature sub-objects.
 - For the **Scanning** function - performs any incomplete shading and saves scanned data into the Model Manager.
 - For the **Real-Time 3D Comparison** function (Qualify only) - saves scanned data into the Model Manager as a point object named the same as the reference object, designates the point object as the test object, and creates a Result object in the Model Manager that indicates differences between the test and reference objects.
- **Cancel** button - cancels all un-OK'd processing in the **Hardware Alignment**, **Features And Datums**, **Scanning**, and **Real-Time 3D Comparison** functional areas.

3-2-1 Alignment

This is a sub-procedure referenced by the Alignment section under [Hardware Alignment Dialog](#) on page 8.

This describes “3-2-1 Alignment” -- how to specify an object's coordinate system by defining the position of three orthogonal planes. The origin of the object's coordinate system will be the point of intersection of the three planes.

Note: In the following procedure, **start** is equivalent to the **Enter** key on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the **Enter** key. **stop** is equivalent to the SpaceBar on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the SpaceBar.

Note: In the following procedure, a reference to the “probe” is the a reference to the tracking ball.

Note: This procedure is written for the case when **Collection Technique** is Single Point. When the collection technique is Time, Distance, or Stabilized Laser, data will be collected automatically and continuously in Steps 4 and 6. Automatic and continuous collection promotes scanning accuracy. Because

collection will be automatic, you will not need to press **start** a second or third time in Step 4, and you will not have to press **start** for a second time in Step 6. You will, however, press **stop** after three or more points are collected in Step 4, after two or more points are collected in Step 6, and after one or more points are collected in Step 8. You will know that a point has been collected automatically, and thus you will know when it's OK to press **stop**, when you see a flash of the red light on the tracker.



1. Click the large Alignment icon, then the  3-2-1 Alignment icon.

Recall that:

The plane orthogonal to the *X* axis is the *YZ* plane.

The plane orthogonal to the *Y* axis is the *XZ* plane.

The plane orthogonal to the *Z* axis is the *XY* plane.

The *letter* on each of the following icons represents the axis to which a plane is orthogonal. The *sign* on each icon represents a *side* of the plane.



2. If the purpose of this alignment is to synchronize the coordinates a test part with a CAD object, look at the CAD object and ascertain the position of the *X*, *Y*, and *Z* axes (the *YZ*, *XZ*, and *XY* planes) with respect to the CAD object. (Note that a CAD object's coordinate system always uses the right-hand rule).
3. Based on information ascertained in the previous step, perform *any two* of the following three actions:
 - Click the **+X** icon *or* the **-X** icon.
(+X means that "above" *YZ* is the positive side of *YZ*.
-X means that "above" *YZ* is the negative side of *YZ*.)
 - Click the **+Y** icon *or* the **-Y** icon.
(+Y means that "above" *XZ* is the positive side of *XZ*.
-Y means that "above" *XZ* is the negative side of *XZ*.)
 - Click the **+Z** icon *or* the **-Z** icon.
(+Z means that "above" *XY* is the positive side of *XY*.
-Z means that "above" *XY* is the negative side of *XY*.)

The first button you press is designated as **Plane 1**.

The second button you press is designated as **Plane 2**.

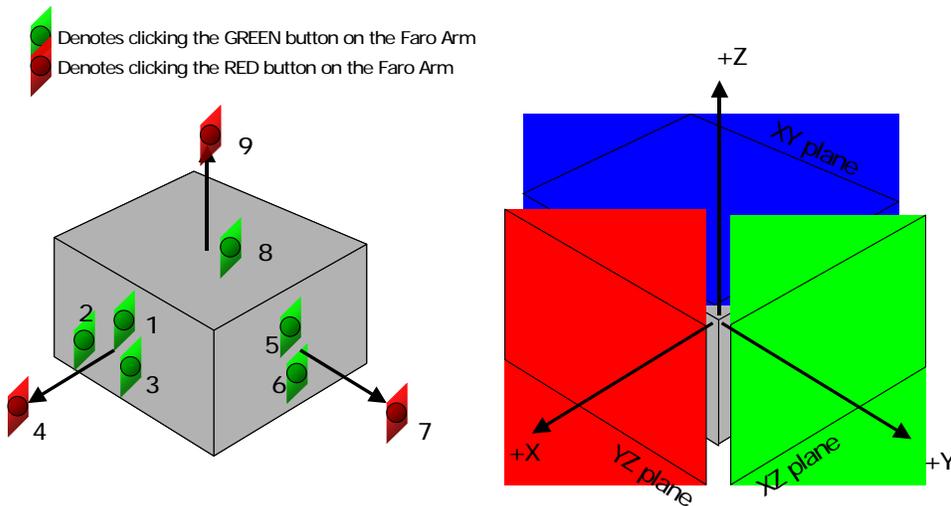
Adhering to the right-hand rule, the software automatically selects a third button (either the + or - variant of the plane you didn't pick), and designates it as **Plane 3**. The sign that the software picks is always the sign of **Plane 1** times the sign of **Plane 2**. (+ * + = +) ; (+ * - = -) ; (- * - = +)

