



**FaroArm®EDGE™ and
ScanArm® Manual
September 2010 - DRAFT**

©FARO Technologies, Inc., 2010. All rights reserved.

No part of this publication may be reproduced, or transmitted in any form or by any means without written permission of FARO Technologies Inc.

FARO TECHNOLOGIES INC. MAKES NO WARRANTY, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, REGARDING THE FAROARM AND ITS MATERIALS, AND MAKES SUCH MATERIALS AVAILABLE SOLELY ON AN “AS-IS” BASIS.

IN NO EVENT SHALL FARO TECHNOLOGIES INC. BE LIABLE TO ANYONE FOR SPECIAL, COLLATERAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING OUT OF THE PURCHASE OR USE OF THE FAROARM OR ITS MATERIALS. THE SOLE AND EXCLUSIVE LIABILITY TO FARO TECHNOLOGIES INC., REGARDLESS OF THE FORM OF ACTION, SHALL NOT EXCEED THE PURCHASE PRICE OF THE MATERIALS DESCRIBED HEREIN.

THE INFORMATION CONTAINED IN THIS MANUAL IS SUBJECT TO CHANGE WITHOUT NOTICE AND DOES NOT REPRESENT A COMMITMENT ON THE PART OF FARO TECHNOLOGIES INC. ACCEPTANCE OF THIS DOCUMENT BY THE CUSTOMER CONSTITUTES ACKNOWLEDGMENT THAT IF ANY INCONSISTENCY EXISTS BETWEEN THE ENGLISH AND NON-ENGLISH VERSIONS, THE ENGLISH VERSION TAKES PRECEDENCE.

FARO[®] FaroArm[®] FARO Laser ScanArm[®] and CAM2[®] are registered trademarks of FARO Technologies, Inc.

Acrobat[®] is a registered trademark of Adobe Systems, Inc.

Bluetooth[®] is a registered trademark of Bluetooth SIG, Inc.

Table of Contents

Chapter 1 : Introduction

General Information.....	3
Regulatory Information	4
Product Environmental Information	7
Precautions	8

Chapter 2 : Setup

The EDGE Packing Contents	9
Packing the EDGE	10
Hardware Setup.....	11
Mounting the Base	11
<i>Surface Mount Plate Dimensions</i>	12
7-Axis Handle.....	14
EDGE Power Supply	14
Supplying Power to the EDGE	14
EDGE Battery Pack	15
<i>Installing the Battery Pack</i>	16
<i>Removing the Battery Pack</i>	16
<i>Charging the Battery Pack</i>	16
Fold-Down Touch Screen Controller	17
Host Computer	17
Wired connections	17
<i>Ethernet</i>	18
Wireless Connections	18
<i>FARO Wireless - Bluetooth</i>	19
<i>FARO Wireless - WLAN</i>	22
<i>Wireless Zero Configuration Reference</i>	26
Auxiliary Port (7th Variable Options Port).....	27

Chapter 3 : Operation

Numerical and Signal Processing	29
Handle LED	29
Error and Status Indicators	30
Referencing the Encoders.....	31

EDGE Handle Buttons 32

Chapter 4 : Probes

EDGE Probes 35

- Custom Probes..... 36
- Installing Probes 36

Renishaw TP-20 Probe Installation and Operation 37

Custom Probe Calibration..... 40

FARO Laser Line Probe 40

- Laser Safety 40
- Laser Radiation Emission 41
- Serial Number Label 42
- Servicing 42
- Hardware Installation 43
- Holding the FARO Laser Line Probe 45
- Hardware Controls and Indicators 45
 - Buttons* 45
 - LEDs* 46
 - Range Finder*..... 46
- Software Setup..... 47
- Calibration..... 47
 - Sphere Calibration* 49
 - Plane Calibration* 52
- DRO 56
- FARO Laser Line Probe Settings..... 57
 - Line Probe Settings* 58
 - Additional Considerations*..... 62

Chapter 5 : Accuracy

Calibration and Certification 67

- EDGE Calibration 67
- EDGE Certification 68
 - Repeatability* 68
 - Volumetric Accuracy* 69

EDGE Performance 70

- Loss of a Degree of Freedom..... 71

Chapter 6 : Maintenance and

Troubleshooting

Normal Maintenance	73
Mounting Stiffness Test	74
Temperature Considerations.....	75
Electrostatic Discharge (ESD).....	76
Troubleshooting	79
Power Issues.....	80
Hardware Communication Issues.....	81
FARO Wireless Connection Issues	82
FARO Wireless FAQ	83
FARO i-Probe FAQ	84
EDGE/ScanArm Performance Verification Checklist	87
<i>Issues That Will Degrade Accuracy</i>	<i>87</i>
<i>EDGE Setup</i>	<i>88</i>
<i>Probe Setup</i>	<i>89</i>
<i>Probe Calibration</i>	<i>89</i>
<i>Mounting</i>	<i>90</i>
<i>Single Point Articulation Test (SPAT).....</i>	<i>91</i>
<i>Calibrated Artifact</i>	<i>92</i>
<i>Diagnosing FARO Laser Line Probe Accuracy Problems.....</i>	<i>93</i>
<i>FARO Laser Line Probe Calibration</i>	<i>95</i>

Chapter 7 : Configuring the FaroArm® in CAM2® Measure

Device Setup	99
Hardware Configuration.....	100
Probes	101
Edit Probe	102
Probe Compensation Overview	103
Compensate Probe	104
<i>Hole Method - Guidance</i>	<i>104</i>
<i>Hole Method</i>	<i>107</i>
<i>Sphere Method.....</i>	<i>109</i>
<i>Six-Axis FaroArm</i>	<i>109</i>
<i>Seven-Axis FaroArm.....</i>	<i>111</i>
View Log	113
Diagnostics	114

Temperature 114

Chapter 8 : Configuring the FaroArm® in CAM2® Q

Device Control Panel..... 115

Technical Support..... 119

Software License Agreement A-1

Purchase Conditions B-1

Industrial Products Service Policy C-1

Industrial Service Policy D-1

Chapter 1: Introduction

Thank you for choosing FARO's Portable Measurement Arm - the FaroArm®EDGE™, and FARO's Portable Laser Line Measurement Arm - the ScanArm®. This document contains detailed instructions on how to use your new USB/TCP-IP communication-based or WLAN/Bluetooth® wireless EDGE, and the FARO Laser Line Probe. Additional information about probes and important guidelines on maintaining your new EDGE/ScanArm is also included. If you have any questions or need further instructions about any procedure, contact your Customer Service Representative by Phone, Fax or E-Mail. See *“Technical Support” on page 43.*

Visit the FARO Customer Care area on the Web at www.faro.com to search our technical support database. The database is available 24 hours a day, 7 days a week, and contains hundreds of solutions to product and application questions.

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

ALL CAPITAL text	Indicates directory names, menu names, buttons, tabs, key names, acronyms, and modes.
monospaced text	Indicates alpha/numeric characters or values you enter in a field on the screen. For example, “Type 0 . 005 for the tolerance setting.”
bold text	Anything you must enter exactly as it appears on your keyboard. For example, to type a:install , you would see text in bold type exactly as it should be entered.
SMALL CAPS text	Indicates dialog box, icon names, and window names.

You may also see a few new words. It is important that you understand the meaning of these words before proceeding.

digitize	To record the XYZ coordinates of a point or location in 3D space. The word digitize is the same as the term <i>measure</i> when referring to points.
choose or select	Means that you are initiating an action. For example, “Select FILE < GRAPHICAL REPORTS < EXPORT DATA.”
left-click, right-click, click, or press	Press and release the LEFT (or RIGHT) MOUSE button. Also used when referring to the EDGE buttons. For example, “After selecting a file from the OPEN FILE dialog box, <i>click</i> OK to open the file” or “ <i>Press</i> ESC at anytime to cancel a command.”
drag	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

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like 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

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like 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.

General Information

The EDGE is a 7-axis, articulated arm with a spherical working volume. Each joint has a rotary optical encoder. The signals from these encoders are processed, using advanced error coding and temperature compensation technology, and positional data is sent to the host computer using various wired and wireless communication protocols.

The Base Assembly contains the majority of the electronics, including a power switch, status indicators, fold-down touch screen controller, battery bay, and communication ports. There are five major communications ports on the EDGE located on the Base Assembly:

- USB 2.0 Host Port (located on the fold-down controller)
- USB 2.0 Device
- Ethernet (802.3)
- Bluetooth® (Internal Base Module)
- Wireless Local Area Network (WLAN 802.11 - Internal Base Module)

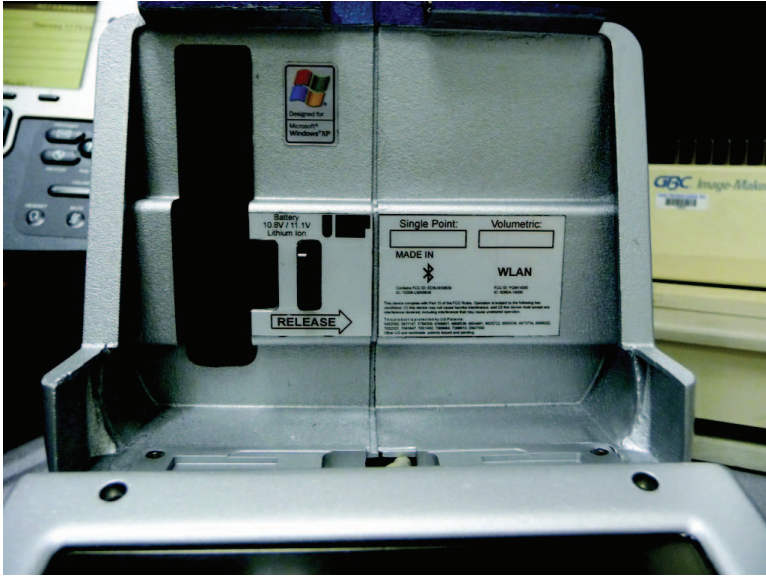
The EDGE uses a non-volatile read/write FLASH memory. This memory stores programming and some calibration data for the EDGE. There are proprietary methods that are capable of erasing, reading, and writing the FLASH memory. These methods are used during manufacturing and field updating. Security for the FLASH is limited to the anonymity of the access methods and the unavailability of documentation for the address structure of the FLASH memory.

The only dynamic data stored in the EDGE are settings which relate directly to the operation of the EDGE. Examples include the probe XYZ position, baud rate for serial EDGES, etc. The EDGE does not maintain in memory, or cache, measurement data of any type. Measurements recorded with the EDGE are sent directly to the properly connected computer.

The Probe End Assembly is found at the farthest point from the base. It is free to rotate, has two control (Red and Green) buttons and two circumferential light pipe indicators that provide visual feedback to the user. This assembly provides for the attachment of probes and handle accessories.

Regulatory Information

Regulatory information for the wireless components of the EDGE is listed on the back of the base. Open the fold-down touch screen controller to see this label.



Bluetooth

FCC ID: ED9LMX9838
IC: 1520A-LMX9838

DECLARATION OF CONFORMITY

FCC Compliance Statement:

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

- 1 This Device may not cause harmful interference, and
- 2 This device must accept any interference received, including interference that may cause undesired operation.

Information To The User:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These

limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/television technician for help.

CAUTION: Any change or modification not expressly approved by FARO Technologies, Inc. may void the user's authority to operate the equipment.

NOTE: Bluetooth can be used concurrently with the USB Device and/or Ethernet ports but not the WLAN (802.11g) port. **The WLAN (802.11b/g) interface is disabled by hardware and firmware.**

DECLARATION OF CONFORMITY

Industry Canada Statement

This device complies with RSS-210 of Industry Canada.

Operation is subject to the following two conditions:

- 1 This device may not cause interference, and
- 2 this device must accept any interference, including interference that may cause undesired operation of the device.

CAUTION: EXPOSURE TO RADIO FREQUENCY RADIATION

The installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population: consult Safety Code 6, obtainable from Health Canada's website www.hc-sc.gc.ca/rpb

Wireless Local Area Network (WLAN 802.11)

FCC ID: YQM14000

IC: 9265A-14000

DECLARATION OF CONFORMITY

FCC Compliance Statement:

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

- 1 This Device may not cause harmful interference, and
- 2 This device must accept any interference received, including interference that may cause undesired operation.

Information To The User:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/television technician for help.

CAUTION: Any change or modification not expressly approved by FARO Technologies, Inc. may void the user's authority to operate the equipment.

NOTE: The WLAN (802.11b/g) can be used concurrently with the USB Device but not the LAN (Ethernet) or Bluetooth ports. **The Bluetooth interface is disabled by hardware and firmware.**

DECLARATION OF CONFORMITY

Industry Canada Statement

This device complies with RSS-210 of Industry Canada.

Operation is subject to the following two conditions:

- 1 This device may not cause interference, and
- 2 this device must accept any interference, including interference that may cause undesired operation of the device.

