CAM2® 2021

Your Complete 3D Measurement Software

FARO®

Legal Notices

Release Notice

This is the June 2021 revision of the FARO CAM2 User Manual. It applies to the FARO CAM2.

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Implementation Notes

This product includes third-party and open source resources. For license and copyright information pertaining to the use of these resources, refer to the following document in the FARO Knowledge Base:
https://knowledge.faro.com/Essentials/General/3rd-Party_Open_Source_License_Information_for_FARO_Products

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Chapter 1: Introduction to CAM2® 2021

CAM2® 2021 is a NIST and PTB-certified CAD-based metrology software package specifically designed to conduct precise measurements and inspections of complex features simply by inputting 3D measurements. There is virtually no limit to the types of measurements you can analyze using CAM2. Through IGES, VDA, CATIA, ProEngineer, or Unigraphics translation, your data can be exchanged with any number of CAD systems.

This document contains all general information and specific instructions needed to use CAM2. If you have any questions or need further instructions for any procedure, contact your Customer Service Representative by Phone, Fax or E-Mail. *See "Technical Support" on page 333.* You can also reach the Customer Service Applications and Training group via Internet e-mail at the following addresses:

- support@faro.com
- applications@faro.com
- training@faro.com

Visit the FARO Customer Service area on the Web at www.faro.com to search our Knowledge Base, which is available 24 hours a day, 7 days a week.

How to Use This Manual

Listed below are some visual and typographical conventions used in each of the sections.

Bold text	Indicates directory names, menu names, buttons, tabs, key names, dialog box names, dialog box items, acronyms, and modes.
`monospaced text`	Indicates alphanumeric characters or values you enter in a field on the screen. For example, "Type `0.005` for the tolerance setting."

It is important that you understand the meaning of the following words before proceeding.

digitize	Indicates the recording of XYZ coordinates of a point or location in 3D space. The word digitize is the same as the term *measure* when referring to points.
choose or select	Indicates that you are initiating an action. For example, "Select **File** > **Insert** > **CAD Parts**."
left-click, right-click, click, or press	Indicates that you press and release the corresponding mouse button or keyboard key. Also used when referring to the hardware device buttons. For example, "After selecting a file from the **Open File** dialog box, *click* **OK** to open the file" or *"Press* **ESC** at anytime to cancel a command."
drag	Indicates that you press and hold the **left mouse** button down and move the mouse. Release the mouse button to finish. This word is often used when changing the size of a window or toolbar.

Warning

WARNING: A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or event that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Caution

CAUTION: A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or event that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

Note

NOTE: A NOTE notice denotes additional information that aids you in the use or understanding of the equipment or subject. Specifically, they are not used when a WARNING or CAUTION is applicable. They are not safety related and may be placed either before or after the associated text as required.

System Requirements

The following are the minimum and the recommended hardware and software requirements for CAM2.

Hardware

- Processor: Dual Core CPU
- RAM: 8 GB
- Hard Drive: 500 GB
- GPU: NVIDIA Quadro® M520
- USB ports: 1 (if using portlock licensing)

Recommended Requirements (For Point Probe Measurements with Large CAD; Moderate Point Cloud Scanning)

- Processor: Quad Core CPU
- RAM: 16 GB
- Hard Drive: 512 GB SSD
- GPU: NVIDIA Quadro® M2200
- USB ports: 1 (if using portlock licensing)

High Performance Requirements (For Intensive Point Cloud Scanning)

- Processor: Quad Core CPU
- RAM: 32 GB
- Hard Drive: 1 TB SSD
- GPU: NVIDIA Quadro® P5000
- USB ports: 1 (if using portlock licensing)

Software

NOTE: The following computer operating systems are supported:

- Microsoft® Windows® 8.1 (64 bit)
- Microsoft® Internet Explorer 10.0

OR

- Microsoft® Windows® 10 version 1607 or later (to support .Net Framework 4.7.1)
- Microsoft® Internet Explorer 11.0

NOTE: We recommend Windows 10 64 bit Professional operating system for point cloud scanning.

Installing CAM2

CAM2 is quick and easy to install. The CAM2 USB includes the software and a standard Windows help file. Also included in this USB is a Portable Document Format (*.PDF) file of the CAM2 manual. You must install Adobe Acrobat Reader, included on the CAM2 USB, to read and print the manual from your computer.

To Install CAM2:

1. Place the CAM2 USB into the computer's USB port. The USB automatically loads and opens the CAM2 window.

    - If the USB does not automatically open the CAM2 window, click **Start > My Computer**, double-click your computer's USB drive (usually D:), and then double-click `autorun.exe`.

2. Click an installer language. Or, click **View Manual** to move to the CAM2 manual menu.

    - Adobe Acrobat Reader is required to view the CAM2 manual. You can install this program from the CAM2 manual menu.

3. If necessary, The CAM2 install program displays a list of auxiliary system programs that are required for CAM2. Click **Install** to continue. Click **OK** to confirm the install of each program. A system restart may also be required during this section of the install.

4. Read the Welcome screen and click **Next**.

5. Read and accept the Software License agreement. Click **Next** to continue.

6. Add or remove a component by clicking on the individual component.

7. Click **Change** to change the destination folder for CAM2, or click **Next** to create the default folder.

8. Click **Install** to begin installing the software.

9. Click **Finish** when the installation is complete.

NOTE: You can also install and manage your CAM2 installation using FARO InTouch. *For more information, see "FARO InTouch" on page 10.*

Licensing CAM2

CAM2 requires the installation of a license. Your licensing option is determined at the purchase of CAM2. There are two licensing options for CAM2:

1. Licensing with a port lock - the license number is recorded into the port lock. Attach the port lock to a USB port on your computer.

2. Licensing with a key code - the key code is printed on the back of the CAM2 package (this box.) Start CAM2 and enter this code into the dialog box.

    - The license key code must be validated using an Internet connection. Once complete, this validation is permanently stored on your computer.

- If you do not have an available Internet connection, contact FARO's customer service team to receive a validation file.

- Each key code can only be activated three times. If you install CAM2 on a new computer, contact FARO's customer service team to deactivate your key code from your old computer.

Contact FARO's customer service team if you need to switch your licensing option, or have another issues with licensing CAM2. *See "Updating Your License" on page 8.*

Licensing Wizard

When you start an unlicensed version of CAM2, the licensing wizard displays. Select from the following options:

- I have a license

  Click **Product Key** and enter your product key

  OR

  Click **Hard Lock Key** and insert your port lock.

- I don't have a license

  Click **Trial** to run a trial version of the software for 30 days

  OR

  Click **Purchase** for additional information from the FARO website on purchasing the software.

- Additional Options

  Click **Network License** to transfer a network license from a server.

  Click **Transfer Key** to transfer a license from another computer.

If you plan to use CAM2 on more than one computer, especially computers on different networks, a hard lock key allows you to easily move the license between computers. Product keys are more convenient for single computer installations.

Select Network License if you are managing multiple licenses over a network. *See "Network Licensing" below.*

Select Transfer Key if you are transferring a product key from another computer. *See "Transferring Network Licenses" on page 8.*

Network Licensing

CAM2 allows management of multiple licenses over a network. This option is available for users who want to employ a separate computer to host a network license without having to install CAM2 on that computer.

Network licenses are hosted on a license server computer and shared to client computers over the network. They can be locked to a USB dongle (port lock) or to the licensing server computer.

When you start CAM2 on any computer in your network, it will search the network for available licenses. If one is found, it will use this license for the time it is executed. When you close CAM2, the license will be released and will be available to other CAM2 installations in the network.

Installing the Sentinel HASP Licensing Software on the License Server

CAM2 licenses are managed with Sentinel HASP from SafeNet. To setup a computer as a license server, you must install the Sentinel licensing software on that computer. Sentinel is automatically installed with CAM2; however, if you do not want to install CAM2 on the computer that hosts the network licenses, you must install Sentinel manually. Do one of the following to install the Sentinel licensing software on the server computer:

•   Click **HASP Network License Manager** on the USB menu and follow the prompts,

<div align="center">**OR**</div>

•   Execute haspdinst.exe –install from a command shell. You can obtain this file from the FARO Technical Support Center site.

To verify the proper installation of the Sentinel licensing software, open an Internet browser on the license server and enter the address *http://localhost:1947/* to open the Sentinel Admin Control Center. If the Sentinel Admin Control Center appears, installation was successful.

Enabling Remote Access on the Server

Before users can access the network licenses, remote access has to be enabled on the server computer:

1. Open an Internet browser on the license server and enter the address *http://localhost:1947/* to open the Sentinel Admin Control Center.

2. In the **Options** window, select **Configuration** to display the configuration tab set.

3. Click the **Access from Remote Clients** tab.

4. Select the **Allow Access from Remote Clients** check box.

5. Click **Submit**.

Network Licenses Attached to a USB Dongle (Port Lock)

You can obtain a special network port lock from FARO Customer Service. This port lock may be plugged into any computer that has the Sentinel HASP drivers installed. This computer will act as the license server and share the licenses over the network (after you enable remote access from clients). Activation of these licenses is not necessary.

If you want to add network licenses to a port lock, you can purchase network licenses linked to a product key. To transfer them to the port lock, attach it to any computer with CAM2 installed and follow the steps to validate the product key and activate the licenses. When validating the key and activating the licenses, you will be asked whether you want to lock the licenses to the computer or to the attached port lock. Select the second option. Once complete, you can remove the port lock from the computer and attach it to the license server again (if you used another computer to activate the licenses).

Network Licenses Attached to a Key Code

You can also lock network licenses to the license server computer using a product key. To do so, install and start CAM2 on the server, then follow the steps to validate the product key and activate the licenses.

•   Click **File** > **Help** > **Open License Information Page** in CAM2

<div align="center">**OR**</div>

- Open *http://localhost:1947* with an Internet browser on the server to verify the proper activation of the CAM2 license. In the **Options** window, select **Products** to display the available CAM2 licenses.

Detaching Network Licenses

If your license server hosts network licenses that are attached to the computer with a key code (not to a port lock), you can detach a network license and temporarily bind it to a client computer. The license can then be used locally on that computer without being connected to the network. When the detached license expires, it is automatically unbound from the client computer and restored to the server.

The license server and the client computer must be configured to allow detaching of network licenses.

To enable license detachment on a server or client computer:

1. Click **Network** License in the Licensing Wizard and enter a host or IP name

OR

2. Click **File** > **Help** > **Manage Licenses** in CAM2

OR

Open *http://localhost:1947/* with an Internet browser on the server or client computer.

3. In the **Options** window, select **Configuration** to display the configuration tab set.

4. Click the **Detachable Licenses** tab.

5. Enable **Detaching of Licenses**.

NOTE: On a server, you may also specify the number of reserved non-detachable licenses and the maximum detach duration.

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6. Click **Submit**.

To detach a license and bind it to your client computer:

1. Open *http://localhost:1947/* with an Internet browser on the client computer.

2. In the **Options** window, select **Products** for an overview of all available local and network licenses. Detachable network licenses are identified by a red arrow.

3. Click the **Detach** button to access the **Detach License** dialog.

4. Select the expiration date to specify the day the license will be restored to the pool.

5. Click **Detach & Attach** to temporarily bind the license to your client computer. It will return to the network license pool when it has expired.

To return a detached license before it expires:

1. Click **Network** License in the Licensing Wizard

OR

2. Click **File** > **Help** > **Manage Licenses** in CAM2

OR

Open *http://localhost:1947/* with an Internet browser on the server or client computer.

3. In the **Options** window, select **Products** for an overview of all available local and network licenses. Detached network licenses are identified by a green arrow.

4. Click the **Cancel License** button and confirm your selection on the following dialog to return the license to the network license pool.

Transferring Network Licenses

To transfer (rehost) a valid CAM2 license from one computer to another:

1. Click **Transfer Key** in the Licensing Wizard and select a license

<div align="center">**OR**</div>

2. On both computers, start CAM2 and click **File** > **Help** > **Manage Licenses**.

3. On both computers, click **More Options** and click **Transfer Key**.

4. On the recipient computer (the computer that will receive the license), select a location to save an information file (ID) and click **Collect and Save Information**.

5. Transfer the ID file to the source computer (the computer which currently contains the license).

6. On the source computer, highlight the license to transfer.

7. Browse to the ID file created in Step 3.

8. Select a location to save a license transfer file (H2H) and click **Generate License Transfer File**.

9. Transfer the H2H file to the recipient computer.

10. On the recipient computer, click the **Apply License File** tab.

11. Select the H2H file created in Step 7 and click **Apply Update**.

License Server Administration

The Sentinel Admin Control Center provides various functions to manage and monitor the usage of network licenses and to diagnose problems. For more information, refer to the Sentinel Admin Control Center help.

Updating Your License

Use the Licensing Wizard to check for any pending license updates. When you run this program, CAM2 will download any pending updates or orders and automatically update your port lock.

• If you do not have an available Internet connection, contact FARO's customer service team to update your license. You will need to create a C2V license file for FARO customer service if you are deleting a license, modifying a license, or activating the software for the first time on a computer that does not have Internet access (also known as an offline activation). Make sure you apply the license you are given before you generate a C2V.

To create a C2V file:

1. Click **Product Key** in the Licensing Wizard.

2. Click **I Don't Have An Internet Connection**.

3. Click **Web Portal**.

4. Click **C2V** and select a destination to save the C2V file.

5. On a computer with Internet access, browse to http://license.faro.com/Portal/activation.

6. Enter your product key, then browse to the C2V file created in Step 4.

7. Click **Activate** to generate and save a V2C file (select the destination).

8. Return to the original computer and click **Next**.

9. Click **V2C** to browse to the V2C file created in Step 7.

10. Click **Next** to apply the V2C file.

Versions

CAM2 is available in two versions: Full and Probing.

Full Version

The Full version of CAM2 contains all available functionality.

Probing Version

The Probing version contains functionality tailored for probe measurement. Functionality for point clouds and scanning is limited:

- **Open**: CAM2 will not open saved measurement files containing point clouds. If you change your license from Full to Probing while a measurement file containing point clouds is open, you will be prompted to save the file before CAM2 closes it. *See "Open" on page 58.*

- **Import Points**: You can import a maximum of 7,000 points, and point clouds are excluded from import. *See "Points" on page 61.*

- **Import Point Cloud**: This command is not available. *See "Point Cloud" on page 61.*

- **Point Cloud To Mesh**: This command is not available. *See "Point Cloud To Mesh" on page 65.*

- **Point Cloud Workspace**: This command is not available. *See "Point Cloud" on page 38.*

- **Manage Devices**: The FARO 3D Imager and FARO Laser Line Probe are excluded from use. *See "Manage Devices" on page 130.*

- **Align Point Cloud**: This command is not available. *See "Align Point Cloud" on page 269.*

- **Preferences**: Point Cloud preferences are not available. *See "Preferences" on page 67.*

- **Construct Cross-Section Scan**: This command is not available. *See "Construct Cross-Section Scan" on page 254.*

- **Measuring a Cross-Section Scan**: This command is available for use with a hard probe only. *See "Measuring a Cross-Section Scan" on page 168.*

Directory and File Locations

The initial location of the files and directories is determined by the options selected during the installation of CAM2. These locations can always be modified as a new default preference file. *See "Preferences" on page 108.*

> **NOTE:** A detailed listing of the directory and file locations is available from FARO Customer Service.

Getting Started

If you have purchased a port lock license, make sure that you have inserted the port lock into the computer's USB port. Although not required, it is recommended that you connect your measuring device to the computer before starting CAM2.

FARO InTouch

FARO InTouch is a software distribution and management application which streamlines the downloading, installation, updating, and execution of FARO software such as CAM2 and RPM. With an internet connection and the auto-update option enabled, you can automatically install the latest version without manually downloading and installing every new released version. You can also launch individual FARO software applications directly from InTouch.

> **NOTE:** FARO InTouch is only compatible with Microsoft® Windows® 10. When installing InTouch for the first time, uninstall any previous versions of CAM2, RPM, Device Center and CAD Translator via the Windows Control Panel before installation.
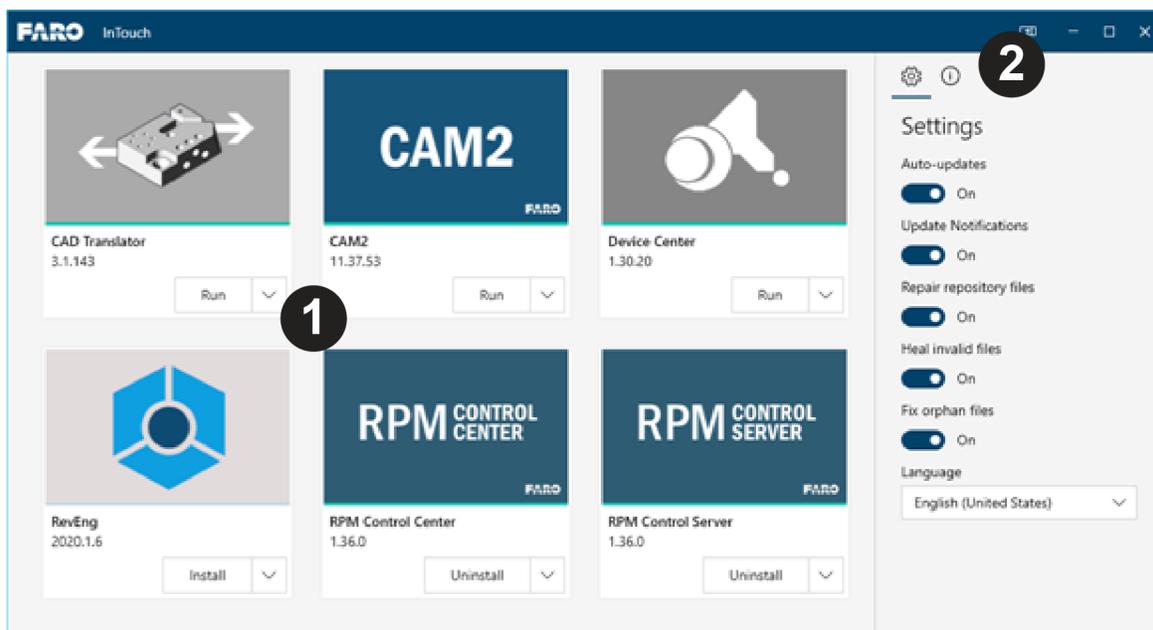
❶**Gallery**. Contains FARO software applications (as tiles).

❷**Sidebar**. Displays the sidebar menu.

Figure 1-1 FARO InTouch panel

Gallery

The FAROInTouch gallery contains all CAM2 software within a single location. Each tile represents an available FARO application.

Application Operation

Each tile has an operation button. Click the down arrow to select from available operation options:

Install: Click to install the application. Any dependent applications will also be installed as part of the installation process.

Update: A newer version is available. Click to update the application. Any dependent applications will also be installed as part of the installation process.

Run: The application is installed and available. Click to start the application.

Uninstall: Click to uninstall the application.

Repair: An issue has been detected with the installation. Click to repair the installation.

NOTE: One or more of these options may not be available depending upon the application status.

Application Status

The colored bar in each tile below the application's icon indicates the application's installation status:

Light Blue: The application is not installed.

Green: The application is installed and available for use.

Red: The application is installed but is not available for use.

Sidebar

The sidebar contains the following menu options:

Auto-Updates

When enabled, this option allows seamless updating of installed applications with new versions.

If Auto-Update is not enabled and Update Notifications is enabled, InTouch application tiles will notify you of available updates which you can manually install.

Update Notifications

When enabled, this option allows InTouch to generate Windows notifications when updates are available, installed, or if an issue is detected.

Repair Repository Files

When enabled, Touch will monitor the health of the repository files and automatically repair as needed.

Heal Invalid Files

When enabled, InTouch will monitor the health of the installed files and automatically heal invalid files.

Fix Orphan Files

When enabled, InTouch automatically fixes files that have lost association to another file.

Language

Select the language from the drop down list.

NOTE: This also changes the language of the installed applications.

System Information

Service Status

Server: The connection to the external server that FAROuses to store and distribute applications globally.

> **Green**: InTouch can communicate with the server.

> **Red**: InTouch cannot communicate with the server, typically due to internet connection issues.

Service: The InTouch service running on the local machine.

> **Green**: The service is running normally.

> **Red**: The service is not running or has stopped. When starting InTouch, this status can appear red for several minutes while the service starts up.

Maintenance: An operation to verify InTouch is running as expected, relating to the repair and healing options within Settings.

> **Green**: The service is running normally.

> **Red**: Maintenance in progress. When starting InTouch, this status can appear red for several minutes while the service starts up.

Starting CAM2

Click the **CAM2 2021** program icon on the Desktop or from FARO InTouch; or, from the Windows **Start** menu, click **All Programs** > **FARO** > **CAM2 2021** and finally the **CAM2** icon.
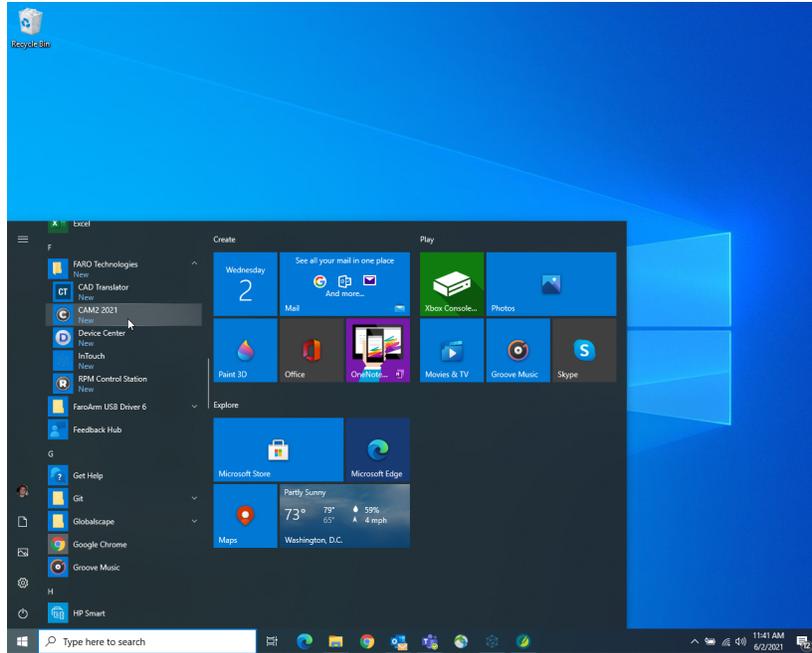
Figure 1-1 CAM2 2021 Program Icon

As the software loads, the software attempts to initialize communication with a primary measuring device.

- If the measuring device is connected properly, **Device Center** displays the device's information.

- If there is no connection between the device and the computer's USB or serial port, or if the device is off, **Device Center** is empty. Connect your measuring device to the computer and click + if not recognized, or continue using CAM2 without a measuring device.

For more information, see "Device Center" on page 128.

NOTE: CAM2also supports multiple devices for simultaneous measurement. *For more information, see "Multiple Devices" on page 129.*
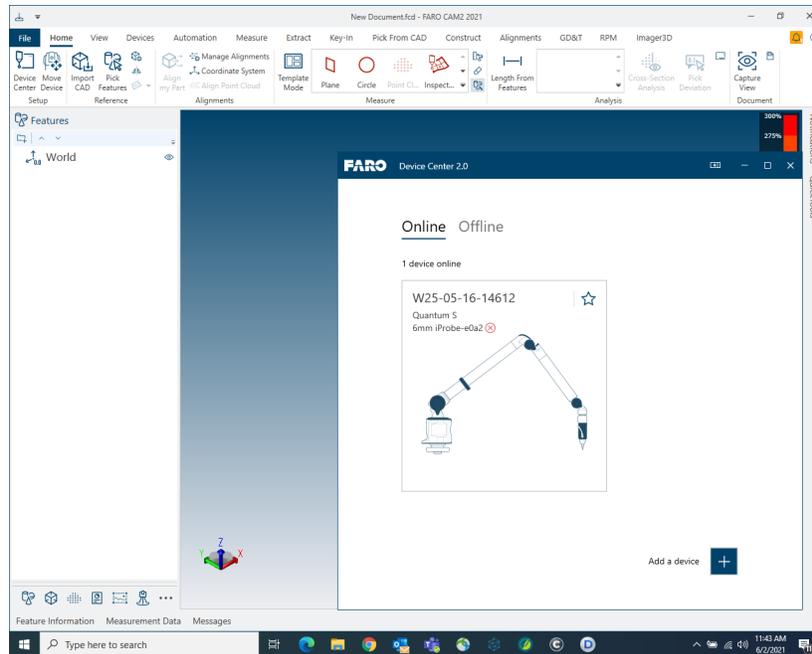
Figure 1-2 Device Control panel

CAM2 Experience Index

When you start CAM2, the CAM2 Experience Index analyzes your computer's graphical capabilities, available memory, and processor speed to assess your CAM2 user experience.

When the analysis is complete, CAM2 presents you with a Calculated Global Score from 1 to 5 (1 being the lowest, 5 being the highest) that gauges your CAM2 experience based on your computer's attributes.

NOTE: If your graphics card driver is outdated, the **Main** window will display a red border and a message indicating the need to update your graphics driver.

Click the Recalculate Experience Index link to refresh the CAM2 Experience Index window.

The CAM2 Experience Index appears the first time you start CAM2 and each subsequent time unless you select the **Never Show Again** check box.

NOTE: You can also access the CAM2 Experience Index from the CAM2 Help screen. *See "Help" on page 29.*

Customer Experience Improvement Program

The CAM2 Customer Experience Improvement Program analyzes and collects anonymous CAM2 error and usage data, which is periodically transmitted to FARO when an Internet connection is available.

By agreeing to the EULA (End-User License Agreement), you agree to participate and accept the sharing of information; however, you can opt out of the program by selecting FARO Customer Experience Improvement Program from the CAM2 Help screen. *See "Help" on page 29.*

NOTE: Participation is mandatory for pre-release versions of CAM2.

For more information about the EULA, see *End User Documents on page 335*

Experimental Features

As part of the FARO Customer Experience Program, some versions of CAM2 contain Experimental Features. These Experimental Features enable you to experiment with new software capabilities in the development stage, and share your feedback directly with the development team.

Enable Experimental Features by clicking Experimental Features on the CAM2 Help screen and opting-in to each feature. *See "Help" on page 29.*

NOTE: To enable Experimental Features, you must first opt-in to the FARO Customer Experience Improvement Program.

By accepting the **Use Experimental Features**, you acknowledge that such features are not an integral part of CAM2 and that FARO cannot be held liable for the quality or continuity of any capabilities exposed via the Experimental Features. We recommend these features be used only in test files, not production files.

Screen Layout

The CAM2 screen contains the following areas.
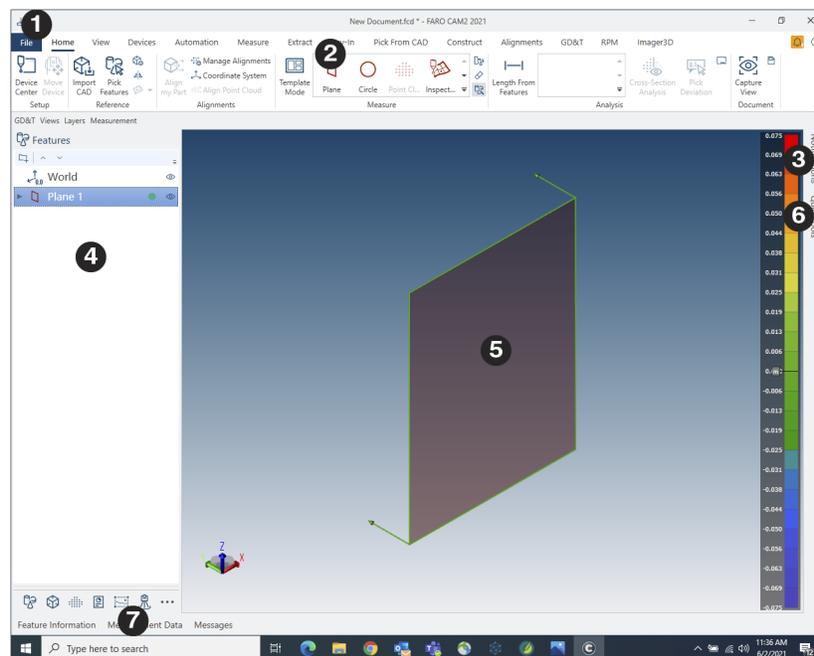
❶ **Quick Access Toolbar**. *See "Quick Access Toolbar" on page 23.*

❷ **Ribbon**. *See "Ribbon" on the next page.*

❸**Notification Center**. *See "Notification Center" on page 24.*

❹ **Navigation Window**. *See "Navigation Window" on page 24.*

❺ **Main Window**. This is the main view window for your part.

❻ **QuickTools** **Control Panel**. *See "QuickTools" on page 26.*

❼ **Messages**, **Measurement Data**, **and Nominals and Tolerances** **Control Panels**. *See Messages on page 26, Measurement Data on page 192, and Nominals and Tolerances on page 194.*

Figure 1-1 CAM2 Screen Layout

Ribbon

The CAM2 Ribbon is designed to help you quickly access the commands that you need to complete a task. Commands are organized into logical groups, which are collected together under tabs. Each tab relates to a type of activity, such as measuring a feature or configuring a measurement device.

Figure 1-1 CAM2 Ribbon

The contents of tabs are customized according to your needs. For example, the **Home** tab contains reporting commands when the **Reporting** panel is active.

To display a tab on the ribbon, move the pointer over the tab name and click the **Left Mouse** button.

Keyboard Shortcuts

Some commands on the CAM2 Ribbon also start using a single keyboard key, or Keyboard Shortcut.

You can configure a Keyboard Shortcut for any command on the Ribbon by right-clicking the command and selecting **Set Keyboard Shortcut**. Using the **Assign Keyboard Shortcut** dialog, you can view the existing Keyboard Shortcut for the command (if applicable), assign a new Keyboard Shortcut, or view the list of existing Keyboard Shortcuts in the application.

You can also view, edit, and print the list of CAM2 Keyboard Shortcuts by clicking **Shortcuts** on the **File** tab. *See "Shortcuts" on page 66.*

For a list of CAM2's Keyboard Shortcuts, see Keyboard Shortcuts and Shortcut Menus on page 307.

Default Tabs

At the top of your screen are the CAM2 tabs. These contain basic commands that you will regularly use.
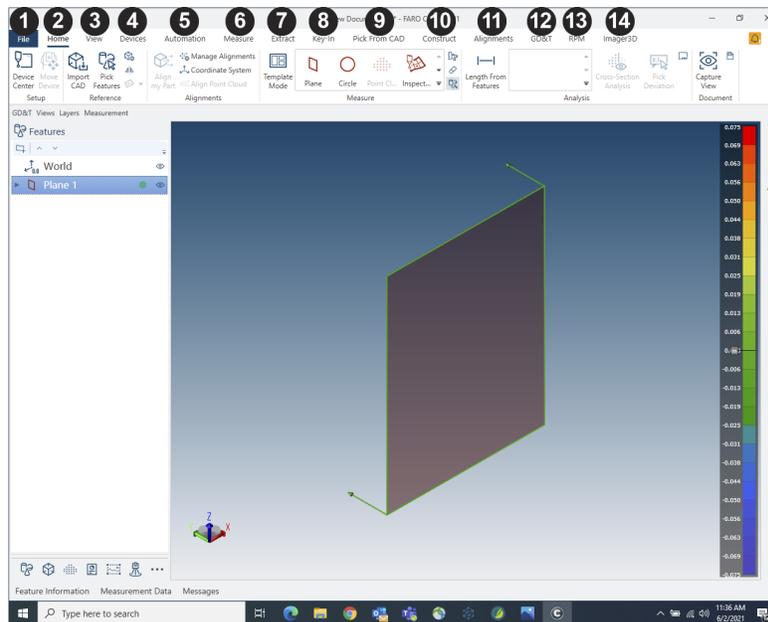
1 File Tab

2 Home Tab

3 View Tab

4 Devices Tab

5 Automation Tab

6 Measure Tab

7 Extract Tab

8 Key-In Tab

9 Pick From CAD Tab

10 Construct Tab

11 Alignments Tab

12 GD&T Tab

13 RPM Tab

14 Imager 3D Tab

Figure 1-1 Default Tabs

File Tab

The File tab allows you to access file commands (Open, Save, etc.), Import, Export, view and configure Preferences, and access Help. *See "File" on page 57.*

Figure 1-2 File Tab

Home Tab

The Home tab contains a basic workflow including setup, reference, alignment, measurement, and analysis commands. *See "Home" on page 95.*

Figure 1-3 Home Tab

NOTE: The contents of the **Home** tab change based on what you have selected in the Navigation Window. *For more information, see "Navigation Window" on page 33.*

View Tab

The View tab contains all the commands that affect how you see the contents of your measurement file on the screen. *See "View" on page 111.*

Figure 1-4 View Tab

Devices Tab

The Devices tab contains all the commands used to configure a measuring device. *See "Devices" on page 127.*

Figure 1-5 Devices Tab

Automation Tab

The Automation tab contains the commands used to automate your measurement processes. *See "Automation" on page 141.*

Figure 1-6 Automation Tab

Measure Tab

The Measure tab contains common commands for measuring. *See "Measure" on page 153.*

Figure 1-7 Measure Tab

Extract Tab

The Extract tab contains common commands for extracting geometric features from point clouds. *See "Extract" on page 199.*

Figure 1-8 Extract Tab

Key-In Tab

The Key-In tab contains commands to create Nominal features using data on drawings or spreadsheets. *See "Key-In" on page 203.*
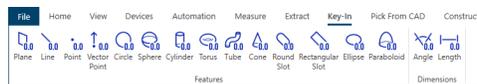
Figure 1-9 Key-In Tab

Pick From CAD Tab

The Pick From CAD tab contains commands to create Nominal features from CAD models that you add to the measurement file. *See "Pick From CAD" on page 217.*

Figure 1-10 Pick From CAD Tab

Construct Tab

The Construct tab contains commands to create Nominal features by construction. *See "Construct" on page 225.*

Figure 1-11 Construct Tab above

Alignments Tab

The Alignments tab contains Alignment and Coordinate System commands. *See "Alignments" on page 265.*
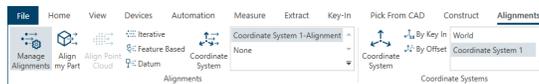
Figure 1-12 Alignments Tab

GD&T Tab

The GD&T tab contains Geometric Dimensioning and Tolerancing (GD&T) commands. *See "GD&T" on page 287.*

Figure 1-13 GD&T Tab

Point Cloud Alignments Tab

The Align Point Cloud tab contains Point Cloud Alignment commands. *See "Align Point Cloud" on page 269.*

Figure 1-14 Point Cloud Alignments Tab

Cross Section Analysis Tab

The **Cross-Section Analysis** tab contains all the commands that affect how you see a Cross Section Scan feature of your measurement file on the screen. *See "Cross-Section Analysis" on page 100.*

Figure 1-15 Cross Section Analysis Tab

NOTE: The **Cross Section Analysis** tab is only available when you select a Cross Section Scan feature (with readings) and click **Cross-Section Analysis** in the **Home** tab.

Image Creator Tab

The Image Creator tab contains Image Creator commands. *See "Image Creator" on page 50.*

Figure 1-16 Image Creator Tab

NOTE: The **Image Creator** tab is only available when you are using Image Creator.

Home Tab (CAD)

The **Home** tab contains the CAD commands. *See "CAD" on page 37.*

Figure 1-17 Home Tab (CAD)

NOTE: This **Home** tab is only available after you click CAD at the bottom of the Navigation Window. *See "CAD" on page 37.*

Home Tab (Point Cloud)

The **Home** tab contains the Point Cloud commands. *See "Point Cloud" on page 38.*

Figure 1-18 Home Tab (Point Cloud)

NOTE: This **Home** tab is only available after you click Point Cloud at the bottom of the Navigation Window. *For more information, see "Point Cloud" on page 38.*

RPM Tab

The **RPM** tab contains commands to interface CAM2 with CAM2® RPM.

Figure 1-19 RPM Tab

NOTE: The **RPM** tab is only available after you install CAM2 RPM.

Imager 3D Tab

The **Imager 3D** tab contains commands to configure your FARO 3D Imager. *See "FARO 3D Imager" on page 139.*

Figure 1-20 Imager 3D Tab Tab

Minimize the Ribbon

There is no way to remove or replace the ribbon with the toolbars and menus found in previous versions of CAM2. However, you can minimize the ribbon to increase available space on your screen.

1. Right-click the ribbon and select **Minimize the Ribbon**, or click the **Minimize Ribbon** icon (upper right).

To use the ribbon while it is minimized, click the tab you want to access, and then click the option or command you want to use when the ribbon expands. Click away from the ribbon, and the ribbon will minimize.

NOTE: To restore the ribbon to full visibility, right-click and select **Minimize the Ribbon** (or click the **Minimize Ribbon** icon) again.

Customize the Ribbon

You can customize the CAM2 Ribbon to arrange the tabs, command groups, and commands as needed to define your own workflow. Use this option to show and hide tabs on the ribbon, add or delete command groups for a tab, add, rearrange, and remove commands on each tab. *See "Ribbon" on page 16.*

1. Right-click the ribbon and select **Customize Ribbon** to display the **Ribbon Customization** window.

The left side of the **Ribbon Customization** window contains a list of all available commands in CAM2. Use the drop-down to switch between a master list and a grouped list of commands arranged by tabs. The right side of the window contains a view of all existing tabs and the command groups for each tab.

• Clear a check box to hide the corresponding tab or command group from the ribbon.

• Select a tab or command, and click **New > New Page** to create a new (empty) tab.

• Highlight a tab and select **New > New Group** to add a new (empty) command group to the tab.

• Highlight a command on the left side of the window and click the right arrow button to add the command to a group on the right side.

- Highlight a command on the right side of the window and click the left arrow button to remove the command from a group.

- Click the up and down arrow buttons to reorder a highlighted command within a tab.

Quick Access Toolbar

The Quick Access toolbar, located at the top left of the CAM2 title bar, consists of a group of frequently used command icons that you can enable for quick access, including Open, Save, Measure Mode, Coordinate Format, and Unit Format.

NOTE: Click Show Quick Access Toolbar Below the Ribbon to move the toolbar below the *Ribbon on page 16*.

Click the Quick Access Toolbar arrow and click a command to add it to the CAM2 title bar for quick access. Commands are added to the bar by the order in which you click them. Click the command name in the Quick Access Toolbar menu again to remove the command.

You may select up to five commands for quick access: Open, Save, Measure Mode, Coordinate Format, and Unit Format.

Open

Open opens a CAM2 measurement file (*.fcd or *.fcdx) that has been previously created, named, and saved. *For more information, see "Open" on page 58.*

Save

Save saves the current file as a CAM2 measurement file (*.fcd or *.fcdx). *For more information, see "Save" on page 58.*

Measure Mode

The **Measure Mode** check box controls the behavior of the Measure commands. *For more information, see "Measure Mode" on page 23.*

Coordinate Format

The measurement file's coordinate system, by default, is Cartesian. To work in another coordinate system (Cylindrical or Spherical), click **Coordinate Format** in the Quick Access Toolbar and select another coordinate system. This remains the same for all new files until changed again.

Figure 1-1 Coordinate Format menu

Cartesian

Point data is displayed in (x, y, z) format:

- x is the value along the x axis.

- y is the value along the y axis.

- • z is the value along the z axis.

Cylindrical

Point data is displayed in (ρ, φ, z) format:

- • ρ is the displacement from the origin in the xy plane.

- • φ is the rotation angle from the +x axis.

- • z is the value along the z axis.

Spherical

Point data is displayed in (ρ, φ, θ) format:

- • ρ is the displacement from the origin.

- • φ is the rotation angle from the +z axis.

- • θ is the rotation angle from the +x axis.

Unit Format

The measurement file's unit of measure, by default, is millimeters. To work in another unit of measure, click **Unit Format** in the Quick Access Toolbar and select another unit of measure. This remains the same for all new files until changed again.

Unit of Measure can also be controlled and configured as a Preference. *For more information, see "Units Tab" on page 74.*

Figure 1-2 Units menu

Notification Center

The Notification Center, located at the top right of the CAM2 title bar, is an automatic notification system which notifies you of issues that need attention, when new versions are available, and other important messages. New notifications appear flagged; click the flag to read the notifications. When you're finished, click **Dismiss All** to clear all notifications from the Notification Center.

Navigation Window

The **Navigation** Window contains all of the CAD parts and features in your measurement file, and also controls the mode in which CAM2 behaves. It is subdivided into Features, CAD, Point Cloud, Report, Image Creator, and Survey sections.
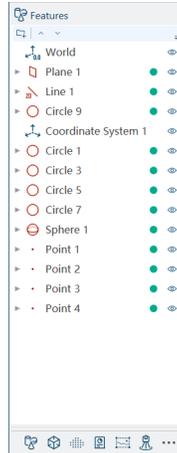
Figure 1-1 Navigation Window

Control Panels

Control Panels are windows that contain all or some of the following:

- menu and submenu commands

- feature data

- an edit box to change a parameter of an item

- a check box to show/hide items

- tree lists of items and sub items

On the right and bottom edges of the **Main Window** are control panels which contain many of the common commands. Each control panel appears as a tab when not in use. The **QuickTools** tab is on the right side, and the **Messages**, **Measurement Data**, and **Feature Information** tabs are on the bottom.

- Click on a tab to display a control panel. Click and drag the tab onto the **Main Window** and the panel automatically collapses and hides.

- Click **Auto Hide** in the upper right corner of the panel to keep the panel's title bar visible.

- Click **Close** in the upper right corner to close a panel.

NOTE: Use **View > View Closed Panels** to control the visibility of the control panels. *See "Panels" on page 122.*

Moving and Docking Control Panels

CAM2 control panels may be moved, arranged, and docked to customize your layout.

Moving a Control Panel

To move a panel, left-click and hold the panel's title bar or tab name. Drag the panel with the mouse to the desired location and release the button to release the panel.

Reordering Control Panel Tabs

Left-click and hold the panel's tab name. Drag the tab to the desired location and release the mouse button.

Docking Icons

Docking Icons appear when you left-click and begin to drag a panel. Drag and release the panel onto one of these icons to instantly dock the panel at the extreme right, left, top, or bottom of the screen (depending on the corresponding icon's arrow). The icons disappear when the panel has been released.

Hiding a Control Panel

Right-click and choose Hide. Use **View Closed Panels** to show the panel. *See "View Closed Panels" on page 112.*
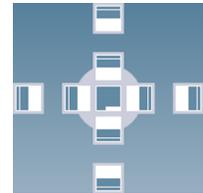
Messages

The **Messages** panel contains informational messages relating to the measurement file.

Figure 1-1 Messages panel

QuickTools

The **QuickTools** panel contains all of the QuickTools commands in your measurement file.
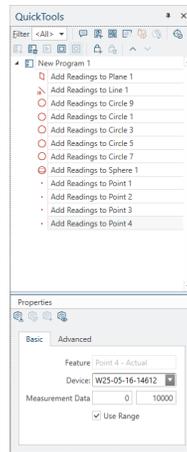
Figure 1-1 QuickTools panel

Views

The **Views** panel contains all of the captured views of your measurement file.

Figure 1-1 Views panel

GD&T

The **GD&T** panel contains GD&T attributes for a selected feature, and is used in conjunction with the GD&T Tab. *See "GD&T Tab" on page 20.*

Figure 1-1 GD&T panel

Measurement Data

The **Measurement Data** panel contains the data for each individual reading, or measurement point, of a feature. It also contains readings for best fit constructions.

Figure 1-1 Measurement Data panel

Feature Information

The **Feature Information** panel contains nominal and tolerance information for each feature in your measurement file.

Figure 1-1 Feature Information panel

Controlling the View

You can manipulate and rotate the contents of the **Main Window** using your mouse.

To manipulate the view:

1. Click and hold the **Right Mouse** button.

2. Drag the mouse left, right, up, and down to move the view.

3. Release the **Right Mouse** button to set the view.

To rotate the view:

1. Click and hold the **Left Mouse** button. This changes the mouse pointer to the rotate icon.

2. Drag the mouse left, right, up, and down to rotate the view.

3. Release the **Left Mouse** button to set the view.

NOTE: Keyboard Shortcuts are available to pan, zoom, and rotate the view. *For more information, see "Keyboard Shortcuts" on page 308.*

Center of Rotation

By default, the rotation center in a new measurement file is the World Coordinate System. Once you've added features and/or CAD to the file, the rotation center becomes the center of all entities (features and CAD) in the measurement file.

You can also change temporarily change the center by left-clicking a feature or CAD surface and dragging the mouse cursor to rotate the view around the center of that feature or surface.

Features

CAM2 Features are the geometric objects that you add to the measurement file. There are four types of CAM2 Features:

- **Measured:** a feature that you create using a measurement device. *See "Measure" on page 153.*

- **Constructed:** a feature that you create from other features or keyed-in values. *SeeConstruct From Selected Features on page 263 and Key-In on page 203*.

- **Dimensioned:** a length or angle calculation between two or more existing features. *See "Dimensions" on page 257.*

- **Nominal:** a feature that is the theoretical, or design, value of a measurement. You create nominals from CAD models, or entered values.

Selecting Features

You may have to select or deselect features that were created in CAM2. To select a feature on the screen, place the pointer over any part of a feature and press the **Left Mouse** button. Selected features appear in **red**. To deselect a feature, click the selected feature again with the **Left Mouse** button.

Device-controlled Mouse

When you use a measuring device with CAM2, the position of the probe controls the mouse pointer. The standard mouse also controls the pointer. *For more information, see "Use Arm as Mouse " on page 78.*

> **NOTE:** Some measurement devices that operate with CAM2 do not constantly send positional data to CAM2, so this command may not work properly. Refer to the user manual included for your device.

CAM2 recognizes which measurement device is active and selects that device for the pointer control. After starting a measurement command, CAM2 only accepts control from the current measurement device and blocks any input except digitized points.

> **NOTE:** The pointer changes from the single arrow mouse pointer to the **Device** icon when CAM2 accepts data from the input device.

Dynamic Device Camera

CAM2's dynamic device camera view displays features as they are measured in the Main window, looking from the device probe.

Pre-Alignment: When picking the nominal features, the view will dynamically adjust to guide you. You can also manually rotate and zoom the view. After you create an alignment, CAM2 reactivates the dynamic camera.

Features With Nominals: If an alignment exists and features containing nominals are measured, the zoom will dynamically adjust based on the probe distance from the feature. This ensures both the probe and nominal feature are visible during the guidance and measurement process.

Features Without Nominals or via Automatic Feature Recognition: If no nominal features exist or Automatic Feature Recognition is used to measure the feature, the zoom will dynamically adjust to display both probe and the captured readings. *See "Automatic Feature Recognition" on page 188.*

When all measurement steps are complete, CAM2 will automatically adjust the view to display all features.

Help

Click **Help** or select **File > Help** to access CAM2's Help screen. From here, you can access Help files for CAM2, FaroArms, FAROLaser Trackers, and the FARO Cobalt. You can also access program logs, the CAM2 Experience Index, the Customer Experience Improvement Program, Experimental Features, the document history, and licensing information. When necessary, you can contact FARO Customer Service and generate support data (a single compressed file which can be emailed to FARO Customer Service).
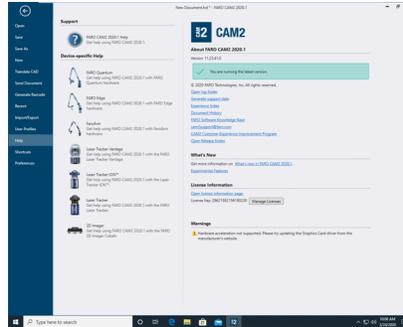
Figure 1-1 CAM2 Help Screen

Online Help

CAM2's Help contains system-based information to enhance your use of the application.

NOTE: Help for measurement commands is available in the **Edit Feature** dialog box for each feature. Select the feature and then select **Edit > Properties**.

When the Online Help appears, select the **Contents**, **Index**, or **Search** tab to open specific help files.

- **Contents** opens a series of books. Double-click the book you want with the **Left Mouse** button, or single-click the book and click **Open**. If you see another book, continue clicking that selection until you see a topic name.

- A topic has a **Question Mark (?)** icon in front of its name. Double-click the topic name to open the topic. Within a topic, you may have additional links directing you to other topics for further information. Click the appropriate link to go to another topic.

- On the **Index** tab you can type the first few letters of topic or word. You can also scroll down to your topic using the scroll bar. Double-click your selection with the **Left Mouse** button, or single-click to highlight the topic and click **Display**.

- The **search** tab allows you to type words and search the whole document for the different topics using the word(s) you selected. Type the word(s) in the space provided in the first window and click **List Topics**.

Electronic Manual

You can open an electronic version of the CAM2 Users Manual with Adobe Acrobat Reader, which is included with your CAM2 USB.

- A Table of Contents is on the left-hand side of your screen under the **Bookmarks** tab. Clicking a bookmark takes you to the selected section.

- You can also search the manual by using **Edit > Find** (**Ctrl+F**).

Using Acrobat Reader Help

Adobe Acrobat Reader has its own electronic manual if you need help. Running Acrobat Reader HELP inside the Acrobat Reader application opens the Acrobat Reader electronic manual.

What is New

The following sections describe new functions and commands that have been added to CAM2, as well as the enhancements made to existing CAM2 commands.

General

FARO InTouch - A software distribution and management application which streamlines the downloading, installation, updating, and execution of FARO software such as CAM2 and RPM. *See "FARO InTouch" on page 10.*

Dynamic Device Camera Improvements - View features as they are measured in the **Main** window, looking from the device probe. *For more information, see "Dynamic Device Camera" on page 29.*

Viewer Performance Improvements - Translation, rotation, and zoom of features and CAD within the **Main** window have been vastly upgraded.

Identification of Features - The Features list displays feature type icons indicating the operation which created the feature. *For more information, see "Features" on page 34.*

Experimental Features - Experiment with new software capabilities in the development stage, and share your feedback directly with the development team. *For more information, see "Experimental Features" on page 15.*

Help

Generate Support Data - Collect and create a single compressed file which can be emailed to FARO Customer Service. *See "Help" on page 29.*

File Tab

Auto Update Report - Control the automatic update of reports as changes are made. *See "Auto Update Report" on page 93.*

Translate Hidden Entities - Specify whether the CAD translation includes wireframe items such as lines and curves. *See "Translate CAD" on page 58.*

Material Compensation Mode - Use three new methods to compensate for material when measuring: Fixture B Side, Part Thickness, and Clamp. *See "Material Compensation Mode " on page 84.*

View Tab

Display Point Cloud Excluded Points - Show and hide point cloud readings excluded by the Point Distance Filter. *See "Display Point Cloud Excluded Points" on page 1.*

Labels - A new labeling engine provides the ability to display feature information annotations in the 3D viewer and report images. *See "Labels" on page 118.*

Automation Tab

Generate QR Code - Add a QuickTools program step to generate a QR code from an existing report. *See "Generate QR Code" on page 147.*

CAD View Commands - Preview a saved CAD View from a QuickTools program step, whether or not you are running a QuickTools program. *See "CAD View Commands" on page 150.*

Alignments Tab

The Manage Alignments and Alignments interfaces have been streamlined to provide a more intuitive experience. *See "Alignments" on page 265.*

Reports

Company Details - Add custom company details to display on the header of the first page of the default report templates. *See "Report" on page 92.*

Chapter 2: Navigation Window

On the left side of the screen is the **Navigation** window. This window is divided into six sections: Features, CAD, Point Cloud, Report, Image Creator, and Survey.
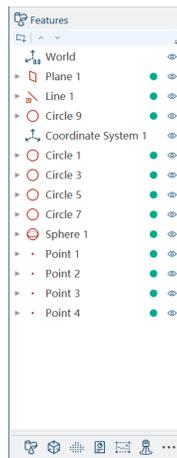
Figure 2-1 Navigation Window

Features

The Features section of the **Navigation** window shows every measured, constructed, and nominal feature in your measurement file. A graphic to the left of the feature name indicates the feature type:

- **Measured/Constructed/Dimension**: The geometric graphic to the left of the feature name.

- **Nominal**: The geometric graphic to the left of the feature name and a target graphic to the right of the feature name.

NOTE: This content of this panel changes if you select **Report** or **Survey**. *For more information, see Report on page 45 and Performing a Survey on page 55.*

Selecting Features

Selecting a feature in the **Navigation** window highlights the feature in the **Main Window**.

- To select a single feature, click the name of the feature with the **Left Mouse** button.

- To select multiple features in consecutive order, hold down the **Shift** key and left-click the first (top) feature, then click the last feature you want.

- To select a group of features not in consecutive order, hold down the **Ctrl** key and left-click each feature you want selected.

Double-click a feature to edit its Properties. *For more information, see "Properties" on page 108.*

Right-click on a selected feature, or multiple features, to quickly start some commands from the Shortcut Menus. *For more information, see "Shortcut Menus" on page 310.*

Naming a Feature

Every feature in a measurement file is given a default name. To change a feature name:

1. Select a feature in the **Navigation** window.

2. Click the feature name again, or press the **F2** key to edit the name.

3. Type a new name and press the **Enter** key to continue.

Renaming Multiple Features

You have the option to rename multiple features at once. To change multiple feature names:

1. Select multiple features in the **Navigation** window.

2. Right-click the selection and choose Rename.

3. Type a new name to be applied to all of the features and click **OK**.

Feature Status Indicator

There are several visual indicators that show you a quick status of the features in your measurement file.

When you measure an existing feature, the feature will appear in **red**.

To the left of the feature is a geometric icon to indicate the feature type. If this icon and the feature name appear in gray, the feature is unsolved. *See "Unsolved Features" on page 330.*

To the right of some features is a Status Indicator graphic. This shows you a quick status of the features in your measurement file. The graphic depends on the status of the feature:

- Black target - Nominal feature.

- **Green** check mark - the feature is in tolerance.

- Flag - the feature is out of tolerance or unsolved.

    - Gray - the feature has no data, or not enough to solve.

    - **Red** - measurement is above the upper tolerance.

    - **Blue** - measurement is below the lower tolerance.

NOTE: Gray and **Green** flags are straight, **Blue** lean to the left and **Red** lean to the right.

Show and Hide Features

To the extreme right of all features is the **Visibility** icon (eye icon). Click the **Visibility** icon to hide a feature. Once hidden, the icon and feature name appear gray. Click the **Visibility** icon again to show the feature.

When hidden, features remain in the feature tree but are not shown in the CAD view.

Feature Association

When you use CAM2 to compare actual (measured and constructed) data to nominal data, both features associate. The association name automatically uses the nominal feature name. Changing the nominal feature name updates the associated name. To associate a measured and nominal feature:

- Drag any nominal feature to a measured or constructed feature.

- Select the measured feature and use the **Feature Information** panel. *See "Nominals and Tolerances" on page 194.*

- Select a nominal feature and **Measure**.

In the feature association, a prefix automatically appends each feature name: "Actual" to the measured feature, and "Nominal" to the nominal feature.

- Click the **arrow** to the left of the feature association's name to expand and collapse the association and hide the features.

NOTE: The Properties of a feature association are the measured or constructed feature properties. *See "Properties" on page 108.* Deleting an association name only deletes the measured or constructed feature. Expand the association and select each contained feature to delete the nominal feature.

Reordering Features

You can change the order of features as shown in the **Navigation** window.

1. Select one or more features in the **Navigation** window to move.

2. Click the Up arrow at the bottom of the panel to move the feature up in the list; or, click the Down arrow to move the feature down in the list.

3. You can press and hold the **Shift** key and drag the feature up and down the list.

NOTE: Dragging a feature *without* pressing and holding the **Shift** key is for grouping nominal and measured/constructed features.

Feature Grouping

When you work with a large number of features, it can be helpful to organize them using groups. To create a feature group folder:

- Click the New Folder icon in the **Navigation** window.

- If desired, edit the default name (Group 1).

- Drag any feature or group onto the folder and release the mouse button.

NOTE: Smart Naming Tab and Show/Hide also apply to folders. *For more information, see Smart Naming Tab on page 76 and Show/Hide on page 114.*

Folder Properties

You can use folders to report features in multiple coordinate systems within the same report. Right-click a folder and select Properties to view the Feature Editor window for the folder. In this window, you can assign a coordinate system, coordinate system type, and unit of measurement for the contents of the folder.

Capture View Data

Right-click a folder and select Capture View Data to assign a specific CAD view to the folder. To change the captured view, change the view as desired, right-click the folder and select Capture View Data.

In the report, this CAD view adds just above the features in the group. *See "Adding Pictures" on page 52.*

CAD

The CAD section of the **Navigation** window shows every CAD feature in your measurement file, and contains a workspace for you to import CAD, edit CAD properties, and fix CAD normals. The commands on the **Home** tab are organized into Reference, Layers, Selection Tools, and Normals groups.

Selecting CAD

Selecting a feature in the CAD section **Navigation** window highlights the CAD feature in the **Main Window**.

- To select a single CAD feature, click the name of the feature with the **Left Mouse** button.

- To select multiple CAD features in consecutive order, hold down the **Shift** key and left-click the first (top) feature, then click the last feature you want.

- To select a group of features not in consecutive order, hold down the **Ctrl** key and left-click each feature you want selected.

Double-click a CAD feature to edit its Properties. *For more information, see "Properties" on page 108.*

Right-click on a selected CAD feature, or multiple CAD features, to quickly start some commands from the Shortcut Menus. *For more information, see "Shortcut Menus" on page 310.*

Show and Hide CAD

To the extreme right of all CAD features is the **Visibility** icon (eye icon). Click the **Visibility** icon to hide a CAD feature. Once hidden, the icon and CAD name appear gray. Click the **Visibility** icon again to show the feature.

When hidden, CAD features remain in the feature tree but are not shown in the Main Window.

Reference

The **Reference** group contains Import CAD and Part Properties commands. *For more information, see Import CAD on page 96 and Part Properties on page 96.*

Layers

The **Layers** group contains the commands for adding, editing, and deleting layers. *For more information, see "Layers" on page 112.*

Adding Features to a Layer

Existing layers are at the top of the list. You can assign any feature in the **Navigation** window to a layer:

- Click features in the **Navigation** window and drag them onto a layer.

- Right-click any feature in the **Features** panel, point to **Assign a Layer**, and choose a layer from the menu.

Selection Tools

The **Selection Tools** group contains the commands for selecting multiple CAD entities. *For more information, see "Selection Tools" on page 38.*

Normals

The **Normals** group contains the Fix Normals command.

⬚ Fix Normals

Fix Normals opens Fix Normals mode. Use Fix Normals mode to change the vector orientation of CAD bodies. Select a CAD file in the **Navigation** window and click **Fix Normals**.

When you open Fix Normals mode, your CAD surfaces will be colored according to their vector orientation relative to the screen:

- **Gray** surface normals are pointing towards the screen, and thus represent good surfaces.

- **Red** surface normals are pointing away from the screen, and represent surfaces that may be inverted relative to the CAD model. You can fix the normals of red surfaces.

Click a **Red** (inverted) surface to flip the surface orientation. Once clicked, the surface color becomes gray, indicating corrected orientation. Fixed (flipped) CAD bodies are appended with a corresponding "flipped" icon in the **Navigation** window.

In some situations, surfaces with high degrees of curvature may point both towards and away from the screen. You will need to determine the optimal orientation.

NOTE: If you invert one surface of a CAD body, all surfaces of that CAD body will invert. If Fix Normals results in a CAD body with both correct and incorrect surface orientations, consider importing a revised CAD file with correct surface orientation.

⋮⋮⋮ Point Cloud

The Point Cloud section of the **Navigation** window contains a workspace for you to edit captured point clouds. The Point Cloud workspace contains only point clouds (no other features), and the **Home** tab displays point cloud editing commands. The commands on the **Home** tab are organized into Selection Tools, Edit Tools, Registration, Filtering, and Smoothing groups.

