FARO Arm®

Caliper 3D™

for Windows™

VERSION 2.43

JULY 1999

FARO®

FARO Technologies, Inc. Internal Control File Locations:
F:\CONTROL\REFERENC\08PRODUC\ENGLISH\Prdpub01 - Caliper 3D\08m01e00 - Caliper 3D - July 1999 - V2.43.pdf
F:\CONTROL\RECORDS\05MANUFA\PARTSPEC\XH17-0052.pdf

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FARO Arm®

Caliper 3D™
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Introduction

Thank you for choosing the FaroArm, "Portable Measurement Arm." This manual is intended to explain proper use of the serial communication-based Gold, Sterling, Bronze or Silver Series FaroArm. Please refer to it for all FaroArm operations. However, should you have any questions or need further clarification of any procedure within this manual, please contact your Customer Service Representative at (800) 736-2771 or FAX (407) 333-8056. The Customer Service, Applications, and Training groups may also be reached via Internet E-mail at the following addresses:

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

This manual provides the general information and the specific instructions you'll need to use the many FaroArm features.

Using This Manual

To help you locate and interpret information easily, this manual uses a series of visual and typographical conventions. The typographical conventions you will see are the following:

ALL CAPITAL text	Indicates directory names, menu names, buttons, tabs, key names, acronyms and modes.
`monospaced text`	Indicates characters you type on your keyboard as instructions for performing an operation.
bold text	Anything you must type exactly as it appears. For example, if you were asked to type **a:install**, you would type all the bold characters exactly as they are printed. Specific values are also displayed as bold characters.
SMALL CAPS text	Indicates dialogue box, icon names, and window names.

When using the FaroArm to measure, you will come across a few new terms. Before proceeding, it is important that these terms be understood.

digitize	To record the XYZ coordinates of a point or location in 3D space. Equivalent to the term "measure" when referring to points.
choose	Means that you are initiating an action by either clicking the mouse or pressing the ENTER key when an item is highlighted. For example, if you have selected a file to open in the OPEN FILE dialogue box, you would *choose* the OK button to proceed and open the file.
click	Press and release the mouse button. Also used when referring to the FaroArm buttons.

FaroArm General Information

This device is a multiple-axis, articulated arm with a spherical working volume. Each joint has a rotary transducer. The signals from these transducers are sent through the controller cable, which attaches to the port at the back of the Controller Box.

Probes

Four probes are supplied with the FaroArm. Each ball probe is stamped with the diameter of the ball (.25", 6mm, .125", 3mm, etc.). The FaroArm'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 will have an impact on measurement accuracy. The error depends on:

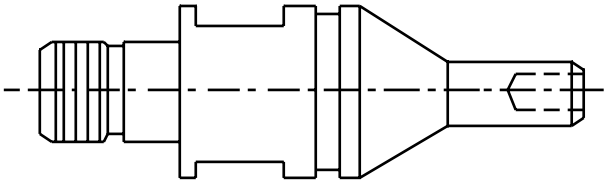


Figure a - Typical Probe

1. Width of the point on the probe
2. Position and placement of the point on the object

The FaroArm probes are manufactured with a common thread size. This thread size may vary with the location of your company and the age of the FaroArm. There are two thread sizes:

- .375" - 24 UNF Imperial Units - Older FaroArms
- 6M x 1 Metric Units - Newer FaroArms

FARO has a thread adapter available to use older probes with newer FaroArms. Contact FARO Customer Service for more details.

Handle-Buttons

The FRONT button is for data collection and the BACK button for data acceptance. The FRONT button is nearest the probe, the BACK button is nearest the handle. The 2-2-2 configuration has two sets of buttons, where the FRONT buttons and BACK buttons are redundant and wired together internally.

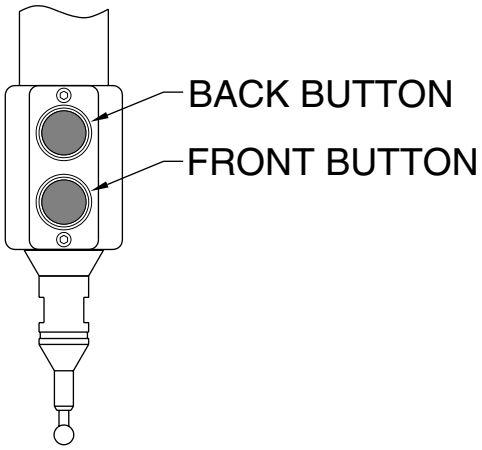


Figure b - FaroArm Handle Buttons

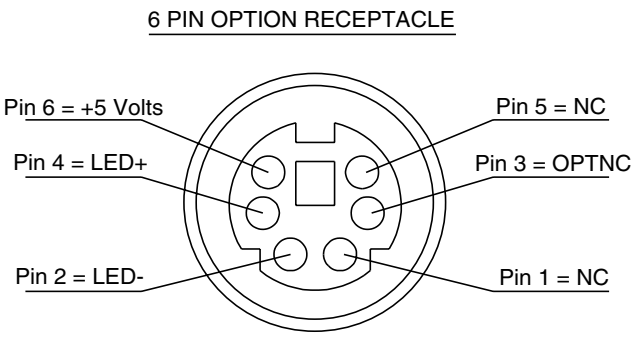


Figure c - Auxiliary Port

Auxiliary Port (7th Variable Options Port)

On the side of the probe handle, opposite the button, there is a six-pin connector that allows two channels of analog input into the FaroArm signal processing board. This is employed for any number of analog input options, such as a conductance-based touch probe. Auxiliary input voltage for #1 & #2 are [±4.5 volts].

Precautions

This is a precision measuring instrument, and while ruggedized for shop use, proper care must be exercised in the operating environment and use of the FaroArm. Proper operation and care includes avoiding the following:

1. Abuse (dropping, twisting at end stops, etc.)
2. Moisture and high humidity
3. Excessive temperature changes without appropriate elapsed time

With proper and thoughtful use of your FaroArm will give you years of service.

Unpacking

The following components and accessories are standard items in every unit shipped.

Gold Series - Packing List

1. Shipping Case
2. Operator's Manual - (This manual)
3. FaroArm
4. Power Supply
5. Four Probes
6. Cone Ball Bar/Ball Bar 360 degrees
7. Serial null modem cable
8. FaroArm Cable (connectors #3 & #4)
9. Surface Mount Plate

Sterling Series - Packing List

1. Shipping Case
2. Operator's Manual - (This manual)
3. FaroArm
4. 12v Power Supply
5. Four Probes
6. Cone Ball Bar/Ball Bar 360 degrees
7. Serial null/modem cable
8. FaroArm Cable (connectors #3 & #4)
9. Clamping Ring and Spanner Wrench

Silver Series- Packing List

1. Shipping Case
2. Operator's Manual - (This manual)
3. FaroArm
4. Power Supply
5. One Factory Ball Probe
6. Three Probes
7. Cone Ball Bar/Ball Bar 360 degrees
8. Serial null modem cable
9. FaroArm Cable (connectors #3 & #4)
10. Surface Mount Plate

Bronze Series- Packing List

1. Shipping Case
2. Operator's Manual - (This manual)
3. FaroArm
4. 12v Power Supply
5. One Factory Ball Probe
6. Three Probes
7. Cone Ball Bar/Ball Bar 360 degrees
8. 25' 9-pin Serial Line
9. 9 to 25 pin Serial Line Adapter
10. Table Mount

NOTE: If a computer was ordered with the FaroArm, the Operator's Manual is shipped in the computer equipment box.

The following are optional accessories. If ordered, the accessories will be included. If you would like to purchase any of these options call your Customer Service Representative (800) 736-2771.

Optional Accessories

The FaroArm Accessories Manual is included with every FaroArm. Please refer to this manual for the installation and operation of Optional Accessories.

Repacking

To prevent damage in shipping the 7 Axis Gold and Sterling FaroArms should be repacked carefully.

Gold Series

1. Pack the Cone Ball Bar/Ball Bar 360 degrees, Power Module, Probe Case and Surface Mount Plate as shown.
2. Rotate tube 1 180° in direction of the arrow about axis 2 and rotate transfer case “A” 180° in direction as shown. See figure e
3. Grab the FaroArm with both hands as shown. See figure f

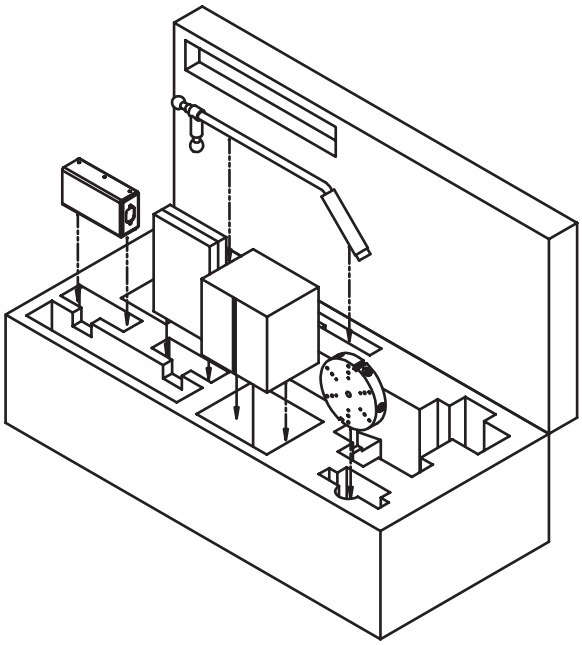


Figure d - Gold Series Case

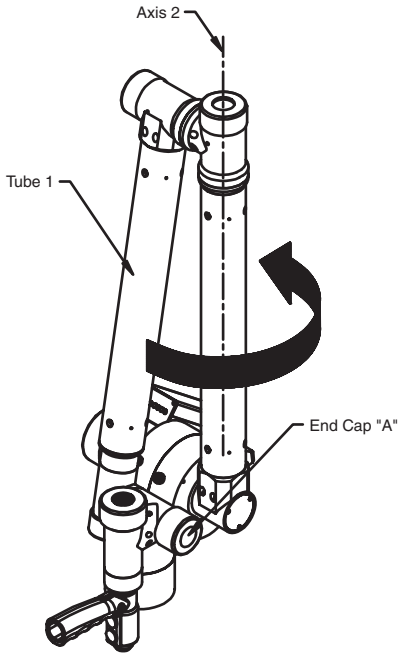


Figure e

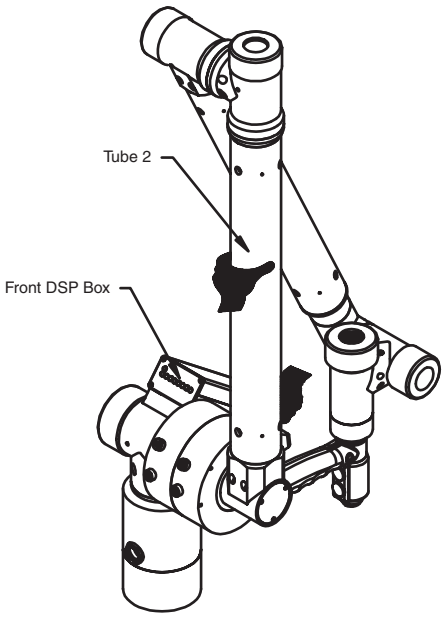


Figure f

4. Insert the FaroArm into the case.

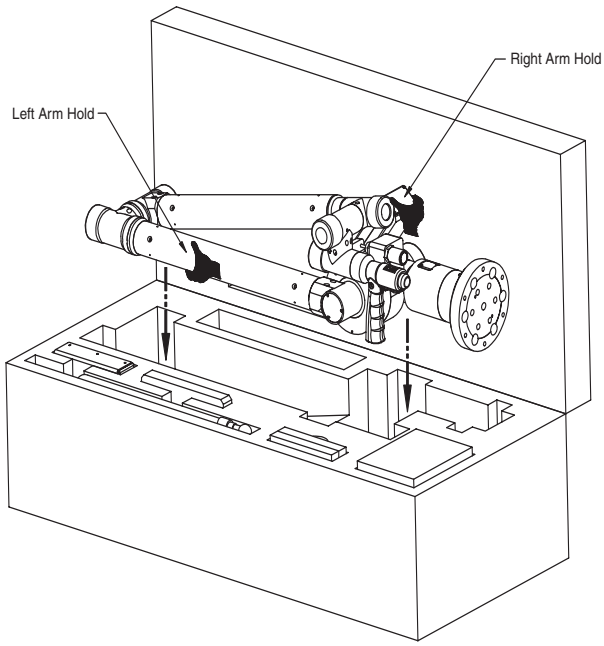


Figure g

Sterling Series

1. Pack the Cone Ball Bar/Ball Bar 360 degrees, Power Module, Probe Case and Surface Mount Plate as shown.

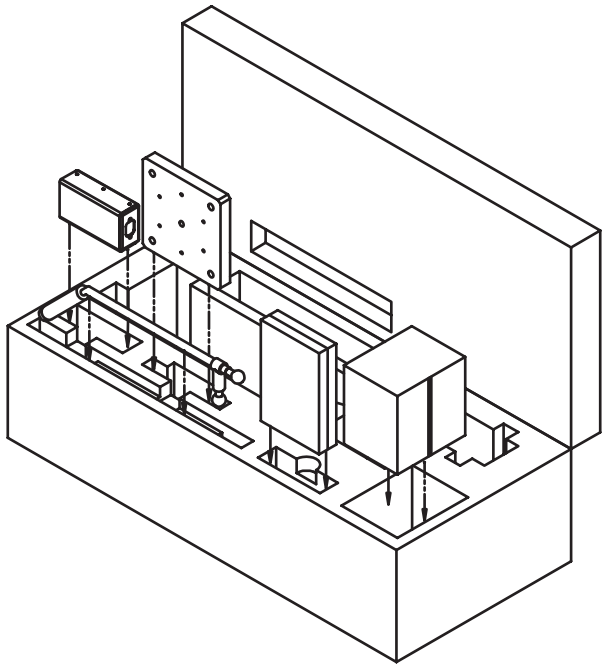


Figure h - Sterling Series Case

2. Rotate tube 1 180° in direction of the arrow about axis 1 as shown in figure j.

3. Rotate transfer case “A” 180° in direction of arrow about axis 2 as shown in figure k.

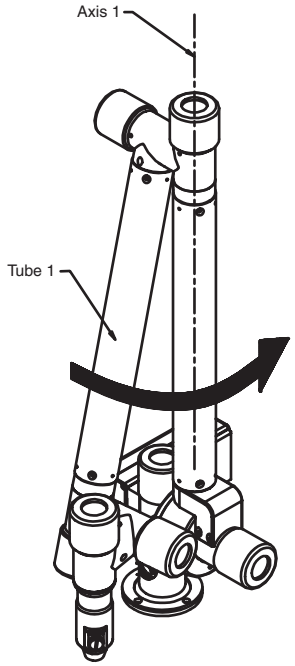


Figure j

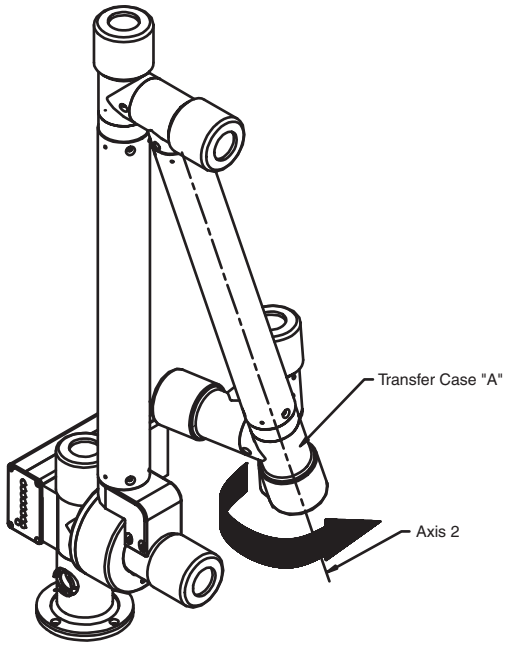


Figure k

4. Grab the FaroArm with both hands. See figure m.

5. Insert the FaroArm into case.

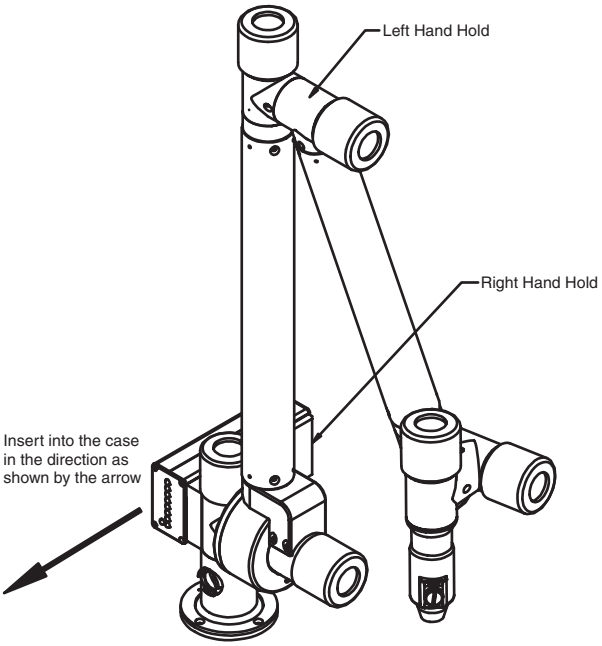


Figure m

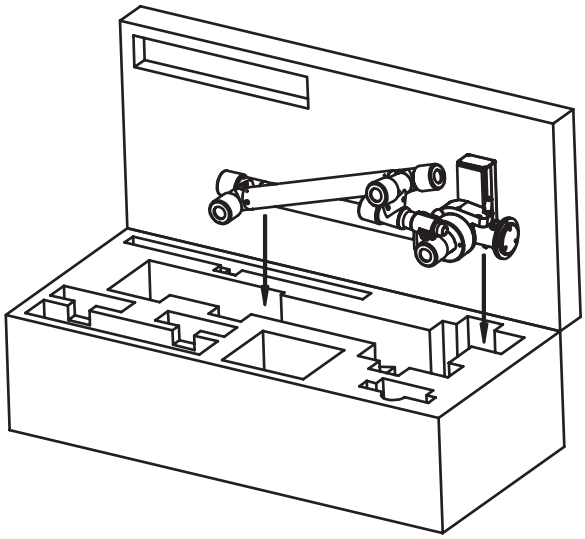


Figure n

Hardware Setup

Mounting the Base

Gold Series

The counter balance by the tension spring generates torque at the base of the FaroArm. Hence, to achieve optimum machine accuracy the mounting must meet certain requirements.

- Using FARO supplied mounts, the torque for all mounting bolts is 100-inch pounds.
- After mounting the arm, test stability of the mount with a dial indicator to check for possible angular or lateral deflection. An angular deflection of the base must not exceed 20 micro inches/inch at this applied torque. The lateral deflection of the base must not exceed 0.001 inches at this applied lateral load.

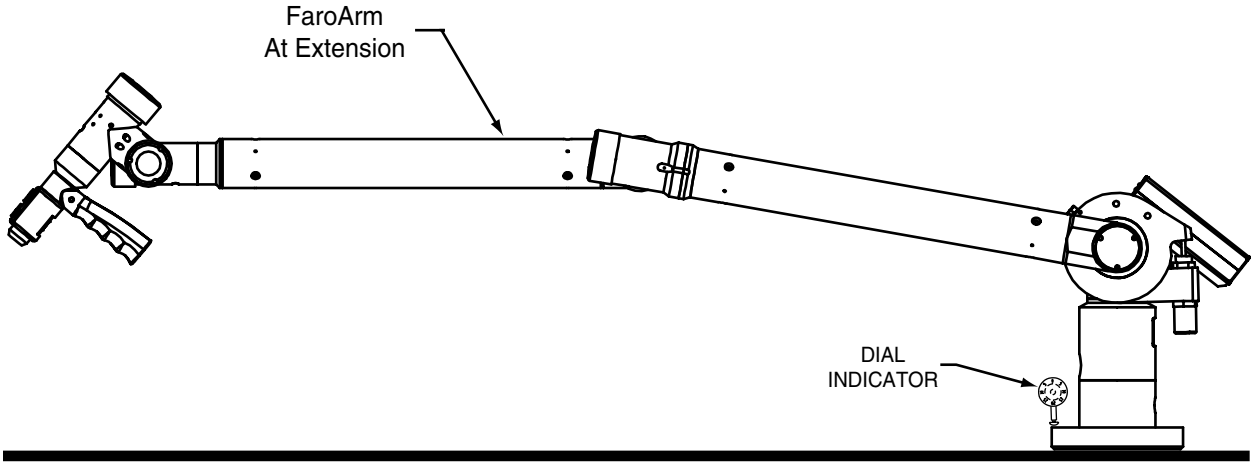


Figure p - Mounting the Gold and Silver FaroArms

- Angular deflection <<: 20 micro inches/inch
- Lateral deflection<<: 0.001

The FaroArm fastens to any flat and rigid surface via the surface mount plate.

- The surface mount plate attaches to any stable surface with four bolts.
- Next, mount the arm to the base plate (with arm attached). The base plate can rotate 360 degrees, but must be mounted securely before operation.
- All mounting bolts should be tightened to 100-inch pounds.

Sterling Series

Attach the 3.5" threaded ring and surface mount plate to any stable location. The FaroArm is placed on top of the 3.5” threaded ring. Screw the threaded collar clamp onto the base of the arm and 3.5” threaded ring and use the spanner wrench to tighten the threaded collar clamp.

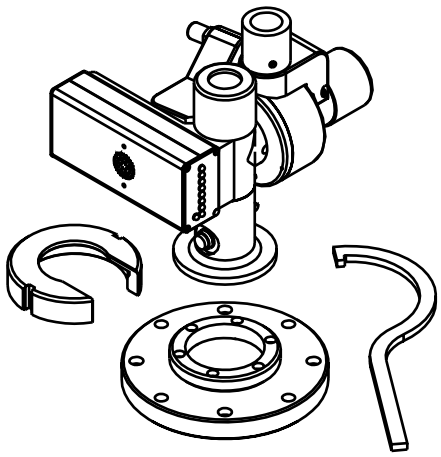


Figure q - Mounting the Sterling FaroArm

Silver Series

The counter balance by the tension spring generates torque at the base of the FaroArm. Hence, to achieve optimum machine accuracy the mounting must meet certain requirements.

- Using FARO supplied mounts, the torque for all mounting bolts is 100-inch pounds.
- After mounting the arm, test stability of the mount with a dial indicator to check for possible angular or lateral deflection. An angular deflection of the base must not exceed 20 micro inches/inch at this applied torque. The lateral deflection of the base must not exceed 0.001 inches at this applied lateral load.
    - Angular deflection <<: 20 micro inches/inch
    - Lateral deflection<<: 0.001

The FaroArm fastens to any flat and rigid surface via the surface mount plate.

- The surface mount plate attaches to any stable surface with four bolts.
- Next, mount the arm to the base plate (with arm attached). The base plate can rotate 360 degrees, but must be mounted securely before operation.
- All mounting bolts should be tightened to 100-inch pounds.

Bronze Series

The portable table clamp fastens to any stable surface in the same manner as a C-clamp. It also can be mounted permanently to any stable surface. The 3.5" threaded ring can be removed from the table mount and attached to an alternative clamp or a permanent location. Most surveying or other portable instrument stands have adapters for the 3.5" thread.

Mounting Stiffness Test

It is the nature of the FaroArm that it is often portable and, therefore, can be mounted in a variety of environments. The FaroArm is counterbalanced and it is the nature of counterbalancing that reaction forces may exist in the mounting due to the applied forces generated by the counterbalancing mechanism. The reaction forces will result in deformations in the mounting, which, if sufficiently, large may degrade the performance of the FaroArm.

The primary forces encountered due to counterbalancing are translation and torsion. These forces are illustrated in Figure r-1. The forces can be further described along or about the 3 major axes of a coordinate system at the mounting base. The translation forces (F) along the axes and the moments (M) about the axes will result in deformations of the base.

The deformation due to the translation force can be measured as depicted in Figure r-2. The user must apply forces (lb or N) using a calibrated load cell at the mounting interface to the maximum level required and measure the associated deformation (in or mm). The torsional forces or moments at the base can be generated by using a calibrated torque wrench. The deformations can be described as a slope (in/in or mm/mm) and can be measured as depicted in Figure r-3. The deformations must not exceed the deformation reported at certification.

