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INTERACTIVE USER GUIDE

3D Scanning for Geomagic Studio and Geomagic Qualify

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1 INTRODUCTION TO SCANNING

1.1 Guide Description

This Guide discusses how to use scanning hardware, how to create a scanning plan, and provides tips for acquiring consistently good scans with the major scanner types. Hard probing is also briefly discussed (see page 21). While some scanners are used as examples, no specific vendor recommendations are made.

Throughout this Guide, you will find live links (light blue text) to resources on the Geomagic web site. To use these links, this Guide is best viewed from a computer with Internet access.

1.2 Scan Quality

Scanning captures an accurate representation of a physical object. Scan quality can be influenced by:

- Scanner calibration,
- Experience of the person performing the scan,
- Environmental conditions like lighting and vibration,
- Stability of the scanner and the object being scanned,
- Shape and size of the object.

1.3 Scanner Types

The four scanner types discussed are handheld scanners, arm-mounted scanners, stationary scanners, and CMM-mounted scanners.

Tip: For a list of compatible scanner output types and available plugins for Geomagic software, refer to the Geomagic Support web pages.

1.3.1 Handheld Scanners

Handheld scanners, like the Creaform Handyscan 3D™ and Z Corporation ZScanner™, are noted for their small size and maneuverability. These scanners establish spatial reference by using reflective targets applied to the object. Both the object and the scanner can be moved during the data capture process without the scanner losing track of the object's location.



Figure 1. Example handheld scanner: Creaform Handyscan 3D EXAscan.

1.3.2 Arm-mounted Scanners

Arm-mounted scanners, like the ones produced by FARO, Perceptron, Laser Design, and Kreon, are some of the more common scanners.

Instead of self-orienting like the handheld models, arm-mounted scanners establish the location of the object in relationship to the arm's base. Because of this, the base of the arm must be mounted on stable surfaces with minimal environmental interference.

Some arm-mounted scanners also have a hard probe. Hard probing is ideal for defining points which are difficult to capture with a scanner: sharp edges, the interior of a cylinder, etc. Hard probing is discussed on page 21.

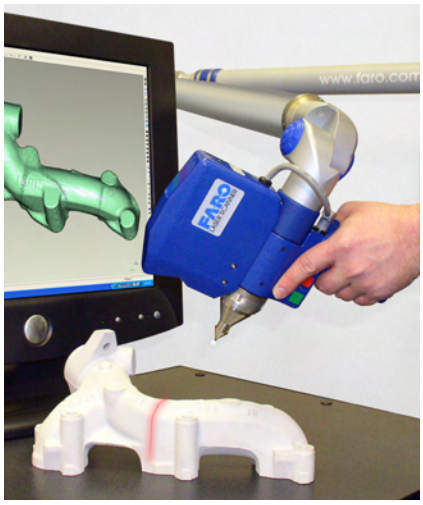


Figure 2. Example arm-mounted scanner: FARO Laser ScanArm.

1.3.3 Stationary Scanners

Stationary scanners can come in almost any size: from the desktop NextEngine scanner to the larger GOM scanners. Stationary scanners can be mounted on a tripod, jig, or robotic arm; or placed on a flat surface. These scanners may use a laser or whitelight to capture data.



Figure 3. Example stationary scanner: Konica-Minolta VIVID scanner.

1.3.4 CMM-mounted Scanners

A CMM-mounted scanner is mounted on a coordinate measurement machine (CMM) and have a probe designed to determine coordinates of points on a work piece. The scanner itself moves while the object stays stationary. Because the scanning pattern is programmed into the CMM's software, data overlap is minimized.

Some, but not all, of the scanning suggestions in this guide are applicable to CMM-mounted scanners.



Figure 4. Example CMM-mounted scanner: LDI RPS 150 Scanner.

2 PREPARING TO SCAN

Preparing to scan involves four steps:

- Determining the intended use of the scan,
- Creating a scanning plan,
- Preparing the part, and
- Preparing the scanner.

Tip: Turn the scanner on 20 to 30 minutes before you intend to use it so the electronics can reach a stable temperature.

2.1 Determining the Intended Use of the Scan

Understanding how the scan data will be used helps determine mechanics of the scanning process (i.e., equipment choice and part positioning during the scan) and which features, if any, should be hard probed. Knowing who will be using the scanned image and what they will need captured will save work—and potential rescanning. Not knowing how the scan will be used is like driving a car without knowing the destination.

2.1.1 Whether to Generate Ordered or Unordered Data

Ordered data is a point cloud of consistent density whose points exist in orderly rows and/or columns. **Unordered data** is a point cloud of variable density that has a point at every location that the scanner detected solid material.