NOTE: If you are using the Probing Version of CAM2, the Point Cloud workspace is not available. *See "Probing Version" on page 9.*

Selection Tools

The **Selection Tools** group contains commands to select portions of point cloud data for editing: Rectangular, Lasso, Polygon, Brush, Invert, and Clear.

The selection tools select all points contained within an area, including visible points and those that may be hidden from view.

NOTE: If you have already selected points, press and hold SHIFT while selecting to add new points to the existing selection. Press and hold CTRL while selecting to remove points from the existing selection.

NOTE: To change the **Main** window view while you select points, press SPACE to switch the mouse mode to view manipulation. When you've changed the view, press SPACE again to switch back to selection mode.

Rectangular

Rectangular selects points using a rectangular (or square) shape. Hold the left mouse button and drag the mouse to begin a rectangular selection around the point cloud data you want to select. Release the mouse button to create the selection.

Lasso

Lasso selects points in a freehand shape. Hold the left mouse button and drag the lasso around the point cloud data you want to select. Release the mouse button when you return to your starting point.

Polygon

Polygon selects points using outlines based on straight-sided polygonal shapes. Click the left mouse button to add an anchor point on the point cloud. As you move the mouse from the point, a thin straight line extends from the anchor point to your mouse cursor. Click again to add a second anchor point, then release your mouse button to join points with the straight line. Continue to add new lines until you end at your first anchor point, completing your polygonal selection.

Brush

Brush selects points in a freehand shape. Hold the left mouse button and drag the mouse to select points. Release the mouse button to create the selection.

NOTE: You can adjust the brush thickness in the upper left corner of the **Main** Window.

Invert

Invert selects the inverse of your currently selected points. Click **Invert** to invert the selection.

Clear

Clear deselects your currently selected points. Click **Clear** to undo the selection.

 Select Bad Points

Select Bad Points selects bad point cloud points. Click **Clear** to undo the selection.

 Front Facing

Front Facing specifies that the selection tools will only include points with normal vectors facing the screen, excluding all points facing away from the screen.

Edit Tools

The **Edit Tools** group contains commands to edit selected portions of point cloud data: Paste New, Cut, Copy, Paste, Split, Merge, and Delete.

 Paste New

Paste New pastes the contents of your clipboard into a new point cloud. This command is only active if you have either copied or cut points from a point cloud.

 Cut

Cut removes the selected points from the point cloud. You can paste the points into an existing or new point cloud.

 Copy

Copy copies the selected points to your clipboard. You can paste the points into an existing or new point cloud.

 Paste

Paste pastes the contents of your clipboard into an existing point cloud. This command is only active if you select a point cloud in the **Features** panel and you have either copied or cut points from a point cloud.

 Split

Split creates a new point cloud from a selection of points. The points are removed from the source point cloud and placed into a new point cloud.

 Merge

Merge combines two or more groups of points into a single new point cloud.

 Delete

Delete permanently removes the selected points from the point cloud.

 Registration

Registration is the joining of two or more spatially disjointed point clouds using common references, effectively stitching multiple point clouds into one.

- Click **Open** to access Registration mode. The **Main** window will split into two halves to facilitate registration.

- Select representative pairs of points from each point cloud by clicking corresponding scan areas in each half of the **Main** window. Point pairs share a common color and number.

- When you have selected at least three point pairs, you can register the scans.

The Registration commands are located in the **Registration** tab across the top of the screen, and the commands are organized into Registration, Import, Edit Tools, View, and Close groups.

 Registration (Group)

The **Registration** group contains the Set Static, Set Movable, Preview, Register, and Unregister commands.

 Set Static

Set Static designates a selected point cloud scan or Registration group as the fixed scan in the registration process. The fixed scan is stationary during the registration process and appears in the left or top **Main** window. A new static assignment will replace any previous placement.

> **NOTE:** You can also drag a point cloud or group from the list onto the left or top **Main** window to designate it as the fixed scan.

 Set Movable

Set Movable designates a selected point cloud scan or Registration group as the movable scan in the registration process. The movable scan moves during the registration process and appears in the right or bottom **Main** window. A new movable assignment will replace any previous placement.

> **NOTE:** You can also drag a point cloud or group from the list onto the right or bottom **Main** window to designate it as the movable scan.

Preview

Preview enables a registration preview mode which updates as you create point pairs. Click **Preview** again to exit preview mode.

NOTE: Preview mode is only available after you choose 3 point pairs.

Register

Register calculates the registration of the left and right (or top and bottom) **Main** windows based on the points you picked. After registration, the scans are placed into a Registration Group folder in the point cloud list. The new group can be used for further registration.

Unregister

Unregister negates the registration calculation of a selected scan or group.

Fine Registration

Fine Registration solves all of the registered point clouds simultaneously in order to distribute the error and improve the overall fit of the registration group.

NOTE: This can be a very time-consuming calculation, especially with a large number of point clouds.

Import

The **Import** group contains the Import Reference Targets command. **Import Reference Targets** from text files (*.txt) or Scanlink binary files.

Edit Tools

The **Edit Tools** group contains the Clear Points, Merge, and Merge All commands.

Clear Points

Clear Points removes all point pairs from the scans in the **Main** windows.

Merge

Merge combines two or more scans or registration groups into a single merged point cloud which appears in the Individual folder.

Merge All

Merge All combines all scans and registration groups into a single merged point cloud which appears in the Individual folder.

View

The **View** group contains the Vertical, Horizontal, Display, and Lock Viewers commands.

Vertical

Vertical splits the **Main** window into left and right panels.

Horizontal

Horizontal splits the **Main** window into top and bottom panels.

Display

Display filters the **Main** window contents as follows:

- **Both** - View scanned point cloud data and targets.

- **Point Cloud** - View scanned point cloud data only.

- **Targets** - View scanned targets only.

Lock Viewers

Lock Viewers protect the contents of the **Main** window panels from user input.

Close

The **Close** group contains the Close Registration command, which exits Registration mode and returns you to Point Cloud Editing mode.

Filtering

Filtering allows you to reduce the number of points in point clouds while still maintaining the characteristics of the scanned object.

Filtering Types

There are 3 different types of filters:

- **Grid filtering:** specify a grid spacing, and CAM2 preserves only one point within a cube of the specified size. For example, a 1 mm grid spacing allows only one point within a 1 mm distance of any other point.

- **Curvature filtering:** in conjunction with grid spacing, curvature filtering preserves point density in areas of higher curvature and preserves fewer points in flatter areas. CAM2 automatically calculates the maximum angle between two adjacent points in the resulting point cloud.

- **Density filtering:** reduce the point cloud to a fixed size. Relative point density is maintained; areas with higher and lower point density will keep their respective densities.

Apply Filtering

To apply a filter to a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click the **Filters** drop-down and select a filter.

Clear Filtering

To clear a filter from a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click **Clear Filter**.

Custom Filtering

You can also create a custom point cloud filter. To create a new filter:

1. Click the **Filters** drop-down and choose **New Filter.**

2. In the **Point Cloud Filter** dialog, enter the name, filter type, and filter parameters.

3. After you create the filter, you can apply it to a point cloud.

Delete Exclusions

To permanently delete filtered points from a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click **Delete Exclusions**.

Smoothing

Smoothing allows you to refine **"noisy"** point cloud data to achieve a smoother surface.

Smoothing differs from Filtering, in that Smoothing computes new points from existing points using user-defined grid-based data organization.

Smoothing Types

There are 2 different types of smoothing methods:

Center Grid: smoothing results in a point cloud containing one point inside any grid cell with one or more points. This creates a very organized grid-like point pattern.

Grid Average: averages the positions of all points within a given grid cell, and the average point represents the grid. This creates a smoother, yet less organized point cloud than Center Grid smoothing.

Apply Smoothing

To apply smoothing to a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click the **Smoothing** drop-down and select a smoothing method.

Clear Smoothing

To clear smoothing from a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click **Clear Smoothing**.

Custom Smoothing

You can also create a custom point cloud smoothing. To create a new smoothing:

1. Click the **Smoothing** drop-down and choose **New Smoothing.**

2. In the **Point Cloud Smoothing** dialog, enter the name, smoothing type, and smoothing parameters.

3. After you create the smoothing, you can apply it to a point cloud.

Delete Exclusions

To permanently delete smoothed points from a point cloud:

1. Select the Point Cloud in the **Features** panel.

2. Click **Delete Exclusions**.

Report

CAM2 employs the DevExpress[TM] reporting engine and layout editor. The robust DevExpress engine has been incorporated into CAM2 to provide dynamic, customizable reports in many file formats.

Reporting Overview

Figure 2-1 Sample CAM2 Report

The DevExpress engine creates customizable reports based on an XML schema that are automatically formatted for the page. The XML Schema is published with the software:
\Program Files\FARO\CAM2\Schema\.

Report data is continually updated as the measurement file data changes.

Report Templates

CAM2 automatically detects new report templates that are placed in the proper directory:
\My Documents\CAM2\Templates\Reporting.

NOTE: It is good practice *not* to replace any of the default CAM2 templates because reinstalling or updating the software will replace all of the default templates.

Editing a Report Template

Select a report format from the **Home** tab and click **Edit Layout**. This starts the DevExpress template editor.

- Select **File > Save As** and save the template with a new name so that you do not accidentally replace the default CAM2 report template.

- The report template is divided into four sections:

  - **PageHeader:** Use this area to add items that will show on the top of every page.

  - **Report:** This is a title section for the first page of the report. The logo image filed is in the upper left corner of this section. All other fields are Labels. Add, arrange, remove, or edit the existing labels.

- **DetailReport:** This section uses the data from the CAM2 file following the current **Active Report List**. Show or hide individual feature data using the **Feature Information** panel. *For more information, see "Nominals and Tolerances" on page 194.*

- **PageFooter:** Use this area to add items that will show on the bottom of every page. Every CAM2 report template has the Page Info field in this section.

Logo Customization

You can change the logo image displayed in default report templates. The file name is specified in the application preferences, and the image size is 3" x 1" with a resolution of 300 dpi.

You can change the report logo image in the **Report** section of the **Preferences and Settings** window. *Logo on page 93*

Document Properties

Extra data (metadata) for a report is stored within the document properties. Document properties are configured in the **Document Header Information** window. *For more information, see "Document Header Information" on page 107.*

This list is not fixed; plug-ins may register additional document properties which will appear in the editor. Document properties are arranged into logical groups (typically by the plug-in that registers them).

NOTE: A plug-in may also override a default document property if it provides duplicate functionality (e.g. Part name in the SPC Graph plug-in).

Reporting Interface

The **Report** window provides an always-available report display that continually updates to reflect measurement file data changes. It resides at the same level as the Main Window, and as such cannot be displayed at the same time as the Main Window.

Click **Report** on the Navigation Window to access the **Report** Window.
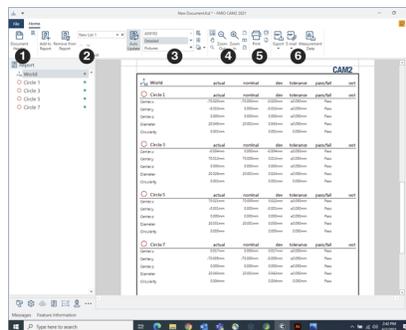
Figure 2-1 Report view

Using the Features Panel

If you select features in the Navigation Window and then click **Report**, a new **Report** list creates and automatically adds the features. There is a CAM2 preference to control this behavior. *See See "Generate From Selection " on page 93..*

Report List

Click **Report** and the **Report** list replaces the **Feature** list in the Navigation Window. You should create a name for the **Active Report** before adding or removing features.

NOTE: This content of this panel changes if you click **survey** or **Image Creator**.

You can create one or more **Active Reports** under a specific name within the measurement file.

To create a list:

- Enter a name in the combo, replacing the *New List 1* default text.

- Press **Enter**.

NOTE: **Active Reports** are automatically saved as you change them. Saved **Active Reports** are stored within the measurement file and may not be used across different measurement files.

Recall an existing **Active Report** by selecting it from the drop-down list box on the **Home** tab.

Delete an existing **Active Report** by selecting it from the drop-down list box and clicking **X** next to the drop-down arrow.

Operations

In the Navigation Window, the features in the **Report** list are included in the report; other features are not. The features are reported in the order they appear in the list. All operations are multi-select capable.

To add a feature to the **Report** list:

- Click **Include Features.**

- Select one or more features in the **Include Features** window, and click **Add**.
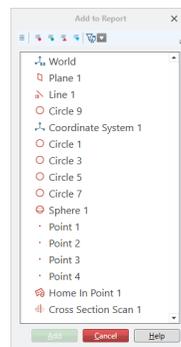
Figure 2-1 Include Features

To remove a feature from the **Report** list:

- Select a feature in the **Report** list.

- Click **Exclude Feature**.

To reorder the features in the **Report** list:

- Select a feature in the **Report** list and drag it up or down the list. Or, select a feature and use the up or down arrows on the **Home** tab.

NOTE: The data contained in the current report automatically updates as features are added, moved, and deleted in the **Report** list.

To add captured View Data to the **Report** list:

- Click **Include Features.**

- Select a captured view in the **Include Features** window. *See "Capture" on page 121.*

- Drag & drop the captured view to place in the required list position.

For more information, see "View Data" on page 121.

Standard Home Tab Report Commands

Document Header: View and edit the current measurement file's document properties. *See "Document Header Information" on page 107.*

Find: Enter text to find in the report.

View and Print Keyboard Shortcuts: View, edit, and print CAM2 Keyboard Shortcuts. *See "Shortcuts" on page 66.*

Include Features: View a list of features in the measurement file, and select one or more to add to the Report List.

Exclude Features: Remove one or more features from the Report List.

Report List: Create, select, and delete a Report List.

Move Up: Move a selected feature up the Report List.

Move Down: Move a selected feature down the Report List.

Layout: Select a report layout.

Edit Layout: Opens the DevExpress report editor containing the selected layout.

Choose Watermark: Add text or a picture to the background of the report page.

Choose Background: Add a background color to the report page.

Select: Use this tool to select an item on the report.

Hand Tool: Use this tool to move the report around the **Report** window.

Zoom Tools: Adjust the printed scale of the report, zoom in, or zoom out of the report in the **Report** window.

One Page: Zoom the entire report to fit one page in the window.

Two Pages: Zoom the entire report to fit two pages in the window.

Page Width: Zoom the entire report to the width of the window.

Print: Select the printer, page range, and number of copies for the report.

Quick Print: Send the report to the current printer.

Page Setup: Adjust the printer page.

Export: Export the report. *See "E-mailing/Saving a Report" below.*

E-Mail: E-mail the report. *See "E-mailing/Saving a Report" below.*

Measurement Data: Export the report's measurement data into a custom format.

E-mailing/Saving a Report

E-mail or Save the report in the following formats: PDF, HTML, MHT, Rich Text, Excel, CSV, Text, and Graphic (BMP, EMF, WMF, GIF, JPEG, PNG, TIFF). Not all formats are available for E-mail and Save.

An e-mail message opens using the default e-mail application with the report file attached. You can edit the message/subject prior to sending.

Printing a Report

Click **Print** to access the **Print** dialog and send the active report to a printer.

Selecting a Report Template

Report templates are listed in the **Home** tab. Selecting a report template in the combo box makes it the active template and the report is updated immediately to reflect the change.

Image Creator

Image Creator on the **Navigation** window enables CAM2's Image Creator, which allows you to add pictures to a QuickTools program step to enhance the automated measurement process.

These pictures appear in the **Measurement** panel when the program is playing. For each **Add Readings**, you can create a single picture or a picture for each reading in the program step.

Image Creator Commands

The Image Creator commands are located in the Image Creator tab across the top of the screen. The Image Creator tab contains all of the commands to create and edit images for QuickTools program steps. The commands on the Image Creator tab are organized into General, Image, Probes, and Zoom groups. *See "Image Creator Tab" on page 21.*

NOTE: While using Image Creator, you can also access the Automation Tab to manage QuickTools programs and the Default Tabs for other common operations. *See Automation Tab on page 18 and Default Tabs on page 16.*

General

The **General** group contains the Properties command.

Image

The **Image** group contains all the commands necessary to add, manage, and base images.

Add

Add adds a new base image to Image Creator.

Remove

Remove deletes a base image from Image Creator.

Replace

Replace changes the base image associated with a QuickTools program step. Select a new image.

Probes

The **Probes** group contains all the commands necessary to add, manage, and delete probe markers.

Reading

Reading adds a reading marker to a base image.

Reading Outside

Reading Outside adds an outside reading marker to a base image.

Reading Inside

Reading Inside adds an inside reading marker to a base image.

Retract

Retract adds a retract point marker to a base image.

Back Button

Reading adds a back button marker to a base image.

Swipe

Swipe adds a swipe reading marker to a base image.

Curl

Curl adds a curl reading marker to a base image.

Zoom

The **Zoom** group contains all the commands necessary to increase and decrease zoom levels for probes and base images.

Zoom Point

Zoom Point zooms a selected marker in or out.

Zoom Image

Zoom Image zooms a selected base image in or out. You can use the slider as well as your mouse's scroll wheel to set the image zoom and 2D offset.

NOTE: In addition to zooming a base image in and out, you can also pan them left, right, up, or down to create the optimal view to complement the corresponding QuickTools program step. The view you set in Image Creator becomes the view associated with the QuickTools program.

Adding Pictures

You can add pictures of a part to each QuickTools program step to show an operator exactly where to take measurements.

When taking pictures, include as many features in a shot as possible without sacrificing space, picture clarity, and quality. Capturing a big cluster of features from far away will not provide enough detailed information for the operator. One picture can be used as many times as needed.

The ideal image size is 640x480 pixels; most cameras have an adjustable setting for the size of a picture. However, you should first add one image to a QuickTools program step, then play the program and look at the picture in the **Measurement** panel.

NOTE: **NOTE:Create From Features** in the Automation Tab instantly creates a QuickTools program containing all features in the active document with automatically-generated images. *See "Creating a QuickTools Program From Features" on page 143.* You can modify the images using Image Creator.

Taking and Importing Images

1. Use a digital camera to take pictures of the part.

NOTE: For best results, take clear, detailed pictures of the part that plainly illustrate the locations to be measured. Take close-up shots of areas where extra detail is needed. Orient the camera in the same way that the operator will be looking at the part.

2. Transfer the pictures to your computer.

3. In CAM2, click the **Image Creator** tab to display the **Image Creator** window.

4. Highlight a program step in the QuickTools panel.

5. Click **Add an image to the step**.

6. Click the plus (+) button.

7. Navigate to the directory that contains the image.

8. Select the image.

9. Click **OK** to add the image to the QuickTools program step. The image is now available for use in all program steps.

NOTE: If using CAD, you can also create images by rotating the CAD in the 3D Viewer and clicking Export As Image. *See "Export As Image" on page 122.*

Creating QuickTools Pictures

A Base picture with probe images allows you to create a visual measurement map. Use the probe images as targets to represent the sphere of a probe or SMR. The sphere is **green,** or **red** to match the **Front** and **Back** buttons of the

FaroArm, or the Gand Hkeyboard keys for the FARO Laser Tracker.

In the **QuickTools** panel, select an existing QuickTools program. You may need to click the Plus sign next to the program name to expand the list of program steps.

To add a picture to a QuickTools program:

1. Select any existing QuickTools program step. Generally, this is an **Add Readings**.

2. Click **Add an image to the step**.

3. Highlight an existing image and click OK, or import a new image. *See "Taking and Importing Images" on the previous page.*

4. Click a marker in the **Probes** group of the Image Creator Tab. *See "Image Creator Tab" on page 21.*

5. Click a location on the base image to place the probe marker.

6. Move the mouse pointer above any probe marker to edit:

    • Click and drag the center of the probe image to move it.

    • Click and drag the lower right corner of the probe image to make it bigger or smaller.

    • Click and drag the upper center of the probe image to rotate it.

    • Hit the Delete key to remove it.

7. Repeat steps 4, 5, and 6 as necessary.

8. Save your measurement file. The pictures save with the measurement file.

Look at the bottom of the **Images** panel and see a thumbnail of the picture. This is a graphical list of the pictures for the selected QuickTools program step.

Multiple Pictures

You can import and select more than one image per QuickTools program step. When you add a second image to a program step, a "filmstrip" appears at the bottom of the view. You can add markers to each image. The marker order determines the order of the markers displayed, and the corresponding image displays with each marker. *For more information, see "Adding Pictures" on page 52.*

Survey

Survey on the **Navigation** window enables CAM2's Survey capability. Surveying is an automated, repetitive measurement process used to track the position(s) of one or more targets over time. The output is a statistical analysis of the change in positions for each target. Optionally, Survey may be used to automatically reposition a measurement device once sufficient movement has been detected.

Active Survey

The Active Survey box contains the name of the currently active survey. To change the active survey, click the drop-down and select a different survey.

Survey Type

- May be done as continuous inspection (user defined number of cycles) or on demand; retains all data for statistical analysis.

- A single, "clean" run through a set of points compared to nominal data; automation of the measurement process.

- Used for locating a detail relative to nominal data; continuous inspection.

- User-configured preferences that persist for later use. You can name, configure, and save custom surveys using Survey Setup.

Survey Setup

Click **Setup Survey Options** in the Survey Type box. From the **Survey Setup** dialog, you can configure the following:

- **Display Label**: The label for the survey.

- **Feature Dwell Time**: The amount of time (in seconds) the Laser Tracker should remain on the target after acquiring its position.

- **Cycle Time**: The amount of time (in seconds, minutes, or hours) to wait between ending one cycle and beginning the next.

- **Moving Average Size**: Determines the number of previous samples used to compute the moving average value (to show recent trends instead of the entire history of the measurement).

- **Feature DRO**: Determines the DRO use for the survey:

  - **On**: (Default) A feature DRO is shown for each point in the survey.

  - **Off**: No feature DROs are shown.

  - **Single**: A single feature DRO is shown during the survey and switches from point to point as the survey progresses.

- **Replace Readings**: Determines the method to retain or replace readings:

  - **Replace Previous**: (Default) Each cycle will completely replace the readings from the previous cycle.

  - **Append**: The point feature will accumulate readings from each cycle of the survey, and the geometry of the feature will be an average of those readings.

  - **Disable Previous**: Geometry will be the same as the Replace Previous option, but old readings will be retained in an unused state.

- **Compare to Nominal**: Determines whether the drift value will be compared to the nominal:

  - **Yes**: The drift value will be computed as drift from the nominal.

  - **No**: The drift value will be computed as the drift from the starting position of the feature.

- **Auto Search**: Determines whether the Laser Tracker will search automatically for a missing target:

  - **Yes**: The Laser Tracker will automatically search for a missed target using the standard search pattern.

- **No**: The Laser Tracker will not attempt to locate a target that is not found immediately after aiming at the expected target location.

- **Exclude Missing Targets**: Determines whether the Laser Tracker will skip targets missed during the current survey on subsequent surveys:

  - **Yes**: Any target missed during a particular cycle of the survey will be skipped on subsequent cycles.

  - **No**: No missed target will be skipped on subsequent cycles.

- **Pause Between Cycles**: Determines whether the survey will automatically pause between cycles.

  - **Yes**: The survey will automatically pause between cycles. In order to proceed to the next cycle in the survey the user must press **play**.

  - **No**: The survey will not pause between cycles.

NOTE: If Pause Between Cycles is enabled, the Cycle Time option is unavailable.

- **Stopping Conditions**: Determines criteria by which the survey should automatically stop:

  - **Stop After a Fixed Number of Cycles**: Enter number of cycles.

  - **Stop After Missing Target**: Enter target number.

  - **Stop After Specific Time**: Date/Time based (hard stopping date/time).

- **Move Device Conditions**: Determines conditions with which to Move Device:

  - **Move After This Many Fixed Cycles**: Enter number of cycles.

  - **Move After Maximum Deviation**: Enter maximum deviation of any reference point.

NOTE: You need at least 3 reference points to set Move Device conditions. *For more information, see "Moving Device Position With a Survey" on page 56.*

When you have set up the survey, click **OK** to use the settings for the current survey or click **Save** to save the settings to the survey template for future use.

Performing a Survey

While the survey is running, CAM2 allows you to control the survey options.

Add Points to the Survey

The points in the top half of the FEATURES panel are included in the survey (In Survey); the points in the bottom half are not (Not In Survey).

To add a point to the survey, click the arrow to the left of the point in the Not In Survey box. The point appears in the In Survey box. All operations are multi-select capable, so you can add multiple points at the same time.

The points are reported in the order they appear in the list. You can reorder the points in the In Survey box by clicking a point and then clicking the up and down arrows to move it.

Survey Controls

The **Survey** group contains commands to start, pause, and stop a survey:

- **Play**: Runs the survey from its current state until a stopping condition is met or you pause or stop the survey. If you play a survey from a paused state, the survey will resume. If you play a survey from a stopped state, the survey data will be reset.

- **Pause**: Suspends the survey in its current state until you resume or stop the survey.

- **Stop**: Ends the survey.

Moving Device Position With a Survey

You can create a new Device Position with a survey by designating at least three of the survey points as reference points.

1. Click the star icon to the right of a point in the In Survey box. The star appears yellow, indicating that the point is designated as a reference.

   NOTE: Click the yellow star to remove this designation.

---

2. Repeat Step 1 for at least two other points in the survey.

3. In the **Survey Setup** dialog, input the number of cycles you want completed before the move is done in the Move Device Conditions box, and click **OK**. *See "Survey Setup" on page 54.*

The device move is automated in the survey. You can view the results of the new device position in the Manage Devices window. *See "Manage Devices" on page 130.*

Reporting Survey Results

When you've successfully completed your survey, click **Summary** to view a brief summary of the data you've compiled. From there, click **Print Report** to access the **Preview** dialog. Use the **Preview** dialog to preview the layout and print, export, or e-mail the contents.

For more information, see Standard Home Tab Report Commands on page 49, E-mailing/Saving a Report on page 50, and Printing a Report on page 50.

Chapter 3: File

The File commands (Open, Save, Import, Export, Preferences, Help, etc.) are located in the **File** tab. Some of these commands are also available on the Quick Access Toolbar at the top of your screen. *For more information, see "Quick Access Toolbar" on page 23.*

Open

Open opens a CAM2 measurement file (*.fcd or *.fcdx) that has been previously created, named, and saved.

If you already have a measurement file open, CAM2 will prompt you to **Save** the current file or close it without saving.

If a CAD file associated with a measurement file cannot be found when you open the measurement file, CAM2 will prompt you to re-establish a link to the CAD. If you do not re-establish a link, CAM2 will open the file without CAD.

To use files created from other CAD systems, create a new measurement file, translate the CAD to the Parasolid CAD format (*.x_b), and add the CAD format file to the new measurement file. *See Translate CAD below, and CAD on page 61.*

> **NOTE:** If you are using the Probing Version of CAM2, saved measurement files containing point clouds will not open. *For more information, see "Probing Version" on page 9.*

Save

Save saves the current file as a CAM2 measurement file (*.fcd) or package file (*.fcdx). If you did not name the measurement file before invoking Save, the **Save As** dialog box will appear. Type a file name in the **Save As** dialog box and click **Save**.

Save As

Save As saves the current measurement file under a new file name. Type a file name in the **Save As** dialog box and click **Save**.

New

New creates a new measurement file. You cannot have multiple files open at the same time, so if a file is already open when you select this command you will be prompted to save that file. If an unsaved (New Document) measurement file is open and you quit the program, you will receive a message to save the measurement file.

Translate CAD

Translate CAD starts the FARO CAD Translator, a separate application that converts your CAD files to the Parasolid® CAD data file format (*.x_b).
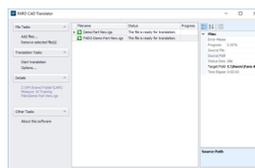
Figure 3-1 FARO CAD Translator

> **NOTE:** You *must* translate all CAD files to the Parasolid CAD data file format. To add the CAD parts to your current measurement file, use **Insert > CAD Parts**. *See "CAD" on page 61.*

CAM2 supports ACIS, AutoCAD 3D, CATIA v4, v5 and v6, Ideas, IGES, Inventor, JT, NX, Parasolid, PRC, PTC Creo, Rhino3D, Solid Edge, SolidWorks, STEP, STL and VDA-FS formats. For other CAD formats, use Rhino software to import your file and save as a STEP file. If you have problems translating CAD files, contact FARO Customer Service for help.

Add Files - Click the Add Files link and select your CAD files. You can select multiple files to translate.

Remove Files - Select a file in the list and click the Remove Selected File(s) link to remove one or more files from the list. This *Does Not* delete the CAD file from your computer.

Target Folder - Select a file in the list and click **Target Folder** to change the target location for each file. The target location is the directory and name for the translated Parasolid CAD file (*.x_b). This location remains the same until you change it.

> **NOTE:** It is good practice to keep your translated CAD files and measurement files in the same folder. Measurement files location is a preference. *For more information, see "Documents (FCD)" on page 68.*

Start Translation - Select a file in the list and click the Start Translation link to start the translation of the file.

Stop Translation - Select a file in the list and click the Stop Translation link to stop the translation of the file.

Options

Healing - The FARO CAD translator has an option to use Healing, or error correction, during the translation process. This option is a preference. *For more information, see "Healing " on page 89.*

Translate Hidden Entities - You can specify whether the CAD translation includes entities on hidden CAD file layers. *For more information, see "Translate Hidden Entities " on page 89.*

Translate Hidden Entities - You can specify whether the CAD translation includes wireframe items such as lines and curves.

Send Document

Select**File > Send Document** to e-mail the current file using the electronic mail system on your computer. Any CAD model file that your measurement file uses is not included in the message attachment. Make sure to send any CAD model file in a separate message.

> **NOTE:** Your e-mail recipient should save all files in the same folder on their computer.

Generate Barcode

CAM2 allows you to generate a 2D barcode optimized for mobile device displays (such as cell phones). Once you generate the barcode, you can scan the barcode and open the associated measurement file or specific QuickTools

Programs in CAM2, including part number and operator information in the document header. *See "QuickTools Programs" on page 142.*

If you generate a barcode and subsequently choose File > Save As, you are prompted whether to update the barcode with the new file path. If you open a document with a barcode mismatched with its current location, you are prompted to update the barcode.

If you generate a barcode and subsequently print a report, the report contains the barcode.

To Generate a Barcode:

1. Click File > Generate Barcode.

2. If prompted to do so, save your measurement file.

3. On the Generate Barcode dialog, specify whether the barcode will open the measurement file or a selected QuickTools program.

4. Click Save as Image to generate the barcode image file, or click Print to save a printable version of your barcode (*.xps format) that you can then send to your printer.

To open a measurement file or QuickTools program using a barcode:

1. Open CAM2.

2. Click File > New.

3. Scan the barcode you generated or printed with your barcode scanner.

Recent

Recent Documents

Recent Documents contains a list of recently accessed or saved measurement files (*.fcd or *.fcdx) in descending order, newest to oldest. Click the name of a document to quickly access it. If you currently have a measurement file open and it is not saved, you will be prompted to save changes to the file before opening the file you just selected.

Recent CAD Parts

Recent CAD Parts contains a list of recently accessed or saved CAD files in descending order, newest to oldest. Click the name of a CAD file to import the CAD into the current measurement file.

Import Export

Import Export contains all the commands to:

• Load data from a file into a CAM2 file.

• Save data to a file from a CAM2 file.

Import

The **Import** menu allows you to add external files to the current measurement file.

![CAD icon]**CAD**

Select **File > Import > CAD** to add Parasolid® CAD format data (*x_t or *.x_b) to your current measurement file. Select one or more CAD files in the **Add CAD Model** dialog, then click **Open** to translate them into Parasolid format and load them into the current measurement file.

Large CAD files or CAD files that may take longer to load than other files should be translated into the Parasolid format using **Translate CAD**. *See "Translate CAD" on page 58.*

NOTE: By default, imported CAD is displayed with both shading and wireframe information. To import files and change options use the FARO CAD translator. *For more information, see "Translate CAD" on page 58.*

The CAM2 CAD translator has an option to use Healing, or error correction, during the translation process. This option is a preference. *For more information, see "Healing " on page 89.*

Points

Select **File > Import > Points** to access the Import Point Data wizard and import a text file (*.txt) containing point-reducible features into the current measurement file. Use the wizard to select the directory location and the name of the file to be imported, select the import configuration (including row offset, units, column order, and separators), and select the features to import as actual or nominal.

- Select **Import Points as Individual Features** to import the text file contents as individual features.

  - Check the **Evaluate Normal Vector By Projecting To CAD** check box to associate normal vectors evaluated by CAD projection. When you enable this option, CAM2 imports all points as vector points, thereby determining a vector for each imported point. From here, you can also specify:

    - **Default Vector**: The vector that CAM2 will use if the distance from the source point to CAD is too large.

    - **Threshold**: The maximum distance a point can lie from CAD for the surface normal to be meaningful. Points with a distance to CAD greater than this number use the Default vector.

NOTE: If you are using the Probing Version of CAM2, you can import a maximum of 7,000 points. *For more information, see "Probing Version" on page 9.*

Point Cloud

Select **File > Import > Point Cloud** to access the Import Point Cloud wizard and import a point cloud from .asc, .ptx, .txt and .xyz formats into the current measurement file. Use the wizard to select the directory location and the name of the file to be imported, select the import configuration (including row offset, units, column order, color, and separators), and select the features to import.

NOTE: If you are using the Probing Version of CAM2, this command is not available. *For more information, see "Probing Version" on page 9.*

Reference Targets

Select **File > Import/Export > Import Reference Targets** to import reference targets from a text file (*.txt) or Scanlink binary file into the current measurement file. *See "Import" on page 42.*

Deviation Markers

Select **File > Import/Export > Deviation Markers**to import deviation markers from a text file (*.txt) into the current measurement file. *For more information, see "Deviation Markers" on page 120.*

Tube

Select **File > Import > Tube** to import a tube from a text file (*.txt) into the current measurement file. Tube data may be imported in XYZ or PTB format.

Select the text file to import, and specify the following:

First Row: the row containing the tube name.

Units: the tube's unit of measurement.

Tube Information: the tube's data format (XYZ or PTB).

Column Separator: the character in the text file denoting column separation. The default is ;.

Decimal Separator: the character in the text file denoting decimal separation (. or ,).

XYZ Format

The text file must contain the tube's name, diameter, and XYZ bend radius. You must create separate lines for each breakpoint.

Example:

```
Tube 1 - Actual

0.494544577826446

0.00;0.00;0.00;1.50

6.35;0.00;0.00;1.50

9.60;7.70;0.00;1.50

13.55;7.60;-0.90;1.50

16.30;10.25;-1.55;1.50

17.45;9.17;3.45;1.50

19.60;7.05;10.65;1.50
```

PTB (Pull, Turn, Bend) Format

The text file must contain the tube's name, diameter, and PTB bend radius. You must create separate lines for each straight.

Example:

```
Tube 1 - Nominal

0.5000
```

```
5.338;0.000;66.898;1.500

6.355;-166.140;68.725;1.500

2.375;174.138;43.839;1.500

1.559;98.932;97.929;1.500

3.466;90.840;5.892;1.500

5.164;0.000;0.000;0.000
```

NOTE: The final PTB straight should have a bend radius of 0.00.

Alignment

Select **File > Import > Alignment** to insert an alignment file (*.fal) into the current measurement file.

Tolerance Preferences

Select **File > Import > Tolerance Preferences**to import a tolerance preference file (*.xml) into the current measurement file. Choose an existing file:

- The tolerance preference file previews in a dialog box.

- Click **Import** to update the tolerances.

NOTE: Select the **Apply to All Features** check box to import and change the tolerances for the features in your current measurement file.

QuickTools From Learn Files

Select **File > Import > QuickTools > From Learn Files** to import a Learn file (QuickTools program made with CAM2 Measure X or CAM2 Measure v4.0) into the current measurement file. *For more information, see "Importing QuickTools From Learn Files" on page 143.*

Shortcut

Select **File > Import > Shortcut** to import a Shortcut into the current measurement file. *For more information, see "Shortcuts " on page 151.*

Export

The **Export** menu allows you to export data from the current measurement file.

Point Data To Text File

Select **File > Export > Point Data To Text File**to access the Export Point Data wizard and export a text file (*.txt) containing point-reducible features from the current measurement file. Use the wizard to select the features to export, select the export configuration (including units, decimal indicator, date, column order, and separators), and select the directory location and the name of the file to be exported. They export as text files ready to be imported into the program.

Point Cloud To Text File

Select **File > Export > Point Cloud To Text File**to access the Export Point Cloud wizard and export a text file (*.txt) containing point cloud features from the current measurement file. Use the wizard to select the point clouds to export, select the export configuration (including units, decimal indicator, date, column order, color, and separators), and select the directory location and the name of the file to be exported. They export as text files ready to be imported into the program.

Deviation Markers

Select **File > Export > Deviation Markers** to export deviation markers (*.txt) from the current measurement file. *For more information, see "Deviation Markers" on page 120.*

Measurement Data to Text File

Select **File > Export > Measurement Data to Text File**to export a text file (*.txt) containing feature data from the current measurement file. Use the wizard to select the features to export, define an export format, and select the directory location and the name of the file to be exported. They export as text files ready to be imported into the program.

NOTE: If you are including this function as part of a QuickTools program, you also have the option of assigning an automated save name prefix for when users run the QuickTools program.

Export Formats

You can define and save a custom data export format. Click the **...** button on the second page of the export wizard to access the **Export Measurement Data Formats** window.

To define a custom format:

1. Enter a name for the format in the Export Format box.

2. Specify export options (Export units, Export decimal indicator, Export date, Export columns, Export document header, Single line export).

3. Specify separators (Column and Decimal).

   - Information is arranged in two major groupings: Properties and Columns.

     - **Properties**: These are the available feature properties, such as Center, Diameter or Length. To add properties to the group, press the + button to choose from a list of properties. To remove properties from the group, select a property in the group and press the X button.

     - **Columns**: These are the types of property values that can be exported (Actual, Nominal, Deviation, Upper Tolerance and Lower Tolerance). Each value in the group has a corresponding icon in the Export Preview below. To add properties to the group, press the + button to choose from a list of properties. To remove properties from the group, select a property in the group and press the X button.

4. Click the double arrow button between the groupings to prioritize them. When you click the button, CAM2 will swap the boxes and update the Export preview accordingly. The priority determines the ordering of the information in the resulting export file. The left box contains the Level 1 (higher priority) grouping, and the right box contains the Level 2 (lower priority) grouping.

5. Click OK to save the export format and return to the wizard.

Measurement Data to CAD

Select **File > Export > Measurement Data to CAD**to export a CAD file containing features from the current measurement file. Use the wizard to select the features to export, select the file format (Parasolid, IGES, STEP, VDA), select the measurement unit, and select a name and save location for the CAD file.

CAD to XGL

Select **File > Export > CAD to XGL** to export an XGL file from the CAD model file in the current measurement file. *For more information, see "CAD" on page 61.*

Tolerance Preferences

Select **File > Export > Tolerance Preferences**to export a tolerance preference file (*.xml) from your current measurement file.

A tolerance preference file consists of a set of upper and lower tolerances for each feature type, and the option to make each toleranced item visible or invisible.

Tube

Select **File > Export > Tube** to export tube data (*.txt) from the current measurement file.

Transformation Matrix

Select **File > Export > Transformation Matrix** to export a transformation matrix from any combination of matrices available in CAM2, such as an alignment and a coordinate system, or a device position and an alignment. You can also export the matrix itself, if necessary.

- Select the matrix for which you want to determine position and orientation.

- If the Use Base Matrix box is unchecked, CAM2 exports the raw matrix that you selected.

- If you check the Use Base Matrix box, you can select the Base Matrix for which you want the transformation to be relative. In this case, the exported transformation will be the matrix that transforms the Base Matrix to the target Matrix.

- Click OK to save the result to one of the following file formats:

  - *.xal file: FARO file format for alignments.

  - *.xdp file: FARO file format for device positions.

  - *.euler file: FARO file format which contains rotation/translation information as a 4x4 matrix, as ZXZ Euler angle decomposition, and XYZ Euler angle decomposition.

Point Cloud To Mesh

Select **File > Export > Export Point Cloud to Mesh** to export a mesh file (*.stl) created from a point cloud.

NOTE: For best results, scan your point cloud at optimum resolution and apply Filtering or Smoothing to organize the points. *See Filtering on page 43 and Smoothing on page 44.*

- Add one or more point clouds.

- Select a meshing profile to apply appropriate export parameters:

  - **Smooth**: for larger parts with flat or large curved surfaces with little to no detail, such as automotive body panels.

- • **Curvature**: for medium-sized parts with curved and small radiused surfaces, such as pressed or molded parts.

- • **Detailed**: for smaller parts with small or fine detail, such as coins.

- • Enter the name of the mesh file and browse to a save location.

- • Click **Finish** to export the mesh file.

NOTE: If you are using the Probing Version of CAM2, this command is not available. *See "Probing Version" on page 9.*

User Profiles

Select **File > User Profiles** to access the **Profiles** window. Use this window to create, apply, import, export, and delete custom user profiles.

User profiles contain custom screen layout settings, including the ordering and position of Control Panels. *See "Control Panels" on page 25.*

To create a user profile:

1. Adjust the Screen Layout as necessary. *See "Screen Layout" on page 15.*

2. Click File > User Profiles. Your screen layout is captured as a user profile which you can then save or export to recall later.

NOTE: When upgrading CAM2 from a previous version, you will be prompted whether to import existing User Profiles.

Help

Select **File > Help** to access CAM2's Online Help. *For more information, see "Help" on page 29.*

Shortcuts

Select **File > Shortcuts** to view, edit, and print the list of CAM2 Keyboard Shortcuts. *For more information, see "Keyboard Shortcuts and Shortcut Menus" on page 307.*

Print

Click **Print** for a preview of a formatted, printable reference sheet containing the current CAM2 Keyboard Shortcut mappings.

Reset to Defaults

Click **Reset to Defaults** to reset all Keyboard Shortcut assignments to their default values.

Edit

Click **Edit** to access the **Customize Keyboard** dialog. Use this dialog to search for specific commands by typing text in Show Commands Containing box. For example, typing "CAD" filters the list of commands to those containing the word CAD.

NOTE: You can also configure a Keyboard Shortcut for any command on the Ribbon by right-clicking the command and selecting **Set Keyboard Shortcut**. *See "Keyboard Shortcuts" on page 16.*

Preferences

Default preferences always load when you start CAM2. These preferences can be applied to the current measurement file, or saved as the default and loaded each time CAM2 is started. There are ten preference groups: File, Display, Panels, Measurement, Alignment, Construction, CAD, Tolerance, Report, and Imager3D.

When you change default Preferences, they appear with pencil icons to indicate their changed status. The changed status persists until you save your changes or exit Preferences without saving.

Figure 3-1 Preferences

Editing Preference Settings

To edit a preference setting, click a preference group to access the parameters, then edit the parameters as desired. Click **OK** to confirm the settings for the current measurement file, or click **Save to Default** to load the preference each time CAM2 is started.

NOTE: Click **Reset to Default** to revert to the default settings most recently saved.

File

The File preferences define auto-save configuration and the locations from which document, CAD, alignment, device position, points, tube, and measurement data are saved and loaded.

Click File in the left window of the **Preferences** window to see the File preferences.

To change any file location, click the associated button and browse to a folder.

Auto-Save of FCD Documents

This preference controls whether CAM2 automatically saves the active measurement file (document), and if so, how often. By default, the auto-save option is enabled at a 5 minute interval.

To disable auto-save, clear the checkbox. To change the interval, enter a new number in the box.

Overwrite Nominals on Point Import

This preference controls the behavior of the software when you import points from a text file into a measurement file with existing nominals.

Click in the drop-down window and select a value:

- **Yes:** The software automatically overwrites nominals when you import points.

- **No:** The software does not overwrite nominals when you import points.

- **Ask:** (Default) You are asked whether to overwrite nominals when you import points. Unless you check the "Never ask me again" check box, the software continues to prompt you each time you import points.

Default File Locations

Documents (FCD)

This preference controls the default file location for document (*.fcd and *.fcdx) files.

Exported CAD

This preference controls the default file location for exported CAD files.

Imported CAD

This preference controls the default file location for imported CAD files.

Alignments

This preference controls the default file location for alignment files.

Device Positions

This preference controls the default file location for device position files.

Points

This preference controls the default file location for points files.

Deviation Markers

This preference controls the default file location for deviation markers.

Tube

This preference controls the default file location for tube files.

Measurements

This preference controls the default file location for measurement data.

Reference Targets

This preference controls the default file location for reference targets.

Barcode Mappings Location

This preference controls the default file location for the barcode mappings file.

Display

The Display preferences determine the way in which CAM2 displays entities, dimensions, labels, and other visual elements.

Click Display in the left window of the **Preferences** window to see the Display preferences.

CAD View Tab

Background Gradient

Top Color

This preference specifies the top color of the background gradient. To change the color, click in the drop-down window and select a color.

Bottom Color

This preference specifies the bottom color of the background gradient. To change the color, click in the drop-down window and select a color.

Features Colors

Measured Features

This preference specifies the color of measured features. To change the color, click in the drop-down window and select a color.

Keyed-In Features

This preference specifies the color of keyed-in features. To change the color, click in the drop-down window and select a color.

Laser Tracker Features

This preference specifies the color of features measured using the FARO Laser Tracker. To change the color, click in the drop-down window and select a color.

Picked From CAD Features

This preference specifies the color of features created using Pick From CAD. To change the color, click in the drop-down window and select a color.

Constructed Features

This preference specifies the color of constructed features. To change the color, click in the drop-down window and select a color.

Point Cloud Features

This preference specifies the color of point clouds. To change the color, click in the drop-down window and select a color.

Selection

Highlight Features On Mouse Hover

This preference specifies whether CAD surfaces and features highlight when the pointer is moved over them.

- **Yes:** (Default) CAD surfaces and features highlight when the pointer is moved over them.

- **No:** CAD surfaces and features do not highlight when the pointer is moved over them.

Face Color

This preference specifies the CAD face selection color. To change the color, click in the drop-down window and select a color.

Edge Color

This preference specifies the CAD edge selection color. To change the color, click in the drop-down window and select a color.

CAD Settings

Render Quality

This preference specifies the balance between quality and performance of CAD rendering. The default is Best Quality; however, users with large CAD files may opt to decrease quality to gain an increase in system performance and a reduced rendering time.

To change the rendering quality, click in the drop-down window and select a value:

- **Best Quality:** The CAD renders in best detail with no performance enhancement.

- **Good Quality:** The CAD renders in good detail with a slight performance enhancement.

- **Balanced:** The CAD rendering and performance are evenly matched.

- **Good Performance:** The CAD renders in less detail with a good performance enhancement.

- **Best Performance:** The CAD renders in lesser detail with the best performance enhancement.

Size and Scale

Whisker Scale

The scale value for whiskers. Each whisker is drawn using the deviation value. This scale value increases that length so that the whisker is visible on the screen.

Whisker Calculation Mode

The mode for calculating whiskers relative to features:

Material (Default): Readings are compared relative to the measured feature.

Nominal: Readings are compared relative to the nominal feature.

Size: Readings are compared relative to the measured feature, with deviation colors relative to the size of the feature rather than the material.

Readings Size

This sets the size of all feature readings in the measurement file. Move the slider to select a size.

Point Feature Size

This sets the size of all point features in the measurement file. Move the slider to select a size.

Inspect Surface Disk Size

The size of the disks drawn to represent inspect surface points. The color is predetermined by the tolerance condition.

Vector Points

Arrow Size

This sets the size of all vector point arrows in the measurement file. Click in the drop-down window and select a size. This includes all point features and feature readings.

Disk Color

The color of the disks drawn on the CAD part. The default is white.

Disk Scale

The scale of the disks drawn on the CAD part; representing a number by which the size of the disks will be scaled. Min. value: 0.01, Max. value 100. The default is 1.

Measurement

Show Closest Point While Measuring

This preference determines whether CAM2 draws a line between the probe and the closest CAD point.

- **Yes:** (Default) A line is drawn between the probe and the closest CAD point.

- **No:** No line is drawn between the probe and the closest CAD point.

Always Show Probe

This preference determines whether CAM2 shows the probe graphic on-screen.

> **NOTE:** When shown, the probe is represented as it appears on the device and is displayed in a 1:1 scale. Changes to the probe diameter will be reflected in the software.

- **Yes:** (Default) CAM2 shows the probe on-screen.

- **No:** CAM2 does not show the probe on-screen.

Show Laser Probe

This preference determines whether CAM2 shows the laser probe on-screen. If Always Show Probe is not enabled, this option is unavailable.

> **NOTE:** When shown, the laser probe is represented as it appears on the device and is displayed in a 1:1 scale.

- **Yes:** (Default) CAM2 shows the laser probe on-screen.

- **No:** CAM2 does not show the laser probe on-screen.

Probe Appearance

This preference determines whether CAM2 shows the on-screen probe graphic as a solid (default), 3D arrow, 2D arrow, or dot. If Always Show Probe is not enabled, this option is unavailable.

> **NOTE:** When shown, the probe is represented as it appears on the device and is displayed in a 1:1 scale. Changes to the probe diameter will be reflected in the software.

Measuring Line Color

This preference specifies the color of the measuring line. To change the color, click in the drop-down window and select a color.

Dimension Settings

This preference specifies the default font used for dimension annotations in the CAD view.

Use Font Size Proportional to Feature Size

(Default) CAM2 uses a font size that scales with the size of the feature dimension.

Use Custom Font Style

 CAM2 uses a user-selected font style and size. Click the button and select a font style and font size.

Use Font Size Preset

CAM2 uses a preset size (Very Small, Small, Medium, Large, or Very Large) for fonts.

General Dimension Color

This preference specifies the color of general dimensions. To change the color, click in the drop-down window and select a color.

Cross-Section Scan Dimension Color

This preference specifies the color of cross-section scan dimensions. To change the color, click in the drop-down window and select a color.

Point Cloud Settings

This preference specifies the visual representation of points clouds.

Apply Lighting To Measured Point Clouds

Activate lighting for measured point clouds.

Point Representation

Display point cloud points as circles or squares. The default value is Squares.

Display Point Cloud Excluded Points

Display point cloud points excluded by the Point Distance Filter. *See "Point Distance Filter" on page 185.*

Cross-Section Scan Analysis Mode Settings

This preference specifies the visual representation of cross-section scans in analysis mode. *For more information, see "Cross-Section Analysis" on page 100.*

Tolerances Visual Representation

This preference specifies the visual representation of tolerances in cross-section analysis mode.

- **Bands:** (Default) Tolerances are shown as bands.

- **Lines:** Tolerances are shown as lines.

- **None:** Tolerances are not shown.

Connectors Visual Representation

This preference specifies the visual representation of connectors in cross-section analysis mode.

- **None:** (Default) Connectors are not shown.

- **Polyline:** Connectors are shown as polylines.

- **Spline:** Connectors are shown as splines.

Color Gradients

Display Color Gradient in CAD View

This preference specifies whether the CAD View displays the color gradient.

- **Yes:** (Default) The CAD View displays the color gradient.

- **No:** The CAD View does not display the color gradient.

Display Color Gradient Labels

This preference specifies the way in which the CAD View displays color gradient labels.

- **Always:** (Default) Color gradient labels are always visible in the CAD View.

- **For Selection:** The CAD View displays a color gradient label for the currently selected entity.

- **Never:** Color gradient labels are not shown in the CAD View.

Other

Enable Anti-Aliasing

This preference specifies whether to enable anti-aliasing during rendering. Turn this option off to improve rendering performance.

- **Yes:** Anti-aliasing is enabled.

- **No:** (Default) Anti-aliasing is not enabled.

Device Position Visibility

This preference specifies the way in which device positions appear in the CAD View.

- **All:** (Default) All device positions appear in the CAD View.

- **Solved:** Only solved device positions appear in the CAD View.

- **Active:** Only the active device position appears in the CAD View.

- **None:** No device positions appear in the CAD View.

Labels Tab

The Labels preferences determine the content and display characteristics of labels in the measurement file.

Settings

Visibility Based Display

This preference specifies whether to auto hide or show labels based upon the label visibility in the 3D viewer.

- **Yes:** (Default) Labels are automatically hidden.

> • **No:** Labels remain visible.

Hide Labels During Measurement

This preference specifies whether to hide labels while Measure Mode to improve feature visibility in the 3D viewer. *See "Measure Mode" on page 23.*

> • **Yes:** (Default) Labels are automatically hidden while in Measure Mode.
>
> • **No:** Labels remain visible.

Display Behavior

This preference specifies label visibility options after measurement.

> • Last Created (default): A label shows only for the most recent feature created.
>
> • Hide All: No created features show labels.
>
> • Show All: All created features show labels..

Style Definitions

You can use, edit, and create new custom style definitions for labels. Specify the default style definitions to be used for Simple, Detailed, and Surface Point, and Callout labels.

Style Properties

The properties that can be configured for label styles are as follows:

> • **Name:** Name of the label style (as it appears in the Style Definitions window).
>
> • **Appearance:** Font style and size, background color, grid color.
>
> • **Single Line Mode:** The label appears as a single line of information.
>
> • **Show Icon:** The label contains an image of the feature's geometry type.
>
> • **Show First Column:** The label contains information in columnar form.
>
> • **Show Header Row:** The label contains a header row.
>
> • **Show Comment:** The label contains comments associated with the feature.

Contents

For Surface Point, Callout, and custom label styles, you can specify additional label content: Actual, Nominal, Deviation, Status, Lower Tolerance, and Upper Tolerance.

Units Tab

The Units preferences determine the display of decimal places in the **Measurement** panel and angle units in the measurement file.

NOTE: See Unit Format to change the measurement file's units.

Angle Unit

The Angle Unit preference controls the level of detail in which the measurement file displays angles.

Click in the drop-down window and select a value:

- **Degrees-Minutes-Seconds:** (Default) The measurement file displays angles in Degree-Minute-Second format (example: 90°5'52.34").

- **Degree:** The measurement file displays angles in Degree format (example: 90.10°).

- **Radians:** The measurement file displays angles in radians (example: 1.2 rad).

Length Unit

The Length Unit preference controls the default unit of measurement (Millimeters, Centimeters, Meters, or Inches). The default is Millimeters. *See "Unit Format" on page 24.*

Click **Customize** to configure the decimal places for a unit of measurement. You can configure the decimal places for existing units or create a new unit (specifying the name, abbreviation, decimal places, and distance in millimeters).

Coordinate Format

The Coordinate Format preference controls the default coordinate system (Cartesian, Spherical, or Cylindrical). The default is Cartesian. *See "Coordinate Format" on page 23.*

Decimal Places

Unit Vector Decimal Places

The Unit Vector Decimal Places preference controls the number of decimal places displayed for any vector.

To change this preference, input a new number.

Laser Tracker Adapters

Default Unit Systems

The Default Unit Systems preference controls the preferred unit format for Laser Tracker probe adapters (Auto, Metric, or Imperial). The default is Auto.

- **Auto:** Automatically sets the units.

- **Metric:** Sets Metric units.

- **Imperial:** Sets Imperial units.

Construction Tab

The Construction preferences govern the components visible in construction dialog boxes.

Include CAD Objects

Indicates whether CAD objects will be visible in construction dialog boxes.

- **Yes:** (Default) CAD objects will be visible in construction dialog boxes.

- **No:** CAD objects will not be visible in construction dialog boxes.

Include Coordinate System Components

Indicates whether Coordinate System components will be visible in construction drop-down boxes.

- **Yes:** (Default) Coordinate system components will be visible in construction drop-down boxes.

- **No:** Coordinate system components will not be visible in construction drop-down boxes.

Enable AutoBestfit Components

Indicates whether CAM2 performs automatic fitting when you select items from the Feature Tree.

- **Yes:** (Default) CAM2 performs automatic fitting when you select items from the Feature Tree.

- **No:** CAM2 does not perform automatic fitting when you select items from the Feature Tree.

Include Ancestry Types

Indicates which feature types will be visible in construction dialog boxes. To change this preference, click in the drop-down window and select a value:

- **All:** (Default) All feature types will be visible in construction dialog boxes.

- **Measured:** Only measured features will be visible in construction dialog boxes.

- **Nominal:** Only nominal features will be visible in construction dialog boxes.

Smart Naming Tab

The Smart Naming preference allows you to create and edit templates that govern naming conventions of specific features and feature groups.

To change a naming template for a feature, click the field to the right of a feature and edit the naming template.

Panels

The Panels preferences determine the appearance and configuration of the panels in CAM2.

Click Panels in the left window of the **Preferences** window to see the Panels preferences.

Measurement Window Tab

The **Measurement** window preferences control the colors, fonts, and font colors of both the **Measurement** panel and the **Feature** window.

DRO

The DRO preferences control the background color, font, font color of the **Measurement** window, decimal places, and the option to use a special Laser Tracker-related cylindrical coordinate system.

NOTE: If you select a very large font for the **Measurement** window prompt, you may need to move the prompt's scroll bar to read the text.

Feature DRO

The **Feature** DRO preferences control the background color, font, font color of the **Feature** window and colors of feature tolerances.

Apply Tolerance Color to Background

When enabled, CAM2 displays corresponding tolerance color backgrounds for live DRO data deviation.

Laser Tracker-Related Cylindrical Coordinate System

When enabled, CAM2 employs a special FARO Laser Tracker-optimized cylindrical coordinate system.

Enable Search Radius

When enabled, a feature's DRO window does not display data (*****) if the Probe is farther than the specified radial distance from the feature's position.

QuickTools Tab
Font Settings

The **QuickTools** preference controls the font and font color of the **QuickTools** message window.

Features Tab
Font Settings

The **Features** preference controls the font and font color of the features as listed in the **Features** panel.

Device Tab

The Device preference determines whether CAM2 displays the **Device Control** panel on startup, and how CAM2 exports device positions.

Device Center

This preference controls the behavior of the **Device Control** panel on CAM2 startup.

- **Yes:** The **Device Control** panel automatically appears when CAM2 is launched.

- **No:** (Default) The **Device Control** panel does not automatically appear when CAM2 is launched.

Device Positions

This preference controls the export preference for device positions in conjunction with the world coordinate system.

- **Yes:** CAM2 exports device positions relative to the world coordinate system.

- **No:** (Default) CAM2 does not export device positions relative to the world coordinate system.

Measurement

The Measurement preferences determine the measurement workflow.

Click Measurement in the left window of the **Preferences** window to see the Measurement preferences.

Figure 3-1 Measurement preferences

General Tab
Auto Repeat Measurement

This preference automatically repeats the most recent measurement command in **Measure** mode.

- **Yes:** (Default) The most recent measurement command automatically repeats.

- **No:** The most recent measurement command does not automatically repeat.

NOTE: This is only active in **Measure** mode. *See "Measure Mode" on page 23.*

Auto-Recognize Features

This preference controls Automatic Feature Recognition. *See "Automatic Feature Recognition" on page 188.*

NOTE: You must disable Arm as Mouse to use this feature. *See "Use Arm as Mouse " below.*

- **Yes:** CAM2 automatically recognizes features (specify maximum allowable form).

- **No:** (Default) CAM2 does not automatically recognize features.

Show Control Window

This preference controls whether the Measurement dialog box appears when you add new measured features.

- **Yes:** The Measurement dialog box appears when you add new measured features.

- **No:** (Default) The Measurement dialog box does not appear when you add new measured features.

Measurement Sound

This preference determines whether CAM2 makes a sound when a measurement device takes measurement readings and end clicks.

If the form of the feature you are measuring is out of tolerance, you will also hear a special sound to indicate the out of tolerance condition.

- **Yes:** (Default) CAM2 makes sounds when the measurement device takes measurement readings and end clicks.

- **No:** CAM2 does not make sounds when the measurement device takes measurement readings and end clicks.

Use Arm as Mouse

This preference controls the interaction of the FaroArm and the CAM2 software.

When enabled, the position of the probe controls the mouse pointer in CAM2. The standard mouse also controls the pointer. CAM2 recognizes which input device is active and selects that device for the pointer control. After starting a measurement command, CAM2 only accepts control from the current measurement input device and blocks any input except digitized points.

Arm as Mouse temporarily disables during **Add Readings**.

