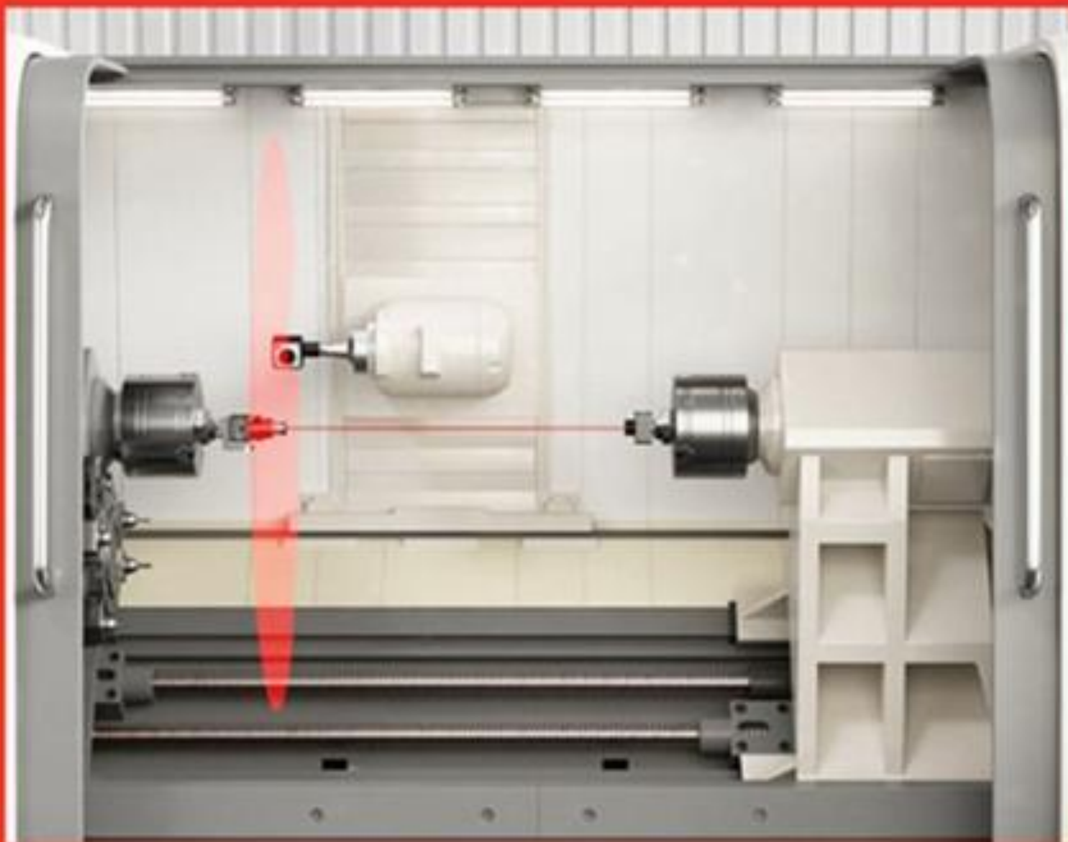

MultiTurn10 Alignment Software

for aligning MultiTurns and Machining Centers

Operations Manual

March 2026

Rev B4

HAMAR LASER

ALIGN WITH THE BEST

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Table of Contents

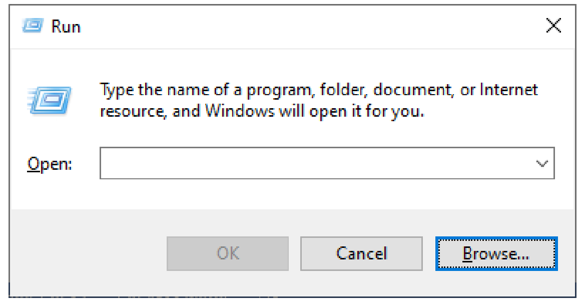
Getting Started

If the MultiTurn10 software is purchased with an alignment system, the software will be installed on the computer's hard drive. If the program is purchased separately, you will need to install the software.

Installing the Program

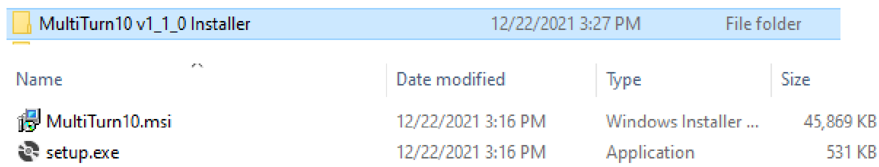
1. Insert the program thumb drive in the appropriate drive.
2. Click **Start** and select **Run**.
3. Click **Browse** and find the drive where the thumb drive is located.
4. Look for the folder *MultiTurn10 v1_1_** Installer* and open it.
5. Click *Setup.exe* to run the installer.
6. Follow the instructions on your screen.

Note: *The minimum recommended screen resolution for running the MultiTurn10 Software is 1024x768.*



Starting the Program

To begin using the MultiTurn10 program, double-click the HLI logo icon on your Windows screen or select the program from the Windows Start Menu. The initialization screen displays, showing the software version and serial number entered at installation.



Terminology and Conventions

The following terminology and conventions are used frequently in this book:

- Click = click *once* with the left mouse button
- Double click = click *twice* with the left mouse button
- Keyboard shortcuts
– The **Alt** key can be used in combination with an underlined character to quickly perform a task. For example, to save data, you may either click **Save Data** or press **Alt-S**.
- The names of buttons in the Machine Tool Geometry program are referred to in bold type: for example, **OK**.

Preparing for an Alignment

There are several preparations that need to be made before beginning a measurement or alignment process. Ensure that accurate records are kept for all procedures.

Hardware Preparation

- Determine what hardware is necessary to perform the alignment, including the laser, target, mounting fixtures, readouts or interface, cables, etc. Make a note of the target model number so that the information can be entered into the program setup.
- If a test or measurement may take more than 3-4 hours, be sure to connect portable computers, interfaces, and other battery-operated devices to their external power supplies.
- Observe safety precautions when setting up hardware. Lock out machines for stationary procedures. If a machine will be running, then set up barriers and/or warning signs and route all cables away from moving parts. Clean and check all equipment, fixtures, and mounting surfaces before beginning any alignment process.

Hamar Product Registration

In order to protect against software pirating, we have implemented a simple product registration procedure. After a Hamar product is installed and when the program is run for the first time, the user is prompted to enter the Product Registration Code (see ***Figure 1***). To obtain the Product Registration Code, send the PC ID Code (automatically generated) displayed on the screen to Hamar Laser Support (Support@hamarlaser.com). A Hamar representative will issue a Product Registration Code via email to complete the registration process. Enter the Product Registration Code and click **Register Product** (see ***Figure 2***). The product is now registered.