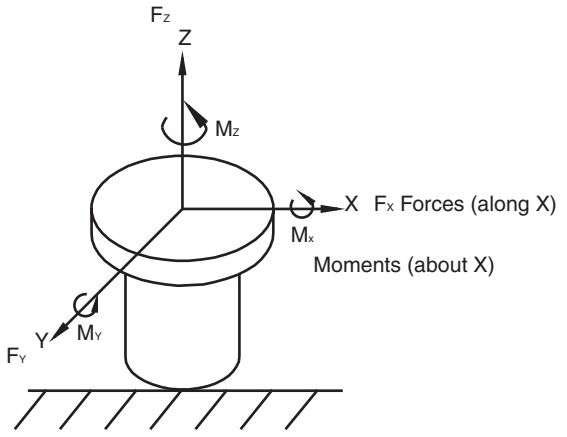


Figure r-1

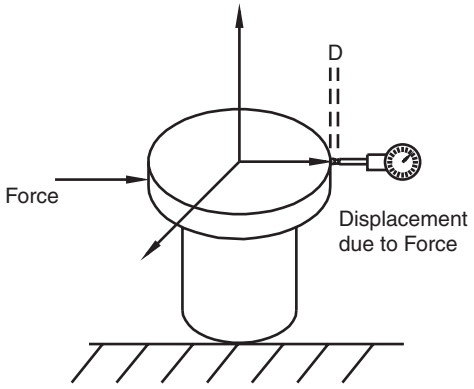


Figure r-2

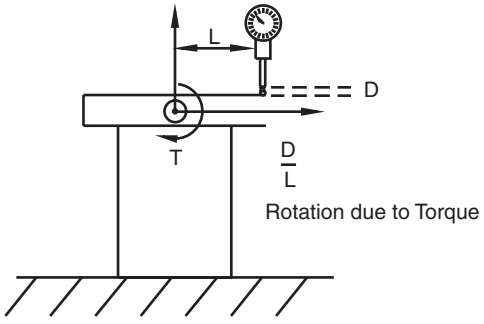


Figure r-3

In general, the excessive translation deformations are added directly to the certified accuracy, while the excessive angular deformations of the base effect accuracy as a more complicated trigonometric function of the length of the reach.

Installing Probes

The probe attaches to the threaded handle end. The dimension of the threads are 6M x 1. To install the probe supplied, use the 12mm, open-ended wrench supplied. When installing the probe, special care should be taken to ensure the probe is properly seated.

Renishaw Probe Installation and Operation (Optional)

The Renishaw Probe collects points with a touch of the stylus to the part. The probe installation requires special hardware (FARO adapter). If the Renishaw Probe is purchased with the FaroArm system, the adapter is installed at FARO's factory.

- FARO's adapter screws into the end of the FaroArm.
- The second component is the Manual Probe Head (PH6). This Manual Probe Head screws into the FARO adapter.
- To install, screw the (TP2, 5-way) probe into the FARO's probe-head adapter with the "C" Spanner (S9).
- Finally, screw the Ruby Ball Stylus into the (TP2 5 way) with the (S7) Stylus Tool. Do not under or over tighten any of the components.
- Connect the black cable to the FaroArm options port.

The measuring software must be configured for the probe. In the software, the auxiliary port needs to be toggled "ON", and some software packages allow for other probe options to be controlled The Renishaw Probe is very sensitive and can be adjusted with an allen wrench (see the Renishaw manual) inserted into the end of the five-way probe.

The probe takes a point if it is bumped or takes multiple points if bounced off the object. Watch the red LED on the probe and listen to the Controller Box to ensure that only one point was taken. The LED turns off and the Controller Box sounds when a point is collected. Press the BACK button to confirm the point. After installation, calibrate the probe with the 1" sphere probe calibration technique.

NOTE: The product numbers in the parentheses are Renishaw part numbers. Refer to the Renishaw user manual for more details.

Custom Probe Creation

Any probe with a sphere or a point can be calibrated. Refer to the Probe Calibration section of the Device Menu section of this manual.

The Controller Serial Box - Sterling Series

Signal and Numeric Processing

The Controller Box contains highly sophisticated signal and numerical processors that allow for the reading of raw data and conversion of this raw data into dimensional coordinates. Inside of the box is an EEPROM chip that allows for controller software updating. The Controller Box automatically senses worldwide, AC input 110/220 VAC, 50-60 HZ.

Cable Connections

The null modem serial cable connects the Power Supply Box's serial port and the host computer's serial port. The six-pin, round, locking cable connects the FaroArm's base (on or off) labeled #4 and the #3 port on the Power Supply Box.

Error and Status Indicator Panel

The front panel of the Controller Box has nine LEDs, one green LED for the power indicator, one red LED for error indication, and seven red LEDs that are error indicators. Volume control is handled through the software. To adjust the volume/sound select the Devices menu and choose the Hardware Configuration dialogue box.

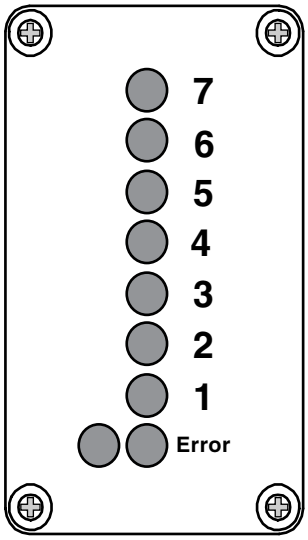


Figure s - Sterling Controller Front View

Referencing Encoder

The six transducer-numbered LEDs are illuminated when the Controller Box power is turned on. In a systematic manner, the user must rotate links 1 through 6 until the lights on the front of the Controller Box turn off. This takes the incremental encoders through their reference positions. **NOTE:** The FaroArm will not operate until all seven red LEDs are off.

The Controller Serial Box - Gold Series

Signal and Numeric Processing

The Controller Box contains highly sophisticated signal and numerical processors that allow for the reading of raw data and conversion of this raw data into dimensional coordinates. Inside of the box is an EEPROM chip that allows for controller software updating. The Controller Box is connected to a Power Supply Box, which automatically senses worldwide, AC input 110/220 VAC, 50-60 HZ 50W.

Cable Connections

The null modem serial cable connects the Power Supply Box's serial port and the host computer's serial port. The six-pin, round, locking cable connects the FaroArm's base (on or off) labeled #4 and the #3 port on the Power Supply Box.

Error and Status Indicator Panel

The front panel of the Controller Box has nine LEDs, one green LED for the power indicator, one red LED for error indication, and seven red LEDs that are error indicators. To adjust the volume/sound select the Devices menu and choose the Hardware Configuration dialogue box.

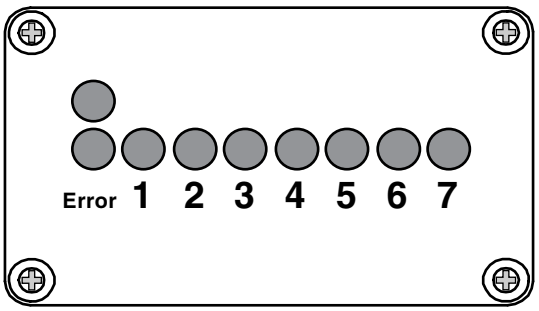


Figure t - Gold Controller Front View

Referencing Encoder

The six transducer-numbered LEDs are illuminated when the Controller Box power is turned on. In a systematic manner, the user must rotate links 1 through 6 until the lights on the front of the Controller Box turn off. This takes the incremental encoders through their reference positions. NOTE: The FaroArm will not operate until all seven red LEDs are off.

The Controller Serial Box - Bronze Series

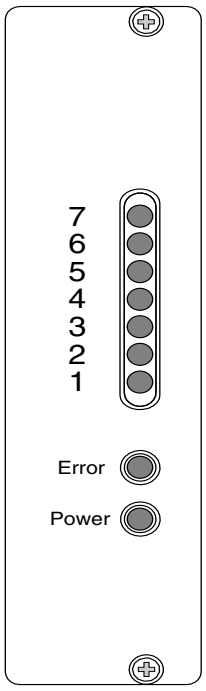


Figure u -Bronze Controller Front View

Signal and Numeric Processing

The Controller Box contains highly sophisticated signal and numerical processors that allow for the reading of raw data and conversion of this raw data into dimensional coordinates. Inside of the box is an EEPROM chip that allows for controller software updating. The Controller Box automatically senses worldwide, AC input 110/220 VAC, 50-60 HZ.

Cable Connections

The serial cable connects the Controller Box (via the serial port) and the host computer serial port. The external 12v. power supply connects to the power port in the back of the Controller Box.

Error and Status Indicator Panel

The front panel of the Controller Box has nine LEDs, one green LED for the power indicator, one red LED for error indication, and seven red LEDs that are error indicators.

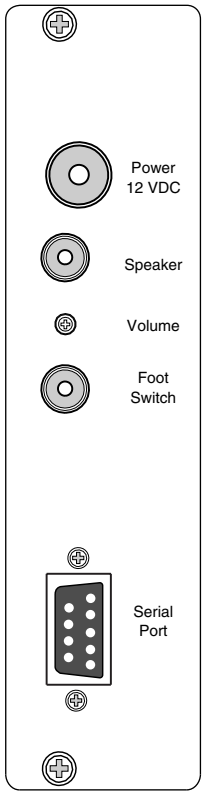


Figure v - Bronze Controller Rear View

The Controller Serial Box - Silver Series

Signal and Numeric Processing

The Controller Box contains highly sophisticated signal and numerical processors that allow for the reading of raw data and conversion of this raw data into dimensional coordinates. Inside of the box is an EEPROM chip that allows for controller software updating. The Controller Box is connected to a Power Supply Box, which automatically senses worldwide, AC input 110/220 VAC, 50-60 HZ 50W.

Cable Connections

The null modem serial cable connects the Power Supply Box's serial port and the host computer's serial port. The six-pin, round, locking cable connects the FaroArm's base (on or off) labeled #4 and the #3 port on the Power Supply Box.

Error and Status Indicator Panel

The front panel of the Controller Box has nine LEDs, one green LED for the power indicator, one red LED for error indication, and seven red LEDs, which are error indicators.

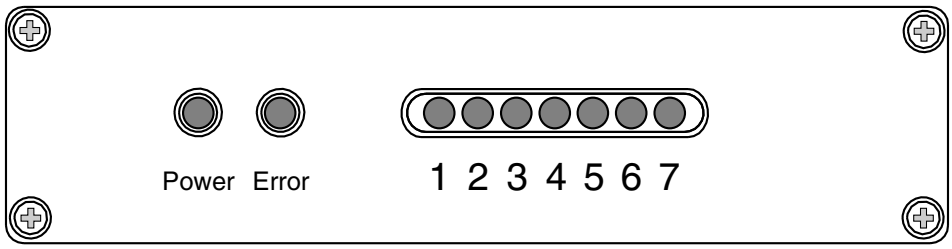


Figure w - Silver Controller Front View

Referencing Encoder

The six transducer-numbered LEDs are illuminated when the Controller Box power is turned on. In a systematic manner, the user must rotate links 1 through 6 until the lights on the front of the Controller Box turn off. This takes the incremental encoders through their reference positions. **NOTE:** The FaroArm will not operate until all seven red LEDs are off.

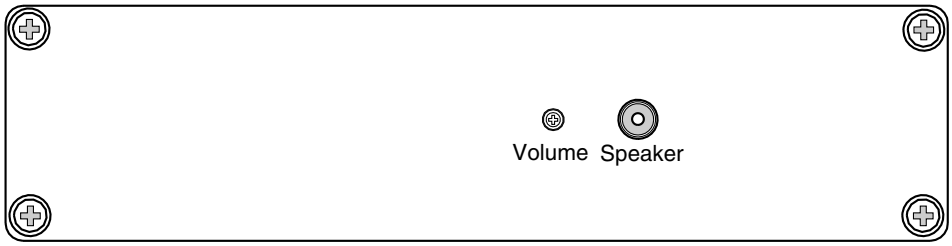


Figure x - Silver Controller Rear View

ERROR CODE	LED PATTERN 1	2	3	4	5	6	7	ERROR CODE	LED PATTERN 1	2	3	4	5	6	7	ERROR CODE	LED PATTERN 1	2	3	4	5	6	7
1	○	○	○	○	○	○	●	22	○	○	●	○	●	●	○	43	○	●	○	●	○	●	●
2	○	○	○	○	○	●	○	23	○	○	●	○	●	●	●	44	○	●	○	●	●	○	○
3	○	○	○	○	○	●	●	24	○	○	●	●	○	○	○	45	○	●	○	●	●	○	●
4	○	○	○	○	●	○	○	25	○	○	●	●	○	○	●	46	○	●	○	●	●	●	○
5	○	○	○	○	●	○	●	26	○	○	●	●	○	●	○	47	○	●	○	●	●	●	●
6	○	○	○	○	●	●	○	27	○	○	●	●	○	●	●	48	○	●	●	○	○	○	○
7	○	○	○	○	●	●	●	28	○	○	●	●	●	○	○	49	○	●	●	○	○	○	●
8	○	○	○	●	○	○	○	29	○	○	●	●	●	○	●	50	○	●	●	○	○	●	○
9	○	○	○	●	○	○	●	30	○	○	●	●	●	●	○	51	○	●	●	○	○	●	●
10	○	○	○	●	○	●	○	31	○	○	●	●	●	●	●	52	○	●	●	○	●	○	○
11	○	○	○	●	○	●	●	32	○	●	○	○	○	○	○	53	○	●	●	○	●	○	●
12	○	○	○	●	●	○	○	33	○	●	○	○	○	○	●	54	○	●	●	○	●	●	○
13	○	○	○	●	●	○	●	34	○	●	○	○	○	●	○	55	○	●	●	○	●	●	●
14	○	○	○	●	●	●	○	35	○	●	○	○	○	●	●	56	○	●	●	●	○	○	○
15	○	○	○	●	●	●	●	36	○	●	○	○	●	○	○	57	○	●	●	●	○	○	●
16	○	○	●	○	○	○	○	37	○	●	○	○	●	○	●	58	○	●	●	●	○	●	○
17	○	○	●	○	○	○	●	38	○	●	○	○	●	●	○	59	○	●	●	●	○	●	●
18	○	○	●	○	○	●	○	39	○	●	○	○	●	●	●	60	○	●	●	●	●	○	○
19	○	○	●	○	○	●	●	40	○	●	○	●	○	○	○	61	○	●	●	●	●	○	●
20	○	○	●	○	●	○	○	41	○	●	○	●	○	○	●	62	○	●	●	●	●	●	○
21	○	○	●	○	●	○	●	42	○	●	○	●	○	●	○	63	○	●	●	●	●	●	●

● INDICATES FLASHING LED

Figure y - Error Codes, 7 LED Controller

ERROR CODE	LED PATTERN 1	2	3	4	5	6	ERROR CODE	LED PATTERN 1	2	3	4	5	6	ERROR CODE	LED PATTERN 1	2	3	4	5	6
1	●	○	○	○	○	○	22	○	●	●	○	●	○	43	●	●	○	●	○	●
2	○	●	○	○	○	○	23	●	●	●	○	●	○	44	○	○	●	●	○	●
3	●	●	○	○	○	○	24	○	○	○	●	●	○	45	●	○	●	●	○	●
4	○	○	●	○	○	○	25	●	○	○	●	●	○	46	○	●	●	●	○	●
5	●	○	●	○	○	○	26	○	●	○	●	●	○	47	●	●	●	●	○	●
6	○	●	●	○	○	○	27	●	●	○	●	●	○	48	○	○	○	○	●	●
7	●	●	●	○	○	○	28	○	○	●	●	●	○	49	●	○	○	○	●	●
8	○	○	○	●	○	○	29	●	○	●	●	●	○	50	○	●	○	○	●	●
9	●	○	○	●	○	○	30	○	●	●	●	●	○	51	●	●	○	○	●	●
10	○	●	○	●	○	○	31	●	●	●	●	●	○	52	○	○	●	○	●	●
11	●	●	○	●	○	○	32	○	○	○	○	○	●	53	●	○	●	○	●	●
12	○	○	●	●	○	○	33	●	○	○	○	○	●	54	○	●	●	○	●	●
13	●	○	●	●	○	○	34	○	●	○	○	○	●	55	●	●	●	○	●	●
14	○	●	●	●	○	○	35	●	●	○	○	○	●	56	○	○	○	●	●	●
15	●	●	●	●	○	○	36	○	○	●	○	○	●	57	●	○	○	●	●	●
16	○	○	○	○	●	○	37	●	○	●	○	○	●	58	○	●	○	●	●	●
17	●	○	○	○	●	○	38	○	●	●	○	○	●	59	●	●	○	●	●	●
18	○	●	○	○	●	○	39	●	●	●	○	○	●	60	○	○	●	●	●	●
19	●	●	○	○	●	○	40	○	○	○	●	○	●	61	●	○	●	●	●	●
20	○	○	●	○	●	○	41	●	○	○	●	○	●	62	○	●	●	●	●	●
21	●	○	●	○	●	○	42	○	●	○	●	○	●	63	●	●	●	●	●	●

● INDICATES FLASHING LED

Figure z - Error Codes, 6 LED Controller

Host Computer

The Controller Box output can be accepted through any host computer serial port 1 or 2 with a null modem cable.

Temperature Considerations

FARO has been awarded a U.S. patent (#5,402,582), and worldwide patents are pending on the concept and the methods for temperature compensation of portable CMM devices. The brief overview contained herein is meant only as the most general of descriptions.

To maintain certified accuracy in a multitude of environments, the monitoring of temperature and the rate of temperature change is required. The FaroArm employs a software/hardware solution (patents pending) where a semiconductor temperature sensor is built into the device at its point of largest mass. This location is critical since it is the last to stabilize after any temperature change.

The temperature measured is compared to the reference temperature stored on the on-board EEPROM (Electrically Erasable Programmable Read-only Memory). The difference in temperature is then applied to the mathematical formulas or kinematics, which define the position of the arm in three-dimensional space. Link length corrections are made constantly by the on-board processor, which adjusts the kinematics and constantly adapts the output to changing environmental temperature. The formulations for the FaroArm are simple since the device is uniformly constructed of Aluminum.

However, because different components heat up or cool at different rates, the device is expected to reach a steady state temperature within a ±5 degree (Celsius) band width for five minutes before measurements can be taken. For convenience, the Controller Box is programmed to beep once when the temperature exceeds a ±5 degree band width and it sends a temperature change error command through the serial line. There is also a built-in routine for the establishment of temperature stability, whereby, the device monitors itself for five minutes and indicates to the user that it is now ready for use.

FaroArm Accuracy

The accuracy testing standard is either North American ASME or European ISO standard. The ANSI B89 describes accuracy as total band-width error. This band width can apply to single-point repeatability, linear displacement accuracy or volumetric performance. Single-point repeatability is measured on a reference sphere, or by using a hard probe in a reference hole. Linear displacement accuracy is measured using step gauges, and volumetric performance is measured with a Ball Bar. Measurements are well distributed in all regions of the working volume. Instrument accuracy can also be described statistically in standard deviations or Sigma. One Sigma error band contains 67.3%, the 2 Sigma contains 95.5% and the 3 sigma contains 99.7% of all measurement errors.

FARO's Sterling Series Model 04 Single-point Repeatability 2 Sigma = ±.0020" or ±.051mm

FARO's Sterling Series Model 06 Single-point Repeatability 2 Sigma = ±.0033" or ±.084mm

FARO's Sterling Series Model 08 Single-point Repeatability 2 Sigma = ±.0040" or ±.102mm

FARO's Sterling Series Model 10 Single-point Repeatability 2 Sigma = ±.0066" or ±.168mm

FARO's Gold Series Model 04 Single-point Repeatability 2 Sigma = ±.0010" or ±.025mm

FARO's Gold Series Model 06 Single-point Repeatability 2 Sigma = ±.0016" or ±.041mm

FARO's Gold Series Model 08 Single-point Repeatability 2 Sigma = ±.0020" or ±.051mm

FARO's Gold Series Model 10 Single-point Repeatability 2 Sigma = ±.0033" or ±.084mm

FARO's Gold Series Model 12 Single-point Repeatability 2 Sigma = ±.0047" or ±.119mm

FARO's Bronze Series Model 06 & 08 Single-point Repeatability 2 Sigma = ±.012" or ±.305mm

FARO's Bronze Series Model 10 Single-point Repeatability 2 Sigma = ±.016" or ±.406mm

FARO's Silver Series Model 06 & 08 Single-point Repeatability 2 Sigma = ±.003" or ±.076mm

FARO's Silver Series Model 12 Single-point Repeatability 2 Sigma = ±.007" or ±.178mm

NOTE: To maintain this accuracy, mounting of the FaroArm is very important. Please see the Hardware Setup section, which describes Mounting procedures.

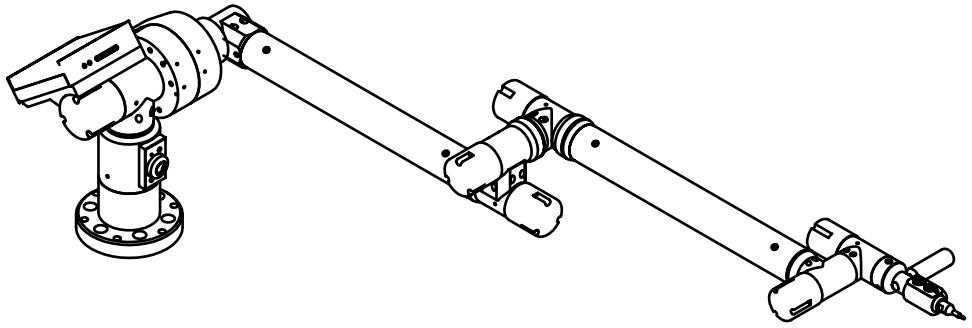
Loss of a Degree of Freedom

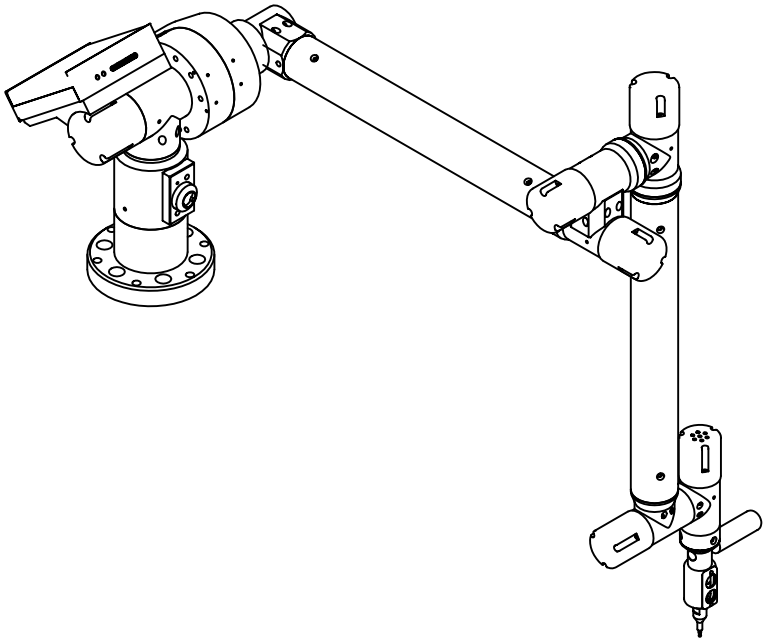
In the working volume of the FaroArm, there can be a loss of a degree of freedom (natural rotation of transfer case). With this loss, bending occurs on the transfer tubes of the FaroArm causing a movement of the probe position that cannot be recorded by the arm's encoder system. Measurement results taken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

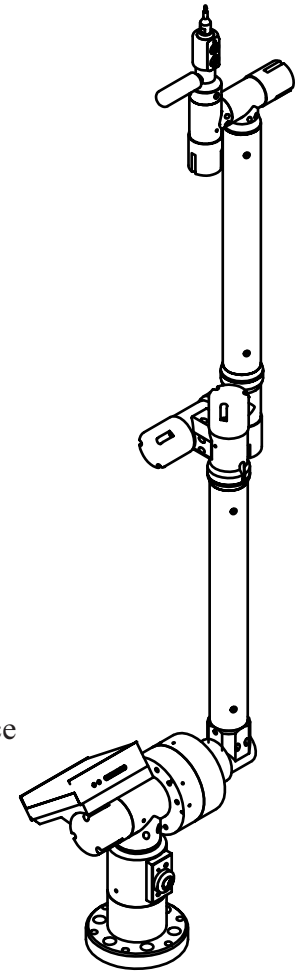
Common areas of measurement in which this loss will occur are:

- When an encoder has reached a hard end-stop
- Directly above the FaroArm
- In close to the base of the FaroArm

The FaroArm 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 FaroArm where a degree of freedom has been lost.