CAUTION: EXPOSURE TO RADIO FREQUENCY RADIATION

The installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population: consult Safety Code 6, obtainable from Health Canada's website www.hc-sc.gc.ca/rpb

Product Environmental Information

Legislation is now in place within the European Union (EU) that regulates waste from electrical and electronic equipment (WEEE). European Directive 2002/96/EC on Waste Electrical and Electronic Equipment (the WEEE Directive) stipulates that WEEE is now subject to regulations designed to prevent the disposal of such waste and to encourage design and treatment measures to minimize the amount of waste that is placed into the waste stream. The objective of the WEEE Directive is to preserve, protect and improve the quality of the environment, protect human health, and stimulate the practical use of natural resources. Specifically, the WEEE Directive requires that producers of electrical and electronic equipment be responsible for the collection, reuse, recycling and treatment of WEEE which the Producer places on the EU market after August 13, 2005.

FARO Technologies, Inc., as a producer of electrical and electronic equipment (EEE), has endeavored to meet these environmental responsibilities for managing WEEE. In so doing, FARO is providing the following to inform its customers about the WEEE collection process:

In order to avoid any potential dissemination of hazardous substances into the environment, FARO has labeled this product with the WEEE symbol (see below) in order to alert the end-user that it should be disposed of within the proper waste management system. That system will recycle, reuse, and dispose of materials from this product in an environmentally sound way.

The symbol represented below, and found on this FARO Technologies product, indicates that this product meets the European Directive 2002/96/EC on Waste Electrical and Electronic Equipment. This symbol, only applicable in European Union countries, indicates that when this product reaches the end of its useful life it should not be disposed of with normal household or municipal waste, but in an established waste stream for WEEE.

Each EU Member State country has established a system for the collection, disposal, and recycling of WEEE. End-users in the EU should contact their local waste administration system for collection instructions concerning this product.

Refer to *www.faro.com* for further environmental information concerning this product.



WEEE Symbol

Precautions

The EDGE is a precision measuring device that is ruggedized for shop use; however, care must still be exercised in the operating environment when using the EDGE. Proper operation and care includes avoiding:

- Solvents.
- Abuse, such as dropping or twisting at end stops.
- Moisture and high humidity.
- Power fluctuations. See “EDGE Power Supply” on page 14.
- Excessive temperature changes without appropriate elapsed time. See “Temperature Considerations” on page 75.

Your FaroArm®EDGE™ can give you many years of service when you treat it with care.

Chapter 2: Setup

The EDGE Packing Contents

The following components and accessories are standard items shipped with every system:

EDGE - Packing List

- Shipping Case
- EDGE
- EDGE Assembly Instructions
- EDGE Manual (this book)
- FaroArm® Accessories Manual
- EDGE Certification Documents
- Dust Cover
- Power Supply with electrical cable
- 7-Axis Handle
- Probe Case:
 - Two probes
 - Renishaw Adapter (i-Probe case only)
 - FARO Calibration Cone
 - FARO Calibration Sphere (i-Probe case only)
 - 12mm wrench
 - FARO probe torque wrench (i-Probe case only)
- USB cable
- Lithium Ion Smart Battery Pack
- Surface Mount Plate

NOTE: There are two different Probe Case options: Standard Probe Case, and i-Probe Case.

Optional Accessories

The *Accessories Manual* that comes with your EDGE lists all of the optional accessories that you can order from FARO. Installation and detailed operational instructions are included.

The *Accessories Manual* is also available on FARO's Web site at www.faro.com. To purchase optional accessories, contact FARO's

Customer Service by Phone, Fax or E-Mail. See “*Technical Support*” on page 43.

Packing the EDGE

The EDGE should be packed very carefully to prevent shipping damage.

- 1 Pack the ①Power Supply, ②Probe Case, and ③Surface Mount Plate as shown.

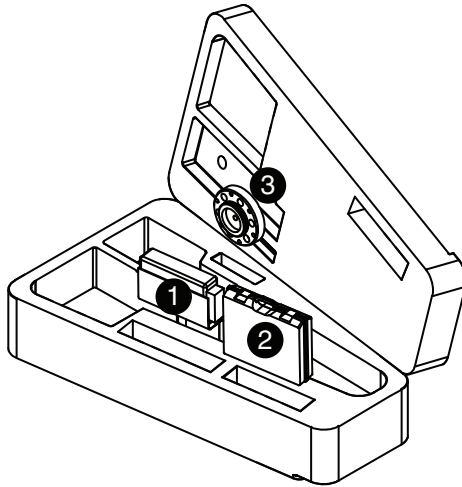


Figure 2-1 Pack the Power Module, Probe Case, and Surface Mount Plate

NOTE: Remove the 7-Axis Handle from the EDGE before packing. See “*7-Axis Handle*” on page 14.

- 2 Grasp the EDGE with both hands as shown.

- 3 Insert the EDGE into the case.

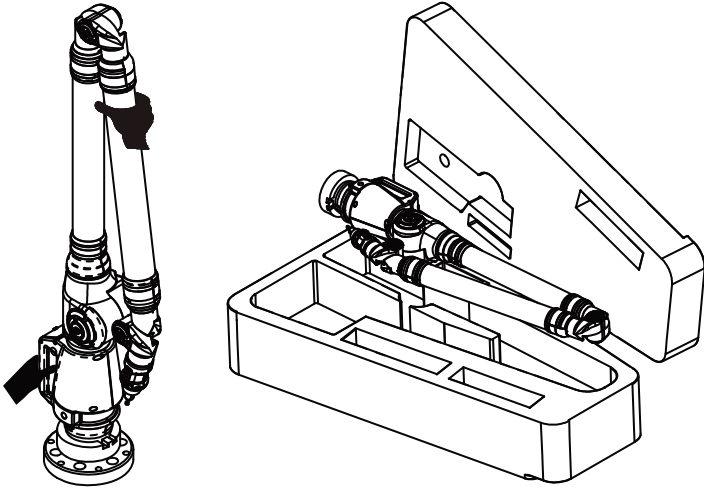


Figure 2-2 Insert the EDGE into the Case

Hardware Setup

The following sections describe the proper setup of the EDGE system. This includes attaching the EDGE to your work surface and connecting the EDGE to your computer.

Mounting the Base

The counterbalance by the tension spring generates torque at the base of the EDGE; therefore, the mount must meet certain requirements to achieve optimum machine accuracy.

NOTE: The EDGE *must* be mounted in a upright position. *Do Not* mount the EDGE in an inverted (upside down) or sideways position.

To mount the EDGE:

- 1 Attach the 3.5" threaded ring and surface mount plate to any stable location. Tighten all mounting bolts to 100-inch pounds.
- 2 Place the EDGE on top of the 3.5" threaded ring.
- 3 Fold out the collar clamp handles and screw the threaded collar clamp onto the 3.5" threaded ring.

- 4 Use the collar clamp handles to tighten the threaded collar clamp.

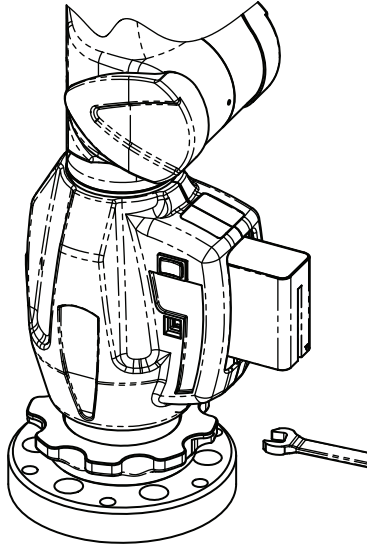


Figure 2-3 Mounting the EDGE

For more information see “*Mounting Stiffness Test*” on page 74 and “*EDGE/ScanArm Performance Verification Checklist*” on page 87.

Surface Mount Plate Dimensions

The Surface Mount Plate is used to clamp or bolt the EDGE to a stable mounting surface. It is an assembly of a standard 3½” mounting ring and a FARO designed base plate.

You can bolt the Surface Mount Plate directly to a surface using the mounting screws in the Probe Case. Make sure to tighten each mounting screw with the hex wrench.

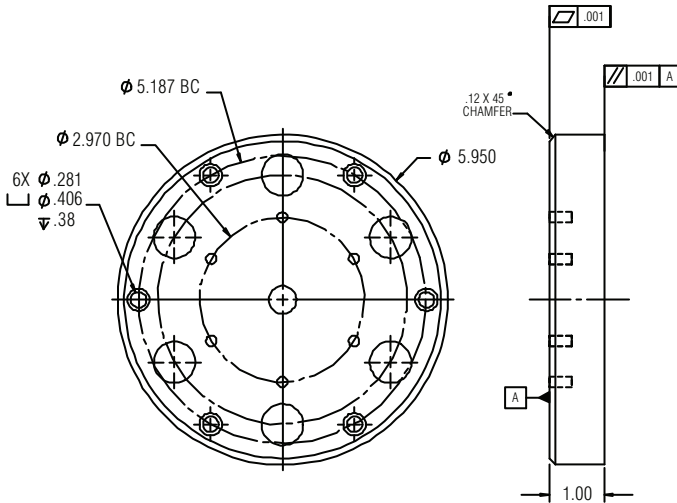


Figure 2-4 Surface Mount Plate dimensions

You can bolt the 3½” mounting ring directly to a surface using the mounting screws in the Probe Case. Make sure to tighten each mounting screw with the hex wrench.

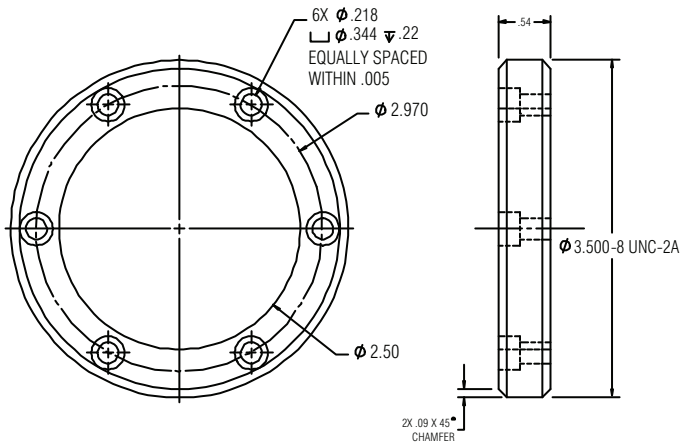


Figure 2-5 Standard 3½” Mounting Ring dimensions

7-Axis Handle

You can attach a pistol-grip handle to the end of the EDGE to give you another control option. The 7-Axis handle *can* be attached/detached while the EDGE is powered On. To attach the handle:

- 1 Loosen the locking ring by turning it counterclockwise.
- 2 Insert the front edge of the 7-Axis handle into the slot.
- 3 Push the 7-Axis handle in so that the connectors connect.
- 4 Tighten the locking ring by turning it clockwise. Do not over tighten the ring.

NOTE: Remove the 7-Axis Handle from the EDGE before packing. See “Packing the EDGE” on page 10.

The FARO Laser Line Probe attaches in the same method. See “FARO Laser Line Probe” on page 40.

EDGE Power Supply

Power the EDGE with the supplied power supply. The power supply is NRTL Listed for US and Canada. For IEC member countries and Europe, the power supply must be certified for the country in which the equipment is sold. Contact FARO’s Customer Service to order a replacement. All servicing should be referred to qualified service personnel.

Rated Voltage:	100 - 240V ~ 47 - 63 Hz
Voltage Tolerance:	+10% or -10%
Rated Input:	1.4A
Sec. Voltage:	+18 VDC
Sec. Current:	3.6A
Pollution Category:	2
Installation Category:	2



CAUTION (INDOOR USE ONLY)

Supplying Power to the EDGE

Place the EDGE in an area with a properly grounded outlet receptacle. The On/Off switch is located on the back side of the base. Ensure the

On/Off switch is in the *OFF* position before supplying power. Connect the Power Supply cord to the port on the back side of the base.

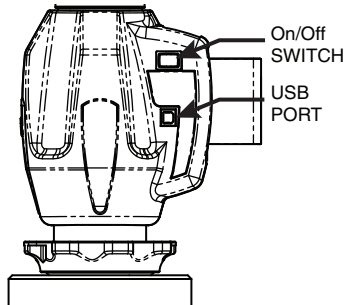


Figure 2-6 Mounting the EDGE

WARNING: Do not disconnect or isolate the ground pin on the power supply cord.

Select the proper power supply cord intended for installation in a protected environment. The power supply automatically adjusts to the voltage.

- For 120V Connection: Use a UL Listed, type SJT or SVT, 3-Conductor, 18 A.W.G. power supply cord, terminating in a molded-on plug cap rated 125 VAC, 15A minimum, with a minimum length of six feet.
- For 220 - 240V Connection: Use an international harmonized, 300V rated, PVC insulated jacket, three conductors of 0.75mm² minimum cross-sectional area, each with a molded-on plug cap marked with proper agency marking for the country where it will be used.