NOTE: When you connect a FaroArm, CAM2 colors dialog box buttons red and green to indicate that the corresponding FaroArm buttons activate the dialog box buttons.

- **Yes:** The FaroArm is used as a mouse.

- **No:** (Default) The FaroArm is not used as a mouse.

Use Automatic Compensation For Surface Points

This preference controls whether CAM2 automatically compensates surface point measurements.

- **Yes:** (Default) CAM2 automatically compensates surface point measurements.

- **No:** CAM2 does not automatically compensate surface point measurements.

Default Compensation Method

This preference specifies the default compensation method for measured features.

Click in the drop-down window and select a value:

- **Use Sampled End Click:** (Default) The **BACK** button, or **H** key, will define probe compensation for each feature.

- **Auto:** Features compensate automatically.

NOTE: Auto compensation uses the orientation position of the probe in each reading. When using this option, collect readings with the probe as perpendicular to the surface as possible.

- **Measure Inside:** Features automatically compensate out for a hole.

- **Measure Outside:** Features automatically compensate in for a stud.

- **None:** No probe compensation.

Default Measure Mode

This preference controls the automatic adding of readings to each Measurement command. *See "Measure and Template Mode" on page 99.*

Click in the drop-down window and select a value:

- **Measure Mode:** (Default) After choosing a Measurement command, the feature is added to the file, the Measurement Panel appears, and you are prompted to add readings to the feature. *See "Measurement Panel" on page 188.*

- **Template Mode:** After choosing a Measurement command, the feature is added to the file but you are not prompted to add readings to the feature.

Measurement Completion Mode

This preference specifies the method in which CAM2 completes measurement. Measurement may be completed after recording a fixed number of readings or recording an end click.

Click in the drop-down window and select a value:

- **End Click:** (Default) Measurement completes after an end click.

- **Fixed Number of Readings:** Measurement completes after a fixed number of readings specified using the Auto Complete Tab preference. *Auto Complete Tab on page 81*

Apply Compensation in Feature Windows

This preference controls whether CAM2 applies compensation in feature windows.

Click in the drop-down window and select a value:

- **Yes:** CAM2 automatically applies compensation in feature windows. All deviations will be relative to the compensated location.

- **No:** CAM2 does not automatically apply compensation in feature windows. All deviations will be relative to the probe center.

- **Ask:** (Default) You are asked if you want CAM2 to apply compensation in feature windows. Unless you check the "Never ask me again" check box, the software will continue to prompt you to do so.

Projection Plane

Use Last Plane

This preference controls the automatic assigning of the last measured plane feature to the Feature Properties of the current feature. *See "Feature Properties" on page 183.*

- **Yes:** (Default) The last measured plane becomes the default plane of projection for subsequent feature measurements.

- **No:** Subsequent feature measurements are established with new planes of projection.

Allow Constructed Actual Planes

This preference allows the use of planes constructed from actual features to be used as projection planes.

- **Yes:** Planes constructed from actual features are usable as projection planes.

- **No:** (Default) Planes constructed from actual features are not usable as projection planes.

Default

This preference defines the default plane for features that require a plane to solve.

Click in the drop-down window and select a value:

- **None:** The feature solves using the readings for the feature *and* the plane.

- **Define:** (Default) A plane feature is added to the file for the feature. You must add readings to the plane to solve the feature.

- **Auto:** CAM2 automatically chooses the most suitable projection plane. If CAM2 cannot find a suitable projection plane, you will be prompted to select a plane (or measure one if you have not already done so).

> **NOTE:** The Auto option predictively selects the best projection plane, and is thus incompatible with the Use Last Plane preference. Use Last Plane will be unavailable if you choose the Auto projection plane option.

Auto Nominal Tab

This preference controls the automatic association of the nearest nominal to a measured feature - providing it falls within the tolerance zone.

> **NOTE:** This function is not active until an Alignment has been created. *For more information, see "Manage Alignments" on page 266.*

Automatically Associate Nominal

This preference determines whether CAM2 automatically associates nominals to measured features.

- **Yes:** (Default) Nominals are automatically associated to measured features.

- **No:** Nominals are not automatically associated to measured features.

- **Orientation:** The orientation tolerance for auto nominal. The default is 5°.

- **Position:** The position tolerance for auto nominal. The default is 0.1.

- **Size:** The size tolerance for auto nominal. The default is 0.1.

Auto Complete Tab

This preference specifies the number of points per feature type to automatically complete a measurement. When this number of readings is reached, CAM2 creates the feature and the measurement process terminates.

When used in conjunction with automatic compensation (Default Compensation Method set to Auto), auto complete provides for a streamlined measurement process.

NOTE: Measurement Completion Mode must be enabled to use this functionality. *For more information, see "Measurement Completion Mode " on page 79.*

To change the number of auto complete points for a feature:

- Click the number field to the right of a feature.

- Edit the number of points for the feature.

Point Cloud Tab

NOTE: If you are using the Probing Version of CAM2, Point Cloud preferences are not available. *See "Probing Version" on page 9.*

Scan Trigger Behavior

This preference determines how the measurement device's button behaves when scanning.

- **Click to Start/Stop:** (Default) The device begins scanning when the button is pressed, and finishes scanning when the button is pressed again.

- **Press and Hold:** The device begins scanning when the button is pressed and held down, and finishes scanning when the button is released.

Default Alignment Sample Size

This preference determines the default number of points to sample from a point cloud used in an iterative alignment. The default value is 50.

Use Last Plane

This preference determines whether the last plane measured becomes the clipping plane for future point cloud measurements.

Defer Recalculation

This preference specifies whether point cloud recalculation is automatic or manual (deferred).

- **Yes:** CAM2 automatically recalculates point cloud data.

- **No:** (Default) The user recalculates point cloud data.

NOTE: If recalculation is deferred, the **Main Window** will contain a small icon which you can click to perform the recalculation.

Keep Raw Data

This preference specifies whether CAM2 uses out-of-core file storage (external memory) to store data at full resolution. When enabled, metrology grade points are kept in memory, making the application more fluid without losing data.

- **Yes:** CAM2 uses out-of-core file storage.

- **No:** (Default) CAM2 does not use out-of-core file storage.

Warn When Raw Data Storage is Deleted or Disabled

This preference specifies whether to notify you when Raw Data storage is deleted or disabled. When Keep Raw Data is disabled, data can no longer be retrieved.

- **Yes:** (Default) CAM2 prompts you when Raw Data storage is deleted or disabled.

- **No:** CAM2 does not prompt you when Raw Data storage is deleted or disabled.

Do Not Show a Dialog With Exported Nominal Mesh File Path

This preference specifies whether to display the file path when exporting a Nominal Mesh. The default is Ask.

Extraction

These preferences control the behavior of feature extraction. *For more information, see "Extract" on page 199.*

Show No Point Selection Control

Show a prompt when no points are selected.

Show No Results Found Control

Show a prompt when no results are found.

Automatically Relate Scan Data To Nominal Data

Enable the automatic extraction of features using a nominal and a point cloud.

Solver Method

Specify the default solver method of feature extraction from nominal. *See "Extraction" on page 186.*

Sampling

Specify the method to extract features from nominal.

Filtering

Show a Dialog When Point Clouds Cannot Be Filtered

Show a prompt when point clouds cannot be filtered.

Scanning

Point Distance Filter

Determines the distance from CAD at which point clouds are not shown. The default value is 3.000 mm.

Comparison to CAD

Controls the frequency by which CAM2 compares scanned points to CAD (Automatic, Always On, or Always Off).

Registration

This preference enables CAM2 to automatically merge registration groups when you exit Registration mode, or after each point cloud measurement. *For more information, see "Registration" on page 41.*

Merge all registration groups when exiting Registration mode

- **Yes:** CAM2 automatically merges registration groups when you exit Registration mode.

- **No:** CAM2 does not automatically merge registration groups when you exit Registration mode.

- **Ask:** (Default) You are prompted whether you want CAM2 to automatically merge registration groups when you exit Registration mode. Unless you check the "Never ask me again" check box, the software will continue to prompt you to do so.

Selection

Select Points Facing The User

Select points with normal vectors facing the screen. *See "Front Facing" on page 40.*

Surface Edge

Edge Tolerance

The degree to which CAM2 refines point cloud normals at edges (Finest, Fine, Normal, Coarse, Coarsest, or Custom). The default value is Fine. Choose Custom to specify minimum edge length, minimum distance from edge, and the angle to edge threshold.

Tubing Tab

Display Breakpoints Under Tube

This preference controls whether CAM2 lists associated cylinders and breakpoints under each tube in the Features list. *See "Features" on page 34.*

- **Yes:** (Default) CAM2 lists the cylinders and breakpoints associated with each tube.

- **No:** CAM2 does not list the cylinders and breakpoints associated with each tube.

Align Tube Automatically

This preference controls whether CAM2 automatically aligns tubes.

When you select a nominal tube, CAM2 creates a new best-fit alignment to align the measured tube to the nominal tube.

If you do not have a nominal tube, CAM2 creates a new coordinate system alignment so that the tube will have:

- The start point at the origin.

- The first segment oriented in the +X direction.

- The first two segments lie on the Z=0 plane.

Automatic tube alignments appear in the **Alignments** window and can be edited normally. *See "Manage Alignments" on page 266.*

- **Yes:** (Default) CAM2 automatically aligns tubes.

- **No:** CAM2 does not automatically align tubes.

Positive Angles Represent A Clockwise Turn

This preference controls the way in which CAM2 represents clockwise and counterclockwise tube directions.

- **Yes:** (Default) Positive angles represent a clockwise turn.

- **No:** Positive angles represent a counterclockwise turn.

Other Tab

Material Compensation Mode

This preference specifies the way in which CAM2 compensates for material when you measure, so you can measure surface points on the material side of a part and compare the points to the CAD model.

The material thickness for the compensation is extracted from the material properties, specified in **Part Properties**, from which the Surface Point is extracted. *See "Part Properties" on page 96.*

- **None:** (Default) CAM2 will not compensate for material.

- **Back Side:** CAM2 will compensate for the part's CAD side.

- **Fixture B Side**: CAM2 will compensate for part's holding fixture.

  - Example: Inspect a fixture directly to the Part CAD single surface model to confirm touch points contacting the part on the 'B' side. The reported data is the actual measured point on the fixture, the dN relative to the fixture surface, and the ISP disc displayed on the CAD 'A' Surface. The error represents the material condition of the fixture touch point.

- **Part Thickness**: CAM2 will compensate for part's thickness.

  - Example: Inspect the part thickness deviation of a part held in a fixture against touch points. A single surface CAD model is used, offset to the probed part side. The reported data is the actual measured point on the Part 'B' side, where the normal is opposite to the CAD surface. The ISP disc is displayed on the CAD 'A' Surface, and rendered differently to indicate the flipped normal. The error represents the material thickness deviation of the part at the touch point.

- **Clamp**: CAM2 will compensate for part's clamping surface.

  - Example: Inspect fixture clamp positions using the Part CAD model to confirm touch points contacting the part on the 'A' side. The reported data is the actual measured point on the clamp surface, where the normal is opposite to the CAD surface. The ISP disc is displayed on the CAD 'A' Surface and rendered differently to indicate the flipped normal. The error represents the material condition of the clamp touch point.

Automatically Take Reading

This preference controls whether CAM2 automatically takes a reading when measuring vector points. *See Measuring a Vector Point on page 174 and Measuring a Home In Point on page 170.*

- **Yes:** CAM2 automatically takes a reading when measuring vector points (specify Home In Zone size).

- **No:** (Default) CAM2 does not automatically take a reading when measuring vector points.

Zone Diameter

This preference sets the default home in zone size. This value, in conjunction with the point and vector, defines a cylindrical zone around the point within which the user is expected to measure the point. The default value is 5 mm.

To change this preference, input a new number.

DRO Refresh Rate

This preference sets the rate at which the DRO refreshes. The default value is 200 ms.

To change this preference, input a new number.

Profile Calculation Method

This preference controls CAM2's calculation of Surface Profiles. *See "Profile of a Surface" on page 297.*

- **Nominal Deviation:** (Default) CAM2 will calculate the profile relative to the nominal surface as per ISO 1660.

- **Absolute Error:** CAM2 will float the profile calculation with the measurement data as per ASME y14.5.

Measurement Mode

Auto-Switch to Measure Mode

This preference controls the behavior of the software when you run **Add Readings** while in **Template** mode.

Click in the drop-down window and select a value:

- **Yes:** The software will automatically switch to **Measure** mode and you proceed to measure features.

- **No:** The software will not automatically switch to **Measure** mode, yet you will be prompted to measure features.

- **Ask:** (Default) You are asked to switch to **Measure** mode. Unless you check the "Never ask me again" check box, the software will continue to prompt you each time you attempt to measure a feature in **Template** mode.

Automatically Measure Features

This preference controls the behavior of the software when you switch to from **Template** to **Measure** mode.

Click in the drop-down window and select a value:

- **Yes:** The software will automatically add readings to all the measured features in the file.

- **No:** The software will not automatically add readings to all the measured features in the file.

- **Ask:** (Default) You are asked if you want to add readings to all the measured features in the file. Unless you check the "Never ask me again" check box, the software will continue to prompt you each time you switch to from **Template** to **Measure** mode.

Include Previously Measured Features

This preference specifies whether **Measure All** includes previously measured features.

Click in the drop-down window and select a value:

- **Yes:** The software will include previously measured features when **Measure All** is invoked.

- **No:** The software will exclude previously measured features when **Measure All** is invoked.

- **Ask:** (Default) You are asked if you want to include previously measured features in **Measure All**. Unless you check the "Never ask me again" check box, the software will continue to prompt you each time you invoke **Measure All**.

Laser Tracker

The Laser Tracker preferences govern the way in which the FARO Laser Tracker interfaces with CAM2.

NOTE: These preference apply to the FARO Laser Tracker only.

RMS Threshold

This preference specifies the upper limit of the Root Mean Square (RMS) threshold to define acceptable reading quality, and how CAM2 behaves when the limit is exceeded. RMS values are visible in the Measurement Panel. *See "Measurement Panel" on page 188.*

Measure Elevation Point

This preference specifies whether to measure a point to be used as a reference to the level plane.

- **Yes:** (Default) CAM2 measures a point to be used as a reference to the level plane.

- **No:** CAM2 will not measure a point to be used as a reference to the level plane.

Automatically Aim at the Next Feature

This preference specifies whether the FARO Laser Tracker should automatically aim at the next feature if the laser beam becomes broken.

- **Yes:** The FARO Laser Tracker automatically aims at the next feature when the laser beam is broken.

- **No:** (Default) The FARO Laser Tracker will not automatically aim at the next feature if the laser beam is broken.

Set Two Face Measurement for Uncompensated Points

This preference specifies whether the FARO Laser Tracker automatically takes one reading with the front sight and one reading with the back sight for uncompensated points.

- **Yes:** The FARO Laser Tracker performs Two Face measurement for uncompensated points.

- **No:** (Default) The FARO Laser Tracker will not perform Two Face measurement for uncompensated points.

TrackArm

The TrackArm preferences govern the way in which the TrackArm interfaces with CAM2.

NOTE: These preferences apply to the FARO TrackArm system only.

Locate TrackArm When Device Detected:

This preference specifies whether CAM2 should automatically locate the TrackArm when detected.

Click in the drop-down window and select a value:

- **Yes:** CAM2 automatically locates the TrackArm when detected.

- **No:** CAM2 does not automatically locate the TrackArm when detected.

- **Ask:** (Default) You are prompted whether to search for the TrackArm when CAM2 detects it.

Temperature Sensors

The Temperature Sensors box contains a list of available and active temperature sensors (External, FaroArm, and Laser Tracker) with which to measure outside temperature. These temperature sensors may be used to scale measurements by applying the temperatures in the Device Position and Alignment dialogs. The reading temperatures for the active measurement device are displayed in the Measurement Data panel. *See "Measurement Data" on page 27.*

Remote

The Remote preferences configure CAM2's remote server.

Remove Server

Check this box to enable a remote server for CAM2.

Create WiFi Network

Check this box to create a WiFi network (specify a name and key).

Alignment

The Alignment preferences determine configuration and profile information for point cloud alignments.

Click Alignment in the left window of the **Preferences** window to see the Alignment preferences.

Point Cloud Alignment

This preference specifies whether CAM2 should automatically attempt an alignment after each point cloud measurement.

- **Yes:** CAM2 performs an alignment after each point cloud measurement.

- **No:** CAM2 does not perform an alignment after each point cloud measurement.

- **Ask:** (Default) CAM2 prompts you whether to perform an alignment after each point cloud measurement.

NOTE: Automatic alignment requires the point cloud to be at least 75% of the volume of the CAD model. If the Point Cloud volume is less, automatic alignment is not available.

Iterative Alignment

Maximum Iterations

This preference controls the maximum iterations for iterative alignments.

Iterative Alignment Tolerance

This preference controls the default tolerance for iterative alignments.

Construction

The CONSTRUCTION preferences determine the way CAM2 handles constructed features.

Auto Best Fit

Indicates whether CAM2 performs automatic fitting when you select items from the Features panel.

- **Yes:** CAM2 performs automatic fitting when you select items from the Features panel.

- **No:** (Default) CAM2 does not perform automatic fitting when you select items from the Features panel.

CAD

The CAD preferences determine the way CAM2 displays CAD files.

Click CAD in the left window of the **Preferences** window to see the CAD preferences.

Surface Stitching Option

This preference specifies the method in which CAD surfaces are "stitched" to minimize error between feature lines.

Click in the drop-down window and select a value:

- **Match Geometry:** CAD surfaces are stitched according to geometric data.

- **Match Topology:** (Default) CAD surfaces are stitched according to topological structures.

CAD Part

The CAD Part preferences define properties for all loaded CAD parts.

Enabled

Indicates whether the CAD model is available for measurements and alignments.

- **Yes:** (Default) The CAD model is available for measurements and alignments.

- **No:** The CAD model is not available for measurements and alignments.

NOTE: If this preference is set to **No**, CAD contents will not considered for picking or measurements.

Visible

Indicates whether the CAD part will be visible in the CAD view.

- **Yes:** (Default) The CAD part will be visible in the CAD view.

- **No:** The CAD part will not be visible in the CAD view.

Material Composition

Indicates the default material composition of the CAD. To change this preference, click in the drop-down window and select a value. The default value is Steel.

Material Direction

Indicates the default CAD compensation. To change this preference, click in the drop-down window and select a value:

- **Above CAD Surface:** (Default) The material begins at the sampled surface and extends upward in a positive direction relative to the surface normal, i.e. the CAD surface represents the "bottom face" of the material.

- **Below CAD Surface:** The material begins at the CAD surface and extends downward in a negative direction relative to the surface normal, i.e. the CAD surface represents the "top face" of the material.

Material Thickness

Indicates the default thickness of the CAD material. The default value is 3mm.

CAD Import

Translate Hidden Entities

Indicates whether the entities on hidden CAD file layers will be included in CAD translation.

- **Yes:** Entities on hidden CAD file layers will be included in CAD translation.

- **No:** (Default) Entities on hidden CAD file layers will not be included in CAD translation.

Translate Curves and Lines

Indicates whether the CAD curves and lines will be included in CAD translation.

- **Yes:** Curves and lines will be included in CAD translation.

- **No:** (Default) Curves and lines will not be included in CAD translation.

Use Direct Translation to Parasolid

Indicates whether CAM2 automatically translates imported CAD into the Parasolid format.

- **Yes:** (Default) CAM2 automatically translates imported CAD into the Parasolid format.

- **No:** CAM2 does not automatically translate imported CAD into the Parasolid format.

Multi-Core Translation

Check this box to allow use of multiple processor cores to increase translation speed.

NOTE: If CAD translation fails, verify whether your PC configuration supports multi-process translation before enabling this option.

Healing

This preference enables healing of CAD model errors when importing CAD data. You can specify the balance between quality and system performance. Large CAD files may warrant a decrease in healing quality to gain an increase in system performance and a reduced healing time.

To configure the healing quality, click in the drop-down window and select a value:

- **None**: Healing is not enabled.

- **Better Speed**: (Default) The CAD heals in lesser detail with the best performance enhancement.

- **Better Quality:** The CAD heals in best detail with no performance enhancement. However, this can sometimes double the import time.

Fix Inverted Faces

Indicates whether CAM2 automatically fixes inverted CAD faces upon import.

- **Ask:** (Default) CAM2 prompts you whether to automatically fix inverted CAD faces upon import.

- **Yes:** CAM2 automatically fixes inverted CAD faces upon import.

- **No:** CAM2 does not automatically fix inverted CAD faces upon import.

Create the Nominals Automatically

Indicates whether CAM2 automatically creates nominals when importing CAD.

- **Ask:** (Default) CAM2 prompts you whether to automatically create nominals when importing CAD.

- **Yes:** CAM2 automatically creates nominals when importing CAD.

- **No:** CAM2 does not automatically create nominals when importing CAD.

Tolerance

The Tolerance preferences determine tolerance behavior and the default tolerances for each feature type.

Click Tolerance in the left window of the **Preferences** window to see the Tolerance preferences.

General Tab
Copy GD&T Tolerances

This preference specifies whether to include GD&T data when copying tolerances from one feature to another (or others).

To change this preference, click in the drop-down window and select a value:

- **Yes:** The software will include GD&T data when copying tolerances.

- **No:** The software will not include GD&T data when copying tolerances.

- **Ask:** (Default) You are asked if you want to include GD&T data when copying tolerances. Unless you check the "Never ask me again" check box, the software will continue to prompt you each time you copy tolerances.

Adaptive Tolerance

This preference determines the 'default' deviation tolerance for an aligned Point Cloud in order to improve the initial Point Cloud colorization.

By default, CAM2 calculates the best fit tolerance according to the active alignment. If the check box is cleared, the Point Cloud will be colored relative to the default tolerance, which may display the point cloud with large red, green, and blue areas.

- **Yes:** (Default) CAM2 will adjust the deviation tolerance to fit the active alignment.

- **No:** The deviation tolerance will not adapt to the active alignment.

Datum Suggestions

This preference specifies the number of datums that the user will be allowed to choose from when assigning datums to a feature. The default value is 3.

NOTE: CAM2 suggests the next N available Datum letters. For example, if the user has elected 3 datum suggestions and has already assigned Datums A and D, the next 3 datums suggested will be B, C and E.

Geometries Tab

Tolerances associate to a geometry type regardless of how that geometry type is created in the measurement file.

To change a default tolerance:

• Click the arrow to the left of a feature type to expand or collapse the tolerance information.

• When collapsed:

   • The value displayed represents a symmetrical tolerance for all properties of that feature type.

   • You can type in a value to override all tolerance values of all properties of that feature type. For example, if a user enters 0.01mm for a circle, it will define a +- 0.01mm tolerance for all circle properties.

   • You can associate a DIN or ISO tolerance classification per feature type. When associating a tolerance classification to a feature, it will apply to all applicable properties of that feature.

NOTE: The collapsed text will change to <custom> if any one value differs, in absolute value, to any other for that feature type.

• When expanded:

   • All properties of the type of feature are displayed.

   • Two boxes contain the lower and upper tolerance for each property. Enter tolerance values as appropriate.

   • Check boxes indicate whether properties are available or unavailable for tolerancing. Place a check in the checkbox to make it available; clear the checkbox to make it unavailable.

• Click **Apply to All** to apply the modified tolerances to all features in the measurement file.

NOTE: Geometry tolerance statistics (Maximum Error, Minimum Error, Form, etc.) are the same for all feature types.

GD&T Tab

Tolerances associate to a GD&T type. To change a default GD&T tolerance:

• Click the arrow to the right of a GD&T tolerance to expand or collapse the tolerance information.

• When collapsed:

   • The value displayed represents a symmetrical tolerance for all properties of that GD&T type.

   • You can associate a DIN or ISO tolerance classification per feature type. When associating a tolerance classification to a feature, it will apply to all applicable properties of that feature.

NOTE: The collapsed text will change to <custom> if any one value differs, in absolute value, to any other for that feature type.

- When expanded:

    - All properties of the type of GD&T tolerance are displayed.

    - Two boxes contain the lower and upper tolerance for each property. Enter tolerance values as appropriate.

    - Check boxes indicate whether properties are available or unavailable for tolerancing. Place a check in the checkbox to make it available; clear the checkbox to make it unavailable.

- Click **Apply to All** to apply the modified GD&T tolerances to all features in the measurement file.

Abbreviations Tab

Choose from two default abbreviation sets:

- **Text based**: Textual abbreviations.

- **Symbol based**: Replaces the text with symbols.

NOTE: When using Symbols, a tool tip will be displayed when hovering the cursor over a symbol in the Feature Information panel.

You can also create custom abbreviations for feature property names. To create abbreviations, you must create a new abbreviation set:

- Type a new name for your abbreviation set in the Abbreviation Set field and press Enter.

NOTE: You cannot edit the abbreviations of the Default abbreviation set.

- Expand the Position, Orientation, and/or Dimension feature property types. For each property type:

    - When collapsed:

        - The value displayed represents an abbreviation for all properties of that feature property type. When you create an abbreviation at the top level, it applies to all sublevels of that feature property type. For example, if you rename Center to C, Center properties become C.x, C.y, and C.z.

    - When expanded:

        - All properties of the feature property type are displayed.

        - Enter abbreviations as appropriate.

- Click **OK** to exit Preferences and apply all feature property abbreviation changes to the measurement file.

Report

The Report preference determines default formatting for reports, including logo selection.

Click Report in the left window of the **Preferences** window to see the Report preferences.

Header

Logo

Image Location

This preference selects the logo file for the report template.

To change this file, click the right column and select a different file.

The selected image appears in the Preview window.

Company Name
Company Details

Your organization's name, address, and contact information.

The selected logo and entered text will display on the header of the first page of the default report templates.

Options

Auto Report

Auto Update Report

This preference controls the automatic updating of reports as changes are made.

Yes: (Default) CAM2 will automatically update reports as changes are made.

No: CAM2 will not update reports automatically.

Generate From Selection

This preference controls the automatic generation of a report template with features selected in the CAD view. With this preference enabled, the user the user highlights the features that are required in the report while still in CAD View. When the user switches to the **Report** tab, the Report opens with the selected features and data formatted for the feature components specified in the **Feature Information** panel.

To change this preference, click in the drop-down window and select a value.

- **Always:** CAM2 will create a new report template each time the user switches to the **Report** tab with one or more features selected.

- **Ask:** CAM2 will prompt the user whether to create a new report template each time the user switches to the **Report** tab with one or more features selected.

- **No:** CAM2 will not generate a report template.

- **Once:** (Default) CAM2 will create the report template once. All subsequent changes to the **Report** tab will not result in the generation of a new report.

Default Format

With Alignment

This preference selects the report format that is used after an Alignment is created.

To change this preference, click in the drop-down window and select a value.

Without Alignment

This preference selects the report format that is used before an Alignment is created.

To change this preference, click in the drop-down window and select a value.

Other

Display Color Gradient in Report Images

This preference specifies whether to show the color gradient in report images. To change this preference, check or clear the check box.

Imager3D

The Imager3D preference determines default 3D Imager workflow.

Use Rotary Table Wizard To Measure Point Cloud

This preference controls whether CAM2 automatically uses the Rotary Table Wizard to measure point clouds.

Click in the drop-down window and select a value:

- **Yes:** CAM2 automatically uses the Rotary Table Wizard to measure point clouds.

- **No:** CAM2 does not automatically use the Rotary Table Wizard to measure point clouds.

- **Ask:** (Default) You are asked if you want CAM2 to automatically use the Rotary Table Wizard to measure point clouds. Unless you check the "Never ask me again" check box, the software will continue to prompt you to do so.

Save Wizard Preset On Scan

This preference controls whether CAM2 automatically saves the Rotary Table Wizard configuration to the selected preset. If no preset exists, CAM2 will create a new one.

Click in the drop-down window and select a value:

- **Yes:** CAM2 automatically saves the Rotary Table Wizard configuration to the selected preset.

- **No:** CAM2 does not automatically save the Rotary Table Wizard configuration to the selected preset.

- **Ask:** (Default) You are asked if you want CAM2 to automatically save the Rotary Table Wizard configuration to the selected preset. Unless you check the "Never ask me again" check box, the software will continue to prompt you to do so.

Attempt Registration After Each Point Cloud Measurement

This preference specifies whether CAM2 automatically merges registration groups after each point cloud measurement. *See "Registration" on page 41.*

- **Yes:** (Default) CAM2 automatically merges registration groups after each point cloud measurement.

- **No:** CAM2 does not automatically merge registration groups after each point cloud measurement.

Exit

Closes CAM2. If an unsaved measurement file is open, you are prompted to save or discard the file.

Chapter 4: Home

The Home commands are located in the **Home** tab across the top of the screen, and contain commonly used functionality organized in a sequential workflow, allowing you to complete most tasks from a single location. The commands on the **Home** tab are organized into Setup, Reference, Alignment, Measure, Analysis, and Document groups.

The contents of the **Home** tab change based on what you have selected in the Navigation Window. *See "Navigation Window" on page 33.*

Setup

The **Setup** group contains the Device Center and Move Device commands.

Device Center

Device Center accesses the **Device Center** panel. *For more information, see "Device Center" on page 128.*

Move Device

Select **Devices** > **Move Device** to access the **Move Device Position** wizard. *For more information, see "Manage Devices" on page 130.*

Reference

The **Reference** group contains all the commands necessary to import CAD, pick features, view CAD part properties, and mirror nominals.

Import CAD

Import CAD adds Parasolid® CAD format data (*.x_b) to your current measurement file. Select one or more CAD files in the **Add CAD Model** dialog, then click **Open** to translate them into Parasolid format and load them into the current measurement file.

Large CAD files or CAD files that may take longer to load than other files should be translated into the Parasolid format using **Translate CAD**. *See "Translate CAD" on page 58.*

NOTE: By default, imported CAD is displayed with both shading and wireframe information. To import files and change options use the FARO CAD translator. *See "Translate CAD" on page 58.*

The CAM2 CAD translator has an option to use Healing , or error correction, during the translation process. This option is a preference. *For more information, see "Healing " on page 89.*

Pick Features

Click **Pick Features** to enable intelligent feature-picking from CAD. Pick Features also extracts the same feature from Point Cloud if aligned. *For more information, see "Pick Features" on page 218.*

Part Properties

PART Properties accesses the **Edit CAD Part Properties** window. The **Edit CAD Part Properties** window contains all loaded CAD parts and the material properties for each CAD part.

Change the CAD Part properties preferences so that all CAD parts add with the same properties.

Composition: The thermal properties of the CAD material for use by alignments.

Thickness: The thickness of the CAD material (in measurement file units).

Direction: The normal direction of the CAD surface.

- **Above CAD Surface:** The material begins at the sampled surface and extends upward in a positive direction relative to the surface normal; the CAD surface represents the "bottom face" of the material.

- **Below CAD Surface:** The material begins at the CAD surface and extends downward in a negative direction relative to the surface normal; the CAD surface represents the "top face" of the material.

> **NOTE:** As you measure the part, you can switch between these surfaces using **Material Compensation**. *See "Material Compensation" on page 182.*

CAD Color: The front and back surface display colors. Change the colors by checking the Override CAD Color box and clicking the Front Surface and Back Surface drop-downs.

Wireframe: The wireframe display color.

Mirror On: The axis on which to mirror the CAD.

> **NOTE:** Mirroring is a state of the CAD part, and must be either made available or unavailable (not both). To view the mirrored and unmirrored CAD part simultaneously, load the part twice and mirror one instance.

Visible: Indicates whether the CAD part is visible in the CAD view.

Enabled: Indicates whether the CAD model is available for use by measurements and alignments.

> **NOTE:** If the CAD is not enabled, it is not considered for picking or measurements.

Mirror Nominal

Mirror Nominal allows you to apply a mirror transformation to all nominals in the measurement file. The mirror transformation occurs along an axis-aligned Mirroring Plane that is supplied as a single coordinate (not a feature) in conjunction with a Plane Offset, such as Y = 5.0mm. You have the option to mirror the features in place or as a copy.

The number of nominal features after the mirror will be the same as before. CAM2 will automatically move any constructed nominals that are based on existing features, and any measurements associated to the existing nominals will remain properly linked but will have the readings removed.

> **NOTE:** The nominals will mirror in place unless the Copy Entity box is selected.

Mirrored Entity Suffix

When you are copying an entity by mirroring, use the Mirrored Entity Suffix box to enter a suffix to be automatically appended to the new nominal feature names. The default suffix is *.

Copy Entity

The initial nominals are retained and a second set of nominals is created, doubling the number of nominal features. CAM2 will duplicate Key-In and Pick from CAD features as Key-In features using the mirror plane. Constructions and dimensions that are built from features will be copied. Any measurements associated to the existing nominals will have corresponding measurements for the newly created construction. Projection planes or home-in features will be replaced with the corresponding mirrored measurement.

> **NOTE:** Measurements, measured features made nominal, and QuickTools will not mirror.

Create Nominal Mesh

Create Nominal Mesh allows you to create a nominal mesh from a selected point cloud and export the mesh file (*.stl) to the default location. Select a meshing profile to apply appropriate parameters to your component:

- **Smooth**: for larger parts with flat or large curved surfaces with little to no detail, such as automotive body panels.

- **Curvature**: for medium-sized parts with curved and small radiused surfaces, such as pressed or molded parts.

- **Detailed**: for smaller parts with small or fine detail, such as coins.

> **NOTE:** You can also right-click the point cloud and select **Create Nominal Mesh** from the context menu.

Alignment

The **Alignment** group contains all the commands necessary to align your part, manage alignments, create a coordinate system alignment, and align a point cloud.

Align My Part

Select **Align My Part** to access the **Create Alignments Wizard**. *For more information, see "Align My Part" on page 268.*

Manage Alignments

Select **Manage Alignments** to access the **Alignments** window. *For more information, see "Manage Alignments" on page 266.*

Coordinate System

Select **Coordinate System** to create a coordinate system alignment. *For more information, see "Coordinate System" on page 276.*

Align Point Cloud

Select **Align Point Cloud** to access point cloud alignment mode. *For more information, see "Align Point Cloud" on page 269.*

Measure

The **Measure** group contains all the commands necessary to select Measure or Template mode, measure features, clear readings, and enable automatic feature recognition.

Measure and Template Mode

Click this icon to switch between **Measure** and **Template** mode.

Measure Mode

The current device's **Measurement** panel automatically opens and you can begin to **Add Readings** to the feature. Select multiple measurement commands and each will be added to the **Measurement** panel in the order that you select the commands.

Template Mode

Template mode disables the automatic adding of readings when you add one or more features to the measurement file. The default mode is a preference. *See "Default Measure Mode " on page 79.*

Select a Measurement command and that measured feature adds to the measurement file. Add readings to the feature manually with **Add Readings** . *See "Add Readings " on page 197.*

When **Template** mode is active, a red border and "Template Mode" text appear around the **CAD** tab of the **Main Window**. *See "Screen Layout" on page 15.*

NOTE: When you switch to **Measure** mode after adding features in **Template** mode, CAM2 will prompt you to measure those features.

Features

The **Features** group contains all the measurement commands for 2D and 3D features. *For more information, see "Features" on page 154.*

Measure All

Measure All measures, or adds readings, to every feature in your file. If you have already measured features, CAM2 prompts you whether to remeasure those features. The measurement order follow the position of the features in the **Features** panel. *See "Reordering Features" on page 36.*

1. Select **Measure** > **Measure All**.

2. Use your measuring device and add readings to the first feature in the **Features** panel.

3. Press the **Back** button, or **H** key, to finish.

NOTE: Pressing the **Back** button, or **H** key, may also define the Probe Compensation. *For more information, see "Probe Compensation" on page 184.*

Clear Readings

Clear Readings clears all readings from *all* entities in the measurement file. *For more information, see "Clear Readings" on page 109.*

Auto-Recognize Features

Auto-Recognize Features enables automatic feature recognition. *For more information, see "Automatic Feature Recognition" on page 188.*

Analysis

The **Analysis** group contains all the commands necessary to create measurement results from features.

Length From Features

Select **Length From Features** to create a dimension between features. *For more information, see "Length From Features" on page 259.*

Construct from Selection Gallery

Select features in the gallery to create dimensions between them. *For more information, see "Length From Features" on page 259.*

Cross-Section Analysis

Use the **Cross-Section** command in the **Analysis** group to select, extract, dimension, control, and add deviation markers to cross-section scan data. Select a cross-section feature (with readings) and click **Cross-Section** to access Cross-Section Analysis mode.

When in Cross-Section Analysis mode, the Navigation Window organizes your content into three folders:

- **CAD Parts**: The list of all CAD parts associated with your cross-section, with individual show/hide capabilities.

- **Dimensions**: The list of all extracted dimensions. *See "Dimensions" on the facing page.*

- **Views**: The list of all saved views. *See "Capture" on page 106.*

The Cross-Section Analysis commands are located in the **Cross-Section Analysis** tab across the top of the screen, and the commands are organized into Selection Tools, Dimensions, Editing, Display, View, Deviation Markers, View Data, and Close groups.

Selection Tools

The **Selection Tools** group contains commands to select portions of cross-sections: Rectangular, Lasso, Polygon, and Brush. *For more information, see "Selection Tools" on page 38.*

Dimensions

Create dimensions from your selection of cross-section data. When you select dimensions in the Navigation Window (Dimensions folder), you can view and edit their nominal and tolerance values in the Feature Information panel.

Dimensions also appear in Report as a detailed listing with specified nominal and tolerance values.

The **Dimensions** group contains commands to extract 2D dimensions to analyze the measured cross-section: Radius, Angle, and Height.

Radius

Radius extracts a radius dimension. Click anywhere on a circular portion of the cross-section, select **Radius**, and CAM2 automatically extracts a radius from the best points in a circular pattern.

Angle

Angle extracts an angle dimension. Click anywhere on a linear portion of the cross section. CAM2 determines the first line using the best points in a linear pattern. Click anywhere on the second linear portion of the cross section, select **Angle**, and CAM2 determines the second line and extracts the angle between the two lines.

Height

Height extracts a height dimension. Click anywhere on a linear portion of the cross section. CAM2 determines the first line using the best points in a linear pattern. Click on a second linear portion of the cross section parallel to the first linear portion, select **Height**, and CAM2 extracts the height between the two lines.

Dimension Label Position

You can reposition dimension labels and graphics in the **Main** window. Place your mouse cursor over a dimension to highlight the dimension. When the dimension is highlighted, click and drag the dimension to reposition it. Each dimension type has specific movable components:

- **Radius**: Click and drag the text. The callout line extends to the new text position.

- **Angle**: Place the mouse cursor on the curved line joining the two angle lines. Click and drag the curved line or the text.

- **Height**: Place the mouse cursor on the line connecting the two portions of the dimension. Click and drag the line in a perpendicular direction.

Edit

Edit enables the selection tool you originally used to select points for the dimension. Click **Edit** and select new points.

Update

Update confirms the dimension recalculation based on the new point(s) you picked.

Editing

The **Editing** group contains commands to edit and subsequently update the cross-section data used for dimension calculation.

Define Area of Interest

Define Area of Interest enables a Rectangular selection of a specific cross-section area. Once you make a selection, the view zooms to that specific rectangular selection.

> **NOTE:** CAM2 removes all measurements and CAD outside of the defined Area of Interest. To restore the complete cross-section, click **Reset**.

Nominal

Nominal shows the portion of the cross-section scan that only contains nominal data. To restore the complete cross-section, click **Reset**.

Exclude Points

Exclude Points excludes selected points from the cross-section and from any cross-section calculations. Use the **Selection Tools** to choose the points to exclude. *See "Selection Tools" on page 38.*

NOTE: CAM2 hides the excluded points from view but does not delete them. To restore the excluded points, click **Reset**.

Reset

Reset restores any points removed by the **Define Area of Interest**, **Nominal**, or **Exclude Points** commands.

Display

The **Display** group contains commands to configure the visual representation of the cross-section.

Tolerance Style

Tolerance Style switches between visual display modes for cross-section tolerances:

None

Tolerance Bands

Tolerance Lines

Connectors Style

Connectors Style switches between visual display modes for cross-section connectors:

None

Connectors Polyline

Connectors Spline.

NOTE: If you select the Connectors Spline style, cross-sections will Export to CAD as Spline entities. *See "Export" on page 63.*

Whiskers

Whiskers shows feature whiskers in the **Main Window**.

NOTE: You can adjust the whisker scale in the **View** tab's **3D View** group. *See "Whisker Scale" on page 114.*

Show Readings

Show Readings shows the actual readings in the **Main Window**.

View

The **View** group contains commands to manipulate the view of the cross-section: 2D Rotation, Reset, Rotate 90° Clockwise, Rotate 90° Counterclockwise, and Center Point.

2D Rotation

2D Rotation switches between a 3D rotation to view the cross-section outside of its cutting plane and a 2D rotation to rotate cross-section within the plane.

Reset

Reset resets the view to the default view. You can also press the **R** keyboard shortcut on the keyboard.

When you have finished configuring the cross-section view, click **Capture View Data** to save the view. *See "Capture" on page 106.*

Rotate 90° Clockwise

Rotate 90° Clockwise rotates the cross-section view 90 degrees clockwise.

Rotate 90° Counterclockwise

Rotate 90° Counterclockwise rotates the cross-section view 90 degrees counterclockwise.

Center Point

Center Point defines the center of rotation when in 2D rotation mode.

Deviation Markers

Deviation Markers show deviation of the measured cross-section relative to CAD at any position on the CAD model. *For more information, see "Pick Deviation" on page 106.*

Pick

Click **Pick** to create deviation markers by picking them on the CAD model. The mouse cursor changes to a box with a selection arrow. Each time you click the CAD model, CAM2 creates a deviation marker and lists the marker's number and XYZ coordinates on the left side of the **Main Window**. Click **Pick** again to exit picking mode.

NOTE: You can automatically create a label at the high and low point on a cross-section, and also define markers at a fixed spacing by setting parameters in the cross-section's properties. *For more information, see "Construct: Cross-Section Scan" on page 254.*

Manage

Click **Manage** to manage deviation markers for the cross-section. The **Manage Deviation Markers** dialog allows you to specify distance, number of markers, and zone size.

Highest/Lowest

Click **Highest/Lowest** to identify the highest and lowest deviations. The highest and lowest marker are each appended with a label.

View Data

Cross-sections can cover large areas, yet the most relevant information may be restricted to specific portions. Capture and recall saved views of specific areas for quick access and inclusion in your reports.

The **View Data** group contains commands to capture, delete, and recall captured views of the cross-section: Capture, Delete, and Recall.

⌖ Capture

Capture saves a copy of the current cross-section view. Saved views appear in the Navigation Window's Views folder (and also Report) in the order in which they were created.

⌖ Delete

Delete removes a saved cross-section view. Click a view in the Navigation Window's Views folder, and click **Delete**.

⌖ Recall

Recall restores the last saved view. Click a view in the Navigation Window's Views folder, and click **Recall**.

✕ Close

Click **Close** to exit cross-section analysis mode.

⌖ Pick Deviation

Click **Pick Deviation** to enter Deviation Marker picking mode. *For more information, see "Deviation Markers" on page 120.*

⌖ Show Feature Window

Show Feature Window displays a **Feature** window (DRO) for a selected feature. *For more information, see "Show Feature Window" on page 124.*

Document

The **Document** group contains the Capture View and Document Header Information commands.

⌖ Capture View

Capture View allows you to save a copy of the current view. *For more information, see "Capture" on page 121.*

Document Header Information

Document Header Information allows you to view and edit the current measurement file's header information in the **Document Header Information** window. You can also save the information as a default information set to recall later. The information entered here also appears on CAM2 reports. *For more information, see "Report" on page 45.*

In the **Document Header Information** window, you can:

*   Control the visibility of each item:
    1. Clear the Visible checkbox to the left of an item to hide the item from view.

    2. Place a check in the Visible checkbox to show the item.

*   Change the values for each item:
    1. Select the Header item.

    2. Click in the **Value** column and enter a new value.

   NOTE: The values remain for every new file until you change them.

---

*   Add custom Header items:
    1. Click **Add New** in the upper left corner of the **Document Properties** dialog box.

    2. Enter a name for the item.

    3. Click in the **Value** column and enter a new value.

    4. Press **Enter** to accept the changes.

*   Remove a custom Header item:
    1. Select the Header item.

    2. Click **Delete** to remove the item from the list.

   NOTE: You can only delete custom Header items.

---

*   Reorder the Header items:
    1. Select the Header item.

    2. Click the **Up** and **Down** arrow keys to move the item up and down the list.

*   Export a Document Header Information text file:
    1. Click **Export**.

    2. Enter a filename, browse to a save location, and click **Save**.

Tolerance Preferences

Tolerance Preferences quickly accesses the Tolerance section of the Preferences. *For more information, see "Tolerance" on page 90.*

±0.1 Copy Tolerances

Copy Tolerances copies all tolerances for a selected feature, and is used in conjunction with **Paste Tolerances**.

NOTE: You have the option to include GD&T data when copying tolerances. *See "Copy GD&T Tolerances" on page 90.*

±0.1 Paste Tolerances

Select a feature, or multiple similar features, and run this command to paste a set of tolerances copied from another feature. **Paste Tolerances** is used in conjunction with **Copy Tolerances**.

Repeat

Repeat invokes the last used CAM2 command. You can also press the Enter keyboard shortcut on the keyboard.

Properties

Select a Feature.[1] and use **Properties** to see and change parameters of any feature or CAD part. This command is a
lso available in the Shortcut Menus. *See "Shortcut Menus" on page 310.*

You can change the properties of measured features. *For more information, see "Feature Properties" on page 183.*

CAUTION: While you can not alter the actual results of a measured feature, adjusting these parameters can alter how the results calculate and display.

You can change the properties of constructed and nominal features. For more information, click the Help button in the **Edit** dialog box.

NOTE: In the dialog boxes, **Create** is replaced by **Modify**. After changing any parameter, click **Modify** to save the changes.

You can change the Part Properties. *See "Part Properties" on page 96.*

You can view the flipped vector state of the feature or CAD part by checking the **Vector Flipped** checkbox.

Preferences

Preferences give you the controls to tailor CAM2 to your needs. User preferences may also be accessed from the File tab. *See "Preferences" on page 67.*

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

◇ Clear Readings

Clear Readings clears all readings from *all* entities in the measurement file.

NOTE: To delete all of the readings from a specific feature, right-click the feature and select **Delete Readings**. *See "Shortcut Menus" on page 310.*

↑ Flip Vector

Flip Vector flips the vector of a feature. This command flips the plane vector of a plane-reducible feature or line vector of a line-reducible feature.

NOTE: A Flip Vector state remains associated with a feature until all readings are cleared using the **Clear All Readings**. Manually deleting all the readings (using the Readings tab) will not disassociate the "Flip Vector" state.

If the vector of a feature is used to define a coordinate system, and the coordinate system is then used for an alignment, flipping the feature's vector will not change the displayed vector of the line since that is controlled by the alignment. However, the alignment will change and features may shift.

You can view the "Flip Vector" state of a feature by checking the **Vector Flipped** checkbox in the **Feature Editor** dialog (accessed with **Properties**).

Chapter 5: View

The View commands are located in the **View** tab across the top of the screen. The **View** tab contains all the commands that affect how you see the contents of your measurement file on the screen. It also allows you to control what you see on the screen, and the user interface. The commands on the **View** tab are organized into Window, 3D View, Camera, Labels, Deviation Markers, and View Data groups.

Window

The **Window** group contains all the commands necessary to display CAM2 at full screen resolution, view closed panels, and work with layers.

Full Screen

Select **View > Full Screen** to enlarge the **CAD** tab to fit the entire screen. You can also press the **Shift + Alt + Enter** keyboard shortcut on the keyboard.

- Click **Close Full Screen** or press **Esc** to exit full screen mode.

View Closed Panels

View Closed Panels accesses a list of closed (but accessible) panels. Click the name of the panel to access the panel.

Layers

All CAD and CAM2 features add to the default layer. Use **Layers** as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file.

NOTE: You can also access the **Layers** panel by clicking **View Closed Panels** on the **View** tab, and then **Layers**. *See "View Closed Panels" above.*

Viewing Features on a Layer

To view all features associated with a layer, click the drop-down arrow to the left of the layer name to expand the layer contents. If the layer does not contain features, no arrow will be visible.

To the extreme right of all layers is the **Visibility** button (eye icon). Click the button to hide a layer. Once hidden, the button appears gray. Click the button again to show the layer.

Creating a New Layer

1. In the **Layers** dialog box, click **New Layer** to create a new layer.

2. Enter a name for the layer.

3. To select a layer color for on-screen viewing, choose a color from the **Override Color** drop-down. You can also clear the color which sets the color to White.

4. Clear the **Visible** box to hide contents of the layer on-screen.

NOTE: You can also enable or disable visibility of a layer by clicking the **Visibility** button (eye icon).

5. Clear the **Enabled** box to hide lock the layer.

6. Click OK.

Editing a Layer

1. In the **Layers** dialog box, highlight the layer and click **Edit** or double-click on the layer name.

2. Edit a name for the layer, edit the override color from the drop-down, and enable or disable the visibility of the layer.

3. Click OK.

Deleting a Layer

In the **Layers** dialog box, highlight the layer and click **Delete**.

NOTE: Deleting a layer automatically moves any features back to the default layer.

Adding Features to a Layer

You can assign any feature in the **Navigation** window to a layer:

- Click features in the **Navigation** window and drag them onto a layer in the **Layers** panel to associate them with the layer. *See "Features" on page 34.*

- Right-click any feature in the **Features** panel, point to **Assign a Layer**, and choose a layer from the menu.

NOTE: To assign CAD features to a layer, click CAD at the bottom of the **Navigation** window. *See "CAD" on page 37.*

Removing Features from a Layer

You can remove any feature from a layer:

- Click the arrow to the left of a layer to expand and view a list of the features on the layer.

- Click **Delete** (**red X**) to the right of the feature.

NOTE: You can also drag a feature to another layer.

3D View

The **3D View** group contains all the commands necessary to select a shading mode, work with layers, configure point size and whisker scale, select and configure custom tolerance indicators, show the grid, and show or hide targets.

Shading Mode

Shading Mode controls the way in which CAM2 applies shading to the view (Shaded + Wireframe, Shaded, and Wireframe). The Shaded +Wireframe view is the default view. You can also press the **S** keyboard shortcut on the keyboard to switch between the three shaded and wireframe views.

Show/Hide

Show/Hide controls the visibility of feature and feature groups in the **Main Window**. Select one or more features in the **Features** panel, then click **Show-Hide** to hide the selected feature(s). While the selection is hidden, the features remain in the **Features** panel but are not shown in the **Main Window**. The eye icon appears gray for the selection, indicating "hidden" status. Click **Show-Hide** again to show the feature(s).

> **NOTE:** You can also access this command in the Navigation Window. *See "Navigation Window" on page 33.*

Show Only Selected

Click the drop-down below **Show/Hide** to access **Show Only Selected**. Click **Show Only Selected** to make only selected features visible and all other features invisible.

> **NOTE: Show Only Selected** also affects folder visibility, though it will not affect the visibility of the features in the folder. CAM2 will only show those features set as visible.

Readings Size

Readings Size controls the size at which CAM2 renders points. Use the slider to adjust the size from small (far left) to very large (far right).

> **NOTE:** To scale the size of Point Features, see **Point Feature Size** in the **Display** group of **Preferences**. *See "Point Feature Size" on page 70.*

Whisker Scale

Whiskers are a single line that visually represent distance data of a feature. There are two types of whiskers:

• **Whiskers** - The whisker shows the deviation of each reading to the feature.

• **Nominal Whiskers** - The whisker shows the deviation of the measured feature to its nominal.

NOTE: Nominal Whiskers will not display unless there is a nominal associated to the measured feature.

You can change the scale of the feature whiskers by clicking the up and down arrows or entering a value.

Select a feature from the **Features** panel, or the CAD View, and click either Whisker command. The whiskers change color according to tolerance condition:

- **Green** - feature is in tolerance

- **Red** - measurement is above the upper tolerance

- **Blue** - measurement is below the lower tolerance

You can also access this command by right-clicking on a feature.

Custom Tolerances

The **Custom Tolerances** drop down contains a list of available tolerance indicators for your measurement file:

- Rainbow (Default) - tolerance conditions are identified by seven corresponding colors.

- Go/No-Go - tolerance conditions are identified by green (in tolerance) and red (out of tolerance).

- Tri-State - tolerance conditions are identified by green (in tolerance), red (above upper tolerance), and blue (below lower tolerance).

Use Manage Custom Tolerances to create, edit, import, export, and delete customized sets of tolerance indicators. *See "Manage Custom Tolerances" below.*

Manage Custom Tolerances

The **Manage Custom Tolerances** window contains color bars that correspond to tolerance conditions (by percentage in/out), and triangles that you can use to specify tolerance indication color schemes.

When you select a tolerance in the **Custom Tolerances** drop down, the measurement file displays tolerance indicator colors according to the triangles you've configured.

Add a Custom Tolerance Indicator

To add a custom tolerance indicator, click **Add** and enter a name for the new color scheme.

Below the name is a line of color boxes that are placeholders to define colors. Each placeholder represents a 25% increment in the tolerance band and the full span of placeholders covers -300% (3x below Lower Tolerance) to +300% (3x above upper tolerance).

- Define a placeholder color by double-clicking the placeholder to create a colored triangle. Right-click a triangle to select the placeholder color or delete the triangle.

- Drag and drop triangles to move them.

NOTE: Placeholders without triangles will appear as follows:

- When to the left of the left-most triangle, the color will match the left-most triangle.

- When to the right of the right-most triangle, the color will match the right-most triangle.

- When between two colored triangles, the color will be a gradient of the two triangle colors. The steps of the gradient are determined by the number of placeholders between the triangles.

- Click **OK** to save your custom tolerance color scheme.

Delete a Custom Tolerance Indicator

To delete a custom tolerance indicator, highlight the tolerance indicator and click **Delete**.

NOTE: The Rainbow, Go-NoGo, and Tri-State tolerance indicators cannot be deleted.

Export (Save) and Import your custom tolerance indicators using the **Export** and **Import** buttons.

Grid

Show-Hide Grid shows or hides the grid in the current view. You can also press the **Number Sign (#)** keyboard shortcut on the keyboard. The grid is only visible in the +X/-X View, +Y/-Y View or +Z/-Z View Preset Views.

Show/Hide Targets

Show/Hide Targets shows or hides point cloud targets in the current view.

Camera

The **Camera** group contains all the commands necessary to configure the view.

Preset Views

The **Preset Views** drop down contains a set of view rotations to a fixed position. All **Views** respond to the current alignment.

+X/-X View

+X/-X View sets the positive XZ plane parallel to the screen. Select the command again to set the negative XZ plane. You can also press the **4** keyboard shortcut on the keyboard.

+Y/-Y View

+Y/-Y view sets the YZ plane parallel to the screen. Select the command again to set the negative YZ plane. You can also press the **5** keyboard shortcut on the keyboard.

+Z/-Z View

+Z/-Z view sets the XY plane parallel to the screen. Select the command again to set the negative XY plane. You can also press the **6** keyboard shortcut on the keyboard.

Isometric SE

Isometric SE sets a southeast isometric view looking at the current alignment parallel to the screen. You can also press the **7** keyboard shortcut on the keyboard.

Isometric SW

Isometric SW sets a southwest isometric view looking at the current alignment parallel to the screen. You can also press the **8** keyboard shortcut on the keyboard.

Isometric NE

Isometric NE sets a northeast isometric view looking at the current alignment parallel to the screen. You can also press the **9** keyboard shortcut on the keyboard.

Isometric NW

Isometric NW sets a northwest isometric view looking at the current alignment parallel to the screen. You can also press the **0** keyboard shortcut on the keyboard.

Reset View

Reset View returns the view to the default settings of your current preset view. You can also press the **R** keyboard shortcut on the keyboard.

Recenter View

Recenter View centers the contents of the **Main Window** according to the active coordinate system.

Reset Rotation

Reset Rotation returns the view rotation to the default view.

Zoom To Area

Zoom To Area zooms to a user-defined window of the CAD view. You can also press the **W** key on the keyboard.

1. Move the mouse pointer to the area of the screen where you want to begin.

2. Click and hold the **Left Mouse** button.

3. Drag the mouse to create a window for the view.

4. Release the **Left Mouse** button to set the view.

You can also use the keyboard and mouse to zoom the view without using this command. To zoom to a window:

1. Press and hold the **Shift** key on the keyboard.

2. Click and hold the **Left Mouse** button.

3. Drag the mouse to create a window for the view.

4. Release the **Left Mouse** button to set the view.

5. Release the **Shift** key to end.

Reset Zoom

Reset Zoom resets the zoom so that all features in the **Main Window** are visible.

2D Rotation

2D Rotation switches between 2D rotation and 3D rotation.

Rotate 90° Clockwise

Rotate 90° Clockwise rotates the view 90 degrees clockwise.

Rotate 90° Counterclockwise

Rotate 90° Counterclockwise rotates the view 90 degrees counterclockwise.

Center Point

Center Point defines the center of rotation when in 2D rotation mode.

Labels

Use the Labels commands to arrange, show, hide, and control the detail level of labels. To apply a label to a feature, right-click the feature in the Feature list or the main window, then select a Label and Label Style.

Label Styles

CAM2 has four default label styles:

Simple

NOTE: The color and icon indicate the overall status (such as maximum deviation) of all feature details.

Detailed

○ Circle 3				
	Actual	Nom	Dev	
Center.x	69.948mm	70.000mm	-0.052mm	↓
Center.y	-0.007mm	0.000mm	-0.007mm	
Center.z	0.000mm	0.000mm	0.000mm	
Diameter	19.909mm	20.000mm	-0.091mm	↓
Circularity	0.051mm	0.000mm	0.051mm	↑
⊕ 0.100mm Ⓜ A B Ⓜ C			0.105mm	↑

NOTE: The status color and icons indicate the deviation of the individual feature details.

Surface Point

⚒ Inspect Surface Point 1		
dN	-0.023mm	

Callout

1	0.075	

NOTE: The color and icon indicate the dN detail deviation.

CAM2 can display labels as 2D or 3D using the Front Facing icon.

Arrange

Click **Arrange** to select one of three different label arrangements. *See "Labels" on page 191.*

Add or remove on-screen labels by right-clicking a feature and selecting **Label**.

NOTE: You can configure the appearance of labels and enable them to auto-arrange via the Display preferences in the **File > Preferences** menu. *For more information, see "Display" on page 69.*

Show All Labels

Show All Labels makes all on-screen labels visible in the current view.

Hide All Labels

Hide All Labels removes all on-screen labels from the current view.

Scale To Screen

Scale To Screen automatically sizes labels relative to the screen and maintains their screen size as you zooms in or out of the 3D viewer.

> **NOTE:** To remove a callout label from the screen, right-click on the callout and select **Delete Callout**.

Labels Front Facing

Labels Front Facingdisplays labels as 2D (front facing on) or 3D (front facing off).

> **NOTE:** When you deselect Front Facing, labels will revert to their previous orientation.

Label Readings

Label Readings creates callout labels on point cloud, polyline, polyline group, and cross section features. When enabled, click the point cloud, polyline, polyline group, or cross section to create numbered labels showing the deviation at the point you clicked. The label numbers correspond to discrete callouts in the report data.

> **NOTE:** To remove a callout label from the screen, right-click on the callout and select **Delete Callout**.

Deviation Markers

Deviation markers show deviation of the measured part relative to CAD at any position on the CAD model. They remain associated with the CAD model after you clear or delete an associated point cloud, and they will continue to show deviation when you record new point cloud data.

Use the Deviation Markers commands to create and adjust deviation markers.

Pick

Click **Pick** to enter picking mode. Create deviation markers by picking them on the CAD model. The mouse cursor changes to a box with a selection arrow. Each time you click the CAD model, CAM2 creates a deviation marker and lists the marker's number and XYZ coordinates on the left side of the **Main Window**. Click **Pick** again to exit picking mode.