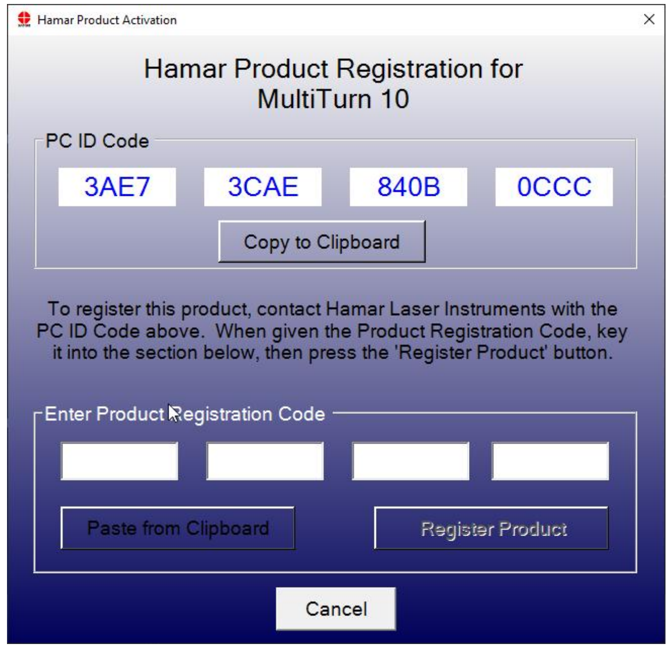


Figure 1 —Product Registration Screen

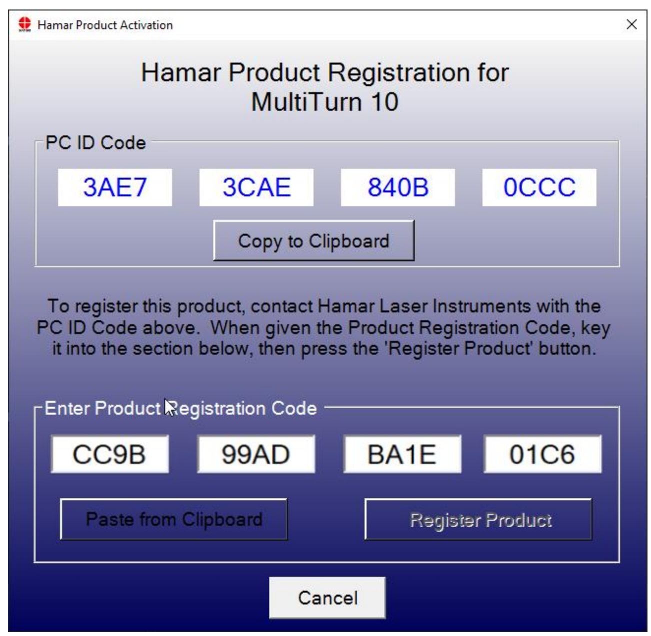


Figure 2 – Enter Product Registration Code

L-702SP 5-Axis Machine Tool & Spindle Alignment System

The L-702SP 5-Axis Machine Tool & Spindle Alignment System is a complete alignment system for aligning spindles on lathes, turning centers and multi-turn machines. It has an automatically rotating turret optic that sweeps a laser scan plane that is perpendicular to the spindle laser, which allows the capability to check the squareness of cross slides or machining axes on lathes and multi-turn machines. With an added magnetic leveling base accessory, the L-702SP can also be used to check machine leveling, alignment and axis squareness.

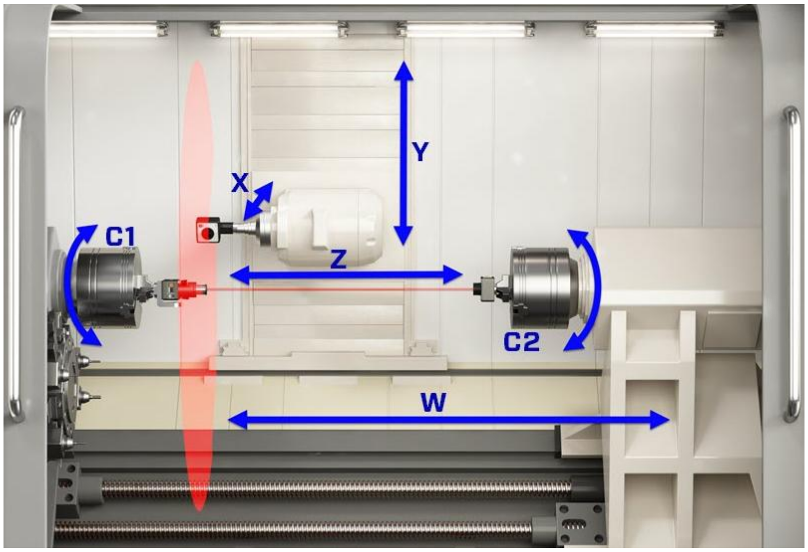


Figure 3 - L-702SP 4-Axis Spindle & Multi-Turn Machine

System Features

- **Fast**: Easy setups let you do a quick alignment check in 20 minutes and get full alignment data in 30-40 minutes on most machines.
- **Easy**: Laser and target mount directly into the spindle and tailstock, respectively, allowing the entire length of even the largest lathes or multiturns to be quickly and easily aligned without changing setups, replacing cumbersome and impractical alignment test bars. With built-in squareness capability, checking cross-slide squareness is a 5- minute operation
- **Accurate**: Ultra-high resolution of up to .00001 in. (0.00025 mm) combined with software to correct mounting errors produces a very accurate alignment, less than .0001 in. (0.0025 mm) and .0001 in/ft (0.0083 mm/m) under good environmental conditions.
- **MultiTurn10 Software:** Designed mainly to take data for multiturns and lathes, it has a 6 step process that guides you through the alignment process. It records the straightness of each axis and the parallelism or squareness between them.

Model L-702SP Spindle & Scan Laser

The Model L-702SP Laser has a low-power, Class II visible-light laser designed to mount in the spindle of a machine tool to project its axis of rotation during alignment. Vertical and horizontal angular controls allow the user to fine-adjust the laser angle to the spindle's precise axis of rotation. The L-702SP is designed for applications where the distance between target and laser is approximately 100 ft. (30 m).

Figure 4 – L-702SP Spindle Laser and Scan Plane

In addition to the spindle laser, the L-702SP version features an automatically rotating turret that sweeps a laser scan plane perpendicular to the laser beam for checking cross-slide/turret axis squareness and multi-turn milling axes.

Built-in levels on the sides provide easy indexing when inverting for error correction readings. A .4995 in. (12.7 mm) mounting stud simplifies fixturing and can be removed to adapt the unit to custom fixtures or other alignment applications.

The L-702SP features a built-in, rechargeable, lithium-ion battery that provides operation for up to 8 hours on a single charge.

The L-702SP works with any Hamar Laser target, readout, or interface and can be used for many types of alignment jobs, including spindle and bore alignment, and measuring and correcting the alignment of a workpiece on the machine.

Applications include:
- Horizontal Boring Mill Indexing Checks for Deep-Bore Applications
- Lathe/Turning applications (cylindrical, OD/ID grinders, lathes)
- Horizontal and Vertical Machining Centers
- Multi-Turn Machining Centers

Laser Control Panel and Functions

Figure 5– L-702SP Control Panel

The Status LEDs

- Status LED – red – indicates the laser is powered on.
- Low Battery LED – red - blinks if the battery is low and needs charging.
- Charging LED – yellow – lights when the rechargeable battery is charging (see **Figure 5**).

The On/Off Button

Press the **I/O** button once to turn it on and press and *hold* to turn it off. The I/O LED will illuminate when the power turns on.

Laser Modes

There are 3 laser modes:

1. **Beam mode** – the laser beam is continuous. This is used for legacy targets using the R-358 Computer Interface and Scan Mode. The STATUS LED will be continuously on (no blinking).
2. **Blink Mode** – this is used for 2-axis cabled targets using the R-1307 Readouts in Pulsed Mode. The STATUS LED will blink continuously.
3. **Double-Blink Mode** – this is used for the T-1295/T-1296 Targets. The STATUS LED will blink twice and pause (continuously).