4. On the physical object, position the probe on a point that lies in **Plane 1**, then click the **start** button. Position the probe on a second point that lies in **Plane 1**, then click the **start** button. Position the probe on a third point that lies in **Plane 1**, then click the **start** button.
You have just defined the position of **Plane 1**.
5. Pull the probe out and away from **Plane 1**, then click the **stop** button.
If **Plane 1** was designated in Step 3 by a + icon, you have established the + side of **Plane 1**.
If **Plane 1** was designated in Step 3 by a - icon, you have established the - side of **Plane 1**.
6. On the physical object, position the probe on a point that lies in **Plane 2**, then click the **start** button. Position the probe on a second point that lies in **Plane 2**, then click the **start** button. There is no need to select a third point on **Plane 2**.
You have just defined the position of **Plane 2**.
7. Pull the probe out and away from **Plane 2**, then click the **stop** button.
If **Plane 2** was designated in Step 3 by a + icon, you have established the + side of **Plane 2**.
If **Plane 2** was designated in Step 3 by a - icon, you have established the - side of **Plane 2**.
8. On the physical object, position the probe on a point that lies in **Plane 3**, then click the **start** button. There is no need to select a second or third point on **Plane 3**.
9. Pull the probe out and away from **Plane 3**, then click the **stop** button.
Based on the right-hand rule, the software already knew the + and - side of **Plane 3**, but this was necessary to complete the process.
10. The current coordinates of the probe appear in a coordinate indicator box. Move the indicator box by dragging it to any location of the screen, or click the **stop** button to close the indicator. Click **Show Coordinates** to re-display the coordinate indicator box.
11. Hover the probe above the YZ plane and verify that the X coordinate in the indicator is appropriately positive or negative.
Hover the probe above the XZ plane and verify that the Y coordinate in the indicator is appropriately positive or negative.
Hover the probe above the XY plane and verify that the Z coordinate in the indicator is appropriately positive or negative.
12. Coordinate system definition is complete. To un-do the coordinate system, click **Reset** and go to Step 2.

Detailed Example

To specify the YZ plane (with a total of four points), then the XZ plane (with a total of three points), then the XY plane (with two points): Designate Plane 1

by clicking the **+X** icon, then designate Plane 2 by clicking the **+Y** icon. The software automatically designates Plane 3 as **+Z**. Make nine clicks, some **start** and some **stop**, according to the illustration below.



Datum and Feature Creation

Datums and features can be created by use of this FARO scanner plugin software, *or* by the use of tools that are native to the Geomagic products. In theory, datums or features can be identified more precisely by touching the original object and by use of the FARO plugin. Depending on the accuracy of the scan and the user's experience, however, it may be advantageous to create datums and features using the native Geomagic tools. To create datums and features using the FARO scanner software:

Note: This procedure is written for the case when **Collection Technique** is **Single Point**.

1. Click the  **Features And Datums** icon.
2. Verify that the **Target Type** is set correctly.
3. Click the icon of a datum type or feature type to be created.
4. Check (or uncheck) the **Show Instructions** box for guidance on how to create each datum or feature type. Instructions also appear below. A summary of the instructions is:
 - Click the **start** button to define points.
 - Click the **stop** button to define offset directions and go on to the next step.
 - When you have finished creating all datums or features of a given type, click the **stop** button again.