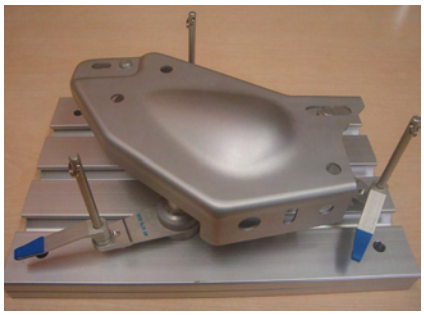
All scanners are capable of outputting ordered data, and ordered data is suitable for most purposes. Some arm-based scanners, also known as line scanners, offer a choice of ordered or unordered data. The uniform density of ordered data lends itself to consistently sized polygons, and therefore can be well suited for Geomagic Studio. The "completeness" of unordered data cam allow a more precise representation of an object, and therefore may lend itself to precise part inspection in Geomagic Qualify.

2.1.2 Scanning Examples

For the inspection of a manufactured part, it is not always necessary to collect data from the entire surface. The goal may be to focus on key features that are subject to manufacturing error. For reverse engineering, however, capturing data from the entire surface is the goal (so that the entire object can be reproduced).

2.1.2.1 Example: Scanning for Geomagic Qualify with an Arm-mounted Scanner

Geomagic Qualify is primarily used for comparing an as-built part with a design. The sheet metal part (Figure 5) will be scanned so it can be compared to the CAD drawing (the design model). For quality analysis, the overall quality and consistency of scanning becomes important because the data will be used to study minute differences between the CAD model and the scanned part. Only areas with inspection interests would need to be captured. These areas should be captured with the highest level of detail. In addition to scanning, you may want to hard probe specific features because hard probed data can be more accurate than scanned data. In Figure 5, right, the hard-probed features are flagged with orange callouts.



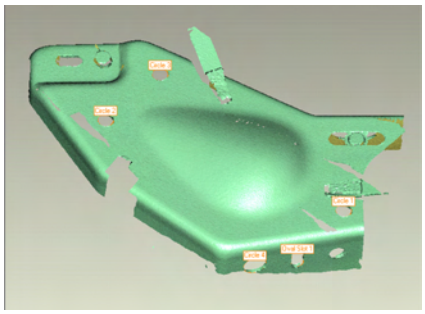
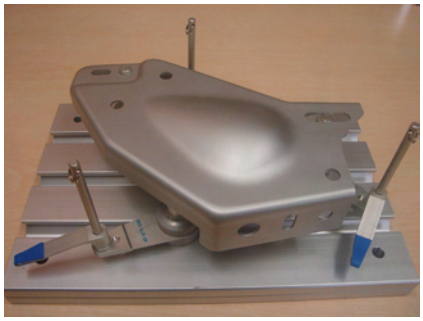


Figure 5. An example part mounted for scanning (left) and the same part as scanned (right).

2.1.2.2 Example: Scanning for Geomagic Studio

Uses of Geomagic Studio include scanning an object for reverse engineering or for duplicating a part with a 3D printer. Reverse engineering is the creation of an idealized representation (like a CAD file, Figure 6, right) from a physical part, and typically requires that data be collected from the entire surface of the part.



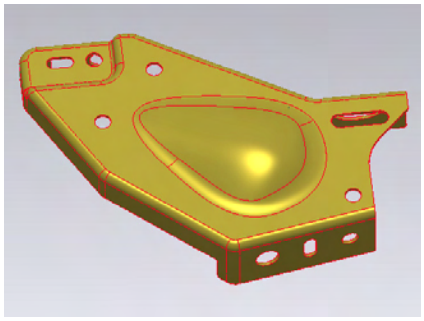


Figure 6. An example sheet metal part (left) and its conversion to a CAD rendering (right) by Geomagic Studio.

2.2 Creating a Scanning Plan

Once you have identified the most important features to capture, then you can plan how to position the object, whether to use reference targets (if necessary), and how to deal with environmental conditions.

Tip: Use test scans to provide immediate feedback on how the resulting data will appear.

2.2.1 Positioning the Scanner and Object

There are three points to keep in mind when determining the best position for the scanner to capture an object:

- The scanner should be perpendicular to the surface being scanned,
- The scanner can capture only what is in its line of sight, and
- The volume the scanner can capture.

2.2.1.1 Preferred Scanner Orientation to the Scanned Object

Holding the scanner perpendicular to the surface being scanned optimizes the amount of light reflected back to the scanner. When you are determining how to position the scanner and object, place the scanner so it can capture as much of the object as possible while remaining perpendicular to the object's surface.

2.2.1.2 Line of Sight

The scanner can capture only what is in its line of sight. If you are scanning a propeller, for example, it will need to be placed so that the scanner can capture the curve of the blades and in between the blades.

If the part needs to be held at a particular location, you must decide the best method for holding the part while scanning. Any solution should allow you to fully capture the part in one setup to minimize the amount of repositioning.

2.2.1.3 Scanner Volume and Scan Path

Scanners have an amount of space (or volume) they can read in a scan. A part that is larger than the scanner's scanning volume may require several passes to capture all sides. Geomagic software plugins for the arm-mounted FARO and Perceptron scanners have a "leap-frogging" capability so that large objects can be captured with a set of smaller volume scans. Each scan overlaps slightly with the previous section. As long as three common targets exist in each overlap section, the scanner can register sections.