NOTE: Power surges, spikes, feedback, and fluctuation in the power source will affect the equipment and its electronic accessories. Please have your power source inspected by a professional to provide the cleanest power source possible.

EDGE Battery Pack

Your EDGE may be powered using the supplied battery pack. Install the battery pack to power your EDGE when you are not near a grounded power outlet. On the front side of the base, open the fold-down touch screen controller to access the battery pack slot.

NOTE: It is not necessary to install the battery pack if the EDGE is connected to a power outlet.

Installing the Battery Pack

Slide the battery pack with the rounded side down.

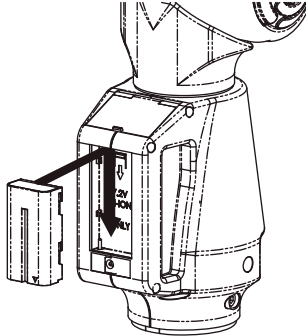


Figure 2-7 Installing the battery

Removing the Battery Pack

Push the battery release lever to the right and pull out the battery pack.

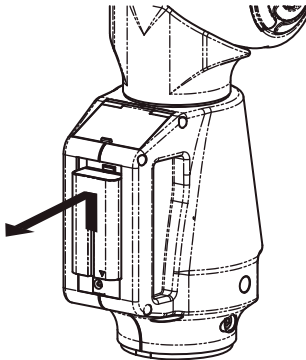


Figure 2-8 Removing the battery

Charging the Battery Pack

Install the battery pack and connect the EDGE to a power outlet and the battery will begin to charge. The battery will charge if the On/Off switch is set to the *OFF* position. Charging automatically stops when the battery pack is completely charged. The DIAGNOSTICS dialog box displays the current status of the battery pack. See “Diagnostics” on page 96. The battery pack also has a built-in charge meter. Press the soft button near the connector and look at the LEDs to see the current charge.

WARNING: Only use the rechargeable battery pack supplied with your EDGE. For information on ordering additional or replacement battery packs, contact FARO's Customer Service by Phone, Fax or E-Mail. See *“Technical Support” on page 43.*

Fold-Down Touch Screen Controller

Located on the front side of the EDGE base is a touch screen controller. The controller is built into a panel that folds-down from the top of the base. Press the locking latch at the top of the base to open the panel, and access the touch screen controller.

Host Computer

The EDGE output is accepted through any PC-compatible computer using the following communication protocols:

- USB 2.0 (Device)
- Ethernet (802.3)
- Bluetooth
- Wireless Local Area Network (WLAN 802.11)

You can use multiple communication protocols with the following limitations:

- USB, Ethernet, and Bluetooth are active at the same time, WLAN is disabled
- USB and WLAN are active at the same time, Bluetooth is disabled.
- WLAN is disabled if Ethernet is active
- WLAN is disabled if Bluetooth is active

Wired connections

USB communication connects from the EDGE to the computer using a standard USB cable. High speed operation is supported.

Ethernet communication connects from the EDGE to the computer using a regular or crossover twisted-pair Ethernet cable (Cat 5, Cat5e or

Cat 6) with RJ-45 connectors. When Ethernet is used the EDGE is configured as a DHCP Client.

The USB and Ethernet connectors are located on the back side of the base.

NOTE: In a multiple computer networking environment, you should consult your Information Technology (IT) department for assistance with installing the EDGE.

CAUTION: Complete all cable connections before applying power to the computer and the EDGE.

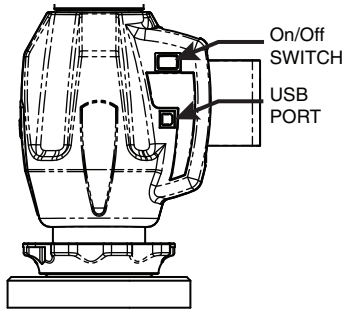


Figure 2-9 EDGE wired communication ports

NOTE: For optimum performance, allow the EDGE to warm-up for at least 30 minutes before using.

Ethernet

- 1 From the MAIN screen, choose CONNECTION.
- 2 Select the ETHERNET icon.
- 3 Select ENABLE TCP/IP.
- 4 Select EHTERNET in the DHCP column.

Wireless Connections

The EDGE is equipped to connect to your computer using different wireless connections.

FARO Wireless - Bluetooth

The EDGE is a Bluetooth® equipped device and can connect to your computer without using a cable.

Bluetooth wireless is a short-range communications technology intended to replace the cables connecting devices. The range of a Class 2 system, such as the EDGE, is approximately 30 feet or 10 meters. Bluetooth devices are generally paired, or associated with each other, either openly or employing security, with one serving as the master device and the second as the slave. In the case of the EDGE:

- The EDGE is the slave.
- The host computer is the master.
- Basic PIN based security is employed.
- The host computer establishes an RS-232 emulation or Serial Port Profile (SPP) connection to the EDGE.
- Once the connection is established the PC and EDGE can transfer data at a rate of 921600bits/second.

NOTE: If a EDGE is connected with USB cable and Bluetooth, only the Bluetooth connection will be active.

EDGE to the Computer Connection

Create the wireless connection between the host computer and the EDGE created using:

- Software supplied with a Bluetooth equipped computer, or an aftermarket USB Bluetooth dongle and software.
- FARO Bluetooth Connection Setup utility software.

NOTE: Implementation will differ among software suppliers, but generally there is a platform specific Bluetooth Wizard that will

search for all Bluetooth devices in range and display them graphically, or in a simple list.

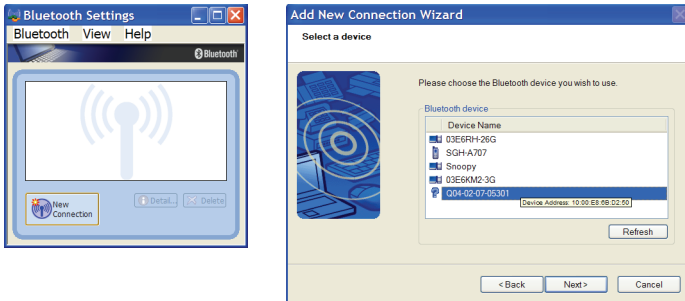


Figure 2-10 Connecting the EDGE to the Computer

All EDGES are identified by their serial number. Once an EDGE is identified in the list, a persistent SPP connection must be created. Once the connection exists, the software will display the connection’s COM port number, for example *COM10*.

Write down your SPP connection COM port

This number is important and will be used later.

NOTE: If the platform specific Bluetooth Wizard finds two COM ports, usually labeled “Incoming” and “Outgoing,” for the EDGE, use the Outgoing COM port.

Computer to the EDGE Driver Connection

The EDGE USB driver connects to the SPP connection using the FARO Bluetooth Connection Setup utility software.

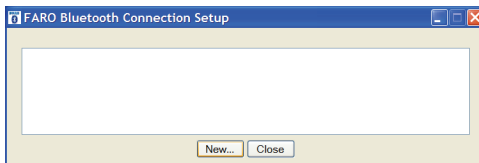


Figure 2-11 Connecting the EDGE to the Computer

- Start FARO Bluetooth Connection Setup utility software program.

- Click the NEW button.

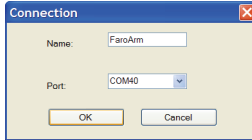


Figure 2-12 Connection Name and COM port

- Type a name for your connection
- In the PORT list select the proper COM from the platform specific Bluetooth Wizard (e.g. COM10). This is the port that you previously wrote down.
- Click the OK button.

A test is automatically run to verify that the COM port is connected to the EDGE.

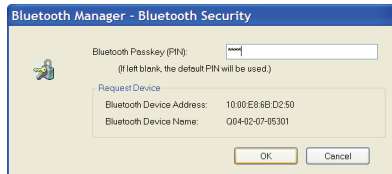


Figure 2-13 EDGE Bluetooth PIN

- Enter the EDGE PIN security code, *f a r o*.
- Click OK to save the connection.

An icon will be created for each Bluetooth pairing. The icon *with* the check box selected is an active connection. The icon *without* a check box selected is an inactive connection.

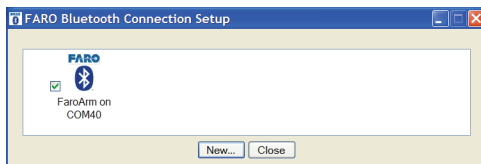


Figure 2-14 Connecting the EDGE to the Computer

NOTE: No more than two (2) EDGE pairings can be active at any one time, but any number can be defined.

Editing a Pairing

Right-click any Bluetooth pairing icon to edit. You can:

- Edit the name and the COM port.

- Test the pairing connection.
- Delete the pairing.

Using the EDGE Bluetooth Pairing

When the measuring software is launched (CAM2 Q, CAM2 Measure, CAM2 Measure X, Geomagic, Polyworks, etc.) the EDGE driver attempts to use any EDGE connection - USB cable and any active Bluetooth pairings. It takes slightly longer, 8 or 10 seconds, for a EDGE to connect and initialize via Bluetooth.

NOTE: If you choose not to connect the EDGE to your computer using the wireless connection, deselect the icon check box in the FARO Bluetooth Connection Setup utility to deactivate the pairing and connect using the USB cable.

Once you start measuring, there is no difference in data transfer between using the Bluetooth connection or the USB cable.

FARO Wireless - WLAN

The EDGE is a Wireless Local Area Network (WLAN) equipped device and can connect to your computer without using a cable.

A WLAN is a series of interconnected computers that communicate with each other over the air waves rather than through a network cable connected to each computer. In a WLAN, a radio communications device called an access point, or wireless router, connects network computers and provides network access. The access point, or wireless router, and the wireless network card in the computer communicate by broadcasting data from their antennas over the air waves.

The EDGE WLAN is normally configured as a DHCP Client. Due to the nature of an open air system network security is very important. Before discussing EDGE WLAN setup a brief WLAN Primer is presented.

WLAN Primer

An EDGE node or station can connect to a WLAN that complies with the IEEE 802.11g standard. The Wi-Fi Alliance (an industry group promoting 802.11 networks) has popularized the term Wi-Fi® for 802.11 compliant networks. The term WLAN, refers to the slightly more generalized concept of the wireless extension of a local area network (LAN), though in practice most implementations use Wi-Fi technology.

The IEEE 802.11 standard specifies a Medium Access Control (MAC) and physical layers (PHY) for wireless connectivity between stations (STAs). A set of stations that have joined the same network have access to the same network services. These services are called a Basic Service Set (BSS). Every BSS has a unique 48-bit identifier called the Basic Service Set Identifier (BSSID). The standard specifies two types of BSS, and Independent BSS (IBSS) and an Infrastructure BSS (BSS).

There are several different PHY layers specified in IEEE 802.11. The Edge uses 802.11g.

IEEE 802.11 further breaks up the 2.4 GHz frequency band into 14 overlapping channels. Each country in the world has its own rules and regulations regarding radio usage. Many countries join together to coordinate these regulations, forming “Regulatory Domains”. Most European, Middle East, North and South American, African countries and Australia and Japan use the same regulations. However, there are differences with regard to which channels and power levels are permitted. The EDGE can support all 14 channels - factory programming is performed for the specific country the EDGE is to be used (this is not a user option).

Independent BSS (IBSS)

An IBSS is used to form an Ad Hoc network between peer STAs. STAs share responsibility for maintaining the IBSS and distributing data to each other. IBSS is *NOT* supported for the EDGE WLAN.

Infrastructure BSS (BSS)

In an Infrastructure BSS there is one special STA called the Access Point (AP). The AP is solely responsible for starting and maintaining the BSS and admitting (or excluding) other STAs. The AP receives all traffic either bound for or originating from every STA that it admits into its BSS. (Exception is contained in IEEE 802.11e amendment for Quality of Service - a special QoS BSS).

The STAs are known as Clients, the AP is known as a Server.

A Distribution System (DS) interconnects a set of AP's to create an Extended Service Set (ESS). The ESS is a super set of all member STAs. The DS distributes data between ESS STAs. An ESS may include LANs (via a gateway).

The simplest and most common configuration is to have an ESS that includes exactly one AP. It is known as a Small Or Home

Office (SOHO). This is the intended configuration for the Edge ARM Stations.

In an Infrastructure BSS, the AP broadcasts Beacon frames that announce the identity and capabilities of its BSS.

Joining a WLAN

An STA joins a WLAN using a three-step process:

- 1 Scanning
- 2 Association
- 3 Authentication

Scanning

STA generates a list of all BSSs (APs in the network) it can detect.

Association

In an Infrastructure BSS the Association process requires a frame exchange between the joining STA and the selected AP. This frame includes the STAs capabilities. The AP will accept or deny the request (Association Response Frame). The STA (Client) learns the BSSID (SSID - Service Set Identifier or WLAN name) and AP MAC address. If the STA is accepted the AP will issue an Association Identifier (AID - logical port) at this time.