Note: In the following procedure, **start** is equivalent to the **Enter** key on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the **Enter** key. **stop** is equivalent to the SpaceBar on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the SpaceBar.

Note: When defining several features on the same plane, you do not need to define that plane for each feature. To recall the last defined plane, click on the plane with a single **start** click followed by a **stop** click.

Creating a DATUM PLANE

1. Click the datum **Plane** icon. 
2. Define a plane by clicking **start** on 3 or more points on the surface of the object.
3. Define the offset direction by clicking **stop** on a single point above the plane.
4. Repeat steps 2 and 3 to define other planes, or click **stop** to return to the dialog.

Creating a DATUM AXIS Using CYLINDER Method

1. Click the datum **Axis** icon. 
2. Click the **Cylinder** method icon. 
3. Define a cylinder by clicking **start** on 6 or more points on the surface of the object.
4. Define the axial direction by clicking **stop** on a single point inside or outside the cylinder.
5. Repeat steps 3 and 4 to define other axes, or click **stop** to return to the dialog.

Creating a DATUM AXIS Using CONE method:

1. Click the datum **Axis** icon. 
2. Click the **Cone** method icon. 
3. Define a cone by clicking **start** on 6 or more points on the surface of the object.
4. Define the axial direction by clicking **stop** on a single point inside or outside the cone.
5. Repeat steps 3 and 4 to define other axes, or click **stop** to return to the dialog.

Creating a DATUM POINT Using SPHERE Method

1. Click the datum **Point** icon. 
2. Click the **Sphere** method icon. 
3. Define a sphere by clicking **start** on 4 or more points on the surface of the object.
4. Click **stop** on a single point inside or outside of the sphere.
5. Repeat steps 3 and 4 to define other points, or click **stop** to return to the dialog.

Creating a DATUM POINT or DATUM POINT TARGET Using CENTROID Method

1. Click the Datum **Point** icon.  or the Datum **Point Target** icon .
2. Click the **Centroid** method icon. 
3. Click **start** on 3 or more close points on the surface of the object.
4. Define the offset direction by clicking **stop** on a single point above the group of points.
5. Repeat steps 3 and 4 to define other points, or click **stop** to return to the dialog.

Creating a DATUM POINT or DATUM POINT TARGET Using SURFACE POINT Method

1. Click the Datum **Point** icon.  or the Datum **Point Target** icon .
2. Click the **Surface** method icon.
3. Define a plane by clicking **start** on 3 or more points on the surface of the object.
4. Define the offset direction by clicking **stop** on a single point above the plane.
5. Click **start** on a single point on the surface.
6. Click **stop** to complete the process.
7. Repeat steps 3 through 6 to define other points, or click **stop** to return to the dialog.

Creating a DATUM POINT Using SINGLE POINT Method

1. Click the Datum **Point** icon. 
2. Click the **Single Point** method icon.
3. Click **start** on a single point.
4. Click **stop** to complete the process.
5. Repeat steps 3 and 4 to define other points, or click **stop** to return to the dialog.

Creating a FEATURE CIRCLE

1. Click the feature **Circle** icon. 
2. Define a plane by clicking **start** on 3 or more points on the surface of the object.
3. Define the offset direction by clicking **stop** on a single point above the plane.
4. Click **start** on 3 or more points on the cylindrical wall perpendicular to the plane.
5. Define the offset direction by clicking **stop** on a single point inside the circle (to make a hole) or outside the circle (to make a protrusion).
6. Repeat steps 2 through 5 to define other circles, or click **stop** to return to the dialog.

Creating a FEATURE SLOT

1. Click the feature **Slot** icon. 
2. Define a plane by clicking **start** on 3 or more points on the surface of the object using the **start** button.
3. Define the offset direction by clicking **stop** on a single point above the plane.
4. Click **start** on 3 or more points on the cylindrical wall of one end of the slot perpendicular to the plane.
5. Define the offset direction by clicking **stop** on a single point inside the slot (to make a hole) or outside the slot (to make a protrusion).
6. Repeat steps 4 and 5 to define the opposite end of the slot.
7. Repeat steps 2 through 6 to define other slots, or click **stop** to return to the dialog.