Arm-mounted scanners are limited by the reach of the arm and can be bulky, so using one for an extended duration is tiring. When you set up the position of the object, make sure you consider the ergonomics so you aren't scanning in an awkward position.

While handheld scanners do not have the same placement limitations, ergonomics should still be considered. Devise a scanning path from start to finish before you begin.

How Targets Appear in the Scanned Model

Scanners typically capture targets as a raised section (shown by the blue circles). Geomagic software has commands for flattening or cutting and filling these raised sections. Since it is easier to fill holes in flat surfaces than on edges or freeform surfaces, typically targets are placed on flat surfaces.

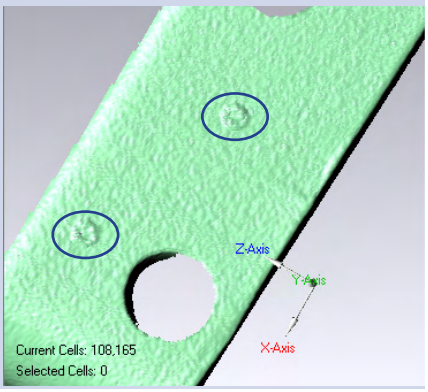


Figure 7. A doorstop scanned with targets applied.

2.2.2 Examining Reference Target Placement

A reference target is a sticker or sphere that serves as a point of reference so it can track it's position relative to the part and which also helps register multiple scan passes into one composite part. Reference targets are generally used with stationary and handheld scanners. Arm-mounted scanners determine their position based on the location of the base, and therefore do not require targets.

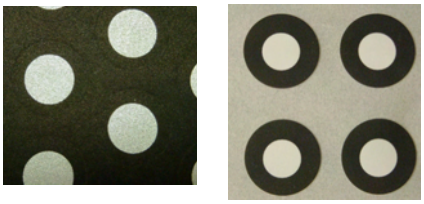


Figure 8. Reflective (left) and non-reflective (right) reference targets.

As you examine the part to be scanned, consider how the object will be positioned in front of the scanner. A scanner generally requires three to five reference targets within each scan so it can register multiple scans together. These targets need to be placed on the part itself, the work area (i.e., turntable), or both. The question to be answered is: what placement offers the best coverage with the fewest reference targets?

Guidelines for placing reference targets are discussed on page 12.

2.2.3 Optimizing for Environmental Factors

The scanning work area should be clean and stable. In the same way that minor vibration blurs a photograph, a scan can be affected by vibration from neighboring machinery.

It is important for arm-mounted scanners to have the arm base securely mounted. Neither the surface nor the arm base should flex when the arm is extended.

In general, diffused room lighting is better than direct light. A direct light source can create a reflection on the object which can scatter the scanner's light source. Reflective surfaces should be treated using developer (see page 12).

The lighting in the room should be the same when calibrating and when scanning. Some adverse lighting conditions can be corrected automatically by the scanner's software. Check the manufacturer's documentation for specific recommendations.

2.3 Preparing the Part

There are two steps for preparing the part:

- Placing reference targets on the part surface according to the manufacturer's recommendations (if necessary) and
- Treating the part surface to create a matte appearance (if necessary).

2.3.1 Placing Reference Targets

The scanner model dictates the target type, target size, and placement. Targets may be reflective or non-reflective stickers or spherical (white or gray balls affixed to the part or workspace). Target placement must be fine-tuned based upon the object being scanned and its proximity to the scanner.

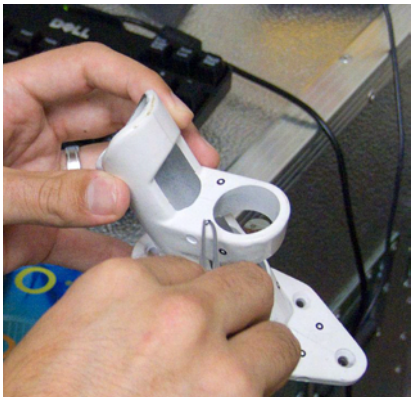


Figure 9. Placing targets on a flagpole bracket.

Targets can be placed on large objects to help the registration of multiple scan passes. Typically, several targets are placed in the overlapping scan regions so that the scanner can determine the scans' registration.

Targets can also be placed on the surface of a turntable so that the scanner can track the movement of the turntable. In this case, targets need not be placed on the object itself as long as the object remains stationary with respect to the turntable.

In some cases, both the object and the turntable might require targets. If you are scanning an object that is larger than the field of view of the scanner, then the targets on the table would track the rotation, while targets on the object assist with registering multiple scans.

2.3.1.1 General Guidelines for Placing Targets

Every scanner has a different resolution, field of view, and specific target type. The best way to learn optimal target placement is through experience and experimentation (and by reading the manufacturer's documentation).