Preventative Maintenance

We recommend that you periodically check over your FaroArm at least once a month. This enables you to spot trouble before it starts and helps provide you with an efficient measuring system.

FaroArm IP Rating

The IP waterproofing rating for the FaroArm is DIN40 050-IP53.

Maintenance of the FaroArm

The FaroArm is a precision instrument containing many sensitive components. It should be handled with care. Here are some steps you can take to prevent problems from developing on your system:

1. When not in use, place a dust cover over the FaroArm and the Controller Box.
2. Clean with dry, dust cloth. For heavy, dirt buildups use a solvent lightly. Safety Solvent #13, by Hernon Manufacturing Inc., or similar is recommended.
3. Power-down the computer and remove the Controller Box cover. Lightly blow the dust from inside.
4. Check the cables for damage to outside insulation, connectors, and pins.
5. Do not lubricate the FaroArm.

6. The FaroArm is calibrated at FARO's factory. The FaroArm needs to be calibrated only after the unit is subjected to a shock that removes metal or causes bending of the FaroArm. Follow these steps to verify the accuracy of the FaroArm.

   - Calibrate a ¼" Ball Probe.
   - Complete a Ball Bar certification: If it fails, print the results, and repeat the certification 2 more times. Print all of the results.
   - Call FARO's Customer Service (800) 736-2771 or FAX (407) 333-8056.

ESD - Bronze Series

Electrostatic Discharge (ESD) refers to pulses generated by the discharge of loaded objects and/or persons. The charge usually comes from friction between two materials, one of which is a nonconductor. This unit does not always respond to ESD, depending on the polarity and intensity of the electrostatic discharge. Although this unit cannot be physically damage by ESD, extra care and proper ESD procedures must still be observed and followed when handling this unit.

If an error occurs in the unit due to ESD, check the Error Message displayed on the screen and follow the steps below to resume normal operation.

If the message displayed is:

1) "Timeout Error on Serial Line"

   a) Press any key on the keyboard and the unit should be back to normal operation.

2) "No Transducer Voltage Error"

   a) Reboot the unit by unplugging the power cord from the wall outlet and wait for at least 5 seconds before plugging it back in.

   b) Press any key on the keyboard and the unit should be back to its normal operation.

Note: If Step 2 was followed, all data will be lost due to powering down. A new set of data should be collected.

ESD - Silver Series

Electrostatic discharge (ESD) refers to pulses generated by the discharge of loaded objects and/or persons. The charge usually comes from friction between two materials, one of which is a nonconductor. This unit does not always respond to ESD, depending on the polarity and intensity of the electrostatic discharge. Although this unit cannot be physically damage by ESD, extra care and proper ESD procedures must still be observed and followed when handling this unit.

If an error occurs in the unit due to ESD, check the Error Message displayed on the screen and follow the steps below to resume normal operation.

If the message displayed is:

1) "Transducer out of calibration."

   a) Press any key on the keyboard and the unit should be back to normal operation.

Note: If the user experiences anything out of normal operation, reboot the unit by unplugging the 20 ft. cable from the power supply module. Wait for at least 5 seconds before powering the unit and communication with host PC is reestablish.

FaroArm Power Supply

All servicing shall be referred to qualified service personnel.

Rated Voltage:	110 - 230V ~ 50 - 60 Hz
Voltage Tolerance:	+10% or -10%
Rated Input:	0.5A - 0.263A
Sec. Voltage:	+12 VDC
Sec. Current:	2.08A Max
Pollution Category:	2
Installation Category:	II

CAUTION
(INDOOR USE ONLY)

PROPER SELECTION OF POWER CORD

The proper selection of the power supply cord intended for installation in a protected environment should be followed as stated below. You, as the user, should place this unit in an area accessible to a properly grounded outlet receptacle. The input power plug is the disconnect device to remove power from the unit.

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 6 feet.

For 220 - 240V Connection: Use an international harmonized, 300V rated, PVC insulated jacket, three conductors of 0.75mm^2 minimum cross sectional area each, with a molded-on plug cap marked with proper agency marking for the country it will be used in..

Caliper 3D™

for Windows™

Introduction

Caliper 3D is the basic operating system of the FaroArm. It may be used as a stand-alone 3D measurement program, or may be indirectly incorporated into your own custom applications. It may also be used for calibration verification and changing probes or end effectors.

This document provides the general information and the specific instructions you'll need to use the many features of Caliper 3D. It includes explanation of all the features and functions available within Caliper 3D, as well as a section which describes each command and option in detail.

System requirements

Hardware

- 386SX/25 MHz or better
- 4 MB RAM or greater suggested
- minimum of 1 MB of hard drive space (used by Caliper 3D)
- free serial port (COM1-COM4)

Software

The Caliper 3D software is uniquely designed for specific computer operating systems. Currently there are two versions of Caliper 3D, one for 16bit Systems (Windows 3.x), and one for 32bit systems (Windows 95/Windows NT). The operating system requirements are:

- Windows 95, Windows NT 3.51, or Windows NT 4.0 operating system

Caliper 3D for Windows requires Adobe Acrobat Reader version 2.1 or later for the electronic manual (HELP)

Using this manual

To help you locate and interpret information easily, this manual uses a series of visual and typographical conventions. The typographical conventions you will see are the following:

ALL CAPITAL text	Indicates directory names, menu names, buttons, keynames and acronyms.
monospaced text	Indicates characters you type on your keyboard instructions for performing an operation.
bold text	Anything you must type exactly as it appears. For example, if you were asked to type **a:installw**, you would type all the bold characters exactly as they are printed.
SMALL CAPS text	Indicates dialogue box or icon names

When using the FaroArm to measure, you will come across a few new terms. Before proceeding, it is important that these terms be understood.

digitize	To record the XYZ coordinates of a point or location in 3D space. Equivalent to the term measure when referring to points.
choose	Means that you are initiating an action by either clicking the mouse or pressing the ENTER key when an item is highlighted. For example, if you have selected a file to open in the OPEN FILE dialog box, choose the OK button to proceed and open the file.
click	Press and release the mouse button. Also used when referring to the FaroArm buttons.

Installing and uninstalling Caliper 3D (Windows 95,NT)

To INSTALL Caliper 3D

- **Windows 95 and Windows NT 4.0**

Use Add/Remove Programs from the Control Panel. Install the setup.exe program from the floppy diskette. Follow the screen instructions for file location and Start Menu options.

- **Windows NT 3.51**

From the FILE menu choose RUN, and run the setup.exe program from the floppy diskette.

NOTE: Please see the Operational Concepts section of this manual for details on installation of FaroArm drivers for other applications.

Installing Adobe Acrobat Reader

Use the same instructions as listed above to install the Adobe Acrobat Reader. Acrobat Reader may be installed in Windows 3.x by following the Windows NT 3.51 instructions. This manual can be viewed under Windows 3.x, however it will not be used for online HELP.

Getting started

Hardware setup

Connect the arm as per instructions in the beginning of this manual. The method of connecting your arm will vary depending on the model you have purchased.

Loading Caliper 3D (Windows 95,NT)

To load the Caliper 3D program, click START, PROGRAMS, FARO, and the Caliper 3D icon. If an attempt to establish communication fails at loading time (perhaps because you are not connected to the arm or power to the serial box is off), a FAROARM dialog box will appear on screen warning you that the arm is not communicating and allow Caliper 3D to operate off line without the FaroArm connected. Use the COMMUNICATIONS… command in the SETTINGS pull down menu to connect to a FaroArm.

Using the menus

Caliper 3D operates from a series of pull down menus located on the Menu Bar immediately below the main window title. Each pull down contains a set of menu items which correspond to commands pertaining to the pull down menu title. For more information about these menus and their commands, see the appropriate menu commands section.

Using HELP (Windows 95,NT)

You may access help on Caliper 3D features wherever you see a HELP button. Clicking on the HELP button will give you context specific help on the feature you are using. Adobe Acrobat Reader is required to read the help file (this document). Adobe Acrobat Reader is freeware and is provided as a part of the Caliper3D diskette set. For more information about Adobe Acrobat, please refer to the online HELP in the Acrobat Reader application.

Navigating The Program

File menu

Command	Description
New	Creates a new file in a new window.
Open	Opens an existing file in a new window. When you finish working with a file or window, close it by using the Close command of the File menu, or by choosing Close from the window's control menu. **NOTE:** You may only have one file open at a time in CALIPER 3D.
Save	Saves the data in the active window with the name, location, and file format you previously set in the SAVE AS dialog box. When you save a file for the first time, you are presented with the Save As dialog box. If you want to change the name, or location of an existing file, choose the Save As… command.
Save As	Displays the SAVE AS dialog box, where you specify the name, and location of the active document to be saved. You can also use this command to create a copy of an existing file and save it under a different name.
Translate	Allows you to translate CALIPER 3DCALIPER 3D data (saved in the MTR format) to another file format. You may translate the MTR file to any one of these file formats: XYZ ABC, XYZ IJK (into part), XYZ IJK (out of part), XYZ only, SPECIAL, DXF, IGES, and ACL. Simply enter the Input file name or click on the Browse button to view and select all the saved MTR files, then enter a file name in the Output file field, and select a file format for the new file. Click on the Ok button to begin the translation. A new file of the specified format will be created, leaving the original MTR file unchanged.
Print	Displays the PRINT FILE dialog box and controls how a file is printed. Before using this command, you must install and select a printer. To install a printer, see your Windows documentation. To select a printer, see Print Setup.
Printer Setup	Displays the PRINT SETUP dialog box, providing a list of installed printers, sets the default printer, and provides access to other printing options for the printer you select.
Exit	Exits the CALIPER 3D program.

Data File Dialogue Box

The Data File dialogue box contains all of the digitized data points. The points are collected in the Caliper 3D native format:

Index X Y Z A B C

In the upper left section of this dialogue box, the current collection mode is displayed.

SP Single Points

ST Stream

LP Locked Plane

The collection mode is changed in the DIGITIZE pull down menu.

In the upper center of this dialogue box is the total number of points collected. The maximum number of points in one file is 9999.

The SAVE button will save the current file. If the file has not been named, a SAVE AS dialogue box will appear. The TRANS button will translate the current file to another format. The DELETE button will delete a specific digitized point. The index number of the point must be entered. The REMARK button will allow for the insertion of a typed remark.

The NEXT INDEX field is used to change the index value for the next digitized point.

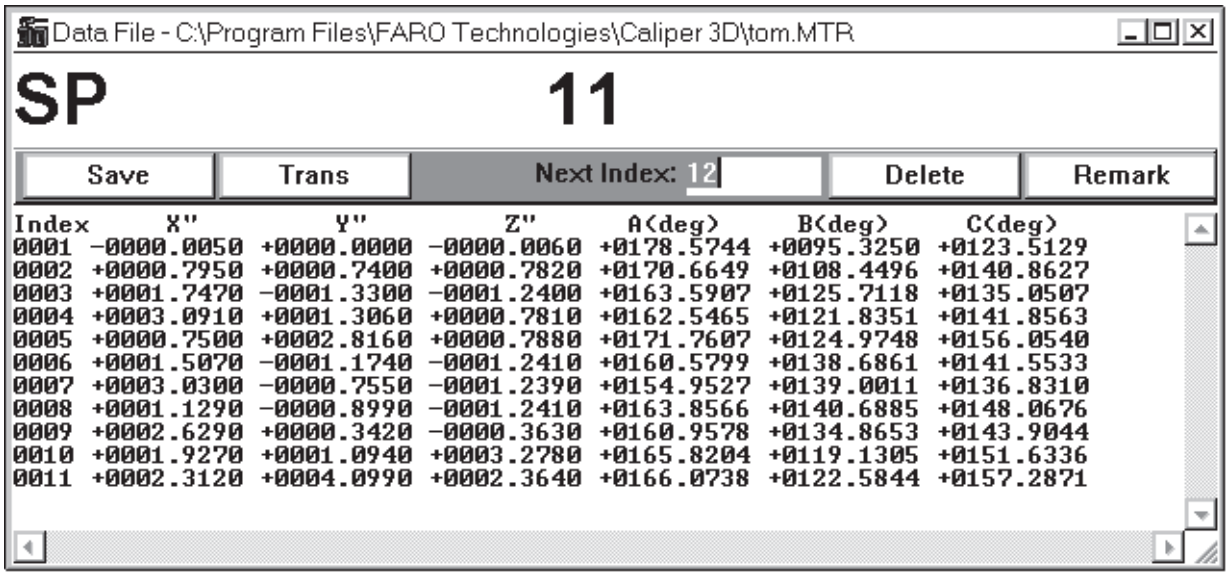


Figure 1 - Caliper 3D Data File Dialogue Box

Settings menu

Command	Description
Configuration…	Displays the GENERAL CONFIGURATION dialog box which allows the user to select the communication settings to be used while running the application.
Probes…	Displays the PROBES LIBRARY dialog box that allows the user to select or specify which probe will be used during measurement.
Communications…	Displays the COMMUNICATIONS flyout menu that allows the user to adjust the serial communications between the FaroArm and the host computer.
Reset Controller	Resets the tips, units, coordinate systems, and communication settings to factory default.
Digital Readout	Displays an additional pull down menu which gives the user the option of displaying the digital readout window, and/or selecting its display parameters (XYZ, ABC, IJK).

Configuration

Units

Allows for selection of the units of measure in either millimeters or inches.

Options

The AUX. SWITCH check box enables use of a trigger probe with the FaroArm and also allows you to set the default de-bounce time. De-bounce time should only be used with Renishaw probes. De-bounce time is the amount of time where no data is passed to the computer after a point has been taken. This feature helps reduce unwanted data points, or "double hits" from being recorded.

The OPTIONS PORT check box reports the two voltage signals of the option port. These signals will be saved in the data file.

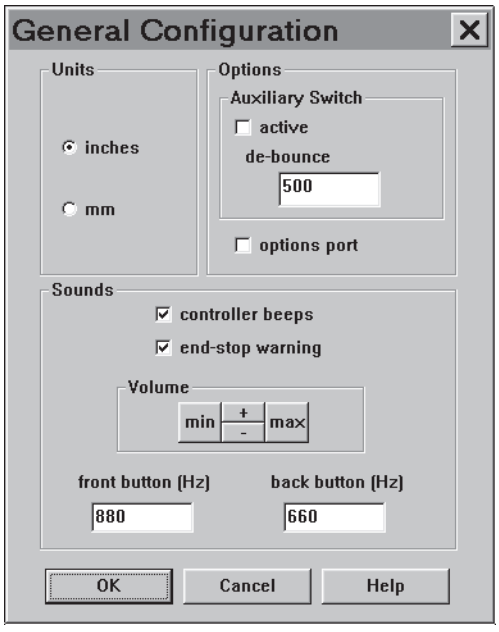


Figure 2 - General Configuration Dialog Box

Sounds

The CONTROLLER BEEPS, and END-STOP WARNING check boxes let the user toggle the sounds ON/OFF for each parameter.

Increasing or decreasing the speaker volume of Gold and Sterling series FaroArms may be controlled by clicking the arrow buttons. Click the MIN. or MAX. buttons to set the speaker to the minimum or the maximum volume.

The FRONT BUTTON field lets the user select the tone frequency to be heard when the FRONT BUTTON is triggered (0-9999 Hz.). The BACK BUTTON lets the user select the tone frequency to be heard when the BACK BUTTON is triggered (0-9999 Hz.).

Probes

The user may select which probe will be used during measurements. Available probes, defined by parentheses, are point probe, ball probe, and custom probe #1. However, you can create as many new probes as you need by clicking on the New button in the Probe Library dialogue box.

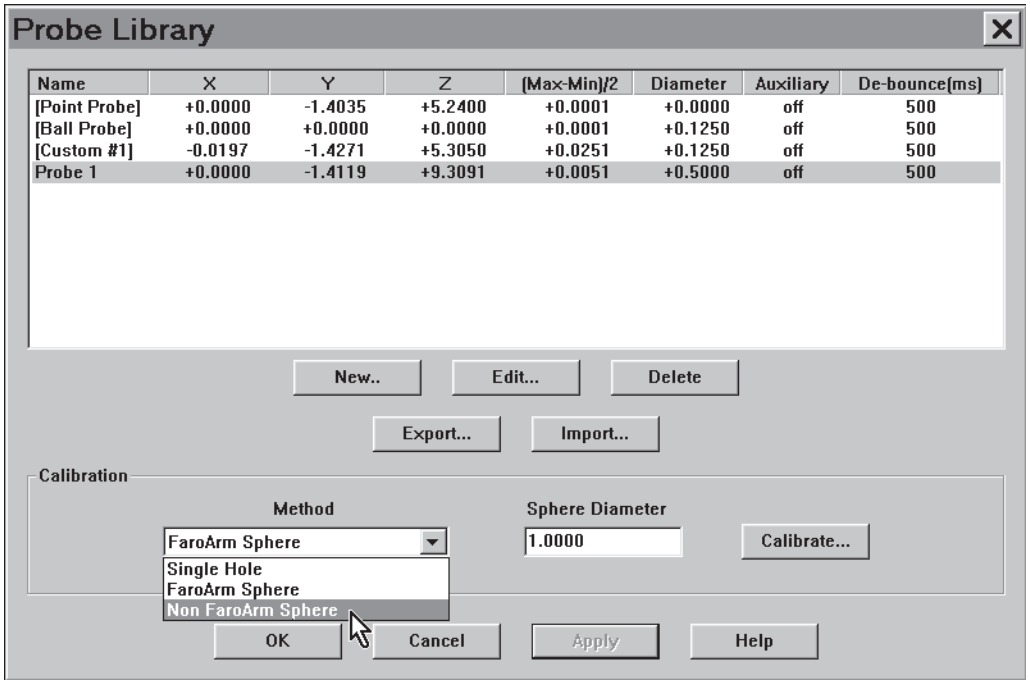


Figure 3 - Probe Library Dialog Box

Current Probe Dimensions

This field reports on the current/selected probe's dimensions. The DIAMETER field displays the diameter of the tip of the currently selected probe, and allows the user to change that value if necessary. Enter a value of 0 (zero) if using a point tip. This value will be used for probe compensation and calibration using the FaroArm sphere.

Calibrate

The SINGLE HOLE option displays the SINGLE HOLE CALIBRATION dialog box, which prompts you to calibrate the selected tip using the single hole method.

The FAROARM SPHERE option displays the FAROARM 1" SPHERE CALIBRATION dialog box, which prompts you to calibrate the selected tip using the FaroArm Sphere method.

The NON FAROARM SPHERE option displays the NON FAROARM FLOATING SPHERE CALIBRATION dialog box, which prompts you to calibrate the selected tip using the Non FaroArm Floating Sphere method.

Calibration Error

This non-editable field reports the computed calibration error of currently selected probe. If this value is zero, the probe has not yet been calibrated.

Single-hole Method

- Digitize 10 points in the hole. Orientate the handle of the FaroArm in Position #1. Rotate or sweep the last axis through as close to 180 degrees of rotation as possible.
- Digitize 10 points in the hole. Orientate the handle of the FaroArm in Position #2. Follow the same rotation or sweeping path as in the first 10 points.

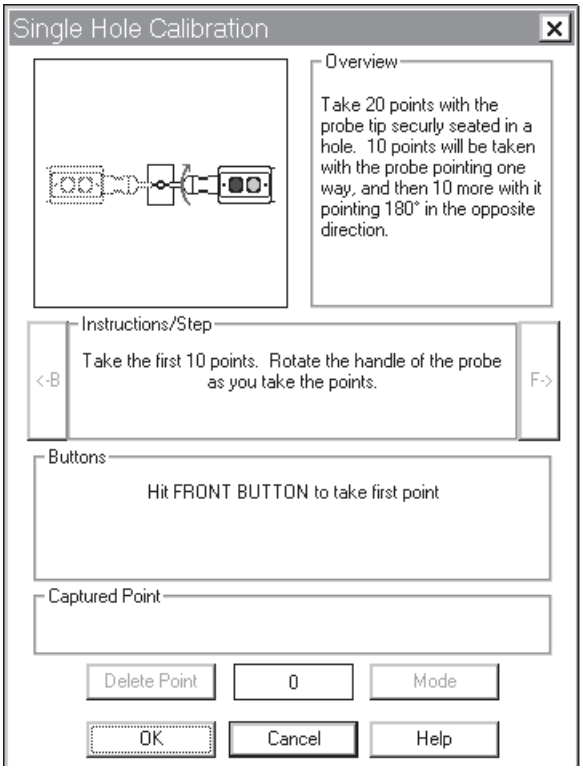


Figure 4 - Single Hole Calibration Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS FIELD: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT FIELD: This section displays the coordinates of the captured point.
BUTTONS AREA: This section contains the standard push buttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is not an active push button in this dialog box. It is only used in Leap Frog to toggle between Point mode and Sphere mode.

The calibration results will then display. The calibration error should be below the stated single point accuracy of the FaroArm being used. The XYZ coordinates for the probe location will then be displayed.

NOTE: For all 20 calibration points digitized, the probe must well seated in the hole. One or two poorly digitized points will significantly affect the optimization process, and therefore affect the accuracy of that probe.

FaroArm Sphere Calibration Method

- Digitize five points around the circumference of the sphere with the probe pointing towards the rear of the Arm. Orient the handle of the FaroArm in Position #1.
- Rotate 180° and digitize five additional points around the circumference of the sphere. This is FaroArm in Position #2. Remember, point the probe toward the rear of the Arm.
- Digitize five points, east to west, across the sphere with the probe pointing toward the center of the sphere. Orient the handle of the FaroArm in Position #2. Point the probe toward the center of the FaroArm Sphere.
- Rotate the handle of the FaroArm back to Position #1 and digitize four points, east to west, across the sphere. Again, point the probe toward the center of the FaroArm Sphere.
- Digitize four points, north to south, down the sphere with the probe pointing toward the center of the sphere. Orient the handle of the FaroArm in Position #1. Point the probe toward the center of the FaroArm Sphere.
- Rotate the handle of the FaroArm back to Position #2 and digitize four points, north to south, down the sphere. Again, point the probe toward the center of the FaroArm Sphere.

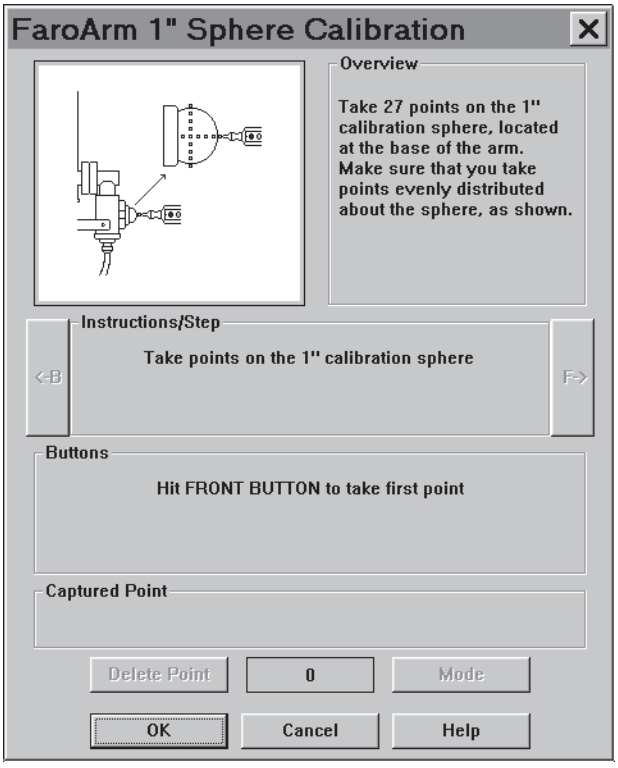


Figure 5 - FaroArm 1" Sphere Calibration Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard push buttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is not an active push-button in this dialog box. It is only used in Leap Frog to toggle between Point mode and Sphere mode.
The calibration results will then display. The calibration error should be below the stated single-point accuracy of the FaroArm being used. The XYZ coordinates for the probe location will then be displayed.