Generate

Click **Generate** to create a series of deviation markers using a custom grid overlay.

Drag the mouse pointer to define a rectangular area on your CAD model. To make adjustments:

- Click and drag the center of the rectangle to move it.

- Click and drag the lower right corner of the rectangle to make it bigger or smaller.

- Click and drag the upper center of the rectangle to rotate it.

- Click and drag the red circles along the axes to adjust the grid spacing. You can also key-in exact values.

When you're ready to create the deviation markers with your grid, press **Enter**. To cancel the operation at any time, press **Esc**.

Key-In

Click **Key-In** to create deviation markers by typing in the XYZ value and threshold. Typing values in different units and coordinate systems.[1]

Z
one Size

Zone Size controls the size of all deviation markers. Enter a different number in the box to adjust the size. The default value is 1 mm.

Delete

To delete a deviation marker, mouse over the deviation marker on the left side of the **Main** window and click the X in the upper right corner.

View Data

The **View Data** group contains commands to capture, delete, and recall custom views: Capture, Delete, and Recall. You can access views in the **Views** panel and include them in reports using the **Report** window. *For more information, see Views on page 27 and Report on page 45.*

Capture

Capture saves a copy of the current view. Saved views appear in the **Views** panel (and also Report) in the order in which they were created.

---

[1]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

Delete

Delete removes a saved view. Click a view in the **Views** panel and click **Delete**.

Recall

Recall restores the last saved view. Click a view in the **Views** panel and click **Recall**.

Export As Image

Export As Image exports the current view to an image file (PNG, JPEG, or BMP format).

Panels

The **Panels** command shows a list of the hidden panels. By Default, many of the panels are hidden.

CAD Part Properties

The **CAD Part Properties** panel contains all loaded CAD parts, the material properties of each CAD part, and controls to modify the global properties of any CAD part.

Figure 5-1 CAD Part Properties panel

For more information, see "Part Properties" on page 96.

Feature Information

The **Feature Information** panel contains a list of nominals and tolerancing information for a selected feature (replicated in feature labels).

Figure 5-1 Feature Information panel

For more information, see "Nominals and Tolerances" on page 194.

NOTE: Only the tolerance value itself may be edited; any additional data used to compute the GD&T Tolerance can only be edited in the **GD&T** panel. *For more information, see "GD&T" on page 287.*

Layers

The **Layers** panel contains the list of layers and features assigned to each individual layer. *For more information, see "Layers" on page 112.*

Measurement

The **Measurement** panel contains the current location of the measuring device's probe and updates as the probe moves through space. The numerical setup of the **Measurement** panel is a preference. *See "Units Tab" on page 74.*
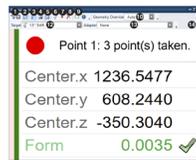
Figure 5-1 Measurement panel

For more information, see "Measurement Panel" on page 188.

Messages

The **Messages** panel contains informational messages relating to the measurement file.

Figure 5-1 Messages panel

Measurement Data

The **Measurement Data** panel contains a list of measurement readings and properties (including XYZ, Deviation from Fit, Device Position, and Probe) for a selected feature.

Figure 5-1 Measurement Data panel

For more information, see "Measurement Data" on page 192.

Feature Readings

Feature Readings shows/hides points that represent the measured readings. Access this command by right-clicking on a feature.

You can change the size of the feature reading point in **Preferences**. *See "Readings Size" on page 70.*

Select a feature from the **Features** panel, or the CAD View, and click **Feature Readings**. The readings change color:

- **Green** (Pass) - reading is in tolerance.

- **Red** - reading is above the upper tolerance.

- **Blue** - reading is below the lower tolerance.

The color shows the deviation of each reading to the feature, and uses the Form tolerance. *See "Tolerance Preferences" on page 63.*

Show Feature Window

Show Feature Window displays a **Feature** window (DRO) for a selected feature. Access this command from the Home menu, by right-clicking on a feature, or pressing the **D** key on the keyboard.

Use a **Feature** window to:

- See the live deviations of a specific feature based on the current location of the probe, including normal (dN) and radial (dR) deviations for circles and cylinders.

- In an assembly, guide a part into position using the coordinate values of a specific feature on the part.

NOTE: Each **Feature** window remains until individually closed.

Configure the Feature window using the controls at the top of the window:

1. **Show Options** - In the upper left corner of the window, click the **Show Options** drop-down and select, or deselect, values to show or hide different deviation values.

2. **Probe Compensation** - In the middle is **Probe Compensation**. Click this button to see the deviation values relative to the compensated probe location; click again to see the deviation values relative to the probe center.

NOTE: The Apply Compensation in Feature Windows preference determines whether probe compensation should be applied to all future Feature windows. *See "Apply Compensation in Feature Windows " on page 79.*

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3. **Lock to Feature** - To the right is **Lock to Feature**. When enabled, the **Feature** window stays locked to the current feature. When not enabled, the **Feature** window will float to the closest feature (not including CAD).

4. **Treat Entities as CAD** - When you have locked the window to the current feature, use **Treat Entities as CAD** to designate CAD entities as features when moving the probe.

The deviation values change color:

- **Green** - the deviation is in tolerance.
- **Blue** - the deviation is out of tolerance in the negative direction.
- **Red** - the deviation is out of tolerance in the positive direction.

NOTE: The values are uncompensated except for the 3D value for surfaces.

You can show tolerance value colors in the DRO's background using the Apply Tolerance Color to Background preference. *For more information, see "Apply Tolerance Color to Background " on page 76.*

3D Distance and Normal Deviation

3D Distance is the distance from a point to a surface represented by XYZ coordinates. *Normal Deviation* (dN) is the simple 3D distance from a point to a surface along the normal vector.

For theoretically infinite features, such as planes or cylinders, the 3D Distance is equal to the Normal Deviation.

For features with trimmed edges, such as surfaces, the 3D Distance is equal to the Normal Deviation if the projected point is in the middle of the surface. If the point being compared is off to the side, falls on the edge, or is otherwise outside the bounds of the surface, the 3D Distance will likely be larger than the Normal Deviation.

For vector points with a fixed nominal point, the 3D Distance will likely be larger than the Normal Deviation if the actual falls outside the zone.

Chapter 6: Devices

The Devices commands are located in the **Devices** tab across the top of the screen. The **Devices** tab contains all the commands used to configure measuring devices, and the commands are organized into Setup, FaroArm, FARO Laser Tracker, and 6Probe groups.

Setup

The **Setup** group contains all the commands necessary to configure, manage, and move your measurement device (s).

Device Center

Device Center accesses the **Device Center** panel. The **Device Center** panel contains a list of all active (detected) devices with the properties of each associated device. You can also press the **P** keyboard shortcut on the keyboard.

The **Device Center** panel automatically manages device connections. If an error or connection issue occurs, the **Device Center** panel will detect the issue and automatically reconnect to your measurement device without affecting the performance of CAM2.

Available devices are shown as tiles, and each tile contains the device's image, model, serial number, and active probe (FaroArm) or SMR (FARO Laser Tracker).

See the CAM2® 2021 chapter in the current device's manual for more details about hardware setup and configuration.

Figure 6-1 Device Center

When you access **Device Center,** all connected measurement devices will be shown as Available. If your device is connected but not shown, you can manually add the device.

Add a Device

From the **Device Center** panel, click + and select **New Device**. **Device Center** will search and list all connected devices. Select an eligible device from the **Select Device Type** dialog, and once connected your device will be shown as Available.

> **NOTE:** If you are attempting to connect a FARO Laser Tracker or 3D Imager and **Device Center** is unable to connect automatically, you can manually enter the IP address or serial number of the device. To connect to an Imager Array, first create the Array by connecting and selecting the required 3D Imagers.

Configure a Device

From the **Device Center** panel, click the device's tile. The expanded view contains detailed Device information (status, model, serial number, firmware version, compensation date), Probe information (type, compensation date, temperature, error), and setup options.

Measurement Mode Setting

This preference defines how the measurement device performs measurement.

- **Single Point Mode**: The measurement device takes a single point.

- **Distance Based Mode**: The measurement device takes points at a specified distance interval (specify the distance).

- **Time Based Mode**: The measurement device takes points at a specified time interval (specify the time in milliseconds).

Multiple Devices

You can connect and use multiple measurement devices simultaneously, with a single software license, without changing computers and merging data. You can connect any combination of FaroArms, FARO Laser Trackers, and/or FARO 3D Imagers and Arrays.

This procedure to connect and define multiple devices involves measuring a set of features with each device, and using the **Device Manager** to assign the features to the second device and calculate each position. *For more information, see "Manage Devices" on page 130.*

For the Super6DoF solution, use the TrackArm wizard. *See "Locate TrackArm" on page 135.*

To configure multiple devices for simultaneous measurement, perform the following steps:

1. Locate three point-reducible features and ensure that each device can reach each feature.

NOTE: You can use more than three features.

---

2. Connect all cables for each device to your computer, power on your devices, computer, and start CAM2.

3. Now connect and define your measuring devices in the CAM2 file:
   - Open the **Device Center** and manually connect any device that has not automatically loaded. *For more information, see "Device Center" on page 128.*

   - Measure the three point-reducible features. Notice the device name, usually the serial number in the Measurement Panel and measure with that device. This is the default device. *For more information, see "Measurement Panel" on page 188.*

   - Measure the three point-reducible features with the second device. In the **Features** panel, right-click each feature and select **Add Readings From...** and select the second device. *For more information, see "Add Readings " on page 197.*

4. Use the Device Manager panel to calculate each position:
   - On the **Device** tab, select **Move Device** to access the **Device Manager** panel. Notice each device and that the first device (default) is first on the list.

   - Select **Device Position 1** of the second device and use the **Select a Feature** drop-down to add the point-reducible features.

   - Click the **Solve** button.

Both devices are now measuring together in the same coordinate system. You can add more devices in the same manner.

![Manage Devices icon] **Manage Devices**

Select **Device** > **Manage Devices** from the **Devices** tab to access the **Device Manager** panel. Use the **Device Manager** panel to update device properties (including edit a device name, disconnect and remap a device, show the **Measurement** panel), and export, import, or configure a device position.

> **NOTE:** If you are using the Probing Version of CAM2, the FARO 3D Imager and FARO Laser Line Probe are not eligible for use. *See "Probing Version" on page 9.*
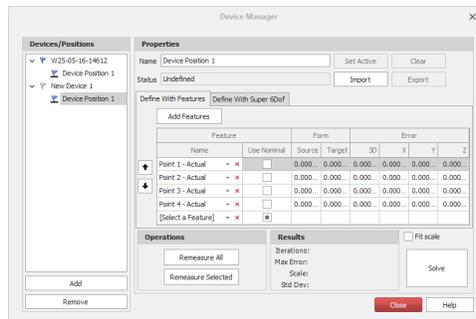
Figure 6-1 Manage Devices

Device Properties

The Properties portion of the **Device Manager** panel allows you to edit a device name, disconnect and remap a device, show the **Measurement** panel, and configure a device position. Select a device on the left side of the panel and execute the following commands:

Edit a Device Name

To edit the name of a device, click in the Name box and input the name as desired.

> **NOTE:** The device name entered here persists throughout the measurement file.

Disconnect a Device

To disconnect a device from CAM2, click **Disconnect** to the right of the Serial Number box. The status of the device will update in the Status box as "Disconnected".

Show/Hide Measurement Panel

To constantly show the **Measurement** panel, select the **Show Measurement** panel checkbox. Clear this checkbox to only show the window during **Add Readings** . *For more information, see "Add Readings " on page 197.*

Set Active

To set a device as default, click **Set Active**. The **Add Readings**, **Remeasure,** and all Measure commands automatically use the default device.

New Position

To create a new device position for a device, click **New Position**. This creates a new and active device position for the device.

Device Position

Select the device's position to access **Device Position** in the **Device Manager** panel.

Device Position stores the location of the device relative to the measurements of your part. If you move or change the device, **Move Device** creates another device position that allows you to continue measuring in the same file. You can also continue measuring to the same feature from another device position. *See "Add Readings " on page 197.*

All readings of measured features are labeled with the current device position. If you create another device position and add readings to a measured feature, you can see the readings sorted by device position. *See "Measurement Data" on page 192.*

If you edit or redefine a device position, only the readings in *that* device position are updated. All of this is independent of any Coordinate System, but any updated features that are included in the alignment cause a recalculation of the alignment.

NOTE: The default device position (Device Position) for each device is in every new file and may not be deleted.

Select an existing device position to:

Set an Active Device Position

To designate the device position as active, click **Set Active** to the right of the Name box. The status of the device position will update in the Devices/Positions box as "Active".

Make a Root Device Position

To designate the device position as the reference for all devices, right-click the device position and select **Make Root**. All device positions will be relative to the root position.

Remove a Device Position

To remove the device position, click **Clear** to the right of the **Name** box.

Add and Measure Device Position Features

Define with Features tab

* Select a Feature.[1]

* You can also select
  features from the CAD View, or the **Features** panel before running the command:

  1. Select the features.

  2. Create a Device Position.

  3. Click **Add Features** in the **Details** box.

* Remove any feature by clicking the **X** next to the drop-down arrow to the right of the feature name.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- Select the **Use Nominal** check box to use the feature's nominal instead of the previously measured value.

Define with TrackArm tab:
- Select a Laser Tracker.

- Lock the beam onto the SMR and mount it onto the FaroArm.

- Press the **Front green** button to activate the Measurement Mode Setting. *See "Measurement Mode Setting" on page 129.*

NOTE: CAM2 automatically selects the correct probe and SMR size if you have already defined them in the **Manage Probes** window.

- Press the **Front green** again to begin scanning. Move the FaroArm in free space. When complete, press the **Back red** button to view the results of the Device Position.

- Press the **Back red** again to accept the results, or press the **Front green** to remeasure.

Operations box:
- Remeasure All - measure all of the device position features in the list.

- Remeasure Selected - measure any selected features in the list.

Click **Apply/Solve** to define the device position. Select the **Fit Scale** check box to calculate the fit by scaling the features.

Results box:
- The **Number of Iterations** of the device position solution.

- The maximum **Error** between the measured and nominal features.

NOTE: The 3D, X, Y, and Z errors for each feature to its nominal are listed to the right of the feature name.

- Any calculated **Scale** of the device position solution.

Click **Close** to exit the **Device Manager** panel.

NOTE: FARO advocates the use of only precision-made, repeatable tooling to define device positions. The FARO tooling kit is comprised of precision spheres and/or "cone" mounts with magnetic bases, which serve as highly repeatable artifacts to minimize error in the device relocation process. Measured features such as circles greatly increase the risk of error in the device relocation process due to potential errors in measurement and manufacturing defects. Errors in the device relocation process will compound, which in turn will compromise the accuracy of all subsequent measurements taken on the part.

Import Reference Points

Select **Devices** > **Import Reference Points** from the **Devices** tab to import a text file (*.txt) containing ERS (External Reference System) points into the current measurement file.

Move Device

Select **Devices** > **Move Device** from the **Devices** tab to access the **Move Device Position** wizard. Use the **Move Device Position** wizard to select the device to move, and choose the target selection method (automatic or manual). You can also press the **M** keyboard shortcut on the keyboard.
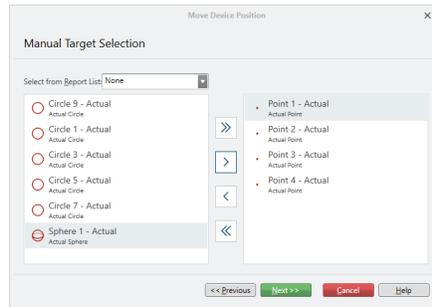
Figure 6-1 Move Device

A Device Position is the location of the measurement device relative to the measurements of your part. To continue measuring in the same measurement file after moving or changing a device, you must create another device position.

NOTE: Selecting **Device** > **Move Device** from the **Device** menu automatically creates a New Device Position for you to configure. This new device position exists until you highlight it and click **Remove**.

To create a new device position, perform the following steps:

1. Measure a minimum of three point-reducible features with the device in the current device position. All point-reducible features are valid except for cones, the tips of which are difficult to accurately reproduce in tactile metrology.

NOTE: You can only use point-reducible features in the **Move Device Position** wizard. *See "Measuring a Point" on page 155.*

---

2. Move the measurement device to a new location.

3. Select **Devices** > **Move Device**. The **Move Device Position** wizard appears.

4. Choose the device you want to move, and choose the target selection method (automatic or manual). Click **Next**.
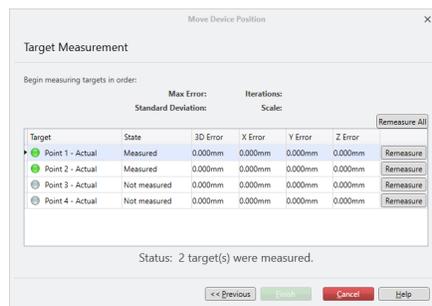
Figure 6-2 Target Measurement

NOTE: Automatic target selection is available only when there are three point features in the file. It is not available with spheres or if there are more than three point features in the file.

Automatic

1. Click **Manage Target Points**. The **Manage Target Points** window contains all Point features in the current measurement file.

   - If necessary, use the Search field to enter filtering text to help you locate points.

   - Click a point to add it to the target list. The point highlights and the target icon appears.

   - Click a selected target to deselect it. The target icon disappears.

   - Click OK to confirm the list of target points. CAM2 will associate the list of selected targets with the measurement file, and will use the list for future device moves.

2. Move your device and remeasure a single reading for each selected target point.

3. Watch the **Measurement** panel and the **Move Device Position** dialog box to see your progress with each target point. As you measure the target points, the marker to the left of the point name becomes green.

4. After you measure the target points, CAM2 calculates the device position and the standard deviation and maximum error appear in the **Move Device Position** dialog box.

5. Click **Finish** to save the device position, or click **Previous** to remeasure the target points.

Manual

1. All of the point features in the file move into the right side of the **Move Device Position** dialog box. Use the arrow buttons to move any unwanted feature to the left side of the dialog box. Click **Next**.

2. Move your device and remeasure a single reading for the target points.

3. Watch the **Measurement** panel and the **Move Device Position** dialog box to see your progress with each target point. As you measure the target points, the marker to the left of the point name becomes green.

4. After you measure the target points, CAM2 calculates the device position and the standard deviation and maximum error appear in the **Move Device Position** dialog box.

5. Click **Finish** to save the device position, or click **Previous** to remeasure the target points.

You can review and edit this device position with the **Manage Devices** command. *See "Manage Devices" on page 130.*

NOTE: FARO advocates the use of only precision-made, repeatable tooling to define device positions. The FARO tooling kit is comprised of precision spheres and/or "cone" mounts with magnetic bases, which serve as highly repeatable artifacts to minimize error in the device relocation process. Measured features such as circles greatly increase the risk of error in the device relocation process due to potential errors in measurement and manufacturing defects. Errors in the device relocation process will compound, which in turn will compromise the accuracy of all subsequent measurements taken on the part.

Export and Import Device Position

Once you create the device position using the **Device Manager** panel, you may export the device position to a CAM2 device position file (*.fdp) or CAM2 Measure X device position file (*.xdp) to be recalled later.

NOTE: The default import/export directory is configured in the **Preferences** window. *For more information, see "Preferences" on page 67.*

To import a device position from a CAM2 device position file (*.fdp) or CAM2 Measure X device position file (*.xdp), click **Import** to the right of the Status box. Browse to the device position file and click Open.

To export a device position to a CAM2 device position file (*.fdp) or CAM2 Measure X device position file (*.xdp), click **Export** to the right of the Status box. Enter a name for the device position file and click Save.

Once a device position file is exported, it can be imported into any measurement file or recalled into a QuickTools program.

Save and Load Device Setup

CAM2 allows measurement with more than one device, each with a unique device position, within a single measurement file. Once you create positions for each device, you can save and load these setups for future use.

NOTE: The default import/export directory is configured in the **Preferences** window. ***For more information, see "Preferences" on page 108.***

Once you create device positions for each device in the measurement file using the **Device Manager** panel, click **Save Setup**. This saves the relationship between multiple, fixed devices for future use.

Click **Load Setup** to load saved positions for multiple devices.

NOTE: If the measurement file does not contain the same devices with which you initially saved the setup, **Load Setup** is unavailable.

Locate TrackArm

Select **Devices** > **Locate TrackArm** from the **Devices** tab to access the **Locate TrackArm** wizard. Use the **Locate TrackArm** wizard to align a FaroArm or FARO ScanArm (with Tracker kit) to a FARO Laser Tracker, so that both systems are measuring within the same coordinate system.

NOTE: This command is only available when your FaroArm and FARO Laser Tracker are connected and available in the Device Manager. *For more information, see "Manage Devices" on page 130.*

Calibrate and locate the TrackArm probe to generate the 3D path, which both devices capture simultaneously. CAM2 then uses the 3D paths to calculate the spatial alignment of the FaroArm relative to the FARO Laser Tracker, and to compute the relocation accuracy of the FaroArm. Each position is calculated using the FARO Laser Tracker as the root position.

You can use the TrackArm Wizard multiple times to relocate the FaroArm without compounding positional errors which may occur using the standard Move Device method. *See "Move Device" on page 133.*

Select Measurement Device

If you have multiple devices connected to CAM2, use the Select Measurement Device drop-down to select a specific device. *See "Multiple Devices" on page 129.*

FaroArm

The **FaroArm** group contains the FARO Laser Line Probe Settings command. Click **Laser Line Probe** to access Laser Line Probe settings.

FARO Laser Tracker

The **FARO Laser Tracker** group contains all the commands necessary to interface with your FARO Laser Tracker using CAM2.

Use commands to control the Laser Tracker instead of hardware buttons. Buttons (and their associated keyboard shortcuts) on the Measurement Panel are used for recording a reading (**G**), recording an end click (**H**), and removing the last reading (**Backspace**). *For more information, see "Measurement Panel" on page 188.*

Self Compensation

Self Compensation starts the Laser Tracker's Self Compensation routine. When complete (approximately five minutes), the Laser Tracker System is within the pointing accuracy specifications and ready to measure.

> **NOTE:** This feature is called **Quick Compensation** when used with the Laser Tracker Vantage.

After the Self Compensation routine, Angular Accuracy Checks should be used to verify the accuracy. *See "Angular Accuracy Checks" below.*

Angular Accuracy Checks

Angular Accuracy Checks starts the Laser Tracker's Angular Accuracy Check routine, which verifies measurement accuracy during the course of a measurement session with minimal disruption. This check should be performed before each measurement session or if the temperature has changed more than 5° Fahrenheit.

Measure Level

Measure Level is a type of hybrid measurement/construction command that uses the built-in level functionality of the Laser Tracker to produce a plane level to the ground (relative to the Laser Tracker) and through another measured point. You can use this feature as an Active Projection plane. *See "Projection Plane" on page 181.*

- Select **Devices** > **Measure Level** to start the measurement of the level plane.

- When complete, a point feature automatically adds to the measurement file. Measure this point to locate the level plane.

It is not possible to add readings to a level feature, nor is it possible to edit a level feature by re-sampling the Laser Tracker to obtain a new level vector. However, you can measure another point and relocate the level plane by editing it's properties. *See "Feature Properties" on page 183.*

Motor On Off

Motor On/Off switches on or off the motors that control the movement of the FARO Laser Tracker's laser beam.

Follow Me On Off

Follow Me On/Off switches on or off the automatic search using the FARO Laser Tracker's cameras.

Smart Find

Smart Find prompts the Laser Tracker Vantage to locate an SMR using its on-board camera and aim at it.

NOTE: Smart Find is available only for the Laser Tracker Vantage.

Aim

Aim aims the Laser Tracker at a selected feature, and allows you to select a feature from the **Features** panel or the **CAD** window and aim the Laser Tracker at the center of the selected feature.

The Laser Tracker must be the active device in the **Device Center** panel to start this command.

With two or more measurement devices connected, **AIM** functionality is optimized if the devices are related using device positions. *For more information, see "Device Position" on page 131.*

NOTE: **Aim** is included in the **Measurement Data** panel to allow aiming at individual readings of measured features. *See "Measurement Data" on page 192.*

Reset

Reset moves the Laser Tracker to the current Reset Point location. If there is a current Reset Point defined, the Laser Tracker executes **Aim** using the specified reset point as the target. If there is no Reset Point, the Laser Tracker executes **Home** and returns to the home position for the selected SMR family.

Search

Search prompts the Laser Tracker to begin a search pattern in an attempt to locate a SMR. Search parameters are specified in the preferences.

Change Adapter

Change Adapter inserts a prompt within a QuickTools program to change the probe adapter. *For more information, see "Change Adapter" on page 147.*

Manage Reset Points

Manage Reset Points allows you to configure an optional Reset Point. If set, the Reset Point acts as an override for the home location. You may revert the Reset Point back to home.

NOTE: Using the Home position for a reset is not the same as using an overridden Reset Point.

Select **Manage Reset Points** to show the **Manage Reset Points** panel.

Set Backsight

Set Backsight switches the FARO Laser Tracker to Backsight mode.

Drive Beam

Drive Beam moves the FARO Laser Tracker's laser beam.

Bundle Adjustment

Bundle Adjustment adjusts multiple device positions at once by refining redundant measurements into the best possible point coordinates. This command becomes available when you have multiple device positions with at least 4 (non-coplanar) measured points.

CAM2 will bring up a Wizard to assist in setting up the alignment.

1. Select the device positions.

2. Select the targets from the list of all measured targets.

3. Configure the Bundle Adjustment calculation parameters:

- Calculation Mode

    - Sequential - Bundle Adjustment is performed every time before calculation of initial guess for next transformation matrix. This setting increases accuracy, especially for long chains of Device Positions.

    - One Step - Initial guesses for all transformation matrices are calculated, then bundle adjustment is performed once for all data. This setting increases computation speed.

- Parameterization Mode

    - Euler Angles (3 parameters)

- Quaternions (4 parameters)

- Error tolerance

  - Input Tolerance Error - This parameter enforces that all readings taken on a single point from a single Device Position must all be located within a sphere with a diameter less than this value.

  - Results Tolerance Error - Once the Bundle Adjustment is solved, all resulting readings for each target must be located within a sphere with a diameter less than this value.

- Device Errors

  - These values represent the standard reported errors of angular and radial measurements for the Laser Tracker. These values should only be modified if known.

4. View connectivity of all positions on the Target Relationship Map.

NOTE: A line connecting 2 positions represents the existence of common targets between those two positions. At this point, CAM2 provides an idea of how good the outcome of the Bundle Adjustment may be. If any error situation is identified, explanatory text will appear in the right-hand column.

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5. View the results of the Bundle Adjustment in the Results window. Use **Print** to print the contents of the Results window.

6Probe

The **6Probe** group contains all the commands necessary to interface with your 6Probe using CAM2. For more information about the setup and operation of the FARO 6Probe, see the *FARO® Laser TrackerVantage* user manual.

Probe Management

Use the **Probe Management** command to access the 6Probe Management panel. Use the **6Probe Management** panel to add, setup, compensate, and check a 6Probe.

Probe Customization

Use the **Probe Customization** wizard to customize up to 12 different commands by configuring actions in the Click, Double Click and Long Press drop downs. Operations assigned to a button are shown in bold.

FARO 3D Imager

The **FARO 3D Imager** group contains all the commands necessary to interface with your FARO 3D Imager using CAM2.

Array Calibration

Use the **Array Calibration** command to calibrate an array of 3D Imagers. For more information, see the *3D Imager Array* section of any FARO 3D Imager user manual.

Scan Phases Configuration

Use the **Scan Phases Configuration** command to create imaging groups of 3D Imagers and control the order that the individual 3D Imagers scan in a 3D Imager array. For more information, see the *3D Imager Array* section of any FARO 3D Imager user manual.

Chapter 7: Automation

The Automation commands are located in the **Automation** tab across the top of the screen. The **Automation** tab contains the commands used to automate your measurement processes, and the commands are organized into QuickTools and Shortcuts groups.

QuickTools

The **QuickTools** group and **QuickTools** panel contain all the commands necessary to create and edit QuickTools programs. QuickTools programs allow you to save a set of CAM2 commands in a list to run anytime the measurement file is open. You can create multiple QuickTools programs in a single file, and play them whenever you choose.

QuickTools Programs

The **QuickTools** group and panel allow you to record, edit, and delete QuickTools programs in either *Coordinate Format on page 23* or Template Mode. The following chart illustrates the behavior of CAM2 when recording QuickTools programs in Measure Mode and Template Mode.

<table>
<tr><th colspan="4" style="text-align:center">QuickTools</th></tr>
<tr><th></th><th></th><th>Not Recording</th><th>Recording</th></tr>
<tr><td rowspan="2">Measure Mode</td><td>Insert Measured Features</td><td>Adds feature to measurement file
Prompts operator to measure feature</td><td>Adds feature to measurement file
Adds measurement step to QuickTool
Prompts operator to measure feature</td></tr>
<tr><td>Manually Invoke "Add Readings"</td><td>Prompts operator to measure feature</td><td>Adds measurement step to QuickTool
Prompts operator to measure feature</td></tr>
<tr><td rowspan="2">Template Mode</td><td>Insert Measured Feature</td><td>Adds feature to measurement file</td><td>Adds feature to measurement file</td></tr>
<tr><td>Manually Invoke "Add Readings"</td><td>Prompts operator to measure feature</td><td>Adds measurement step to QuickTool</td></tr>
</table>

 Recording QuickTools Programs

Record a QuickTools program in Measure Mode or Template Mode. The QuickTools control command buttons are at the bottom of the list, just above the **Properties** panel. To create a QuickTools program:

1. Open the **QuickTools** panel and click **New Program**. *See "QuickTools" on page 26.*

<div style="text-align:center">OR</div>

Click **New** on the Automation Tab.

2. Type a name for your program or use the default name.

3. Click **Record** to begin recording the program.

4. Measure your part to add measurement steps to the program.

NOTE: You can select multiple features and select **Add Readings** to create multiple measurement steps in the QuickTools program, but the current measurement mode will be applied to each of the features added in this manner. The person playing the QuickTools program may override the measurement mode for a feature being measured, but the next feature will load the measurement mode with which it was created.

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5. Click **Stop** to stop adding program steps.

6. Save your measurement file. QuickTools programs are stored within each measurement file.

Dragging Features Into Programs

Instantly add steps to a QuickTools program by dragging features and feature groups from the **Features** panel to a QuickTools program. *For more information, see "Navigation Window" on page 33.*

NOTE: Dragging a feature group adds all of the features in that group as individual QuickTool steps.

Creating a QuickTools Program From Features

Click **Create From Features** to instantly create a new QuickTools program containing all features in the active document.

For all features constructed from CAD, CAM2 automatically captures the view orientation and associates the image to the feature.

Automated Images

CAM2 automatically associates an image to each feature measurement step, totaling the number of number of readings needed to measure minimum geometry plus one end click image. On each image, CAM2 places a green marker using a uniform distribution of readings on the 3D feature governed by the 3D position of the nominal. The final image has a red marker placed at the location of the representative point on the feature (e.g., center, plane point).

You can modify the images using Image Creator. *See "Image Creator" on page 50.*

NOTE: For optimal automated image results, adjust the view when you are constructing features from CAD so that the view orientation provides a clear picture of the feature to be measured.

Importing QuickTools From Learn Files

You can import SoftCheck Tools files and Learn files created with CAM2 Measure X or CAM2 Measure 4.0 into the current measurement file for use in a QuickTools program:

1. From the **File** menu, click **Import > QuickTools > From Learn files**.

2. Select an existing SoftCheck Tools file or Learn file (*.sct or *.xln) and click **Import**.

3. All supported steps from the imported file appear in the QuickTools program.

NOTE: Unsupported steps are highlighted and captured in an error report after the import process. You can save the report for future reference.

Editing QuickTools Programs

You can add, reorder, and delete the steps of a QuickTools program. The QuickTools control command buttons are at the bottom of the list, just above the **Properties** panel. To create a QuickTools program:

1. Open the **QuickTools** panel.

2. Select an existing QuickTools program. You may need to click the Plus sign next to the program name to expand the list of program steps.

3. Edit the steps:

   • Move a step by dragging any step up and down the list, or by clicking the up/down arrow buttons.

   • Delete a step by choosing the step and clicking **Delete**.

   • Add more steps to the program by clicking **Record**.

4. Save your measurement file. QuickTools programs are stored within each measurement file.

NOTE: If you have multiple devices assigned to add measurement steps, use the **Filter** drop-down window to only show steps assigned to a specific device.

▷ Playing QuickTools Programs

Play a QuickTools program to measure the features in your measurement file. The QuickTools control command buttons are at the bottom of the **QuickTools** panel, just above the **Properties** panel.

1. Open the **QuickTools** panel.

2. Select a QuickTools program.

3. In the **Properties** panel, click the **Session Data** drop-down and select one of the following:

   • **Do Not Edit Session Data**: CAM2 will not present the operator with the **Document Header Information** window.

   • **Prompt For Session Data**: (Default) CAM2 presents the operator with the **Document Header Information** window.

   • **Import Session Data**: Import a specified text file containing document header information when the QuickTools program starts. Each line indicates a property of the header, can contain 2 or 3 strings separated by a semicolon, property names and values, and True/False states (when missing, the default value is True).

NOTE: You can create a document header text file using the Export command in the **Document Header Information** window. *For more information, see "Document Header Information" on page 107.*

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4. Check the **Clear Existing Measurement Data** box to clear all existing measurement data when the QuickTools program is run.

5. Check the **Maximize Measurement Window** box to display the Measurement Panel at full screen size.

6. Check the **Re-Use Open Feature Window** box to keep the feature window constant while the operator plays the QuickTools program.

7. Click **Play**.

The program steps will run in the list order. You cad add concurrent measurements from multiple devices if multiple devices are connected. If steps are assigned to different devices, the first step for each device will run at the same time.

A **Measurement** panel opens for each Add Readings step and is automatically set from the properties of the program step. *For more information, see "Command Properties" on page 149.*

- The collection mode is automatically set from the properties of the program step.

- The number of readings for the program step is automatically set from the properties of the step. Watch the **Measurement** panel for each reading and take an end click point after the last reading.

- The number of readings can also be a range, or a minimum and a maximum, number of points. Take an end click point after the minimum number of readings, or keep digitizing until you reach the maximum number of readings.

- Close the **Measurement** panel to skip any Add Readings program step.

The **Measurement** panel can also have a picture if one exists in the QuickTools program step. *See "Image Creator" on page 50.*

Automating QuickTools Programs

You can automatically play a QuickTools program without first opening CAM2.

Open a command line to start CAM2 with the measurement file (*.fcd) containing the QuickTools program, and add /runQT:<ProgramName> to the command.

For example, if you wanted to run the QuickTools program called "My Program 1" in the Measurement file, you would open a command line and enter:

`cam2measure.exe c:\MeasurementFile.fcd /runQT:My Program 1`

When the QuickTools program runs, CAM2 shows the **Measurement** panel at full screen size.

Locking QuickTools Programs

Lock a QuickTools program to secure the program from being edited, overwritten, or deleted from the measurement file.

The **Lock** icon is visible in the **QuickTools** panel. When locked, users may not modify the QuickTools program.

1. Select the QuickTools program to be locked.

2. Click **Lock**.

3. In the **Credentials** window, enter a password to lock the program. Enter the password again to confirm.

4. Click OK to apply the lock.

NOTE: Use this same password to unlock the program. After all modifications are complete, click **QuickTools** to lock the program again.

CAUTION: If you forget a password, there's no way to recover it. Consider keeping a backup copy of the measurement file with a QuickTool that isn't password-protected.

Unlocking QuickTools Programs

Click **Lock** and enter the password to unlock the program. Click **Lock** to restore the lock. To remove the lock, click **Remove Lock**.

Removing the QuickTools Program Lock

The **Remove Lock** icon is visible in the **QuickTools** panel. It is active when you select a locked QuickTools program. This permanently removes the lock from the QuickTools program.

1. Select the locked QuickTools program.

2. Click **Remove Lock**.

3. In the **Credentials** window, enter the password for this program.

4. Click OK to permanently remove the lock.

NOTE: To temporarily unlock the QuickTools program, click **Lock**.*For more information, see "Unlocking QuickTools Programs" on page 146.*

Deleting QuickTools Programs

Delete a QuickTools program to completely remove it from the measurement file. The QuickTools control command buttons are at the bottom of the **QuickTools** panel, just above the **Properties** panel.

1. Select the QuickTools program to be deleted.

2. Click **Delete** to delete the QuickTools program.

NOTE: You must enter the password to delete a locked QuickTools program.

QuickTools Tools

The **QuickTools** Tools drop-down menu, located on the QuickTools menu bar, contains steps that may be included in a QuickTools program. *For more information, see "QuickTools Program Commands" on page 148.*

Add Comment

Add Comment inserts a comment into a QuickTools program while you are in Record Mode. A comment is a textual message that a user will see when playing the QuickTools program, must acknowledge by clicking OK, and can thus be used to help guide the user through the program by providing important information at key points. Comments may be placed at any position within the QuickTools program.

Add Report

Add Report creates a report macro at the end of a QuickTools program. When you select this command, the Report View Settings dialog lets you select a report list, a report template, export options, and file format. When the QuickTools program is played, this command will open the **Report** tab for the user to create and print a report. *For more information, see "Report" on page 45.*

Generate QR Code

Generate QR Codegenerates a QR code from an existing report to be displayed when running a QuickTools program. When the QR code is scanned by a smart phone (for example), the feature names and actual results are displayed. You can also save the QR code to a file.

Fine Registration

Perform **Fine Registration** after several scans have been completed. Scans can be pre-registered with the rotary table and/or photogrammetry targets.

NOTE: This QuickTools program command is only available for the FARO 3D Imager.

Extract Feature

Extract a feature using CAM2's extraction commands. This can be used in tandem with a **Freeze/Unfreeze Recalculation** command to force extraction. *For more information, see "Extract" on page 199.*

Change Adapter

Change Adapter inserts a prompt into a QuickTools program, in either **Measure** mode or **Template** mode, to change the SMR/adapter of the FARO Laser Tracker device, or the current probe of the FaroArm. *For more information, see "QuickTools Program Commands" on page 148.*

When executing this step of a QuickTools program, the user is guided through the process of changing the adapter. When the adapter change is successful, the user can continue running the QuickTools program.

Set Active Device Position

Set Active Device Position inserts a program step to move the device position. While recording the command, the new Device Position will be defined based on existing targets. *For more information, see "Move Device" on page 133.*

Solve Device Position

Solve Device Position inserts a program step to solve the device position. When the operator runs the QuickTools program, the **Device Manager** panel prompts the operator to remeasure the targets and solve the device position before continuing. *For more information, see "Move Device" on page 133.*

Freeze Recalculation

Freeze Recalculation inserts a program step to suspend all recalculations while the operator runs the QuickTools program.

> **NOTE:** If you do not add Unfreeze after a Freeze command, all pending recalculations will occur at completion of the QuickTools program.

Unfreeze Recalculation

Unfreeze Recalculation inserts a program step to enable all pending recalculations.

QuickTools Program Commands

QuickTools programs may contain several types of program steps, or commands.

- **Add Report:** The operator is automatically presented with the **Report** Window. *For more information, see "Add Report" on page 147.*

- **Aim:** Aims the Laser Tracker at the center of a selected feature. *For more information, see "Aim" on page 137.*

> **NOTE:** Click **Search** to enable Search mode for your Aim step. When enabled, the Laser Tracker automatically enters search mode (similar to Survey) if it aims and does not find a target. The QuickTools program step will pause until the Laser Tracker finds a target or ends the search. *For more information, see "Survey" on page 53.*

- **Angular Accuracy Checks:** CAM2 starts the Laser Tracker's Angular Accuracy Check routine. *For more information, see "Angular Accuracy Checks" on page 136.*

- **Change Adapter:** The operator is prompted to change the probe adapter of the measurement device. *For more information, see "Change Adapter" on page 138.*

- **Clear Existing Measurement Data:** When the operator runs the QuickTools program, CAM2 clears all existing measurement data in the measurement file.

- **Add Comment:** The operator is presented with informational text boxes at key points in the program. *For more information, see "Add Comment" on page 147.*

- **Export:** CAM2 exports all measurement data to a text or CAD file. Specify export options and file format. *For more information, see "Export" on page 63.*

- **Import Points:** When the operator runs the QuickTools program, CAM2 imports a predetermined points file, or else prompts the operator to select the file to be imported.

- **Maximize Measurement Panel:** When the operator runs the QuickTools program, the **Measurement** panel is displayed at full screen size.

- **Measure:** CAM2 prompts the operator via the **Measurement** panel to add readings to measured features or add measurements to constructed features.

- **Measure Level:** CAM2 prompts the operator to produce a plane level to the ground (relative to the Laser Tracker) and through the origin. *For more information, see "Measure Level" on page 136.*

- **Prompt for Session Data:** When the operator runs the QuickTools program, CAM2 presents the operator with the Document Header Information window. *For more information, see "Document Header Information" on page 107.*

- **Re-Use Feature Window:** CAM2 reuses an existing feature window (if one is open) for the step instead of opening a new one. *For more information, see "Show Feature Window" on page 124.*

- **Save File:** CAM2 prompts the operator to select a name and save location for the measurement file.

- **Self Compensation:** CAM2 starts the Laser Tracker's Self Compensation routine. *For more information, see "Self Compensation" on page 136.*

- **Set/Solve Alignment:** CAM2 sets an alignment active. When the operator runs the QuickTools program, CAM2 presents the operator with the option to cease running the program when the maximum allowable alignment error is exceeded. You can also configure the QuickTools program to stop without giving the operator an option.

- **Show Feature Window:** CAM2 displays a **Feature** window (DRO) for a selected feature. *For more information, see "Show Feature Window" on page 124.*

- **View:** The CAD View contents zoom, pan, or change viewpoints.

NOTE: Construction, Dimension, Coordinate System, and Device Position commands are not added to QuickTools programs because these features are just waiting for data to solve.

Command Properties

Some QuickTools program steps have properties that you can edit in the **Properties** panel, located just below the QuickTools control command buttons. To change the program step properties:

1. Open the **QuickTools** panel.

2. Select an existing QuickTools program. You may need to click the Plus sign next to the program name to expand the list of program steps.

3. Select any step.

CAD View Commands

Use the **CAD View** buttons to assign, preview, or delete a specific view of the CAD part for any QuickTools program step.

Select any QuickTools program step.

Save CAD View for Step: Manipulate the position of the CAD part in the CAD View window as desired, and click this button to save this view to the QuickTools program step.

Clear Saved CAD View: Click this button to delete an associated CAD View from the QuickTools program step. If no CAD View has been saved to this step, this button is unavailable.

Recenter To Saved CAD View: Click this button to recenter the view to a saved CAD View from the QuickTools program step. If no CAD View has been saved to this step, this button is unavailable.

Preview Saved CAD View: Click this button to preview an associated CAD View from the QuickTools program step, whether or not you are running a QuickTools program. If no CAD View has been saved to this command, this button is unavailable.

Add Readings Properties Basic Tab

Use the **Basic** tab to change the device and number of readings for the program step.

1. Select an existing device from the **Device** drop-down window.

2. Enter the number of readings for the step.

   • Select the **Use Range** check box and enter the minimum and maximum number of points.

Add Readings Properties Advanced Tab

Use the **Advanced** tab to set the collection mode; single point or any of the available scanning modes. *For more information, see "Scanning" on page 190.*

1. Select the collection mode from the **Sample Mode** drop-down window.

2. Enter any Interval and Distance values if necessary.

3. Select the Replace Existing Readings check box to replace any existing readings in the feature.

NOTE: Insert **Clear Readings** at the beginning of your QuickTools program to delete all the readings from every feature in your file. *For more information, see "Clear Readings" on page 109.*

QuickTools in Measure Mode

Using Measure Mode to create a QuickTools program will measure a part and record everything about the measurement process. *See "Measure Mode" on page 99.*

You should have at least one device connected. This mode records every necessary measurement step, and for Add Readings (measurement) commands automatically sets the following properties:

- The current device.

- The collection mode.

- The number of readings.

The properties are set after you finish the measurement. *See "Measurement Panel" on page 188.*

QuickTools in Template Mode

Using Template Mode to create a QuickTools program enables you to create your program without measuring your part or without a device connected. *See "Template Mode" on page 99.*

This mode records every necessary measurement step, and for **Add Readings** measurement steps the default command properties are set. Change these properties in the **Properties** panel. *See "Command Properties" on page 149.*

CAM2 Control Station

The CAM2Control Station is a standalone application that allows you to run QuickTools programs without first opening RPM. Control Station is a component of CAM2® RPM.

Shortcuts

The **Shortcuts** group contains all the commands necessary to create and edit shortcuts. Just as QuickTools programs allow you to automate basic measurement commands, Shortcuts allow you to define quick composite measurement commands, such as the length between two circles or a bolt-hole pattern. Shortcuts are based on a measurement command or routine that you've defined in the measurement file.

Shortcut Gallery

The shortcut gallery contains over 20 pre-defined shortcuts, such as Angle Two Lines and Length Two Circles. Scroll through the gallery using the right-hand side arrows, and click an icon to run the shortcut.

Creating a Shortcut

Use a feature that you've created to make a shortcut, enabling you to replicate that feature with the shortcut.

1. Click the feature for which you want to create a shortcut in the *See "Navigation Window" on page 33.*.

2. Click **New** in the **Shortcuts** group.

3. Enter a name for the new shortcut in the Shortcut Name box.

4. Click **Image** to associate an image with the new shortcut. This image will become the icon for the shortcut in the measurement file.

5. Click OK to create the new shortcut. The shortcut appears in the **Shortcuts** group.

Editing a Shortcut

1. Click the shortcut in the **Shortcuts** group that you want to edit.

2. Click **Edit** in the **Shortcuts** group.

3. Edit a name of the shortcut in the Shortcut Name box.

4. Click **Image** to associate a different image with the shortcut. This image will become the icon for the shortcut in the measurement file.

5. Click OK to save changes to the shortcut.

Deleting a Shortcut

1. Click the shortcut in the **Shortcuts** group that you want to delete.

2. Click **Delete** in the **Shortcuts** group to delete the shortcut.

Importing a Shortcut

1. Click **Import** in the **Shortcuts** group.

2. Browse to the name of the shortcut you want to import (*.xml).

3. Click **Open** to save changes to the shortcut.

Exporting a Shortcut

1. Click the shortcut in the **Shortcuts** group that you want to export.

2. Click **Export** in the **Shortcuts** group.

3. Browse to the location you want to save the exported shortcut (*.xml).

4. Click **Save** to export the shortcut.

Chapter 8: Measure

The Measure commands are located in the **Measure** tab across the top of the screen.

- Click a command to add a measure feature to the measurement file. Click multiple times to quickly add features.

- Some **Measure** commands also are assigned to Keyboard Shortcuts on your keyboard. *See "Keyboard Shortcuts" on page 308.*

NOTE: When describing functions of the **Measure** tab, the terms *measuring* and *digitizing* are used interchangeably.

The commands on the **Measure** tab are organized into Features, Projection Plane, and Options groups.

Features

The **Features** group contains all the measurement commands for 2D and 3D features.

⬚ Measuring a Plane

You can also press the **F3** keyboard shortcut on the keyboard.

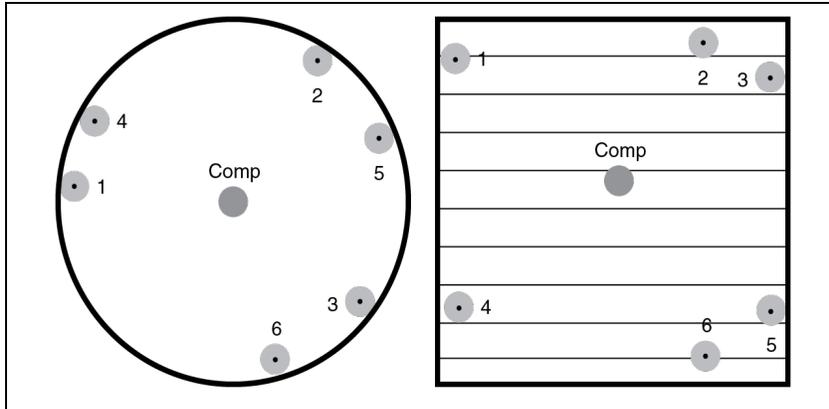| Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	3
See "Scanning" on page 190.	
XYZ Results	Center point of Plane
Vector	The surface normal (perpendicular to the plane)

See "Best Fit Plane" on page 328.

2D ⟍ Measuring a 2D Line

You can also press the F4 keyboard shortcut on the keyboard.

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	2
See "Scanning" on page 190.	
XYZ Results	End1 of the Line End2 of the Line
Vector	The Line from beginning to end

The first two digitized points determine the vector direction of the line. End 1 is the furthest point in the negative direction and End 2 is the furthest point in the positive direction.

See "Best Fit Line" on page 327.

Measuring a Point

You can also press the **F2** keyboard shortcut on the keyboard.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	No
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point
Vector	none

See "Best Fit Point" on page 328.

Measuring an Inspect Surface Point

You can also press the **F5** keyboard shortcut on the keyboard.

Use this command to measure a single point on surface at any location. To measure in an exact area of a surface, use **Measuring a Home In Point**. *See "Measuring a Home In Point" on page 170.* To measure multiple points (point cloud) on your CAD model in a single feature, use **Inspect Surface**. *See "Inspect Surface" below.*

This command requires a nominal surface from a CAD model. The default surface is the CAD model - any available surface. You can select a specific surface in the **Features** panel, or the CAD View before starting this command.

Minimum Readings to Solve	1
XYZ Results	The Point: The measured surface point compensated along the surface normal.
Vector	The vector of the surface at the measured point.

Comp

- If the **Automatically Create Nominal** check box is selected, a nominal surface point is automatically added to your file, and grouped with the Actual Inspect Surface point. It is the closest point on the surface. *See "Dynamic Nominals" on page 195.*

A round disk represents the Inspect Surface Point measurement. The disk color is predetermined by the tolerance condition. The size of the disk is a preference. *See "Size and Scale" on page 70.*

Inspect Surface

Use this command to measure single or multiple points (point cloud) on your CAD model. To measure a single point on a surface at any location, use **Measuring an Inspect Surface Point**. *See "Measuring an Inspect Surface*

Point" above. To measure an exact area of a surface, use **Measuring a Home In Point**. *See "Measuring a Home In Point" on page 170.*

Each reading for this feature automatically creates a nominal point on the closest surface of your CAD model. The end click determines the compensation vector of the digitized point(s).

NOTE: Surface points measured away from a selected surface appear as surface edge points.

A round disk represents each reading of the Inspect Surface measurement. The disk color is predetermined by the tolerance condition. The size of the disk is a preference.

See "Size and Scale" on page 70.

Measuring a Point Cloud

Use this command to measure single or multiple points (point cloud) for Export or inspection of a surface. Readings are not available with this feature.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
See "Probe Compensation" on page 184.	No
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point: The digitized point compensated along the surface normal.
Vector	none

NOTE: This command is only available if a FARO Laser Line Probe is connected to your FaroArm and it is the active device, or the FARO 3D Imager is the active device.

To measure a surface and compare to a nominal surface, use **Measuring an Inspect Surface Point** or **Inspect Surface**. *See Measuring an Inspect Surface Point on the previous page, and Inspect Surface on the previous page.*

Decimation Capture

Should the FARO Laser Line Probe's data density be too high, you can reduce the density using the Decimate option in the Measurement Control Window or the point cloud's Feature Properties. Enable Decimation and set the decimation factor for the point cloud capture process. The number entered in the field will determine the number of captured points per line. For example, a value of 10 indicates that CAM2 will record every tenth point, effectively reducing the number of captured points by a factor of 10.

Scanning Filter

You can apply a scanning filter to filter visible point cloud data. *See "Scanning Filter" on page 186.*

Labels

You can add callout labels to individual readings in this feature and show deviation at a specific location.

⬧Measuring a Surface Edge

Use this command to extract single or multiple points (point cloud) on surface edges. Readings are not available with this feature.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
See "Probe Compensation" on page 184.	No
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point: The digitized point compensated along the surface normal.
Vector	none

NOTE: This command is only available if a FARO Laser Line Probe is connected to your FaroArm and it is the active device, or the FARO 3D Imager is the active device.

To measure a surface and compare to a nominal surface, use **Measuring an Inspect Surface Point** or **Inspect Surface**. *See Measuring an Inspect Surface Point on page 156, and Inspect Surface on page 156.*

Keep Raw Data

Check the Keep Raw Data check box to store all Laser Line Probe data and recalculate.

Surface

Select the surface to use for edge comparison to CAD.

Edge Tolerance

Select the level of detail to capture edge data:

- **Finest**: The Laser Line Probe takes very sharp edge data.

- **Coarsest**: The Laser Line Probe takes more rounded edge data.

Point Distance Filter

Specify a distance from CAD to exclude point data. Measure will filter all points further from CAD than this value.

⬭Measuring a Circle

You can also press the F10 keyboard shortcut on the keyboard.

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See*	Yes

"Probe Compensation" on page 184.	
Minimum Readings to Solve	3
See "Scanning" on page 190.	
XYZ Results	Center point of Circle
Vector	Same as Plane
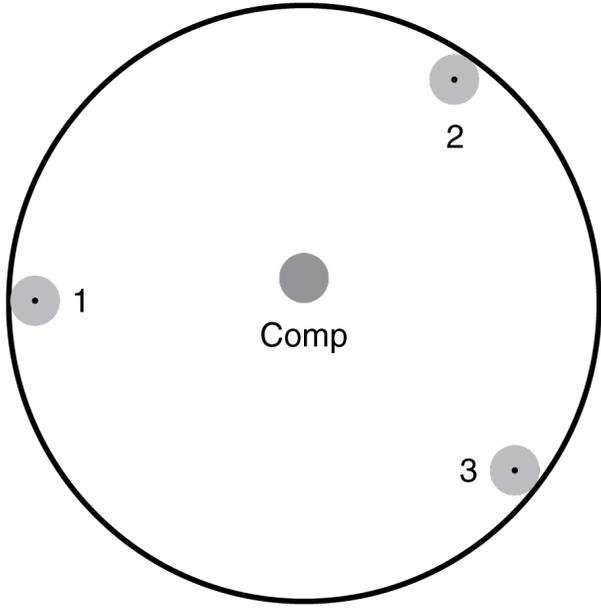
See "Best Fit Circle" on page 325.

Measuring a Sphere

You can also press the **F12** keyboard shortcut on the keyboard.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	4
See "Scanning" on page 190.	
XYZ Results	Center point of Sphere
Vector	none
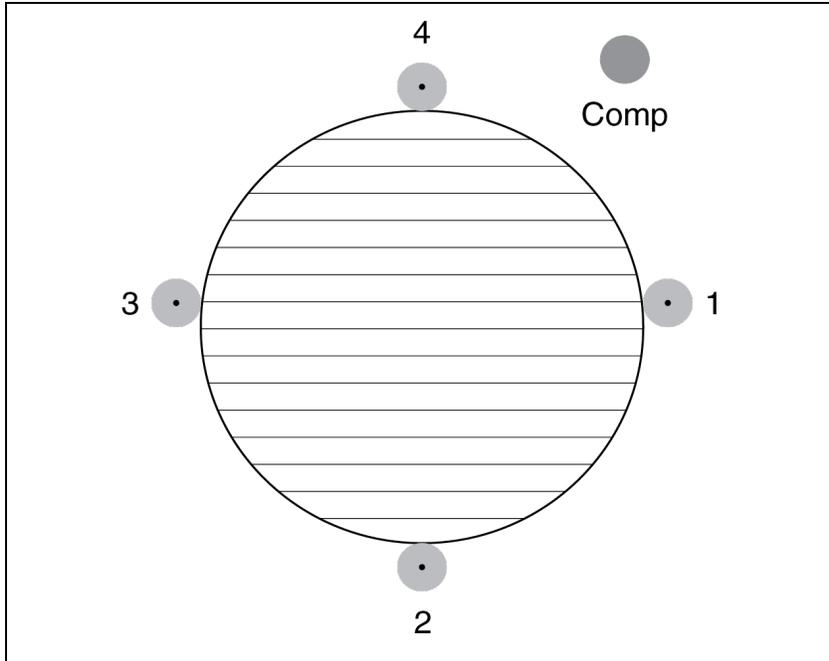
See "Best Fit Sphere" on page 329.

⬭ Measuring a Cylinder

You can also press the F11 keyboard shortcut on the keyboard.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	6
See "Scanning" on page 190.	
XYZ Results	Center of Cylinder at first end.
Vector	Center Line of Cylinder from bottom to top

The first two digitized points determine the vector direction of the cylinder.

See "Best Fit Cylinder" on page 326.

Measuring a Torus

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	9
See "Scanning" on page 190.	
XYZ Results	Center Point
Vector	

1. Digitize three points at one cross-section of the torus.

2. Digitize three points at a second cross-section of the torus.

3. Digitize three points at a third cross-section of the torus.

NOTE: You *must* digitize the first nine points in the correct order. Digitize any additional points anywhere on the torus.

 # Measuring a Tube

You can measure a round tube with a series of simple feature measurements. There are three ways in which you can measure a tube: by Cylinders, by Break Points, and by Line Segments.

Measure Tube by Cylinders

When you measure a tube by cylinders, CAM2 combines the measured planes (END-B and END-A) and cylinders (tube segments) to construct the tube, then applies the round tube diameter and bend radius values to create the final tube feature. All features automatically add to a group. *See "Feature Grouping" on page 36.*

NOTE: This command will not work in **Template** mode, so CAM2 automatically switches to **Measurement** mode if necessary. *See "Measure Mode" on page 23.*

NOTE: Two tube segments are required to create a tube feature.

---

1. Enter the information for the tube feature:

   • Enter the name for the tube.

   • Check the Override Diameter box and enter a value, or CAM2 will average the measured diameters from the tube.

   • Choose existing planes for the starting (END-B) and ending (END-A) or < Define > to measure each plane.

NOTE: Both Starting Plane and Ending Plane have modifiers to fine-tune tube length. High Point uses the highest reading of the plane to maximize tube length, Low Point uses the lowest reading of the plane to minimize tube length, and None ignores these modifiers.

   • Choose an existing nominal tube feature, if you have an existing nominal tube in the file.

   • Enter a Bend Radius.

   • Click **Create** to create the tube and begin measuring.

2. Measure the plane at END-B. *See "Measuring a Plane" on page 154.*

3. Measure each *straight* segment of the tube as a cylinder. Be sure to measure these cylinders in the proper order (END-B to END-A). *See "Measuring a Cylinder" on page 160.*

NOTE: Do not digitize any points on any curved sections unless CAM2 instructs you to do so. Measure curved sections as a Torus. *See "Measuring a Torus" on the previous page.*

A cylinder measurement is *always* expected since there are many cylinders that can form a round tube. When you cancel the cylinder measurement, you will see a message that the cylinder measurement was unsuccessful. If you

have no more segments to measure, click **No** to end the cylinder measurement and continue with the plane measurement at END-A.

4. Measure the plane at END-A. *See "Measuring a Plane" on page 154.*

NOTE: You can scan the planes and cylinders of a round tube. *See "Scanning" on page 190.*

Measure Tube by Breakpoints

When you measure a tube by breakpoints, CAM2 combines the measured planes (END-B and END-A) and breakpoints to construct the tube, then applies the round tube diameter and bend radius values to create the final tube feature. All features automatically add to a group. *Feature Grouping on page 36 and Breakpoints on the next page*

1. Enter the information for the tube feature:

- Enter the name for the tube.

- Enter a diameter, or CAM2 will average the measured diameters from the tube.

- Choose existing planes for the starting (END-B) and ending (END-A) or < Define > to measure each plane.

- Choose an existing nominal tube feature, if you have an existing nominal tube in the file.

- Enter a Bend Radius.

- Click **Create** to create the tube and begin measuring.