Authentication

Apply Security - establish a secure wireless network. WPA2-Personal is recommended for the FARO WLAN security (based on IEEE 802.11i and Advanced Encryption Standard -AES). The password is the real key to security!

Establishing a FARO WLAN Connection

There are a minimum of three stations to be configured. This may be performed in any order but the typical order is:

- 1 Setup Access Point
- 2 Setup EDGE
- 3 Setup Host Computer

Access Point (AP)

Normally the Access Point is configured first. This setup may have been done by the your companies IT department. If this is the case, IT should provide the Network Name (SSID) and Password.

All Clients must use the same SSID and Password as the AP.

The recommended security setting is either WPA-PSK (TKIP encryption algorithm) {Good} or WPA2-PSK (AES-CCMP

encryption algorithm) { Better, if available }. You should use a Password of 10 or more random alphanumeric characters.

NOTE: Wi-Fi Protected Access (WPA).

The EDGE User Console - WLAN Client Setup Sequence

The Access Point should be configured and running.

- 1 From the MAIN screen, choose CONNECTION.
- 2 Select the Wi-Fi icon.
- 3 Select Enable TCP/IP.
- 4 Select DHCP WiFi to Network in the DHCP column.

NOTE: Only expert users should the Static IP option.

- 5 Click the NEXT arrow icon in the lower right corner of the screen.
The next screen is a list of active APs.
- 6 Select an active AP.
- 7 Click the NEXT arrow icon in the lower right corner of the screen.
The next screen is WiFi security. Enter the exact settings for the AP.

NOTE: The Password is case sensitive.

The Host Computer Setup

The Access Point should be configured and running.

The ease of configuring client stations depends principally on the configuration utility used. Windows XP comes with its own configuration utility built in, Windows Zero Configuration Utility (WZC). However, there are other configuration utilities that offer better efficiency, easier configuration, and better wireless monitoring. Most client cards come with their own wireless configuration utility, though others depend on Windows. Here we'll describe the configuration of client stations using WZC, which is the lowest common denominator for most users.

- 1 Add preferred network - Enter SSID (example here is "My Network SSID").
- 2 Configure Client to the same settings as the AP. To do so, click on the PROPERTIES button. The SECURITY PROPERTIES dialog box appears. The first text box will already be filled in with the SSID selected for the preferred network name.
- 3 In the NETWORK AUTHENTICATION drop-down window, select WPA-PSK.

- 4 In the DATA ENCRYPTION drop-down window, select TKIP.
- 5 The last step is most important - the Network Key entered and confirmed must be the same as the network key (password) that was entered on the AP.

NOTE: Network keys are case sensitive.

Wireless Zero Configuration Reference

The Wireless Zero Configuration programming interface is no longer supported as of Windows Vista and Windows Server 2008. Instead, use the Native Wifi API, which provides similar functionality. For more information, see *About the Native Wifi API* on the Microsoft web site. [http://msdn.microsoft.com/en-us/library/ms705969\(v=VS.85\).aspx](http://msdn.microsoft.com/en-us/library/ms705969(v=VS.85).aspx)

This section contains information on the programming interface for the Wireless Zero Configuration service on Windows XP. The topics include:

- *Wireless Zero Configuration Functions*
[http://msdn.microsoft.com/en-us/library/ms706587\(v=VS.85\).aspx](http://msdn.microsoft.com/en-us/library/ms706587(v=VS.85).aspx)
- *Wireless Zero Configuration Structures*
[http://msdn.microsoft.com/en-us/library/ms706600\(v=VS.85\).aspx](http://msdn.microsoft.com/en-us/library/ms706600(v=VS.85).aspx)

Wireless Zero Configuration is a Windows service on Windows XP that is used to configure and manage wireless network connections on a wireless adapter. The Wireless Zero Configuration service is normally started at boot time. The programming interface for the Wireless Zero Configuration service can be used only if the Wireless Zero Configuration service has been started. If the Wireless Zero Configuration service is not started, then the Wireless Zero Configuration functions will return an error.

To enable the Wireless Zero Configuration service so it starts up automatically:

- Select the START button
- Select the SETTINGS option and then select CONTROL PANEL
 - If you are using the Windows XP view, select the PERFORMANCE AND MAINTENANCE category and then select ADMINISTRATIVE TOOLS.
 - If you are using the Classic View, then select ADMINISTRATIVE TOOLS.
- Click the SERVICES icon in the left pane.

- Click the WIRELESS ZERO CONFIGURATION icon in the right pane and change the Startup Type drop-down window to AUTOMATIC. This setting will set the service to start automatically at boot time.
- Click the START button to start the Wireless Zero Configuration service and click the OK button.

The Wireless Zero Configuration can also be started and stopped from a command prompt. To start the Wireless Zero Configuration, run the following command:

```
net start wzcsvc
```

To stop the Wireless Zero Configuration, run the following command:

```
net stop wzcsvc
```

Auxiliary Port (7th Variable Options Port)

On the front side of the EDGE base, an optional communications port is available to connect external equipment. To get a list of approved FARO devices, contact your Customer Service Representative by Phone, Fax or E-Mail. See *“Technical Support”* on page 43.

WARNING: Only use FARO approved devices in this port. For more information about approved FARO devices, contact FARO’s Customer Service. Using other devices could damage your system and will void your maintenance/warranty service plan.

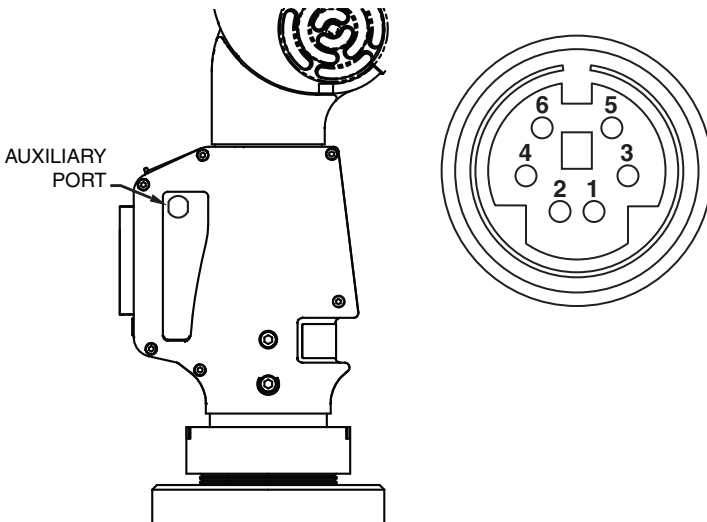


Figure 2-15 Auxiliary Port

Chapter 3: Operation

Numerical and Signal Processing

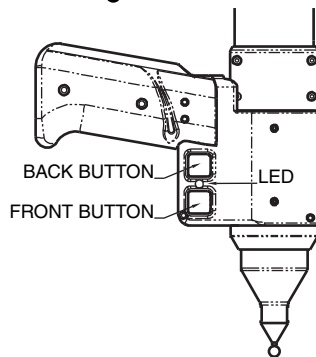
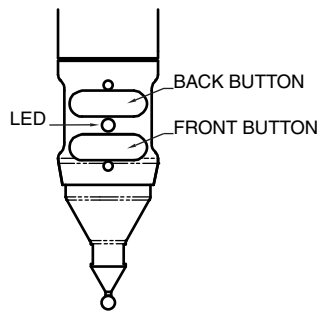
The EDGE includes a complete electronics system located within the body of the EDGE. Signals from each joint are processed and positional data is sent out to the computer.

NOTE: The EDGE electronics go into standby mode, or turn off, after two hours of no encoder movement. Move the EDGE to exit standby mode and reference the encoders to continue measuring. See “Referencing the Encoders” on page 31.

Handle LED

After applying power to the EDGE, the LED is SOLID GREEN while an internal startup check runs. After this is complete, the LED indicates the following:

- **FLASHING RED** - if the EDGE successfully communicates with the computer, and the encoders are not referenced. See “Referencing the Encoders” on page 31.
- **OFF** - if the EDGE successfully communicates with the computer, and the encoders are referenced. See “Referencing the Encoders” on page 31.
- **SOLID GREEN** - if the EDGE successfully communicates with the computer, and the encoders are referenced - Renishaw Probe only. See “Renishaw TP-20 Probe Installation and Operation” on page 37.



Error and Status Indicators

Through the driver interface to the measuring software, the EDGE generates and displays errors in the END STOP/STRESS WARNING dialog box.

- The encoder end stop warnings - This warning appears when an encoder reaches one end of its rotation.

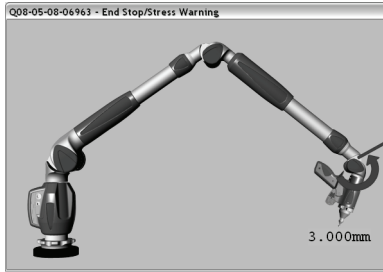


Figure 3-1 EDGE end stop warning

- The tube stress stop warnings - This warning appears when there is stress on one of the tubes or encoder joints. The stress stop warnings may be disabled. See "Hardware Configuration" on page 82.

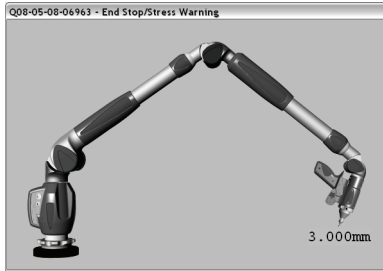


Figure 3-2 EDGE stress stop warning

- The unknown FARO i-Probe warning - This warning appears when a FARO i-Probe is attached to the EDGE and never calibrated. For accurate measuring, you *must* calibrate the probe. Use your measuring software to setup and calibrate the probe. See “Probes” on page 83.

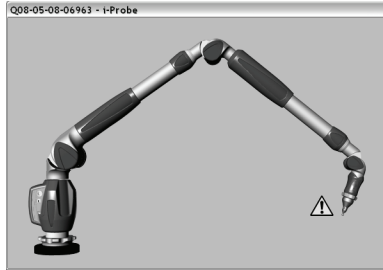


Figure 3-3 Unknown FARO i-Probe warning

- The missing FARO i-Probe warning - This warning appears when no probe is attached to the EDGE.

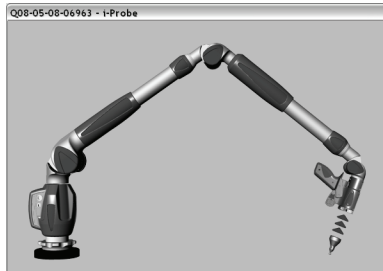


Figure 3-4 Unknown FARO i-Probe warning

- Other errors appear in a message box.

NOTE: The EDGE does not output data until the error has been cleared.

Referencing the Encoders

You must reference each of the six (or seven) encoders in the EDGE before the system can output data. The REFERENCE ENCODERS dialog box shows all six encoders in error until each is referenced. In a

systematic manner, rotate joints 1 through 6 (7) until each warning clears.

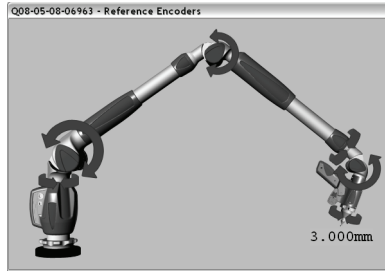


Figure 3-5 Referencing the encoders

NOTE: The EDGE must be properly connected to the host computer running the measuring software to see the REFERENCE ENCODERS dialog box.

EDGE Handle Buttons

The EDGE has two sets of two buttons and an LED, where the FRONT buttons and BACK buttons are redundant and wired together internally.

When a button is pressed, the LED light turns on (green or red) and the Computer sounds. See “Handle LED” on page 29.

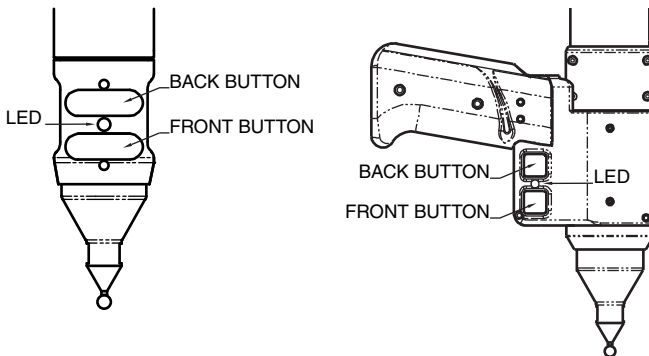


Figure 3-6 EDGE Handle Buttons

The FRONT button is used to collect data, and the BACK button to accept the data.

- The FRONT button is green and nearest the probe.
- The BACK button is red and is nearest the handle.