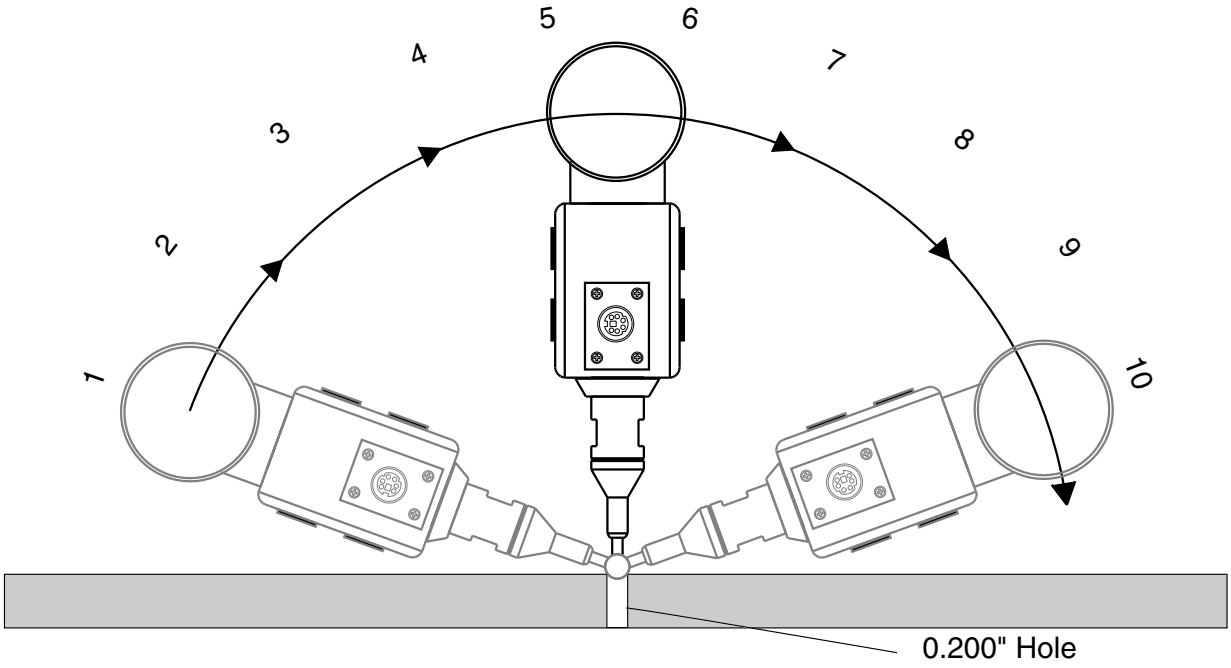


Figure 6 - Single Hole Calibration

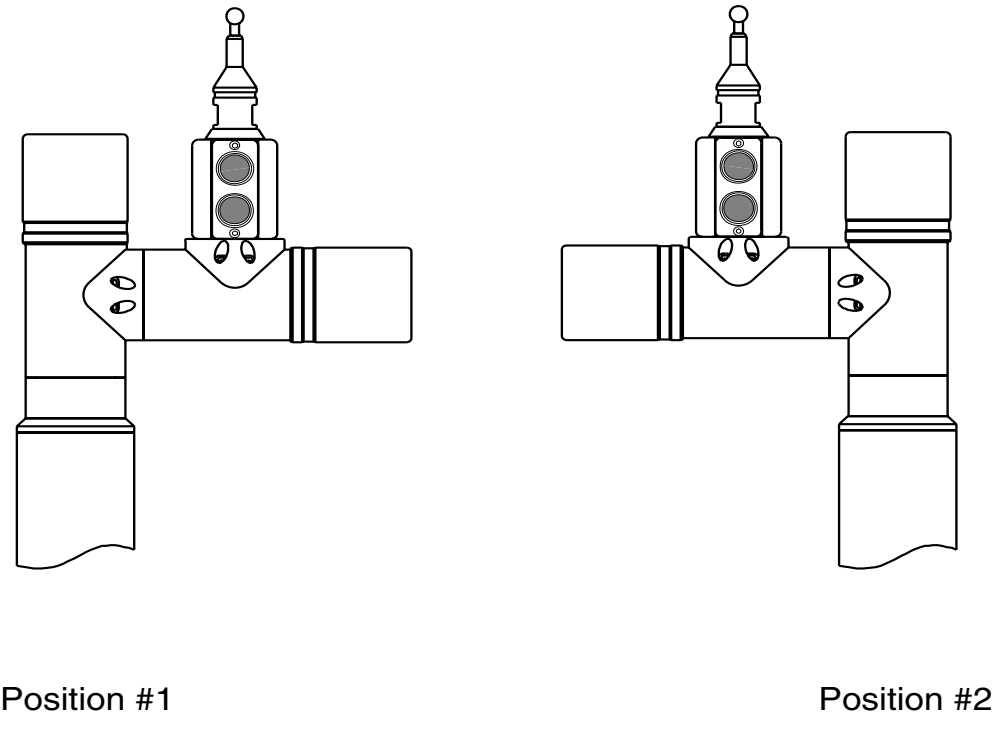


Figure 7 - Calibration Positions

NOTE: For all 27 calibration points digitized, the probe must be in full contact with the reference sphere. One or two poorly digitized points will significantly affect the optimization process, and therefore affect the accuracy of that probe.

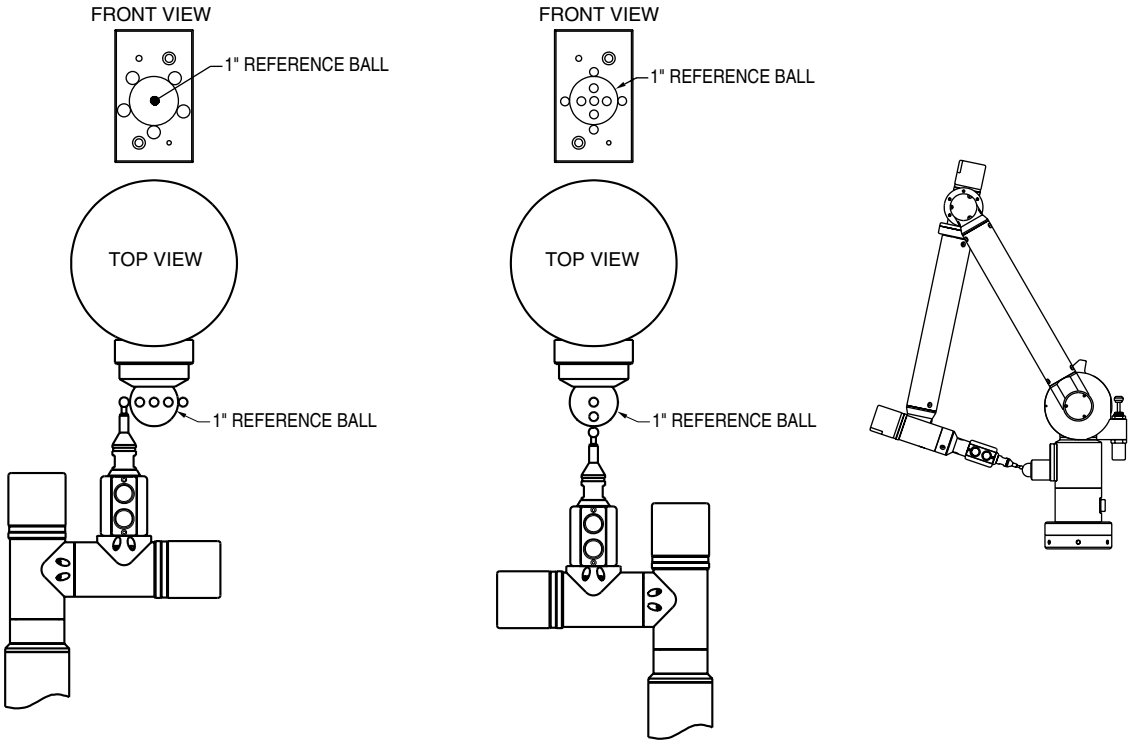


Figure 8 - FaroArm Sphere Calibration

Non FaroArm Sphere Calibration Method Configuration

This method is used to calibrate a probe using a non FaroArm Sphere. First, you must enter the Sphere Diameter you are using, then click the Calibrate button to display the NON FAROARM FLOATING SPHERE CALIBRATION dialogue box. Then, follow the procedures in the Instructions/ Steps section of the dialogue box. The procedures are similar to calibrating with a FaroArm Sphere. However, the location of the digitized points and the probe angle position are very specific. Each of the 25 calibration points are described in the dialogue box.

Remember: For all 25 calibration points digitized, the probe must be in full contact with the reference sphere. One or two poorly digitized points will significantly affect the optimization process, and therefore affect the accuracy of that probe.

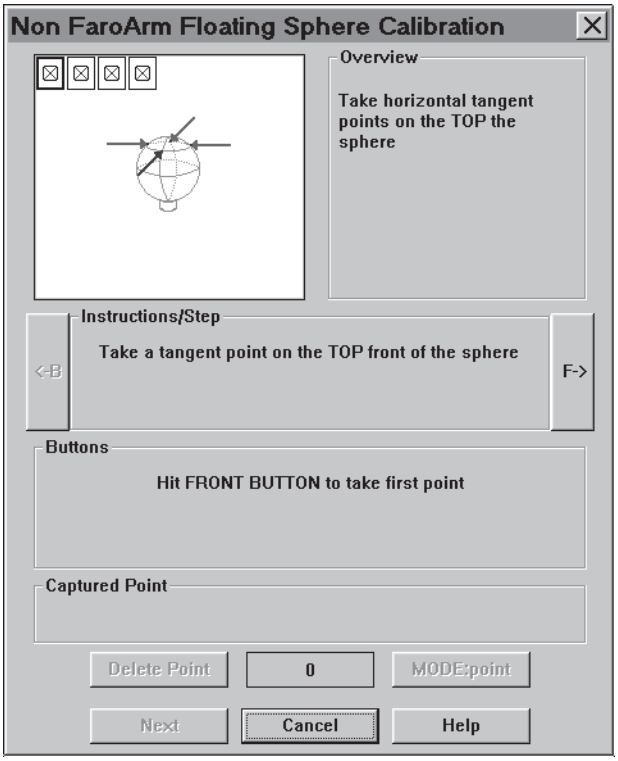


Figure 9 - Non-FaroArm Floating Sphere Calibration Dialog Box

Enter Tip Length

If you design a custom end effector for the FaroArm, the accuracy of the measurement depends on the end effector's design and material used. If the tip is not a point or a ball, the length dimension of the new custom end effector ***must*** be entered into the software.

After you calibrate your probe using the Single Hole, FaroArm Sphere, or Non-FaroArm Sphere calibration method, you must enter a tip length. The TIP LENGTH is added to the value of the Z coordinate in whichever units of measurement you have selected. It represents the *difference* in length between the ¼" ball probe and the probe you will be using. If the custom probe is longer than the ¼" ball probe, enter a positive value. If the custom probe is shorter, enter a negative value. The probe calibration values are saved until you recalibrate the probe, giving you the option of changing and selecting probes without having to recalibrate each time.

Enter the new length dimension of the custom probe. This length dimension is equal to the ***difference*** between the new custom probe and the length of the standard ¼" ball probe. First measure the ¼" ball probe length (base to center of ball), then measure the length of the custom probe.

The length you want to enter is:

CUSTOM LENGTH - ¼" PROBE LENGTH = NEW CUSTOM LENGTH

B - A = C

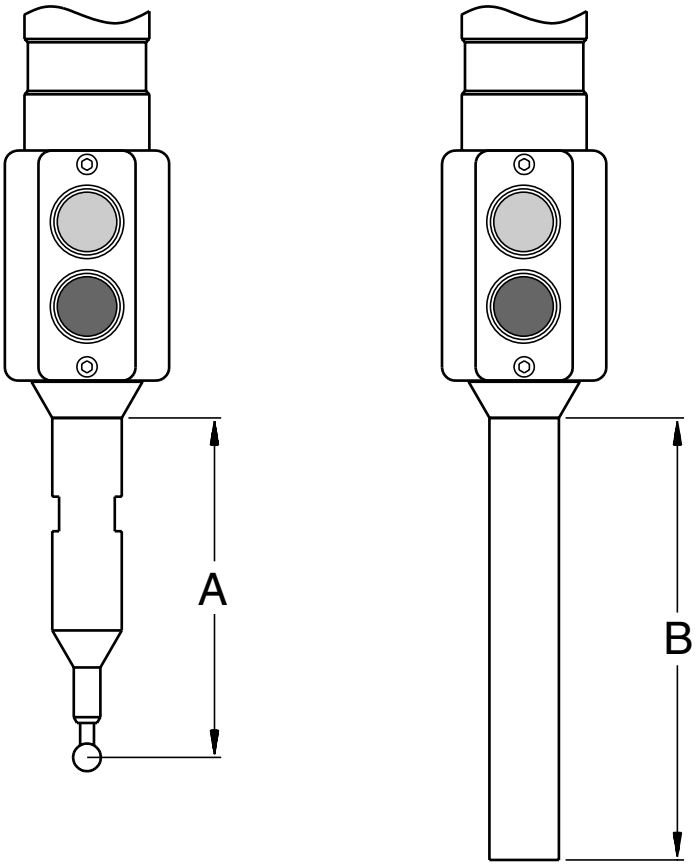


Figure 10 - Probe Lengths

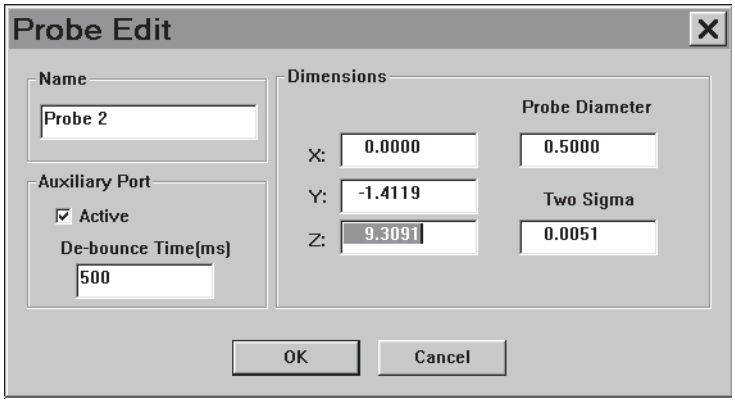


Figure 11 - Probe Edit Dialog Box

Communications

The Communication flyout displays the Settings and Close Communications When Out-of-focus selections. Settings allow you to select the Baud Rate (4800-115200), and Data/Parity (8/N, 7/E).

When Close Communications When Out-of-focus is checked, Caliper closes the communications port when it loses focus. When this selection is not checked, Caliper's communications port remains open and continues talking to the Arm, even when it loses focus.

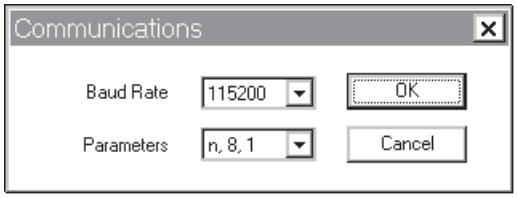


Figure 12 - Communications Dialog Box

Communication Parameters

Serial communication allows the computer to receive positional and rotational information directly from the FaroArm via the serial/controller box. Therefore, it is very important that the parameters for data transfer be set correctly to ensure that the data will be received and interpreted correctly. The default serial communication parameters used in Caliper 3D are as follows:

PORT:	COM1
BAUD RATE:	9600 BPS
DATA BITS:	8 bits
PARITY:	none
STOP BITS:	1 bit

Digitize Menu

Command	Description
Setup	Displays the DIGITIZE Setup dialog box which allows the user to select or define the digitization parameters to be used during measurement.
Remark...	Lets the user add a remark/comment to the EDIT window. This remark will be saved to file along with the data when saving occurs.
Lock Angles	Lets the user Lock/Unlock the angle display. This feature may be used to ensure that all angles recorded will be identical throughout the data collection, for example when creating a file for a tool pass at a constant angle. The angle will be locked to the angle of the arm at the moment of selection.
Single Point	Selects the Single Point digitization mode.
Stream	Selects the Stream digitization mode.
Locked Plane	Selects the Locked Plane digitization mode. This mode assumes that the user has defined one or more locked planes in the working envelope of the FaroArm (see Setup above). Each time the probe tip crosses one of the locked planes, a point will automatically be digitized.
Beep On Capture	Enables/Disables a computer generated sound on point capture.
Buffer Font Size	This value controls the size of the font in the Data File Dialogue Box.

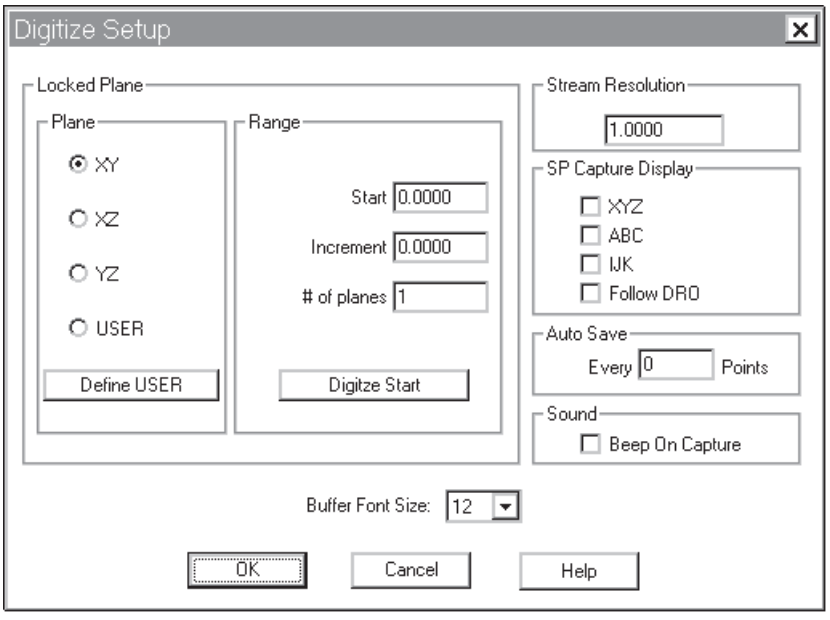


Figure 13 - Digitize Setup Dialog Box

The Digitize Setup

Locked Plane - Plane

Lets the user select which plane will be the main locked plane if the Locked Plane item of the Digitize menu is selected. Available planes are XY, XZ, YZ, and USER. The XY, XZ, and YZ planes are the machine coordinate planes which have their origin at the center of the 1" ball located at the base of the arm.

The USER DEFINE button lets the operator define the USER plane using the Three Point alignment method. The digitization sequence of the points determines the direction of the perpendicular. Counterclockwise produces a (+) direction perpendicular, and clockwise produces a (-) direction perpendicular.

Locked Plane - Range

The START field lets the user define how far away from the main locked plane the point collection is to begin. This usually comes into play when you have selected one of the three machine coordinate planes (XY, XZ, YZ) as your main locked plane. These three planes have their origin at the base of the arm, which is usually not where you would want to begin data collection.

The INCREMENT FIELD lets the user specify the desired spacing between the locked planes.

The # OF PLANES field lets the user specify how many locked planes are to be defined based on the first locked plane previously defined.

The DIGITIZE START button will allow the user to digitize the location of the location of the first locked plane.

Stream Resolution

Allows the user define the minimum distance between consecutive points taken during a scan.

SP Capture Display

Forces the single point capture display to report a combination of the XYZ, ABC, and IJK parameters, or to default to the DRO (digital readout) display.

Auto Save

Allows the user to determine if/when the automatic save feature should be activated to prevent data loss (save automatically at every X points you digitize). Set the number of points to 0 (zero) to turn this feature OFF.

Locked Plane - a definition

A locked plane is a user defined plane whereby every time the digitizer probe crosses that plane, a point is automatically digitized. One may have a single, or multiple locked planes at any given time. Multiple locked planes must be defined as being parallel and equidistant to each other.

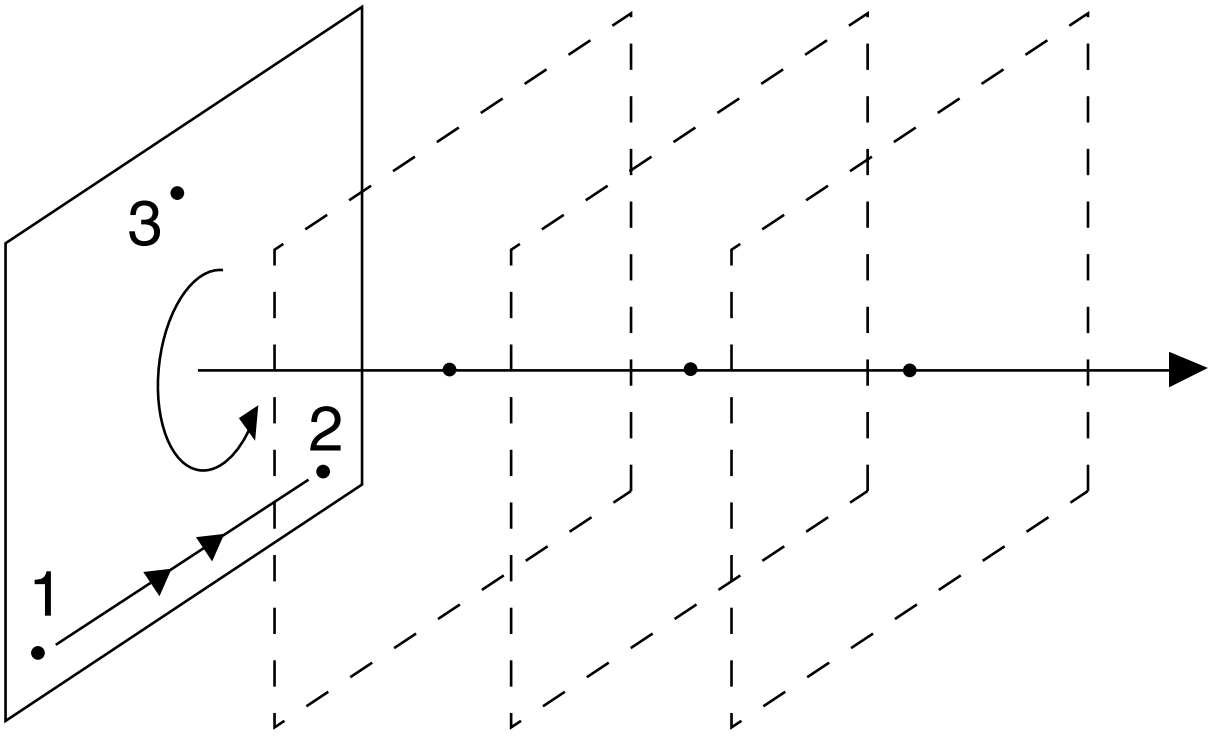


Figure 14 - Locked Planes

Alignments Menu

Command	Description
Three Point	The Three Point Alignment requires the user to digitize three datum greater than 11 inches apart in an approximate equilateral triangle to establish an alignment.
Three Sphere	The Three Sphere Alignment requires the user to establish three datum (one per sphere), greater than 11 inches apart in an approximate equilateral triangle to establish an alignment.
Datum Point	The Datum Point Alignment method is much like the Three Point alignment. The user will be prompted to key in the values for each point in the desired coordinate system. Next, the user will be prompted to measure the Datum, and the entered values will be assigned to each measured Datum.
Key In/Save/Recall	The Key In Alignment selection allows the user to override the FaroArm's machine coordinate system.
Plane/Line/Point	The Plane/Line/Point Alignment option leads the user through digitizing an object plane, a line on the positive X axis, and a point at the origin, all three of which will be used in establishing the object coordinate system.
Three Plane	The Three Plane Alignment allows the user to setup an alignment with the origin located at the intersection of three *orthogonal* planes.
Clear Alignment	This option resets the alignment to the FaroArm's machine coordinate system of X, Y, Z, I, J, K equal to 0, 0, 0, 0, 0, 1. The machine coordinate system origin is located at the center of the 1 inch reference sphere at the base of the arm.
Leap Frog	The Leap Frog Alignment option was designed to permit movement of the FaroArm around large objects while maintaining the original object coordinate system which was created using one of the other alignment menu items.