2. Measure the plane at END-B. *See "Measuring a Plane" on page 154.*

3. Measure each breakpoint in the proper order (END-B to END-A).

NOTE: Do not digitize any points on any curved sections unless CAM2 instructs you to do so. Measure curved sections as a Torus. *See "Measuring a Torus" on page 161.*

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4. Measure the plane at END-A. *See "Measuring a Plane" on page 154.*

Measure Tube by Line Segments

When you measure a tube by line segments, CAM2 combines the measured planes (END-B and END-A) and line segments (tube segments) to construct the tube, then applies the round tube diameter and bend radius values to create the final tube feature. All features automatically add to a group. *See "Feature Grouping" on page 36.*

1. Enter the information for the tube feature:

- Enter the name for the tube.

- Enter a diameter, or CAM2 will average the measured diameters from the tube.

- Choose existing planes for the starting (END-B) and ending (END-A) or < Define > to measure each plane.

- Choose an existing nominal tube feature, if you have an existing nominal tube in the file.

- Enter a Bend Radius.

- Click **Create** to create the tube and begin measuring.

2. Measure the plane at END-B. *See "Measuring a Plane" on page 154.*

3. Measure each line segment in the proper order (END-B to END-A).

NOTE: Do not digitize any points on any curved sections unless CAM2 instructs you to do so. Measure curved sections as a Torus. *See "Measuring a Torus" on page 161.*

---

4. Measure the plane at END-A. *See "Measuring a Plane" on page 154.*

Construction

A round tube constructs along this polyline from start to end using the diameter value.

For more information, see "Construct Tube: From Features" on page 250.

Breakpoints

After measuring all the tube segments, breakpoints automatically add to the drawing file and are viewable in the **Measurement Data** panel. *See "Measurement Data" on page 192.* Breakpoints are constructed points and are the intersection of tube segments along the tube:

•   END-B and the first straight segment.

•   First and second segment, second and third, third and fourth, etc.
     •   A radius constructs at the intersection point using the bend radius value.

•   END-A and the last straight segment.

A polyline constructs from through all of the breakpoints from END-B to END-A.

Alignment

If you have selected a nominal tube, a Feature Based alignment automatically adds to the drawing file and solves. *See "Feature Based" on page 275.*

If you do not have a nominal tube, you should create a coordinate system using the first, last, and another breakpoint with the Coordinate System. *See "Coordinate System" on page 278.*

The Align Tube Automatically user preference determines whether CAM2 automatically aligns tubes. *See "Align Tube Automatically " on page 83.*

Reporting

When you create a report containing your tube, the report will contain:

1. Breakpoints with 3D errors.

2. View of tube bending corrections.

3. Sections with nominal, actual and errors showing breakpoints and PTB information.

4. Text report presentation.

For more information, see "Report" on page 45.

◭ Measuring a Cone

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	6
See "Scanning" on page 190.	
XYZ Results	Apex of Cone
Vector	Center Line of Cone from Apex

See "Best Fit Cone" on page 326.

⬭ Measuring a Round Slot

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	6
See "Scanning" on page 190.	
XYZ Results	Center point of Slot Length and Diameter
Vector	Same as Plane
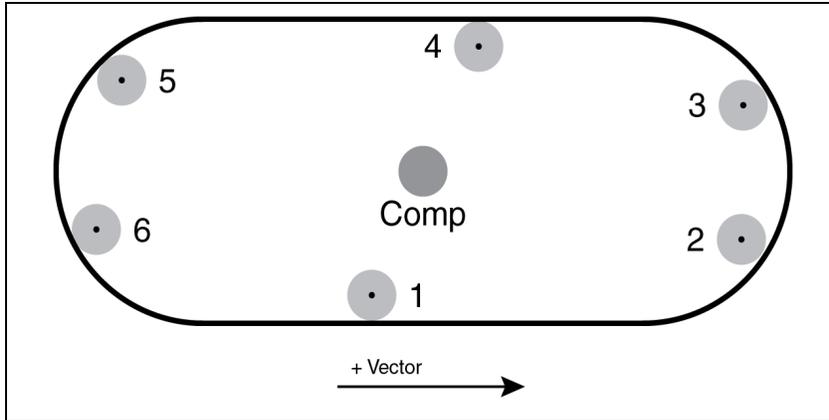
NOTE: You can digitize points on the straight sides of the round slot.

In the **Feature Information** panel, there are two length values for the round slot:
- **Length** (end to end)
- **Center to Center Length**

By default, the **Length** (end to end) check box is selected and the **Center to Center Length** check box is clear. *See "Nominals and Tolerances" on page 194.*

The first two digitized points determine the vector direction of the line. *See "Best Fit Round Slot" on page 329.*

◇ Measuring a Rectangular Slot

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	6
See "Scanning" on page 190.	
XYZ Results	Center point of Slot Length and Width
Vector	Same as Plane
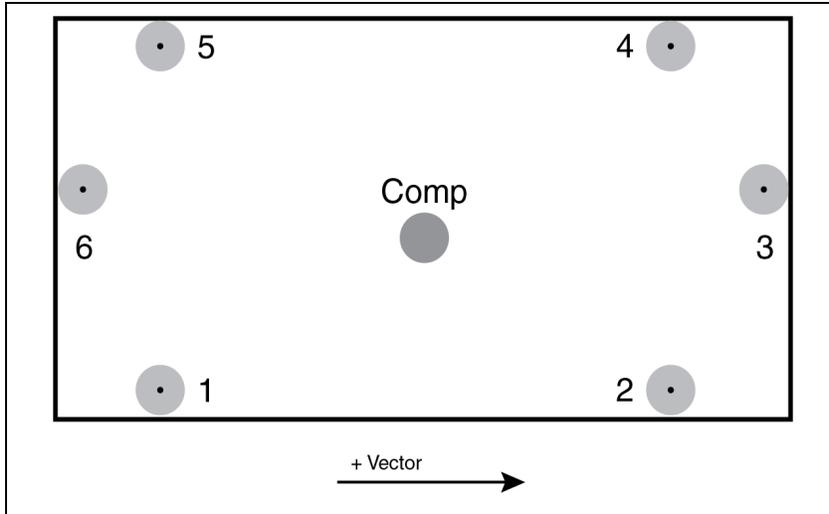
The first two digitized points determine the vector direction of the line. *See "Best Fit Rectangular Slot" on page 329.*

Measuring an Ellipse

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	5
See "Scanning" on page 190.	
XYZ Results	Center point of Ellipse
Vector	Same as Plane
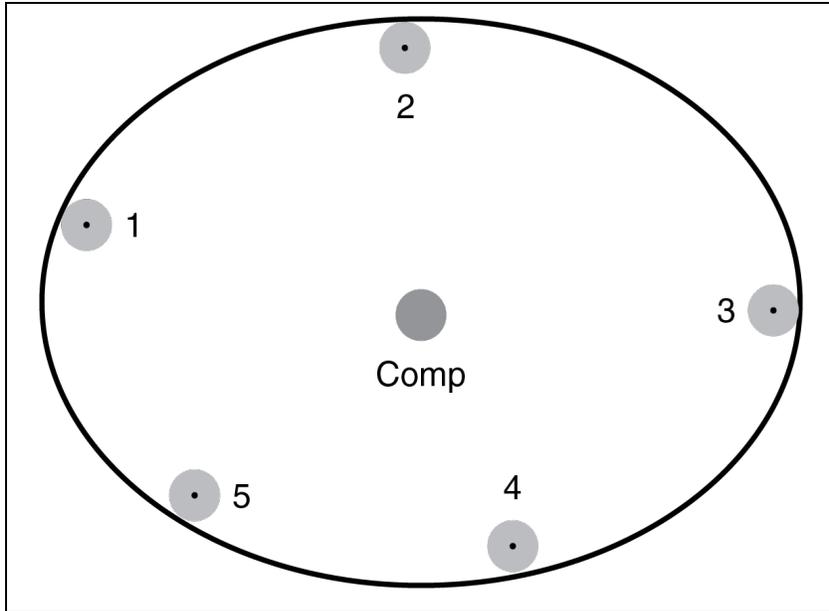
See "Best Fit Ellipse" on page 327.

Measuring a Cross-Section Scan

Use this command to measure a cross section of a surface.

NOTE: If you are using the Probing Version of CAM2, this command is available for use with a hard probe only. *See "Probing Version" on page 9.*

Probe Compensation needed? *See "Probe Compensation" on page 184.*	No
Minimum Readings to Solve	2
See "Scanning" on page 190.	
XYZ Results (Must be a feature with an associated nominal surface)	The Point: The digitized point compensated along the surface normal.
Vector	The vector of the surface at the measured point.

NOTE: To measure one or more polylines or cross sections with a contact probe, use **Measuring a Polyline** and **Measuring a Polyline**. *See Measuring a Polyline on page 176 and Measuring a Polyline Group on page 178.*

- **Name:** Type in a name for the Cross-Section Scan.

- **Automatically Create Nominal:** Automatically create a nominal cross section from a CAD surface.

- **Base Plane:** Specify a base plane for the cross section scan.

- **Base Distance:** Enter a distance value. While recording measurements, CAM2 ignores any point that is too far from the first.

- **Point Distance Filter**: Specify a distance from CAD to exclude point data. CAM2 will filter all points further from CAD than this value.

- **Keep Raw Data:** Keep the raw measurement data with the cross section. Enable this option to allow for recalculation.

- **Use Hard Probe:** Use a hard probe to measure the cross section. This is only available if a Laser Line Probe is connected to your FaroArm and it is the active device.

NOTE: When you align to CAD, the hard probe takes readings when the touch point crosses the plane (instead of the probe center). This ensures accurate cross-section scanning on slanted surfaces.

Deviation Markers

Deviation markers show deviation of the measured part relative to CAD at any position on the CAD model. *For more information, see "Deviation Markers" on page 120.*

Click the **Deviation Markers** tab to activate picking mode. With each click on the cross section, CAM2 creates a deviation marker and lists the marker's number and XYZ coordinates on the left side of the **Main Window**. Click the **measure** tab to exit picking mode.

- **Show Highest and Lowest Deviation Callouts:** Show a label at the highest and lowest deviation points. As you remeasure the cross section, these labels automatically appear in the minimum and maximum deviation locations.

- **Create By:** Create deviation markers at a fixed separation distance, or specify the total number of markers to be created. When data becomes available, CAM2 will automatically create deviation markers and display labels.

- **Zone Size**: Specify the size of all deviation markers. The default value is 1 mm.

- Click **Create** to add the feature to your measurement file.

3D Measuring a 3D Line

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	No
Minimum Readings to Solve	2
See "Scanning" on page 190.	
XYZ Results	End1 of the Line

	End2 of the Line
Vector	The Line from beginning to end

The first two digitized points determine the vector direction of the line. End 1 is the furthest point in the negative direction and End 2 is the furthest point in the positive direction.

See "Best Fit Line" on page 327.

Measuring a Planar Point

Projection Plane needed? *See "Projection Plane" on page 181.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	No, the point is automatically projected to the selected plane.
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point
Vector	none

See "Best Fit Point" on page 328.

Measuring a Home In Point

Use this command to measure a surface at a specific nominal location. To measure a surface at any location, use **Measuring an Inspect Surface Point**. *See "Measuring an Inspect Surface Point" on page 156.*

NOTE: You must create a nominal point or nominal vector point before starting this command.

You always see the **Measure Home In Point** properties dialog box regardless of the Show Control Window preference setting. *See "Show Control Window " on page 78.*

NOTE: You may find it helpful to enable Wireframe View to aid in identifying the Home In point. *For more information, see "Shading Mode" on page 114.*

- **Name:** Type in a name for the Home In Point.

- **Approach Type:** The location of the compensation point determines probe compensation direction. Compensation will be along the approach vector but the "away versus towards" is determined by the compensation point.

- Key-In - Type the IJK values in the **Approach Vector** box. Typing values in different units and coordinate systems[1]

- Select Surface - Select a Feature.[2] To Sample (measure) the surface of the part before measuring the point, select <Define>.

    - Flip Approach Vector - Flip the vector of the nominal surface.

- **Target Point:** Select a Point.[3] This point is the specific location, or "target point" on the surface.

- **Surface:** Select a Surface.[4] This is unavailable if **Key-In** is selected.

- **Home In Zone Diameter:** The Home In Zone Diameter is the diameter of a cylindrical zone created from the nominal point and the surface normal.

    - When the probe is in this zone, you can measure the surface. A point is not recorded if the probe is outside the zone.

- **Rotation Angle:** You may find that you have to rotate the view on the screen before you can Home In on a point. To rotate the view, enter a Rotation Angle.

- **Approach Vector:** Type the IJK values in the **Approach Vector** box. Typing values in different units and coordinate systems[5] This is unavailable if **Select Surface** is selected.

- Click **Create** to add the feature to your measurement file.

---

[1]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a surface. You can also click the name of the surface with the Left Mouse button in the Surfaces panel. To select a surface from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a surface with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the surface with the Left Mouse button in the Main Window.

[5]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

Measuring Points

Click **Create** in the **Home In Point** dialog box to add the feature to your measurement file.
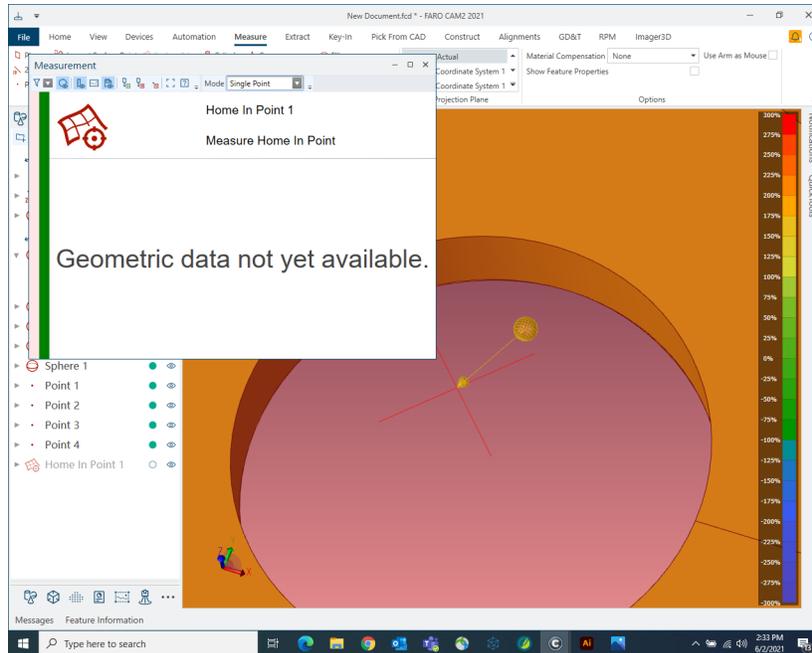
Figure 8-1 Measuring a Home-In Point

1. You now see the nominal point, the Home In Zone and the current position of your probe.

NOTE: CAD files may be oriented opposite of the Home-In Point.

---

2. Place the probe on the surface of the part and move it into the Home In Zone. Watch the screen and listen for the Home In Sound.

NOTE: The 3D distance from the probe to the point, and the depth to the point appear in the **Measurement** panel during the measurement of each Home In point.

---

3. Measure the surface:

• Press the **Front** button, or **G**key, to measure the surface point. You can digitize 1 to 3 points - the closest reading to the nominal point is used for the measured point.

• Pull away from the surface and press the **Back** button, or **H**key, to define probe compensation.

NOTE: It is possible to be within the Home In zone and not be touching the surface, ensure that the device is touching your part.

Measuring a High/Low Point

Use this command to measure a set of points and calculate the point with the highest deviation in relation to the reference feature. The **High Point** uses the highest positive deviation, and the **Low Point** uses the highest negative deviation.

NOTE: This command calculates 3D distance (the absolute distance between two points), not 3D displacement.

You always see the **Measurement Point** properties dialog box regardless of the Show Control Window preference setting. *See "Show Control Window " on page 78.*

• Select **High Point** or **Low Point.**

• Select the Reference feature type.

    • Select[1] a Reference feature.

• Select the
Probe Compensation. *See "Probe Compensation" on page 184.*

Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point: The three-dimensional (3D) distance between the point with the highest deviation and the reference feature.
Vector	none
 Figure 8-1 Measuring a High Point	 *Figure 8-2 Measuring a Low Point*

NOTE: If you select Plane-Reducible for the Feature Type, <Define> is a selection in the **Reference feature** drop-down. Select <Define> to measure a plane as the Reference feature before measuring the point. *See "Measuring a Plane" on page 154.*

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

Measuring a Surface Point

Projection Plane needed? *See "Projection Plane" on page 181.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	3
See "Scanning" on page 190.	
XYZ Results	The center point of the mini plane
Vector	The surface normal (perpendicular to the mini plane)

Measure three or more points in a small area on the surface. The points best fit into a mini plane.

Only use this command to measure points when you do not have a CAD model. To measure surfaces, use **Inspect Surface Point**, **Home In Point**, or **Vector Point**. These commands use or create exact nominal points on CAD surfaces. *See Measuring an Inspect Surface Point on page 156, Measuring a Home In Point on page 170 and Measuring a Vector Point below.*

Measuring a Vector Point

Use this command to measure a surface at a specific nominal location by selecting an existing nominal Vector Point. *See Vector Point on page 205 and Vector Point on page 218.* To measure a point on a surface, anywhere on the surface, use **Measuring an Inspect Surface Point**. *See "Measuring an Inspect Surface Point" on page 156.*

You can use Vector Points in an Iterative Alignment. *See "Iterative" on page 271.*

You always see the **Measure Vector Point** properties dialog box regardless of the Show Control Window preference setting. *See "Show Control Window " on page 78.*

- **Name:** Type in a name for the Vector Point.

- **Nominal Point:** Select a Point.[1] Select an existing nominal Vector Point.

- **Home In Zone Size:** The Home In Zone Size is the diameter of a cylindrical zone created from the nominal Vector Point.

- **Ignore Range:** Switch off the range control, when appropriate. CAM2 will take a reading once the probe is within the zone, regardless of range.

- Click **Create** to add the feature to your measurement file.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

Measuring Points

Adding Readings to Vector Points differs slightly depending on the Alignment.

- If an Alignment does not exist or exists but is *not* solved; the Vector Point highlights.

    - Touch the surface with the device in the approximate location.

    - Press the **Front** button, or **G** key, to measure the surface point. You can digitize 1 to 3 points - the closest reading to the nominal point is used for the measured point.

    - Pull away from the surface and press the **Back** button, or **H** key to define probe compensation.

- If an Alignment exists and is solved CAM2 guides you to the nominal point. *See "Measuring Points" on page 172.*

A round disk represents the Vector Point measurement. The disk color and size is a preference. *See "Size and Scale" on page 70.*

If the vector point is obstructed by a CAD surface, CAM2 will automatically apply transparency to reveal the Vector Point and surface. Once within range of the surface, the view will fix perpendicular to the surface to aid probe guidance to the required location.

NOTE: If the Automatically Take Reading preference is enabled, CAM2 will automatically measure a Vector Point when the probe is inside the home in zone. *See "Automatically Take Reading " on page 84.*

Measuring a Compensate Axis Point

Use this command to measure a point with a special axis compensation calculation.

Projection Plane needed? *See "Projection Plane" on page 181.*	No
See "Probe Compensation" on page 184.	Yes
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point
Vector	none

The compensation of the point will always be made along the main coordinate system axis (X, Y or Z) most parallel to the compensation direction; therefore, points are *only* compensated in the X, Y, or Z directions with this command. The choice of the axis and direction (+/-) will depend on the largest component of the retract vector.

See Measuring a Surface Point to compensate for probe radius in other directions. *See "Measuring a Surface Point" on page 174.*

See "Best Fit Point" on page 328.

CAUTION: This command should only be used by expert users; it can be a source of large errors in the measurement process.

Measuring a Surface Edge Point

Projection Plane needed? *See "Projection Plane" on page 181.*	No
See "Probe Compensation" on page 184.	Yes
Minimum Readings to Solve	1
See "Scanning" on page 190.	
XYZ Results	The Point: The digitized point compensated to the surface edge.
Vector	none

- If the **Automatically Create Nominal** check box is selected, a nominal surface point is automatically added to your file, and grouped with the Actual Surface Edge point. It is the closest point on the surface edge. *See "Dynamic Nominals" on page 195.*

Measuring a Polyline

Probe Compensation needed? *See*	Yes

"Probe Compensation" on page 184.	
Minimum Readings to Solve	2
See "Scanning" on page 190.	
XYZ Results (Must be a feature with an associated nominal surface)	The Point: The digitized point compensated along the surface normal.
Vector	The vector of the surface at the measured point.

Use this command to measure a single 2D or 3D polyline. To measure multiple polylines, or cross-sections, use **Measuring a Polyline**. *See "Measuring a Polyline Group" on the next page.*

- **Name:** Type in a name for the Polyline.

- **2D Plane:** Select the 2D Plane check box and select an existing plane. Select a Plane.[1] All measurement r

 eadings will project to the plane before the polyline is calculated.

- **Select Surfaces:** Select the **Surfaces** check box and select the CAD Assembly or individual surfaces from the list. Select from the List.[2] The surfaces will become the nominal surface for the polyline. Each point of the p

 olyline is automatically associated to the closest nominal surface.

- **Minimum Scan Distance:** Enter a distance value. CAM2 removes any point that is too close to the next.

- **Auto Nominal Maximum Distance:** Enter a distance value. A surface is not associated to any point of the polyline if the point is outside this distance.

- **Maximum Scan Distance:** Enter a distance value. While recording measurements, CAM2 ignores any point that is too far from the first.

- Select the Probe Compensation. *See "Probe Compensation" on page 184.*

- Select the Type.

- **Measure on CAD Side**: Select the Measure on CAD Side check box to measure the polyline on the part's CAD side.

- Click **Create** to add the feature to your measurement file.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[2]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

☐ Measuring a Polyline Group

Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve each Polyline	2
See "Scanning" on page 190.	
XYZ Results (Must be a feature with an associated nominal surface)	The Point: The digitized point compensated along the surface normal.
Vector	The vector of the surface at the measured point.

Use this command to measure multiple polylines or cross-sections. Cross-sections appear as translucent planes during measurement. To measure a single 2D or 3D polyline, use **Measuring a Polyline**. *See "Measuring a Polyline" on page 176.*

- **Name:** Type in a name for the Polyline Group.

- **Project to Surface:** Select the **Project to Surface** check box and select the CAD Assembly or individual surfaces from the list. Select from the List.[1] The surfaces will become the nominal surface for the polyline g
roup. Each polyline point is automatically compensated to the closest nominal surface. By default, the projection surface will be the entire CAD Assembly.

- **Automatically Create Nominal**: Select the Automatically Create Nominal check box to create a nominal polyline in addition to the polyline group. The nominal polyline will be projected to the CAD if a CAD surface is selected.

- **Measure on CAD Side**: Select the Measure on CAD Side check box to measure the polyline group on the part's CAD side.

- **Select the Probe Compensation Method**. *See "Probe Compensation" on page 184.*

- **Polyline Lock**: Select the Polyline Lock check box to select a polyline lock type:

  - **Parallel**
    - **Base Plane:** Select a Plane.[2] This defines the direction of all parallel planes and the base position for a
ll planes.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

- **Base Distance**: Enter a value to define an offset relative to the base plane where the first lock plane will start. Using a positive value will determine an offset in the positive direction relative to the plane normal and a negative value will do the opposite.
- **Distance Between Planes**: Enter the distance between the planes to be defined.
- **Number of Planes:** Enter the number of cross-sectional planes for the polyline group.
- **Planes on Negative Side of Base Plane**: Select the Planes on Negative side of Base Plane check box to define planes in the positive sense and flip them to negative plane direction.

- **Radial**
  - **Rotation Line:** Select a Line.[1] This defines the radial cross-sectional plane.
  - **Zero Angle Direction**: Select a line-reducible feature. The plane defined by this vector and the rotation line will define the base plane.
  - **Rotation Angle (Degrees)**: Enter the angle between the planes.
  - **Number of Planes:** Enter the number of cross-sectional planes for the polyline group.
  - **Planes on Negative Side of Base Plane**: Select the Planes on Negative side of Base Plane check box to define planes in the positive sense and flip them to negative plane direction.

- **Cylinder**
  - **Axis Line:** Select a Line.[2] This defines the axis for all defined cylinders.
  - **Cylinder Sections**
    Distance: Enter the radial distance between each of the cylinders.
  - **Number of Cylinders:** Enter the number of cylinders to be created.

- **Minimum Scan Distance:** Enter a distance value. CAM2 removes any point that is too close to the next.

- **Maximum Scan Distance:** Enter a distance value. While recording measurements, CAM2 ignores any point that is to far from the first.

- **Auto Nominal Maximum Distance:** Enter a distance value. A surface is not associated to any point of the polyline group if the point is outside this distance.

- Click **Create** to add the feature to your measurement file.

Polyline Group Examples

Parallel Locked Planes

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

Figure 8-1 Parallel Locked Plane Polylines

Radial Locked Planes
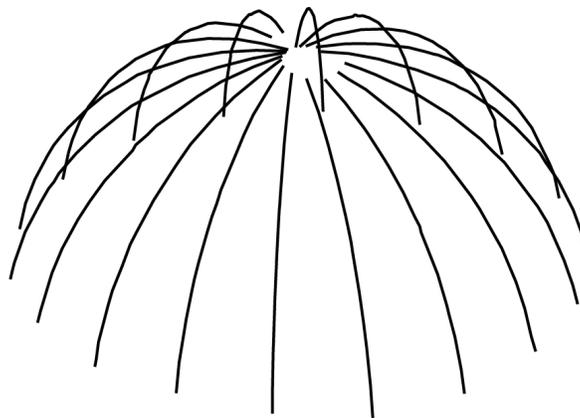
Figure 8-2 Radial Locked Plane Polylines

Measuring a Single Point Circle

Use this command to measure a single point in a hole that is smaller than the probe diameter. The circle diameter then calculates by using the distance to the projection plane and the probe diameter from the measured center of the probe.

Should the projection plane not cut the sphere of the probe, the resulting diameter will equal the primary probe offset times two. If you use an arm probe or SMR without an adapter, the circle will equal the diameter of the probe or SMR sphere. If you use a pin nest, the circle will equal the diameter of the pin.

Projection Plane needed? *See "Projection Plane" on the facing page.*	Yes
Probe Compensation needed? *See "Probe Compensation" on page 184.*	No
Minimum Readings to Solve	1
See "Scanning" on page 190.	

XYZ Results	The Point
Vector	Same as plane

NOTE: The probe should be well-seated in the hole when digitizing the point. Ensure that your probe is sufficiently larger than the hole to be measured. You can also edit (via Preferences) the auto nominal orientation, position, and size coefficients that control the size difference between measured and nominal circles. *For more information, see "Automatically Associate Nominal " on page 80.*

Measuring a Paraboloid

Projection Plane needed? *See "Projection Plane" below.*	No
Probe Compensation needed? *See "Probe Compensation" on page 184.*	Yes
Minimum Readings to Solve	8
See "Scanning" on page 190.	
XYZ Results	Apex of Paraboloid
Vector	Center Line of Paraboloid from Apex

See "Best Fit Paraboloid" on page 327.

Projection Plane

All two-dimensional (2D) features are entities in which the digitized readings are projected to a plane. All measurement readings are projected onto this plane before best fit calculations are started.

Click the Projection Plane drop-down menu and select an option:

- Select a Plane.[1]

NOTE: Constructed

actual planes may be available. The Allow Constructed Actual Planes preference controls this option. *For more information, see "Allow Constructed Actual Planes " on page 80.*

- Choosing <Define> adds an additional feature to the measurement file. You will digitize a plane before you digitize the points of the feature. Notice the messages in the Prompt area in the Measurement Panel for the active device. *See "Measurement Panel" on page 188.*

- Choosing <Auto> projects the points of the feature to an automatically selected plane. Notice the messages in the Prompt area in the Measurement Panel for the active device. *See "Measurement Panel" on page 188.*

- Choosing NONE uses the same points of the feature to create a plane.

See Default on page 80, and Use Last Plane on page 80.

2D FEATURES: circles, ellipses, slots, 2D lines, planar points, high/low points, and 2D polylines.
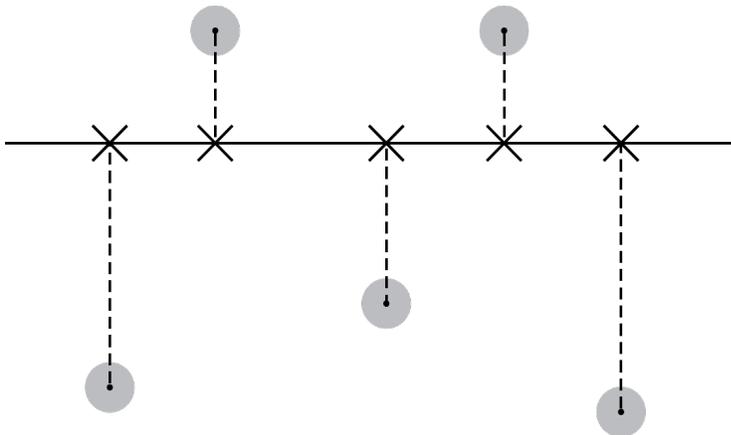
Figure 8-1 Digitized readings projected to a plane

To offset a projection plane, first measure a plane and then construct a parallel plane. *See "Construct Plane: By Offset" on page 229.*

Options

The **Options** group enables quick access to measurement options such as Material Compensation, Show Feature Properties, and Use Arm As Mouse.

Material Compensation

Material Compensation enables you to select material compensation options:

- **None:** (Default) No compensation.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

- **Back Side:** Measure a side of a part with a common material thickness (plastics, sheet metal, etc.) that you cannot touch with your measurement device.

- **Fixture - B Side:** Inspect a fixture to confirm touch points contacting the part on the 'B' side. The actual measured point lies on the fixture, with dN relative to the fixture surface and the reading is shown on the CAD 'A' surface. The error represents the material condition of the fixture touch point.

- **Part Thickness:** Inspect the part thickness deviation of a part held in a fixture, against touch points. Use a single surface CAD model offset to the probed part side. The actual measured point lies on the 'B' side, where the normal is opposite to the CAD surface. The reading is shown on the CAD 'A' surface, and indicates the flipped normal. The error represents the material thickness deviation of the part at the touch point. Specify the thickness and direction of your material by editing the Part Properties of your CAD file. *See "Part Properties" on page 96.*

- **Clamp:** Inspect fixture clamp positions, using the part's CAD model to confirm touch points contacting the part on the 'A' side. The actual measured point lies on the clamp surface, where the normal is opposite to the CAD surface. The reading is shown on the CAD 'A' Surface, and indicates the flipped normal. The error represents the material condition of the clamp touch point.

Show Feature Properties

This preference controls whether the **Feature Properties** panel appears when you add new measured features. *See "Show Control Window " on page 78.*

Use Arm As Mouse

This preference controls the interaction of the FaroArm and the CAM2 software. When enabled, the position of the probe controls the mouse pointer. *See "Use Arm as Mouse " on page 78.*

Feature Properties

Most measured features have three properties: Plane, Material Compensation, and Probe Compensation. Plane projection features also have Depth Scanning properties. Properties for other features are described later in this chapter.

You can edit the properties of an existing measured feature:

- Select a feature from the **Features** panel or the CAD View.

- Click **Home > Properties.** You can also right-click the feature in the **Features** panel and select **Properties** from the shortcut menu. In the **Feature Properties** panel you can:

  - Edit the name.

  - Select or clear the Material Compensation check box.

  - Select a projection plane (2D features only).

  - Change the probe compensation.

By default, the **Feature Properties** panel does not appear during each measure command. *See "Show Control Window " on page 78.*

NOTE: Some features always require you to set properties before creating the feature and ignore this preference.

Comments

The **Features** panel contains a Comments field into which you can type a textual comment. Features with comments are identified by a comment icon in the **Features** panel. You can view the comment quickly by moving the pointer over the icon.

NOTE: You can include your comment in the feature's label by selecting the Show Comments In Label check box.

Plane

Click the Plane drop-down menu and select a projection plane. Select a Plane[1]

Solver Method

This option allows you to best-fit a feature so that all readings are outside (maximum) or inside the feature (minimum), and applies to the following feature types: Circle, Sphere, Plane, 2D Line, Round Slot, Rectangular Slot, Cylinder and Cone.

Measure on CAD Side

Select this check box if you are measuring a side of a part with a common material thickness (plastics, sheet metal, etc.) that you cannot touch with your measurement device.

Set the composition and global thickness of your material by editing the Part Properties of your CAD file. *See "Part Properties" on page 96.*

Display As Arc

This option allows you to display a circle as an arc using only the actual readings taken.

•   When cleared (default), the circle will draw as normal.

•   When selected, the circle will only cover the span of the readings.

Probe Compensation

The coordinates of all readings digitized with a spherical probe are located at the center of the probe. CAM2 calculates for the difference between the center and circumference of the probe when you press the **Back** button, or **H** key. There are five methods to define the probe compensation:

•   **Auto:** automatically compensates using the orientation position of the probe in each reading. When using this option, collect readings with the probe as perpendicular to the surface as possible.

•   **Sampled End Click:** press the **Back** button, or **H** key to define probe compensation for *each* feature.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the FEATURES panel. To select a plane from the MAIN WINDOW, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the MAIN WINDOW. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the MAIN WINDOW.

- **Measured Inside:** automatically compensates out for a hole.

- **Measured Outside:** automatically compensates in for a stud.

- **None:** no probe compensation.

Press the **Back** button, or **H** key, to end any measurement command. The probe compensation is calculated after any best fitting of the measured feature. The current probe compensation method is a preference. *See "Default Compensation Method " on page 79.*

NOTE: Some measured features do not require probe compensation. Pressing the **Back** button, or **H** key, stops **Add Readings** . *See "Add Readings " on page 197.*

Plane-Lock Scanning

Plane-lock Scanning enables you to specify a depth value for a plane projection feature. As you measure the feature, CAM2 will automatically record a measurement whenever the probe traverses a plane offset a given depth value below the projection plane. Plane-lock Scanning is especially helpful when measuring thin sheet metal planar features.

Plane-lock Scanning options are as follows:

- **Enable Plane-lock Scanning:** Enables Plane-lock Scanning. If selected, you will measure on the offset plane. If cleared, you will measure on the projection plane.

- **Plane Offset:** (used in conjunction with Enable Plane-lock Scanning) The depth value for the offset plane.

- **Enable Sound:** Provides sound guidance with distance to depth plane. This option is not available if Enable Plane-lock Scanning is cleared.

- **Measure on Offset Plane:** Records a measurement when the center of probe crosses the offset plane. This option is not available if Enable Plane-lock Scanning is cleared.

NOTE: The Plane-lock Scanning offset option is only applicable to plane projection features (Circle, 2D Line, Round Slot, Rectangular Slot, Ellipse, and Planar Point).

Point Distance Filter

When you have aligned point cloud data with a CAD model, the point distance filter excludes point cloud data a specified distance from CAD. Depending on the filter setting, you may see an increase or decrease of visible points in relation to the CAD model. An alignment change may also affect point visibility.

NOTE: Applying this filter only hides points. To permanently delete filtered points, click **Delete Exclusions** in the **Feature Properties** panel.

Even Distribution

When working with a cross-section, Even Distribution samples points at a custom space interval. Check the Even Distribution check box, and enter the Point Spacing to sample points on the Cross Section. The default spacing is 1mm. Average deviations will display on the given area of the cross-section.

Comparison to CAD

Comparison to CAD allows you to compare a point cloud to CAD without an alignment.

- **Automatic:** (Default) CAM2 will compare a point cloud to CAD when you align them.

- **Always On:** CAM2 will always compare a point cloud to CAD even if an alignment is not present.

- **Always Off:** CAM2 will not compare a point cloud to CAD even if an alignment is present.

Scanning Filter

A scanning filter enables you to filter visible point cloud data by decimation or grid filter.

NOTE: Applying a scanning filter only hides points. To permanently delete filtered points, click **Delete Exclusions** in the **Feature Properties** panel.

- **Decimate**: Use decimation to reduce the density of the point cloud. The decimation factor determines the number of points per line. For example, a value of 10 indicates that Measure will show every tenth point, effectively reducing the number of visible points by a factor of 10.

- **Grid**: Occasionally, you may scan portions of a part on which data has already been captured. Similar to Decimation, grid filtration avoids more than one point in a grid pattern. Enable Grid Filtering and enter the grid size. This will also control the resulting point density.

When using a Grid filter, point cloud data will be colored according to point quality based on the angle of incidence. Points outside of the acceptable angle will display red to indicate lower quality. You can replace the lower quality points by changing the angle of incidence (in the Measurement > Registration preferences) and then rescanning to improve point cloud accuracy. *See "Registration " on page 83.*

3D Imager

Registration governs CAM2's behavior when encountering bad points. *See "Registration " on page 83.*

Plane Definition

Plane Definition provides additional planar control governing feature extraction from point clouds.

Plane: Select the feature's projection plane.

Use Offset Projection Plane: Specifies the way in which CAM2 chooses points to calculate the feature's projection plane. The option is only available when you select NONE for the projection plane. Specify the following parameters:

- **Offset:** The minimum distance from the outline of the measured feature at which CAM2 includes points for projection plane calculation. All points closer than the minimum distance from the outline of the feature will be excluded.

- **Threshold:** The width of the band in which to extract points for fitting the projection plane.

NOTE: In the case of a circle, the zone will represent a disc around the fitted feature that will specify points to calculate the projection plane.

Extraction

Extraction provides additional point selection control governing feature extraction from point clouds.

Extraction options are as follows:

- **Standard Projection:** CAM2 ignores all points on the plane and takes all remaining points to be on the feature (circle or 2D line) to extract. CAM2 projects the remaining points to the projection plane and calculates the feature.

NOTE: The projection plane can be pre-selected or extracted from the selection. *See "Selecting a Projection Plane for Extracting 2D Features" on page 201.*

Depth Scan: Specifies the way in which Specify the following parameters takes the points that will be projected to the plane for fitting the feature. Select this option to exclude data close to the edge of the holes. Specify the following parameters:

- **Offset:** The minimum distance from the Projection Plane at which CAM2 includes points for the feature calculation. All points closer than the minimum distance from the projection plane will be excluded.

- **Thickness:** The width of the band in which to extract points for fitting the feature.

- **Thin Material:** CAM2 ignores points outside the plane and calculates the largest circle that can fit inside the gap from the hole. Select this option when scanning thin sheet material that prevents you taking interior data.

- **Solver Method**: Best-fit a feature so that all readings are outside (maximum) or inside the feature (minimum).

Laser Line Probe Measurement

CAM2 allows direct feature measurement with a Laser Line Probe, extracting features from the Laser Line Probe data.

1. Calibrate your Laser Line Probe using the Device Center. *For more information, see "Device Center" on page 128.*

2. Set CAM2 to either **Measure** mode or **Template** mode. *For more information, see "Measure Mode" on page 23.*

3. From the menu, select the feature to measure. Depending on your mode:

- the feature adds to the **Features** list.

<div align="center">

OR

</div>

- the feature adds to the **Features** list and you are immediately prompted to measure.

4. Digitize your part while staying within the measurement range of the Laser Line Probe. Watch the indicator in the **Range Finder** dialog box as you move the Laser Line Probe. After you press the **Back** button, calculated readings add to the feature from the Laser Line Probe data.

Scanning Tolerance

As you scan your aligned part, CAM2 shows the deviations from tolerance:

• Green - the measurement is in tolerance.

• Red - the measurement is above the upper tolerance.

• Blue - the measurement is below the lower tolerance.

Scanable Features

You can scan the following features with a Laser Line Probe: planes, circles, edge lines, spheres, cylinders, tubes, and point clouds. Selecting any other feature types will automatically switch to the ball probe.

Automatic Feature Recognition

CAM2 can provide an extremely simplified measurement workflow by automatically recognizing features as you measure. When you enable automatic feature recognition, you can begin recording measurements without first invoking a measurement command.

NOTE: Automatic feature recognition is enabled and configured in Preferences. You must disable Arm as Mouse to use this feature. *For more information, see Auto-Recognize Features on page 78 and Use Arm as Mouse on page 78.*

---

1. Record a measurement using your measurement device. The Measurement Panel appears. *See "Measurement Panel" below.*

2. Continue to record measurements, and the **Measurement** panel shows the results and appropriate feature name as CAM2 computes the geometry that best fits the recorded measurements.

NOTE: You can override CAM2's automatic computation by clicking the Geometry Override drop-down in the **Measurement** panel to manually select a geometry type. Available geometry types depend on the threshold set in Preferences.

---

3. When you finish recording measurements, record an end click to terminate the measurement of the feature.

Measurement Panel

The **Measurement** panel opens automatically with each measurement command. Each measurement device, connected to CAM2, has a unique **Measurement** panel. Look in the title area of the panel to see the serial number, or name, of the device.

Figure 8-1 Measurement Panel

NOTE: Refer to the *CAM2 2021* chapter in your hardware device's user manual for more information about specific controls in the **Measurement** panel.

Setup

❶ The **Measurement** panel displays the Rectangular XYZ and Form values by default, which update as you record measurements. In the upper left corner of the window, click the **Show Options** drop-down and select, or deselect, values to show or hide different values. Some of these values use tolerances, For example:

- The Form value has an Out of Tolerance indicator to the right of the value. After you add one more than the minimum number of readings, the value calculates and shows In, Above or Below tolerance using the features current form tolerance value. *For more information, see "Tolerances" on page 196.*

❷ Show/hide the Geometric Data - geometric data and statistics associated with the current measurement.

❸ Show/hide the device's Digital ReadOut (DRO) - the current location of the measuring device's probe and updates as the probe moves through space. The numerical setup of the DRO is a preference. *See "Units Tab" on page 74.*

❹ Show/hide the Measurement Image - the image for the current measurement. *For more information, see "Image Creator" on page 50.*

❺ Show/hide the Measurement Prompt - the text area that contains informational messages relating to the current measurement.

Measuring

❻ Record Measurement. This is the same as pressing the **Front** button on the FaroArm, or the **G** key, on your computer keyboard.

❼ Record End Click. This is the same as pressing the **Back** button on the FaroArm, or the **H** key, on your computer keyboard.

❽ Remove Last Point. You can also press the **Backspace** key on your computer keyboard.

NOTE: Press and hold the **Back** button on the FaroArm to remove multiple readings in reverse order.

Sizing

❾ Full Screen. Maximize the **Measurement** panel to fill the entire computer screen. Click this button again to return to the original size.

Geometry Override

❿ Use the **Geometry Override** drop-down window to override CAM2's Automatic Feature Recognition by manually selecting a geometry type. *See "Automatic Feature Recognition" on the previous page.*

NOTE: Automatic recognition is enabled and configured in Preferences. *See "Auto-Recognize Features " on page 78.*

Cancel

❶❶ Closing the **Measurement** panel cancels the measurement.

Laser Tracker Family and Probe

❶❷ Use the **Target** drop-down window to select an SMR size (FARO Laser Tracker only).

❶❸ Use the **Adapter** drop-down window to select a probe size (FARO Laser Tracker only).

Scanning

❶❹ Use the **Mode** drop-down window to switch the reading collection mode during the measurement process. Options for the modes are located in the **Device Control** panel. See the CAM2 chapter in the user manual of your current measuring device for more information.

- **Single Point**: press the **Front** button, or the **G** key, to collect a single reading.

- **Time Interval**: press the **Front** button, or the **G** key, to start the time interval. Collect a single reading over time.

- **Distance Interval**: press the **Front** button, or the **G** key, to start the distance interval. Collect a single reading when the probe moves a distance.

NOTE: If the current probe is a Laser Line Probe on the FaroArm, it is best to use the **Time Interval** setting with a very small time interval. Setting the time interval to 5ms collects point data at the FaroArm's maximum speed.

Feature Changes During Measurement

During the adding of readings, or measurement, of a feature it is possible to change the following using the drop-down list boxes in the **Measurement** panel:

- The projection plane of any 2D feature;
- The projection surface for an Inspect Surface or Inspect Surface Point feature; and
- Probe settings

before the feature solves. This is useful if you are measuring many of the same type of feature that slight differences or special needs.

Live Measurement Results

The **Measurement** panel provides real-time feedback of the geometry currently being measured. RMS values of the last reading display in the window (Laser Tracker only). *For more information, see "RMS Threshold " on page 86.* Geometric values appear in the window as soon as the minimum number of points required to solve the feature have been recorded. The values displayed in the window automatically update each time a new reading is recorded.

> **NOTE:** For large numbers of readings at a high rate (such as scanning), the user must pause for a sufficient period of time to allow the geometry to solve without affecting the rate of point collection.

Automatic Probe Compensation

Solved geometry must be automatically probe-compensated to accurately represent the measured geometry; as such, automatic probe compensation is the default for all measured features. In this mode, the **back** button click will only be used to end the measurement of a feature, not to indicate the compensation direction.

Sampled End Click compensation may be used when the automatic or forced inside/outside compensation techniques do not suffice. In this scenario, geometric values shown while measuring may not match the resulting geometry solved after the end click is taken. The current probe compensation method is a preference. *See "Default Compensation Method " on page 79.*

> **NOTE:** Measurement of geometry that always requires a single sample will automatically complete after the first sample is taken.

Layers

Use layers as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file. *For more information, see "Layers" on page 112.*

Labels

After adding the minimum number of readings to solve the feature, and an end click point, the feature draws on the CAD view and an on-screen label adds to the measurement file.
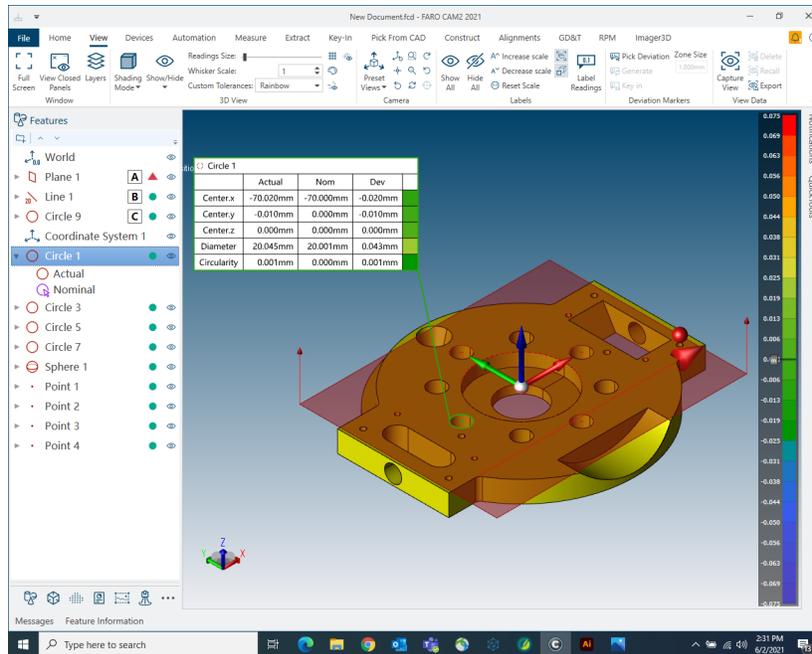
Figure 8-1 Feature Labels

This label shows the current data for the feature and the border changes color to show any Out of Tolerance condition:

- **Green** - the feature is in tolerance

- **Red** - measurement is above the upper tolerance

- **Blue** - measurement is below the lower tolerance

Select a feature, or multiple features, and each label shows relevant values for the feature. If the feature contains actual values, the label shows actual values. If the feature contains nominal values, the label shows nominal values. If the feature contains both actual and nominal values, the label shows actual values, nominal values, and deviation.

NOTE: XYZ positional data does not show without a solved alignment.

When a feature is not selected, the label only shows the feature name. Move the pointer over the label to temporarily show all of the values. Add or Remove values from the labels using the **Feature Information** panel. *See "Nominals and Tolerances" on page 194.*

To move a label, drag the label around the CAD view or press **L** to automatically arrange the label in the view.

To show or hide a label, right-click the current feature in the **Features** panel or the CAD view, and select **Label** from the shortcut menu. Right-click again and select **Detailed Label** to change the label to the detailed format.

There are many preferences to control the visibility, content and behavior of the feature labels. *See "Display" on page 69.*

Measurement Data

Measurement data consists of the individual digitized points of the feature.

NOTE: Selecting a "By Best Fit" constructed feature shows each individual feature and its data to the constructed feature.

Figure 8-1 Measurement Data panel

Select a feature, or multiple features, from the **Measurement Data** panel and use the **Measurement Data** panel to:

1. Analyze the readings of a feature.

   • The default sort order of the rows is by the ID column. This is also the order of the readings as they were added to the feature. Click a column to sort the readings by that column, and click again to reverse the sort.

2. Remove a reading from the feature and re-calculate the feature using the remaining readings.

   • Clear the check box in the **On** column to remove a reading. Click **Apply** to re-calculate the feature using the selected features.

3. Change the probe of existing readings.

   • Select from the List[1] the readings.

   • Click **Edit Probe Settings**.

   • In the **Edit Probe Settings** dialog box, change the probe settings and click **OK**. You can also enter values manually for any offsets.

4. Permanently delete a reading.

   • Select a reading, right-click and select **Delete** from the shortcut menu.

NOTE: The **Clear Readings** deletes all readings from every feature in your file. *See "Clear Readings" on page 109.*

5. Generate a report of the readings of a feature, or multiple features.

   • Click **Report** to quickly generate a report. *For more information, see "Standard Home Tab Report Commands" on page 49.*

6. Aim the FARO Laser Tracker to the location of an individual reading.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

• Select a reading, right-click and select **Aim** to point the Laser Tracker at the location of the reading.

Panel Settings

Change the order of the columns by dragging the top of a column to the left or right. Resize a column by dragging the top edge of a column to the left or right. Hide a column by dragging the top of a column down to the bottom of the **Measurement Data** panel.

Right-click on the top of any column to get a shortcut menu:

1. Select Sort Ascending to Sort Descending to change the sort order of the readings.

2. Select Column Chooser to see a list of hidden columns. To unhide a column, drag the column from the list back to the **Measurement Data** panel.

3. Select Best Fit to automatically size the column.

4. Select Best Fit (all columns) to automatically size all the columns in the **Measurement Data** panel.

Nominals and Tolerances

Add and edit nominal and tolerance information to a feature in the **Feature Information** panel. Use this panel to:

• Add single or multiple nominal features to a feature.

• Type in nominal values and create a nominal feature.

• Change the default Upper and Lower tolerance values for each actual result and see the Deviation values from nominal.

• Select or clear individual values for a feature. This controls visibility of the values on the on-screen label and the report.

• Associate a DIN or ISO tolerance classification to a feature. Selecting a tolerance class in either the lower or upper tolerance column will set the tolerance values for both upper and lower tolerances. When associating a tolerance classification to a feature, it will apply to all applicable properties of that feature.

Figure 8-1 Feature Information panel

NOTE: You can select multiple features and edit each in the panel. *See "Selecting Features" on page 34.*

Panel Settings

Each value has a check box; clear this check box to remove it from the on-screen label and the report. Use **Show Only Selected** at the bottom of the **Feature Information** panel to only show features with checked boxes.

Single Nominal

1. Select a feature from the **Features** panel or the CAD view.

2. In the top row of the **Feature information** panel, click the Nominal Feature column cell, then click the drop-down arrow.

3. Select a Feature.[1]

NOTE: Clicking **X**

in the **Nominals Feature** column removes the nominal feature from the current feature.

Multiple Nominals

1. Select a feature from the **Features** panel or the CAD view.

2. In each row of the **Feature Information** panel, click the Nominals Feature column cell, then click the drop-down arrow. Use the scroll bar on the right side of the panel to move down the list and see other values.

3. Select a Feature.[2]

NOTE: Clicking **X**

in the **Nominal Feature** column removes the nominal feature from the current feature.

Typing Nominal Values

1. Select a feature from the **Features** panel or the CAD view.

2. In each row of the **Feature Information** panel, click in the Nominal column. Type a numeric nominal value and press the **Enter** key. Use the scroll bar on the right side of the panel to move down the list and see other values.

Adding a nominal feature to a measured, or constructed, feature creates a group in the Navigation Window. *See "Navigation Window" on page 33.*

Dynamic Nominals

In a few instances, the nominal feature is more complex than the measured feature. In some measured features, CAM2 automatically associates a complex nominal to a simple measured feature. When this happens the simple measured feature is projected (shortest distance) to the complex nominal. The Actual to Nominal data is the simple measured feature and the projected simple nominal feature.

For example, an **Inspect Surface Point** has a measured point and an associated nominal surface. The projected nominal point is the closest point anywhere on the surface. *See "Measuring an Inspect Surface Point" on page 156.*

Automatic Nominals

Once an Alignment is complete, any new measured feature is compared to all nominals and CAD parts in the measurement file. *For more information, see "Alignments" on page 265.*

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

If a similar nominal feature is found it is automatically associated. If there is a feature in a CAD part, that feature automatically adds as a nominal and associated to the measured feature. Automatic Nominals is a preference with default search vales. *For more information, see "Automatically Associate Nominal " on page 80.*

Tolerances

NOTE: In addition to traditional rectangular tolerances, CAM2 also supports many GD&T tolerances. *For more information, see "GD&T" on page 287.*

You can change tolerance values for an individual or selected group of features. You can also change the default tolerance values for the entire file in the **Tolerance Preferences**. *See "Tolerance Preferences" on page 63.*

1. Select a feature in the **Features** panel or from the **CAD** window.

2. In the **Feature Information** panel, select or clear the check box in the first column for each value to tolerance.

3. Change an individual tolerance value by clicking in the **Lower** or **Upper** cell and typing a numeric value.

The OOT (Out of Tolerance) and Tolerance columns show the measured to nominal deviations. Each feature parameter cell changes color to show any Out of Tolerance condition:

• **Green** (Pass) - measurement is within the upper and lower tolerance

• **Red** - measurement is above the upper tolerance

• **Blue** - measurement is below the lower tolerance

The Tolerance column graphically shows the amount of tolerance that is consumed by the deviation (Pass), or the amount above or below tolerance. If the deviation is more than four times the tolerance a plus or minus sign is added to the bar.

NOTE: You will *not* see some feature values in the on-screen label and the report if an Alignment has not been completed. *See "Manage Alignments" on page 266.*

Changing Multiple Values

You can change the lower and upper tolerance value for multiple values of a feature:

1. Select a feature in the **Features** panel or from the **CAD** window.

2. In the **Feature Information** panel, hold down the **Shift** key and left-click the first (top) parameter, then click the last parameter you want. For example, the lower tolerance X Y and Z locations.

3. Type a numeric value into any tolerance field and press **Enter**.

You can change the lower and upper tolerance for *all* values of a feature:

1. Select a feature in the **Features** panel or from the **CAD** window.

2. In the **Feature Information** panel, left-click the empty cell at the top of the lower or upper tolerance column.

3. Type a numeric value into any tolerance field and press **Enter**.

Add Readings

Add Readings adds readings to an existing measured feature. You can also press the **Insert** keyboard shortcut on the keyboard.

1. Select a feature in the **Features** panel or the **CAD** window.

2. Right-click the feature in the **Features** panel and select **Add Readings** from the shortcut menu. If the probe is visible on-screen, it will flash green when you add readings.

3. Use your measuring device and add more readings to the feature using the **Front** button, or **G**key.

4. Press the **Back** button, or **H**key, to finish. If the probe is visible on-screen, it will flash red when you press the **Back** button, or **H**key.

NOTE: You can also use the buttons in the Measurement Panel. *For more information, see "Measurement Panel" on page 188.*

NOTE: Pressing the **Back** button, or **H**key, may also define the Probe Compensation. *For more information, see "Probe Compensation" on page 184.*

If you select multiple features the measurement order follow the position of the features in the **Features** panel. *See "Reordering Features" on page 36.*

Using Multiple Devices

If you have multiple devices connected to CAM2, use the shortcut menu to select a specific device.

1. Select a feature in the **Features** panel or the **CAD** window.

2. Right-click the feature and select the **Add Readings From** flyout.

3. Select a measurement device and add readings to the feature.

Chapter 9: Extract

The Extract commands are located in the **Extract** tab across the top of the screen. The Extract commands allow you to extract geometric features from a point cloud by selecting points in the View window. Feature extraction may not be as accurate as hard probing; however, if the material is soft or flexible, extraction will be more accurate and repeatable than hard probing.

The commands on the **Extract** tab are organized into Manual Probing, Selection Tools, Features, and Options groups.

Layers

Use layers as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file. *For more information, see "Layers" on page 112.*

Manual Probing

The **Manual Probing** group contains commands to manually pick points from a point cloud in order to extract a feature: Probing Mode, Remove Last, and Clear Probings.

Probing Mode

Click **Probing Mode** to enable manual point picking for feature extraction from a point cloud. As you pick points, the list of extractable features calculated from the points appears on the left side of the **Main** window. To create a feature from the list, click the feature.

Remove Last

Removes the last point you picked.

Clear Probings

Clears all picked points.

Selection Tools

The **Selection Tools** group contains commands to select portions of point cloud data for geometry calculation: Rectangular, Lasso, Polygon, and Brush. *For more information, see "Selection Tools" on page 38.*

Editing Point Selections
Adding Points

To add to the current point selection, press and hold the **SHIFT** key while selecting more points. When you're finished, the resulting selection will include points from the existing selection and the new selection.

NOTE: While you add points this way, the selection cursor is appended with a small '+' sign.

Subtracting Points

To subtract points from the current selection, press and hold the **CTRL** key while selecting the points to subtract. When complete, the resulting selection will exclude the points you most recently selected from the existing selection.

NOTE: While you subtract points this way, the selection cursor is appended with a small '-' sign.

From Properties

As you view the feature's properties using the Feature Properties window, the feature's points are highlighted in the **Main** window. From here, you can reselect points in the **Main** window using the Adding Points and Subtracting Points methods. When you have updated the point selection, click **Modify** to save changes to the feature. *See "Feature Properties" on page 183.*

Clear

Clear resets the active point selection.

Features

The **Features** group contains all the geometric features that can be extracted from the point cloud: plane, 2D line, circle, sphere, cylinder, cone, torus, vector point, round slot, and rectangular slot. **Any 3D Feature** creates a geometric feature that best fits your selected points. **Extract All** extracts all nominal features from CAD, all measured features from existing nominals, and all measured features from selected points.

Extraction from Point Clouds

To extract a feature from a point cloud:

- Use the **Selection Tools** to select a region of points that fully contains the feature to extract.

- In the **Features** group, select the feature type to be extracted.

- CAM2 extracts the feature.

Extraction from Nominal

When a point cloud is aligned to a CAD model, CAM2 can automatically extract geometric features from the point cloud when you pick a nominal CAD feature.

To extract a measured feature from a nominal:

- Load a CAD model and align to it.

- Measure a point cloud over CAD features.

- Pick a feature from the CAD model.

- CAM2 creates the nominal feature and extracts the measured feature from the Point Cloud.

NOTE: The Extraction - Automatically Relate Scan Data to Nominal Data user preference must be enabled to use this feature. *See "Extraction " on page 82.*

Selecting a Projection Plane for Extracting 2D Features

You can specify the projection plane from which to extract a line or circle (2D features) using the **Select Projection Plane** drop-down list on the **Measure** tab. *See "Measure" on page 153.*

- **Auto**: (Default) CAM2 will determine the best existing projection plane for this new feature. If no such plane exists, CAM2 will extract the plane from the point cloud data.

- **None**: CAM2 will extract a projection plane from the data, and then extract the 2D feature using this projection plane.

- **<Any other plane>**: CAM2 will use the selected projection plane as the projection plane for the feature you are extracting.

NOTE: As with any measured 2D feature, you can also edit the Properties of the extracted feature and modify the feature's projection plane. *For more information, see "Properties" on page 108.*

Options

The **Options** group contains options to define a Sampling Method.

Sampling Method

Click **Sampling** to select a sampling method: standard projection or thin material.

Chapter 10: Key-In

The **Key-In** commands are located in the **Key-In** tab across the top of the screen, and are organized into Features and Dimensions groups.

Use these commands to create Nominal features using data on drawings or spreadsheets.

Layers

Use layers as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file. *For more information, see "Layers" on page 112.*

Features

The **Features** group contains all the construction commands for 2D and 3D features.