Handle Storage

The EDGE has a magnetic attached to tube 2 for easy storage of the

Chapter 4: Probes

EDGE Probes

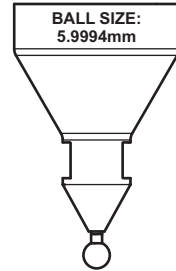
Two standard probes, one (1) 6mm Ball and one (1) 3mm Ball, are supplied with the EDGE. Each ball probe is stamped with the *exact* diameter of the ball (3.9997mm, 5.9994mm, etc.).

Start your measuring software (CAM2 Q, CAM2 Measure, CAM2 Measure X, Geomagic, Polyworks, etc.) and edit the existing 3mm and 6mm probes. Enter the exact diameter in the MODIFY PROBE dialog box for each ball probe. See “*Edit Probe*” on page 84.

The EDGE’s point of measurement on any ball probe is the center of the ball. Third-party feature measurement or quality control software compensates for the radius of the ball probe. Point probes are only recommended when the software will not compensate for the radius of the ball probe. The point probe has an impact on measurement accuracy. The error depends on:

- the width of the point on the probe
- the position and placement of the point on the object

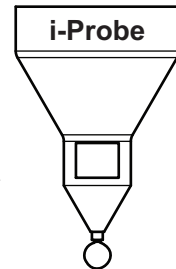
NOTE: For accurate measuring, you *must* calibrate the probe. Use your measuring software to setup and calibrate the probe. See “*Probes*” on page 83.



FARO i-Probe

The EDGE uses the optional FARO i-Probe. This is an electronically serialized intelligent probe that automatically provides its actual *exact* ball diameter to the EDGE and monitors probe body temperature to compensate for thermal deformation.

NOTE: FARO i-Probes will not attach to Platinum or Fusion series FaroArms. Installing the i-Probe to anything other than a Quantum series FaroArm damages the i-Probe.



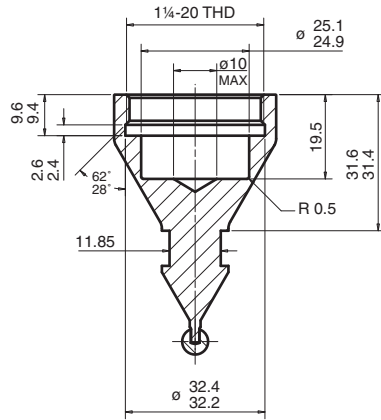
Custom Probes

You can create any size probe to attach to the EDGE.

- The EDGE Probe thread size is 1¼-20.
- The base of the probe should follow the shape of the FARO probes.

Your custom probe should be as rigid as possible. Any deflection in the probe will add inaccuracy to the EDGE system.

NOTE: FARO Technologies Inc. does not guarantee the accuracy of the EDGE with the use of a custom probe.



Installing Probes

The probe attaches to the threaded handle at the end of the EDGE. Use the 12mm wrench in the Probe Case to install the probe.

NOTE: Use the FARO probe torque wrench to tighten the FARO i-Probe. The probe wrench will break free when you apply the proper amount of torque.

- Hold the button area near the end of the EDGE with one hand.

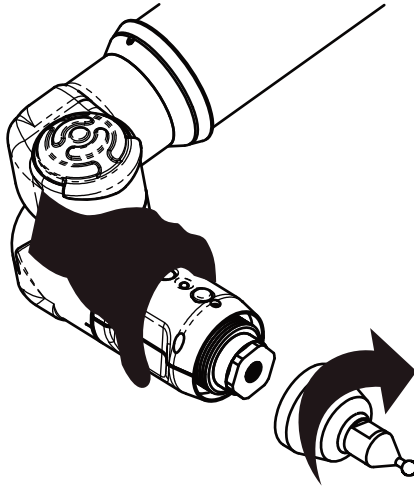


Figure 4-1 Installing a Probe

CAUTION: Do not hold the EDGE except in the button area when installing a probe. Holding the EDGE at the last joint may stress the tube and damage the system.

- Rotate the probe clockwise and thread the probe into the EDGE.
- Use the 12mm wrench to hand-tighten the probe.

CAUTION: Only *hand-tighten* the probe with the 12mm wrench. Do not over-tighten the probe.

Use your measuring software to setup and calibrate the probe. See “Probes” on page 83.

Renishaw TP-20 Probe Installation and Operation

The EDGE supports the Renishaw TP-20 touch-trigger probe by using the FARO i-Probe adapter to connect the TP-20 probe module to the EDGE handle. Simply attach this assembly just as you would any other probe. See “Installing Probes” on page 36.

The Renishaw TP-20 touch-trigger probe automatically digitizes a point by touching the stylus to the part.

NOTE: The Renishaw TP-2 Probe is *not* supported.

EDGE TP-20 Probe Kit

The EDGE TP-20 Probe kit contains:

- A magnetized TP-20 probe body
- Medium Force Probe Module
- Renishaw (S1) C Spanner wrench
- Renishaw (S7) stylus tool
- Renishaw (CK200) cleaning kit
- Renishaw Probe tip: 2mm (M2 D2R L10)
- Renishaw Probe tip: 6mm (M2 D6R L10)
- EDGE i-Probe adapter

NOTE: The product numbers in the parentheses are Renishaw part numbers. See the *Renishaw User's Manual* for more details.

To install the TP-20 Probe:

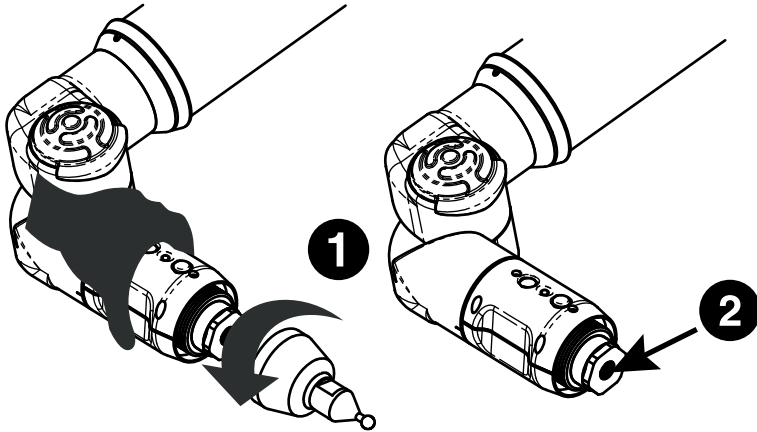


Figure 4-2 Installing a Renishaw Probe

- 1 Remove the current probe.
- 2 Install the EDGE i-Probe adapter. Tighten using the 12mm torque wrench.

- 3 Screw the TP-20 probe body into the EDGE i-Probe adapter and hand-tighten with the C Spanner (S9) wrench.
- 4 Attach a probe module to the TP-20 probe body. On the probe body and probe module are triangle, half-moon, and square markers that must be aligned for the probe to work properly.
- 5 Screw the Renishaw Probe tip into the probe module with the stylus tool (S7). Do not under- or over-tighten any of the components.

Probe Modules for the TP-20 Probe

Probe modules are available from Renishaw in three trigger force ratings:

- Standard Force Probe Module (Black cap)
- Medium Force Probe Module (Gray cap)
- Extended Force Probe Module (Brown cap)

Refer to the *Renishaw TP-20 Installation and User's Manual* for the TP-20 Probe assembly instructions.

Measuring Software

The measuring software must be configured for the probe.

- In CAM2 Q, choose the DEVICES < DEVICE CONTROL command and click the PROBE MANAGEMENT button. See “Change Probe” on page 98.
- In CAM2 Measure choose the PROBES command. See “Probes” on page 83.
 - Create a new probe and switch the auxiliary port to the ON position by placing a check mark in the Aux Switch check box. See “Edit Probe” on page 84.
 - Calibrate the probe using the FARO Calibration Sphere, or any precision sphere, after installation. See “Sphere Method” on page 91.

Some software packages have other probe options that must also be controlled. See the *Renishaw User's Manual* for more information.

The probe digitizes a point when it makes contact with an object. It may digitize multiple points when bounced off an object. Watch the LED light on the EDGE handle and listen to the sounds of the computer to

ensure that only one point was digitized. The LED light turns off and the computer sounds when a point is digitized.

Custom Probe Calibration

Any probe with a sphere or a point can be calibrated. See “*Compensate Probe*” on page 86.

FARO Laser Line Probe

The FARO Laser Line Probe is a non-contact probe that collects digitized points using a laser and a camera. The laser is projected onto your part as a line, the camera takes a picture of the shape and position of the line, and creates several points. These individual points are then sent to the computer.

Laser Safety

The FARO Laser Line Probe outputs a visible red laser beam. Although this is a CDRH Class II and IEC Class 2M power level, operation of the device requires the operator to avoid direct exposure to eyes at all times.

You should avoid direct exposure to your eye at all times. Although the human blink reaction to bright light provides a natural mechanism of protection to this visible laser beam, use caution while handling the FARO Laser Line Probe by pointing it at only the target object.

CAUTION: USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS LASER LIGHT EXPOSURE.

Laser Radiation Emission

When the FARO Laser Line Probe is operating, a laser beam emits from the aperture at the front of the FARO Laser Line Probe. See Figure 4-3 for the location of the laser beam aperture.

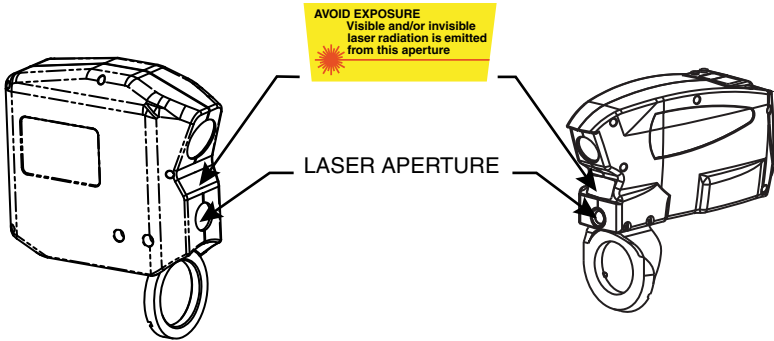


Figure 4-3 Laser Aperture

When the laser is operating, the LEDs on the back of the unit illuminate. See Figure 4-4 for the location of the laser emission indicator.

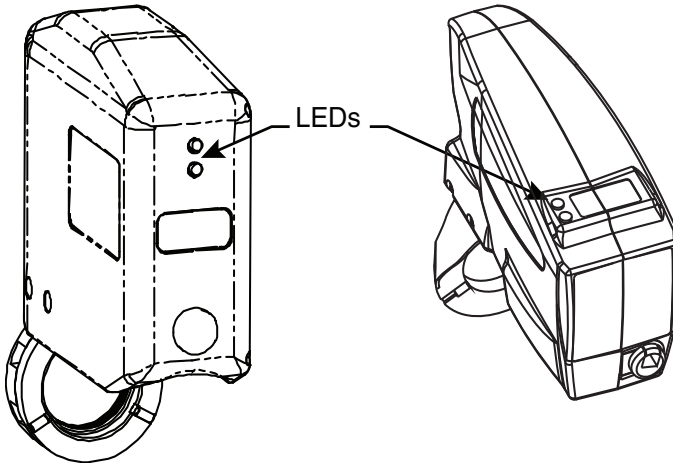


Figure 4-4 Laser emission indicator

These LEDs also indicate the range of the laser to the target surface. *For more information, see “LEDs” on page 46.*

CAUTION: VIEWING THE LASER OUTPUT WITH CERTAIN OPTICAL INSTRUMENTS (EYE LOUPES, MAGNIFIERS, AND MICROSCOPES, ETC.) WITHIN A DISTANCE OF 100 MM MAY POSE AN EYE HAZARD.

Laser power up to 5 mW at 660 nm in a diverging beam could be accessible in the interior of the FARO Laser Line Probe.

WARNING: DO NOT ATTEMPT TO OPEN THE FARO LASER LINE PROBE CASE. THERE ARE NO USER SERVICEABLE PARTS.

Serial Number Label

The FARO Laser Line Probe Serial Number label contains the serial number, laser information, certification, warning logotype and manufacturing date. See Figure 4-3 for the location of the laser beam aperture.

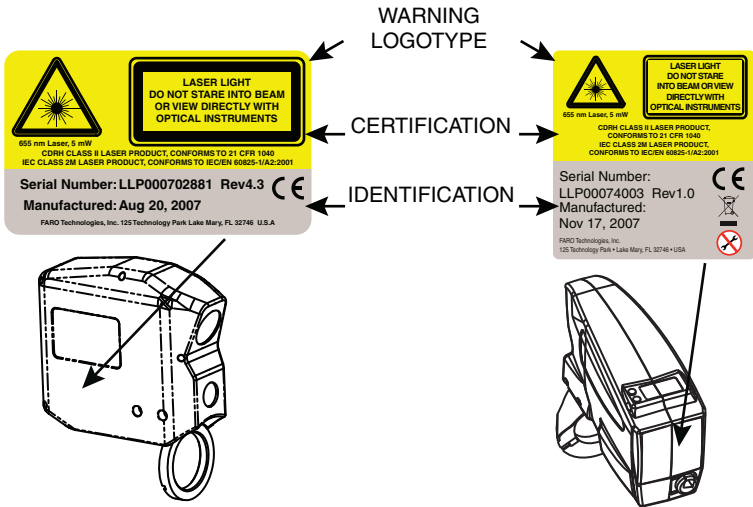


Figure 4-5 Serial Number label

Servicing

The FARO Laser Line Probe should only be serviced by FARO Customer Support technicians. There are no user serviceable parts in this device. DO NOT attempt to open the casing or disassemble the device at any time.