Three Point Alignment Method

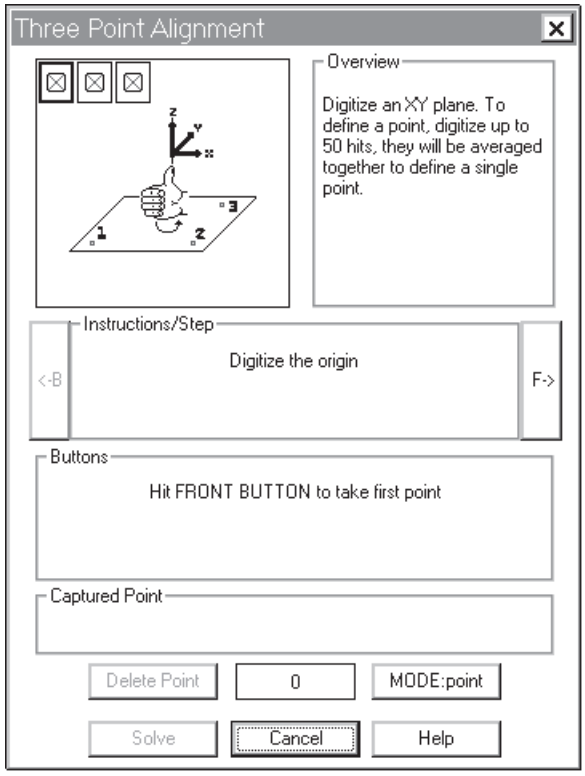


Figure 15 - Three Point Alignment Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is used to toggle between Point mode, Circle mode, and Sphere mode.

To setup an alignment using the 3 point method:

1. Digitize between 1 and 50 points at the origin of the desired coordinate system; These coordinates will be averaged to become datum #1, which will define your origin.
2. Digitize between 1 and 50 points at location along the positive X axis, at a distance greater than 11 inches from datum #1; These points will be averaged to become datum #2, and will establish your +X axis.
3. Digitize between 1 and 50 points at location on the positive XY plane, at a distance greater than 11 inches from datum #1 and #2; These points will be averaged to become datum #3 and will establish your +XY plane.

All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

NOTE: This coordinate system may be setup using a distance of less than 11 inches if desired. The software will display an warning message if this is done.

Three Sphere Alignment Method

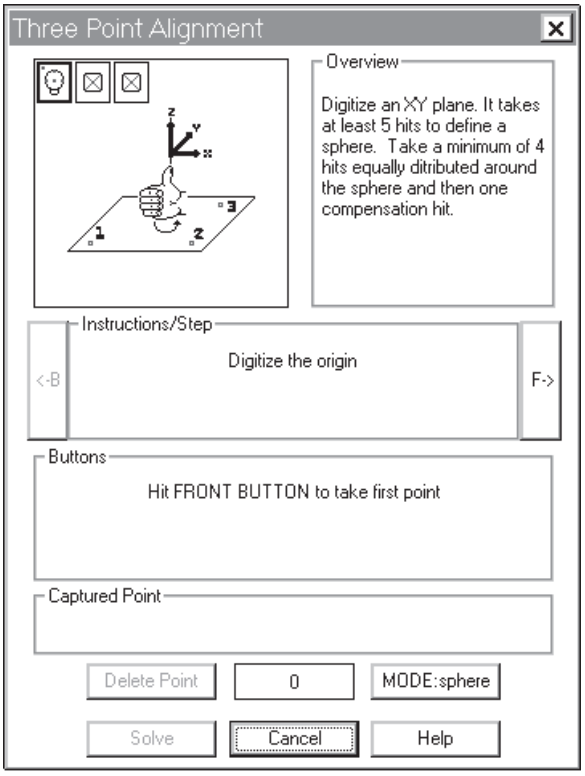


Figure 16 - Three Sphere Alignment Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is used to toggle between Point mode, Circle mode, and Sphere mode.

To setup an alignment using the three sphere method:

1. Digitize between 5 and 50 points on the sphere located at the origin of the desired coordinate system; Make sure that you take points on all sides of the sphere; These points will be best fit to become a sphere, with it's center defining your origin.
2. Digitize between 5 and 50 points on the sphere located along the positive X axis, at a distance greater than 11 inches from datum #1; Make sure that you take points on all sides of the sphere; These points will be best fit to become a sphere, with it's center establishing your +X axis.
3. Digitize between 5 and 50 points on the sphere located on the positive XY plane, at a distance greater than 11 inches from datum #1 and #2; Make sure that you take points on all sides of the sphere; These points will be best fit to become a sphere, with it's center , establishing your +XY plane.

All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

NOTE: This coordinate system may be setup using a distance of less than 11 inches if desired. The software will display an warning message if this is done.

Datum Point Alignment Method

The Datum point alignment is most often used when you are unable to reach the object's origin. It assumes that the object you will be working on has an already established internal coordinate system, and that you want to set the FaroArm's coordinate system to match the part's coordinate system. The datum coordinates that you will specify are positions defined with respect to the part's coordinate system. Once these coordinates are specified, you will be required to establish their positions with respect to the FaroArm's machine coordinate system so that the subsequent data will be collected with respect to the object's coordinate system.

Datum coordinates may be entered from the keyboard, digitized, or loaded from a file. If a datum is to be digitized, click the datum type, and then click the Digitize XYZ button. The digitized data will automatically be entered in the dialogue box.

Note: Any of the three input methods may be combined to enter the datum values.

The alignment may be calculated using the Absolute, or the Best-fit method. The Absolute method will match the 1st datum, match the line between datum 1 and datum 2, and use datum 3 to rotate about that line. The origin and the line are preserved and most of the error is located around datum 3. The Best-fit method will compare each datum and distribute the error evenly throughout all of the datums.

The coordinates may be saved to a file by choosing the SAVE button. This file can be loaded into the command by choosing the LOAD button.

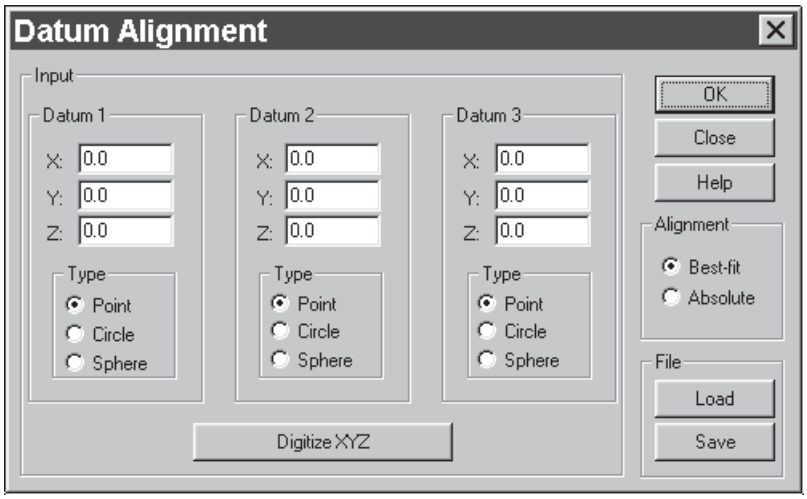


Figure 17 - Datum Alignment Dialog Box

To setup a datum point alignment:

1. Select the DATUM POINT item in the ALIGNMENT menu
2. Enter the X, Y, and Z coordinates of datum #1, as well as whether it is a point, sphere, or a circle.

3. Enter the X, Y, and Z coordinates of datum #2, as well as whether it is a point, sphere, or a circle.
4. Enter the X, Y, and Z coordinates of datum #3, as well as whether it is a point, sphere, or a circle.
5. Click on the OK button
6. Digitize up to 50 points per datum (1-50 for point, 7 for circles, or 5-50 for spheres) to reference the datum's entered positions.

All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

Key In/Save/Recall Alignment Method

Normally, X, Y, Z, A, B, C are 0, 0, 0, 0, 0, 0 and the center of the 1" precision ball located on the FaroArm base, and the displayed coordinates will be reported in this default alignment. This remains true until a object alignment is setup. The Key In Alignment lets the user redefine the coordinates of the 1" reference ball. The user can therefore use multiple FaroArms when measuring a part, and impose the same coordinate system on all of these arms by keying in the object coordinates.

The user may Save or Recall a saved coordinate setup by clicking on the SAVE or LOAD buttons in the Key In Alignment dialog box.

NOTE: The positional coordinates of each FaroArm base is most often measured in relationship to the part's coordinate system by two lasers.

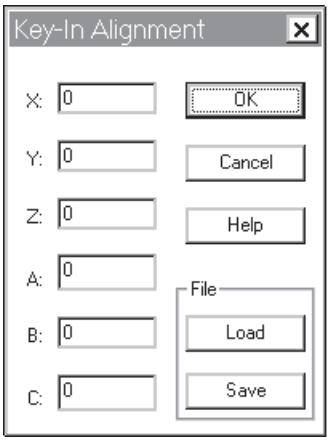


Figure 18 - Key-In Alignment Dialog Box

To setup an alignment using the key in method:

1. Select the KEY IN/SAVE/RECALL item in the Alignment menu.
2. Enter the new X, Y, Z, A, B, C parameters for the arm.
3. Click on OK.

All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

Plane/Line/Point Alignment Method

To setup a plane/line/point alignment:

1. Select the PLANE/LINE/POINT item from the Alignment menu.
2. Select which plane will be defined (XY, XZ, or YZ).
3. Select which line (axis) will be defined
4. Enter the offset coordinates for the point that will be defined as the origin. If no offset is desired, enter 0 (zero).

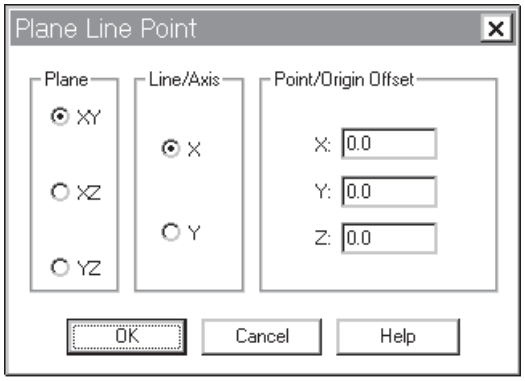


Figure 19 - Plane/Line/Point Alignment Dialog Box

5. Click on OK.
6. Digitize three points to define the plane selected in step #2. These three points should be in an approximate equilateral triangle, established at the furthest reach on the surface of your part.
7. Digitize two points to define the axis selected in step #3. The first point will define the starting point of the axis, and the second point will define the positive direction of the axis.
8. Digitize a point to define your origin. This origin will be offset by the X, Y, and Z coordinates entered in step #4.

All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

Three Plane Alignment Method

To setup a three plane alignment:

1. Select the THREE PLANE item from the Alignment menu.
2. Select which plane will be defined as your 1st plane (XY, XZ, or YZ).
3. Select which plane will be defined as your 2nd plane (XY, XZ, or YZ depending on plane 1).
4. Enter the offset coordinates for the point that will be computed to be the origin. If no offset is desired, enter 0 (zero).

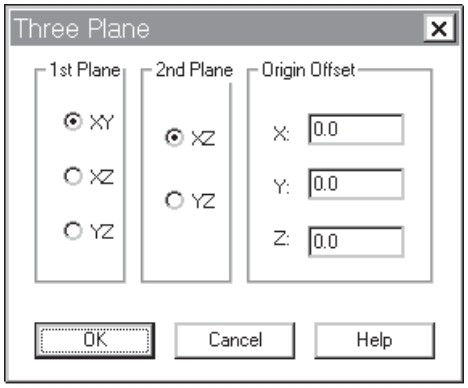


Figure 20 - Three Plane Alignment Dialog Box

5. Check the PROBE COMPENSATION box if desired. If the probe compensation is ON, the coordinates of the digitized point will be offset by the amount of the probe tip radius, in the direction of the probe compensation vector. You will be requested to establish the direction of the probe compensation vector in alignments which require it. If the probe compensation is OFF, the coordinates of the digitized point will be that of the center of the probe tip itself. Click on OK.
6. Digitize three points to define the 1st plane selected in step #2. These three points should be in an approximate equilateral triangle, established at the furthest reach on the surface of your part.
7. Digitize two points to define the 2nd plane selected in step #3. The first point will define the starting point of the axis, and the second point will define the positive direction of the axis.
8. Digitize a point to establish the 3rd plane. The third plane will be defined as mutually perpendicular to the first two planes.
9. The origin is computed to be at the intersection of these three planes. The location of this origin will be offset by the amount specified in step #4.

NOTE: Remember that the three planes are assumed to be orthogonal. If you are working with three planes that are not orthogonal, you may not make the assumption that your origin will be established at the intersection of your three planes. All future output data will be displayed in the coordinate system you have just defined. This coordinate system does not reset on a reboot, it must be reset each time a change is required.

Leap Frog Procedure

The Leap Frog procedure is designed to permit movement of the FaroArm around large objects while maintaining the coordinate system data which was originally created using one of the alignment methods. It involves digitizing the three datums of a "Leap Frog Jig" from two different arm positions, after which the transformation matrix used by the arm to measure position is recalculated based on the arm's displacement, and updated so that all points digitized after the Leap Frog will be reported in the original coordinate system. This procedure may be repeated numerous times to reposition the FaroArm around a large object.

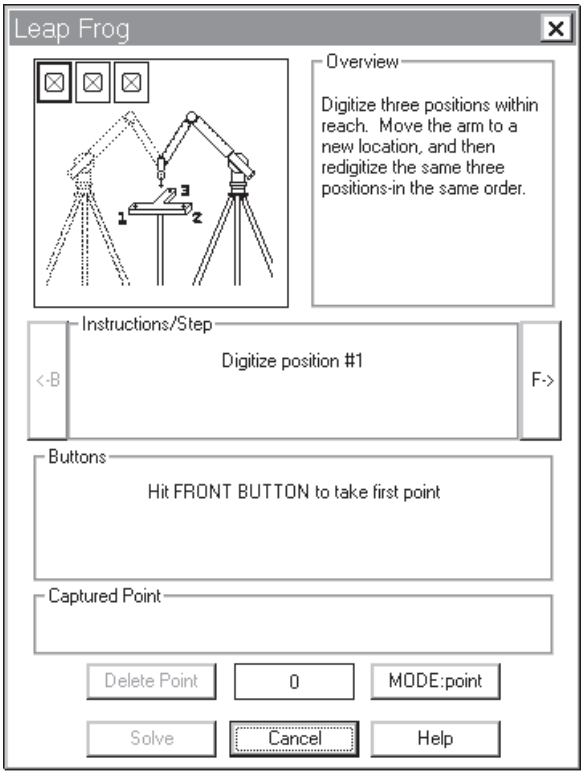


Figure 21 - Leap Frog Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. The SOLVE button activates when enough points have been digitized to solve for the matrix. You can toggle the MODE button between Point mode, Circle mode, and Sphere mode.

To perform a Leap Frog

1. Place the Leap Frog Jig within reach toward the direction which you wish to relocate the arm.
2. Digitize three datum points on the Leap Frog Jig.
3. Relocate the arm, keeping the Leap Frog Jig in position.
4. Re-digitize the same three datum points of the Leap Frog Jig.

All data digitized from this new position will now display in the original object coordinate system.

Leap Frog Recover

Leap Frog Recover is designed to recover a temporary Leap Frog coordinate system, should the FaroArm loose power. This command is useful when the FaroArm can not be moved without disconnecting the power. If a temporary Leap Frog coordinate system does not exist, the command will not continue.

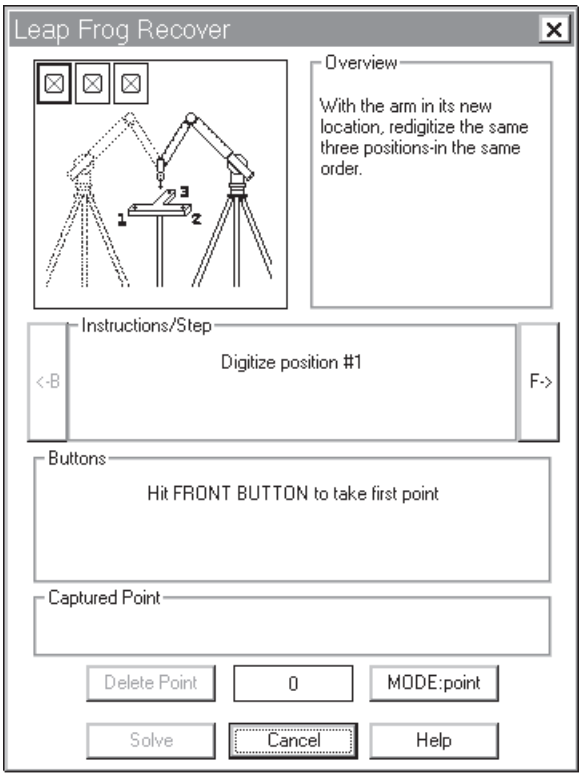


Figure 22 - Leap Frog Recover Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. The SOLVE button activates when enough points have been digitized to solve for the matrix. You can toggle the MODE button between Point mode, Circle mode, and Sphere mode.

To recover a Leap Frog system

1. Measure the Leap Frog Jig using the Leap Frog command.
2. Relocate the arm, keeping the Leap Frog Jig in position.
3. Select the Leap Frog Recover command.
4. Re-digitize the same three datum points of the Leap Frog Jig.

All data digitized from this new position will now display in the original object coordinate system.

Certification Menu

Command	Description
Ball Bar	Ball Bar Certification provides the user with a built-in technique for the verification of the FaroArm's accuracy. The Ball Bar accuracy test is based on the ANSI B89 1.12 standard and is accomplished by using the supplied Ball Bar with cone end, ¼ inch Ball End Effector, and the FaroArm's base socket. .
Step Gauge	This selection will allow the user to verify the accuracy of the FaroArm's linear displacement. The Step Gauge has multiple increments of one inch steps (blocks).
Sphere-Sphere	This operation will measure and statistically report the FaroArm's displacement accuracy using the distance between any two spheres. For instruction, the two spheres of the step gauge are used in the program.

Ball Bar Certification

To perform a Ball Bar accuracy test:

1. Place the ball bar's 1" ball into the FaroArm's base socket
2. Place the ¼" ball probe into the cone end of the ball bar
3. Make sure that the probe tip stays flush in the cone end of the ball bar and that the ball bar's 1" ball stays flush into the base socket.
4. Take a series of 50 points while you move the ball bar to various locations throughout the arm's working envelope.
5. Take care not to allow any of the transfer cases to reach their 'end-stop' position, as bending can occur in the arm and inaccuracies may result.
6. When done, close the data window and the results will be displayed.

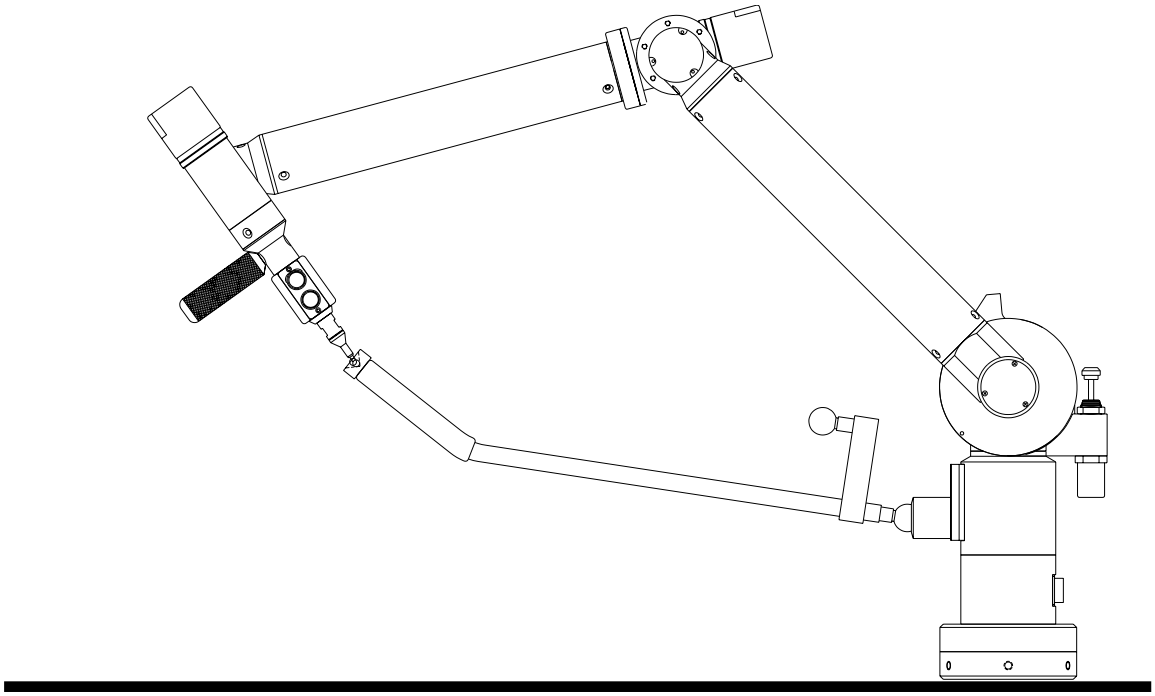


Figure 23 - Ball Bar Test Position

Step Gauge Certification

This operation will measure and report the FaroArm's linear displacement accuracy.

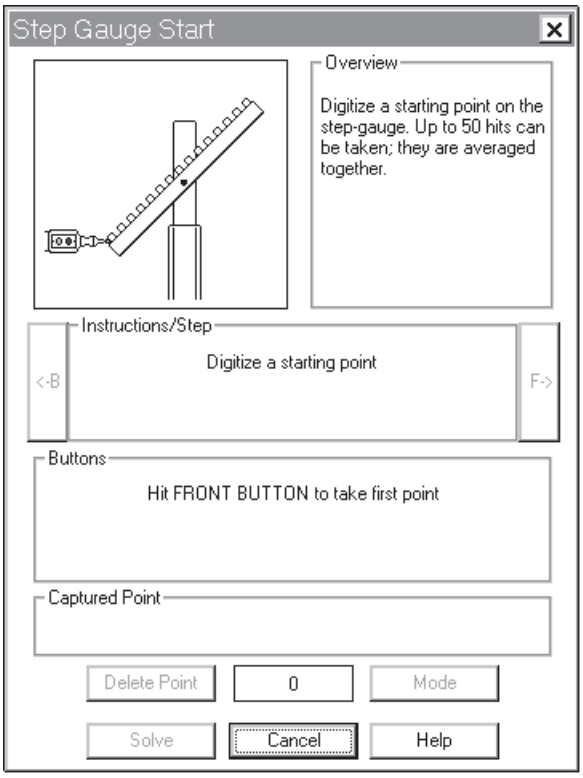


Figure 24 - Step Gauge Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is not an active pushbutton in this dialog box.

To perform a Step Gauge accuracy test:

1. Setup the object coordinate system by collecting datum #1 on the left end of the step gauge, datum #2 on the right end of the step gauge (to setup the +X axis), and datum #3 somewhere in space (to setup the +XY plane). Refer to the 3 point alignment for details.
2. Once the alignment is complete, digitize the reference point on step #1 at the base of the step gauge.
3. Digitize a point on the base of each one inch incremental steps.
4. Close the data window to show the result and min/max errors of linear displacement.

Sphere-Sphere Certification

This operation will measure and report the FaroArm's displacement accuracy using the distance between **any** two spheres. For instruction, the two spheres of the step gauge are used here.