To change the mode, press the **I/O** power button once.

L-702SP Scan button

To switch the L-702SP to *Scan Mode* (laser plane), you must first put the laser into *Beam Mode*. Then the pentaprism optic in the turret needs to be rotated into place to create the scan plane by turning the set screw (see Switching L-702SP Turret into Scan Mode on Page 6 for instructions). Then press the **SCAN** button to turn on the turret laser rotation and create a scan plane. Press the **SCAN** button again to turn it off.

A/C Connector

The L-702SP comes with a rechargeable battery. The connector is shown below.

L-702 A/C Adapter Connector

Pitch/Roll Adjustment Knob

The adjustment knobs use *differential* micrometers, allowing both coarse and fine functions.

- ***Coarse* Adjustment** – loosen the set screw to enable the coarse adjustment.
- ***Fine* Adjustment** – tighten the set screw to disable the coarse adjustment and enable the fine adjustment (it rotates within the coarse adjustment), which is 12 times finer adjustment resolution.

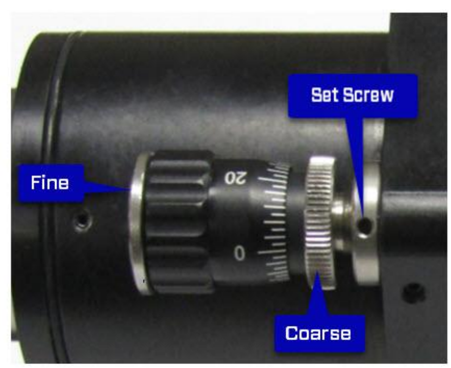


Figure 6– Differential Micrometer

Switching L-702SP Turret to Scan Mode

Warning - Do not stare into the beam.

To create the L-702SP perpendicular laser scan plane, a flip mechanism is used to move a pentaprism into the laser beam that bends the beam 90 degrees. This creates a perpendicular laser beam that emits from the side of the spindle, which is then rotated to create the scanning laser plane.

The flip mechanism is controlled by a "flip" screw in the top of the spindle. Use a standard screwdriver to lightly turn the screw until you feel a "click", which is created by a small magnet that holds the prism in place. You can confirm that the mechanism is properly in place by noting if the laser beam emits from the hole in the side of the turret.

Figure 7 - L-702SP flip mechanism for Scan Mode

Warning – do not over-turn or attempt to tighten the "flip" screw. This could damage the mechanism.

L-702SP Laser Dimensions

Figure 8 - L-702SP Laser Dimensions

The T-1295/T-1296 5-Axis Wireless Spindle & Scan Targets

Hamar Laser's T-1295/T-1296 5-Axis Targets are designed to work with our L-702SP Spindle/Machine Tool Laser. With Bluetooth communication and multiple measuring axes, the T-1295/T-1296 targets are multi-purpose targets that can be used for many different applications.

- Offers 3 measurement modes:
  - ❖ *Center Mode* - 2-axis center measurement for use with the L-702SP's through-beam.
  - ❖ *Angular Mode* - 2-axis angular measurement for use with the L-702SP's through-beam.
  - ❖ *Flatness (Scan) Mode* - single-axis flatness measurement for use with the L-702SP's auto-rotating laser plane in Scan Mode.
- PSD (Position Sensing Detector) Size:
  - ❖ T-1295: 1.3 x .51 in. (33x13 mm) PSD
  - ❖ T-1296: .39 x .39 in. (10x10 mm) PSD
- Resolution:
  - ❖ *Center* (2 axis & 1 axis):
    - T-1295: .00002 in. (0.0005 mm)
    - T-1296: .00001 in. (0.00025 mm)
  - ❖ *Angular* (2 axis) – Standard 3 in. Lens:
    - T-1295: .00008 in/ft. (0.007 mm/m)
    - T-1296: .00004 in/ft. (0.0035 mm/m)
  - ❖ *Angular* (2 axis) – High-Res 6 in. Lens:
    - T-1295: .00004 in/ft. (0.0035 mm/m)
    - T-1296: .00002 in/ft. (0.0018 mm/m)
- Wireless communication via Bluetooth Class 1 radio with 100 ft. (30 m) of communication range.
- Accuracy is < 1.0% of the measurement.
- PSD concentric to the mounting stud to < .0005 in. (0.012 mm).
- The T-1295/T-1296 are designed so the measuring plane of the target is right at the face plate of the mounting stud, giving better accuracy on spindle alignments.
- Accelerometer rotation axis (6th axis) helps to orient the PSD sensor axes to the alignment axes of the spindle.
- Lithium polymer rechargeable battery with 14 hours of battery life.

Figure 9– T-1295/T-1296 5-Axis Wireless Spindle & Scan Target

How to use the T-1295/T-1295 Targets

The T-1295/T-1296 Targets are designed for use with the L-702SP in Double-Blink Mode (center/angular measurements) or Scanning Beam Mode (flatness measurements using the L-702SP's rotating scan plane). The targets have a .4995 in. (12.69 mm) mounting stud for mounting spindles and fixtures. The center of the target PSD sensor is aligned to the mounting stud to <.0005 in. (0.012 mm).

Below are descriptions of the target LED's and their functions:

Center Mode

This is the default mode when the target is turned on. It is recommended to use the light/dust shield while using the target in center mode, which is held in place with magnets. While in this mode, the values shown in MultiTurn10 Software display boxes show the center (offset) values of the target relative to the laser beam. It follows the same sign convention as shown Page 28, *Interpreting the + and – Signs.*

Figure 10- T-1295/T-1296 Target with light shield installed

Angular Mode

To use the T-1295/T-1296 Targets in Angular Mode, insert the T-1295-AO-3 Lens (or the A-1295-AO-6 Lens), making sure to line up the red or yellow dots at 12:00 when you insert it. Then click on the **Angle** button in Step 2 or 5 (see below) and the values will switch to the angular display. Using the lens, converts the display readings in MultiTurn10 to angular values with the following raw-value resolution:

Figure 11- T-1295/T-1296 Target with T-1295-AO-3 Lens installed correctly

<u>T-1295-AO-3</u>: in/3 in. (mm/76.2 mm), which is converted in the software displays to: in/ft (mm/m) when you click on the Angle Button (see below).
<u>T-1295-AO-6</u>: in/ 6 in. (mm/152.4 mm), which is converted in the software displays to: in/ft (mm/m) when you click on the Angle Button.

Note if the displays are left in Center Mode, then the values shown in the displays are *raw* values and will be in the units shown above.

Figure 12 - MultiTurn10 Step 5 – showing Angle Mode turned on

Scanning Laser Mode

The T-1295/T-1296 Targets can be converted to scanning targets to be used with the L-702SP laser in **Scanning Mode**, which creates a laser plane. To change, the T-1295/1296 target into Scanning Mode, make sure the L-702SP is *turned off* or the laser beam is blocked. Then press and hold the Power Button. The **ON-TGT** LED will blink instead of being continuously on, as it is when it's in **2-Axis Center Mode**. See page 4 for how to put the L-702SP into Scan Mode. To return the T-1295/1296 to ***2-Axis Center Mode,*** power down the target and turn it back on.