⬚ 0.0 Plane

Requires: three sets of XYZ values, or one XYZ value and a normal vector value.

- **Name:** Type in a name for the constructed plane.

- **Plane:** Select a radio button:

    - **Points:** Type in the XYZ values. Typing values in different units and coordinate systems[1]

                        OR

    - **Point:** Type in the XYZ value. Typing values in different units and coordinate systems[2]

    - **Normal:** Type in the XYZ values. Typing values in different units and coordinate systems[3]

-

    Click **Create** to create the plane.

NOTE: The vector of the constructed plane is determined by the Right-Hand Rule. *For more information, see "Right-Hand Rule" on page 330.*

╲ 0.0 Line

Requires: two points.

- **Name:** Type in a name for the constructed line.

- **Point on Line:** Select a radio button:

    - **Point2 on Line:** Type in the XYZ values. Typing values in different units and coordinate systems[4]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[3]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[4]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

OR

- **Line Vector:** Type in the IJK values. Typing values in different units and coordinate systems[1]

- **Length:** Type in the length value. Typing values in different units[2]

- Click **Create** to create the line.

0.0 Point

Requires: an X, Y, and Z value.

- **Name:** Type in a name for the constructed point.

- **Points:** Type in the XYZ values. Typing values in different units and coordinate systems[3]

- Click **Create** to create the point.

0.0 Vector Point

Requires: an X, Y, and Z value and a normal vector.

- **Name:** Type in a name for the vector point.

- **Point:** Type in the XYZ values. Typing values in different units and coordinate systems[4]

- **Vector:** Determine from CAD or Type in:

  - **From CAD:** Select the **Determine Vector from CAD** check box to calculate the point's vector from a CAD model.

  - **Vector:** Type in the IJK values. Typing values in different units and coordinate systems[5]

Selection

- **Zone Type:** Choose from 3 zone types:

  - **Cylindrical** creates a circular zone.

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[3]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[4]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[5]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

> - Diameter: enter the zone size.
>
>> - **Rectangular** creates a rectangular zone.
>>
>>> - Length: enter the zone length (longest).
>>>
>>> - Width: enter the zone width (shortest).
>>>
>>> - Angle: enter the orientation angle
>>
>> - **Round Slot** creates a rounded slot zone.
>>
>>> - Length: enter the zone length (longest)
>>>
>>> - Radius: enter the zone width (shortest)
>>>
>>> - Angle: enter the orientation angle

- **Threshold:** is the distance from the CAD surface (+/-). Readings outside this value will be ignored for the vector point calculation.

- **Ignore Range:** is used only with tactile measurement.

Extraction

Project to nominal vector: This option will project the calculated extracted point to the nominal vector in order to report deviation in the surface normal direction (dN). (default)

NOTE: If you manually extract an actual vector point (as opposed to automatic extraction using a nominal), this option is deselected by default and reported deviation is X,Y,Z and dN when associated to a nominal Vector Point.

Solver Method:

- Standard: calculates the mean point in vectorial direction.

- Maximum: calculates the highest point in vectorial direction.

- Minimum: calculates the lowest point in vectorial direction.

- Click **Create** to create the vector point.

⊙0.0 Circle

Requires: an XYZ coordinate, a vector, and a diameter.

- **Name:** Type in a name for the constructed circle.

- **Circle:** Type in the XYZ values. Typing values in different units and coordinate systems[1]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

- **Normal:** Type in the IJK values. Typing values in different units and coordinate systems[1]

- **Diameter:** Type in the diameter value. Typing values in different units[2]

- Click **Create** to create the circle.

The constructed circle is located at the entered values in the current coordinate system.

Sphere

Requires: a diameter and X, Y, and Z values.

- **Name:** Type in a name for the constructed sphere.

- **Center:** Type in the XYZ values. Typing values in different units and coordinate systems[3]

- **Diameter:** Type in the diameter value. Typing values in different units[4]

- Click **Create** to create the sphere.

Cylinder

Requires: a diameter, and two center points, or a vector and a length.

- **Name:** Type in a name for the constructed cylinder.

- **Point on Axis:** Select a radio button:

  - **Point 2 on Axis:** Type in the XYZ values. Typing values in different units and coordinate systems[5]

    OR

  - **Axis Vector:** Type in the IJK values. Typing values in different units and coordinate systems[6]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters.
To change the coordinate system, click the arrow on the right side of the dialog box and select
from the menu. CAM2 automatically converts the values to the current coordinate system during
the feature construction.
[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.
[3]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.
[4]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.
[5]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.
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- **Length:** Type in the length value. Typing values in different units[1]

- **Diameter:** Type in the diameter value. Typing values in different units[2]

- Click **Create** to create the cylinder.

Torus

Requires: a center point, direction number of the torus axis, major diameter, minor diameter, start vector, and sweep angle.

- **Name:** Type in a name for the constructed torus.

- **Center Point**: Type in the XYZ values. Typing values in different units and coordinate systems[3]

- **Point on Axis:** Select a radio button:

  - **Point on Axis:** Type in the XYZ values. Typing values in different units and coordinate systems[4]

    OR

  - **Axis (Normal):** Type in the IJK values. Typing values in different units and coordinate systems[5]

- **Major Diameter**: Type in the outermost or largest diameter of the torus.

- **Minor Diameter**: Type in the innermost or smallest diameter of the torus.

- **Start Vector**: Type in the IJK values. Typing values in different units and coordinate systems[6]

- **Sweep Angle**: Type in the size of the segment to construct. Full sweep angle (360°) constructs the whole torus.

- Click **Create** to create the torus.

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[3]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[4]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

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Tube

Requires: a diameter, PTB or XYZ, and bend radius.

NOTE: PTB is sometimes labeled as yBC.

- **Tube Diameter**: Type in the diameter of the tube.

- **Default Bend Radius**: Type in the default value for the tube's bend radius. This value will automatically populate the Bend Radius field as you input PTB or XYZ data.

- **Key-in Tube Data As:** Select a radio button:

  - **PTB:** Type in the Pull, Turn, Bend, and Bend Radius values. Typing values in different units and coordinate systems[1]

  OR

  - **XYZ:** Type in the Breakpoints and Bend Radius values. Typing values in different units and coordinate systems[2]

- Click **Create** to create the tube.

Cone

Requires: see the options below.

- **Name:** Type in a name for the constructed cone.

There are five different methods for this construction. Select from the **Construct Cone by** drop-down:

  - **Apex:** Type in the XYZ values. Typing values in different units and coordinate systems[3]

  - **Axis Direction:** Type in the IJK values. Typing values in different units and coordinate systems[4]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

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- **Distance to Apex:** Type in a distance value.

- **Angle:** Type in the angle value. Typing values in different units[1]

- **Half Angle:** Clear this check box if you are entering the full angle of the cone.

- Click **Create** to create the cone.

The constructed cone is located at the entered values in the selected coordinate system.

Apex, Axis Position and Angle

- **Apex:** Type in the XYZ values. Typing values in different units and coordinate systems[2]

- **Axis Position:** Type in the XYZ values. Typing values in different units and coordinate systems[3]

- **Angle:** Type in the angle value. Typing values in different units[4]

- **Half Angle:** Clear this check box if you are entering the full angle of the cone.

- Click **Create** to create the cone.

The constructed cone is located at the entered values in the selected coordinate system.

Axis, Point on Axis, Diameter at Point and Angle

- **Axis Direction:** Type in the IJK values. Typing values in different units and coordinate systems[5]

- **Point on Axis:** Type in the XYZ values. Typing values in different units and coordinate systems[6]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

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- **Diameter at Point:** Type in a diameter value. Typing values in different units[1]

- **Angle:** Type in the angle value. Typing values in different units[2]

- **Half Angle:** Clear this check box if you are entering the full angle of the cone.

- Click **Create** to create the cone.

The constructed cone is located at the entered values in the selected coordinate system.

Axis, Point on Axis, Distance to Apex and Diameter at Point

- **Axis Direction:** Type in the IJK values. Typing values in different units and coordinate systems[3]

- **Point on Axis:** Type in the XYZ values. Typing values in different units and coordinate systems[4]

- **Distance to Apex:** Type in a distance value. Typing values in different units[5]

- **Diameter at Point:** Type in a diameter value. Typing values in different units[6]

-
  Click **Create** to create the cone.

The constructed cone is located at the entered values in the selected coordinate system.

Axis, Axis Position, Distance from Point to Apex and Angle

- **Axis Direction:** Type in the IJK values. Typing values in different units and coordinate systems[7]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

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[6]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[7]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

- • **Axis Position:** Type in the XYZ values. Typing values in different units and coordinate systems[1]

- • **Distance from Point to Apex:** Type in a distance value. Typing values in different units[2]

- • **Angle:** Type in the angle value. Typing values in different units[3]

- • **Half Angle:** Clear this check box if you are entering the full angle of the cone.

- • Click **Create** to create the cone.

The constructed cone is located at the entered values in the selected coordinate system.

⌀0.0 Round Slot

Requires: a center point, the vector of the major and minor axes, and the length and the diameter of the round slot.

- • **Name:** Type in a name for the constructed rectangular slot.

- • **Center:** Type in the XYZ values. Typing values in different units and coordinate systems[4]

- • **Normal:** Type in the IJK values. Typing values in different units and coordinate systems[5]

- • **Axis:** Type in the IJK values. Typing values in different units and coordinate systems[6]

- • **Length:** Type in the length value. Typing values in different units[7]

- • **Diameter:** Type in the length value. Typing values in different units[8]

- • Select or clear the Length is End to End check box.

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

[2]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

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[7]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

[8]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 automatically converts the value to 254 millimeters.

• Click **Create** to create the round slot.
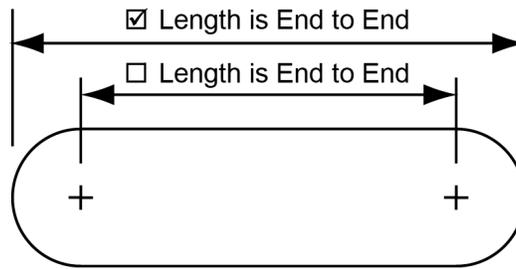
Figure 10-1 Round Slot on the previous page

•

0.0 Rectangular Slot

Requires: a center point, the vector of the major and minor axes, and the length and the width of the rectangular slot.

• **Name:** Type in a name for the constructed rectangular slot.

• **Center:** Type in the XYZ values. Typing values in different units and coordinate systems[1]

• **Normal:** Type in the IJK values. Typing values in different units and coordinate systems[2]

• **Axis:** Type in the IJK values. Typing values in different units and coordinate systems[3]

• **Length:** Type in the length value. Typing values in different units[4]

• **Width:** Type in the length value. Typing values in different units[5]

• Click **Create** to create the rectangular slot.

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

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⬭ Ellipse

Requires: a center point, the vector of the major and minor axes, and the length of the major and minor axes.

- **Name:** Type in a name for the constructed ellipse.

- **Center:** Type in the XYZ values. Typing values in different units and coordinate systems[1]

- **Normal:** Type in the IJK values. Typing values in different units and coordinate systems[2]

- **Axis:** Type in the IJK values. Typing values in different units and coordinate systems[3]

- **Major:** Type in the major length value. Typing values in different units[4]

- **Minor:** Type in the minor length value. Typing values in different units[5]

- Click **Create** to create the ellipse.

⬭ Paraboloid

Requires: an apex, the focal point of the major and minor axes, and the length and the diameter of the paraboloid.

- **Name:** Type in a name for the constructed paraboloid.

- **Apex:** Type in the XYZ values. Typing values in different units and coordinate systems[6]

- **Focal Point:** Type in the XYZ values. Typing values in different units and coordinate systems[7]

---

[1]You can type a value in any unit, and CAM2 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 automatically converts the values to the current coordinate system during the feature construction.

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- **Length:** Type in the length value. Typing values in different units[1]

- **Diameter:** Type in the length value. Typing values in different units[2]

-
  Click **Create** to create the paraboloid.

Dimensions

The **Dimensions** group contains **Dimension Angle By Key In** and **Dimension Length By Key In**. The number of digits in the dimension data is a preference. *See "Units Tab" on page 74.*

Dimension Angle By Key-In

Requires: a numeric value.

- **Name:** Type in a name for the angle dimension.

- **Angle:** Type in the value.

- Click **Create** to create the dimension.

Dimension Length By Key-In

Requires: a numeric value.

- **Name:** Type in a name for the length dimension.

- **Length:** Type in the value. Typing values in different units[3]

- Click **Create** to create the dimension.

---

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Chapter 11: Pick From CAD

The Pick from CAD commands are located in the **Pick From CAD** tab across the top of the screen.

Use these commands to create Nominal features from CAD models that you add to the measurement file. *For more information, see "CAD" on page 61.*

Layers

Use layers as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file. *For more information, see "Layers" on page 112.*

Pick Features

Click **Pick Features** to enable intelligent feature-picking mode. When enabled, you can create a nominal feature with a single click anywhere on your CAD model without first having to specify the feature type. In the case of similar features, CAM2 will provide you with options to select the nominal feature you'd like to create; for example, you can create a nominal circle, ellipse, or round slot when you click a hole on your CAD model.

NOTE: Intelligent feature-picking mode does not support Point, Vector Point, Inspect Surface Point, or Paraboloid feature types.

To exit the **Automatic** mode:

- Click the **Automatic** button in the lower right corner of the **Main** window

- Click **Automatic** again

- Click a different CAD picking command.

Point

Create a constructed point from a CAD model.

- **Name:** Type in a name for the constructed point.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed point.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[1]

Vector Point

Create a vector point from a CAD model.

- **Name:** Type in a name for the vector point.

Selection

- **Zone Type:** Choose from 3 zone types:

  - **Cylindrical** creates a circular zone.

    - Diameter: enter the zone size.

  - **Rectangular** creates a rectangular zone.

    - Length: enter the zone length (longest).

---

[1]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.

- • Width: enter the zone width (shortest).

    - • Angle: enter the orientation angle

  - • **Round Slot** creates a rounded slot zone.

    - • Length: enter the zone length (longest)

    - • Radius: enter the zone width (shortest)

    - • Angle: enter the orientation angle

- • **Threshold:** is the distance from the CAD surface (+/-). Readings outside this value will be ignored for the vector point calculation.

- • **Ignore Range:** is used only with tactile measurement.

Extraction

Project to nominal vector: This option will project the calculated extracted point to the nominal vector in order to report deviation in the surface normal direction (dN). (default)

NOTE: If you manually extract an actual vector point (as opposed to automatic extraction using a nominal), this option is deselected by default and reported deviation is X,Y,Z and dN when associated to a nominal Vector Point.

Solver Method:

- • Standard: calculates the mean point in vectorial direction.

- • Maximum: calculates the highest point in vectorial direction.

- • Minimum: calculates the lowest point in vectorial direction.

- • Click on any CAD surface to create the vector point.

Inspect Surface Point

Create an inspect surface point from a CAD model. Select the feature, or select a nominal point on a surface, surface trim line, polyline, or spline to create the feature.

NOTE: This command automatically creates an actual Inspect Surface Point feature.

- • **Name:** Type in a name for the vector point.

- • Click on any CAD surface to create the vector point.

Paraboloid

Create a constructed paraboloid from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed paraboloid.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed ellipse.

- **Points:** Select a nominal point to create the feature. *See "Select Nominal Points" on page 1.*

> **NOTE:** The vector of the paraboloid is determined by the CAD view at the time you construct the paraboloid. If necessary, use **Flip Vector** to change the vector of the constructed paraboloid. *See "Flip Vector" on page 109.*

Plane

Create a constructed plane from a CAD model. Select the feature, or select a nominal point on a surface, surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed plane.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed plane.

- **Points:** Select a nominal point to create the feature. *See "Select Nominal Points" on page 1.*

> **NOTE:** The vector of the plane is determined by the CAD view at the time you construct the plane. If necessary, use **Flip Vector** to change the vector of the constructed plane. *See "Flip Vector" on page 109.*

Line

Create a constructed line from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed line.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed line.

- **Points:** Select a nominal point to create the feature. *See "Select Nominal Points" on page 1.*

> **NOTE:** The vector of the line is determined by the CAD view at the time you construct the line. If necessary, use **Flip Vector** to change the vector of the constructed line. *See "Flip Vector" on page 109.*

Circle

Create a constructed circle from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed circle.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed circle.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[1]

> **NOTE:** The vector of the circle is determined by the CAD view at the time you construct the circle. If necessary, use **Flip Vector** to change the vector of the constructed circle. *See "Flip Vector" on page 109.*

Sphere

Create a constructed sphere from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed sphere.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed sphere.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[2]

Cylinder

Create a constructed cylinder from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed cylinder.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed cylinder.

- **Points:** Select a nominal point to create the feature.*See "Select Nominal Points" on page 1.*

> **NOTE:** The vector of the cylinder is determined by the CAD view at the time you construct the cylinder. If necessary, use **Flip Vector** to change the vector of the constructed cylinder. *See "Flip Vector" on page 109.*

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[1]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.
[2]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.

Torus

Create a constructed torus from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed torus.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed torus.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[1]

Cone

Create a constructed cone from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed cone.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed cone.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[2]

- Click **Create** to create the cone.

NOTE: The vector of the cone is determined by the CAD view at the time you construct the cone. If necessary, use **Flip Vector** to change the vector of the constructed cone. *See "Flip Vector" on page 109.*

Round Slot

Create a constructed round slot from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed round slot.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed round slot.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[3]

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[1]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.
[2]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.
[3]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.

NOTE: The vector of the slot is determined by the CAD view at the time you construct the slot. If necessary, use **Flip Vector** to change the vector of the constructed slot. *See "Flip Vector" on page 109.*

Rectangular Slot

Create a constructed rectangular slot from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed rectangular slot.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed rectangular slot.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[1]

NOTE: The vector of the slot is determined by the CAD view at the time you
construct the slot. If necessary, use **Flip Vector** to change the vector of the constructed slot. *See "Flip Vector" on page 109.*

Ellipse

Create a constructed ellipse from a CAD model. Select the feature, or select a nominal point on a surface trim line, polyline, or spline to create the feature.

- **Name:** Type in a name for the constructed ellipse.

- **Add Statistics:** Check this box to add geometric statistics (tolerancing information) to the constructed ellipse.

- **Points:** Select a nominal point to create the feature. Select Nominal Points[2]

NOTE: The vector of the ellipse is determined by the CAD view at the time you
construct the ellipse. If necessary, use **Flip Vector** to change the vector of the constructed ellipse. *See "Flip Vector" on page 109.*

---

[1]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.

[2]When choosing points from a CAD model, click any part of the surface, individual points, surface trim lines, polylines, or splines. When picking a line, you use the point at which the mouse pointer intersects the line.

Chapter 12: Construct

The Construct commands are located in the **Construct** tab across the top of the screen. The **Construct** tab contains eleven feature commands, including seven that "flyout" to additional Construction commands. The commands on the **Construct** tab are organized into Features, Dimensions, Patterns, and Construct From Selected Features groups.

Layers

Use layers as a way to group and organize features. You can show and hide layers to help simplify your CAD view. Changes made to layers are saved along with the CAM2 measurement file. *For more information, see "Layers" on page 112.*

About Constructions

You can use Constructed features in other constructions, dimensions, coordinate systems, or measurements.

Automatic Constructions

CAM2 automatically creates a construction when you create a construction feature using nominal features and then create and measure measured features associated to the individual nominal features. *See Pick From CAD on page 217 and Key-In on page 203*.

For Example:
- Add nominals to your measurement file, four circles in a bolt pattern.
- Construct a circle by best fit using those four circles. This is a nominal constructed circle.
- Add Measurements to the four nominal circles.
- Add Readings to each of the four measured circles.
- A Constructed feature, by best fit, using the four measured circles automatically adds to the measurement file and associates to the nominal constructed circle.

Expand Geometry

CAM2 also extracts non-center points from lines, cylinders, round slots, and rectangular slots for use in constructions. Right-click a feature and select **Expand Geometry** to instantly add the following points to your measurement file:

- **Line**: Start, End, Midpoint.
- **Cylinder**: Base, Top, Midpoint.
- **Round Slot**: Center 1, Center 2.
- **Rectangular Slot**: First Corner, Second Corner, Third Corner, Fourth Corner.

Using Actual and Nominal Features

If you select a combination of Actual (measured and constructed) and Nominal features in any **Construct** command, a drop-down arrow adds to **Create** in the dialog box. Select **Create as Nominal** or **Create as Actual** from the drop-down list.

> **CAUTION:** Although at times it may be necessary to mix nominal, measured, and constructed features when creating constructions, do it rarely and with caution because mixing types of features to create a construction might cause inaccuracies in your measurement data.

Features

The **Features** group contains all the commands necessary to construct 2D and 3D features.

Construct Plane

A plane is constructed from point-reducible features, entered values, the intersection of features, or a CAD model.

Construct Plane: By 3 Points and 3 Offsets

Requires: three points and three offset distances.

- **Name:** Type in a name for the constructed plane.

- **Points:** Select a Point.[1]

- **Offsets:** Enter positive
  or negative offset distances. Typing values in different units and coordinate systems.[2]

- Click **Create** to create the plane.

The plane is constructed so the perpendicular distance from the plane to the selected points, using the offset values. The direction of the offset is determined by the selected points, and follows the Right-Hand Rule. *See "Right-Hand Rule" on page 330.*

NOTE: A plane can be constructed above or below the three points, which is why the order that the points are selected determines which plane is created.
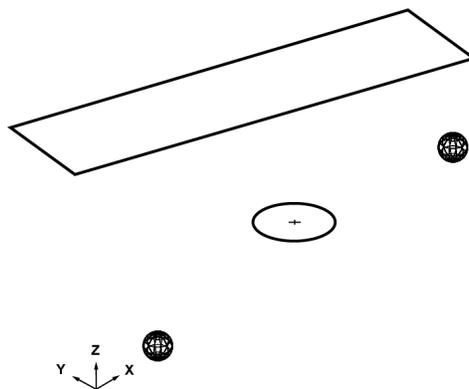
Figure 12-1 Construct Plane: By 3 Points and 3 Offsets

Construct Plane: By Best Fit

Requires: three point-reducible features.

- **Name:** Type in a name for the constructed plane.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

- **Points:** Select from the List.[1]

  - After you add the
    minimum number of features a preview feature draws in the **Main Window** and the dialog box displays
    preview feature data.

- Click **Create** to create the line.

The selected features are constructed into a Best Fit Plane. *See "Best Fit Plane" on page 328.* Use the
Measurement Data panel to see the point data of the feature. *For more information, see "Measurement Data" on
page 192.*

Construct Plane: By Bisection

Requires: two planes.

- **Name:** Type in a name for the constructed plane.

- **Planes:** Select a Plane.[2]

- Click **Create** to create
  the line.

  - If the two planes are not parallel, another plane is constructed equidistantly from both planes.

  - If the two planes are parallel, another plane is constructed midway between the two planes, with the same
    vector as the first plane.
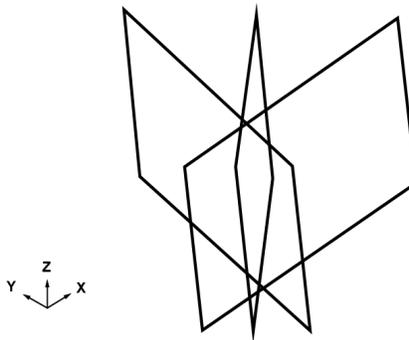
Figure 12-1 Construct Plane: By Bisection

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[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse
button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the
sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-
consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left
Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of
the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list
box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in
the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

NOTE: There are two possible solutions that are determined by the vector of the selected planes. *For more information, see "Flip Vector" on page 109.*

Construct Plane: By Offset

Requires: a plane and an offset value, a point and an offset distance, or a vector and an offset value.

- **Name:** Type in a name for the constructed plane.

- **Plane:** Select a Plane.[1]

- **Offset:** Select a radio button:

  - **Absolute Offset:** Enter a positive or negative offset distance. Typing values in different units.[2]

                                        OR

  - **Point:** Select a Point.[3]

  - **Offset:** Enter a positive or negative offset distance. Typing values in different units.[4]

                          OR

  - **Along Normal:** Select a Plane.[5]

  - **Offset:** Enter a positive or negative offset distance. Typing values in different units.[6]

- Click **Create** to create the line.

To construct a parallel plane, select the plane as a vector and type in an offset value.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.
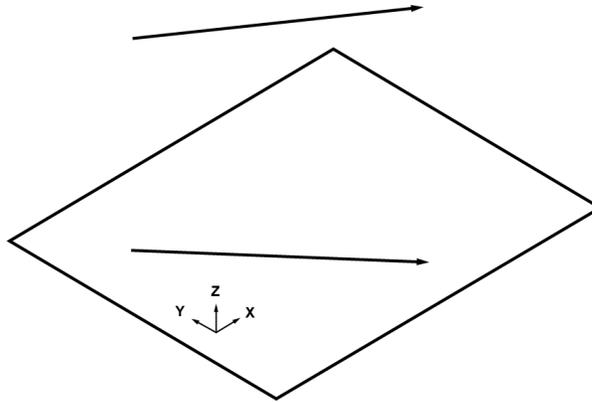
[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[4]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[5]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[6]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

Figure 12-1 Construct Plane: By Offset

Construct Plane: Perpendicular

Requires: a line (two points) and a point.

- **Name:** Type in a name for the constructed plane.

- **Line:** Select a radio button:

    - **Line:** Select a Line.[1]

        OR

    - **Points:** Select a Point.[2]

- **Point:** Select a Point.[3]

The plane is constructed
perpendicular to the line and through the point. The normal vector of the constructed plane is the same as the vector of the selected line.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.
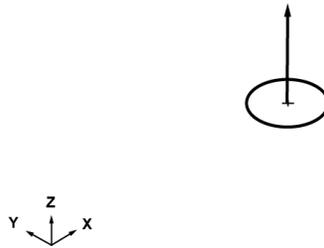
Figure 12-1 Construct Plane: Perpendicular

Construct Line

A line is constructed from point-reducible features, entered values, the intersection of features, or a CAD model.

Construct Line: By Best Fit

Requires: point-reducible or line-reducible features for a 3D line, and point-reducible or line-reducible features *and* a plane for a 2D line.

- **Name:** Type in a name for the constructed line.

- **Points/Lines:** Select from the List.[1]

- **Plane:** Select a Plane.[2] Or clear the **U se Plane** check box.

  - After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the line.

If the **Use Plane** check box is selected, the features are projected to the plane before constructed into a Best Fit Line. *See "Best Fit Line" on page 327.* Otherwise, the features are fit to a plane. Use the **Measurement Data** panel to see the point data of the feature. *For more information, see "Measurement Data" on page 192.*

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

Construct Line: By Axis Best Fit

Use this command to determine best-fit centerlines for shafts or gears containing different-sized cylinders.

Requires: line-reducible features for a 3D line, and line-reducible features *and* a plane for a 2D line.

- **Name:** Type in a name for the constructed line.

- **Lines:** Select from the List.[1]

- **Plane:** Select a Plane.[2] Or
  clear the **Use Plane** check box.

  - After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the line.

If the **Use Plane** check box is selected, the features are projected to the plane before constructed into a Best Fit Line. *See "Best Fit Line" on page 327.* Otherwise, the features are fit to a plane. Use the **Measurement Data** panel to see the point data of the feature. *For more information, see "Measurement Data" on page 192.*

Construct Line: By Bisection

Requires: a line and another line.

- **Name:** Type in a name for the constructed line.

- **Lines:** Select a Line.[3]

- Click **Create** to create
  the line.

  - If the two lines are not parallel, another line is constructed equidistantly from both lines.

  - If the two lines are parallel, another line is constructed midway between the two lines, with the same vector as the first line.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

Figure 12-1 Construct Line: By Bisection

NOTE: There are two possible solutions that are determined by the vector of the selected lines. *For more information, see "Flip Vector" on page 109.*

Construct Line: By Intersection of 2 Planes

Requires: two planes.

- **Name:** Type in a name for the constructed line.

- **Planes:** Select a Plane.[1]

- Click **Create** to create
  the line.

The line is constructed from the intersection of the two selected planes. The length of the line is determined by the extent of the first plane selected for the construction
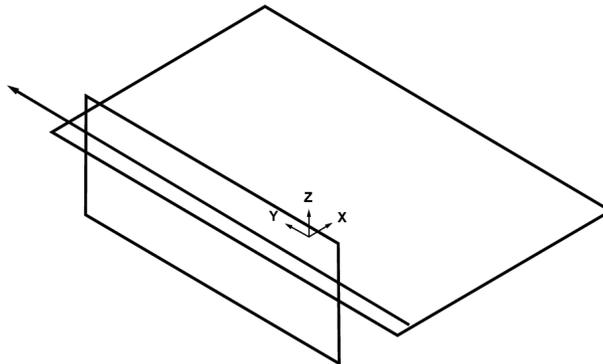
Figure 12-1 Construct Line: By Intersection of 2 Planes

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

Construct Line: By Offset

Requires: a plane, two points, and/or two offsets.

- **Name:** Type in a name for the constructed line.

- **Plane:** Select a Plane.[1]

- **Offset:** Select a radio
button:

  - **Line:** Select a Line.[2]

  - **Offsets:** Enter a
  positive or negative offset distance. Typing values in different units.[3]

                    OR

  - **Points:** Select a Point.[4]

  - **Offsets:** Enter positive
  or negative offset distances. Typing values in different units.[5]

- Click **Create** to create the line.

The line is constructed by the order of the selected points and follows the . This command is often used to construct a coordinate axis from two points at a known distance from that axis.

NOTE: There are two possible solutions that are determined by the order you select the points.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[3]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[5]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

Figure 12-1 Construct Line: By Offset

Construct Line: By Projection

Requires: a plane and a line (two points).

- **Name:** Type in a name for the constructed line.

- **Line:** Select a radio button:

    - **Line:** Select a Line.[1]

          OR

    - **Points:** Select a Point.[2]

- **Plane:** Select a Plane.[3]

- Click **Create** to create
  the line.

The line is constructed from the projection of the selected line to the selected plane.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

Figure 12-1 Construct Line: By Projection

Construct Line: Parallel

Requires: a line (or two points) and another point and/or an offset, or a distance in an existing plane.

- **Name:** Type in a name for the constructed line.

- **Source Line:** Select a radio button:

    - **Line:** Select a Line.[1]

         OR

    - **Points:** Select a Point.[2]

- **New Line:** Select a radio button:

    - **Point:** Select a Point.[3]

         OR

    - **Offset:** Type in the XYZ values. Typing values in different units and coordinate systems.[4]

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[4]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

<div align="center">OR</div>

- **Plane:** Select a Plane.[1]

- **Offset:** Type in the
  XYZ values. Typing values in different units and coordinate systems.[2]

- Click **Create** to create the line.

The line is constructed parallel to the selected line and through the point, or parallel to the selected line in the selected plane.
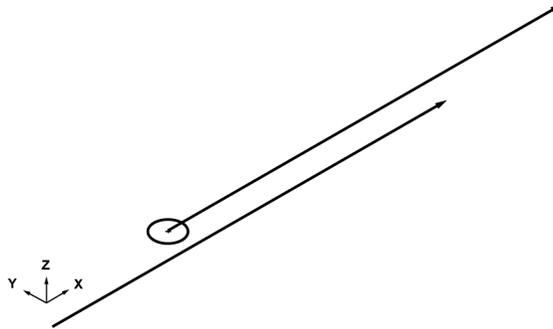
Figure 12-1 Construct Line: Parallel

Construct Line: Perpendicular

Requires: a plane and a point.

- **Name:** Type in a name for the constructed line.

- **Plane:** Select a Plane.[3]

- **Point:** Select a Point.[4]

- Click **Create** to create
  the line.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.
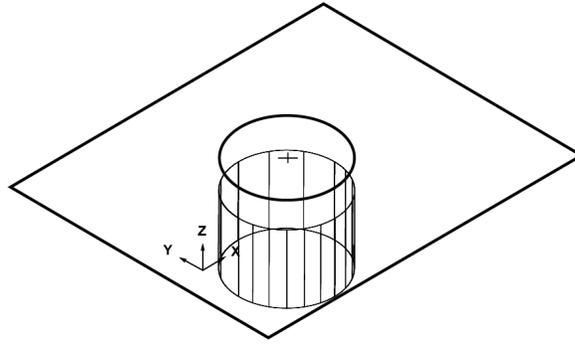
[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

The line is constructed perpendicular to the selected plane and through the point, or perpendicular to the selected line and through the point.

Figure 12-1 Construct Line: Perpendicular

Construct Point

A point is constructed from point-reducible features, entered values, the intersection of features, or a CAD model.

Construct Point: By Best Fit

Requires: point-reducible features.

- **Name:** Type in a name for the constructed point.

- **Points:** Select from the List.[1]

    - After you add the
      minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the point.

The selected features are constructed into a Best Fit Point. *See "Best Fit Point" on page 328.* Use the **Measurement Data** panel to see the point data of the feature. *For more information, see "Measurement Data" on page 192.*

Construct Point: By Midpoint

Requires: two features.

- **Name:** Type in a name for the constructed point.

- **Features:** Select a Feature.[2]

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- Click **Create** to create the point.

- The point is constructed between the two selected points, or the Midpoint.
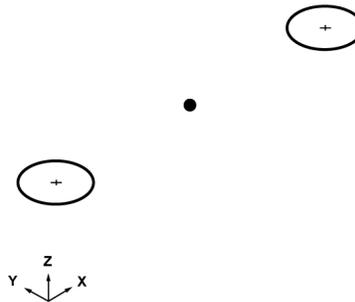
Figure 12-1 Construct Point: By Midpoint

Construct Point: By Intersection

Requires: two features or three planes.

- **Name:** Type in a name for the constructed point.

- **Point:** Select a radio button:

  - **Features:** Select a Feature.[1]

      OR

  - **Planes:** Select a Plane.[2]

- Click **Create** to create the
  point.

Two Feature Examples

The point is constructed at the intersection of two lines.

---

[1] When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2] When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

Figure 12-1 Construct Point: Two Lines

NOTE: If the two lines do not intersect, a point is created at the midpoint of the segment and is defined by the shortest distance between the lines.

The point is constructed at the intersection of the two circles.
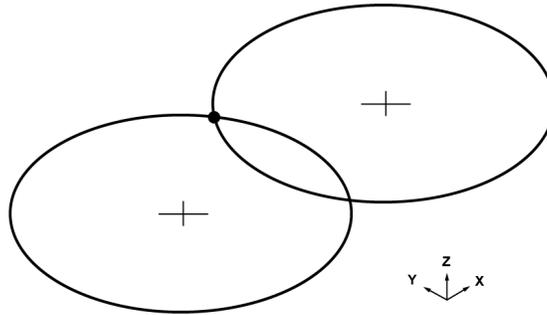
Figure 12-2 Construct Point: Two Circles

NOTE: There are two possible solutions for this point based on the order in which the circles are selected. The constructed point is determined by the Right-Hand Rule. *See "Right-Hand Rule" on page 330.*

The point is constructed at the intersection of the line and a plane.
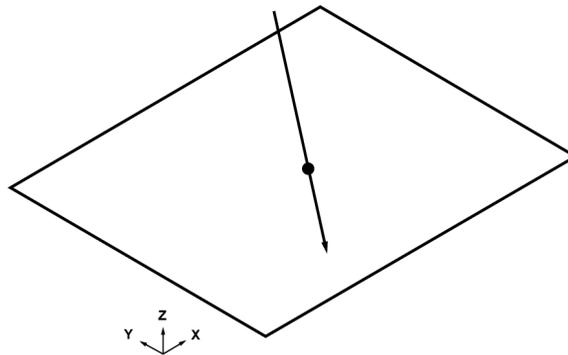
Figure 12-3 Construct Point: Line and Plane

• *Line and Circle:* the line is projected to the plane of the circle and the point is constructed where the line exits the circle.

• *Line and Cylinder:* where the line exits the cylinder.

• *Line and Sphere:* where the line exits the sphere.

NOTE: Since the point is constructed at the exit point (second intersection) the vector direction of the line is important. *For more information, see "Flip Vector" on page 109.*

Three Planes Example

The point is constructed at the intersection of three planes.
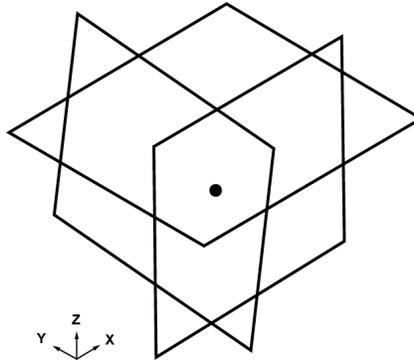
Figure 12-4 Construct Point: Three Planes

○
● Construct Point: By Offset

Requires: a point and a 3D offset distances.

- **Name:** Type in a name for the constructed point.

- **Point:** Select a Point.[1]

- **Offset:** Select a radio
  button:

  - **Absolute Offset:** Enter a positive or negative offset distance. Typing values in different units.[2]

                          OR

  - **Along Line:** Select a Line.[3]

  - **Distance:** Enter positive or
    negative offset distances. Typing values in different units.[4]

                          OR

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[4]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

- **Along Normal:** Select a Plane.[1]

- **Offset:** Enter positive or negative
  offset distances. Typing values in different units.[2]

- Click **Create** to create the point.

The point is constructed offset from the selected point.

Figure 12-1 Construct Point: By Offset

Construct Point: By Projection

Requires: a point and a feature.

- **Name:** Type in a name for the constructed point.

- **Point:** Select a Point.[3]

- **Feature:** Select a
  Feature.[4]

-

   Click **Create** to create the point.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

Point Projection Examples

The point is constructed from the projection of the selected point to the selected line.
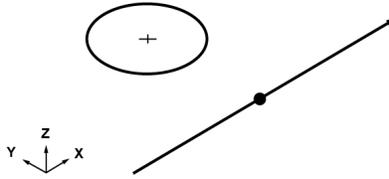
Figure 12-1 Construct Point: Point Project to a Line

The point is constructed from the projection of the selected point to the selected plane, or surface. If you select the X, Y, or Z axis you may also select any coordinate system to guide the projection.
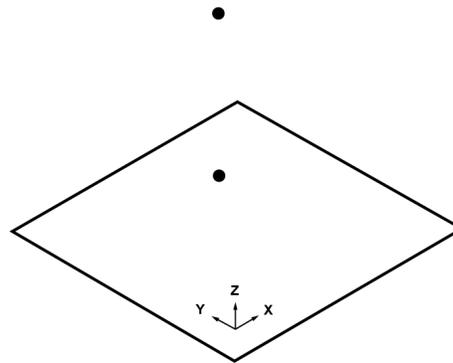
Figure 12-2 Construct Point: Point Project to a Plane/Surface

Construct Circle

A circle is constructed from point-reducible features, the intersection of features, entered values, or a CAD model.

Circle Vectors

Some **Construct** > **Circle** commands have an option to select the vector direction of the constructed circle. This vector direction is for the finished constructed circle - *not* the direction of the construction.

Construct Circle: By Best Fit

Requires: a plane and a minimum of three point-reducible features.

- **Name:** Type in a name for the constructed circle.

- **Points:** Select from the List.[1]

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

- **Plane:** Select a Plane.[1] Or clear the **Use Plane** check box.

  - After you add the
    minimum number of features a preview feature draws in the **Main Window** and the dialog box displays
    preview feature data.

- Click **Create** to create the dimension.

If the **Use Plane** check box is selected, the features are projected to the plane before constructed into a Best Fit
Circle. *See "Best Fit Circle" on page 325.*. Otherwise, the features are fit to a plane. Use the **Measurement Data**
panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Circle: By Intersection of a Plane and a Feature

Requires: a plane and a sphere, a plane and a cone, or a plane and a cylinder.

NOTE: This constructs a best fit circle at the intersection of the plane and the feature. It *does not* create an
ellipse. *See "Construct Ellipse: By Intersection" on page 253.*

- **Name:** Type in a name for the constructed circle.

- **Plane:** Select a Plane.[2]

- **Sphere, Cone,
  Cylinder:** Select a Feature.[3]

- **Lock Plane of Circle:** The
  intersection points can project to one of two planes. Select a radio button:

  - In Plane of Feature 1

  - Perpendicular to Feature 2

- Click **Create** to create the dimension.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of
the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list
box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in
the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.
[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of
the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list
box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in
the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.
[3]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left
Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the
From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Win-
dow. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

Figure 12-1 Construct Circle: Plane Intersect

⃝ Construct Circle: By Offset

Requires: a circle and a 3D offset.

- **Name:** Type in a name for the constructed circle.

- **Circle:** Select a Feature.[1]

- **Offset:** Select a radio button:

  - **Absolute Offset:** Type in positive or negative X, Y, and Z offset distances. Typing values in different units and coordinate systems.[2]

  - **Offset Along a Line:** Select a Line.[3] Type in an offset distance. Typing values in different units and coordinate systems.[4]

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[4]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

- • **Offset Along a Normal:** Select a Plane.[1] Type in an offset distance. Typing values in different units and c

    oordinate systems.[2]

- • **Flip**

    Vector: Reverse the vector of the constructed circle by selecting this check box. *See "Circle Vectors" on page 243.*

- • **New Diameter:** Change the diameter of the constructed circle by selecting this check box and typing in the diameter value. Typing values in different units and coordinate systems.[3]

Construct Circle: By Coaxial Intersection

Requires: two intersecting coaxial cones, or the intersection of a coaxial cone and cylinder.

NOTE: Features must be located and orientated relative to each other so that their surfaces of revolution intersect.

- • **Features:** Select a Feature.[4]

- • **Angle Tolerance:** Type in
    the angle to determine co-linearity (maximum 5°).

- • Click **Create** to create the circle.

Construct Circle: From Cone

Requires: a cone, and a distance, diameter, or feature.

- • **Name:** Type in a name for the constructed circle.

- • **Cone:** Select a Feature.[5]

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[3]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[5]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- **Distance:** Type in a positive or negative distance. The distance you enter is measured from the apex of the cone. The diameter of the circle is determined by the diameter of the cone at the constructed center point of the circle. Typing values in different units.[1]

- **Diameter:** Type in a diameter. The
circle is constructed at the position within the cone. Typing values in different units.[2]

- **Feature:** Select a Feature.[3] The selected features diameter is used, and the circle is
c
onstructed at the position within the cone.

- Click **Create** to create the cone.

Construct Sphere

A sphere is constructed from point-reducible features, entered values, or a CAD model.

Construct Sphere: By Best Fit

Requires: five point-reducible features.

- **Name:** Type in a name for the constructed sphere.

- **Points:** Select from the List.[4]

  - After you add the
    minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the sphere.

The selected features are constructed into a Best Fit Sphere.*See "Best Fit Sphere" on page 329.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Sphere: By Offset

Requires: a sphere, two points, and/or two offsets.

---

[1]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.
[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.
[3]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.
[4]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

- **Name:** Type in a name for the constructed sphere.

- **Feature:** Select a Feature.[1]

- **Offset:** Select a radio button:

  - **Absolute Offset:** Enter a positive or negative offset distance. Typing values in different units.[2]

  OR

  - **Along Line:** Select a Line.[3]

  - **Distance:** Enter positive or
    negative offset distances. Typing values in different units.[4]

    OR

  - **Along Normal:** Select a Plane.[5]

  - **Offset:** Enter positive or negative
    offset distances. Typing values in different units.[6]

- **New Diameter:** Change the diameter of the
  constructed circle by selecting this check box and typing in the diameter value.

- Click **Create** to create the sphere. Typing values in different units.[7]

Construct Cylinder

A cylinder is constructed from point-reducible features, entered values, or a CAD model.

Construct Cylinder: By Best Fit

Requires: a minimum of three point-reducible features.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[4]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[5]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[6]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

[7]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

- **Name:** Type in a name for the constructed cylinder.

- **Points:** Select from the List.[1]

  - After you add the
    minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the cylinder.

The selected features are constructed into a Best Fit Cylinder. *See "Best Fit Cylinder" on page 326.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Cylinder: From Circles

Requires: a minimum of two circles.

- **Name:** Type in a name for the constructed cylinder.

- **Select Entities To Fit Through:** Select from the List.[2]

  - After you add the minimum number of circles, a
    preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the cylinder.

  - CAM2 computes the cylinder axis fitting a line through all circle centers.

  - The diameter of the cylinder will compute as an average of the diameters of all circles used in the construction, OR will be overridden by a keyed-in diameter value.

The selected circles are constructed into a Best Fit Cylinder. *See "Best Fit Cylinder" on page 326.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

NOTE: For best results, use circles that are approximately co-linear with normal vectors in the same approximate direction as the axis of the resulting cylinder.

Construct Torus

A torus is constructed from existing features.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

Construct Torus: By Best Fit

Requires: a minimum of nine point-reducible features.

- **Name:** Type in a name for the constructed torus.

- **Points:** Select from the List.[1]

  - After you add the
    minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the torus.

The selected features are constructed into a Best Fit Torus. *See "Best Fit Torus" on page 330.* Use the **Measurement Data** panel to see the point data of the feature. *For more information, see "Measurement Data" on page 192.*

Construct Tube

A tube is constructed from existing measured or nominal features.

Construct Tube: From Features

Requires: two planes, two or more cylinders, a tube diameter and a tube bend radius.

- **Name:** Type in a name for the constructed tube.

- **Override Diameter**: Check the box and enter a value, or automatically use the average diameter from the features.

- **Start Plane**: Select a Plane.[2] This is END-B.

- **End Plane**: Select a Plane.[3]
  T
  his is END-A.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

NOTE: Both Start Plane and End Plane have modifiers to fine-tune tube length. High Point uses the highest reading of the plane to maximize tube length, Low Point uses the lowest reading of the plane to minimize tube length, and None ignores these modifiers.

- **Default Bend Radius**: Enter the Bend Radius of the tube.

- **Tube Joints**: Select a Feature.[1] Select each feature and then click **Enter** to add more features. Select the c

  ylinders in order from start to end.

- Click **Create** to create the tube.

Breakpoints

Breakpoints are constructed points and are the intersection of features along the tube:

- END-B and the first straight segment.

- First and second segment, second and third, third and fourth, etc.
    - A radius constructs at the intersection point using the bend radius value.

- END-A and the last straight segment.

A polyline constructs from through all of the breakpoints from END-B to END-A.

Construction

A round tube constructs along this polyline from start to end using the diameter value.

Construct Cone

A cone is constructed from point-reducible features, entered values, or a CAD model.

Construct Cone: By Best Fit

Requires: a minimum of six point-reducible features.

- **Name:** Type in a name for the constructed cone.

- **Points:** Select from the List.[2]

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

- After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the dimension.

The selected features are constructed into a Best Fit Cone. *See "Best Fit Cone" on page 326.* Use the **Measurement Data** panel to see the point data of the feature. *For more information, see "Measurement Data" on page 192.*

Construct Slot

Rectangular and round slots are constructed from existing features or a CAD model.

Construct Rectangular Slot: By Best Fit

Requires: six point-reducible features.

- **Name:** Type in a name for the constructed rectangular slot.

- **Points:** Select from the List.[1]

  - After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- Click **Create** to create the rectangular slot.

The selected features are constructed into a Best Fit Rectangular Slot.*See "Best Fit Rectangular Slot" on page 329.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Round Slot: By Best Fit

Requires: six point-reducible features.

- **Name:** Type in a name for the constructed round slot.

- **Points:** Select from the List.[2]

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

- • After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- • Click **Create** to create the round slot.

The selected features are constructed into a Best Fit Round Slot.*See "Best Fit Round Slot" on page 329.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Ellipse

An ellipse is created from point-reducible features, entered values, or a CAD model.

Construct Ellipse: By Best Fit

Requires: a minimum of three point-reducible features.

- • **Name:** Type in a name for the constructed ellipse.

- • **Points:** Select from the List.[1]

  - • After you add the minimum number of features a preview feature draws in the **Main Window** and the dialog box displays preview feature data.

- • Click **Create** to create the ellipse.

The selected features are constructed into a Best Fit Ellipse. *See "Best Fit Ellipse" on page 327.* Use the **Measurement Data** panel to see the point data of the feature.*For more information, see "Measurement Data" on page 192.*

Construct Ellipse: By Intersection

Requires: a cylinder and a plane.

- • **Name:** Type in a name for the constructed ellipse.

- • **Cylinder:** Select a Feature.[2]

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- **Plane:** Select a Plane.[1]

- Click **Create** to create
  the ellipse.
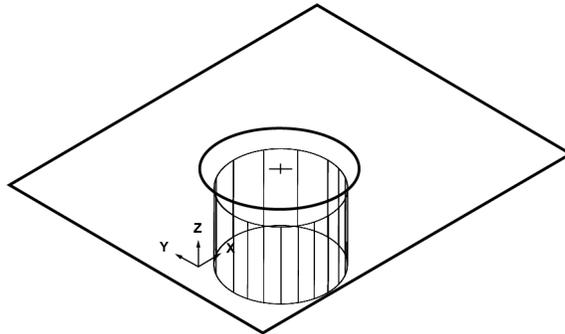
Figure 12-1 Construct Ellipse: By Intersect

Construct Cross-Section Scan

A cross section scan is created from an existing point cloud feature.

NOTE: If you are using the Probing Version of CAM2, this command is not available. *See "Probing Version" on page 9.*

Construct: Cross-Section Scan

Requires: a point cloud and a cross-section plane.

- **Name:** Type in a name for the constructed cross-section scan.

- **Comments:** Type in additional information for the constructed cross-section scan.

- **Show Comments In Label:** Append comments to the constructed cross-section scan's label.

Construction

- **Point Cloud To Draw Cross-Section:** Select from the List.[2]

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse but-
ton in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.
[2]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

Cutting Plane

- **Plane**: Select a Plane.[1]

- **Offset**: Specify the plane's base distance.

- **Cross-Section from Screen**: Check this box, then create a line for the cross-section's base plane. From the **Main Window**, pick two points, or click and drag to create a line defining the base plane.

Create Multiple

- **Space Between Cross-Sections**: Specify a distance between individual cross-sections when you construct multiple cross sections simultaneously.

- **Number of Cross-Sections** or **End Feature**: Specify the number of cross-sections to be created, or define an end feature that will control the total number of cross-sections.

Representative Points

- **Point Distance Filter**: Specify a distance from CAD to exclude point data. CAM2 will filter all points further from CAD than this value.

- **Even Distribution**: Specify a spacing threshold to distribute points evenly.

Advanced

- **Automatically Create Nominal**: Automatically create an associated nominal when you create the cross-section scan.

- **Tolerance Bandwidth**: Specify a tolerance band around the plane to determine an acceptance threshold for candidate points.

- Click **Create** to create the cross-section scan. If the points are connected, the result is a single polyline.

Deviation Markers

Deviation markers show deviation of the measured part relative to CAD at any position on the CAD model. They remain associated with the CAD model after you clear or delete an associated point cloud, and they will continue to show deviation when you record new point cloud data. *For more information, see "Deviation Markers" on page 120.*

Construct Polyline From Points

A polyline is created from existing surface points. This allows you to measure and report individual points, and also to create a surface profile report from multiple points in a polyline.

Construct: Polyline From Points

Requires: a minimum of two surface points.

- **Name:** Type in a name for the constructed polyline.

[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon

that appears. This selects the drop-

down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

- **Select Entities To Fit Through:** Select from the List.[1]

- Click **Create** to create the polyline.

Split Point Cloud

Use the **Split Point Cloud** command to create individual point cloud features from a larger point cloud feature.

By CAD Surfaces

Requires: a point cloud and a nominal CAD part. The point cloud must be aligned to the CAD part. *For more information, see "Alignments" on page 265.*

NOTE: All CAD surfaces must be assigned to the default layer. This command is not available if any new layers exist. *For more information, see "Layers" on page 112.*

- Individual point cloud features are automatically created from the point cloud and the boundary of each nominal CAD surface.

By Layers

Requires: a point cloud and a nominal CAD part. The point cloud must be alignment to the CAD part. *For more information, see "Alignments" on page 265.*

NOTE: The CAD surfaces must be assigned to new Layers. Surfaces on the default layer are ignored. *For more information, see "Layers" on page 112.*

- Individual point cloud features are automatically created from the point cloud and the boundary of all nominal CAD surface on each layer.

Expand Geometry

Use the **Expand Geometry** command to create individual point features using the geometry of any:

- **Line** - Constructs the **1** start, **2** mid, and **3** end points.
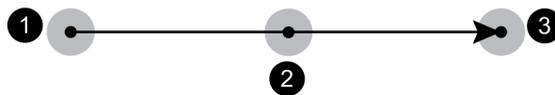
- **Cylinder** - Constructs the **1** base, **2** mid, and **3** top points.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

- **Round Slot** - Constructs two center points.

- **Rectangular Slot** - Constructs all four corner points.
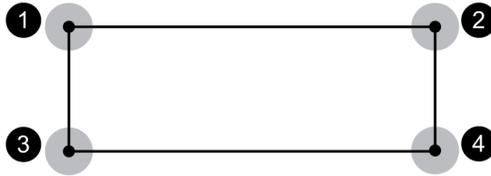
Dimensions

The **Construct** tab across the top of the screen contains **Angle From Features** and **Length From Features**. Dimensions appear on the screen with the dimension data. The number of digits in the dimension data is a preference. *For more information, see "Units Tab" on page 74.*

Automatic Dimension

CAM2 automatically creates a dimension when you create a dimension feature using nominal features and then create and measure measured features associated to the individual nominal features. *See Pick From CAD on page 217 and Key-In on page 203.*

For Example:
- Add nominals to your measurement file, two circles.
- Add a length dimension between those two circles. This is a nominal dimension.
- Add Measurements to the two nominal circles.
- Add Readings to each of the two measured circles.
- A Dimension feature, length: from features, using the two measured circles automatically adds to the measurement file and associates to the nominal dimension.

Angle

Angle commands calculate the angular difference between two features.

 Angle From Features

Requires: two features or three points.

- **Name:** Type in a name for the angle dimension. Select the **Two Features** or **Three Points** radio button.

- **Features:** Select a Feature.[1]

    OR

- **Points:** Select a Point.[2]

- Click **Create** to create
  the dimension.

Two Features Example

The angle dimension is the angle between the two lines.

NOTE: If the lines do not intersect, the calculated angle is the projection of the first line to the second line.

90° 0' 16.06"
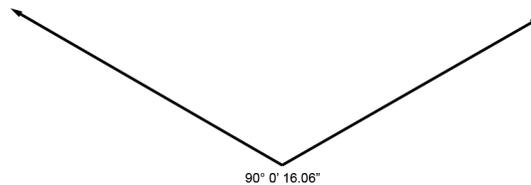
Figure 12-1 Angle: Line/Line

The angle dimension is the angle between the line and the plane.

90° 30' 26.62"
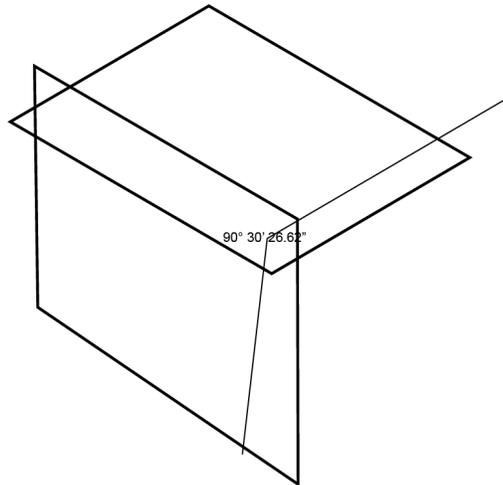
Figure 12-2 Angle: Line/Plane

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

The angle dimension is the angle between the two planes.
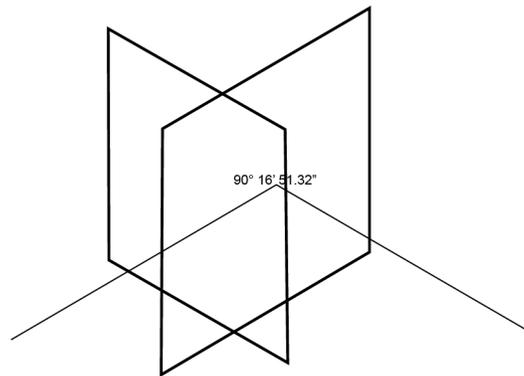
Figure 12-3 Angle: Plane/Plane

Three Points Example

The angle dimension is constructed from the first point to the second, using the third point as the apex.
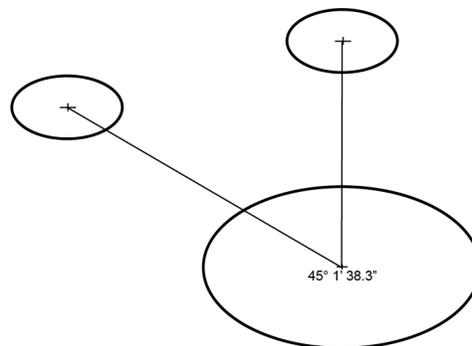
Figure 12-4 Angle: Three Points

Length

Length commands calculate the length between two features and report changes in X, Y, and Z axis and the 3D distance.

Length From Features

Requires: two features.

- **Name:** Type in a name for the length dimension.

- **Length:** Select a Feature.[1] Select plane, line or point for each feature.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- Click **Create** to create the dimension.

Line-Line

The length dimension is the shortest distance from the first to the second line.
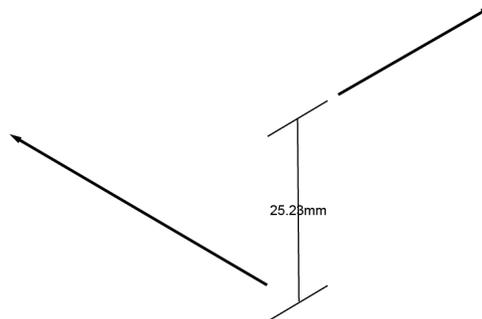
Figure 12-1 Length: Line/Line

Coplanar Lines

If the lines are coplanar, the length is measured from the center point of one line to the center point of the other line.

> **NOTE:** If the lines do not intersect, the length dimension is the shortest vertical distance between the two lines. If the lines are greater than 3 degrees deviation from parallel, the length cannot solve. *See* Figure 12-1

Parallel Lines

The resulting dimension is the distance between the parallel lines. Measured lines will never be exactly parallel, so the two lines are analyzed to see if they are not parallel before the final calculation is displayed. This calculation will give you a non-zero result.

Skew Lines

Skew lines do not lie on the same plane. In such cases, the result will be the shortest distance between the lines as if they were infinite. If the lines intersect, the length dimension will be 0.

Co-Planar Non-Parallel Lines

All lines that are co-planar and non-parallel will intersect, so normally this would create a 0 length; however, the resulting dimension is the distance from the mid-point of the first line to the second line as if it were infinite.

> **NOTE:** The result of co-planar non-parallel lines may not provide repeatable results.