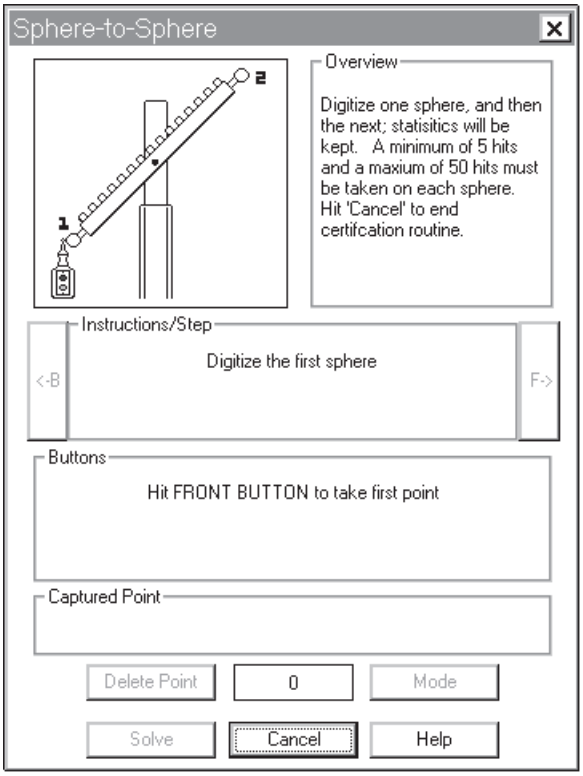


Figure 25 - Sphere-Sphere Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
Instructions/Step Field: This section instructs the user throughout the procedure by displaying each step as required.
Buttons Field: This section instructs the user on which button to use for what purpose throughout the procedure.
Captured Point Field: This section displays the coordinates of the captured point.
Buttons Area: This section contains the standard pushbuttons Ok, Cancel, Help. Delete Point deletes the point that was just digitized, and Mode is not an active pushbutton in this dialog box.

To perform a Sphere-Sphere accuracy test:

1. Digitize between 5 and 50 points on sphere #1.
2. Digitize between 5 and 50 points on sphere #2..
3. When done, the Sphere-to-Sphere Statistics dialog box will appear (Figure 20), displaying the pertinent information of the two datum.
4. Keep or discard this information, and repeat as many times as desired. The statistics that appear in the statistics dialog box are cumulative and may be saved, printed, or discarded.
5. Press the Cancel button of the Sphere-Sphere dialog box to stop this certification procedure.

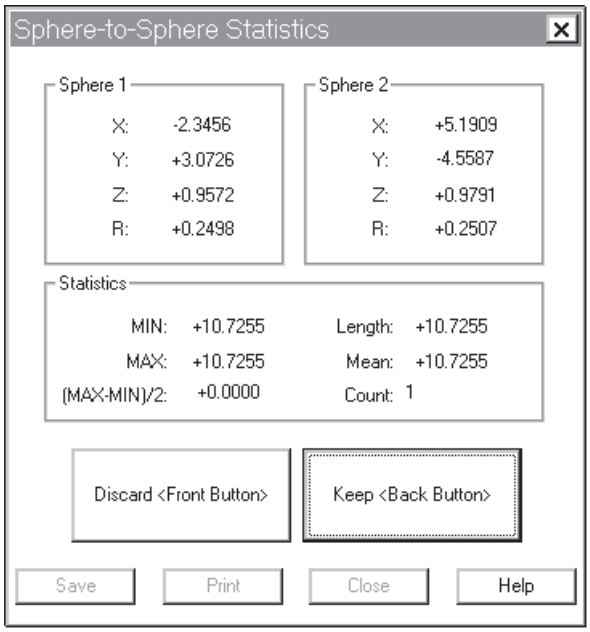


Figure 26 - Sphere-Sphere Results Dialog Box

Measure Menu

Caliper 3D allows for the measurement of circles, spheres, and a distance between two points. The displayed results are:

Circle	one value which is the XYZ center of the circle. Above the value a REM statement will display the circles radius and measurement error
Sphere	one value which is the XYZ center of the sphere. Above the value a REM statement will display the spheres radius and measurement error
Distance	one value which is the center of each feature measured. Above the value a REM statement will display the 3D distance between the two measured entities.

NOTE: When more then the minimum amount of points are measured for a circle(3) or a sphere(4), Caliper3D will average the points together and construct a "best fit" measurement. The result is the XYZ center of the best fit feature. The displayed error is the distance from the feature to the furthest measured point.

Circle

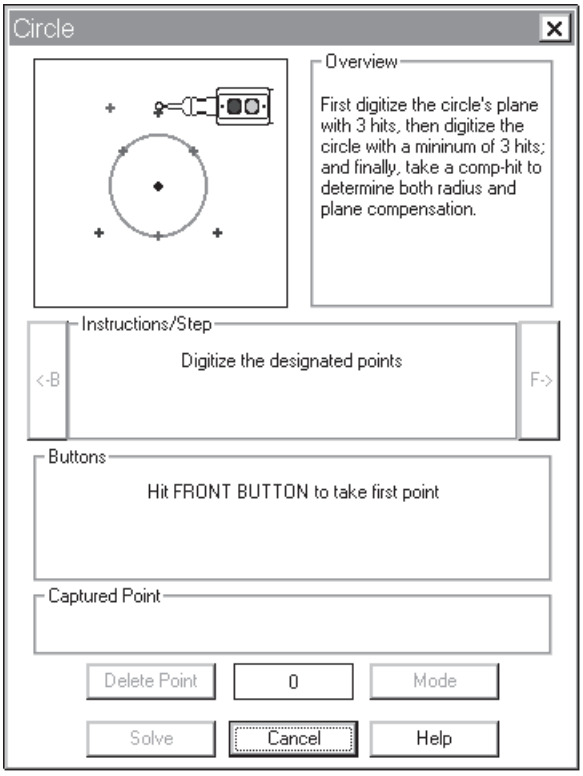


Figure 27 - Measure Circle Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is used to toggle between Point mode, Circle mode, and Sphere mode.

To Measure a Circle:

1. Digitize 3 points which will define the plane of the circle.

2. Digitize between 3 and 96 points to define the circle.

3. Digitize a single point for probe compensation of the circle and plane.

NOTE: Since a single point is used for compensation, make sure the probe position is inside the circle and above the plane.

Sphere

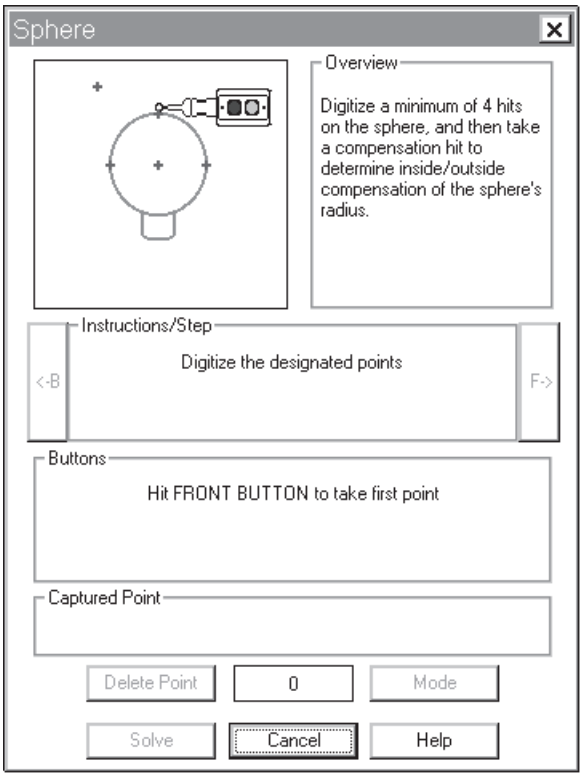


Figure 28 - Measure Sphere Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is used to toggle between Point mode, Circle mode, and Sphere mode.

To Measure a Sphere:

1. Digitize 4 -99 points which will define the sphere.
2. Digitize a single point for probe compensation.

Distance

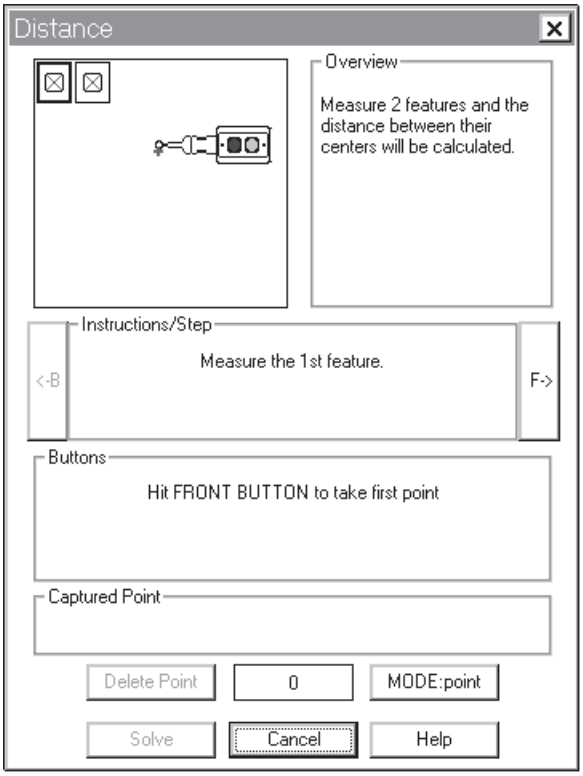


Figure 29 - Measure Distance Dialog Box

OVERVIEW Field: This section displays an overview of the procedure to be performed.
INSTRUCTIONS/STEP Field: This section instructs the user throughout the procedure by displaying each step as required.
BUTTONS Field: This section instructs the user on which button to use for what purpose throughout the procedure.
CAPTURED POINT Field: This section displays the coordinates of the captured point.
BUTTONS Area: This section contains the standard pushbuttons OK, CANCEL, HELP. DELETE POINT deletes the point that was just digitized, and MODE is used to toggle between Point mode, Circle mode, and Sphere mode.

To Measure a Distance:

1. Digitize 1 -99 points which will define the ***first*** point, sphere, or circle. Digitize a single point for probe compensation if necessary.
2. Digitize 1 -99 points which will define the ***second*** point, sphere, or circle. Digitize a single point for probe compensation if necessary.

Build Menu

Selecting BUILD will help the user locate a pre-defined location in 3D space. The BUILD dialog box will be displayed. Click on the File button and select the ACL file to be used. Once the file is selected, its contents will appear in the bottom portion of the screen. Select the line containing the coordinate you wish to locate by either using the cursor keys, or press the frontbutton to navigate forward or back button to navigate backward in the ACL file coordinate list. The selected line number will appear in the LINE NUMBER box. Then click on the Setup button to display the BUILD SETUP Dialog Box and choose which plane you want to be on and how close to the point to want to get (tolerance). The rest of the screen is separated into two main sections:

- The left side of the screen displays the end effector data, giving both its delta and a visual representation of its position from the desired location.
- The right side of the screen displays the angle of approach to the correct point, giving both its delta and a visual representation of its rotation from de desired approach.

Notice that the North, South, East, and West arrows on either side simply go blank and that the TARGET STATUS displays ON when you are within the tolerance of the desired coordinate.

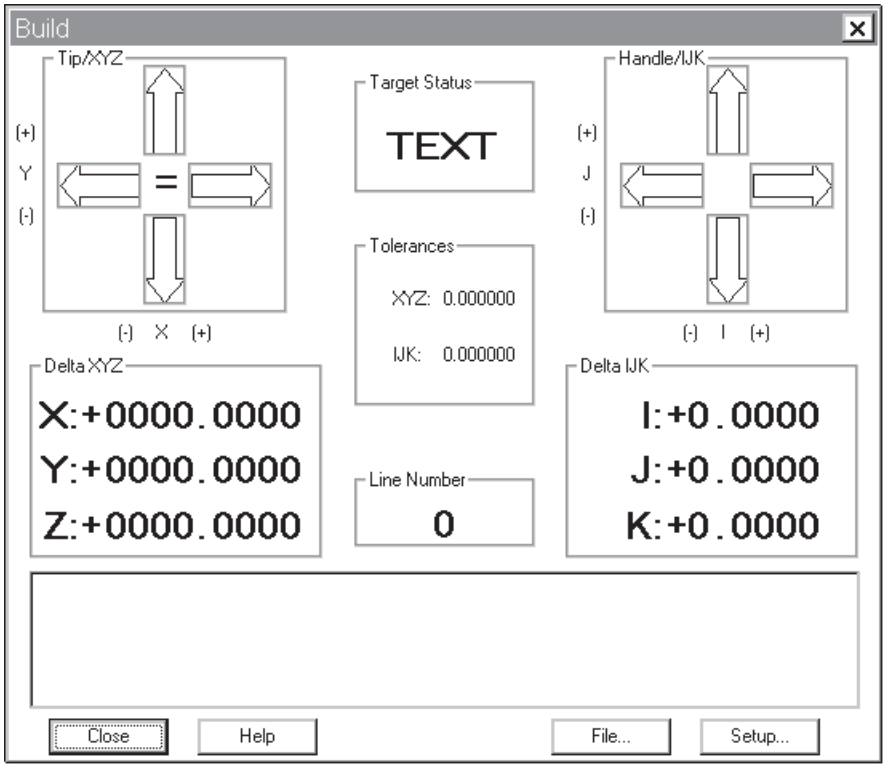


Figure 30 - Build Screen Dialog Box

The Build Setup

Plane Selection

The PLANE group of the dialog box allows the user to select which working plane is to be used to locate the desired points, XY, XZ, YZ, or AUTO. By selecting AUTO, the program will automatically determine which plane to use by selecting the plane which is *most perpendicular* to the probe's line of approach. Remember this fact when you are trying to locate your data point, as approaching the location in parallel fashion will fool the program into thinking that the desired plane isn't where you know it is!

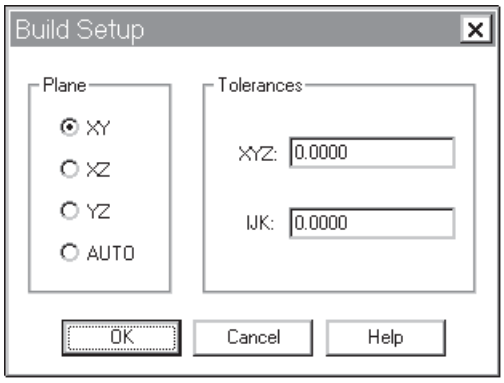


Figure 31 - Build Setup Dialog Box

Tolerances Section

The Tolerances setting lets the user specify how close to the original point they wants to be before the target arrows go blank and the Target Status says ON.

Diagnostic Menu

Command	Description
Terminal	Serial communication can be verified using this selection. The TERMINAL dialog box will be displayed requesting the user to enter a communication command. Once you have entered the command, click on the SEND button. The command will be sent to the arm serially, and the appropriate response will be sent back to the host computer. The response will vary depending on the command sent. See the List of Communication Commands for the expected responses.
Display	The DIAGNOSTIC DISPLAY dialog box will enable the user to examine the arm's joint angles, the tip's position with respect to the machine coordinate system, the ambient testing temperature, and the status of the front and back buttons.
Temperature	This selection will display the current temperature of the FaroArm and the elapsed time of temperature sampling. After five minutes of sampling, the software will report the minimum, maximum, and the stability of the temperature.

Help Menu

Command	Description
Contents	Displays the contents of this Caliper 3D manual through Adobe Acrobat Reader.
How to Use Help	As you browse through Caliper 3D Table of Contents in the Adobe Acrobat file, single-clicking on a Main heading in the Bookmark section of Adobe Acrobat Reader takes you immediately to that section. Single-clicking on the plus sign to the left of each heading opens additional subsections. Single-click on those subsections to go to that page. Return to the Main Table of Contents in the manual by clicking on the Table of Contents section.
About Caliper 3D	Displays information about your copy of Caliper 3D, including version number, and copyright.

Operational Concepts

Software Interfaces

Detailed descriptions of the interfaces for these programs are on the following pages. Please call INDUSTRIAL CUSTOMER SERVICE at (800) 736-2771 to obtain updates of available programs that will interface with the Faro Arm CMM.

CADKEY® and AutoCAD®, are registered trademarks of CADKEY, Inc., AutoDesk, Inc,. respectively.

Cadkey V7

Install the CADKEY7 Drivers.

NOTE: The installation process will modify the MOUSECAP file in the CADKEY7/ENGLISH/ sub directory. this file holds all of the input device definitions for CADKEY7. When running the FARO installation program you will be asked for the Device number for the FaroArm. This number should be one higher than the total number of devices listed in the CADKEY CONFIG program.

- You must install CADKEY7 first.
- The Caliper 3D install diskette is located in the back of your manual.
- Check under what directory you have CADKEY installed.

1. Insert the Caliper 3D disk into the floppy drive.
2. From the C:> type A: and hit Enter.
3. Type DRIVERS and hit Enter.
4. Select Install CADKEY Drivers from Main menu and hit Enter. Use the UP and DOWN Arrow Keys to select different options
5. Select Install CADKEY7 from CADKEY menu.
6. Select the Drive you wish to install to. The default is C:
7. Enter the directory where the Caliper 3D files are located.
8. Type in The name of the Directory where the CADKEY files are installed. This will default to \CADKEY - double check the name of your CADKEY directory!!
9. Type in the device number for the FARO Arm. This number needs to be one higher than the last driver listed in the CADKEY CONFIG program.
10. A message will appear that indicated a modification of the MOUSECAP file.
11. A backup of the original MOUSECAP file is created and named MOUSECAP.01.

Start The CADKEY7 CONFIG Program.

1. Start CADKEY7 Program.
2. From the Main Menu Choose:

- (7) CONTROL
- (8) SYSCMND
- (2) TEXT

3. Type CONFIG and hit Enter.
4. From the Configuration Utility Main Menu Choose:
    - (2) Set input device option
    - CADL input device
    - select the METRECOM INDUSTRIAL device
    - Type in the Com Port where the FaroArm is connected
    - (3) Return to Main Menu
5. From the Configuration Utility Main Menu Choose:
    - (7) Automatic file loading
    - press ENTER to accept the default macro library file
    - press ENTER to accept the startup macro file name
    - type FARO_SCN for the CADKEY Dynamic Extension.
6. select (9) to Exit and Save the Configuration

The Communication Baud rate must be changed to 19200. The CADKEY interface will only work at the 19200 baud rate.

- Choose (9) APPLIC from the CADKEY Main Menu
- Choose Utility from the Dialogue box menu. This will start the CaliperSA program
- Press Return until the Utilities menu is reached
- Choose (7) Default Settings
- Choose (2) Communications
- Choose the COM port where the SpaceArm is connected.
- Choose (3) for 19200 baud rate
- Choose (1) for 8,n,1
- Choose (1) for No Change
- Choose (0) for Exit program

To collect points using the FaroArm, choose (9) APPLIC from the CADKEY Main Menu. A dialog box will appear with the COLLECT 3D POINTS and COLLECT 3D STREAMS.

AutoCAD R12

Installation and Operation for Release 12
NOTE: you must install AutoCAD R12 first
The install diskette is located in the back of your manual.
1. Check under what directory you have AutoCAD installed.
2. From the A: prompt type DRIVERS and follow the prompts.
3. Choose which version of AutoCAD you are installing for, DOS or Windows.
4. Enter the directory where Caliper 3D is installed.
5. Enter the Drive where the drivers should be installed.
6. Enter the Directory where the drivers should be installed.

Command Line Text for DOS and Windows

Commands on command line are as follows:

(xload"C:/CALIP/ACSERIND.EXE")
Binary file that enables AutoCad to communicate with the arm.

(SINGLE_PNTS)
Digitizes points and places them in the ACAD database. Press the front button to digitize a point and the back button to confirm.

(CALIP3D)
CALIP3D lets you perform various tasks. The default for the Faro Arm will be set here.

(SCAN_STREAM)
Press front button to start and release button to pause and follow the prompts.

(SCAN_STREAM) command prompts the user for a 3D Polyline through the stream of points or just the stream of points to show on the display. Digitized points are auto-loaded into the ACAD data base at each set resolution.

(FARO_POINT)
For the AutoLISP user there is a point command called (FARO_Point). The FARO_Point command will not appear on the pull-down FARO menu, but it will load with the (xload"C:/calip/ascerind.exe") or pull-down menu (Load FARO Driver).

The (FARO_POINT) command will not show a point on the screen, but will return the X,Y, & Z. Simply type (FARO_POINT) on the command line or insert into an AutoLISP program. To digitize the point, press the front button only.

Pull Down Menu

Installation of pull down menu using the DOS edit command as an example.

The following text "POP10" must appear in your **C:\acad\support\adad.mnu** file, after the POP9 menu statement. The text below is recorded in **C:\calip\doc\acad_mnu.txt** Copy this POP10 menu statement and paste it in the acad.mnu file after POP9 menu statement.

```
***POP10
[FARO]
[~—              ]
[Load FARO Driver](xload"C:/CALIP/ascerind.exe")
[Unload FARO Driver](xunload"ascerind.exe")
[Single Points](single_pnts)
[Scan Streams](scan_stream)
[Caliper 3D](calip3d)
```

AutoCAD R12 for Windows

Installation and Operation, Release 12 for Windows
NOTE: you must install AutoCAD R12 for Windows first
The install diskette is located in the back of your manual.
1. Check under what directory you have AutoCAD installed.
2. From the A: prompt type DRIVERS and follow the prompts.
3. Choose which version of AutoCAD you are installing for, DOS or Windows.
4. Enter the directory where Caliper 3D is installed.
5. Enter the Drive where the drivers should be installed.
6. Enter the Directory where the drivers should be installed.

The following text "POP11" must appear in your **C:\acadwin\support\adad.mnu** file, after the POP10 menu statement. The text below is recorded in **C:\calip\doc\acad_mnu.win** Copy this POP11 menu statement and paste it in the acad.mnu file after POP10 menu statement.

```
***POP11
[FARO]
[~—              ]
[Load FARO Driver](xload"C:/CALIP/ascerind.exe")
[Unload FARO Driver](xunload"ascerind.exe")
[Single Points](single_pnts)
[Scan Streams](scan_stream)
[Caliper 3D](calip3d)
```

Configuration of AutoCAD R12 for Windows

To setup the communications port in Windows, follow these instructions:

1. Under MAIN GROUP in Windows, go to CONTROL PANEL.
2. SELECT PORTS and configure the port with the communication parameters you intend to use, e.g.. com1: 19200, N,8,1
3. CLOSE PORTS and open 386 ENHANCED. Pick the communications port being used and set it to always warn. Close the CONTROL PANEL, the configuration is complete.

AutoCAD R13 for Windows

The Faro13 program is installed along with the Caliper 3D software. From the AutoCAD TOOLS pull down menu select APPLICATIONS… and load the FARO13.ARX program file. The default file location is C:\Program Files\FARO Technologies\Caliper 3D\AutoCAD\faro13.arx. After loading, type **FARO** at the **Command:** prompt. If a FaroArm is connected a FARO dialogue box will appear which contains a digital read out (DRO). In the upper left corner of this dialogue box is a Windows Icon which contains a pull down menu. This menu is used for changing the digitizing collection mode as well as accessing the FaroArm settings.

This driver will input XYZ data directly to AutoCAD as single points or as a polyline.

MicroMeasure

NOTE: When running MM3, MM4, or PC-DMIS connect to communication port #1 (Com 1)
MM III:

For MM3 to communicate with the Controller Box, Caliper 3D communications parameters must be set to: 4800 baud, even parity, 7 data bits, and 1 stop bit; (4800, e, 7, 1), also select the ¼" Ball probe. MM3 uses the first hit for probe (inner/outer) compensation. Hence, the probe vector should have a positive component along the compensation vector.

Calibrate Probe

To calibrate a tip, use Caliper 3D. Do not use the tip qualification in MM3. To set the probe diameter exactly in MM3, select the second option ("adjust probe diameter") under the "Micro Measure III" menu item from the main menu system. You will be shown a list of previously qualified tips, and asked to enter a tip number to change or add. Enter a tip number and then enter the diameter of the tip in inches. The next time you use Micro Measure III, the tip will be available, You must then calibrate and select the tip in Caliper 3D, or it will be useless in Micro Measure III.

MicroMeasure 4 with Unix

For MM4 to communicate with the Controller Box, Caliper 3D must be used to set the communications parameters to: 4800 baud, even parity, 7 data bits, and 1 stop bit; (4800,e,7,1). MM4 uses the first hit for probe (inner/outer) compensation. Hence, the probe vector should have a positive component along the compensation vector.