Whether placing reflective or non-reflective targets, follow these guidelines:

- Place targets on an object in random locations to improve the capture. Using a grid-like pattern could potentially confuse the scanner.
- Make sure the targets do not cover important features.
- Apply targets before using developer or other surface treatment to give the targets a cleaner surface upon which to stick (unless you are using a permanent coating like spray paint).
- Place targets on flat surfaces when possible. Scanners do not capture sharp curves or edges cleanly, so targets on these areas may not be recognized properly.

Tip: Placing targets on the mount or jig holding the part to be scanned can minimize the number of targets required on the part itself.

2.3.1.2 Examples

The turntable in Figure 10 had targets applied to it but the bracket does not. If the bracket is moved, the scanner will not be able to register the scans.

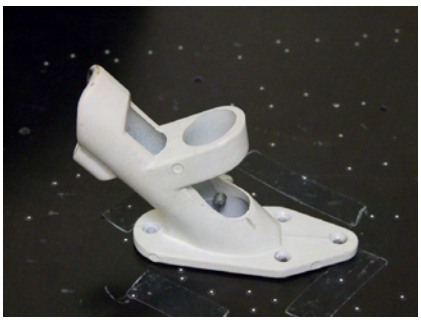


Figure 10. Flagpole base on a turntable.

Figure 11 shows the flagpole bracket with targets applied. Because the targets are placed directly on the part, this part can be moved without the scanner losing track of it.

Targets are placed on the interior because this is also an area of interest.



Figure 11. Flagpole base with targets on the exterior and interior.

Target Placement on Work Areas

The work area shown has a work table with holes for mounting or clamping, a turntable, and an upside-down bowl used as pedestal on the turntable.

Small objects can be placed on the pedestal for scanning. The pedestal and felt can be removed to allow a medium-sized object to be placed on the turntable. The felt covers additional targets that would be used with objects too large to fit on the pedestal.

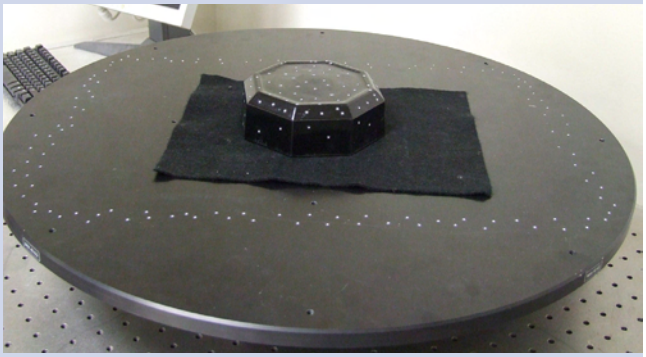


Figure 12. Turntable with a pedestal and targets.

2.3.2 Preparing the Part Surface

Reflective surfaces scatter the scanner light and create noise artifacts in the final data. Laser and white-light scanners do better when scanning matte, white surfaces. Developer, like Magnaflux Spotcheck Developer, is a powder-based spray commonly used to create a flat white surface for scanning. Developer is available at welding supply stores.

Other products used for treating surfaces include some athlete's foot treatments, spray deodorant with titanium oxide, and tempera paint from a compressor. White spray paint is also used (to create a more permanent coating).

2.3.2.1 How to Coat a Part

A part must be sprayed with a uniform, light coat. The thinner the coating, the better. Adding more than a thin coat of developer can impact a part's thickness when scanning.

Developer comes off easily and is prone to fingerprints. Mounting an object to a surface (such as a bolt through the center of a threaded section) can provide a hand-hold for moving the part after spraying. You can also spray a portion of the part (leaving a section as a hand-hold), complete the first scan, clean the part, respray the area used as a hand-hold, and then rescan as needed.

The following steps are a general procedure for applying developer to a part.

1. Apply targets before spraying—otherwise the targets slip off the white part.
2. If necessary, mount the part or decide which section will be used as a hand hold.
3. Hold the can 12 to 18 inches from the part and spray a light first coat, and set the object aside to dry for a few minutes.
4. After the developer has finished drying, respray any areas that need it.



Figure 13. Spraying a part.

5. If necessary, clean any targets with a cotton swab prior to scanning.

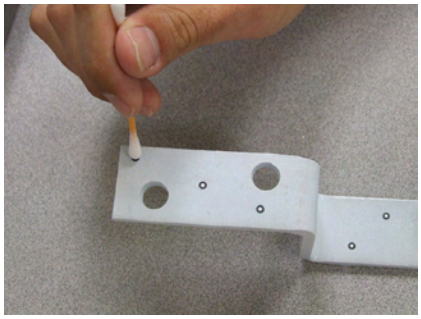


Figure 14. Cleaning targets.

2.3.2.2 Examples of Surface Preparation

The main symptoms of bad preparation are fingerprints, smudges, and uneven coating.

The block in Figure 15 was prepared, handled, and then clamped, causing scratches and dents in the coating. The developer was also applied in uneven thickness. This part should be cleaned and resprayed.