Creating a FEATURE RECTANGLE

1. Click the feature **Rectangle** icon. 

2. Define a plane by clicking **start** on 3 or more points on the surface of the object using the **start** button.
3. Define the offset direction by clicking **stop** on a single point above the plane.
4. Click **start** on 2 or more points on one of the rectangular walls perpendicular to the plane.
5. Define the offset direction by clicking **stop** on a single point away from the rectangle wall.
6. Repeat steps 4 and 5 for the remaining three walls, working in a counter-clockwise order.
7. Repeat steps 2 through 6 to define other rectangles, or click **stop** to return to the dialog.

Creating a FEATURE LINE

1. Click the feature **Line** icon (for the intersection of two planes) 
2. Click **start** on 3 or more points on the surface of the object.
3. Define the offset direction by clicking **stop** on a single point above the plane.
4. Click **start** on 2 or more points on a rectangular wall perpendicular to the plane.
5. Define the offset direction by clicking **stop** on a single point away from the wall.
6. Repeat steps 2 through 5 to define other lines, or click **stop** to return to the dialog.



Move Device

“Move Device” is a specialized procedure for aligning the multiple scans of objects that must be scanned from more than one point of view of the tracker. It involves the collection of reference points, moving the object or the tracker itself, and re-collection of the same reference points to re-establish bearings.

The following summary describes a process of scanning, moving the tracker because the object is large, and continuing with the scan.

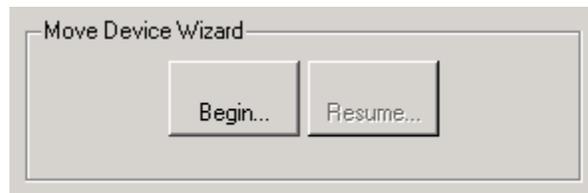
Note: *In the following procedures, a reference to the “probe” is the a reference to the tracking ball.*

1. Scan part of an object.
2. If “Move Device” is not necessary, save the scan by pressing **OK**.
If “Move Device” is necessary (because a physical constraint did not allow a complete scan), press the **Alignment** icon button.

3. Press the **Move Device Wizard** button.
4. In the **Move Device Wizard**, click **Begin**.
5. On the Reference Point Collection Panel, use the probe to identify four to seven reference points on the physical object, each by one of four methods. On paper, write the name of each point, its location and identification method. Then click **Next**.
6. In response to a prompt, move the physical part or the tracker itself, then click **OK**.
7. On the Target Point Collection Panel, use the probe to re-identify the named reference points. As a result, the software can recalculate the orientation of the tracker with respect to the physical object. The next scan will be a continuation of the previous scan. Press **Next**.
8. On the Correspondence Report Panel, the software displays the precision to which it was able to associate the target points to the reference points. Eliminate any associations that are unacceptable, then press **Done** to specify that reference points and target points are sufficiently "connected." Go to Step **1** to scan more of the same physical object.

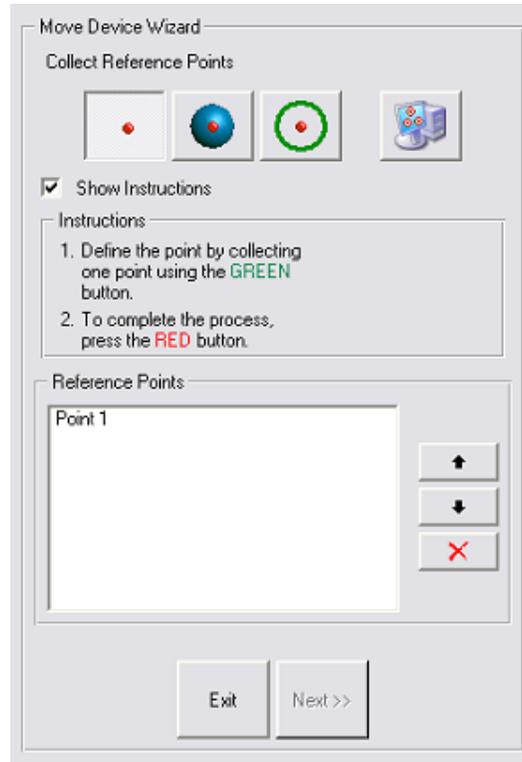
The detailed process is:

1. Press the **Scanning** icon button, then **Start Scan**. Scan as much of the physical object as space or the length of the arm allows.
2. If "Move Device" is not necessary, save the scan by pressing **OK**.
If "Move Device" is necessary (because a physical constraint prevented a complete scan), press the **Alignment** icon button.
3. Press the **Move Device Wizard** button. The Move Device Wizard group appears on the dialog.
4. This is the "Move Device" Home Panel. The buttons are:
 - **Begin** button - begins a new "Move Device" process. Go to the Reference Point Collection Panel in Step **5**.
 - **Resume** button - returns to the panel on which you previously pressed **Exit** and saved the state of the "Move Device" process: the Reference Point Collection Panel in Step **5**, the Target Point Collection Panel in Step **7**, or the Correspondence Report Panel in Step **8**.



"Move Device" Home Panel

5. On the Reference Point Collection Panel, use the probe to identify four to eight reference points on the physical object, each by one of three methods described below, *or* click **Previous Targets** to re-use the set of targets from a previous “move”. On paper, write the name of each point, its location, and collection method. Then click **Next**.



Reference Point Collection Panel

- Reference Point Collection Methods:
 -  **Single Point** - You will touch the probe ball to a single point on the physical object. For precision, the single point should be in a tight corner such as an inverted cone or hole whose diameter is smaller than the probe ball.
 -  **Sphere Center** - You will touch the surface of a sphere, either on the inside or outside, then a point in space to specify inside or outside. The defined point will be the center of the sphere.
 -  **Circle Center** - You will touch three or more points to define a plane, then several points on the inside or outside of a cylinder. The defined reference point will be the intersection of the plane and the axis of the cylinder.

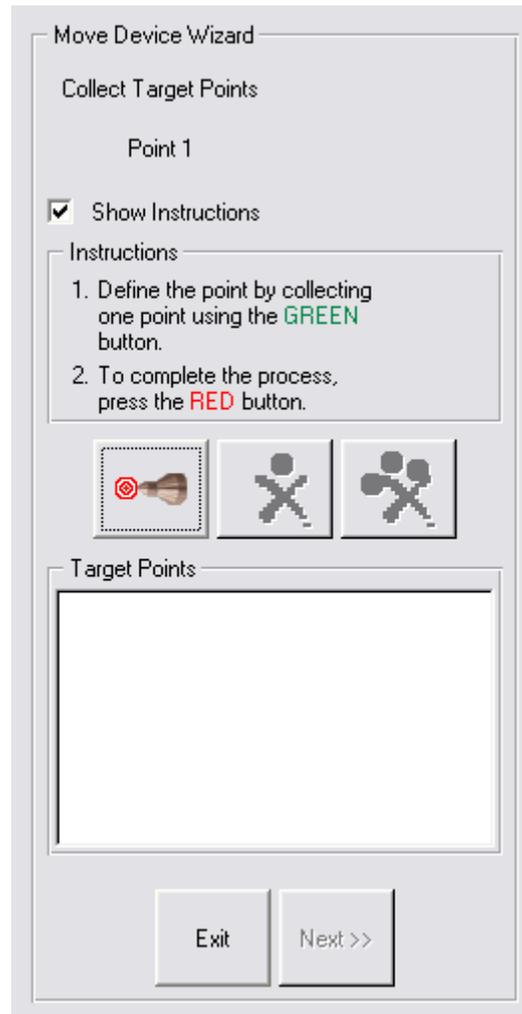
-  **Previous Targets** - You will replicate the same set of target points that were used in the previous “move”. Use this method when the same points will still be within reach of the probe after the tracker or part is moved.
 - **Show Instructions** checkbox - specifies whether to display instructions on how to collect center points.
 - **Instructions** - the instructions, if requested.
 - **Reference Points** section
 - **List of Points** - lists the collected reference points by name. Each name is based on the method by which it was collected, such as Single Point 1, Circle Center 1, Circle Center 2, and Sphere Center 1.
 - **Up** and **Down** button - changes the order in which the reference points must be *re*-collected on the Target Point Collection Panel at step 7.
 - **Delete** button - deletes the highlighted reference point from the list.
 - **Exit** button - stops the reference point collection process, and returns to the “Move Device” Home Panel in Step 4. The prompt is “Save Current State?” The choices are:
 - **Yes** - saves the state of the “Move Device” process (in an un-named temporary location), returns to the “Move Device” Home Panel. The **Resume** button on the “Move Device” Home Panel will bring you back to this Reference Point Collection panel.
 - **No** - returns to the “Move Device” Home Panel without saving the state of this process. On the “Move Device” Home Panel, the **Resume** button will be inactive.
 - **Cancel** - returns to this Reference Point Collection panel, as if **Exit** had not been pressed.
 - **Next** button - Reference points have been collected, so the scanning device or the part can be moved. You will be prompted to move the device or the test part. Go to Step 6.
6. This is the Prompt to Move Device or Part. Move the tracker or the physical part, click **OK**, then go to the Target Point Collection Panel in Step 7.