To enter MM4, Unix must be booted. At the "boot:" prompt, hit enter. Next, hit Ctrl-D when asked to. When the login screen shows up, type "MM4" for the password. When the main MM4 screen appears, hit the upper left most power-on icon, if its indicator is red. If it is green, hit the icon directly below it to initialize the CMM.

Geomet

To connect with Geomet, use Caliper 3D and set the communications Parameters to 9600 baud, even parity, 7 data bits, and 1 stop bit (9600, e,7,1). For Geomet to function at all, you MUST have a printer hooked up and on-line . If you do not, Geomet will behave unpredictably.

Unix

1. Printer should be on-line.
2. Press enter at after boot-up for Unix or type DOS to enter DOS.

   (NOTE: Unix and DOS partition hard drives only)

3. Single user password and login-name is root.

Unix exit commands

1. Type: Root
2. Type: Root
3. Type: init 0 ,then wait while system is exiting

PC Avail

For Avail to communicate with the Controller Box, Caliper 3D communications parameters must be set to: 4800 e71, also the ¼"Ball probe. From the Unix prompt type Avail to start Avail. Next, select the operation of measure. Under branching, pick Servo, and set it to man_hrdprb. To set the probe diameter select Probe, then pick diameter and type the tip diameter (e.g. .25). The last step is to enable the probe, therefore select enable under probe pick. You are now ready to measure. The first hit should be away from measurement feature for proper probe compensation.

PC-DMIS 3.24

The probe diameter must be entered with in PC-DMIS. The part aliment is set-up also in PC-DMIS. For PC-DMIS to communicate with the Controller Box, Caliper 3D communications parameters must be set to 38400 7,1, also select the ¼" Ball probe. PC-DMIS operates only when the software key (module) is installed into the printer port. The probe compensation vector is the same a Micro Measure. To run PC-DMIS, select it from the menu, or type "pcdmis" in the C:\pcdmis3 directory. You are then shown the parts list; either select a part or login a new one. After this, pcdmis attempts the communicate with the CMM.

Perceval

The FaroArm can be used with Perceval, however a special command must be sent to the FaroArm using Caliper3D.

- Start Caliper3D for Windows
- Run the TERMINAL command in the DIAGNOSTIC Menu, and type `_X1`
- Exit Calip3D, and restart arm

Once the user performs the _X1 command, the box will stay in Perceval mode on every start. To disconnect from Perceval, run the TERMINAL command, and type _X0. Exit Calip3D, and restart arm.

Caliper 3D Errors

Many of the error messages listed in this section are not error conditions but decision-making situations that you will encounter in your use of Caliper 3D for Windows. Once you are familiar with Caliper 3D, most of these decisions will no longer be "problems", but a routine aspect of using the program. Be aware that certain errors, although not fatal, may lead to errors in data processing if not corrected. e.g.: error in alignment setup will cause inaccurate datum collection.

The following list contains some of the common messages that may occur while you are working with Caliper 3D. The messages are listed in alphabetical order.

DSP Beep Codes

Normal
2 QUICK 6000Hz BEEPS FOLLOWED BY 2 SLOWER 4000Hz BEEPS 1 SECOND LATER
normal boot, SERIND is loaded and ready
2 QUICK 6000Hz BEEPS FOLLOWED BY 3 VERY QUICK 4000Hz BEEPS
loader program is staying resident and ready
Errors
2 QUICK 6000Hz BEEPS FOLLOWED BY 2 1500Hz BEEPS
issued by SERIND
SERIND detected a configuration error, not calculating any positions, will respond to serial commands and report errors.
2 QUICK 6000Hz BEEPS FOLLOWED BY 3 1500Hz BEEPS THAT REPEAT EVERY SECOND
issued by loader
DMA failure, stuck in infinite loop
4 1500Hz BEEPS THAT REPEAT EVERY 1 SECOND
issued by MEMCHK
SRAM failure, stuck in infinite loop

LED Error Patterns

Please note that the FaroArms running with the serial box use a 6 LED system which uses a reverse bit error pattern as shown below.

ERROR CODE	LED PATTERN 1	2	3	4	5	6	ERROR CODE	LED PATTERN 1	2	3	4	5	6	ERROR CODE	LED PATTERN 1	2	3	4	5	6
1	●	○	○	○	○	○	22	○	●	●	○	●	○	43	●	●	○	●	○	●
2	○	●	○	○	○	○	23	●	●	●	○	●	○	44	○	○	●	●	○	●
3	●	●	○	○	○	○	24	○	○	○	●	●	○	45	●	○	●	●	○	●
4	○	○	●	○	○	○	25	●	○	○	●	●	○	46	○	●	●	●	○	●
5	●	○	●	○	○	○	26	○	●	○	●	●	○	47	●	●	●	●	○	●
6	○	●	●	○	○	○	27	●	●	○	●	●	○	48	○	○	○	○	●	●
7	●	●	●	○	○	○	28	○	○	●	●	●	○	49	●	○	○	○	●	●
8	○	○	○	●	○	○	29	●	○	●	●	●	○	50	○	●	○	○	●	●
9	●	○	○	●	○	○	30	○	●	●	●	●	○	51	●	●	○	○	●	●
10	○	●	○	●	○	○	31	●	●	●	●	●	○	52	○	○	●	○	●	●
11	●	●	○	●	○	○	32	○	○	○	○	○	●	53	●	○	●	○	●	●
12	○	○	●	●	○	○	33	●	○	○	○	○	●	54	○	●	●	○	●	●
13	●	○	●	●	○	○	34	○	●	○	○	○	●	55	●	●	●	○	●	●
14	○	●	●	●	○	○	35	●	●	○	○	○	●	56	○	○	○	●	●	●
15	●	●	●	●	○	○	36	○	○	●	○	○	●	57	●	○	○	●	●	●
16	○	○	○	○	●	○	37	●	○	●	○	○	●	58	○	●	○	●	●	●
17	●	○	○	○	●	○	38	○	●	●	○	○	●	59	●	●	○	●	●	●
18	○	●	○	○	●	○	39	●	●	●	○	○	●	60	○	○	●	●	●	●
19	●	●	○	○	●	○	40	○	○	○	●	○	●	61	●	○	●	●	●	●
20	○	○	●	○	●	○	41	●	○	○	●	○	●	62	○	●	●	●	●	●
21	●	○	●	○	●	○	42	○	●	○	●	○	●	63	●	●	●	●	●	●

● INDICATES FLASHING LED

Please note that the FaroArms running with the serial box use a 7 LED system which uses a reverse bit error pattern as shown below.

ERROR CODE	LED PATTERN 1	2	3	4	5	6	7	ERROR CODE	LED PATTERN 1	2	3	4	5	6	7	ERROR CODE	LED PATTERN 1	2	3	4	5	6	7
1	○	○	○	○	○	○	●	22	○	○	●	○	●	●	○	43	○	●	○	●	○	●	●
2	○	○	○	○	○	●	○	23	○	○	●	○	●	●	●	44	○	●	○	●	●	○	○
3	○	○	○	○	○	●	●	24	○	○	●	●	○	○	○	45	○	●	○	●	●	○	●
4	○	○	○	○	●	○	○	25	○	○	●	●	○	○	●	46	○	●	○	●	●	●	○
5	○	○	○	○	●	○	●	26	○	○	●	●	○	●	○	47	○	●	○	●	●	●	●
6	○	○	○	○	●	●	○	27	○	○	●	●	○	●	●	48	○	●	●	○	○	○	○
7	○	○	○	○	●	●	●	28	○	○	●	●	●	○	○	49	○	●	●	○	○	○	●
8	○	○	○	●	○	○	○	29	○	○	●	●	●	○	●	50	○	●	●	○	○	●	○
9	○	○	○	●	○	○	●	30	○	○	●	●	●	●	○	51	○	●	●	○	○	●	●
10	○	○	○	●	○	●	○	31	○	○	●	●	●	●	●	52	○	●	●	○	●	○	○
11	○	○	○	●	○	●	●	32	○	●	○	○	○	○	○	53	○	●	●	○	●	○	●
12	○	○	○	●	●	○	○	33	○	●	○	○	○	○	●	54	○	●	●	○	●	●	○
13	○	○	○	●	●	○	●	34	○	●	○	○	○	●	○	55	○	●	●	○	●	●	●
14	○	○	○	●	●	●	○	35	○	●	○	○	○	●	●	56	○	●	●	●	○	○	○
15	○	○	○	●	●	●	●	36	○	●	○	○	●	○	○	57	○	●	●	●	○	○	●
16	○	○	●	○	○	○	○	37	○	●	○	○	●	○	●	58	○	●	●	●	○	●	○
17	○	○	●	○	○	○	●	38	○	●	○	○	●	●	○	59	○	●	●	●	○	●	●
18	○	○	●	○	○	●	○	39	○	●	○	○	●	●	●	60	○	●	●	●	●	○	○
19	○	○	●	○	○	●	●	40	○	●	○	●	○	○	○	61	○	●	●	●	●	○	●
20	○	○	●	○	●	○	○	41	○	●	○	●	○	○	●	62	○	●	●	●	●	●	○
21	○	○	●	○	●	○	●	42	○	●	○	●	○	●	○	63	○	●	●	●	●	●	●

● INDICATES FLASHING LED

Error Codes

BASIC ERROR (MAJOR ERROR)	EXTENDED ERROR (MINOR ERROR)	DESCRIPTION
1	0	hardware error, transducer #1
2	0	hardware error, transducer #2
3	4	hardware error, transducer #3
4	0	hardware error, transducer #4
5	0	hardware error, transducer #5
6	0	hardware error, transducer #6
7	0	transducer #1 out of calibration
8	0	transducer #2 out of calibration
9	0	transducer #3 out of calibration
10	0	transducer #4 out of calibration
11	0	transducer #5 out of calibration
12	0	transducer #6 out of calibration
13	0	no transducer voltage
14	# of points	not enough points taken for this command
15	0	points taken are too close together
16	0	temporary system not repeatable to 0.1"
17	0	no solution for system of points
18	0	error writing internal data -EEPROM not responding
19	0	zero or negative radius given -(1" ball calibration)
20	0	serial number mismatch -only a warning
21	0	serial number is zero / arm not calibrated -arm is unusable/inaccurate
22	0	controller box floating point math error.
23	0	temperature deviation error - the temperature has changes more than 5° in the last 5 minutes
24	0	checksum error - might be reported while any type of file is sent, error receiving file
25	0	error writing FLASH - program unable to write FLASH - maybe FLASH not erased first/damaged
26	0	DMA or A/D error - either the DMA INT's are not working, or the A/D INT's are out.
26	1	Capture line stuck high
26	2	Capture line stuck low
26	3	I2C error, buffer error
26	4	I2C error, CRC
26	5	I2C error, address
26	80	I2C error, T. case 1
26	82	I2C error, T. case 2
26	84	I2C error, T. case 3
26	86	I2C error, T. case 4
26	88	I2C error, T. case 5
26	90	I2C error, T. case 6(only on 7 axis arms)
26	92	I2C error, T. case 6 or 7(depending on 6 or 7 axis arm)
26	144	I2C error, temperature sensor
27	0	hardware error, transducer #7
28	0	transducer #7 out of calibration
29	1	UART error, buffer error
29	2	UART error, not enough room to send
30	X	Renishaw bounced > 16ms, "X" is # of bounces
59	0	missing/invalid external data
60	0	error initializing serial port - will not report this over serial line.
61	0	error reading internal (EEPROM) data -invalid data in EEPROM
62	0	analog interface board initialization error

Troubleshooting

Ball Bar shows excessive error

- must use ¼” probe
- check length of ball bar before accepting point
- recalibrate tip
- during test, watch 1"ball and tip to ensure flush seating

Error indicator and flashing LED’s

- refer to your FaroArm User Guide, LED error codes.

Error message on host computer

- refer to Caliper 3D Errors

Error time-out on serial port

- lost communication, check null modem cable
- check A/C power
- check host computer configuration input device

No serial communication from controller box

- check cable
- check baud rate

Leap Frog repositioning fails

- make sure that distance between the points or target spheres on the leap frog target are at least 11" apart

Probe calibration fails

- redo probe calibration, checking that all 27 points were taken
- make sure that probe tip is in contact with 1" ball
- be sure to exercise full sweep of arm and 1" ball during calibration

Switches (front & back) will not respond

- check LED’s on controller
- has arm traveled through all reference points?
- turn auxiliary port OFF

Too Fast

- missed one point, slow movement down

Unable to be establish coordinate system

- make sure that distance between origin, X-axis, and XY-plane points are at least 11" apart from each other

Way too Fast

- missed four points, stream will be canceled
- stream rate is too dense, reset stream resolution

ESD - Bronze Series

Electrostatic discharge (ESD) refers to pulses generated by the discharge of loaded objects and/or persons. The charge usually comes about through friction between two materials, one of which is a nonconductor. This unit does not always respond to ESD, depending on the polarity and intensity of the electrostatic discharge. Although this unit cannot be physically damage by ESD, extra care and proper ESD procedures must still be observed and followed when handling this unit.

If an error occurs in the unit due to ESD, check the Error Message displayed on the screen and follow the steps below to resume normal operation.

If the message displayed is:

1.) "Timeout Error on Serial Line", do

a) Press any key on the keyboard and the unit should be back to normal operation.

2.) "No Transducer Voltage Error", do

a) Reboot the unit by unplugging the power cord from the wall outlet and wait forat least 5 seconds before plugging it back in.

b) Press any key on the keyboard and the unit should be back to its normal operation.

NOTE: If step 2 was followed all data will be lost due to power down. A new set of data should be collected.

ESD - Silver Series

Electrostatic discharge (ESD) refers to pulses generated by the discharge of loaded objects and/or persons. The charge usually comes about through friction between two materials, one of which is a nonconductor. This unit does not always respond to ESD, depending on the polarity and intensity of the electrostatic discharge. Although this unit cannot be physically damage by ESD, extra care and proper ESD procedures must still be observed and followed when handling this unit.

If an error occurs in the unit due to ESD, check the Error Message displayed on the screen and follow the steps below to resume normal operation.

If the message displayed is:

1) "Transducer out of calibration",

   a) Press any key on the keyboard and the unit should be back to normal operation.

NOTE: If the user experiences anything out of normal operation, reboot the unit by unplugging the 20 ft. cable from the power supply module. Wait for at least 5 seconds before powering the unit and it will re-establish communication with host PC.

FaroArm Power Supply

All servicing shall be referred to qualified service personnel.

Rated Voltage:	110 - 230V ~
	50 - 60 Hz
Voltage Tolerance:	+10% or -10%
Rated Input:	0.5A - 0.263A
Sec. Voltage:	+12 VDC
Sec. Current:	2.08A Max
Pollution Category:	2
Installation Category:	II

CAUTION
(INDOOR USE ONLY)

PROPER SELECTION OF POWER CORD

The proper selection of power supply cord intended for installation in a protected environment should be followed as stated below. You as the user should locate this unit in an area accessible to a properly grounded outlet receptacle. The input power plug is the disconnect device to remove power from the unit.

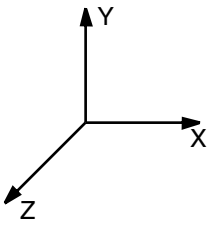
For 120V Connection: Use a UL Listed, type SJT or SVT, 3-Conductor, 18 A.W.G. power supply cord, terminating in a molded-on plug cap rated 125 VAC, 15A minimum, with a minimum length of 6 feet.

For 220 - 240V Connection: Use an international harmonized, 300V rated, PVC insulated jacket, three conductors of 0.75mm^2 minimum cross sectional area each, with a molded-on plug cap marked with proper agency marking for the country it will be used in.

Eulerian Angles

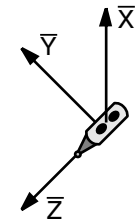
Eulerian Angles define an orthogonal coordinate system that results from three successive rotations from a fixed coordinate system.

The three successive rotations are:
A is a rotation about the Z axis giving X′,Y′,Z′ = **A**
B is a rotation about the X′ axis giving X′′,Y′′,Z′′ = **B**
C is a rotation about the Z′′axis giving X′′′,Y′′′,Z′′′ = **C**

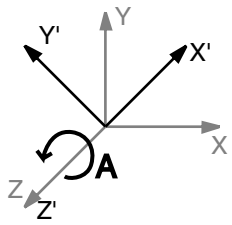


Part Coordinate System

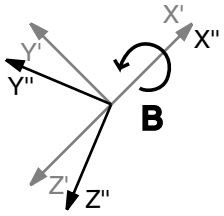
Note: All Rotations are Counter Clockwise



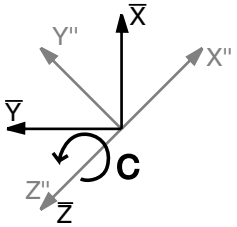
Probe Coordinate System



① Rotate "A" about Z Axis to yield X', Y', Z'



② Rotate "B" about X' Axis to yield X", Y", Z"



③ Rotate "C" about Z" Axis to yield X, Y, Z

Direction cosines I, J, and K may be computed from 2 of 3 Eulerian angles. The direction of these vectors are “in” to the part, or “out” of the FaroArm probe.

I = (sin B sin A)
J = (-sin B cos A)
K = cos B

Technical Support

FARO Technologies Inc. is committed to providing the best technical support to our customers. Our Service Policy is detailed in Appendix A of this manual. If you have any problem using one of our products, please follow these steps before contacting our Technical Support Team:

- Be sure to read the relevant sections of the documentation. Many times the answer is right there.
- Document the problem you are experiencing. Be as specific as you can. The more information you have, the easier the problem will be to solve. Use the worksheet in Appendix A as a guide.
- If you still cannot resolve your problem, have your FaroArm **SERIAL NUMBER** available ***before calling.***

You may contact our Technical Support Team directly if you are eligible under the FARO Service Policy (see Appendix A). Technical Support hours are from 8:00AM to 5:00PM Eastern Standard Time, Monday through Friday. You may also fax in your problems or questions 24 hours a day.

ALL USERS

- FAX SUPPORT (407) 333-8056

Faxes sent outside regular working hours (8:00AM to 5:00PM EST Monday through Friday) will usually be answered before 12:00PM EST the next working day. Please be sure to use the **Customer Service Industrial Fax Form** located in Appendix A of this manual, and include your return FAX and phone numbers, and the name of the certified user.

CERTIFIED USERS

- PHONE SUPPORT (800) 736-2771 US / (407) 333-9911

Technical Support hours are 8:00AM to 5:00PM EST, Monday through Friday. Should our staff be on other calls, please leave a voice mail message; calls are always returned within 4 hours. Please remember to leave a detailed description of your question and your FaroArm serial number. And do not forget to include your name, fax, phone and extension number, so we may reach you promptly!

Appendix A

INDUSTRIAL PRODUCTS SERVICE POLICY

FARO HARDWARE UNDER WARRANTY

A one-year warranty comes with the purchase of new FARO manufactured hardware products. Supplemental service plans are also available at additional cost. See Appendix D for further details.

- The following is a summary of what service can be obtained under the Standard warranty.

  1. Factory repairs on FARO manufactured hardware product defects (see attached Customer Service Fax Form for troubleshooting);

  2. Factory repairs are usually completed within 7 working days of FARO's receipt of the defective item. The customer is responsible for returning the hardware to FARO in the original packing container or custom case;

  3. FARO will return the hardware via 2 day air service to the Continental US. Outside the Continental US, FARO will return the hardware to the customs broker via 2 day air service. Expedited service can be arranged at the customer's expense if the customers' corporate account number is provided;

  4. Free telephone support, for technical problems and applications, for all certified users. For every FaroArm or training purchased free certification is provided. (See certification section);

  5. Warranties can be renewed annually on FARO manufactured hardware products;

  6. A warranty **cannot** be purchased if the original or renewed warranty has expired;

  7. All warranties will be due for renewal in one of the following quarterly months; March, June, September or December. The quarterly month after the ship date month will be the month the warranty expires. Example: The hardware was shipped on January 10, 1996, the renewal will be due by March 31, 1997;

  8. Warranties are transferable to subsequent owners under certain conditions:

     - The FaroArm is currently under warranty
     - New owner is, or becomes, a certified user.
     - A FARO warranty transfer form is completed, and submitted to Customer Service.

  9. Free Caliper 3D upgrades.

FARO HARDWARE NOT UNDER WARRANTY

- Caliper 3D software updates must be purchased for the current published list price.
- Telephone support will cost $2.00 per minute, or the customer may use the Customer Service Fax Form (sample attached) for troubleshooting problems via fax at no charge.
- If the initial troubleshooting does not resolve the problem, then all factory assessments and repairs on FARO manufactured products will follow the following procedure:

    1. The customer obtains a service number from FARO's Customer Service Department;

    2. The customer sends the part to FARO with the service number on the label along with $1,500 payment or a corporate purchase order for system testing and evaluation which includes calibration and recertification;

    3. The payment will be applied towards the total service cost beyond the initial payment. The estimate repair cost will be given to the customer prior to the repair. The total cost must be paid prior to beginning the service;

    4. System testing and evaluation can take up to 30 days. FARO manufactured part repairs can take up to 60 days. However, the part will be scheduled for service as soon as it arrives at FARO's factory;

    5. FARO will return the repaired part via UPS ground service in the USA only. If the customer is outside the continental USA, FARO will return the repaired part via UPS ground service directly to the customs broker. Expedited service can be arranged at the customer's expense if the customers' corporate account number is provided.

FARO SOFTWARE UNDER WARRANTY

- A one-year warranty comes with the purchase of all new FARO-developed software.
- The warranty includes:

    1. Free telephone and fax support for all certified users (see certification section);

    2. Free updates and new releases of FARO developed software.

- Warranties can be renewed annually for FARO developed software.
- All warranties will be due for renewal in one of the following quarterly months; March, June, September or December. The quarterly month after the purchase month will be the month the warranty expires. Example: The software purchase was made in January 10, 1996, the renewal will be due by on March 31, 1996.

FARO SOFTWARE NOT UNDER WARRANTY

- Once the warranty has lapsed on FARO software, the following applies:

  1. Telephone support will cost $2.00 per minute;

  2. Questions may be faxed to FARO's Customer Service department at no charge. Please use the Fax Form attached;

  3. Once out of warranty the customer may elect to purchase the current software upgrade at 50% of the current list price. Warranty renewals for subsequent years will be available at the current published warranty renewal rate.

HARDWARE & SOFTWARE TRAINING

- FARO's training program is designed to instruct trainees in the operation of FARO's hardware and/or software which the customer has purchased. The training classes are set up for each trainee to obtain valuable hands on application exposure. This will help the trainees in their everyday use of the hardware and/or software. FARO also feels that once the trainee completes the training, finding solutions to problems or applying applications will be simpler. Details are as follows:

  1. The training class will prepare attendees to successfully attain an operators certification (see certification section for more details);

  2. FARO also has a "Train The Trainer" course available for customers who have an in-house training department. Please contact Customer Service for details;

  3. The fee schedules for advanced additional training courses can be obtained from Customer Service, or the Industrial Training Department.

CERTIFICATION REQUIREMENTS

The FaroArm operator's inherent ability to understand 3-D concepts may be in their background training. However, the precision with which the operator performs 3D measurements with the FaroArm is critical in establishing the accuracy and repeatability of the results of subsequent measurements.

In order to establish the proficiency of FaroArm operators, FARO has instituted an Operator Certification program, where each operators knowledge and understanding of the FaroArm is evaluated. The successful operator is awarded a certificate which identifies him/her as an accredited FaroArm operator. The requirements are as follows:

1. Attend a FARO conducted basic training course, either at a FARO Facility or onsite at your facility.

2. Certification.will be awarded once the class has been completed, and then the certified user will be registered for hardware and software support.

To certify an operator please please call FARO Technologies, Inc. Training Department, 1-800-736-0324 for updated information.

FaroArm REPAIR FEE SCHEDULE

(Out of Warranty Owners Only!)

SYSTEM TESTING AND EVALUATION FEE:

A fee is charged for any system testing and evaluation. This includes system diagnosis, calibration and/or re-certification, and applies to all FaroArms. However, this fee does not include disassembly/repair costs if required. An estimated cost for disassembly/repair will be given to the customer prior to the repair. The disassembly/repair charges must be paid in full prior to the actual disassembly/repair. However, if no repairs are needed the fee will be applied to the cost of system testing and evaluation. All evaluations contain a re-certification. Re-certification will be performed on an "as needed" basis.