Figure 13 - T-1296/1296 Control Panel

***Note**: You must also put MultiTurn10 into Scan Mode using the dropdown list in Step 3.*

T-1295/T-1296 ON-TGT LED

The **ON-TGT** LED has several colors and actions to indicate certain functions:

Continuous Green – means the target is detecting the laser beam properly.
Continuous Red – means the target is not detecting the laser beam.
Blinking Green – means the target is detecting the laser scan plane (Scan Mode) properly.
Blinking Red – means the target is not detecting the laser scan plane (Scan Mode).

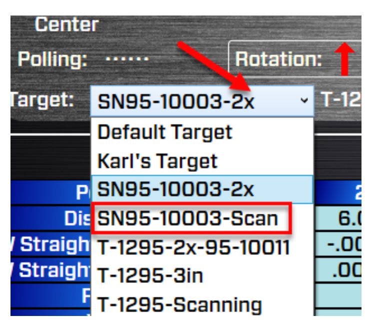
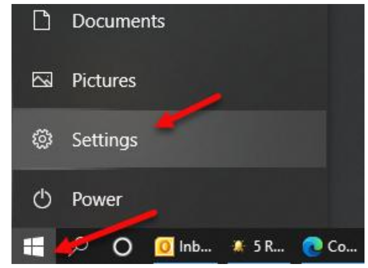


Figure 14- Target Scan Mode Selection Step 3

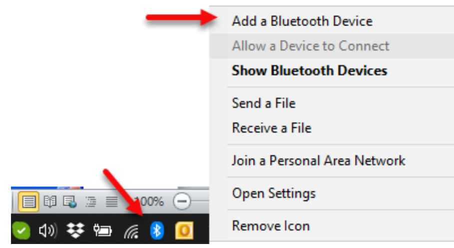
How to Pair the T-1295/T-1296 Target's Bluetooth to a PC

For your computer to see the Bluetooth device, you need to turn it on.

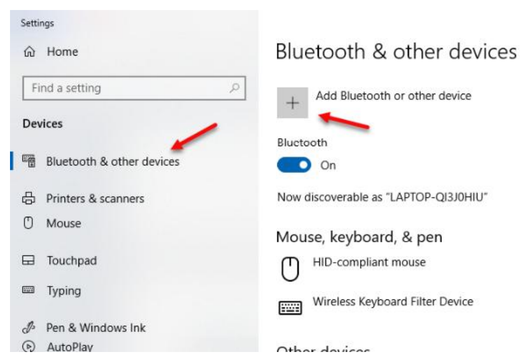
1. Tap on **Start** (the Microsoft Logo) > **Settings**.
2. Navigate to **Devices** and go to **Bluetooth**



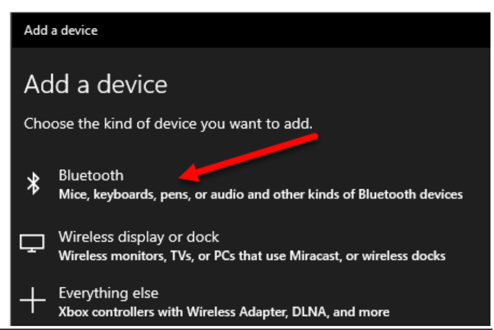
Or click on the **Bluetooth** icon in the system tray and click on Add a **Bluetooth Device**.

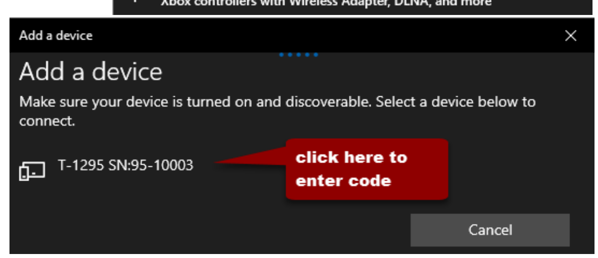


3. Make sure the Bluetooth toggle is in the **On** position. (You'll know it is working because you'll notice the message that reads "Your PC is searching for and can be discovered by Bluetooth devices.")
4. Click on **Add Bluetooth or other device**

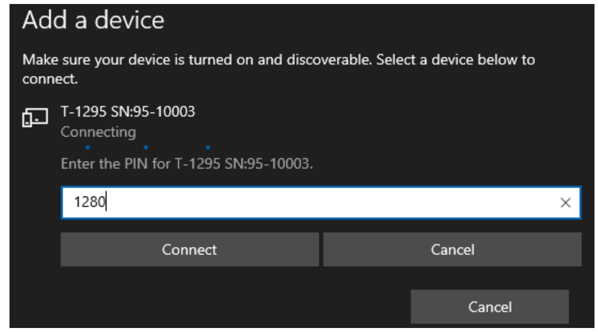


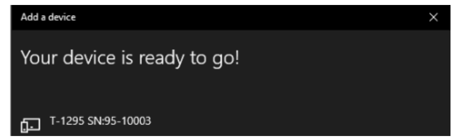
5. Select the device type you want to connect (usually, you will select **Bluetooth**). You will see the devices listed under **Add a Device.**





6. Enter 1280 for the passcode when prompted and hit **Connect**. Your Target is now paired and ready to be used. Exit Settings window





L-702SP Mounting Accessories

A series of mounting fixtures for the L-702SP Laser and T-1295 5-Axis Universal Geometry Measuring Target to aid in measuring hard-to-measure axes on enclosed machining centers, boring mills and multiturn machines.

L-702MB Laser Mounting Mag Base

- Used to mount the L-702SP on flat surfaces for: Flatness measurements of surfaces.
- Flatness, straightness & squareness measurements of machine tool axes.

To hold the laser in place, use the thumb screw to tighten the mounting stud. Make sure to tighten very tightly to ensure a rigid mount and avoid laser drift issues.

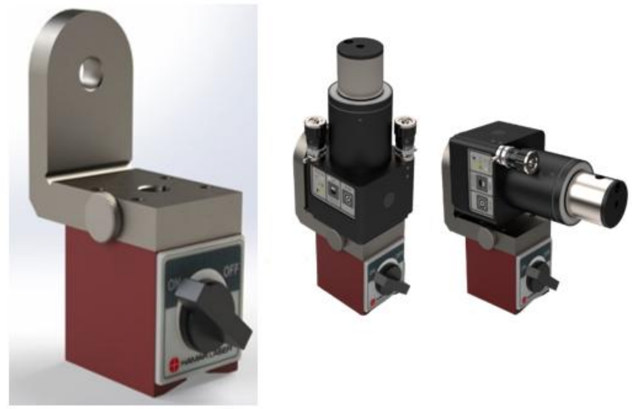


Figure 15- L-702MB laser mounting mag base

L-702RA – Right Angle Spindle Mounting Fixture

Used to mount the L-702SP Laser and T-1295 Target at right angles to the spindle axis for use on:

- Boring mills.
- Horizontal and Vertical Machining Centers to measure other axes with the L-702SP mounted in the spindle.
- Multi-turn machines to measure X & Y axes

To hold the laser in place, use the thumb screw to tighten the mounting stud. Make sure to tighten very tightly to ensure a rigid mount and avoid laser drift issues.

Figure 16- L-702RA right angle spindle mounting fixture

T-242 Target Straightness Measuring Base

Used to hold the T-1295 5-Axis Target to measure vertical and horizontal straightness of machine tool axes and surfaces. Comes with X-Y micrometers to center the target to the laser beam in X (H) & Y (V) and mag base and set of posts.