If the FARO Laser Line Probe is not operating properly, contact FARO Customer Support. If it has malfunctioned, power down the system, remove it from the EDGE and return it to FARO Customer Support for repair.

WARNING: DO NOT ATTEMPT TO OPEN THE FARO LASER LINE PROBE CASE. THERE ARE NO USER SERVICEABLE PARTS.

Hardware Installation

Installing the FARO Laser Line Probe is similar to any other EDGE probe. However, there is a Trim Ring ③ on the end of the handle that must be removed for the FARO Laser Line Probe to install correctly.

- 1 Turn Off the EDGE.
- 2 Remove any standard probe from the EDGE.
- 3 Remove the Trim ring from the EDGE handle.

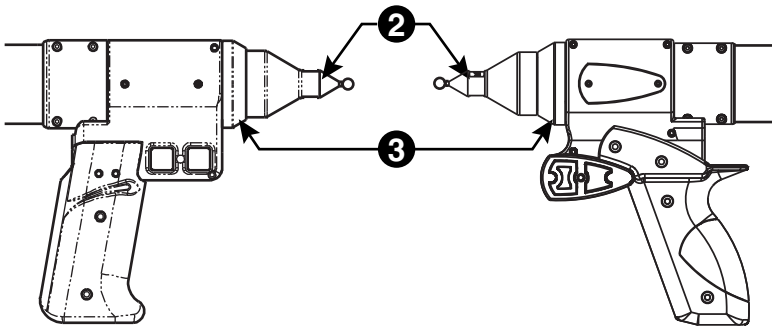


Figure 4-6 Remove Probe and Trim Ring

- 4 Attach the FARO Laser Line Probe by sliding it onto the top of the EDGE handle. Slide the ring all the way to the back of the threaded area, rotating the head slightly until the alignment pins seat into the alignment slots.
- 5 Thread the locking collar into place and tighten with the 12mm wrench from the EDGE Case. Do not over tighten the locking collar.
- 6 Install the 6mm or 3mm standard ball probe. See “Installing Probes” on page 36.

- 7 Connect the plug from the FARO Laser Line Probe to the options port. The options port is located on the back of the EDGE handle. Tighten the threaded connector.

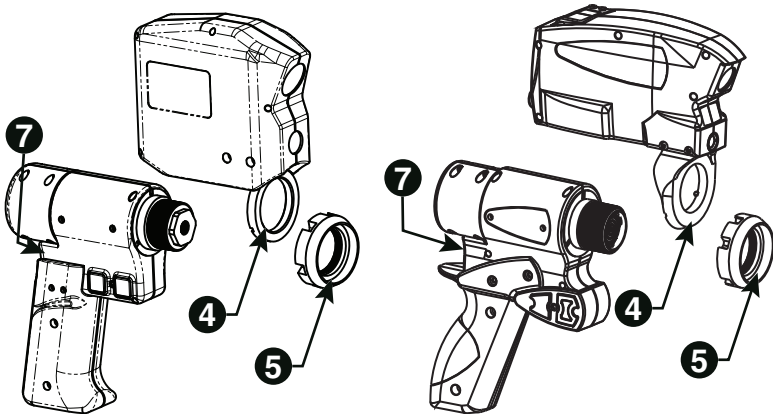


Figure 4-7 Install the FARO Laser Line Probe

CAUTION: Before inserting the connector, make sure that the power is *OFF*.

- Clean the top and bottom lenses with the cloth from the FARO Laser Line Probe Case. Dirt and grease on either lens can cause poor results.
- Connect the EDGE to the computer using the USB cable, and turn on the computer.
- Connect the EDGE power supply and switch on the EDGE. This also powers the FARO Laser Line Probe.
- Start the application software.

NOTE: Allow the FARO Laser Line Probe to warm-up:

- 60 minutes for version 1
- 30 minutes for version 2
- 15 minutes for version 3

Holding the FARO Laser Line Probe

Never grab the FARO Laser Line Probe while measuring. Simply hold the EDGE's pistol grip. Holding the FARO Laser Line Probe can cause inaccuracy due to bending of its mounting bracket.

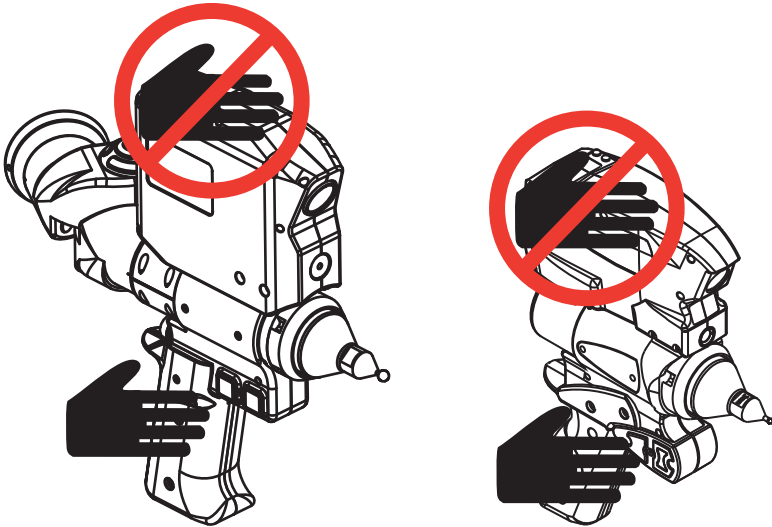


Figure 4-8 Holding the FARO Laser Line Probe

NOTE: Avoid touching both lenses. Clean the top and bottom lenses with the cloth from the FARO Laser Line Probe Case. Dirt and grease on either lens can cause poor results.

Hardware Controls and Indicators

The EDGE/FARO Laser Line Probe system uses the FRONT (Green) and BACK (Red) and two LEDs on the back of the FARO Laser Line Probe.

Buttons

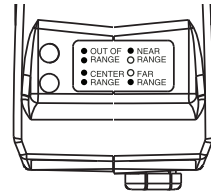
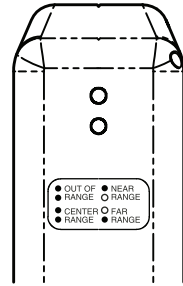
Use the FRONT (green) button to start data collection. Points are only sent to the computer when the laser is in range. Once you start collecting data, press the FRONT button again to pause.

Use the BACK (red) button to end any measurement command.

LEDs

The two LEDs, on the back of the FARO Laser Line Probe, indicate the distance to the target object from the FARO Laser Line Probe. Remember, data is only sent to the computer when the FARO Laser Line Probe is in range.

- Out of Range (two Red LEDs). The Laser Line Probe is too close or too far from the part.
- Center Range (two Green LEDs) The Laser Line Probe is in the center of the range.
- Near Range (top Green LED only) The Laser Line Probe is in range, closer to the part.
- Far Range (bottom Green LED only) The Laser Line Probe is in range, farther from the part.



Additionally, the software uses the RANGE FINDER dialog box to show the distance and position from the FARO Laser Line Probe to your part.

Range Finder

The FARO Laser Line Probe software has a RANGE FINDER dialog box. This dialog box graphically displays the laser to part distance and the area of the laser line that the camera is processing.

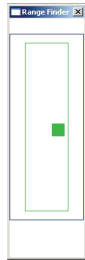


Figure 4-9 Laser Line Probe in range

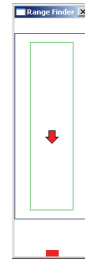


Figure 4-10 Laser Line Probe not in range

When the FARO Laser Line Probe is within the operating range, the center of the target displays as a small box in the RANGE FINDER dialog box, see Figure 4-9.

The box moves as the FARO Laser Line Probe moves:

- Up - as you move the Laser Line Probe closer to your part
- Down - as you move the Laser Line Probe farther from your part
- Left - the right side of the line is in range
- Right - the left side of the line is in range

The target box changes color:

- Green - all of the laser is in range
- Blue - some of the laser is in range
- Red - none of the laser is in range

When the FARO Laser Line Probe is outside of the operating range, the target box moves to a side of the RANGE FINDER dialog box and an arrow in the center of the dialog box points to the target box, see Figure 4-10.

If the FARO Laser Line Probe is set to automatic exposure, there is an additional symbol in the upper left corner of the RANGE FINDER dialog box. The symbol changes describes the exposure:

- Red Minus Sign (-) - low exposure
- Green Circle (O) - good exposure
- Red Plus Sign (+) - high exposure

For more information, see “FARO Laser Line Probe Settings” on page 57.

Software Setup

The EDGE/FARO Laser Line Probe system can be used with many software packages. Refer to the particular application software for installation and proper use of the software with the FARO Laser Line Probe.

NOTE: Some software packages automatically add the EDGE software driver to your computer. To ensure that you have the latest version of the EDGE software driver, install the CD-ROM found inside your FARO Laser Line Probe Case.

Calibration

After you complete the installation and warm-up of the FARO Laser Line Probe and the standard probe, this system of probes must be calibrated. Calibration requires measuring the FARO Calibration Sphere or FARO Calibration Plate, with the standard probe and the FARO Laser Line Probe.

NOTE: Clean the top and bottom lenses with the cloth from the FARO Laser Line Probe Case. Dirt and grease on either lens can cause poor results.

- 1 In your measuring software, start the PROBE command.
- 2 Choose a standard ball probe, 6mm or 3mm.

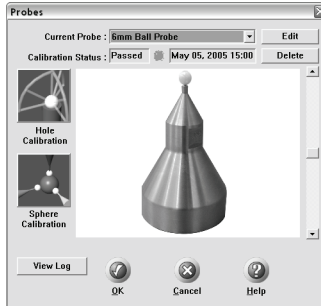


Figure 4-11 Standard ball probe

NOTE: If your ball probes are stamped with the *exact* diameter, enter the exact diameter in the MODIFY PROBE dialog box for each ball probe. See "Edit Probe" on page 84.

- 3 Calibrate the standard ball probe using the single hole calibration method. See "Hole Method" on page 89.
- 4 In the PROBES dialog box, choose the Laser Probe probe in the CURRENT PROBE drop-down window.

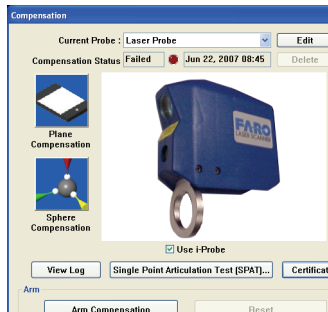


Figure 4-12 Probes dialog box

- 5 Choose the PLANE CALIBRATION or the SPHERE CALIBRATION button.
- 6 You can choose to use the previously measured plane or sphere, or measure the plane or sphere. Click OK to calibrate the FARO Laser Line Probe, or measure the plane or sphere.

- The laser turns on and the laser beam is visible unless you are measuring the plane or sphere. After you successfully measure the plane or sphere, the laser turns on and the laser beam is visible.

Sphere Calibration

Calibrate the FARO Laser Line Probe. You will digitize 24 points in three positions.

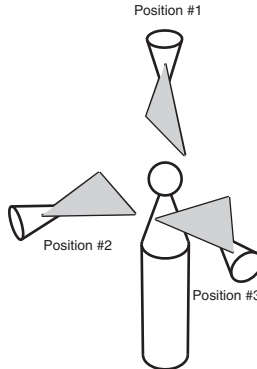
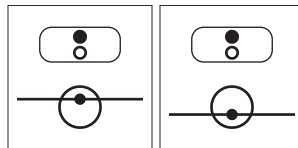


Figure 4-13 Calibration Positions

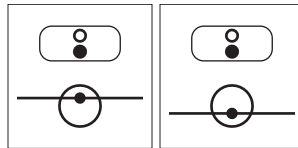
NOTE: Avoid touching both lenses. Clean the top and bottom lenses with the cloth from the FARO Laser Line Probe Case. Dirt and grease on either lens can cause poor results.

- 1 Digitize eight points on the top of the calibration sphere with the FARO Laser Line Probe pointing in position #1, see Figure 4-13.

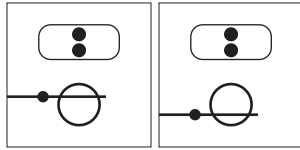
Digitize two points in the Near range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



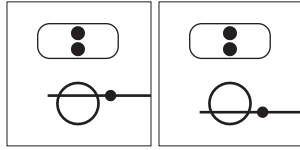
Digitize two points in the Far range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



Digitize two points in the Center range with the left side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.