Figure 15. Block with uneven surface preparation.

The doorstop shown to the right has two fingerprints (Figure 16). The part can either be cleaned and resprayed, or the area with the fingerprints can be used as a hand-hold or clamping area.

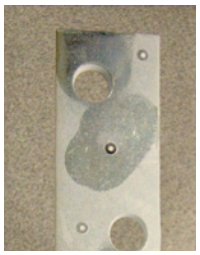


Figure 16. Doorstop with fingerprints.

2.4 Preparing the Scanner

Preparing the scanning area is like preparing for a photography session. Remove unwanted objects from the area and optimize the environment.

2.4.1 Checking the Hardware

Check the scanner and the part to make sure things are adjusted, tightened, connected, and placed appropriately:

- If you are using a handheld scanner, verify that the cord is long enough to reach where you plan to scan.
- If you are using an arm-mounted scanner, make sure the arm base is securely fixed and that the laser head is mounted properly.
- If you are using a stationary scanner, verify the scanner has the appropriate lenses installed to capture the correct volume of the object, that the scanner is the proper distance from the object, and that the bolts/mounts/tripod heads are tightened.

2.4.2 Calibrating the Scanner

Calibration defines the relationship or location of the scanner in space to a coordinate system. Calibration also can correct misaligned optics. Scanning with an improperly calibrated scanner is a common (and correctable) cause of poor scan data. Calibration should be performed on a regular basis. Each scanner has a unique calibration method. See the manufacturer's guidelines.

2.4.2.1 Symptoms of a Bad Calibration

Bad calibration is evident in the scanned data. The data may not mesh properly when a registration is attempted. The registraion may fail. The surface may appear mottled, like roof shingles. This section provides two examples of bad calibration.

Tip: In Geomagic Studio or Geomagic Qualify, turn on Object Color in the Display Manager to display individual scans in unique colors. The scans should appear integrated. If the scans do not mesh well, the colors will look like fish scales or roof shingles.

The doorstop was scanned using the arm-mounted scanner. The scanner was not calibrated prior to beginning the scan. Once the data was seen in Geomagic Studio, the problem with the scanner's calibration became apparent.

Zoom in to the model displayed in Figure 17 to review the uneven edges indicating a bad calibration.

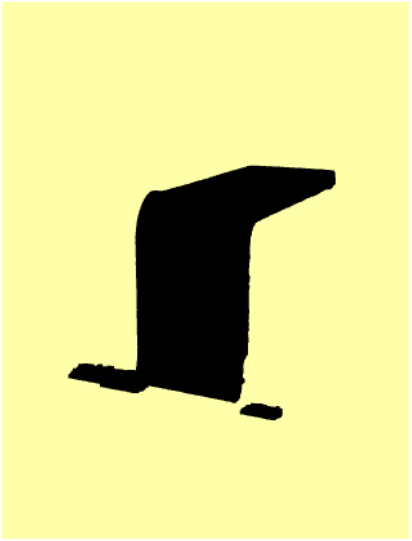


Figure 17. Model showing a bad calibration.

This scan of a smooth sheet metal part is uneven at points A and B because of poor calibration.

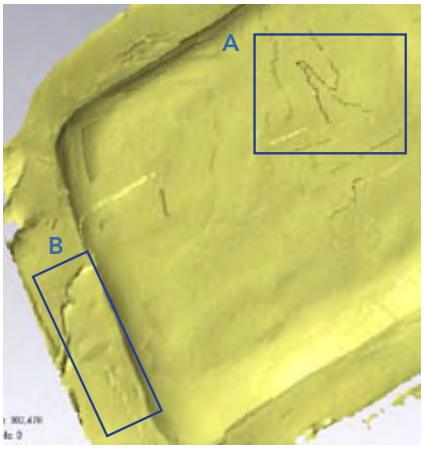


Figure 18. Bad calibration.

2.4.2.2 Example of a Good Calibration

The scan, at right, shows the results from a properly calibrated scanner. The surfaces now appear smooth and the lip around the lower curve is gone.

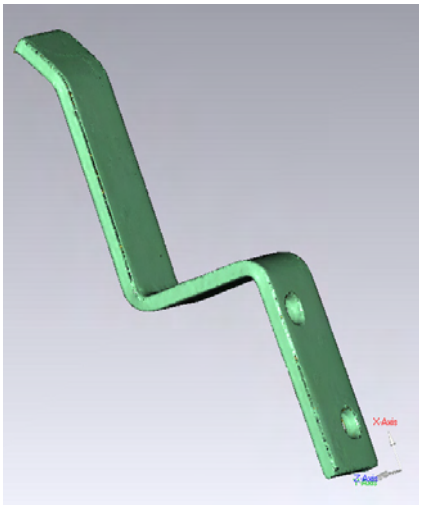


Figure 19. Good calibration.