Prompt to Move Device or Part

7. On the Target Point Collection Panel, use the probe to re-identify the named reference points. When the wizard prompts for the re-identification of a particular reference point, use the written notes to re-create the

reference point using the same method by which it was originally identified.



Target Point Collection Panel

The controls are:

- **Show Instructions** - specifies whether to display the **Instructions** box
- **Instructions** box - instructs the user how to collect the reference point.

-  **Define Targets** button - press this to re-start the identification of targets (to re-start identifying the points that were previously identified as reference points). When this dialog first pops up, it is already in target collection mode, so use this button to *re*-start the process if you have pressed the **stop** button.
 -  **Re-Define Last Target** icon button - after pressing the **stop** button to stop collection, press this to delete the most recently collected target point and to automatically re-start the identification of targets.
 -  **Clear All Targets** icon button - after pressing the **stop** button to stop collection, press this to delete all collected target points. To re-start collection of target points, you must press the **Define Targets** button.
 - **Exit** button - stops the target point collection process, and returns to the "Move Device" Home Panel in Step 4. The prompt is "Save Current State?" The choices are:
 - **Yes** - saves the state of the "Move Device" process (in an un-named temporary location), returns to the "Move Device" Home Panel. The **Resume** button on the "Move Device" Home Panel will bring you back to this Target Point Collection panel.
 - **No** - returns to the "Move Device" Home Panel without saving the state of this process. On the "Move Device" Home Panel, the **Resume** button will be inactive.
 - **Cancel** - returns to this Target Point Collection panel, as if **Exit** had not been pressed.
 - **Next** button - Press this when all reference points have been re-identified by use of the probe. Go to the Correspondence Report Panel in Step 8.
8. The Correspondence Report Panel displays the precision to which the software was able to associate the target points to the reference points. Eliminate any associations that are unacceptable, then press **Done** to

specify that reference points and target points are sufficiently “connected.” Go to Step **1** to scan more of the same physical object.



Correspondence Report Panel

The controls and indicators are:

- **Best Fit Result** list - a list of the associations of target points to reference points.
- **Delete** button (applicable only when there are four or more point pairs in the **Best Fit Result** list) - allows any target/reference pair to be deleted from the result list. When a pair is deleted, the data is lost and the remaining pairs are immediately re-evaluated.
- **Datum Deviations** list - displays the precision to which each of the reference/target pairs was associated. A pair with a large deviation was not scanned precisely enough, and may be hindering the best-fit more than it is helping, and is therefore a candidate for deletion.
- **Done** button - Press this to accept this set of reference points and associated target points (and modify the cumulative transformation matrix) and return to the FARO Scanning panel (in Step **1**) for continuation of the scan process.

Detailed Examples

This section contains examples that are referenced earlier in this document.

EXAMPLE OF “LAST TEST MODEL ALIGNMENT” WITH GEOMAGIC QUALIFY

This example demonstrates the use of Last Test Model Alignment in a CAI process with Geomagic Qualify. This assumes a working knowledge of Geomagic Qualify.

This procedure has two variants: the “Feature And Datum Technique” and the “Scanning Technique”.