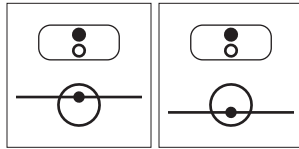


Digitize two points in the Center range with the right side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.

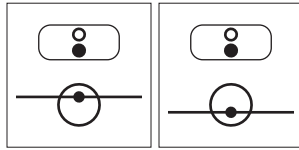


2 Digitize eight points on a side of the calibration sphere with the FARO Laser Line Probe pointing in position #2, see Figure 4-13.

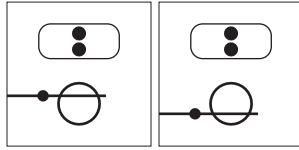
Digitize two points in the Near range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



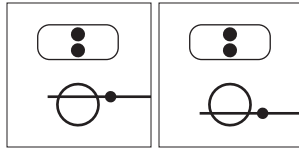
Digitize two points in the Far range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



Digitize two points in the Center range with the left side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.

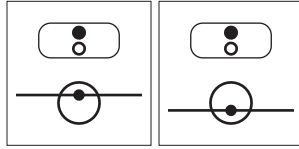


Digitize two points in the Center range with the right side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.

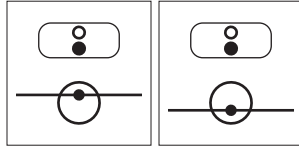


- 3 Digitize eight points on the front of the calibration sphere with the FARO Laser Line Probe pointing in position #3, see Figure 4-13.

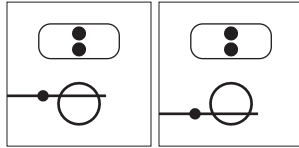
Digitize two points in the Near range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



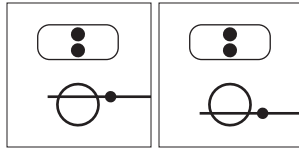
Digitize two points in the Far range with the center of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



Digitize two points in the Center range with the left side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



Digitize two points in the Center range with the right side of the laser. One point on the upper half of the calibration sphere and the other on the lower half.



The digitized calibration points then calculate and the CALIBRATION STATUS updates. If the probe passes, the current date and time is added to the probe information. You can view the details for all probe calibrations by clicking the VIEW LOG button. See “View Log” on page 95.

You now have two probes to digitize your part. Use the PROBES command to switch between the standard ball probe and the FARO Laser Line Probe.

NOTE: If you remove the FARO Laser Line Probe, you *must* re-calibrate the standard ball probe to guarantee the accuracy of the measurements. For more information, see “Compensate Probe” on page 86.

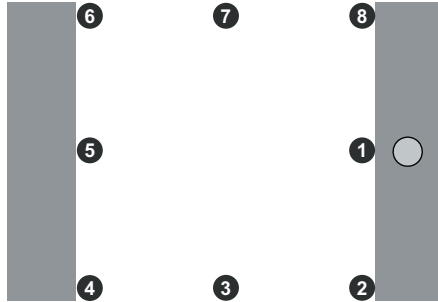
Plane Calibration

Calibrate the FARO Laser Line Probe. You will digitize the FARO Calibration Plate, once with the ball probe, and then three times with the FARO Laser Line Probe.

1 Digitize the White area of the FARO Calibration Plate with the ball probe.

- Touch the white surface with the ball probe and press the FRONT button.
- Digitize eight points on the white surface.

NOTE: Digitize each point near an edge of the surface to avoid marring the middle of the surface.




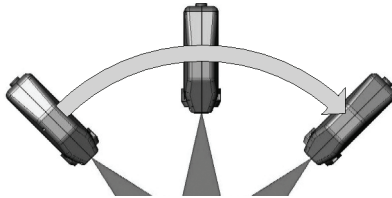
- Pull the probe away from the surface and press the BACK button.

The flatness of the white surface is calculated and the results are displayed in the dialog box. If the results *Fail*, click the RETRY button to redigitize the white surface. Click OK to continue.

NOTE: Avoid touching both lenses. Clean the top and bottom lenses with the cloth from the FARO Laser Line Probe Case. Dirt and grease on either lens can cause poor results.


2 Digitize the white area of the FARO Calibration Plate with the FARO Laser Line Probe in a sweeping motion. You should collect at least 200 scan lines in the FARO Laser Line Probe calibration. If not, repeat the calibration moving the FARO Laser Line Probe slower in each step.

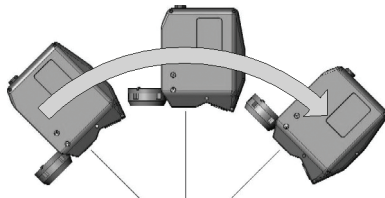
- Aim the laser line at the middle of the white surface.
- Move the FARO Laser Line Probe until the laser is in the Center Range. .
- Press the FRONT button and move the FARO Laser Line Probe while pointing to the center of the white surface. Rotate the FARO Laser Line Probe as much as possible - at least 90 degrees.



- Press the BACK button.



3 Digitize the white area of the FARO Calibration Plate with the FARO Laser Line Probe in a sweeping motion. You should collect at least 200 scan lines in the FARO Laser Line Probe calibration. If not, repeat the calibration moving the FARO Laser Line Probe slower in each step.

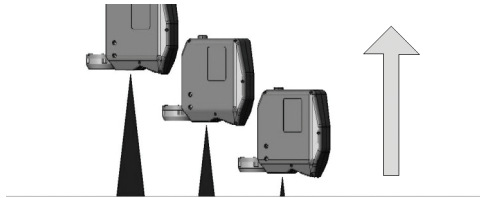
- Rotate the FARO Laser Line Probe 90°.
- Aim the laser line at the middle of the white surface.
- Move the FARO Laser Line Probe until the laser is in the Center Range. .
- Press the FRONT button and move the FARO Laser Line Probe while pointing to the center of the white surface. Rotate the FARO Laser Line Probe as much as possible - at least 90 degrees.



- Press the BACK button.

4 Digitize the White area of the FARO Calibration Plate with the FARO Laser Line Probe.

- Aim the laser line at the middle of the white surface.
- Move the FARO Laser Line Probe until the laser is closer than the Near Range. .
- Press the FRONT button and slowly move the FARO Laser Line Probe beyond the Far Range  while pointing to the center of the white surface.



- Press the BACK button.

The digitized calibration points then calculate and the CALIBRATION STATUS updates. If the probe passes, the current date and time is added to the probe information. You can view the details for all probe calibrations by clicking the VIEW LOG button. See “View Log” on page 95.

You now have two probes to digitize your part. Use the PROBES command to switch between the standard ball probe and the FARO Laser Line Probe.

NOTE: If you remove the FARO Laser Line Probe, you *must* recalibrate the standard ball probe to guarantee the accuracy of the measurements. For more information, see “Compensate Probe” on page 86.

DRO

Some software packages add a Digital ReadOut (DRO) window to the screen. The DRO window displays the current location of the probe in the current coordinate system.

- If the FARO Laser Line Probe is in range, the X, Y, Z coordinate is the center of the laser line. Note that this may not be the center of the complete laser line because some part of the laser line may be out of range.

- If the FARO Laser Line Probe is out of range, then no coordinate is available and the DRO displays a row of asterisks (*****).

FARO Laser Line Probe Settings

Modify the settings of the FARO Laser Line Probe for your part. The default settings are for digitizing the calibration sphere or plane that has an opaque white surface. You can control the following:

- Scan Rate - the number of lines per second that the FARO Laser Line Probe records and sends to your current file. Fewer lines per second requires you to move the FARO Laser Line Probe slower.
- Scan Density - the amount of points each line contains. More points in each line creates a larger file. If you are digitizing a relatively flat surface, use less points.
- Material - controls the camera which records the laser line. Different part material colors and textures reflect the laser line differently.
- Advanced Settings - controls the exposure settings of the camera.

To change the FARO Laser Line Probe settings:

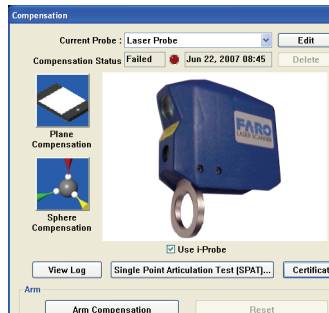


Figure 4-14 Probes dialog box

- Choose the Laser Probe probe in the PROBES dialog box
- Click the EDIT button.

In the MODIFY PROBE dialog box, you will see all of the information about the FARO Laser Line Probe.

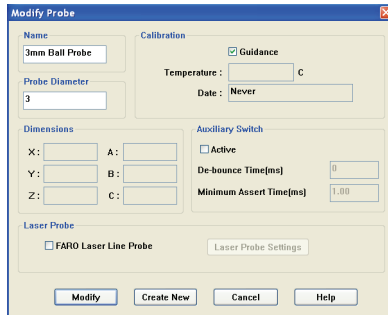


Figure 4-15 Modify Probe dialog box

- Click the LASER PROBE SETTINGS button to modify the settings of the FARO Laser Line Probe.

Line Probe Settings

Choose the LASER PROBE SETTINGS button to show the FARO LASER LINE PROBE CONTROL dialog box. When the FARO Laser Line Probe is within the operating range, you will see the line in the PREVIEW AREA of the dialog box.

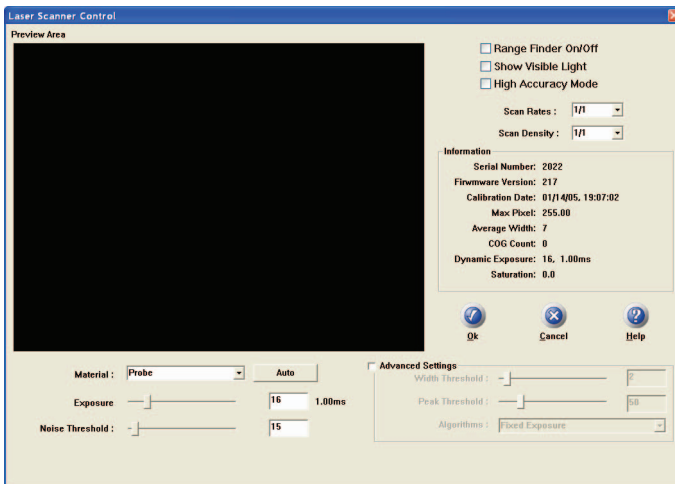


Figure 4-16 FARO Laser Line Probe Control dialog box

- Disable the RANGE FINDER dialog box by clearing the Range Finder On/Off check box.

- Select the SHOW VISIBLE LIGHT check box to add all visible light to the Preview window.

NOTE: Adding all visible light to the preview window will decrease the number of frames per second sent to the computer and should only be used when diagnosing problems with the FARO Laser Line Probe.

- Select the HIGH ACCURACY MODE check box to operate the FARO Laser Line Probe in the High Accuracy mode. High Accuracy mode can improve the performance of the FARO Laser Line Probe by up to 30%, but reduces your field of view by 1/2 and shortens your effective maximum scanline width to 2/3 of the normal width.

Scan Rate and Density

Use the Scan Rate Density settings for data reduction. Reducing the number of points the FARO Laser Line Probe collects can improve system performance, increase scanning speed and potentially reduce unwanted noisy data.

- Scan Rate - choose the number of scan lines per second. 1/1 is the normal rate of scan lines per second, set this to discard scan lines.

NOTE: Always set the scan rate to 1/1 when calibrating the FARO Laser Line Probe.

- Scan Density - choose the number of points on each scan line. 1/1 is all of the points on the laser line, set this to discard points on each line.
- Information - displays the unique information for the current FARO Laser Line Probe.

Basic Settings

- From the MATERIAL drop-down window choose any existing material setting. Use the commands in this drop-down window to save material settings.

NOTE: The current material setting is stored on your computer and in the EDGE. If you connect the EDGE to another computer, the current material will be *Unknown*. Save the material settings to copy the settings from the EDGE to the new computer.

- Click the AUTO button to set the Exposure and Noise Threshold levels for the current material. Hold the FARO Laser Line Probe in position, pointing at the surface, until the process completes. You can also set the values manually:
 - Exposure - How long the “shutter” is open and the sensor is exposed to light in the camera. Enter a number from 1 to 80; the corresponding value in milliseconds appears next to it. Light colors and reflective surfaces are better captured with low exposure levels. Darker colors typically require higher exposure levels. The default value is 16.
 - Noise Threshold - The FARO Laser Line Probe measures the intensity, or return power, of all pixels and each pixel of the laser line projected onto a surface using a scale from 0 to 255. All data having intensity below the Noise Threshold value is considered noise or “chatter” that is too faint to be usable and is simply ignored. Dark colors or surfaces that tend to absorb light may benefit from a lower value. Increasing this value will filter out more data. Setting this value to 255 considers all data to be noise. The default value is 15.