$ 1,500.00

REPAIR TIMES:

Calibration and/or Re-certification Only - Can take up to 14 days to complete.

Disassembly and Repair - Can take up to 60 days to complete. This time is dependent on the supply of purchased components.
Includes Calibration and Re-certification

125 TECHNOLOGY PARK, LAKE MARY, FL 32746

CUSTOMER SERVICE INDUSTRIAL FAX FORM

From: User Name:_____

Certified? _____ **Yes** _____**No**

Certification Number:_____

FaroArm Serial Number:_____

(Serial number is located on the FaroArm, or your certified user card)

Return Fax Number:_____

Return Voice Number:_____

Problem:

Where & when does it occur?:

What have you done to fix the problem?:

FAX to: (407) 333-8056

Transfer of Warranty Service Plan Agreement

_____(SELLER'S CORPORATE OR INDIVIDUAL NAME AS APPLICABLE),

hereby waives all rights under the warranty service policy for

FaroArm Serial Number _____

AnthroCAM Port Lock Number _____

purchased originally on _____(DATE).

_____(BUYER'S CORPORATE OR INDIVIDUAL NAME AS APPLICABLE),

hereby assumes all rights and obligations of the Hardware and/or Software Warranty Service Policy from

_____ (Date of Transfer).

This transfer is only valid under the following conditions.

1. The FaroArm is currently under warranty
2. New owner is, or becomes, a certified user.
3. This warranty transfer form is completed, and submitted to Customer Service.

AGREED

_____
(PRINT SELLER'S CORPORATE OR INDIVIDUAL NAME AS APPLICABLE),

BY x _____

_____
(PRINT NAME OF SIGNATORY)

_____
(PRINT SELLER'S CORPORATE OR INDIVIDUAL NAME AS APPLICABLE),

BY x _____

_____
(PRINT NAME OF SIGNATORY)

FARO TECHNOLOGIES, INC.

Approved by x _____

_____
(PRINT NAME OF SIGNATORY)

Appendix B

Purchase Conditions

All Purchase Orders (hereafter, the "Order") for FARO - provided products and services (hereafter, the "Product") are subject to the following terms and conditions, which are agreed to by the Purchaser. All capitalized terms are defined in Section 9 hereafter.

1.00 Payment of Purchase Price

1.01 Purchaser hereby promises to pay to the order of FARO all deferred portions of the Purchase Price, together with interest on late purchase price payments payable at 1.5% per month (18% per annum).

1.02 The Purchaser grants to FARO a security interest in the products sold pursuant to the Order, which may be perfected by UCC-1 Financing Statements to be recorded in the applicable County of the Purchaser's business location and filed with the Secretary of State's Office, which security interest will remain in effect until payment in full of the purchase price together with interest on late purchase price payments payable thereon had been received by FARO.

1.03 If the Purchaser fails to make full payment of the purchase price within the period set out in the Order, FARO shall at its option have the following remedies, which shall be cumulative and not alternative:

a) the right to cancel the Order and enter the Purchaser's premises to re-take possession of the Product, in which event the Purchaser agrees that any down-payment or deposit shall be forfeited to FARO, as liquidated damages and not as a penalty, and all costs incurred by FARO in connection with the removal and subsequent transportation of the Product shall be payable by the Purchaser upon written demand;

b) the right to enter the Purchaser's premises and remove any Software, components of the Product or other items necessary in order to render the Product inoperative;

c) the right to withhold all services which would otherwise be required to be provided by FARO pursuant to the Warranties set out in Section 5 hereof;

d) terminate any existing software license agreement and

e) pursue any other available remedy, including suing to collect any remaining balance of the purchase price (i.e., accelerate the payment of the purchase price causing the entire balance to immediately become due and payable in full).

f) Customer will be charged a 20% restocking fee for refusal to accept equipment as delivered. Equipment must returned unopened within 10 business days of receipt at customer facility.

1.04 If Purchaser fails to make payment(s) in accordance with the terms of this Order, the Purchaser's Products may be rendered inoperable until such payment terms are met.

No waiver by FARO of its rights under these conditions shall be deemed to constitute a waiver of subsequent breaches or defaults by the Purchaser. In the event more than one Product is being purchased pursuant to the Order, unless otherwise set forth herein, each payment received by FARO from Purchaser shall be applied pro rata against the cost of each product rather than being applied to the purchase price of any product.

2.00 Delivery and Transportation

2.01 Delivery dates are estimates and not guarantees, and are based upon conditions at the time such estimate is given.

2.02 FARO shall not be liable for any loss or damage, whether direct, indirect or consequential, resulting from late delivery of the Product. The Purchaser's sole remedy, if the Product is not delivered within 90 days of the estimated delivery date, shall be to cancel the Order and to recover from FARO without interest or penalty, the amount of the down-payment or deposit and any other part of the purchase price which has been paid by the Purchaser. Notwithstanding the foregoing, such right of cancellation shall not extend to situations where late delivery is occasioned by causes beyond FARO's control, including, without limitation, compliance with any rules, regulations, orders or instructions of any federal, state, county, municipal or other government or any department or agency thereof, force majuere, acts or omissions of the Purchaser, acts of civil or military authorities, embargoes, war or insurrection, labor interruption through strike or walkout, transportation delays and other inability resulting from causes beyond FARO's control to obtain necessary labor, manufacturing facilities or materials from its usual sources. Any delays resulting from such causes shall extend estimated delivery dates by the length of such delay.

2.03 Responsibility for all costs and risks in any way connected with the storage, transportation and installation of the Product shall be borne entirely by the Purchaser. If any disagreement arises as to whether or not damage to the Product was in fact caused in storage, transit or on installation, the opinion of FARO's technical advisors, acting reasonably, shall be conclusive.

3.00 Installation and Operator Training

3.01 The Purchaser shall be responsible for installation of the Product, including, without limitation, the preparation of its premises, the uncrating of the Product and setting up of the Product for operation. Purchaser may elect to order contract services from FARO to perform this service should they elect to do so.

4.00 Warranties and Limitation of Liability

4.01 FARO warrants that (subject to Section 4.06), the Product shall be free from defects in workmanship or material affecting the fitness of the Product for its usual purpose under normal conditions of use, service and maintenance. A complete statement of FARO's warranty service is set forth in Appendix A.

4.02 FARO warrants that the Software shall operate according to specifications and the System

shall operate and perform in the manner contemplated in connection with the usual purpose for which it is designed.

4.03 The warranties set out in paragraphs 4.01 and 4.02 above (together called the "Warranties") shall expire at the end of the twelve (12) month period commencing on the first day of the first quarter after the date of shipment from the FARO factory (the "Warranty Period").

4.04 Subject to the limitations contained in Section 4.06, the Warranties shall apply to any defects found by the Purchaser in the operation of the FaroArm or the Software and reported to FARO within the Warranty Period. If the FaroArm or the Software is found by FARO, acting reasonably, to be defective, and if the defect is acknowledged by FARO to be the result of FARO's faulty material or workmanship, the FaroArm or the Software will be repaired or adjusted to the extent found by FARO to be necessary or at the option of FARO, replaced with a new FaroArm, Software or parts thereof at no cost to the Purchaser.

4.05 Claims under the Warranties shall be made by delivering written notice to FARO of the defect in the System, the FaroArm, or the Software. Within a reasonable time of receipt of such notice, FARO shall have the System, FaroArm and Software diagnosed by its service personnel and warranty service will be provided at no cost to the Purchaser if the System, FaroArm or Software is found by FARO to be defective within the meaning of this Section.

(If, in the reasonable opinion of FARO after diagnosis of the system, the FaroArm and Software are not defective, the Purchaser shall pay the cost of service, which shall be the amount that FARO would otherwise charge for an evaluation under a non-warranty service evaluation.

4.06 The Warranties do not apply to:

a) Any defects in any component of a System where, if in the reasonable opinion of FARO, the FaroArm, Software or System has been improperly stored, installed, operated, or maintained, or if Purchaser has permitted unauthorized modifications, additions, adjustments and/or repair to any hard drive structure or content, or any other part of the System, or which might affect the System, or defects caused or repairs required as a result of causes external to FARO workmanship or the materials used by FARO. As used herein, "unauthorized" means that which has not been approved and permitted by FARO.

b) The Warranties shall not cover replacement of expendable items, including, but not limited to, fuses, diskettes, printer paper, printer ink, printing heads, disk cleaning materials, or similar items.

c) The Warranties shall not cover minor preventive and corrective maintenance , including, but not limited to, replacement of fuses, disk drive headcleaning, fan filter cleaning and system clock battery replacement.

d) Any equipment or its components which was sold or transferred to any party other than the original Purchaser without the expressed written consent of FARO.

4.07 Factory Repairs

a) IF SYSTEM IS UNDER WARRANTY: The Purchaser agrees to ship the Product to FARO in the original packing containers. FARO will return the repaired or replacement Product. FARO will incur the expense of the needed part and all return shipping charges to the Purchaser. FARO may authorize the manufacturer of a component of the Product to perform the service.

b) IF SYSTEM IS UNDER PREMIUM SERVICE PLAN: When practical and subject to availability, FARO will make available to the Purchaser substitute component parts or FaroArm's ("Temporary Replacements") while corresponding parts of the Purchaser's system or FaroArm are undergoing repair at FARO's factory. Shipping charges for these "Temporary Replacement" parts or FaroArm's will be the responsibility of FARO.

c) IF SYSTEM IS NOT UNDER WARRANTY: The Purchaser is responsible for the cost of the replacement part or software, and all shipping charges. All charges shall be estimated and prepaid prior to commencement of repairs.

4.08 Nothing herein contained shall be construed as obligating FARO to make service, parts, or repairs for any product available after the expiration of the Warranty Period.

4.09 Limitation of Liability

FARO shall not be responsible under any circumstances for special, incidental or consequential damages, including, but not limited to, injury to or death of any operator or other person, damage or loss resulting from inability to use the System, increased operating costs, loss of production, loss of anticipated profits, damage to property, or other special, incidental or consequential damages of any nature arising from any cause whatsoever whether based in contract, tort (including negligence), or any other theory of law. FARO's only liability hereunder, arising from any cause whatsoever, whether based in contract, tort (including negligence) or any other theory of law, consists of the obligation to repair or replace defective components in the System or FaroArm subject to the limitations set out above in this section.

This disclaimer of liability for consequential damage extends to any such special, incidental or consequential damages which may be suffered by third parties, either caused directly or indirectly resulting from test results or data produced by the system or any component thereof and the Purchaser agrees to indemnify and save FARO harmless from any such claims made by third parties.

4.10 The foregoing shall be FARO's sole and exclusive liability and the Purchaser's sole and exclusive remedy with respect to the system.

THE SOLE RESPONSIBILITY OF FARO UNDER THE WARRANTIES IS STATED HEREIN AND FARO SHALL NOT BE LIABLE FOR CONSEQUENTIAL, INDIRECT, OR INCIDENTAL DAMAGES, WHETHER THE CLAIM IS FOR BREACH OF WARRANTY, NEGLIGENCE, OR OTHERWISE.

OTHER THAN THE EXPRESS WARRANTIES HEREIN STATED, FARO DISCLAIMS ALL

WARRANTIES INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

4.11 FARO does not authorize any person (whether natural or corporate) to assume for FARO any liability in connection with or with respect to the Products. No agent or employee of FARO has any authority to make any representation or promise on behalf of FARO, except as expressly set forth herein, or to modify the terms or limitations of the Warranties. Verbal statements are not binding upon FARO.

4.12 The Warranties extend only to the Purchaser and are transferable, only under the following conditions:

- The FaroArm is currently under warranty
- New owner is, or becomes, a certified user.
- A FARO warranty transfer form is completed, and submitted to Customer Service.

All claims under the Warranties must originate with the Purchaser, or any subsequent owner, and the Purchaser will indemnify and save FARO harmless from any claims for breach of warranty asserted against FARO by any third party.

4.13 Oral representations of FARO or its sales representatives, officers, employees or agents cannot be relied upon as correctly stating the representations of FARO in connection with the system. Refer to this purchase order, any exhibits hereto and any written materials supplied by FARO for correct representations.

4.14 PURCHASER ACKNOWLEDGES THAT IT HAS PURCHASED THE SYSTEM BASED UPON ITS OWN KNOWLEDGE OF THE USES TO WHICH THE SYSTEM WILL BE PUT. FARO SPECIFICALLY DISCLAIMS ANY WARRANTY OR LIABILITY RELATED TO THE FITNESS OF THE SYSTEM FOR ANY PARTICULAR PURPOSE OR ARISING FROM THE INABILITY OF THE PURCHASER TO USE THE SYSTEM FOR ANY PARTICULAR PURPOSE.

5.00 Design Changes

5.01 The FaroArm, the Software and the System are subject to changes in design, manufacture and programming between the date of order and the actual delivery date. FARO reserves the right to implement such changes without the Purchaser's consent, however, nothing contained herein shall be construed as obligating FARO to include such changes in the FaroArm, Software or System provided to the Purchaser

6.00 Non-Disclosure

6.01 All Software including, without limitation, the Operating System Program and any FARO special user programs, provided to the Purchaser as part of the system, either at the time of or subsequent to the delivery of the FaroArm, is the intellectual property of FARO. The Purchaser shall not reproduce or duplicate, disassemble, decompile, reverse engineer, sell, transfer or assign, in any manner the Software or permit access to or use thereof by any third party. The Purchaser shall forthwith execute any further assurances in the form of non-disclosure or licensing agree-

ments which may reasonably be required by FARO in connection with the software.

7.00 Entire Agreement / Governing Law / Miscellaneous / Guarantee

7.01 These Purchase conditions constitute the entire agreement between FARO and the Purchaser in respect to the Product. There are no representations or warranties by FARO, express or implied, except for those herein contained and these conditions supersede and replace any prior agreements between FARO and the Purchaser.

7.02 No representative of FARO has any authority to modify, alter, delete or add to any of the terms or conditions hereof. Any such modifications shall be absolutely void unless made by instrument in writing properly executed by an actual authorized employee or agent of FARO.

7.03 The terms and conditions hereof shall be binding upon FARO and the Purchaser, and shall be construed in accordance with the laws of the State of Florida, United States of America.

7.04 FARO shall be entitled to recover all of its reasonable fees and costs including, but not limited to, its reasonable attorneys' fees incurred by FARO in connection with any dispute or litigation arising thereunder or in connection herewith, including appeals and bankruptcy or creditor reorganization proceeds.

7.05 These conditions shall not be construed more strictly against one party than another as a result of one party having drafted said instrument.

8.00 Definitions

8.01 "FARO" means FARO Technologies, Inc.

8.02 "Purchaser" means the party buying the Product and who is legally obligated hereunder.

8.03 "Software" means all computer programs, disk drive directory organization and content, including the diskettes containing such computer programs and disk drive directory organization and content, sold pursuant to the Order.

8.04 "Product" means the FaroArm, the Software, operating manuals and any other product or merchandise sold pursuant to the Order. If the Purchaser is buying only a FaroArm, or the Software, Product will mean the product being purchased by the Purchaser pursuant to the Order.

8.05 "System" means a combination of the FaroArm, the Software, the Computer, and optional parts associated with the FaroArm.

8.06 "Certified user" means any person who has completed and passed the a written exam issued by FARO. The exam is available upon request.

8.07 "Purchase Order" means the original document issued from the Purchaser to FARO, listing all parts and/or services to be purchased and the agreed purchase price

8.08 "Warranty Transfer Form" means a document to be completed for the transfer of the FARO Warranty. This document is available from FARO upon request.

Appendix C

Software License Agreement

This Software License Agreement is part of the Operating Manual for the product and software System which you have purchased from FARO TECHNOLOGIES INC. (collectively, the "Licenser"). By your use of the software you are agreeing to the terms and conditions of this Software License Agreement. Throughout this Software License Agreement, the term "Licensee" means the owner of the System.

I. The Licensor hereby grants the Licensee the non exclusive right to use the computer software described in this Operating Manual (the "Software"). The Licensee shall have no right to sell, assign, sub-license, rent or lease the Software to any third party without the Licenser's prior written consent.

II. The Licenser further grants the Licensee the right to make a backup copy of the Software media. The Licensee agrees that it will not decompile, disassemble, reverse engineer, copy, transfer, or otherwise use the Software except as permitted by this Section. The Licensee further agrees not to copy any written materials accompanying the Software.

III. The Licensee is licensed to use the Software only in the manner described in the Operating Manual. Use of the Software in a manner other than that described in the Operating Manual or use of the Software in conjunction with any non-Licenser product which decompiles or recompiles the Software or in any other way modifies the structure, sequence or function of the Software code, is not an authorized use, and further, such use voids the Licenser's set forth below.

IV. The only warranty with respect to the Software and the accompanying written materials is the warranty, if any, set forth in the Quotation/Purchase Order and Warranty Appendix B pursuant to which the Software was purchased from the Licenser.

V. THIS WARRANTY IS IN LIEU OF OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE SOFTWARE AND WRITTEN MATERIALS. IN NO EVENT WILL THE LICENSER BE LIABLE FOR DAMAGES, INCLUDING ANY LOST PROFITS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE SOFTWARE, NOTWITHSTANDING THAT THE LICENSER MAY HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, THE LICENSER WILL NOT BE LIABLE FOR ANY SUCH CLAIM BY ANY OTHER PARTY.

VI. In the event of any breach by the Licensee of this Agreement, the license granted hereby shall immediately terminate and the Licensee shall return the Software media and all written materials, together with any copy of such media or materials, and the Licensee shall keep no copies of such items.

VII. The interpretation of this Agreement shall be governed by the following provisions:

A. This Agreement shall be construed pursuant to and governed by the substantive laws of the State of Florida (and any provision of Florida law shall not apply if the law of a state or jurisdiction other than Florida would otherwise apply).

B. If any provision of this Agreement is determined by a court of competent jurisdiction to be void and non-enforceable, such determination shall not affect any other provision of this Agreement, and the remaining provisions of this Agreement shall remain in full force and effect. If any provision or term of this Agreement is susceptible to two or more constructions or interpretations, one or more of which would render the provision or term void or non-enforceable, the parties agree that a construction or interpretation which renders the term of provision valid shall be favored.

C. This Agreement constitutes the entire Agreement, and supersedes all prior agreements and understandings, oral and written, among the parties to this Agreement with respect to the subject matter hereof.

VIII. If a party engages the services of an attorney or any other third party or in any way initiates legal action to enforce its rights under this Agreement, the prevailing party shall be entitled to recover all reasonable costs and expenses (including reasonable attorney's fees before trial and in appellate proceedings).

Appendix D

Industrial Service Policy

This Service Plan (hereafter, the "Plan") is part of the Operating Manual for the product and software purchased from FARO TECHNOLOGIES INC. (hereafter, "FARO"). The Plan and all of the optional additions, are subject to the conditions in Appendices A,B,&C, and are subject to change. This appendix refers to FARO's service plans as written in the sales advertising literature, and is meant to provide additional details that the literature does not permit.

1.00 The purchase of the Plan shall occur with the purchase of the FARO products.

1.01 The plan shall apply to systems exclusively created or authored by FARO.

1.02 The plan shall be inclusive to the entire system, and can not be extended or transferred through the sale of any part of the system to a third party unless the entire system has been sold or transferred.

1.03 The plan shall consist of two areas of coverage;

a) Hardware - The FaroArm and all of the associated optional parts, and the Computer if provided by FARO.

b) Software - All computer programs, authored by FARO, which are used in conjunction with the FARO provided Hardware.

1.04 The plan shall not cover Hardware or Software which has been subjected to misuse or intentional damage. FARO reserves the right to determine the condition of all returned Hardware and/or Software.

1.05 FARO shall determine the service method and contractor to service/repair all hardware which is not directly manufactured by FARO. All outside contractor terms and conditions are available from FARO and are incorporated herein by reference.

1.06 FARO shall not be responsible for any non FARO authored software which inhibits the operation of the system. Furthermore the plan will not cover the re-installation of any software.

1.07 The Hardware and Software are subject to changes in design, manufacture, and programming. All updates are as follows;

a) Hardware - The FaroArm and all of the associated optional parts, and the Computer are not subject to updates.

b) Software - All computer programs, authored by FARO, which are used in conjunction with the FARO provided Hardware, will be updated if the Plan is current.

c) 3rd Party Software - All computer programs, non authored by FARO, will not be updated under the Plan. The purchaser is responsible for the acquisition of all 3rd party software updates and warranty service or claims.

2.00 **Definitions**

2.01 "FARO" means FARO Technologies, Inc.

2.02 "Purchaser" means the party buying the Product and who is legally obligated hereunder.

2.03 "Software" means all computer programs, disk drive directory organization and content, including the diskettes containing such computer programs and disk drive directory organization and content, sold pursuant to the Order.

2.04 "Product" means the FaroArm, the Software, operating manuals and any other product or merchandise sold pursuant to the Order. If the Purchaser is buying only a FaroArm, or the Software, Product will mean the product being purchased by the Purchaser pursuant to the Order.

2.05 "System" means a combination of the FaroArm, the Software, the Computer, and optional parts associated with the FaroArm.

2.06 "Hardware" means The FaroArm and all of the associated optional parts, and the Computer if provided by FARO.

2.07 "Software" means all computer programs, authored by FARO, which are used in conjunction with the FARO provided Hardware.

The following is a layman's definition of the coverage.

Basic Service Plans

All shipping times below are to destinations within the Continental United States. Outside the Continental US, FARO will ship equipment directly to the customs broker.

- Basic Service Plans are contracted at time of purchase or at any time while a unit is covered by a FARO hardware and FARO software service plan (as described in more detail later.)

- The Basic Service Plan covers all of the major components of the Turnkey System sold by FARO. This typically covers the FaroArm controller box, the FARO provided computer, and FARO authored software.

- Shipping costs, including insurance from the Purchaser to FARO are the responsibility of the Purchaser. FARO will be responsible for all return shipping costs including insurance.

- All reasonable efforts will be made to keep the service repair time within seven working days. The equipment will be returned via 2-Day air service, therefore total service repair time will vary due to return shipping location. Items less than 20lbs. will be returned via 1-Day service.

- The Basic Service Plan is offered as a package only and cannot be broken into separate components. Separate component coverage is available through purchase of FARO's standard warranty programs (See Appendix B).

- Since the FaroArm is designed to be used with many other software packages not authored by FARO. This service plan can be purchased in its entirety to cover only FARO produced or authored products. For items not produced or authored by FARO, the customer is responsible for securing their own separate warranty or service plan coverage.

Hardware Coverage

FaroArm:

Covered

- All parts and labor for FaroArms failing under normal use as described in Appendix B
- Annual recertification and 15-point annual checkup of the FaroArm.

Not Covered

- Misuse
- Intentional damage
- Wear and tear of probes, ball bars, auxiliary hardware products such as cables, wrenches, hex keys, screwdrivers, etc.

Computer:

Covered

- Faro contracts with 3rd party service providers for this service. The terms and conditions of FARO's contract with the provider apply herein and are incorporated herein by reference. Ask your Customer Service Rep for a copy of this document.
- Typically, these services include repair of the computer, memory cards, and video monitors.

Not Covered

- All exclusions contained in the 3rd party service providers polity which is incorporated herein by reference.
- Software operating system installation
- User intentional or unintentional removal of key software property or files.

Software Coverage

Covered

- Periodically FARO Technologies may update its proprietary software. Service plan subscribers will be shipped these software updates upon their release.

Not Covered

- End users are responsible for the procuring and installation of 3rd party authored or S/W updates as required to use with FARO authored software products unless FARO Technologies resold these packages to the end user as an authorized reseller. Examples of 3rd party authored S/W are: DOS, Windows, AutoCAD, AutoSurf, SurfCAM and others.

Premium Service Plans

The Premium Service Plans additionally provide loaner FaroArms and Computers when service is required. All equipment shipping costs are paid for by FARO (both ways). FARO will make its best effort to ship all loaner FaroArms within 24 hours of the receipt of the purchasers request, once the need for a service has been verified by FARO. FARO will make its best effort to ship all loaner Computers within 72 hours of the receipt of the purchasers request.

125 Technology Park
Lake Mary, FL 32746
(800) 736-2771