3 SCANNING

Three example parts were scanned using the handheld, arm-mounted, and stationary scanner. These parts required the following preparation:

- The exhaust manifold had reflective targets and a matte coating applied so it could be scanned with the handheld scanner.
- The doorstop was coated with developer in preparation for scanning with an arm-mounted scanner.
- The flagpole bracket had targets applied (but did not require surface treatment) for scanning with a stationary scanner.

3.1 Common Guidelines

The following guidelines are useful for most scanners:

- Perform a test scan to verify that the proper view of the object is visible within the scanner's bounding box.
- Optimize the ergonomics.
- Monitor the software and hardware indicators to keep the scanner and object within the scanner's bounding box.
- Check exposure settings if the object is moved during scanning or if lighting conditions change.

3.2 Handheld Scanners

3.2.1 Technique Suggestions

The handheld scanner follows a trail of three to five reflective targets at all times to register or align what it is scanning.

When you are scanning, move the scanner over the object in smooth, even movements perpendicular to the object's surface. Some scanners have an indicator that shows when the scanner is too far, too close, or the optimal distance from the object.

3.2.2 Example

The exhaust manifold was scanned using a Creaform Handyscan. The part was spray painted white with a permanent coating and reflective targets were applied. No special mounting was required since the part could be rotated to capture all sides.

The manifold was scanned on a desk under artificial light and daylight from a window. The lighting did not adversely affect the scanning.

The scanner was calibrated first (Figure 21) by using the built-in calibration function in the Geomagic plugin. During calibration, the laser appears as a cross hair on the manifold.

The manifold was scanned in slightly overlapping passes. The scanner was held approximate at a 90° angle to the manifold. The lights on top of the scanner helped the operator keep the scanner an optimal distance from the manifold.

As the scan was performed, the data appeared on the screen (see model to the right). This feedback provided immediate information on which sections needed additional scanning passes.

The manifold took approximately 10 minutes to scan.



Figure 20. Laser during calibration.



Figure 21. The Handyscan scanning the manifold using Geomagic Studio with a Handyscan plugin.

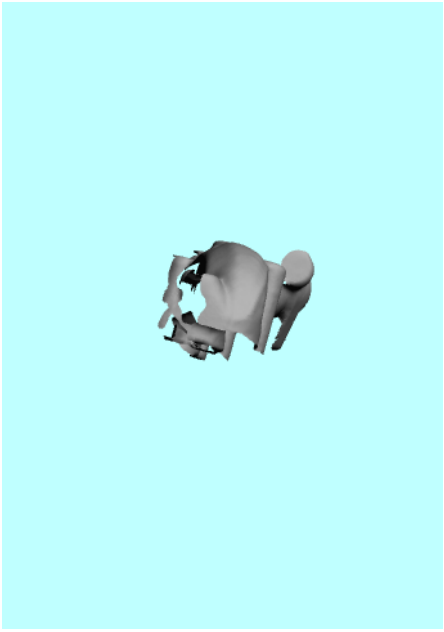


Figure 22. Actual 3D file of the scanned data.

Handling the Arm-mounted Scanner

These figures show examples of the proper and improproer way to grip the arm-mounted scanner.



Figure 23. Correct grip



Figure 25. Incorrect grip.



Figure 24. Incorrect grip.

3.3 Arm-mounted Scanners

3.3.1 Technique Suggestions

Here are some general guidelines to keep in mind when using the arm-mounted scanner:

- Make sure the scanner arm is not over-extended.
- Hold the grip with either one hand or two and allow the arm to move freely (without bumping into things).
- Monitor both the laser scanner and the motion of the arm.
- Make sure the scanner is perpendicular to the object being scanned (Figure 26).
- Use evenly spaced, slightly overlapping smooth strokes like painting a wall with a paint roller in one direction.
- Do not grasp the laser scan head no matter how convenient a hand-hold it might be.
- Do not use the arm as a grip because the electronics can be jostled and the arm's temperature can increase.



Figure 26. The FARO Laser Scanarm held at the proper angle for scanning.

3.3.2 Example

The doorstop was scanned using a FARO arm-mounted scanner in two sessions. The doorstop was prepared with developer (one end left untreated). The untreated section was used first as a hand-hold and then sprayed and scanned during a second session.

Scanning was performed under fluorescent lighting. The doorstop was secured to a table using a C-clamp placed on the untreated section. The base of the scanner arm was bolted to the table.

The Geomagic plugin did not have to be adjusted for lighting conditions.

The scanner and hard probe tip were calibrated first using the Geomagic plugin prompts.

Before beginning the scan itself, the table was selected as a clipping plane. As the scan was performed, data associated with the table's plane was automatically discarded.

During scanning, the scanner was held at an approximately 90° angle and moved in slow, even passes. Each pass overlapped its predecessor by 10-20 percent. Once the top surface was captured, the doorstop was flipped over, reclamped, and scanned.

Because one end of the part was used as a hand-hold (and thus bare metal), the doorstop was cleaned and then re-sprayed with developer. The hand-hold section was then scanned.