Plane-Plane

The length dimension is the perpendicular length from the center point of the first plane to the second plane.
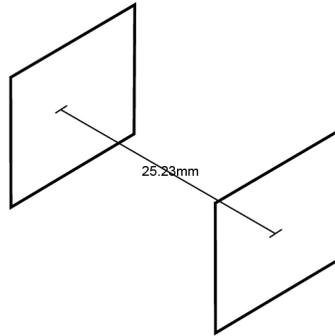
Figure 12-2 Length: Plane/Plane

NOTE: If the planes do not intersect, the length dimension is the shortest vertical distance between the two planes. If the planes are greater than 3 degrees deviation from parallel, the length cannot solve. Figure 12-2

Point-Line

The length dimension is the shortest distance between the point and the line.
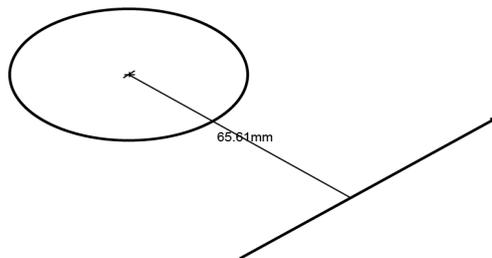
Figure 12-3 Length: Point/Line

Point-Point

The length dimension is the shortest distance between the two points.
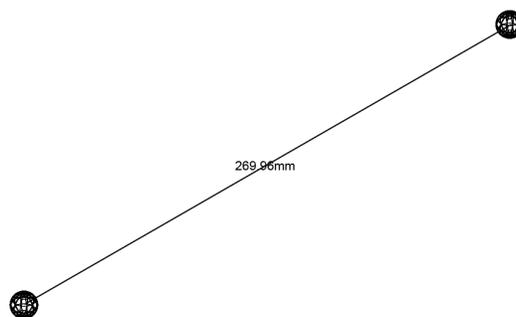
Figure 12-4 Length: Point/Point

Point-Plane

The length dimension is the shortest distance between the point and the plane.
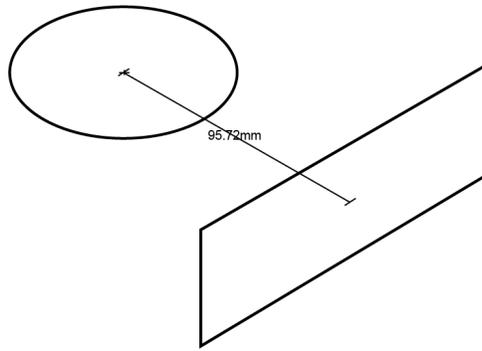
Figure 12-5 Length: Point/Plane

Point-Surface

The length dimension is the shortest distance between the point and the surface.
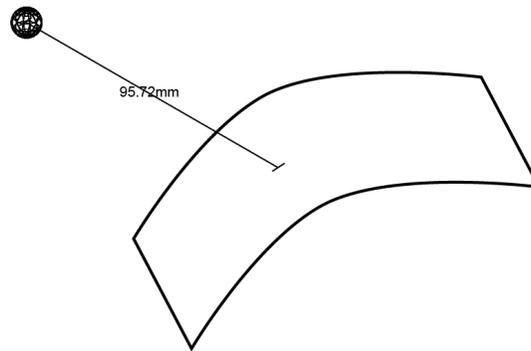
Figure 12-6 Length: Point/Surface

NOTE: A surface *has* boundaries, so the shortest distance is the distance from the point to the surface *or* surface edge.

Patterns

The **Patterns** group includes the commands to create a pattern of features and report their position. To tolerance the position of a pattern:

1. In the **Patterns** group, click **Create**.

2. On the **Features** panel, select **Pattern 1**.

3. Click **Include**.

4. In the Include **Features** dialog box, Select from the List.[1]

5. Click **Position** and enter the position tolerances.

NOTE: A feature can only be in one pattern.

Measure will check the pattern position and display errors for the pattern and for each component feature.

To remove a pattern:

1. On the **Features** panel, select the pattern.

2. In the **Patterns** group, click **Delete**.

To remove features from a pattern:

1. On the **Features** panel, select the feature in the pattern group.

2. In the **Patterns** group, click **Exclude**.

Construct From Selected Features

The **Construct From Selected Features** group contains construction commands based on the features you select.

This group is empty until you select one or more features within the measurement file. When you make a selection, CAM2 populates the gallery with construction commands appropriate to the type of feature(s) that you select. For example, if you select a single circle, CAM2 populates the **Construct From Selected Features** gallery with **Construct Point**. If you select two circles, CAM2 populates the gallery with **Construct Line**, **Construct Point**, **Angle From Features**, and **Length From Features**.

Click any command in the **Construct From Selected Features** gallery to add the construction to the measurement file.

---

[1]When in a dialog box, click in the Selected Choices window. Select a single feature by clicking the name of the feature with the Left Mouse button. Select multiple, consecutive features from the Feature panel by holding down the Shift key, clicking the first (top) feature in the sequence with the Left Mouse button, then clicking the last feature in the sequence with the Left Mouse button. Select multiple features in non-consecutive order by holding down the Ctrl key and clicking each feature with the Left Mouse button. You can also click a feature with the Left Mouse button in the Main Window, or the name of the feature with the Left Mouse button in the Features panel.

Chapter 13: Alignments

The Alignment and Coordinate System commands are available in the **Alignments** tab across the top of the screen. The commands on the **Alignments** tab are organized into Alignments and Coordinate Systems groups.

Alignments

The Alignments group on the **Alignments** tab contains the following Alignment commands:

- Manage Alignments
- Align My Part
- Align Point Cloud
- Iterative
- Feature Based
- Datum

Alignments in which nominal data (CAD) is matched to measured data (Part) are often called "Coordinate System" alignments. This can be a best fit of features or an exact fit of constructed coordinate systems. *See "Alignment Using Coordinate Systems" on page 278.*

Alignments use all the active readings of measured features, regardless of the device position. Editing the readings of an alignment feature (feature used in an alignment command) causes a recalculation of the alignment. *See "Measurement Data" on page 192.*

After completing an Alignment you should run **Camera**. This will help you see the part as you are measuring. *See "Camera" on page 116.*

NOTE: CAM2 only supports coordinate systems.

If you are using multiple alignments in your measurement file, quickly switch between each coordinate system by choosing it from the **Alignment** drop-down window. This drop-down window is a toolbar, and its default location is just under the pull-down menus at the top of the CAM2 window.

Manage Alignments

Select **Manage** to access the **Alignments** window. The **Alignments** window consists of three components: The **Alignment Methods** box, the **Alignments** list, and the drop-down menu. You can also press the **A** keyboard shortcut on the keyboard.
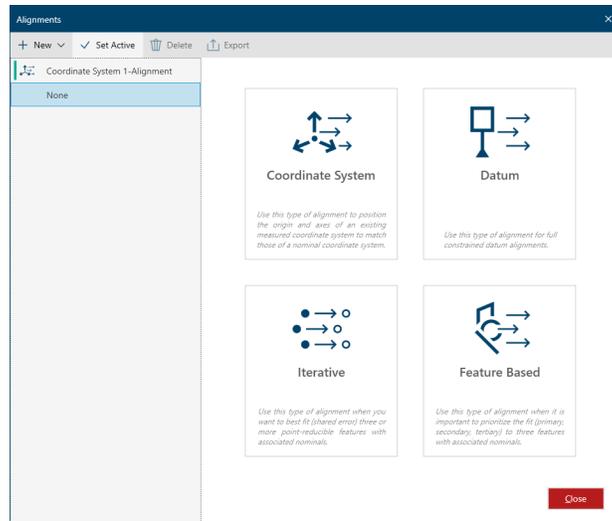
Figure 13-1 Alignments window

Alignment Requirements

Alignments require Measured/Constructed features with associated nominals, or two Constructed Coordinate Systems (Measured and Nominal). These alignments move the Measured/Constructed features to their nominals according to the position of each feature.

- The **Alignment Methods** box contains four tiles for each creation method: Coordinate System, Datum, Iterative, and Feature Based.

- The **Alignments** list contains a list of created alignments. The green check icon indicates the active alignment. Highlight an alignment to view the alignment's properties in the **Details** box.

- The **Details** box contains properties pertaining to the alignment highlighted in the **Existing Alignments** box, including Name, Measured Coordinate System, Nominal Coordinate System, and Material.

New

Click the **New** drop-down and select an alignment creation method: Coordinate System, Datum, Iterative, Feature BasedImport.

Set Active

From the **Alignments** window, highlight an alignment in the **Alignments** list and click **Set Active** to make that alignment current.

NOTE: The active alignment is identified by a green check icon.

NOTE: To "clear" the alignment, select NONE from the **Alignments** list.

Recalculation

When you edit one or more features comprising an alignment, CAM2 automatically recalculates the alignment based on the updated information.

NOTE: Recalculation may be time-consuming depending on the complexity of the alignment. You may find it beneficial to remove the alignment, edit the component features, and then re-create the alignment.

Delete

Click **Delete** to delete any selected Alignment.

Export

Click **Export** to export the selected alignment to .fal, .xal, .euler, or .txt formats.

Align My Part

Select **Align My Part** to access the **Create Alignments Wizard**. Use the wizard to define an alignment by picking nominal features or surfaces, and then measuring those features or surfaces to create the alignment.

The **Create Alignments Wizard** prompts you to create a Surface Point alignment or a Feature Based alignment.

Surface Point Alignment

To create a Surface Point alignment using the **Create Alignments Wizard**:

1. Highlight **Surface Point Alignment**, and click **Next**.

2. Pick points (Inspect Surface Points) on the CAD model. *See "Measuring an Inspect Surface Point" on page 156.*

3. When you have picked enough points to constrain all degrees of freedom, the **Measure The Alignment Points** button appears. Click this button to begin measurement. The view will update to show the nominal feature to be measured.

4. Measure the features in the order they were created. As you measure the features, CAM2 begins to compute an alignment. After you measure the third feature, the alignment computation provides a rough idea of the final outcome.

5. After you measure all of the features, the **Alignment Results** dialog displays each measurement along with the standard deviation, number of iterations, and maximum error. From here, you can remeasure all features, remeasure out of tolerance features, or click Finish to create the alignment using the existing measurements.

Feature Based Alignment

A Feature Based Alignment constrains each feature to degrees of freedom, and once the 6 degrees of freedom are constrained, the alignment can be created. Fully constrained alignments can be created regardless of the number of features selected.

To create a Three Feature Alignment using the **Create Alignments Wizard**:

1. Edit the name (if required).

2. Select **Primary Feature** from the dropdown list and the degrees of freedom locked by the feature will be indictated in green.

3. Select **Secondary Feature** from the dropdown list and the degrees of freedom locked by the feature will be indictated in green.

4. Select **Tertiary Feature** from the dropdown list (if required) and the degrees of freedom locked by the feature will be indictated in green.

NOTE: Once all 6 DoF icons are green the alignment can be created.

---

5. Click the **Material** drop-down to apply material and temperature compensation, if needed.

6. Click Create

Align Point Cloud

Select **Align Point Cloud** to access point cloud alignment mode. To further improve the point cloud alignment, use aligning points to define a set of references to lock the alignment to the correct surfaces based on point pairs.

- The **Main** window will split into two halves to facilitate point cloud alignment.

- Select representative pairs of points from the point cloud and the CAD model by clicking corresponding areas in each half of the **Main** window. Point pairs share a common color and number.

The Align Point Cloud commands are located in the **Point Cloud Alignment Mode** tab across the top of the screen, and the commands are organized into Alignment, Aligning Points, View, and Close groups.

NOTE: If you are using the Probing Version of CAM2, this command is not available. *See "Probing Version" on page 9.*

Alignment

The **Alignment** group contains the Solve Alignment, Preview Alignment, Advanced, Include All, Exclude All, and Create commands.

Solve Alignment

Solve Alignment updates the current alignment. The **Main** window shows an animation of the point cloud and features as the alignment calculates.

Preview Alignment

Preview Alignment enables an alignment preview which appears when you've selected six aligning point pairs, and updates as you continue to select aligning points. Click **Preview Alignment** to exit preview mode.

Advanced

Advanced opens the **Alignments** window. Use the **Alignments** window to manage the point cloud alignment. *See "Manage Alignments" on page 266.*

Include All

Include All specifies whether to use point cloud data in the alignment calculation.

Exclude All

Exclude All specifies whether to exclude all point cloud data from the alignment calculation.

Create

Create creates a new alignment.

Aligning Points

The **Aligning Points** group contains the Show All, Add, and Clear Points commands.

Show All

Show All shows all aligning points in the **Main** window and in an Aligning Points folder in the Features section of the **Navigation** window.

NOTE: This option is useful when you have multiple point cloud alignments, as you can reuse aligning points from other alignments.

Add

Add creates aligning points.

Clear Points

Clear Points removes all point pairs from the scans in the **Main** windows.

View

The **View** group contains the Vertical, Horizontal, and Lock Viewers commands.

▦ Vertical

Vertical splits the **Main** window into left and right panels.

▤ Horizontal

Horizontal splits the **Main** window into top and bottom panels.

🔒 Lock Viewers

Lock Viewers protect the contents of the **Main** window panels from user input.

⤬ Close

The **Close** group contains the Close command, which exits Point Cloud Alignment mode.

⇢ Iterative

Use this type of alignment when you want to best fit (shared error) three or more point-reducible features.

In the **Alignments** window, click **Iterative**, or select **Iterative** from the **New** drop-down.

Requires: three or more point-reducible features with associated nominals, or four inspect surface/vector points and one feature point (RPS alignment).
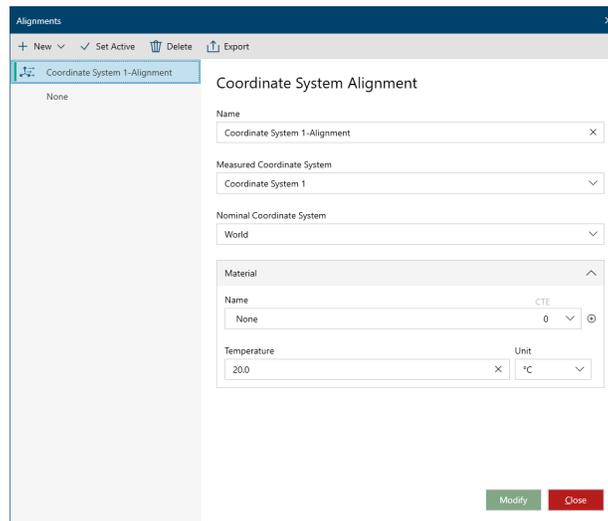
Figure 13-1 Alignments window - Iterative

NOTE: If a measured feature does not have a nominal, you must add one to continue. *For more information, see "Nominals and Tolerances" on page 194.*

You can align point clouds to CAD data using an Iterative alignment. Point cloud data aligned to CAD is colored according to tolerance information. When you have loaded CAD and you have measured one or more point clouds, create an Iterative alignment by selecting one or more point clouds to best-fit align to the entire CAD assembly. Should the Iterative alignment not be optimal, you can define a set of Aligning Points (user-defined point pairs) to lock the alignment to the correct surfaces.

Home-in points with nominal surface points cannot be used in an iterative alignment; you can only home in to a nominal point.

Details box:
- Select a Feature.[1]

To create an Iterative
alignment:

1. Edit the name (if required).

2. Select the required features in the Features list. *See "Features" on page 34.*

3. Click the ⊕ to add the selection to the UI, or select each feature from the drop-down lists.

You can also apply additional feature options:

4. **Use Custom Weights**: Specify feature specific weights, and is accessed from the ••• Feature Options icon.

You can expand the Advanced Options bar for additional options:

5. **Max Iterations**: Specify a maximum number of iterations. A smaller value may reduce alignment time, and result in a less accurate alignment; a larger value may increase alignment time, but result in a more accurate alignment.

NOTE: The Alignment Results will show the number of iterations needed, and this value will typically be less than the max iterations value. If the value is equal, increase the max iteration value and reapply the alignment.

6. **Sample Size**: Applies to any Inspect Surface feature included in the alignment. This value is ignored for Point Cloud.

7. **Use Custom Weight**: Toggles Weight table, as with ••• icon.

8. **Fit Scale**: Toggles Fit Scale.

NOTE: When Fit Scale is active, Constraints and Material are not supported.

9. **Constraints**: Enable constraints to be added to the alignment:

---

[1] When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- **Planar**: select a Plane reducible feature from the dropdown list.

- Linear and Point

  - Select a point reducible feature from the dropdown list.

  - **Line Reducible**: select a line reducible feature from the dropdown.

  OR

  - **From Two Points**: select 2 point reducible features from the drop down list to establish a line.

10. Select the **Material** from the drop-down.

11. Click **Create** to solve the alignment.

NOTE: View the alignment results and errors in Manage Alignments by selecting the alignment from the list. *See "Manage Alignments" on page 266.*

Advanced Options

Options box:
- Enter a Maximum Iterations number for the calculations, or use the default value. Use this number if your alignment calculation seems to "loop" between two or more solutions. Change the default value using the Maximum Iterations preference. *See "Maximum Iterations " on page 87.*

- Enter a Tolerance for the Iterative best fit error of the Measured to Nominal features, or use the default value. Change the default value using the Iterative Alignment Tolerance preference. *See "Iterative Alignment Tolerance " on page 87.*

- Click **Apply/Solve**.

Results box:
- Alignment accuracy.

Fit Scale

You can select to scale the measured features during the best fit calculations. The scale is the ratio between the measured features and their nominal features.

- Select the **Fit Scale** check box to scale measured features during best fit calculations.

Set Weights

Each feature can have an X, Y, and Z coordinate value used with a higher priority in the calculation.

- Select the **Set Weights** check box to add the Weights columns to the feature list.

- Enter a value for the X, Y, and Z coordinate value for each feature. The default value is 1; input a number greater than 1 to emphasize a weight.

NOTE: When you check the **Set Weights** check box, CAM2 will automatically calculate weight values for measured vector points. *For more information, see "Measuring a Vector Point" on page 174.* For all other feature types, weights of 1,1,1 are set by default. You can then change the values.

Constraints

To add a constraint to an iterative alignment, click the **Type** drop down and select the constraint type: Linear or Planar.

Linear Constraint

Select a line constraint by which a measured line must lie on a common axis. The part will translate and rotate on that line to minimize the errors of features added to the list of alignment features.

In order to define the line constraint, you must select a line, two features to make a line, or select a point.

Planar Constraint

Select a plane constraint by which the measured plane must be perfectly matched to the nominal plane. The part will translate and rotate on that plane to minimize the errors of features added to the list of alignment features.

In order to define the plane constraint, you must pick a Nominal plane and measure it, then add two or more point features that will constrain the translation and rotation of the part within that constraint plane.

NOTE: Surface Points may only be used when the normal component of the nominal surface is not parallel to the nominal constrained plane.

Polyline Groups and Planar Constraints

Using the plane constraint, you can measure one or more parallel lock plane polyline features and add them to the list of features to perform the iterative alignment. These polylines will be best fit to the corresponding surfaces while holding the plane constraint and are ideal for determining the pitch angle of propellers or wings and different offsets from the base.

Material Temperature

CAM2 adjusts measurements to the current part temperature entered. A nominal temperature of 20°C (68°F) is used. The ability to scale for temperature allows you to measure parts in areas that are either warmer or cooler. The measurement results are adjusted for thermal expansion or contraction.

To scale for material temperature changes:

- In the **Details** box, click the drop-down arrow and select a material from the library of materials. You will see the coefficient of linear expansion next to the material name. You cannot change this value.

- Enter the temperature of the part, and select Celsius (°C) or Fahrenheit (°F) from the drop-down arrow.

NOTE: If the material you are using is not available in the library and you know the coefficient of linear expansion of the material you are using, click **Plus (+)** next to the **Materials** drop-down arrow. In the **Create New Material** dialog box, enter a name and coefficient of linear expansion value for the new material. Click **OK** to add this material to the library.

Feature Based

Use this type of alignment when it is important to prioritize the fit (primary, secondary, tertiary) to three features.

Requires: three features with associated nominals. The type of features is determined by the Alignment method.

- **Method:** Select[1] an Alignment method.

- **Features:** Select[2]

  a
  Primary, Secondary, and Tertiary feature.

NOTE: Associated nominals are required for this command. If a measured feature does not have a nominal, you must add one to continue. *For more information, see "Nominals and Tolerances" on page 194.'*

The alignment solves as:

- The primary feature moves exactly to its nominal. There will be no alignment error between this actual and nominal feature.

- The secondary feature moves as close to its nominal without moving the primary feature. There may be some alignment error between this actual and nominal feature.

- The tertiary feature moves as close to its nominal without moving the primary of secondary features. Most of the alignment error is between this actual and nominal feature.

NOTE: You can also create a Three Feature Alignment from CAD using Align My Part. *For more information, see "Align My Part" on page 268.*

Datum

Use this type of alignment when it is important to prioritize the fit (primary, secondary, tertiary) to three previously assigned planar or linear datum features. Datum alignments support the same Datum Reference Frame alignments

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

as those created in GD&T mode, some of which are not possible using a Feature Based alignment. *For more information, see "GD&T" on page 287.*

Requires: three planar or linear datum features.

- **Features:** Select[1] a Primary, Secondary, and Tertiary datum feature.

The alignment solves
as:

- The primary feature moves exactly to its nominal. There will be no alignment error between this actual and nominal feature.

- The secondary feature moves as close to its nominal without moving the primary feature. There may be some alignment error between this actual and nominal feature.

- The tertiary feature moves as close to its nominal without moving the primary of secondary features. Most of the alignment error is between this actual and nominal feature.

To create a Datum alignment:

1. Edit the name (if required).

2. Select a **Primary Datum** from the drop-down list.

3. Select a **Secondary Datum** from the drop-down list.

4. Select a **Tertiary Datum** from the drop-down list.

5. Click **Create**.

NOTE: View the alignment results in Manage Alignments by selecting the alignment from the list. *See "Manage Alignments" on page 266.*

Coordinate System

Select **Coordinate System** to create a coordinate system alignment.

For simplicity, there are two coordinate systems for use in a coordinate system alignment:

1. World Coordinate System (WCS) - a coordinate system containing the associated nominal features. This is the default coordinate system of a new file.

2. Measured Coordinate System (MCS) - a coordinate system containing the Measured and Constructed features. *See "Alignment Using Coordinate Systems" on page 278.*

NOTE: You can also construct a Nominal Coordinate System (NCS) using **Coordinate System**. *See "Coordinate System" on page 278.*

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

Requires: a Constructed and a Nominal coordinate system.

- **Measured Coordinate System:** Select a Coordinate System.[1]

- **Nominal Coordinate System:** Select a Coordinate System.[2]

The Measured Coordinate System (MCS) moves to the Nominal
Coordinate System (NCS) *or* the World Coordinate System (WCS). *See "Coordinate Systems" on the next page.*

NOTE: In most cases, the MCS to NCS alignment removes the need for rotating and translating a
Constructed Coordinate System to match the World Coordinate System.

To create a Coordinate System alignment:

1. Edit the name (if required).

2. Select a Measured Coordinate System from the drop-down list.

3. Select a Nominal Coordinate System from the drop-down list.

4. Click the **Material** bar to expand the material and temperature options.

5. Select the material from the drop-down.

6. Select the ⊕ icon to enter a new material and CTE.

7. Enter the material **Temperature**.

8. Select the temperature **Unit** (ºF or ºC).

9. Click **Create**.

Import

Select **Import** to create the current alignment from a file.

1. From the **Alignments** window, click the **New** drop-down and selectFeature BasedImport

2. Edit the name (if required).

3. Click the **Imported File Name** field to browse and select the alignment file to be imported (.fal, .xal or .txt
   format).

4. Click the **Material** drop-down to apply material and temperature compensation, if needed.

5. Click **Create** to import and set the alignment active.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

Select Alignment

Use the Select Alignment drop-down window to select the active alignment for all features. *See "Alignments" on page 266.*

Coordinate Systems

The Coordinate Systems group on the **Alignments** tab consists of Coordinate System commands.

CAUTION: Although, at times it may be necessary to mix nominal, measured, and constructed features when creating constructions, do it with caution. Mixing types of features to create a construction might cause inaccuracies in your measurement data.

Coordinate System

Using the existing features in a file, you can click **Coordinate System** to construct a coordinate system. You can also press the **C** keyboard shortcut on the keyboard to create a coordinate system. There are two tabs in the **Construct Coordinate System using the Wizard** dialog box:

- Basic Tab
- Advanced Tab

NOTE: The default coordinate system is World, which is the same coordinate system as your measurement device.

- Nominal Coordinate Systems, NCS, are generated from nominal and/or constructed features.

- Measured/Constructed Coordinate Systems, MCS, are generated from measured and/or constructed features.

If you are using multiple coordinate systems in your measurement file, quickly switch between each coordinate system by choosing it from the **Coordinate System** drop-down. *For more information, see "Select Coordinate System" on page 286.*

Alignment Using Coordinate Systems

One way to align Measured data with Nominal CAD data:

1. Create a Coordinate System from the Nominal CAD data. This is known as the Nominal Coordinate System (NCS).

2. Create a Measured Coordinate System from the measured/constructed data. This is known as the Measured Coordinate System (MCS).

3. Create a new Coordinate System alignment and select these two coordinate systems in the command. *See "Coordinate System" on page 276.*

NOTE: CAM2 only supports coordinate systems.

Basic Tab

Use the **Basic** tab when you have a plane, a line, and a point that define the coordinate system.

Requires: three features that define a coordinate system.

- **Name:** Type in a name for the coordinate system.

- **Plane Feature:** Select a Plane.[1] You can also select the coordinate axis that this feature defines. The default A

  xis value is +Z.

- **Line Feature:** Select a Line. [2] You can also select the coordinate axis that this feature defines. The default A

  xis value is +X.

- **Point Feature:** Select a Point.[3]

Other Functions:

- **Align With:** Select a Coordinate System.[4] The coordinate system automatically aligns with another existing c

  oordinate system. The default value is World. *For more information, see "Coordinate System" on page 276.*

NOTE: After you create a coordinate system alignment by checking the Align With checkbox and clicking **OK**, clearing the checkbox will not remove the alignment.

- **Offset:** Select the check box and type the XYZ location for the origin of the new coordinate system. Typing values in different units and coordinate systems.[5]

-

  Rotation: Select the check box and type the amount of rotation around any of the three axes. (Negative values are allowed.)

NOTE: If you select both **Offset** and **Rotate About** check boxes, you can select to offset or rotate first.

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a plane, or plane reducible, feature. You can also click the name of the plane with the Left Mouse button in the Features panel. To select a plane from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a plane with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the plane with the Left Mouse button in the Main Window.

[2]When in a dialog box, click the drop-down arrow and scroll down to select a line, or line reducible, feature. You can also click the name of the line with the Left Mouse button in the Lines panel. To select a line from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a line with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the line with the Left Mouse button in the Main Window. Note: Two points can also be used to define a line. You can construct a line using two points using Construct Line: By Best Fit.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a point, or point reducible, feature. You can also click the name of the point with the Left Mouse button in the Points panel. To select a point from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a point with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the point with the Left Mouse button in the Main Window.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

[5]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

Click **OK** to create the coordinate system. The features construct a coordinate system. Any coordinate system offset and rotation follows the .

NOTE: If you select a hybrid of measured and nominal features as Primary, Secondary, and Origin features, you have the option of creating the coordinate system as Actual or Nominal. Click the drop-down arrow on **OK** to create the coordinate system as Actual or Nominal.

Basic Coordinate System Examples

The coordinate system constructs in the plane. All features temporarily project to the plane in the construction of the coordinate system.

Plane/Line/Point

This is commonly referred to as the 3-2-1 coordinate system: **3** points (plane) - **2** points (line) - **1** point (point).

- **Plane Feature:** a plane.

- **Line Feature:** a line.

- **Point Feature:** a point. This defines the origin (0,0,0) of the coordinate system.
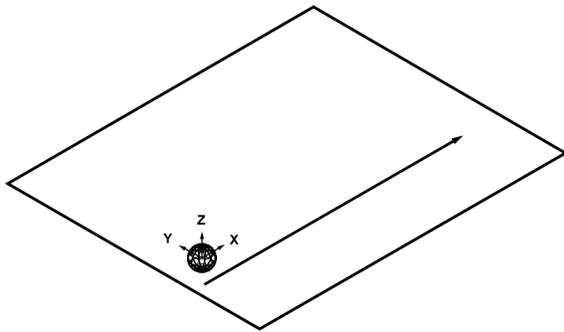
Figure 13-1 Plane/Line/Point

Advanced Tab

Use the **Advanced** tab when you have features for, or features that construct a plane, a line, or a point that define the coordinate system.

Requires: features that define a coordinate system.

- **Name:** Type in a name for the coordinate system.

- **Primary:** Click the **Plane** or **Line** icon. Select a Feature.[1] You can select the coordinate axis that this feature defines. The default Axis value is +Z. You can type in an offset value for the feature.

  - **Plane** icon: Select features that define a plane. Three point-reducible, two line-reducible, two point and one line-reducible, or a plane. The Right-Hand Rule determines the axis direction of the plane when you use multiple features. *See "Right-Hand Rule" on page 330.*

  - **Line** icon: Select features that define a line. Two point-reducible or a line. The order of the two points determines the axis direction of the line.

- **Secondary:** Click the **Plane** or **Line** icon. Select a Feature.[2] You can select the coordinate axis that this feature defines. The default Axis value is +X. You can type in an offset value for the feature.

  - **Plane** icon: Select features that define a plane. Three point-reducible, two line-reducible, two point and one line-reducible, or a plane. The Right-Hand Rule determines the axis direction of the plane when you use multiple features. *See "Right-Hand Rule" on page 330.*

  - **Line** icon: Select features that define a line. Two point-reducible or a line. The order of the two points determines the axis direction of the line.

- **Origin:** Select a Feature.[3]

  - **Hold Position:** the coordinate system is at the center of the feature.

---

[1] When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[2] When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

[3] When in a dialog box, click the drop-down arrow and scroll down to select a feature. You can also click the name of the feature with the Left Mouse button in the Features panel. To select a feature from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a feature with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the feature with the Left Mouse button in the Main Window.

- **Hold to Primary:** the coordinate system is at the closest point on the primary feature from the origin feature.

- **Hold to Secondary:** the coordinate system is at the closest point on the secondary feature from the origin feature.

- **Hold to Key-In:** the coordinate system corresponds to the location (primary, secondary and origin) keyed-in by the user.

Other Functions:

- **Align With:** Select a Coordinate System.[1] The coordinate system automatically aligns with another existing c

  oordinate system. The default value is World. *For more information, see "Coordinate System" on page 276.*

- **Offset:** Select the check box and type the XYZ location for the origin of the new coordinate system. Typing values in different units and coordinate systems.[2]

-

  Rotation: Select the check box and type the amount of rotation around any of the three axes. (Negative values are allowed.)

NOTE: If you select both **Offset** and **Rotation** check boxes, you can select to offset or rotate first.

Click **OK** to create the coordinate system. The features construct a coordinate system. Any coordinate system offset and rotation follows the Right-Hand Rule. *See "Right-Hand Rule" on page 330.*

Advanced Coordinate System Examples

Plane/Line (two points)/Point

This is commonly referred to as the 3-2-1 coordinate system: **3** points (plane) - **2** points (line) - **1** point (point).

- **Primary:** a plane. The plane vector defines the axis.

- **Secondary:** two points. Point 1 to Point 2 defines the axis.

- **Origin:** a point. This defines the origin (0,0,0) of the coordinate system.

---

[1]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

Figure 13-1 Plane/Line (two points)/Point

Plane/Plane/Plane

This is commonly referred to as the 3 Plane coordinate system.

- **Primary:** a plane. The plane vector defines the axis.

- **Secondary:** a second plane. The plane vector defines the axis.

- **Origin:** a third plane. This defines the origin (0,0,0) of the coordinate system. The origin is the intersection of the three planes, and the plane vector defines the axis.
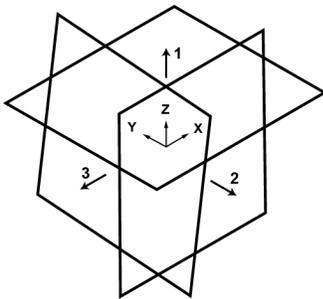
Figure 13-2 Plane/Plane/Plane

Plane/Plane/Point

- **Primary:** a plane. The plane vector defines the axis.

- **Secondary:** a second plane. The plane vector defines the axis.

- **Origin:** a point. This defines the origin (0,0,0) of the coordinate system.
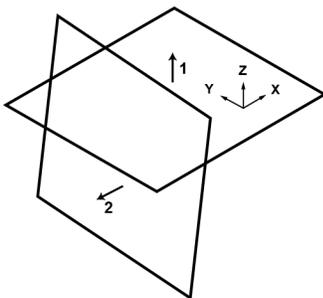
Figure 13-3 Plane/Plane/Point

Point/Point/Point

This is commonly referred to as the 3 Point coordinate system.

• **Primary:** three points.Point 1, to Point 2, to Point 3 define the plane.

• **Secondary:** two points. Point 1 to Point 2 defines the axis.

• **Origin:** a point. This defines origin (0,0,0) of the coordinate system.

Figure 13-4 Point/Point/Point

Plane/Line/Point Hold Secondary

This is commonly referred to as the Perpendicular Intersection coordinate system.

• **Primary:** a plane. The plane vector defines the axis.

• **Secondary:** a line. The line vector defines the axis.

• **Origin:** a point. Select the **Hold Secondary** radio button. This defines the origin (0,0,0) of the coordinate system and moves it to the nearest point on the line.
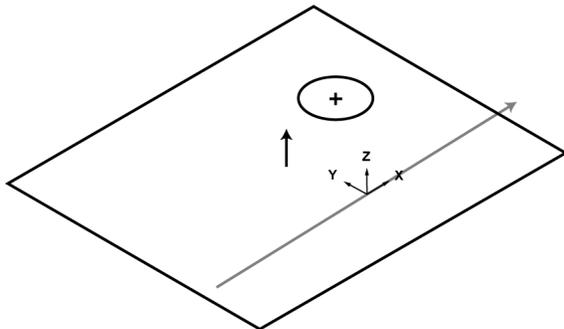
Figure 13-5 Plane/Line/Point Hold Secondary

Plane/Line/Line

This is commonly referred to as the Line/Line Intersect coordinate system.

• **Primary Feature:** a plane. The plane vector defines the axis.

• **Secondary Feature:** a line. The line vector defines the axis.

• **Origin Feature:** a second line. This defines the origin (0,0,0) of the coordinate system. The origin is the point at which the second line intersects the first line. The line vector defines the axis.
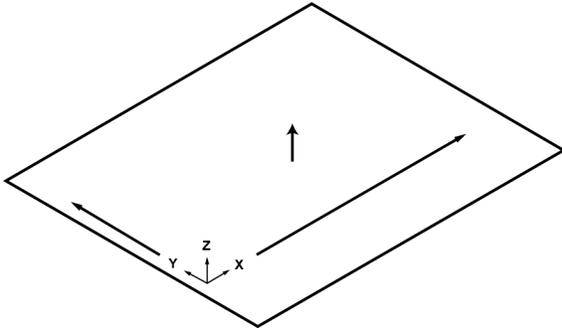
Figure 13-6 Plane/Line/Line

By Key-In

Type the coordinates of the new origin, a point on the X axis and a point on the XY plane to define the coordinate system.

- **Name:** Type in a name for the coordinate system.

- **Origin:** Type in the XYZ values. Typing values in different units and coordinate systems.[1]

- **Point on X Axis:** Type in the XYZ values. Typing values in different units and coordinate systems.[2]

- **Point on XY Plane:** Type in the XYZ values. Typing values in different units and coordinate systems.[3]

- **Align With:** Select a Coordinate System.[4] The coordinate system automatically aligns with another existing coordinate system. The default value is World. *For more information, see "Coordinate System" on page 276.*

- Click **Create** to create the coordinate system.

---

[1]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[3]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[4]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

⬆↗↙ By Offset

Create a new coordinate system by rotating and/or offsetting (moving) an existing coordinate system.

- **Name:** Type in a name for the coordinate system.

- Select a Coordinate System.[1]

- **Offset:** Select the check box
and type the XYZ location for the origin of the new coordinate system. Typing values in different units and coordinate systems.[2]

-
  Rotation: Select the check box and type the amount of rotation around any of the three axes. (Negative values *are* allowed.)

NOTE: If you select both **Offset** and **Rotate About** check boxes, you can select to offset or rotate first.

- **Align With:** Select a Coordinate System.[3] The coordinate system automatically aligns with another existing coordinate system. The default value is World. *For more information, see "Coordinate System" on page 276.*

- Click **Create** to create the coordinate system.

Offset and Rotation are applied according to the Right-Hand Rule. *See "Right-Hand Rule" on page 330.*

Select Coordinate System

Use the Select Coordinate System drop-down window to select the active coordinate system for all features. *See "Coordinate Systems" on page 278.*

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[1]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

[2]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0,0,0 mm but your feature is 5,5,10 inches. Type 5in, 5in, 10in and CAM2 2020 automatically converts the value to 127, 127, 254 millimeters. To change the coordinate system, click the arrow on the right side of the dialog box and select from the menu. CAM2 2020 automatically converts the values to the current coordinate system during the feature construction.

[3]When in a dialog box, click the drop-down arrow and scroll down to select a coordinate system. You can also click the name of the coordinate system with the Left Mouse button in the Coordinate Systems panel. To select a coordinate system from the Main Window, move the pointer over the drop-down list box and click the From Screen icon that appears. This selects the drop-down list and you can then click a coordinate system with the Left Mouse button in the Main Window. If the drop-down list is already selected, then just click the coordinate system with the Left Mouse button in the Main Window.

Chapter 14: GD&T

The Geometric Dimensioning and Tolerancing (GD&T) commands are located in the **GD&T** tab across the top of the screen.

The **GD&T** (Geometric Dimensioning and Tolerancing) tab contains commands for a part that is toleranced using the GD&T system. The GD&T system accurately displays dimensions and tolerances in a specific graphical format on a drawing.

- GD&T is represented by a series of symbols that have specific meanings.

- GD&T tolerances allow you to measure parts and compare them to a datum to ensure that specific design and tolerance requirements are met. *See "Datum" on page 291.*

- GD&T tolerances and results add to each feature in the report.

- GD&T form tolerances appear with the appropriate name and image in the **Feature Information** panel, reports, and labels.

- GD&T labels are automatically added to the **Main** window.

The commands on the **GD&T** tab are organized into Datum, Orientation, Location, Profile, and Run Out groups.

Figure 14-1 GD&T

CAM2 includes the following GD&T tolerances:

GD&T Tolerance	GD&T Command
Form	○ Circularity
	⌒ Cylindricity
	▱ Flatness
	— Straightness
Orientation	⊥ Perpendicularity
	∠ Angularity
	⦥ Parallelism
Location	◎ Concentricity
	⊕ Position
	Regardless of Feature Size (RFS)
	Maximum Material Condition (MMC)
	Least Material Condition (LMC)
Profile	⌓ Profile of a Surface
	⌒ Profile of a Line
Runout	⟋⟋ Total Runout

GD&T in Labels

When you add a GD&T tolerance to a feature, a label adds to the **Main** window. You can drag this label around the view, adjust the text size, align it to the screen view, and add more details to the label using the Labels commands on the **View** tab. *For more information, see "Labels" on page 118.*

The position and detail level of the label stores in every captured view. *For more information, see "View" on page 104.*

Applying GD&T Tolerances to Multiple Features

When you add a GD&T tolerances to a feature, you can quickly apply those tolerances to multiple features:

1. Select the feature with GD&T tolerances from the **Features** panel.

2. Right-click and select **Copy Tolerances**.

3. Select the feature(s) from the **Features** panel to receive the copied GD&T tolerances.

4. Right-click and select **Paste Tolerances**.

5. Click **Yes** to apply the copied tolerances to the selected feature(s).

Exact Feature Length

The Orientation GD&T tolerances use the location of the readings to calculate the length of the feature. Sometimes this is not very accurate because it is difficult to digitize to the edge of your part.
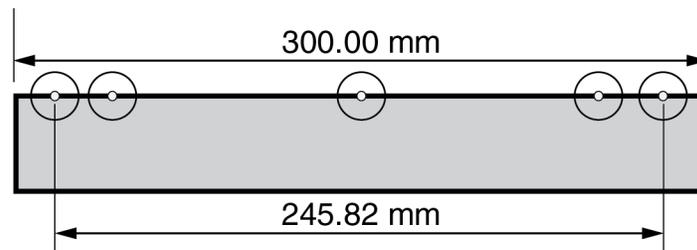
For example, you are reporting the parallelism of a line to a datum. The edge of your part is 300 mm, however the furthest readings are less than 300 mm apart. To enter an exact length for a feature:

1. Create an Orientation GD&T tolerance.

2. Right-Click the feature in the **GD&T** panel and select **Override Length** from the shortcut menu.

3. Select the **Override Length** check box and type in the length value. Typing values in different units.[1]

The GD&T tolerance calculates the readings and extends the feature length from the center of the measured feature in both directions.

---

[1]You can type a value in any unit, and CAM2 2020 converts the value to the default unit value. For example, the default value is 0mm but the diameter is 10inches. Type 10in and CAM2 2020 automatically converts the value to 254 millimeters.

Datum

The **Datum** group includes the commands for creating and defining planar and linear datums.

The datum is the theoretically exact plane or line (axis) from which a dimensional measurement is made, and is used for comparison in the Orientation, Runout, and Location GD&T tolerances. The Form and Profile GD&T tolerances do not require a datum because they use simple geometry for comparison.

To define a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Planar** or **Linear**.

3. In the Letter drop-down list, choose the letter to identify the Datum; only unassigned Datum letters are available.

NOTE: You can also right-click a feature from the **Features** panel and select **Assign a Datum**.

To delete a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, select **Planar** or **Linear** to remove the datum from the feature.

Datum Scheme Status Indication

The **GD&T** control frame indicates datum scheme status with a color-coded control frame border behind the datum callouts:

•   Black - the selected datum scheme may be used.

•   **Red** - the selected datum scheme is invalid/incomplete and cannot be used.

NOTE: The black control frame border color signifies that the datum scheme *may* be used, and does not guarantee that the datum scheme will be able to solve when the position tolerance solves. Red indicates the datum scheme cannot be used whatsoever.

Datum scheme status is determined according to type, number, and geometry of datums selected, whether all degrees of freedom are constrained, the geometry of the nominals (e.g., three planes that are all parallel are invalid), and whether all datums have both an actual and nominal feature.

Composite Datums

Create a Composite Datum for your part with the **Manage Datums** command. A Composite Datum consists of two or more datum features that work in tandem to constrain certain degrees of freedom during an assembly process.

To create a composite datum:

1. In the **Manage Composite Datums** dialog box, select each datum in **Available Datums** panel.

2. Click **Create**.

NOTE: The create button is available only if the selected datums will create a composite datum.

To delete a datum:

1. In the **Manage Composite Datums** dialog box, select an existing in **Available Composite Datums** panel.

2. Click **Delete**.

Click **Close** to exit.

Form

CAM2 automatically adds Form tolerances to each feature.

◯ Circularity

To tolerance the measured form of a circle:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, type a tolerance from your drawing for **Circularity**, or use the default.

To remove any GD&T from tolerance:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, clear the **Circularity** check box.

See "Circularity" on page 314.

⌀ Cylindricity

To tolerance the measured form of a cylinder:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, type a tolerance from your drawing for **Cylindricity**, or use the default.

To remove any GD&T from tolerance:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, clear the **Cylindricity** check box.

See "Cylindricity" on page 318.

▱ Flatness

To tolerance the measured form of a plane:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, type a tolerance from your drawing for **Flatness**, or use the default.

To remove any GD&T from tolerance:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, clear the **Flatness** check box.

See "Flatness" on page 315.

Straightness

To tolerance the measured form of a line:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, type a tolerance from your drawing for **Straightness**, or use the default.

To remove any GD&T from tolerance:

1. Select an existing feature from the **Features** panel.

2. In the **Feature Information** panel, clear the **Straightness** check box.

See "Straightness" on page 316.

Orientation

The **Orientation** group includes the commands for Perpendicularity, Angularity, and Parallelism tolerances.

Perpendicularity

Perpendicularity measures the condition of a surface, center plane, or axis at a right angle (90 degrees) to a datum plane or axis. To tolerance a plane or line to a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Perpendicularity**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. ***See "GD&T" on page 27.***

4. Click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

You can also enter the Exact Feature Length. *See "Exact Feature Length" on page 290.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Perpendicularity" on page 318.

∠ Angularity

Angularity measures how much a surface, axis, or plane can deviate from an angle described in the design. This tolerance requires a datum reference, and no bonus tolerance is permissible. To tolerance a plane or line to a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Angularity**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. Click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

You can also enter the Exact Feature Length. *See "Exact Feature Length" on page 290.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

NOTE: The feature being toleranced must have a nominal associated or you must specify an angle value.

See "Angularity" on page 314.

╱╱ Parallelism

Parallelism measures the condition of a surface or center plane that is equal in distance at all points from the datum plane. To tolerance a plane or line to a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Parallelism**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. ***See "GD&T" on page 27.***

4. Click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

You can also enter the Exact Feature Length. *See "Exact Feature Length" on page 290.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Parallelism" on page 317.

Location

The **Location** group includes the commands for Concentricity and Position tolerances.

◎ Concentricity

Concentricity measures how well a cylinder fits inside of another cylinder. To tolerance a cylinder to a datum:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Concentricity**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. Click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

You can also enter the Exact Feature Length. *See "Exact Feature Length" on page 290.*

NOTE: The resulting cylinder used for calculation will hold the midpoint of the original cylinder and be resized so that the new length is equally divided on either side.

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Concentricity" on page 317.

Concentric Circles

You can apply concentricity to circle features. To do so, define a datum circle as a linear datum and assign concentricity to the circle. The concentricity calculation for the circle will treat the circle as a cylinder of 0 length, thus comparing the position of the center of the circle relative to the Datum axis.

⊕ Position

True Position is defined as a cylindrical tolerance zone about the nominal center line, through the thickness of the material into which the hole was drilled (or the height of the stud). This tolerance requires three datum references that can make an orthogonal coordinate system. To tolerance the position of a feature:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Position**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. Click the Material Condition drop-down list, to the right of the tolerance, and select:
   • RFS - Regardless of Feature Size
   • MMC - Maximum Material Condition
   • LMC - Least Material Condition

NOTE: Any position bonus is automatically calculated and appears in the tolerance frame.

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5. Click the Datum Reference drop-down list and select a datum. Repeat this step to select two more datums.

NOTE: You can specify a datum scheme for each Position tolerance. If the actuals are not solved before CAM2 calculates the statistic, the Active Alignment is used. *See "Active Alignment" below.* Click the **GD&T** button in the lower right corner of the **Main** window to exit.

---

6. The GD&T label displays the results. *See "Labels" on page 118.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See RFS and MMC for a Measured Circle on page 321, RFS and MMC for a Measured Shaft on page 322, and True Position on page 323.

Active Alignment

You can compute statistics using the active alignment instead of a specified datum alignment. To do so, select **Active Alignment** in the primary datum field for Position tolerances.

NOTE: By default, CAM2 computes statistics using the active alignment until you select datums; however, selecting **Active Alignment** in the primary datum field clears any selected datum scheme. Datum features must be valid in order to perform the alignment. The **GD&T Tolerances** reference frame indicates datum scheme validity, a red border indicates an invalid datum scheme.

Profile

The **Profile** group includes the commands for Profile of a Line, Profile of a Polyline Group, and Profile of a Surface tolerances.

Profile of a Line

Profile of a Line is a two-dimensional geometric tolerance that controls how much a polyline, or curve, can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal curve contour that will hold the entire measured surface. To tolerance the profile of a line:

1. Select an existing polyline or cross-section feature from the **Features** panel.

2. On the **GD&T** tab, click **Profile of a Line**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. ***See "GD&T" on page 27.***

4. If necessary, click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Profile of a Line" on page 320.

Profile of a Polyline Group

Profile of a Polyline Group is a two-dimensional geometric tolerance that controls how much a group of polylines, or curves, can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal curve contour that will hold the entire measured surface. To tolerance the profile of a polyline group:

1. Select an existing polyline group from the **Features** panel.

2. On the **GD&T** tab, click **Profile of a Polyline Group**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. If necessary, click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

Profile of a Surface

Profile of a Surface is a three-dimensional geometric tolerance that controls how much a surface can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal surface contour that will hold the entire measured surface.

NOTE: CAM2 calculates Surface Profiles using the Active Alignment or an established 3 Datum reference frame. *For more information, see Alignments on page 266 and Datum on page 291*.

To tolerance the profile of a surface:

1. Select an existing inspect surface point or point cloud feature from the **Features** panel.

2. On the **GD&T** tab, click **Profile of a Surface**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. If necessary, click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel and.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Profile of a Surface" on page 319.

Run Out

The **Run Out** group includes the command for Total Runout tolerancing.

↗↗ Total Runout

Total Runout controls the composite surface variations of circularity, cylindricity, parallelism, straightness, taper and profile of a surface where applied to features constructed around a datum axis. Total Runout applied to surfaces constructed perpendicular to a datum axis controls composite variations of perpendicularity and flatness. The tolerance is applied simultaneously at all circular and profile measuring positions as the part is rotated through 360°.

You will need to measure a cylinder (feature), and a plane (datum) perpendicular to the cylinder. Make sure to rotate the cylinder the full 360° as you are adding readings. It is recommended that you measure down the length of the shaft, rotate the shaft a little, and continue measuring until you rotate the shaft all the way around. To tolerance the total runout of a cylinder:

1. Select an existing feature from the **Features** panel.

2. On the **GD&T** tab, click **Total Runout**.

3. In the **GD&T** panel, type a tolerance from your drawing, or use the default. *See "GD&T" on page 27.*

4. Click in the right control frame and select a datum. *See "Datum" on page 291.*

5. The GD&T label displays the results. *See "Labels" on page 118.*

You can also enter the Exact Feature Length. *See "Exact Feature Length" on page 290.*

NOTE: The resulting cylinder used for calculation will hold the midpoint of the original cylinder and be resized so that the new length is equally divided on either side.

To remove any GD&T tolerance:

1. Select an existing feature from the **Features** panel.

2. Right-click the tolerance frame in the **GD&T** panel and select **Delete**.

See "Total Runout" on page 321.

Chapter 15: CAM2® 2021 Remote

CAM2® 2021 Remote offers an interface to control CAM2, in combination with the iPhone®, iPod® Touch, or iPad®. The ability to invoke commands without needing to go back to the computer is essential when you are working at a distance.

To enable remote control of CAM2 and your FARO Laser Tracker or FaroArm:

- Connect your computer to an existing wireless network, or set up an ad hoc network on your computer.

- Connect your iPhone, iPod Touch, or iPad to that wireless network.

- Start the CAM2 Remote application, and connect to your FARO Laser Tracker or FaroArm.

Using a Wireless Network

If your computer is already connected to a network that has a wireless router, get the current Internet Protocol, or IP, address (*nnn.nnn.nnn.nnn*) for the wireless network, and use CAM2 Remote to connect to that network. Continue to Setting up the Remote Device. In that section, use your current wireless network name and security key.

Using an Ad Hoc Network

This section details how to setup a computer-to-computer, or ad hoc, network on your computer running Windows XP, Windows Vista, or Windows 7. Create an ad hoc network only if you do not have an existing wireless network.

NOTE:Windows 10 does not support this method.

Windows XP

NOTE: Make sure your iPhone, iPod Touch, or iPad has been registered and working properly prior to CAM2 installation.

1. Open the **Start** menu and click **Control Panel**.

2. Under **Pick a category**, click **Network and Internet Connections**.

3. Under **or pick a Control Panel icon**, click **Network Connections**.

4. Right-click your wireless network connection, and then click **Properties**.

5. In the **Wireless Network Connection Properties** dialog box, click the **Wireless Networks** tab.

6. On the **Wireless Networks** tab, under **Preferred networks**, click **Add**.

7. In the **Wireless network properties** dialog box, on the **Association** tab, type the name of your ad hoc wireless network in **Network name (SSID)** box. For example, you could type `FARO Remote`.

   • Clear the **The key is provided for me automatically** check box and select the **This is a computer-to-computer (ad hoc) network** check box.

   • Create a 13-digit password and type it in both the **Network key** and **Confirm network key** boxes. For the best security, include letters, numbers, and punctuation. Then click OK.You will also need to enter this key into your iPhone, iPod Touch, or iPad later.

8. Click OK again to save your changes.

Windows Vista

NOTE: Make sure your iPhone, iPod Touch, or iPad has been registered and working properly prior to CAM2 installation.

1. Open the **Start** menu.

2. Click **Connect To**.

3. Click **Setup a Connection or Network**.

4. Click **Setup a Wireless Ad Hoc Network** and click **Next**.

5. Enter the new network name such as `FARO Remote`.

6. Enter a Security Key. You will also need to enter this key into your iPhone, iPod Touch, or iPad later.

7. Check **Save This Network**.

Windows 7

NOTE: Make sure your iPhone, iPod Touch, or iPad has been registered and working properly prior to CAM2 installation.

---

1. Open the **Start** menu and click **Control Panel**.

2. Click **Network and Internet**, then click **Network and Sharing Center**.

3. Under **Change your networking settings**, click **Setup a New Connection or Network**.

4. Click **Setup a Wireless Ad Hoc (computer-to-computer) Network**.

5. Click **Next** twice.

6. Enter the Network name such as `FARO Remote`.

7. Select the Security WAP (or WEP) and enter the Security key or password. You will also need to enter this key into your iPhone, iPod Touch, or iPad later.

8. Select the **Save This Network** checkbox.

9. Click **Turn on Internet Connection Sharing**.

Setting up the Remote Device

This section details the installation of operating system software for the iPhone, iPod Touch, or iPad and the CAM2 Remote application. Before continuing, you should have already registered your iPhone, iPod Touch, or iPad and created an iTunes account.

Apple iOS Software

Before you begin, make sure that the iPhone, iPod Touch, or iPad has the latest operating system software installed. To check this:

1. Connect the iPhone, iPod Touch, or iPad to your PC or Notebook and start iTunes.

2. In iTunes select the iPhone, iPod Touch, or iPad device on the left side of the screen. iTunes shows the version of the installed operating system software.

3. Click **Check for update**.

If there is a new update, iTunes will ask you to install it. Install the update.
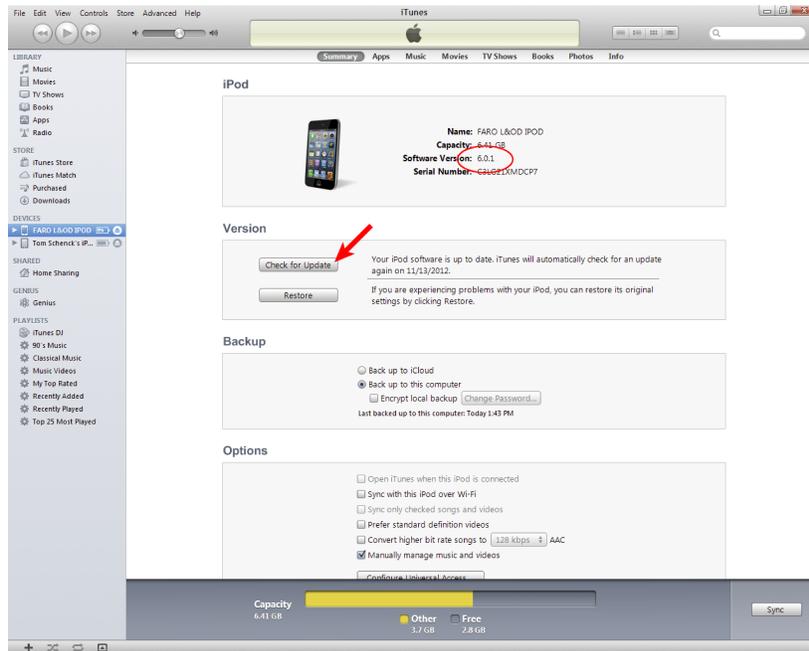
Figure 15-1 Apple iTunes

NOTE: CAM2 Remote requires iOS 3.1.1 or later and has been fully tested on iOS 4.

CAM2 Remote Application

The CAM2 Remote application is a free download from the iTunes store.

1. In iTunes, select the iTunes Store.

2. Search for CAM2 Remote and download the application.

3. After the download is complete, select the iPhone, iPod Touch, or iPad device and click **Sync**. This copies the CAM2 Remote application to your iPhone, iPod Touch, or iPad.

Setting up the Wi-Fi Connection

This section details how to setup your iPhone, iPod Touch, or iPad in order to control CAM2 via a Wi-Fi network connection. Make sure your computer's Wi-Fi connection is active and switch on the iPhone, iPod Touch, or iPad.

1. On the **Start** screen, touch the **Settings** application.

Figure 15-1 Start Screen

2. On the **Settings** screen touch WiFi.

Figure 15-2 Settings

3. Active the WiFi by touching the On/Off switch.

4. On the **Wi-Fi Networks** screen you should see a list of all available Wi-Fi networks including the network that you just setup on your computer (FARO Remote). Touch this network.

5. Enter the Security Key, or Password, from the network that your setup on your computer (FARO Remote). Please notice that this key is case-sensitive (you have to touch Shift on the onscreen keyboard **EACH TIME** before entering a capital letter).

6. Touch **Join**.

7. Press the **Home** key to return to the **Start** screen.

Manually Connecting to the Network

If the network does not appear on **Wi-Fi Networks** screen:

1. Touch **Other**.

2. On the **Other Network** screen, type your network name (FARO Remote).

3. Touch **Security** and choose WEP. Touch Other network to return to the **Other Network** screen.

4. On the **Other Network** screen, type the Security Key, or Password, from the network that your setup on your computer (FARO Remote). Please notice that this key is case-sensitive (you have to touch Shift on the onscreen keyboard **EACH TIME** before entering a capital letter).

5. Touch **Join**.

Starting CAM2 Remote

Since CAM2 Remote will control the CAM2 software, make sure that you have started the CAM2 software on your computer and check that at least one measuring device is connected.

Before starting the CAM2 Remote application, you must get the Internet Protocol, or IP, address for your wireless network connection. You will enter this twelve digit address (*nnn.nnn.nnn.nnn*) just after starting the CAM2 Remote application.

1. On your computer, open the **Start** menu and click **Run**.

2. Type `cmd` and press OK.

3. Type `ipconfig` and press **Enter**.

4. Look for the Wireless Network Connection section and write down the twelve digit IP address (*nnn.nnn.nnn.nnn*). Close the command window.

5. On your remote device, Touch CAM2 Remote.

6. Enter the twelve digit IP address and touch **Connect**.

7. On the **Devices** screen, touch a measuring device to control remotely.

CAM2 Remote Screens

This section describes the CAM2 Remote screens. The **Commands** screen and the **QuickTools** screen are the two main screens. After selecting a command or QuickTools program, the three sections of the **Measurement** panel screen shows you the measurement data.

Commands Screen

The Commands screen contains all of the CAM2 measurement commands. Touch a command to measure.

Starting a command with CAM2 Remote:
- Automatically adds a measurement feature to the CAM2 measurement file

- Switches CAM2 to **Measurement** mode

- Switches CAM2 Remote to the **Measurement** screen

QuickTools Screen

Touch QuickTools at the bottom of the screen to see a list of any QuickTools in the current measurement file. Touch a QuickTool to measure.

NOTE: This list automatically refreshes if you change to another CAM2 measurement file on your computer.

Measurement Screen

The CAM2 **Measurement** panel is your control panel during measurement, providing the current measurement mode, the position of the probe, the position and form of the feature being measured, and an image of the part when running a QuickTools program. *For more information, see "Measurement Panel" on page 188.*

This same information is also now available in the **Measurement** screen of CAM2 Remote. Use the buttons on this screen to measure:

- **Return to Commands** - Touch the button in the upper right corner of the screen to return to the **Commands** screen.

- **Probe Settings** - Touch the button in the upper right corner of the screen to change the probe/tooling, and the measurement mode.

- **Record Measurement** - Touch the button in the lower left of the screen to add a reading to the feature.

- **Record End Click** - Touch the button in the lower center of the screen to add an end click to the feature.

- **Remove Last Point** - Touch the button in the lower right of the screen to remove the last reading from the feature.

The **Measurement** screen has three screen sections. Notice the three dots just above the three buttons that indicate the current section. Slide the screen to the left or right to change:

Feature Information (left dot) - This section shows the results for the feature.

QuickTools Picture (center dot) - This section shows any QuickTool images for the feature.

Live Digital Readout (right dot) - This section shows a live X,Y,Z location of the probe.

Operating and Troubleshooting

As you are using the CAM2 Remote application to control your CAM2 measurement file, you should be aware of potential issues with the wireless connection.

Preventing Disconnection

The ad hoc network connection will be disconnected if the iPhone, iPod Touch, or iPad Auto-Locks. Consider setting the Auto-Lock time to 5 Minutes or Never to prevent frequent disconnects (**Settings** > **General** > **Auto-Lock**).