1. Load a CAD object into the Model Manager and designate it as the reference object.
2. (Only for the *Feature And Datum Technique*) use **Tools > Datums > Create Datums** or **Tools > Features > Create Features** to create datums and features on the reference object.
3. Start the tracker plugin.
4. Perform one of the following:
 - *Feature And Datum Technique* - Probe the corresponding datums and features on a test object that is resting in a test fixture (without laser scanning the test object). The datums and features become sub-objects of a special special “blank” test object named “Features/ Datums” that records the position of the datums and features with respect to the test fixture.
 - *Scanning Technique* - Scan a portion of the object, at least enough points that it could be aligned to the reference object using the best-fit alignment function of Geomagic Qualify.
5. Exit the plugin by clicking the **OK** button.
 - *Feature And Datum Technique* - In the Model Manager, note the existence of the CAD object and the new test object called “Features/ Datums”. Note the existence of feature and datum sub-objects under the Features/Datums object.
 - *Scanning Technique* - Continue to the next step.
6. Perform one of the following:
 - *Feature And Datum Technique* - Use **Tools > Alignment > Datum/ Features Alignment** on the test and reference objects (which aligns the reference object with the special test object by aligning their common datums and features).
 - *Scanning Technique* - Use **Tools > Alignment > Best Fit Alignment** on the test and reference objects (which aligns the reference object with the test object by detecting the similarity of their surfaces).

The side effect of this process is that it creates an internal *transformation matrix*, which is a mapping of the spatial difference between the reference object and the test object.
7. Place a new test part in the test fixture.

8. Start the tracker plugin again, and click the **Hardware Alignment** icon.
9. Click the  **Use Last Test Alignment** button. This is a special alignment technique that uses the most recent transformation matrix to specify the spatial difference between the reference object and the test object. The net result is that scan data from the test part will be correctly aligned with the reference object. Next, you will scan the test part.
10. Click the large **Scanning** icon. Begin scanning. Scan data appears on the screen in alignment with the CAD reference object.
11. Exit the plugin by clicking the **OK** button. In the Model Manager, notice that the newly created scan object is now the test object.
12. To prepare to scan another test object, go to step 8. Every new test object will be aligned correctly.

EXAMPLE OF SCANNING

Note: This procedure is written for the case when **Collection Technique** is **Single Point**.

Note: In the following procedure, **start** is equivalent to the **Enter** key on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the **Enter** key. **stop** is equivalent to the **SpaceBar** on the keyboard or any key that has been programmed on a FARO Remote Controller to represent the **SpaceBar**.



1. Click the **Scanning** icon.
2. In the **Tracker Controls** group, specify the type of tracker bball by picking a **Target Type**.
3. In the **Scanning Options** group, set the **Collection Technique** to **Single Point**.
4. To perform a scan and thus create an object in the Geomagic Model Manager:
 - Click the **Start Capture** icon  .
 - Click the **start** button.
 - Slide the tracker ball on the surface(s) of the object. Depending on the **Collection Technique**, a point will be collected when you press **Enter**, when the ball is stable, when the ball has traveled a distance, or at regular time intervals.
 - Click the **stop** button to end scanning.

EXAMPLE OF REAL-TIME 3D COMPARISON

This section describes the concepts of computer-aided inspection with Geomagic Qualify and any Geomagic scanner plugin.

1. The first step of a CAI process is to align the coordinate system of a reference object to the tracker so that collected data can be compared to the reference object in the same coordinate system. Use one of the alignment methods summarized at **Hardware Alignment** on page 8.
2. Next, designate a CAD object as the reference object in the Geomagic Model Manager.
3. Click the **Real-Time 3D Comparison** icon button.
4. Click the **Initialize** button. The **Start Capture** icon button becomes active.
5. Click the **Start Capture** icon button.
6. Use the the procedure under [Example of Scanning](#) on page 28.
7. If the physical part is larger than the reach of the tracker, go to [Move Device](#) on page 20, then return to this step.
8. If more scanning is necessary, go to Step 5.
9. When scanning is complete, click **OK** on the dialog. Scanned data is saved into the Geomagic Model Manager, the saved object is automatically designated as the test object in the Model Manager, and the comparison results are saved to a Result object in the Model Manager.