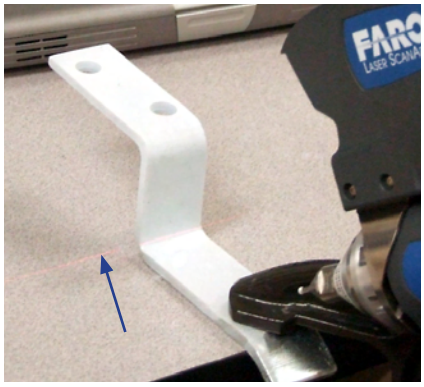


Figure 27. Laser line from scanner on the doorstop.

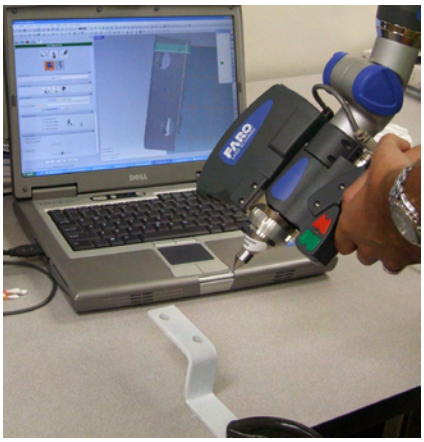


Figure 28. Data appears on the screen as the scanner is moved over the doorstop.

3.4 Stationary Scanners

3.4.1 Technique Suggestions

When scanning with a stationary scanner, keep the following suggestions in mind:

- Make sure that you have enough targets so the scanning session can be completed without having to place additional targets.
- Adjust the scanner's scanning area so that it best fits the object's size.
- Optimize the number of scans because too many captured points increase data processing time.

3.4.2 Example

The flagpole bracket was scanned on a turntable using a GOM ATOS stationary scanner in a room lit with fluorescent lights. The scanner itself is attached an arm with a base that extends from the floor almost to the ceiling.

The flagpole bracket presented a particular challenge because the exterior and interior of the holes had to be captured. Because the flagpole bracket had to be moved so the scanner could capture the interior of each opening, targets were placed on the part and not on the turntable. Careful consideration was given to the target placement so that as the flagpole bracket was moved at least three points stayed in the scanner's field of vision.

Both of the scanner's lenses were calibrated with each other. The exposure was also modified to correct for the lighting conditions.

The turntable can be used in two ways: to rotate the part while the scanner automatically captures a predefined number of scans or the turntable can be turned using a manual control. Because of line of sight considerations with this part, the turntable was used to manually rotate the part. After each slight turn, the exposure setting and the scanner's proximity to the part had to be checked. Even though the part moved, the scanner was able to track the part and align each scan.

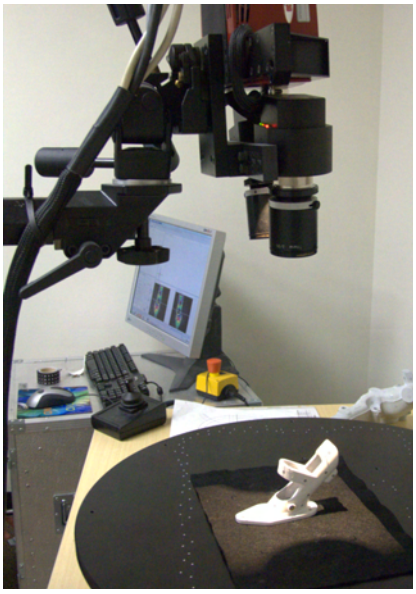


Figure 29. The flagpole base on the turntable during the scanning process.

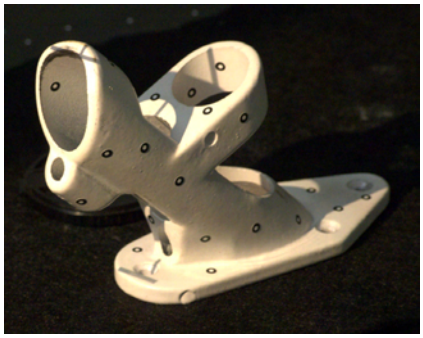


Figure 30. One of the views used to capture the interior of the flagpole base (note the targets on the interior).

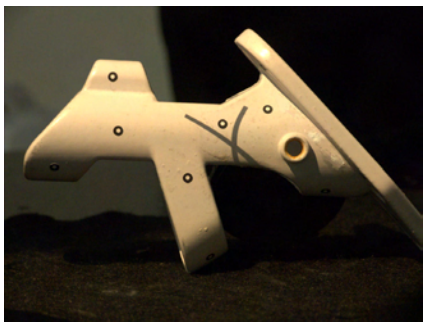


Figure 31. Flagpole base scanned from the side.

4 HARD PROBING

Hard probing is often performed along with scanning because probing collects highly accurate data from features or areas of special interest. Arm-mounted devices often have a laser scanner and a hard probe.