If the device loses the ad hoc connection, it will default to the next available wireless network that is available and configured on the iPhone, iPod Touch, or iPad.

iPhone, iPod Touch, or iPad Troubleshooting

If you are encountering problems with the Wi-Fi connection this could have several reasons:

- Is your iPhone, iPod Touch, or iPad already connected to another wireless network?

  - Microsoft Windows does not support a wireless network connection with a simultaneous ad hoc wireless connection. If you are connected through a Wi-Fi network use that network to connect to the device and do not create an ad hoc wireless connection.

  or

  - On the WiFi Network screen, touch the arrow next to the network name and then touch **Forget Network**.

- Do you have the latest iPhone, iPod Touch, or iPad software installed? Older versions might have problems with setting up a stable connection to the computer.

- Have you entered the Security key correctly? Try to enter the Security key again. Please notice that the Security key is case-sensitive and that you have to click Shift on the onscreen keyboard each time before you enter a capital letter.

- In rare circumstances the iPhone, iPod Touch, or iPad accepts the ad hoc network but the network cannot be used.

  1. On the **Start** screen, touch **Settings**.

  2. Touch WiFi.

  3. Make sure a check mark is visible before your ad hoc network name.

  4. Touch the arrow next to your ad hoc network name.

  5. The IP address should begin with169.254.xxx.xxx on Windows XP and 192.168.xxx.xxx on Windows Vista and Windows 7.

  If there is no IP (blank field), this is why CAM2 can't connect. Wait about 60 seconds on that screen and a new IP address will be assigned automatically.

Chapter 16: Keyboard Shortcuts and Shortcut Menus

There are many Keyboard Shortcuts and Shortcut menus to quickly launch some commands in CAM2.

NOTE: Keyboard Shortcuts function for the active device only. *See "Device Center" on page 128.*

Keyboard Shortcuts

The following is a list of Keyboard Shortcuts, or keyboard shortcuts, that you can use to quickly start some CAM2 commands.

Keyboard Shortcut	Function
Arrow keys **2,4,6,8** on numeric keypad	Pans the view in the specified direction.
F1	Help
F2	Measuring a Point
F3	Measuring a Plane
F4	Measuring a 2D Line
F5	Measuring an Inspect Surface Point
F10	Measuring a Circle
F11	Measuring a Cylinder
F12	Measuring a Sphere
Insert	Add Readings
G	Record Measurement
H	Record End Click
Backspace	Remove Last Point
SHIFT + A	Measure All
SHIFT + R	Measure
ALT + ENTER	Feature Properties
Plus Sign (+) on keyboard	Increase Whisker Scale
Minus Sign (-) on keyboard	Decrease Whisker Scale
4	+X/-X View
5	+Y/-Y View
6	+Z/-Z View
7	Isometric SE
8	Isometric SW

Keyboard Shortcut	Function
9	Isometric NE
0	Isometric NW
I **Plus Sign (+)** on numeric keypad	Zoom In
O **Minus Sign (-)** on numeric keypad	Zoom Out
E	Reset Zoom
W	Zoom To Area
7 on numeric keypad	Rotate Around X Counterclockwise
9 on numeric keypad	Rotate Around X Clockwise
1 on numeric keypad	Rotate Around Y Counterclockwise
3 on numeric keypad	Rotate Around Y Clockwise
0 on numeric keypad	Rotate Around Z Counterclockwise
Period (.) on numeric keypad	Rotate Around Z Clockwise
S	Switch between the three shaded and wireframe views
Shift + Alt + Enter	Full Screen
Number Sign (#)	Grid
R	Reset View
L	Labels
ESC	Cancels the Current Measurement
P	Device Center
D	Show Feature Window
A	Manage Alignments Alignment
C	Coordinate System Coordinate System Alignment
M	Move Device
Delete	Delete any selected item
Enter	Repeat Last Command
Home	Reset

Keyboard Shortcut	Function
T	Motor On Off
B	Set Backsight
V	Drive Beam
X	Change Measurement Mode
CRTL + N	New file
CRTL + O	Open file
CRTL + S	Save file
CRTL + B	Generate Barcode
CRTL + P	Preferences
Spacebar	Change Selection Mode
CRTL + Shift + L	Open Log Directory
ALT + F4	Exit CAM2

Shortcut Menus

Right-click in areas of the CAM2 window or control panels to quickly access commands.

Any Panel's Title Bar

- **Floating** - Undock a panel from the edge of the screen.
- **Dock** - Move and attach a floating panel to the edge of the screen.
- **Auto Hide** - Set the panel to Auto Hide mode.
- **Hide** - Temporarily hide a panel. Use **View Panels** to show any hidden panel. *For more information, see "Panels" on page 122.*

Any Selected Feature or Feature Label

NOTE: Some menu items are not available for all feature types, or if multiple features are selected.

- **Rename** - Edit the feature name. Press the **Enter** key to continue.
- **Delete** - Permanently delete the feature from the file.
- **Assign A Layer** - Move the feature to an existing layer. *See "Layers" on page 112.*
- **Label** - Show or Hide the feature's label. *See "Labels" on page 191.*
- **Label Style** - Specify the style of the feature's label. *See "Labels" on page 118.*
- **Features Readings** - View the feature's readings in the **Main** window. *See "Measurement Data" on page 27.*
- **Whiskers** - View the feature's whiskers in the **Main** window. *See "Whisker Scale" on page 114.*

- **Nominal Whiskers** - View the feature's nominal whiskers in the **Main Window**. *See "Whisker Scale" on page 114.*
- **Add Measurement** - Create a measured feature and associate the selected feature as a nominal.
- **Add Readings** - Add readings to the feature with the current device.
- **Add Readings From** - Add readings to the feature with any device.
- **Measure** - Add readings to the feature with any device, and replace all existing readings.
- **Clear Readings** - Permanently delete all readings from the feature. *See "Measurement Data" on page 192.*
- **Aim** - *Laser Tracker Only*, Aim at the feature with the current device. *See "Aim" on page 137.*
- **Aim With** - *Laser Tracker Only*, Aim at the feature with any device. *See "Aim" on page 137.*
- **Construct** - Choose any available construction. *See "Construct From Selected Features" on page 263.*
- **Import CAD Part(s)** - Add a CAD part to the measurement file. *See "CAD" on page 61.*
- **GD&T Mode** - Opens the GD&T mode. *See "GD&T" on page 287.*
- **Copy Tolerances** - Copy all tolerances for the feature. *See "Copy Tolerances" on page 108.*
- **Paste Tolerances** - Paste a set of tolerances copied from another feature. *See "Paste Tolerances" on page 108.*
- **Generate Shortcut** - Create a shortcut. *See "Shortcuts " on page 151.*
- **Make Nominal** - Designate the feature as nominal. *See "Features" on page 34.*
- **Capture View** - Capture the current view and store it with the feature. *See "Capture View" on page 106.*
- **Clear View** - Clear the captured view of the feature.
- **Recall View** - Recall the captured view of the feature.
- **Zoom To Features** - Zoom in to the feature.
- **Flip Vector** - Reverses the direction of the feature's normal vector. *See "Flip Vector" on page 109.*
- **Properties** - Edit the feature. *See "Properties" on page 108.*

Any Selected Reading in the Measurement Data Panel

- **Aim** - FARO Laser Tracker only - Automatically point the laser beam to the X,Y,Z coordinate of the reading.
- **Delete** - Permanently delete the reading from the file.

For more information, see "Measurement Data" on page 192.

Any Tab in the Ribbon

- **Show Quick Access Toolbar Below The Ribbon** - Places the Quick Access Toolbar below the ribbon. *For more information, see "Quick Access Toolbar" on page 23.*
- **Minimize** - Minimize the appearance of a ribbon. *For more information, see "Minimize the Ribbon" on page 22.*
- **Customize Ribbon** - Customize the appearance of a ribbon. *For more information, see "Customize the Ribbon" on page 22.*

Any Selected QuickTools Program

- **Play** - Start playing the contents of a QuickTools program.
- **Stop** - Stop playing the contents of a QuickTools program.
- **Record** - Start recording, or adding to, a QuickTools program.
- **Delete** - Permanently delete the QuickTools program from the file.

Chapter 17: Operational Concepts

This chapter describes some glossary terms, definitions, and specifics on tolerances in CAM2 2021.

GD&T Tolerances

The following are examples of the Geometric Dimensioning and Tolerancing for measured circles, which show the Maximum Material Condition (MMC) and the Regardless of Feature Size (RFS) options. For more information on GD&T Tolerancing, refer to *GEO METRICS III - The Application of Geometric Dimensioning and Tolerancing Techniques,* by Lowell W. Foster, and published by Addison-Wesley Publishing Company Inc.

Angularity
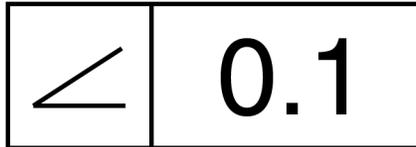
Angularity measures how much a surface, axis, or plane can deviate from an angle described in the design. This tolerance requires a datum reference, and no bonus tolerance is permissible.
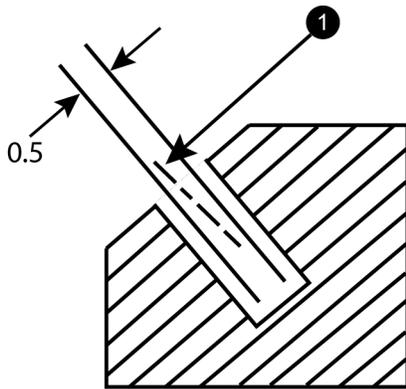
❶ Possible Axis Orientation

In the figure above, the angularity tolerance is used to control the center axis of an angled hole. The tolerance zone of 0.5 is indicated by the parallel lines.

This form of angularity tolerance applies only in the drawing view in which the tolerance is specified, and requires the permissible variation to be defined for other views.

NOTE: In GD&T, the degree of permissible variation is not specified as a tolerance on the angle. Instead, an indirect method is used where one specifies a tolerance zone at a specified angle from a datum, within which a part feature, axis, or center plane must lie.

Circularity

Circularity measures the form deviation of a circle.
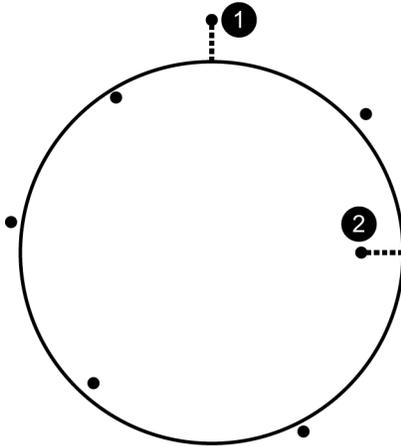
① Maximum Error

② Minimum Error

In this example, the circle is measured with seven points. The Circularity calculation is the Maximum distance plus the Minimum distance.

NOTE: The result and report values for the circle show the maximum error as a positive number, and the minimum error as a negative number. These positive and negative signs indicate the direction of the maximum and minimum error readings from the circle. The Circularity result value is the absolute distance between the maximum and minimum error.

Flatness
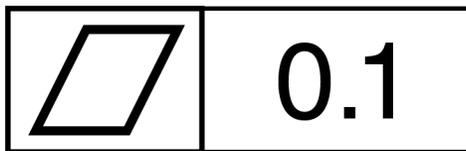
Flatness measures the form deviation of a plane.
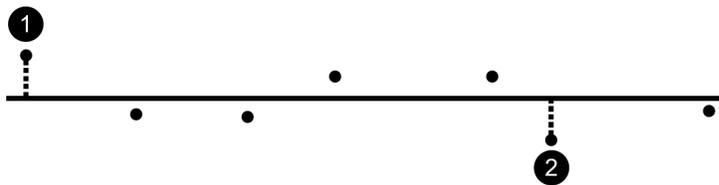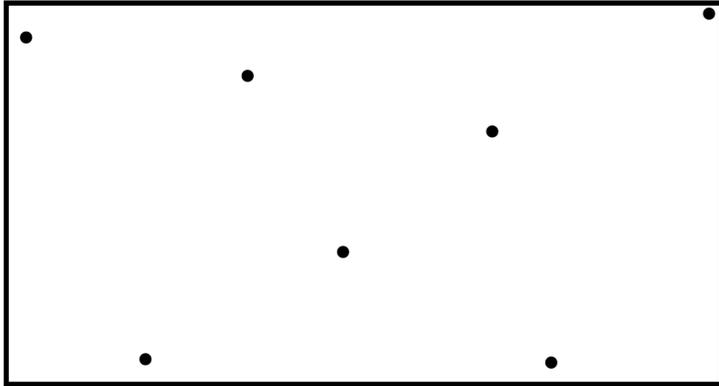
① Maximum Error

② Minimum Error

In this example, the plane is measured with seven points. The Flatness calculation is the Maximum distance plus the Minimum distance.

NOTE: The result and report values for the plane show the maximum error as a positive number, and the minimum error as a negative number. These positive and negative signs indicate the direction of the maximum and minimum error readings from the plane. The Flatness result value is the absolute distance between the maximum and minimum error.

Straightness

—	0.1
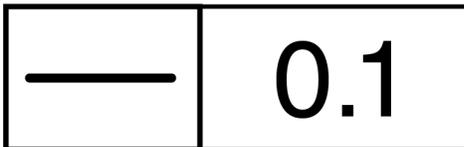
Straightness measures the form deviation of a line.
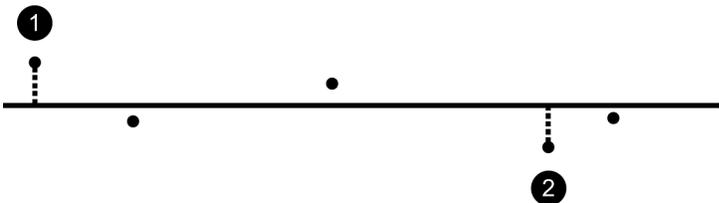
① Maximum Error

② Minimum Error

In this example, the line is measured with seven points. The Straightness calculation is the Maximum distance plus the Minimum distance.

NOTE: The result and report values for the line show the maximum error as a positive number, and the minimum error as a negative number. These positive and negative signs indicate the direction of the maximum and minimum error readings from the line. This calculation does not add a positive and a negative number together for a smaller value. The Straightness result value is the absolute distance between the maximum and minimum error.

Concentricity

Concentricity measures how well a cylinder (line) fits inside of another cylinder (line).
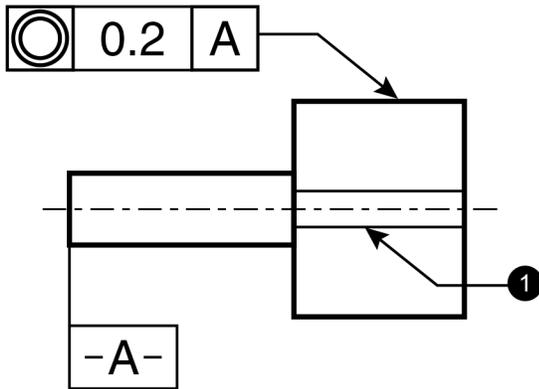
1 0.2 Tolerance Zone

The center line of the measured cylinder is compared to the center line of the datum cylinder. The center line of the measured cylinder must be inside the tolerance zone. Concentricity is always RFS (Regardless of Feature Size) for the diameter of the cylinder. However, the measured length of the cylinder is critical in the calculation.

Parallelism

Parallelism measures the condition of a plane that is equal in distance at all points from the datum plane.
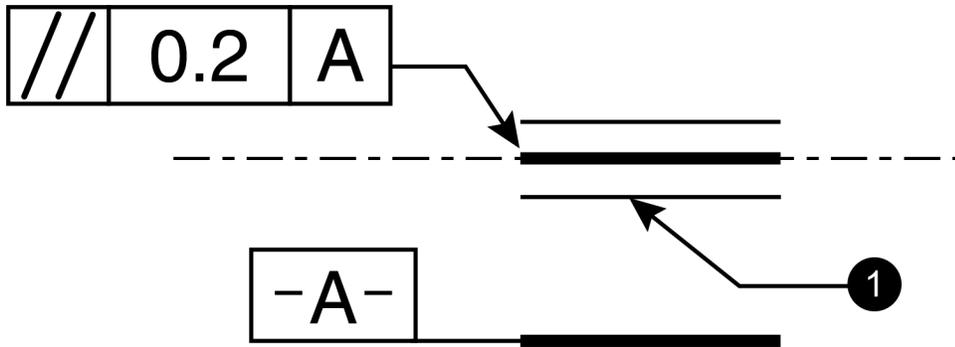
❶ 0.2 Tolerance Zone

The measured plane, line, or cylinder, is compared to the datum plane, line, or cylinder. The measured feature must be inside the tolerance zone. The measured length of the feature is critical in the calculation.

Perpendicularity

Perpendicularity measures the condition of a plane at a right angle (90 degrees) to a datum plane.
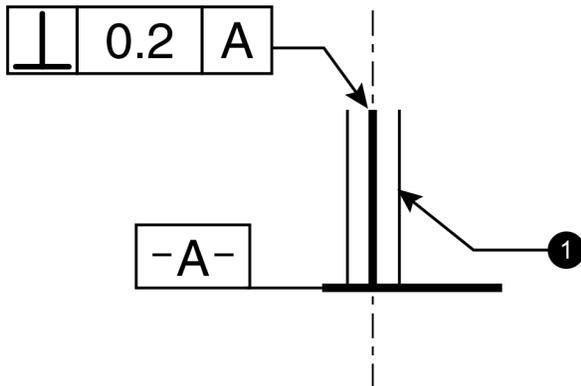
❶ 0.2 Tolerance Zone

The measured plane, line, or cylinder, is compared to the datum plane, line, or cylinder. The measured feature must be inside the tolerance zone. The measured length of the feature is critical in the calculation.

Cylindricity
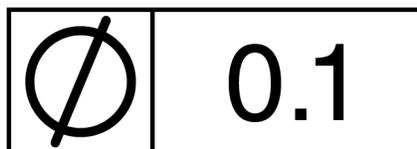
Cylindricity measures the form deviation of a cylinder.
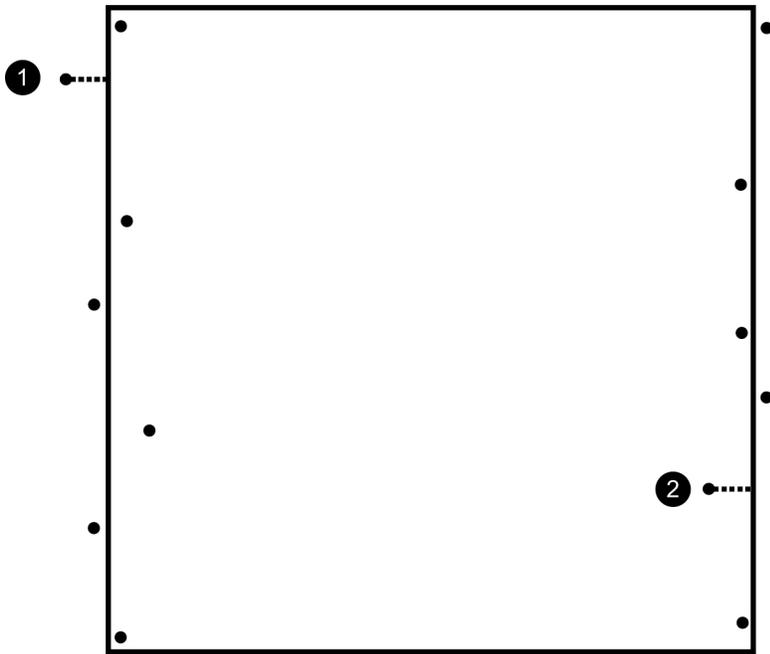
❶ Maximum Error

❷ Minimum Error

In this example, the cylinder is measured with 13 points. The Cylindricity calculation is the Maximum distance plus the Minimum distance.

NOTE: The result and report values for the cylinder show the maximum error as a positive number, and the minimum error as a negative number. These positive and negative signs indicate the direction of the maximum and minimum error readings from the cylinder. This calculation does not add a positive and a negative number together for a smaller value. The Cylindricity result value is the absolute distance between the maximum and minimum error.

Profile of a Surface
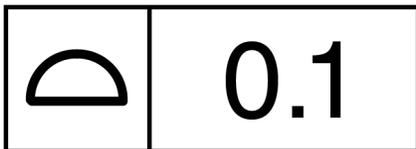
⌓	0.1

Profile of a Surface is a three-dimensional geometric tolerance that controls how much a surface can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal surface contour that will hold the entire measured surface.
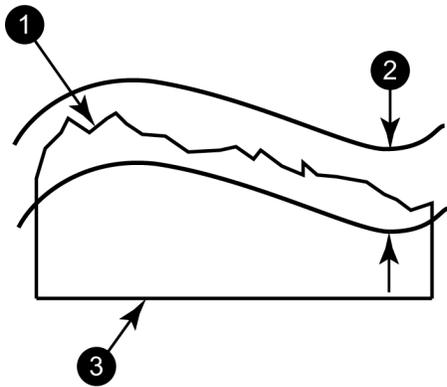
❶ Actual Profile

❷ 0.8 tolerance zone equally spaced about the true profile, or 0.4 each side

❸ Datum Plane A

In the figure above, the surface profile tolerance of 0.8 is equally spaced on either side of the true profile. The true profile must be situated between the uniform boundary of 0.4 (upper and lower) with respect to Datum Plane A.

NOTE: The profile will be out of tolerance if one point has a deviation larger than half the tolerance value.

Profile of a Line
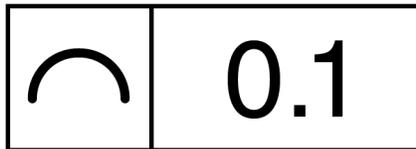
Profile of a Line is a two-dimensional geometric tolerance that controls how much a polyline, or curve, can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal curve contour that will hold the entire measured surface.
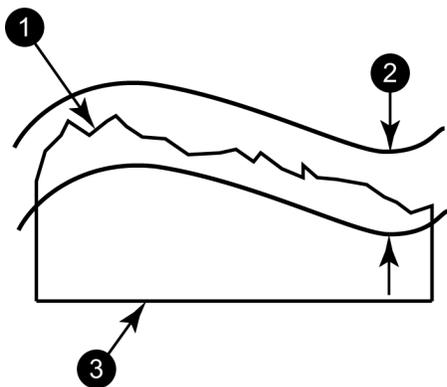
❶ Actual Profile

❷ 0.8 tolerance zone equally spaced about the true profile, or 0.4 each side

❸ Datum Plane A

In the figure above, the line profile tolerance of 0.8 is equally spaced on either side of the true profile. The true profile must be situated between the uniform boundary of 0.4 (upper and lower) with respect to Datum Plane A.

NOTE: Profile of a Line is computed as the most positive error value minus the most negative error value (or zero if no negative errors).

Total Runout

Total Runout controls the composite surface variations of circularity, cylindricity, parallelism, straightness, taper and profile of a surface where applied to features constructed around a datum axis. Total Runout applies to an entire surface simultaneously, not just individual circular elements.
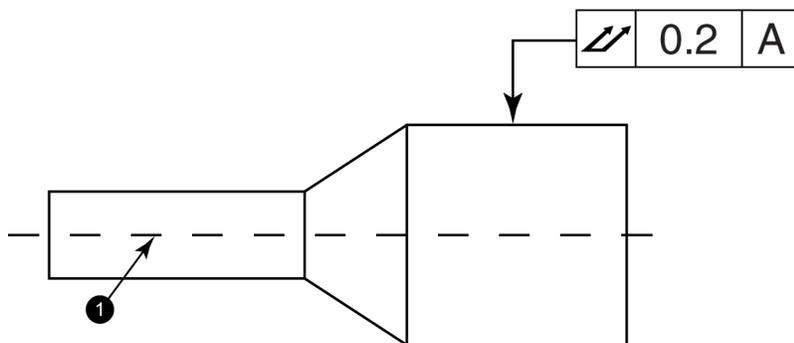
❶ Datum A

In the figure above, the Total Runout tolerance of 0.2 indicates that the entire surface must have cylindrical surface variation of less than 0.2 relative to Datum A as the part is rotated. The tolerance is applied simultaneously at all circular and profile measuring positions as the part is rotated through 360°.

RFS and MMC for a Measured Circle

Measured	Nominal	+Tol.	-Tol.	Deviation	Out of Tol.
X: 0.100	0.000	+0.010	-0.010	0.100	0.090
Y: 0.000	0.000	+0.010	-0.010	0.000	*****
Z: 0.000	0.000	+0.010	-0.010	0.000	*****
Diam: 1.050	1.000	+0.010	-0.010	0.050	0.040
RFS: 0.200[1]		+0.020[3]		0.200	0.180[5]
MMC: 0.200[2]		+0.040[4]		0.200	0.160[6]
Bonus is at its maximum: 0.020					

1. Measured RFS = twice the 2D distance between the Nominal and Measured points.

2. Measured MMC = twice the 2D distance between the Nominal and Measured points.

- CIRCLE: The MMC bonus is the difference between the measured diameter and the minimum limit, not to exceed total size of the tolerance band. There is no bonus if the part is smaller than the maximum limit.

- SHAFT: The MMC bonus is the difference between the measured diameter and the maximum limit, not to exceed total size of the tolerance band. There is no bonus if the part is larger than the maximum limit.

3. "+Tol" of RFS = Entered by operator.

4. "+Tol" of MMC = "+Tol" of RFS + Bonus.

5. "Out of tolerance" of RFS = Measured RFS minus the RFS tolerance.

6. "Out of tolerance" of MMC = Measured MMC minus the MMC tolerance.

RFS and MMC for a Measured Shaft

Measured	Nominal	+Tol.	-Tol.	Deviation	Out of Tol.
X: 0.016	0.000	+0.010	-0.010	0.016	0.006
Y: 0.000	0.000	+0.010	-0.010	0.000	*****
Z: 0.000	0.000	+0.010	-0.010	0.000	*****
Diam: 1.002	1.000	+0.010	-0.010	0.002	*****
RFS: 0.032^1		$+0.020^3$		0.032	0.012^5
MMC: 0.032^2		$+0.020^4$		0.032	0.004^6
Bonus = 0.008					

1. Measured RFS = twice the 2D distance between the Nominal and Measured points.

2. Measured MMC = twice the 2D distance between the Nominal and Measured points.

- CIRCLE: The MMC bonus is the difference between the measured diameter and the minimum limit, not to exceed total size of the tolerance band. There is no bonus if the part is smaller than the maximum limit.

- SHAFT: The MMC bonus is the difference between the measured diameter and the maximum limit, not to exceed total size of the tolerance band. There is no bonus if the part is larger than the maximum limit.

3. "+Tol" of RFS = Entered by operator.

4. "+Tol" of MMC = "+Tol" of RFS + Bonus.

5. "Out of tolerance" of RFS = Measured RFS minus the RFS tolerance.

6. "Out of tolerance" of MMC = Measured MMC minus the MMC tolerance.

True Position

ANSI Y 14.5M is very specific in its description of the meaning and usage of true position tolerance. FARO has incorporated True Position into CAM2 2021 with the intent of matching this specification as close as possible, based upon the amount and type of data that is made available during a normal measurement session.

True Position is defined as a cylindrical tolerance zone about the nominal center line, through the thickness of the material into which the hole was drilled (or the height of the stud). This tolerance requires three datum references that can make an orthogonal coordinate system. A point-reducible datum is not supported; however, bonus tolerance is permissible for MMC and LMC. To apply the concept of True Position to CAM2 2021 measurements, one must make some simplifying assumptions.

1. The datum features specified on the engineering drawing were used in the coordinate system.

2. There are small deviations between the nominal primary datum and the measured primary datum.

3. Material thickness is much less than the diameter of the feature.

4. Feature centerlines are perpendicular to the primary datum.

Regarding MMC and RFS, CAM2 2021 can apply these conditions to datums and features. CAM2 2021 calculates the True Position of features as follows:

*   For measured 2D features, the true position is calculated as twice the distance between the measured and the nominal as projected to the plane of the measured feature.
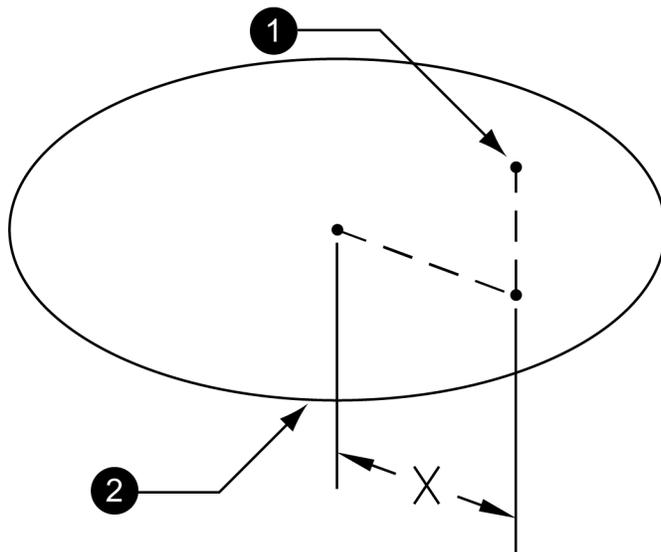
❶ Nominal

❷ Measured Circle

X = Distance between measured and nominal in plane of measured circle.
True Position = 2 * X

Figure 17-1 True Position of a Circle

A more exact definition would be twice the distance between the measured and the nominal, as projected to the plane of the nominal feature. But, since the plane of the nominal feature is not generally provided, it is practical to use the plane of the measured if the aforementioned simplifying assumptions are valid.
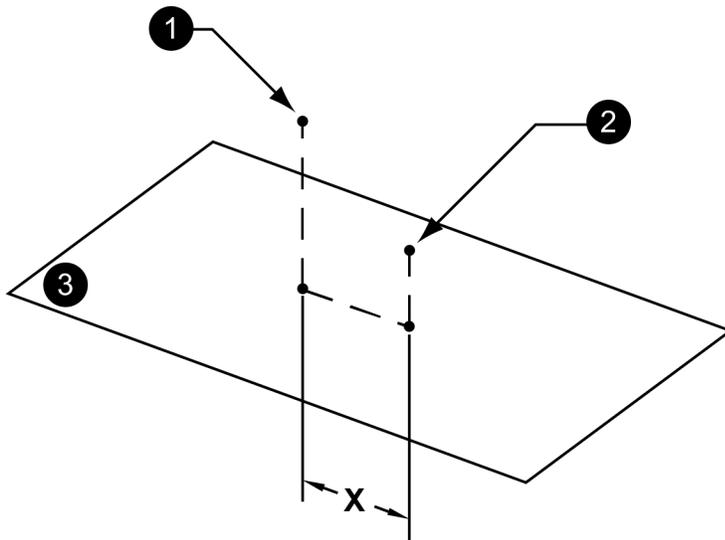
1 Measured

2 Nominal

3 XY Plane

X = Distance between measured and nominal in the XY plane.
True Position = 2 * X

Figure 17-2 True Position of a Point

MMC cannot be applied if there is no measured diameter from which to calculate a bonus tolerance. If the features cannot be measured as circles and do not lie in the XY plane, then manual calculations will need to be performed to determine the true position.

Glossary and Definitions

This section describes the glossary terms and definitions used in this manual.

Best Fit Arc
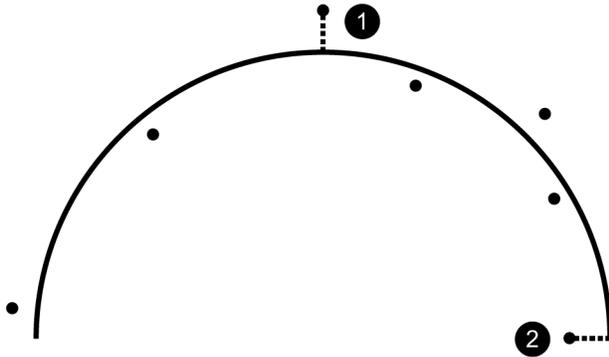
❶ Maximum Error

❷ Minimum Error

Best Fit Circle
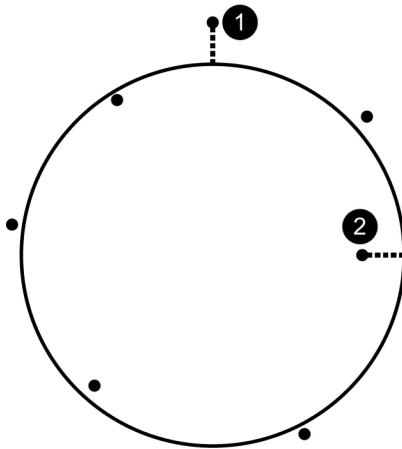
❶ Maximum Error

❷ Minimum Error

Best Fit Cone
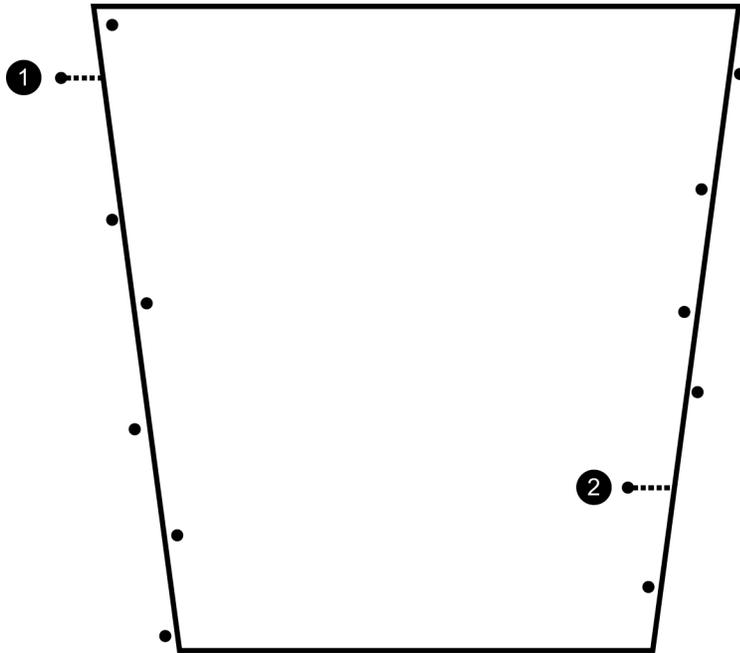
1 Maximum Error

2 Minimum Error

Best Fit Cylinder
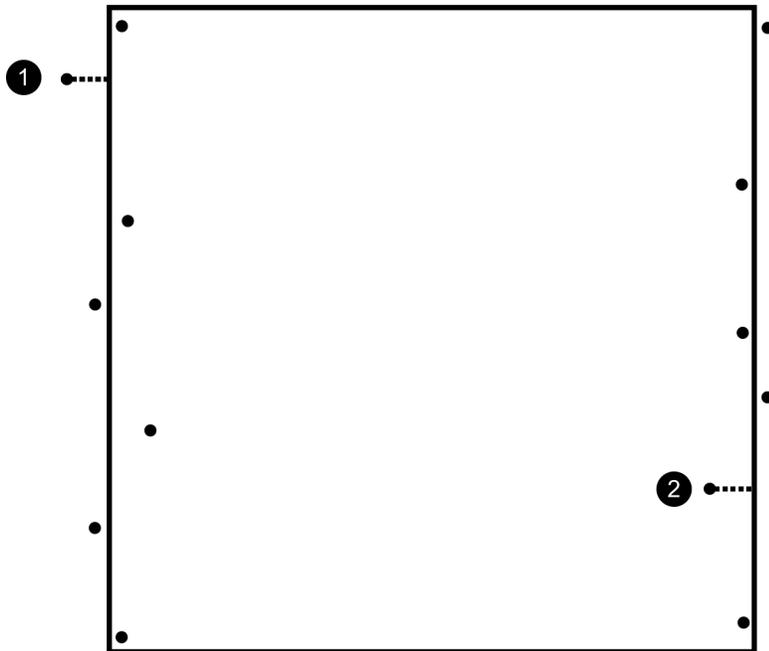
1 Maximum Error

2 Minimum Error

Best Fit Ellipse
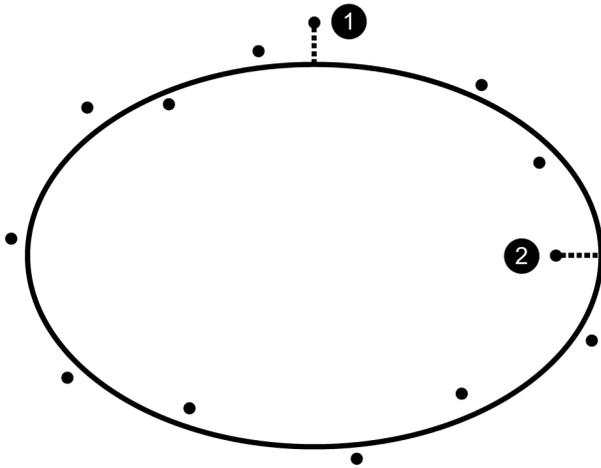
❶ Maximum Error

❷ Minimum Error

Best Fit Line
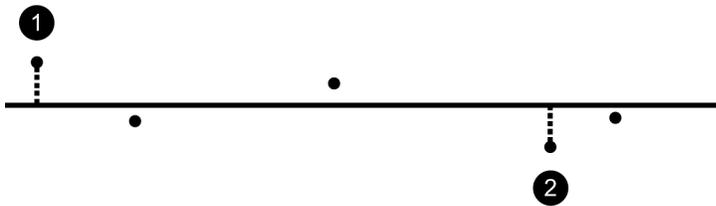
❶ Maximum Error

❷ Minimum Error

Best Fit Paraboloid
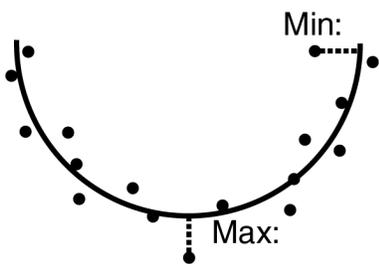
❶ Maximum Error

❷ Minimum Error

Best Fit Plane
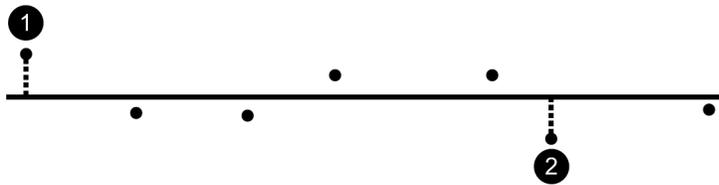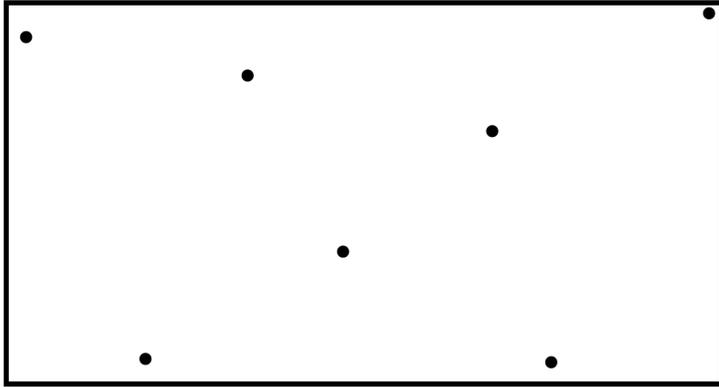
❶ Maximum Error

❷ Minimum Error

Best Fit Point
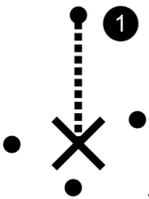
❶ Maximum Error

Best Fit Rectangular Slot
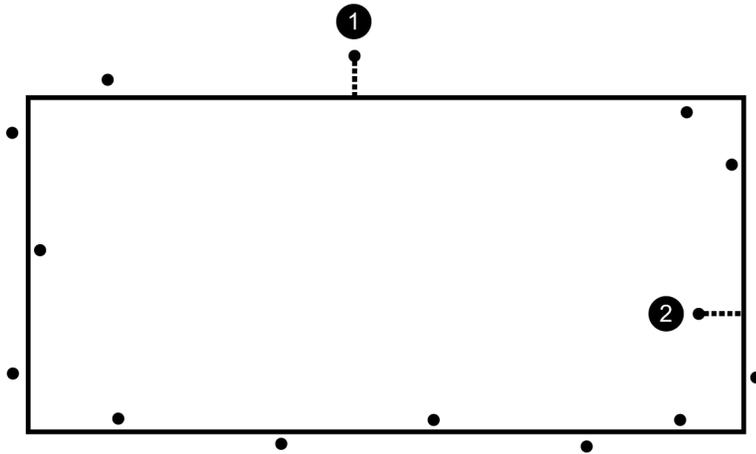
❶ Maximum Error

❷ Minimum Error

Best Fit Round Slot

❶ Maximum Error

❷ Minimum Error

Best Fit Sphere
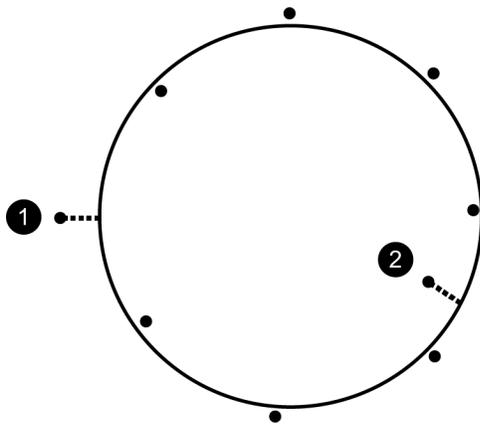
❶ Maximum Error

❷ Minimum Error

Best Fit Torus
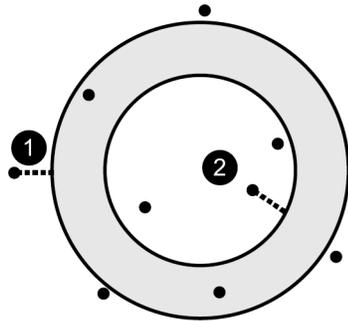
❶ Maximum Error

❷ Minimum Error

Right-Hand Rule

Cartesian coordinates describe the position of points in space relative to three mutually perpendicular axes X, Y, & Z. The intersection of these axes form the origin, or zero of the system.

Each axis emanates from the origin according to the right-hand rule. The right-hand rule defines the positive direction of each axis, such that when the hand is positioned according to the figure below, the + Z points along the thumb, the + X axis points along the index finger, and the + Y axis points along the middle finger.
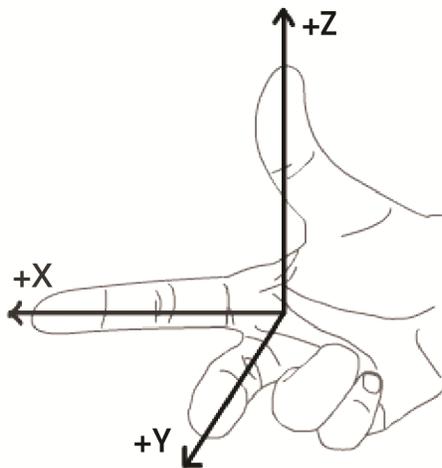
NOTE: CAM2 2021 does not support left hand rule coordinate systems.

Unsolved Features

A feature that does not have the minimum readings to complete the calculation of the feature, or a feature that has enough readings and fails the best-fit calculation.

Digitize the Required Number of Points

Measuring a small percentage of a feature does not provide the most accurate representation of the feature. Since CAM2 2021 constructs a best-fit feature from the points you collect, the number of points collected and the spacing of those points directly impact the accuracy of the measurement result.

A common principle applies regardless of the feature you measure. The more points you collect, and the more evenly you distribute them over the part, the more repeatable your measurement result will be. For optimal results, we recommend collecting two times the minimum points plus one.
(Minimum number of points x 2 + 1).

When considering the distribution of the points over the part, remember that even distribution is best. If there are times when only a portion of the feature is accessible, then take as many points as you can on that portion. While this is not the ideal situation, taking as many points as you can will help ensure a better representation of the feature.

Measurement Command (Not requiring a projection plane)	Minimum number of points needed to solve the feature	Optimal number of points to solve the feature
Plane	3	7
Cone	6	13
Cylinder	6	13
Line 3D	2	5
Point	1	1
Sphere	4	9
Ring	6	13

Measurement Command (Requiring a projection plane)	Minimum number of points needed to solve the feature	Optimal number of points to solve the feature
Arc	3	7
Circle	3	7
Ellipse	6	13
Line 2D	2	5

Measurement Command (Requiring a projection plane)	Minimum number of points needed to solve the feature	Optimal number of points to solve the feature
Rectangular Slot	6	13
Round Slot	6	13

Technical Support

FARO Technologies, Inc. is committed to providing the best technical support to our customers. If you have any problem using one of our products, please follow these steps before contacting our Technical Support Team:

• Be sure to read the relevant sections of the documentation to find the help you need.

• Visit the FARO Customer Care area on the Web at *www.faro.com* to search our Knowledge Base. This is available 24 hours a day 7 days a week.

• Document the problem you are experiencing. Be as specific as you can. The more information you have, the easier the problem will be to solve.

• If you still cannot resolve your problem, have your device's Serial Number available *before calling*.

Support Hours (Monday through Friday)

North America:

8:00 a.m. to 7:00 p.m. Eastern Standard Time (EST).

Europe:

8:00 a.m. to 5:00 p.m. Central European Standard Time (CET).

Asia:

8:30 a.m. to 5:30 p.m. Singapore Standard Time (SST).

Japan:

9:00 a.m. to 5:00 p.m. Japan Standard Time (JST).

China:

8:30 a.m. to 5:30 p.m. China Standard Time (CST).

India:

9:30 a.m. to 5:30 p.m. India Standard Time (IST).

You can also e-mail or fax any problems or questions 24 hours a day.

Phone

North America:

800 736 2771, +1 407 333 3182 (Worldwide)

Mexico:

001-866-874-1154

Brazil:

0800-047-4271, +55 11 3500-4600

Europe:

+800 3276 7378, +49 7150 9797-400 (Worldwide)

Asia:

1800 511 1360, +65 6511 1350 (Worldwide)

Japan:

0120.922.927, +81 561 63 1411 (Worldwide)

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+662.7441273-6 (Worldwide)

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End User Documents

All documents related to the Software End User License Agreement, Purchase Conditions, and FARO Products Service Policy can be found on the FARO Knowledge Base at the following URL: *https://knowledge.faro.com/Essentials/General/FARO_End_User_License_Agreement_Location*.

Glossary

3

3D
Three dimensional

3D Distance
The distance between a nominal feature's center and a measured/constructed feature's center.

3D Dynamic
Refers to the rotation of a computer model of a part in virtual space.

3D Image
The three dimensional representation of an object.

3D Modeling
The creation of a three dimensional mathematical model of an object; typically performed using digitizing devices.

3D Surface
The three dimensional representation of the boundary of a region in space.

A

Actual Feature
A feature or measurement that exists and is not merely potential or theoretical.

Alignment
The establishing of a coordinate system on a part, typically in reference to a coordinate measurement machine. See also "CMM."

Angle
The figure defined by two lines extending from the same point.

Angularity
Angularity measures how much a surface, axis, or plane can deviate from an angle described in the design.

Apex
In reference to an angle, the point from which the two lines of the angle emanate. See also "Vector."

Arc
A segment of a circle.

Axis
Any line used as a fixed reference in conjunction with one or more other references for determining the position of a point or a series of points.

B

Basic Measurement Strategy, CAM2 2021
Look at what you need to measure and consider the following questions: What should you include in the formal Report? Which features (geometric elements) do you need to capture? Which features can you Measure directly (i.e., planes, circles, cylinders, lines, etc)? Which features do you need to Construct (e.g., bolt hole circle) Which Dimensions do you need? (e.g., circle center to circle center) What logical sequence should you use to move around the part and capture the features? For example, left to right, top to bottom, or measure all planes first, then circles, etc.

Best Fit

Creating a feature that fits a set of points so each point is the shortest distance to the feature.

Bisect

To divide into two equal parts.

Bisector

A feature (line or plane) which is created and equidistant at all points from two existing features.

Bolt Hole Pattern

A group of holes which is intended to accept bolts from a mating part in an assembly.

C

CAD

Computer-Aided Design

CAD/CAM

CAD refers to computer-aided design. CAM refers to computer aided modeling. Some software packages perform both functions and are referred to as CAD/CAM.

CAE

Computer-Aided Engineering

CAMM (CAM2)

Computer-Aided Manufacturing Measurement

Circle

A closed planar curve in which every point on the curve is equidistant from the center.

Circularity

Circularity measures the form deviation of a circle.

Coincident Points

Points that have the same XYZ value.

Collinear

Data points which lie on the same line.

Computer Aided Design (CAD)

Software which replaces or augments manual drafting and design. Allows parts to be designed using computer software, and stored in an electronic database.

Concentricity

Concentricity measures how well a cylinder (line) fits inside of another cylinder (line).

Cone

A basic or prismatic feature defined as a region generated by revolving a right triangle about one of its legs.

Conicity

The deviation of measured data points from the resultant cone.

Construction

A feature created from measured features.

Coordinate System

A system of representing points in a space of given dimensions by coordinates, such as the Cartesian coordinate system or the system of celestial longitude and latitude. A coordinate system is a system by which uses one or more features, or coordinates, to uniquely determine the position of a point or other geometric element as a frame of reference.

Coplanar

Points or features which lie in the same geometric plane.

Corner

The point resulting from the intersection of three planes.

Cross Section

A section made by a plane cutting anything transversely, especially at right angles to the longest axis.

Curvature

The deviation of a feature from a straight line.

Curvature change

The change in the slope of a curved feature.

Cylinder

A geometric feature formed by extruding a circle along its centerline in a direction normal to its plane.

Cylindrical

A part which is similar to a cylinder in shape.

Cylindricity

Cylindricity measures the form deviation of a cylinder.

D

Datum

A datum (plural datums or data) is a reference from which measurements are made. In engineering and drafting, a datum is a reference point, surface, or axis on an object against which measurements are made.

Datum Coordinate

The XYZ values of a feature used to establish an alignment.

Device Position

The location of the measurement device relative to the measurements of your part.

Diameter

The width of a circular of cylindrical feature.

Digitizing

Storing data points in the computer system. See also "Scanning."

Dimensioning

The function of determining the relationship between geometric features.

Distance

The degree of separation between geometric features.

Drawing

The engineering documentation that indicates how a part is to be manufactured, assembled, or installed.

DRO

Digital ReadOut. The display of XYZ coordinates on the screen.

E

Edge points

Data points which lie on the edge or border of a part.

Electrostatic Discharge (ESD)

Electronic pulses generated by the discharge of loaded objects and/or people.

Ellipse

A geometric feature resulting from the intersection of a plane with a cylinder at an angle other than 90 degrees.

Entity

A feature or object in a CAD database.

ESD

Electronic pulses generated by the discharge of loaded objects and/or people.

Ethernet

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN).

Evaluation / to evaluate

The review of a product or process for suitability for its intended purpose.

External shape

The boundary which encloses a geometric form.

F

Fabrication drawing

An engineering drawing that specifies how a part is to be manufactured.

Feature

Refers to an attribute of a part or a geometric object. See also "Solved Feature" and "Unsolved Feature"

Feature Reducibility

Part of a feature that can be used for constructions and dimensioning.

Field of View (FOV)

The horizontal and vertical angle that the FARO 3D Imager cameras view.

Filtering

Filtering allows you to reduce the number of points in point clouds while still maintaining the characteristics of the scanned object.

Fine Registration

Fine Registration solves all of the registered point clouds simultaneously in order to distribute the error and improve the overall fit of the registration group. See also "Registration."

Fit

How easily two mating parts can be assembled.

Flatness

Flatness measures the form deviation of a plane.

Form

The maximum bandwidth (Max. Error added to the Min. Error) of error that a set of measured points deviates from the true form of the resultant feature calculated from that set of points.

G

GD&T

Geometric Dimensioning and Tolerancing. A system of specifying engineering design and drawing requirements with respect to actual function and relationship of part features.

Geometric features

A shape that can be expressed using standard shapes i.e. circle, line, and arc.

H

Hardware

Refers to the mechanical portion of a computer-based system. Opposite of Software.

Hardware lock

Dongle or port lock. Provides software security using a computer chip that attaches to the parallel (printer) port on a computer.

Hot Keys

See also "Keyboard Shortcuts."

I

Inputting

Refers to the keying in of data.

Intersection

A meeting or crossing at a point.

ISO

International Organization for Standardization

Isometric

A "3D" view of a part from a direction which is equiangular from each coordinate axis.

Iterative Alignment

A means of aligning measured data to CAD data by best fitting through many repetitions or iterations.

J

Jump drive

See also "USB Drive."

K

Key-in

To manually enter data using a keyboard.

Key-in alignment

The software function that creates a new coordinate system based upon translation and rotation relative to an existing coordinate system.

Keyboard Shortcuts

One keystroke commands which invoke a software function.

L

Layer

A software tool used to group features and entities.

Least Material Condition (LMC)

Line-to-plane

A type of angular dimension.

Line intersect

A type of alignment based upon a plane and two lines.

M

Max. (Maximum) Error

The largest distance from a reading above or outside a best-fit feature.

Maximum Material Condition (MMC)

Maximum material condition is that condition of a part feature wherein it contains the maximum amount of material within the stated limits of size. For a hole, the MMC is defined as the condition when the diameter is at the lowest end of its tolerance band. For a stud, the MMC is defined as the condition where the diameter is at the highest end of its tolerance band.

Measure

To capture data points to determine the size, position, and form of feature. See also "Digitizing" and "Scaning."

Mid-Point

A point which is equidistant from two other points.

Min. (minimum) Error

The largest distance from a reading below or inside a best-fit feature.

MT

Material Thickness

N

NIST

National Institute of Standards and Technology

Nominal

The theoretical value for a feature.

Nominal Feature

A feature with nominal values created from a CAD entity of keyed in values.

Normal

The vector which defines a direction perpendicular to a curve or surface at a specific point.

O

Off-line

Any function which does not require a specific device to be connected.

Offset

To create a feature that is equidistant by a specified distance at all points.

On-line

A function which indicates that a specific device must be connected to perform a specific function.

Orientation

In reference to Geometric Dimensioning and Tolerancing, it is the type of dimension that pertains to the orientation of one feature relative to a datum feature. Such as Parallelism, Perpendicularity and Concentricity.

Origin

The point from which the axes of a coordinate system emanate.

Orthogonal coordinates

Coordinates which are perpendicular.

Out Of Tolerance (OOT)

The condition where the measure value exceed the nominal value combined with the tolerance value.

P

Pan
In CAD, to change the position of the viewing window relative to the model.

Parallel
Two lines or planes which are equidistant at all points.

Parallelism
Parallelism measures the condition of a plane that is equal in distance at all points from the datum plane.

Perpendicular intersect
A type of alignment which requires a plane, line and point, where the origin is defined at the projection of the point on to the line.

Perpendicularity
Perpendicularity measures the condition of a plane at a right angle (90 degrees) to a datum plane.

Plane
A geometric feature defined by a point and a vector. A flat surface.

Plane-to-Plane
A type of distance dimension which yields the perpendicular distance between the centroid of the second plane and the first plane.

Point-to-Line
A dimension type which yields the perpendicular distance between the point and the line.

Point-to-Point
A dimension type which yields the 3D distance between two points.

Point Cloud
A set of points in a three-dimensional coordinate system that are typically intended to be representative of the external surface of an object.

Point reducible feature
A feature that has a repeatable center point such as a circle or sphere.

Polyline
A multi-segmented line.

Position
The location of a feature in a coordinate system.

Prismatic
Taking the shape of a prism or 3 dimensional object whose faces are represented by regular geometric features.

Prismatic features
A feature that can be represented by regular geometric shapes. The opposite of curves and surfaces.

Profile of a Line
A Line is a two-dimensional geometric tolerance that controls how much a polyline, or curve, can deviate from the true profile. It represents the smallest tolerance zone conforming to the nominal curve contour that will hold the entire measured surface.

Profile of a Surface
A three-dimensional geometric tolerance that controls how much a surface can deviate from the true profile. It represents

the smallest tolerance zone conforming to the nominal surface contour that will hold the entire measured surface.

Project to
To reproduce or move in a prescribed direction.

Projection Plane
For all 2D features, the plane that all readings are projected to before best fit calculations are started.

Q

QuickTools
A set of RPM commands in a list to play anytime the drawing file is open, facilitating repeatable part measurement.

R

Re-capturing
In reference to digitizing, the re-measurement of erroneous data points.

Reading
The individual point of a feature measured with the device.

Readout
The visual display of data on a computer screen. See also "Digital ReadOut."

Rectangular
A polygonal shape whose corners intersect at right angles.

Regargless of Feature Size (RFS)

Registration
Registration is the joining of two or more spatially disjointed point clouds using common references, effectively stitching multiple point clouds into one. See also "Fine Registration."

Resolution
The number of decimal places that a measurement device can reliably display.

Reverse Engineering
The creation of design or CAD data from an existing or prototype part.

Right Hand Rule
A coordinate system where the positive direction of each axis is described by three fingers of the right hand.

Rotation
Angular motion about a specified point or axis.

Roundness
The deviation of the measured data points from the true form of the resultant circle.

S

Slot
An elongated hole with round or squared ends.

Smoothing
Smoothing allows you to refine "noisy" point cloud data to achieve a smoother surface.

Software
Refers to the application of a computer-based system. Opposite of Hardware.

Solve

To calculate the results of a measurement or feature.

Solved Feature

A feature with enough readings to calculate. See also "Unsolved Feature."

Spherical

A shape which is similar to that of a sphere.

Sphericity

The amount by which the measured data points deviate from the resultant sphere.

Spline

A smooth curve which cannot be represented by a simple mathematical function.

Straightness

The amount by which the measured points deviate from the resultant line.

Surface

The outer boundary of an object.

Surface off-set

An output surface that is equidistant from an input surface at all points.

Surfacing

The technique of creating 3D models by defining the outer boundary of objects in virtual space.

T

Tolerance

A zone of accuracy in both size and placement of a feature. For example, a hole of a diameter of 1.00 ± 0.01 located at the x, y, z of 1.000, 1.000, 0.000 $\pm$ 0.005 means a 1 unit diameter hole can be between 1.01 and 0.99 in size and the location can be plus or minus 0.005 units from the specified nominal location. You determine the quality of a part by comparing your actual values to the nominal values within a tolerance range.

Total Runout

Total Runout controls the composite surface variations of circularity, cylindricity, parallelism, straightness, taper and profile of a surface where applied to features constructed around a datum axis.

True Position

Refers to a GD&T callout that specifies how a feature such as a hole is to be positioned on a part as well as toleranced. A true position callout may also specify additional tolerance or "bonus" if the hole is over-sized or if a shaft is under-sized (maximum or least material condition; MMC or LMC).

U

Unit Vector

A directional line with a non-dimensional magnitude of one. The line may be associated with the normal vector of a surface at a specific location. The vector is described in relation to the current alignment using the letters I, J, and K that are associated to X, Y, and Z.

Universal Serial Bus (USB)

Universal Serial Bus (USB) is an industry standard that establishes specifications for cables and connectors and protocols for connection, communication and power

supply (interfacing) between computers, peripherals and other computers.

Unsolved Feature

A feature without enough readings to calculate. See also "Solved Feature."

USB

Universal Serial Bus (USB) is an industry standard that establishes specifications for cables and connectors and protocols for connection, communication and power supply (interfacing) between computers, peripherals and other computers.

USB Drive

A storage device integrated with the USB interface.

V

Vector

A term used to describe the direction of a line or object that may or may not have a magnitude. The line may be associated with the normal vector of a surface at a specific location. The vector is described in relation to the current alignment using the letters I, J, and K that are associated to X, Y, and Z.

Vertex

The point of intersection of two sides of an angle.

Volume

The amount of space occupied in three dimensions.

W

Whisker

A single line that visually represent distance data of a feature.

X

X, Y, Z

Refers to the Cartesian Coordinate System for three-dimensional space.

Z

Zoom

A command used to change the view of the design on the screen, specifically to show a closer view.

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