T-243 Target Flatness Measuring Base

Used to hold the T-1295 5-Axis Target to measure flatness of machine tool axes and surfaces. The target rotates 360° on a very flat surface built into the T-243 fixture to ensure the target can always be pointed at the laser. The flatness of target rotation is ± .0001 in. (0.0025 mm)

Figure 18 - T-243 Target Flatness Measuring Base

Figure 17 - T-242 Target Straightness Measuring Base

The T-261A 4-Axis Target

The T-261 4-Axis Target reads both center and angle (pitch and yaw) simultaneously, allowing a real-time display of misalignment. The target data has a resolution with the R-358 of .00001 in/ft. (0.0008 mm/m) in angle mode and .00001 in. (0.0005) in in centering mode. Two bubble levels on the top and bottom make it easy to position when inverting for NORMIN procedure (see Appendix B, beginning on Page 80).

When the target is purchased as part of a system, it is calibrated at the factory before shipping. If the target is purchased separately, then the user must calibrate it, or enter the HLI-supplied calibration factors into MultiTurn10, before use. An alignment\calibration fixture and a target stand, available from Hamar Laser, are required for calibration. The procedure is outlined in Appendix C, beginning on Page 82

The R-358 Computer Interface

The R-358 Computer Interface provides high accuracy (resolution is .00001 in. or 0.0005 mm) for downloading live target data into a computer. It attaches to the computer with a cable and is powered by a lithium-ion battery for up to 8 hours of life. The battery automatically turns on when the target starts taking measurements and turns off when the program is closed down. An AC adapter/charger is provided, and the unit features "charging" and "power" LED indicators.

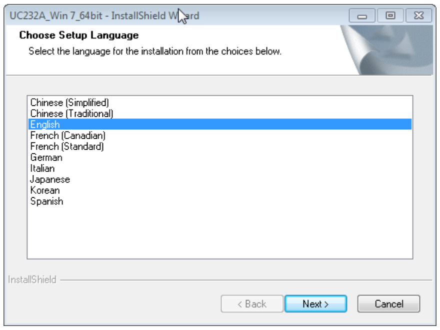
Installing the (RS-232) USB to Serial Converter Cable Driver for R-358 Interface

For use with the T-261 Target only. This driver is required for the R-358 Computer Interface and to communicate with targets via the computer USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

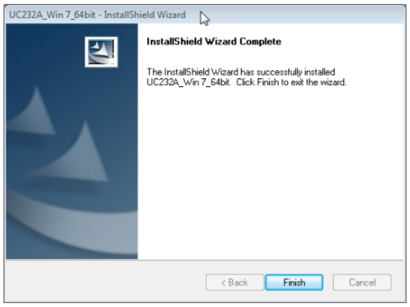
Important Windows Note

You must install the software driver for the USB cable BEFORE plugging in the USB cable into your computer. The driver is located on the same thumb drive as Lathe9 software.

Installing the Driver



1. Insert the Flash drive in an available USB port.
2. Select **My Computer**, locate the **REMOVABLE DISK** icon and click to open it.
3. Select the USB Drivers folder.
4. Open the **GUC232A_Win8** folder and double-click **GUC232A_Windows_8_Setup.exe** to initiate the installation process. The **Install Driver** dialog box displays.
5. Select the language for the installation and click **Next** to continue.
6. Once the installation is complete, the **Installation Successful** message displays. Click **Finish** to exit.



Connecting to the R-358 Computer Interface

The R-358 Computer Interface connects the T-261 Target to a computer for automatic downloading of the target data into Lathe9 or other HLI software. This enables the software to offer real-time data displays, perform calculations, and plot results. The R-358 attaches to the computer with a USB/RS-232 (supplied with the R-358) converter cable and is powered by a lithium-ion battery or an AC adapter.

Note: *Before using the R-358 Computer Interface, ensure that the battery is fully charged or that the AC charger/adapter is plugged in.*

1. **Connect the T-261 target to the INPUT connector on the FRONT of the R-358 Interface.**
   The interface can support one 4-axis target. It can also support two 2-axis targets with the use of an optional splitter cable. Make sure to screw in the flat-head screws to securely hold the connector in place.

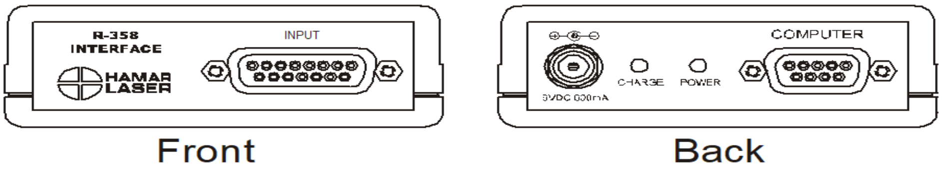


Figure 20 - R-358 Interface Connection

Note: *The R-358 power is turned on by the software when you click any of the MultiTurn10 steps that have live data displays. When turned on, the green* ***POWER*** *LED on the R-358 lights.*

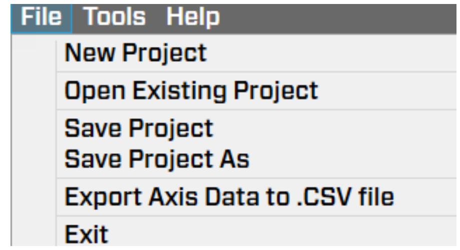
2. **Connect the R-358 Interface to the computer.**
   After installing the USB converter cable drivers on your laptop, connect the RS-232 extension cable provided to the *back* of the R-358 (labeled COMPUTER) and screw in the plastic thumb screws. Then connect the USB/RS-232 Converter cable to the RS-232 extension cable and plug it into the computer's USB port.

Figure 21 - USB to Serial Converter Cable

MultiTurn10: Creating, Opening and Saving Files

File Menu –

- **New Project:** Select a project type, enter the new project name, and press the Create button.



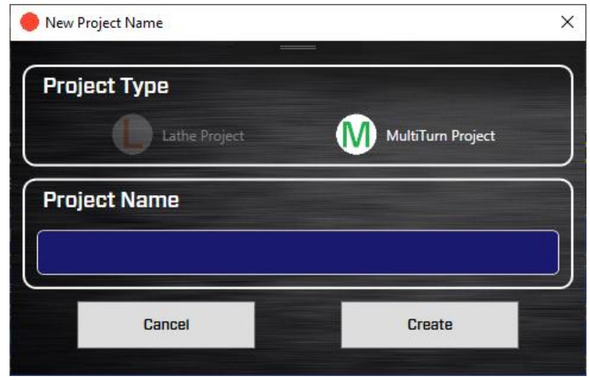


Figure 22- Creating a New Project

- ***Open Existing Project:*** The open project dialog displays two sections of the existing project. The Recent Projects) contains a list of the most recently saved projects, in reverse chronological order. The **All Projects** section contains a list of all projects found, in alphabetical order. To open a project, click on a project and click the **Open Project** button. Alternatively, you can double-click on a project name to open it.

- ***Save Project:*** Select this option to save the current project.
- ***Save Project As:*** This option allows you to save the existing project under a new name.
- ***Export Project to *.CSV File:*** This option allows exporting of collected data to a *.CSV (comma-separated values) file. This allows users to import the collected data into other programs, such as a spreadsheet, for custom processing.