4.1 Preparing for Hard Probing

When preparing to hard probe, make sure that the part is secure and that the correct probe tip is installed.

4.1.1 Securing the Part

Because hard probing touches the part, it must secured to the table by using a jig, clamp, or other fixturing mechanism.

4.1.2 Checking Probe Tip Size

The probe tip should fit inside the areas to be probed. When hard probing a feature, like a slot, the Geomagic plugin will prompt you to probe points on the interior or exterior of that feature. If the probe tip is larger than the features to be captured, it could limit your ability to probe points. The part at right shows two features at the top of the part and the probe tip has to fit inside these features.

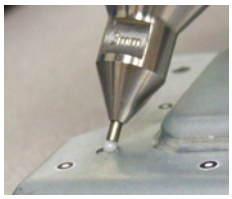


Figure 32. A 3 mm hard probe.

In this example, a circular feature is being probed with a 3 mm probe. The tip is small enough to capture data around the feature and the interior rim as well.

If the same action is performed with a 6 mm probe, the probe is be too large to fit inside the feature.

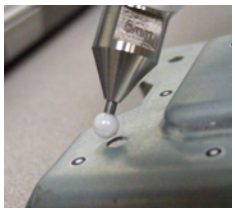


Figure 33. A 6 mm hard probe.

Tip: For instructions on changing the probe tip and changing settings, refer to the manufacturer's documentation.

4.2 Calibration

Calibration defines the relationship or location of the scanner in space to a coordinate system. Whenever the probe size is changed, you must verify the scanning software lists the correct probe tip and recalibrate.

If using multi-sensor metrology (a device with both scanning and hard probing capabilities), both the scanner and the hard probe must be calibrated. If the probe tip is not calibrated, the software could place a feature in the wrong spot. The software calculates the point locations based upon the radius of the tip. For example, if you are using a 6 mm probe and the software's settings indicate a 3 mm probe, then the probed points will be off by 1.5 mm.

5 ADDITIONAL RESOURCES

5.1 Interactive User Guides

Once the scanning is done, the data is ready to be further processed by Geomagic Qualify or Geomagic Studio. Two interactive user guides are available on the Geomagic web site: Four Basic Workflows for Studio 10 and Basic Workflow for Qualify 10. Both guides provide step-by-step instructions and sample data files that can be loaded into the software.

In addition to the user guides, self-paced training and video product demos are available for Geomagic Studio and Geomagic Quality.

5.2 Glossary

The vocabulary used with 3D scanning and related technologies is specialized. Some commonly used definitions are included below. A more complete glossary is available on the Geomagic Resources web page.

CMM. Coordinate Measurement Machine. Mechanical systems designed to move a measuring probe to determine coordinates of points on a work piece surface. CMMs are comprised of the machine itself, the measuring probe, and the measuring software.

Developer. A powder-based spray from the company Mangaflux commonly used to create a flat white surface for scanning.

Feature. A physical or imaginary construct on an object, such as a plane, slot, or edge, that can be used for reference by other tools.

Hard probe. A sensing device that captures point data mechanically (see A in the illustration at right). Laser scanners often have hard-probe attachments for special-purpose data capture.

Laser scanner. A 3D digital device (see B in the illustration at right) that works by projecting laser light onto surfaces while cameras triangulate the profile of the laser as it sweeps, enabling the object to be digitized in 3D.

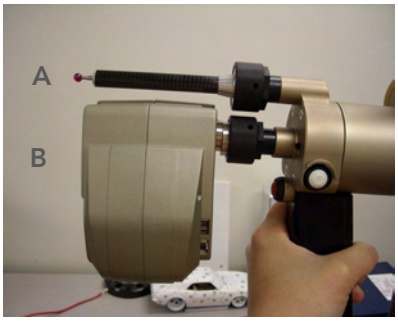


Figure 34. An arm-mounted scanner with a hard probe (A) and laser (B).

Model. A file that defines one or more objects and subobjects.

Ordered data. A point cloud of consistent density whose points exist in orderly rows and/or columns.

Photogrammetry. Method of measuring based on stereo photography and the extraction of x,y coordinates and distance measurement in a plane perpendicular to the line of sight, and extracting z values.

Point cloud. A set of x,y,z data that is located in three dimensional space used to represent three dimensional objects. A point cloud may or may not have i,j,k data that defines the normal vector for the corresponding x,y,z data subset.

Scanner. A device used to capture physical objects in a digital format.

Acticulating arm. A physically anchored articulating mechanism for mounting a hand-held scanner and through up to 7 degrees of freedom can position and record the scanner location to return accurate measured point coordinates on an object being scanned.

Unordered data. A point cloud of variable density whose points exist at any location in space. Also called "raw" data.

Whitelight scanner. A digital shape sampling sensor that projects light in a pattern of lines on an object and through triangulation measures deviation of the original pattern based on the distortion of the surface of the object and calculates the surface representation data