Advanced Settings

- Select the ADVANCED SETTINGS check box to modify more material settings:
 - Width Threshold - When determining the Center of Gravity (COG) for the laser line, groups of pixels are analyzed. This sets the minimum number of pixels to define a COG group of pixels. The default value is 5. This means that if the FARO Laser Line Probe picks up several clusters of light in one column, due to angle of incidence, reflection, or any other external interference, only clusters with at least 5 pixels will be considered COG candidates. Pixels must also meet the Noise Threshold criteria, which is a value of 2.

- **Peak Threshold** - For a COG group to be valid, one of the pixels must be above this value. The default value is 50. Increasing the Peak Threshold is useful with reflective surfaces that may shine or produce flares in the FARO Laser Line Probe. If a FARO Laser Line Probe column captures more than one laser light source, only the groups or clusters with at least one pixel at Peak Threshold will be considered. Groups must also meet Noise Threshold and Width Threshold criteria.
- **Algorithm** - Select an exposure setting:
 - *Automatic - Full*: As you digitize, the Exposure setting automatically adjusts to maintain the proper saturation level. This automatic mode uses the entire exposure range of the FARO Laser Line Probe. In this mode, you may notice a slight decrease in speed as the FARO Laser Line Probe automatically adjusts from one surface type to another.
 - *Automatic - Highly Reflective*: This is an automatic setting for use with reflective, or shiny, materials. This automatic mode uses the lower half of the exposure range of the FARO Laser Line Probe.
 - *Automatic - Normal*: This is an automatic setting for use with non-reflective, or dull, materials. This automatic mode uses the upper half of the exposure range of the FARO Laser Line Probe.
 - *Fixed Exposure* - The Exposure setting is constant.

NOTE: The three Automatic settings disable the AUTO button and ignore the Exposure and Noise Threshold sliders.

Choosing any of the three Automatic settings adds an exposure indicator to the RANGE FINDER dialog box. In the RANGE FINDER dialog box:

- A green dot in the upper left-hand corner of the RANGE FINDER dialog box indicates that the exposure has been adjusted and you are ready to scan.
- The indicator changes to either a red “+” (plus) or “-” (minus) sign indicating that the FARO Laser Line Probe is either over-exposed or under-exposed, and it is automatically adjusting the exposure. The FARO Laser Line Probe does not collect data during this adjustment, however this automatic adjustment process is very fast.

For more information, see “Range Finder” on page 46.

During the calibration of the FARO Laser Line Probe, this setting temporarily changes to *Automatic - Normal* except when using *Fixed Exposure*. For more information, see “*Calibration*” on page 47.

- Choose Save As... in the MATERIAL drop-down window to save a material setting.

In general, the default values for all settings described here will yield acceptable data on most surfaces. The EXPOSURE parameter requires more frequent adjustments based on the different surface finishes you are scanning.

Keep in mind that given the vast range of colors, textures and finishes, there is no exact science for these FARO Laser Line Probe Settings that work best on a particular surface. Finding the optimum settings may require some practice.

Additional Considerations

- First, if accuracy is not an issue, even failing probe calibration will not prevent you from using the FARO Laser Line Probe to show the concept of gathering point clouds quickly and easily, directly into software applications. The ScanArm *does* use the new probe calibration, even if it fails.
- Second, if the probe calibration does fail, you should look at the probe calibration log to see by how much. If the error is acceptable, you should be able to scan effectively for medium accuracy applications.
- Third, if you need to measure in a high accuracy application, or you have a requirement that the probe calibration pass, make sure you allow the FARO Laser Line Probe to warm-up for the amount of time recommended for your model. See “*Diagnosing FARO Laser Line Probe Accuracy Problems*” on page 93.

Chapter 5: Accuracy

Calibration and Certification

The EDGE is designed to endure the typical stress and impact loads of a “factory floor” measuring tool, as well as survive multiple transportation cycles while maintaining its accuracy throughout its usable life. In order to fully appreciate what is meant by “Lifetime Calibration,” you must first understand several basic concepts of measurement equipment.

Calibration versus Certification

In most cases the terms “calibration and certification” are used together, and are often mistakenly used interchangeably. This generally occurs because traditional Coordinate Measuring Machines are often calibrated every time they are certified. In reference to the EDGE, there are two types of calibration: the EDGE calibration and the probe calibration.

EDGE Calibration

Calibration is the procedure by which a measurement device is optimized to perform accurate measurements. This may be done through mechanical adjustments, as well as software corrections.

Specialists at FARO’s production facility perform the factory calibration. This calibration utilizes patented hardware and software (not available to the user) to determine the true dimensions and kinematics of the EDGE. The results of the factory calibration are imprinted to memory located in the EDGE electronics. The EDGE is permanently calibrated, such that it does not require mechanical adjustments during normal operation.

The EDGE will only lose its calibration (stop functioning within FARO's published standards) if one or more of the following occurs:

- Bending of the transfer cases (long, tube sections).
- Damage to the encoder-bearing interface joints (where tubes, bearings and encoders are mated).

- Failure of the encoder-electronics system (changes motion into electrical data).
- Physical (plastic) deformation can occur in the EDGE after excessive impact with another object or an end-stop. The impact may cause the transfer cases to bend, the joint housings to deform, or the encoder-bearing interface pin system to loosen.

Any of these problems require FARO's Customer Service Department to disassemble the EDGE, repair the necessary item(s), and perform a factory calibration. A factory calibration is necessary since the physical nature of the EDGE has been changed.

Since the EDGE will always require repair if it loses calibration, and will only lose calibration if it is damaged, there is never a need for a field or user-site calibration.

EDGE Certification

The measuring software has commands that allow you to perform tests that certify the accuracy and repeatability of your EDGE. The certification commands allow you to test the EDGE using a single hole, a ball bar, or a step gauge.

The values measured in all of these certifications include 100% of the measured points. We will always refer to this as the "Max. minus Min. over Two," or the Maximum measurement subtracting from the Minimum measurement divided by two $(\text{Max.} - \text{Min.}) / 2$.

If any test fails, print the results and repeat the certification two more times. Print all of the results and contact FARO's Customer Service by Phone, Fax or E-Mail. See *"Technical Support"* on page 119.

Repeatability

Perform the single point repeatability test to check the probe and repeatability using a hole or a cone. You must use a firmly secured object with a hole at least 1mm smaller than the ball probe. If a cone hole is used, extreme care must be taken to ensure that the probe is seated at each "measurement."

- Use a calibrated ball probe. See *"Installing Probes"* on page 36 and *"Compensate Probe"* on page 104.
- Run the Single Point Certification command.
 - 1 Measure points in the hole, or cone, from multiple directions.

- 2 Make sure that you move the joints of the EDGE while measuring the points.
- 3 Do not digitize a point if any of the encoders reach their end stop.
See “Error and Status Indicators” on page 30.
- 4 Avoid a position where a degree of freedom is lost in the EDGE.
See “Loss of a Degree of Freedom” on page 71.

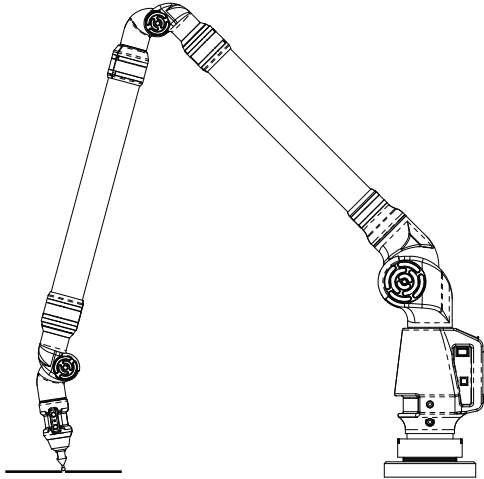


Figure 5-1 Single Point Certification

Volumetric Accuracy

Perform a Sphere to Sphere or Step Gauge in order to certify the volumetric accuracy of the equipment.

- Use a calibrated ball probe. *See “Installing Probes” on page 36 and “Compensate Probe” on page 104.*
- Run the Sphere to Sphere, or Step Gauge Certification command.
 - 1 Measure points on each sphere, or on each step from multiple directions.
 - 2 Make sure that you move the joints of the EDGE while measuring the points.
 - 3 Do not digitize a point if any of the encoders reach their end stop.
See “Error and Status Indicators” on page 30.
 - 4 Avoid a position where a degree of freedom is lost in the EDGE.
See “Loss of a Degree of Freedom” on page 71.

EDGE Performance

The EDGE performance testing standard is the North American ASME or European ISO standard. EDGE test methods are a subset of those given in the B89.4.22 standard. Single-point repeatability is measured using a hard probe in a reference hole. Volumetric performance is measured using a traceable length artifact. Measurements are well distributed in all regions of the working volume.

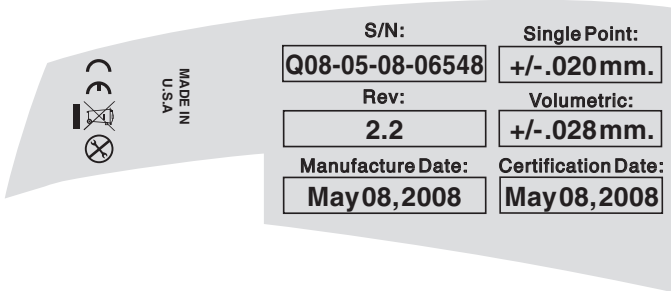
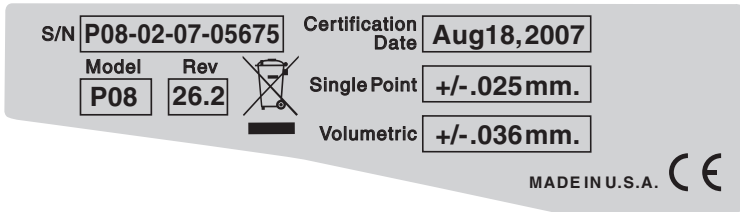
Single Point Articulation Performance Test (SPAT)

The EDGE's calibrated probe is placed into the calibration cone, or a conical socket, and individual points are automatically measured as you move the elbow of the EDGE from one side to the other, and back. Each individual point measurement is analyzed as a range of deviations in X, Y, Z. This test is a method for determining articulating measurement machine repeatability. *For more information, see "Single Point Articulation Test (SPAT)" on page 91.*

- FARO reports this as $(\text{Max.} - \text{Min.})/2$, or the Single Point repeatability value.

This represents the error as the range of error between the least value and the highest value.

The specifications of your EDGE are listed on the Serial Number label on the left side of the base.



NOTE: For optimum performance, correctly mounting and operating the EDGE is very important. *For more information, see “EDGE/ ScanArm Performance Verification Checklist” on page 87.*

Volumetric Maximum Deviation

This value is determined by using traceable length artifacts, which are measured at various locations and orientations throughout the working volume of the EDGE. This test is a method for determining articulating measurement machine accuracy. The deviation value is the difference between the measured value and the true, or nominal, value.

Loss of a Degree of Freedom

In a working volume of the EDGE there can be a loss of a degree of freedom (natural rotation of transfer case). With this loss, temporary bending occurs on the transfer tubes of the EDGE causing a movement of the probe position that cannot be recorded by the EDGE’s encoder system. Measurement results taken in these positions are not accurate. This condition is never encountered in the calibration of the EDGE. Common areas of measurement where this loss occurs are:

- when an encoder has reached a hard end-stop,
- directly above the EDGE, or

- in close to the base of the EDGE.

The EDGE should always feel fluid in its movement. If excessive force is needed to move to a measuring location, a degree of freedom has probably been lost. The following figures illustrate some of the possible positions of a EDGE where a degree of freedom has been lost.

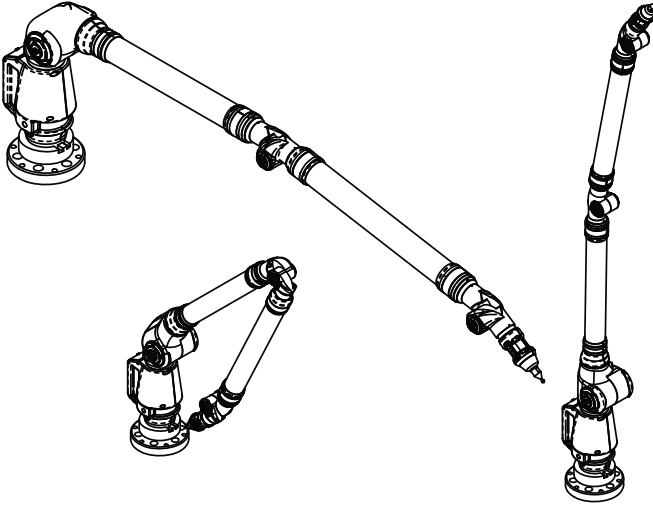


Figure 5-2 Loss of a Degree of Freedom