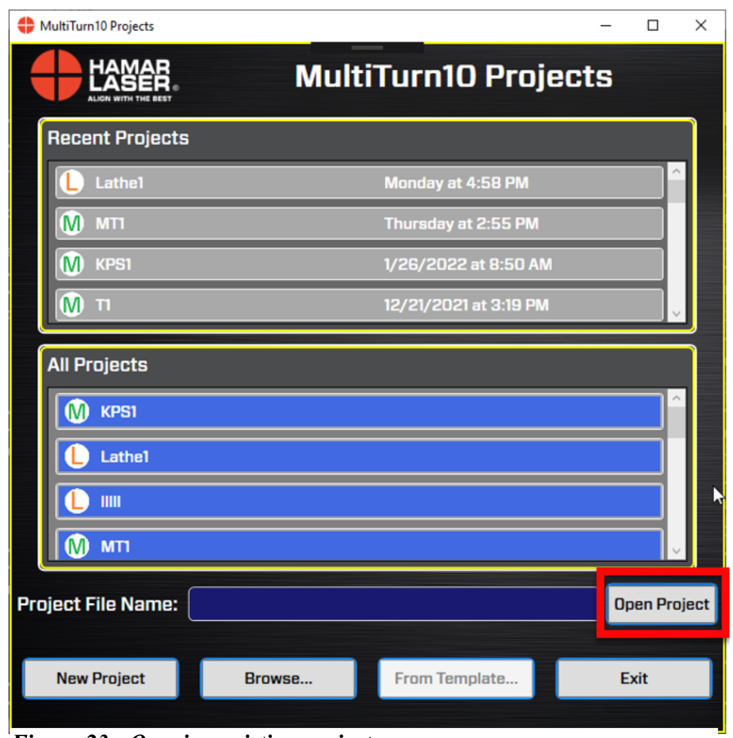


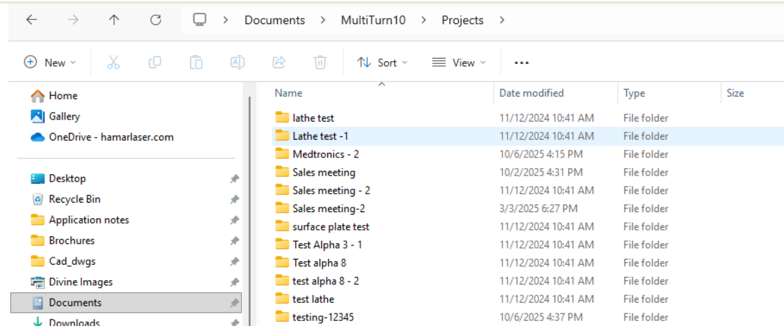
Figure 23 - Opening existing project

Saving Projects and Data

File Location

Files are saved in the *Documents/Lathe_10/projects* folder.

Each project is saved into a dedicated folder in the Projects folder that you specified in the New File dialog box.



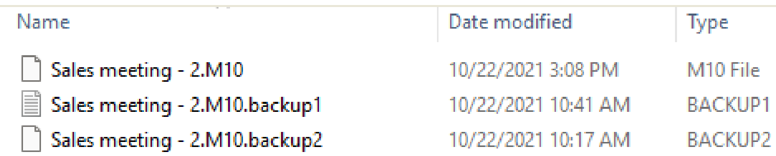
File Structure

In each Multiturn10 folder, there are several data files.

- The ****.MT10* file contains all the data taken during the session.
- The ***.MT10.backup* are backup files recorded during each session you save data.

The data format for these files is XML. The file can be opened in Notepad and viewed there. All data is recorded in microns. Divide all values by 1000 to get millimeters.

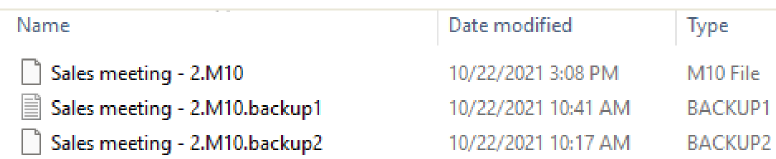
Warning! Do not delete or modify the L10 files in these folders as Multiturn10 will be unable to open the project.



Restoring File Backups

To restore older version backup:

1) Rename original file to something else, or delete it
2) Rename backup by removing the ".backupn" part. In the example, change "Sales meeting-2.MT10.backup1" to "Sales meeting-2.MT10"



Converting Raw Data Values in CSV files to Inches or Millimeters

- To get inches for dimensions and center values: inches = (micron value/1000) / 25.4
- To get in/ft for angular values: in/ft = mm/mm value *12.
- To get mm's for dimensions and center values: mm=micron value/1000
- To get mm/m for angular value: mm/m = mm/mm value*1000

Tools Menu:

Preferences

This option allows changing various user preferences for this program. To navigate this screen, you can use scrollbars and/or arrow keys to scroll up and down through the various settings. You can also use the *Navigation Buttons* on the top right of the screen to jump directly to specific sections.

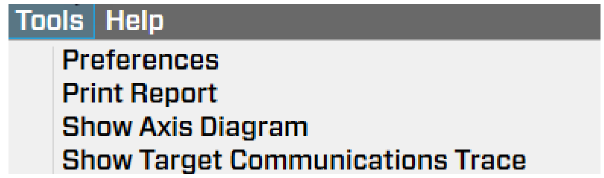
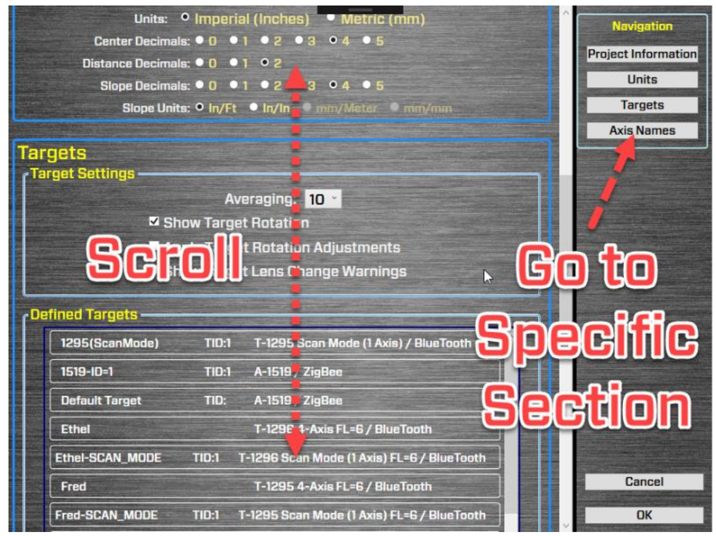


Figure 24 - Preferences location



Project Information

Enter information for the project, company name, address, phone and other contact information. You can also enter information for the Factory and the Machine. There is also a field for entering project notes. This information is printed in the report.

You can also add a company logo to the report by clicking **Use Company Logo on Reports.** Click on the bar with the 3 dots and a Windows screen will open, allowing you to navigate to the folder containing the logo file. Click on the file and hit OK to save.

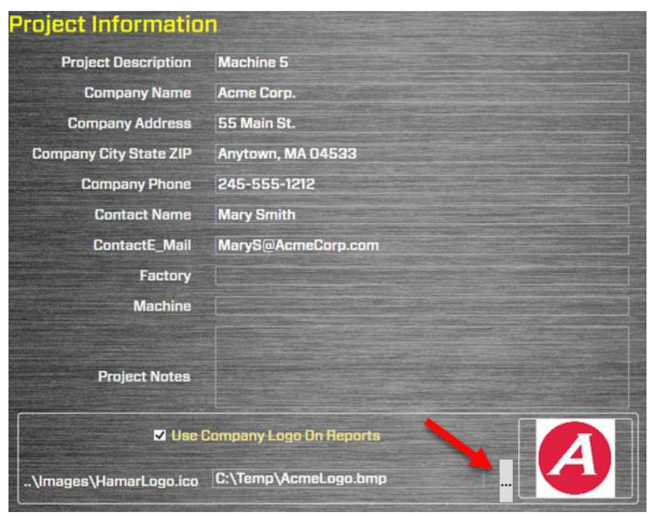


Figure 25 - Entering project information and company logo

Preferences: *Units*

This section allows specification of various measurement value settings.

- **Center Decimals:** These are the number of decimal places to show in the ***Center*** display in Steps 2, 3, 5 and 6, as well as the values recorded in *Step 3: Spindle Axis Straightness* grid.
- **Distance Decimals:** The number of decimals for dimensions in *Step 1: Machine Setup*, such as point spacing, headstock dimensions, etc.

Figure 26 - Preferences - selecting project units.

- **Slope Decimals:** These are the number of decimal places to show in the ***Angular*** display in Steps 2, 3, 5 and 6, as well as the values recorded in *Step 3: Spindle Axis Straightness* grid.
- **Slope Units:** For Imperial, choose in/ft or in/in. For Metric, choose mm/m or mm/mm. Note, *in/in* and *mm/mm* are "unitless" and are the same value, so .005 in/in = 0.005 mm/mm.

Preferences: *Targets Settings*

- **Averaging:** The number of readings from a target that are averaged before the value is displayed in the real-time data displays. A lower *Averaging* number will increase the speed at which the values update. Typically, use a lower *Averaging* value when bucking-in (aligning) the laser beam to reference points and a higher value when taking data to minimize measurement noise.

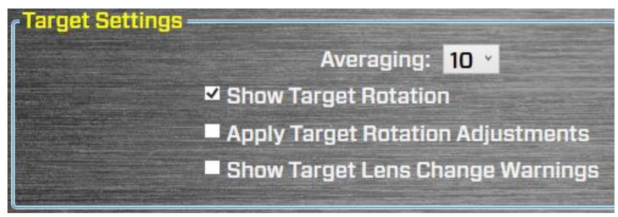


Figure 27 - Preferences - Target averaging.

- **Show Target Rotation**: Allows choice of displaying the target rotation angle (0° to 360°) in the data display areas in the data displays. This feature is supported by the T-1295 & T-1296 Targets. The A-1519-2.4ZB, T-212 or T-261 targets do support this feature.

Figure 28 - Preferences - Target rotation.

- **Apply Target Rotation Adjustments**: For targets that have rotation sensors, this "corrects" for the target not being either at 0°or 180° when taking rotation axis data in Step 5. This function use trigonometry to adjust the display values to what they would be if the target was right at 0 or 180 degrees. This increases the accuracy of the measurement values when taking data and allows for less care with putting the target directly at 0 or 180 degrees. In short, it makes it easier to use.

- **Show Target Lens Change Warnings**: Some target models switch between *Center* and *Angle* modes. When changing modes, a warning message can be displayed to remind the user to insert or remove the lens. This option allows this warning to be enabled or disabled. This message will also be disabled by clicking the "Don't Show this again" checkbox.

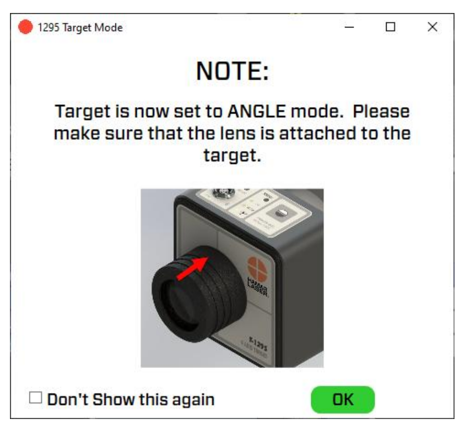
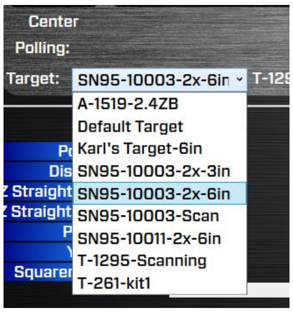


Figure 29 - T-1295 lens change warning window.

Define Targets

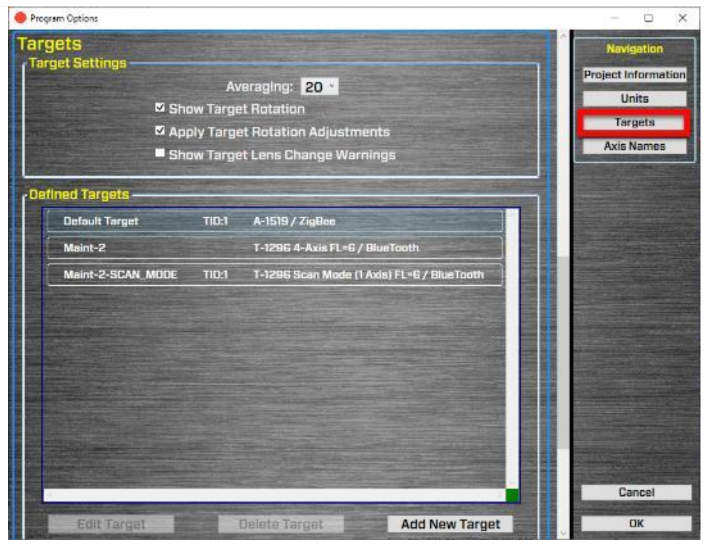
The **Defined Targets** area in Preferences shows what targets have been set up in MultiTurn10. These targets will appear in the dropdown menus in the real-time display boxes in Steps 2, 3, 5 and 6. This allows for easy switching target types, especially when switching from *Beam* to *Scan* Modes with the L-702SP.



Define Targets - Setup Procedure

When you buy a new system and laptop from HLI, target setup and calibration factors are already pre-configured into Multiturn10. However, if you are installing Multiturn10 on your laptop, then you must follow this procedure to set up the target and enter calibration factors.

1. Click the **Target** button



2. Click **Add New Target** to specify and set up a target type and computer interface if needed. There will be a dropdown list of target types supported by Multiturn10. Pick the target type by clicking on it. You will then be prompted to supply calibration factors for the targets, which vary by target type. You will need to supply the:

   - Serial Number
   - Calibration Date
   - Calibration Factors

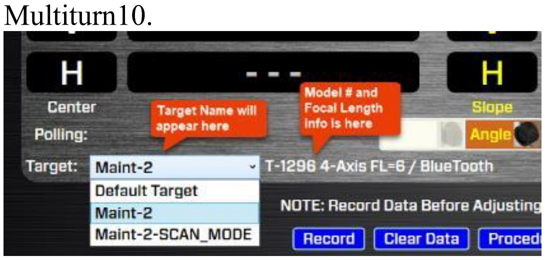
3. Select Target Type

Select the target type by clicking on the picture.

4. Selecting - *T-261 Target*

If you choose the T-261 Target, then MultiTurn10 will automatically select the R-358HR Computer Interface since they work as a set.

a. **Target Name** – enter the target "nickname". This name will show up in the Target area on the data displays. The target part number and focal length are automatically displayed by Multiturn10.



b. **Serial Number & Calibration Date**– enter the target serial number and date that comes with the T-261

c. **Calibration Factors**. You will need to input the 8 target calibration factors that are supplied with the target.

Note: *the calibration values vary from .85 to 1.2.*

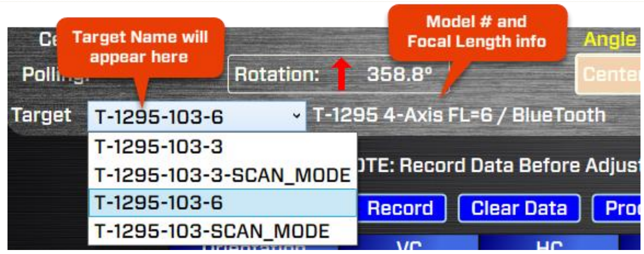
Note 2: *All R-358 Computer Interfaces come in HR Mode. However, if you have our discontinued R-355 Interface, you will need to upgrade to the R-358 to use Multiturn10.*

4. Selecting – *T-1294/T-1295/ T-1296/T-1297 Targets 2-Axis Mode*

Click on **Target Type/Interface** to choose the T-1294, T-1295, T-1296 or T-1297 targets, select the target number with "*2 Axis Mode*".

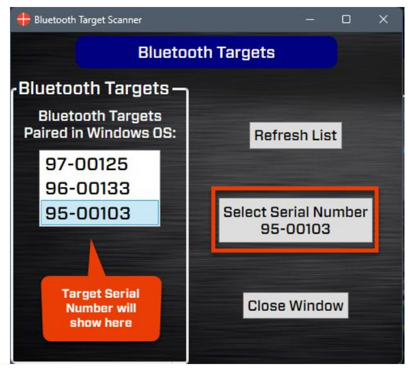
Note - *Scan Mode will automatically be added as a target type for each T-1294/T-1295/T-1296/T-1297 selected. Scan Mode is needed with the L-702SP Laser but is typically not used with Multiturn10.*

a. **Target Name**. Enter a "nickname" for the target. This name will show up in the Target drop-down list on the data displays. We suggest using the target part number, serial number and lens focal length in the nickname. The target part number and focal length descriptions are also displayed by Multiturn10.



b. **Serial Number** and **Calibration Date** – Enter the serial number and calibration date (supplied with the system), or you can load it from the Bluetooth list, by clicking on **Scan for Bluetooth Targets.**

You will first need to pair the target with the laptop (Page 9**:** *How to Pair the T-1295/T-1296 Target's Bluetooth to a PC*). Once paired, you can click on **Scan for Bluetooth Targets** to see if your target is being recognized by Windows OS. If you see your target serial number, click on it and then click on the **Select Serial Number** button to select it.

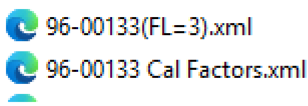


c. **Calibration Factors**

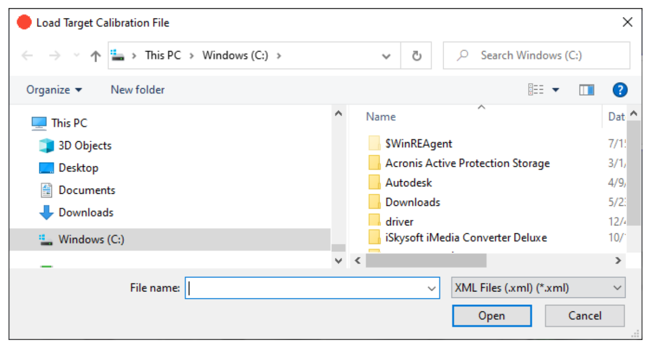
Hamar Laser supplies several calibration factors that need to be entered into the software. The values are entered either in microns or as a multiplier, or you can load them from 2 *XML files* that are on the USB drive supplied with the system by clicking on **Import From File.** The files are:

1. Focal Length (xx-xxxx(FL=X.xml)

2. Span Error Cal Factor (xx-xxxx Cal Factors.xml)



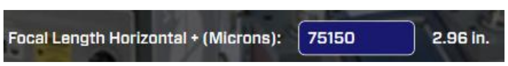
- **Vertical/Horizontal Slope Offset –** This is a calibration factor to ensure the squareness of the PSD to the mounting stud. This is an offset that is subtracted from the raw value. There are separate factors for the V & H axes of the target.
- **Vertical/Horizontal Focal Length –** This is a calibration factor to correct the error in the focal length of the lens. This is the actual focal length, which Multiturn10 uses instead of the nominal value. There is a separate factor for the "+" and "–" values of each of the V & H axes, for a total of 4 factors.



- **Vertical/Horizontal Span Error –** This is a calibration factor to correct for an error when moving the target by a known and calibrated amount, either .025 (0.635 mm) or .05000 in. (1.270 mm). This is a multiplier that is multiplied by the raw value. These values vary from 0.8 to 1.2. There is a separate factor for the "+" and "–" values of each of the V & H axes, for a total of 4 factors.

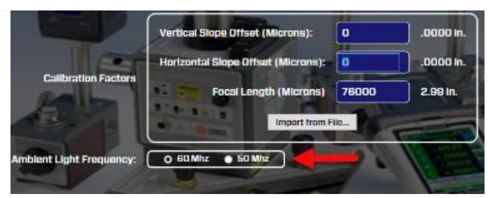
WARNING – clicking on Lens Type (3-Inch or 6-Inch) will insert the nominal values into the Focal Length entry boxes, overwriting any previously entered calibration factors. If this happens, you can either hit Cancel or hit the Focal Length button to reload the factors.

***Note**: 3 in. = 76,200 microns and 6 in. = 152,400 microns. These are the nominal values and can be used if the actual cal factor is not available. After entering the value, when you click on OK or another box, it will update the white number to the inch equivalent.*



d. **Ambient Light Frequency** – The T-1295/1296 Targets utilize an ambient light correction feature that improves accuracy. It is important to make sure that the electrical frequency selected here matches the frequency at the plant.

Note – *the target must be turned on and the Bluetooth be paired with the PC to change the frequency. Normally, this is set at the factory to match the country it is being shipped to.*



e. Defined Targets

You can set up multiple targets if desired. The target names and modes will appear in the **Defined Targets** area.

To select a target, go to **Steps 2, 4, 5 or 6**, choose from the ***Target*** dropdown list where up to 10 target setups may be stored.

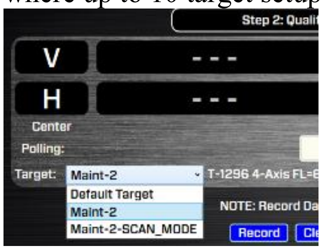


Figure 30 - List of Targets

Figure 31- Defining Targets

***Note** – Multiturn10 saves the last target you used in a Preferences XML file and it also saves the target you used in a saved data file. When opening Multiturn10, if you select a New File, it will automatically select the last target used (from the Preferences XML file) when going to Step 2. However, if you select a saved file, then Multiturn10 will select the target that was used to take the data when you go to Step 2.*

5. Selecting the A-1519-2.4ZB Wireless Target

- **Target Name**: (Required) This is a "nick name" that you will assign to this target, and can be any text that you choose (no spaces, though). Throughout the program, when collecting data, you will have the option to select from the target that you have defined and this name will appear in the dropdown lists (see **Figure 31** above).
- **Serial Number**: (Required). The serial number of the target, usually printed on the actual target.
- **Target Network ID**. This is the Target Zigbee® radio ID set within the target. On the side of A-1519 targets, there are screw-adjustable switches that set the Target ID, so the number entered here must match the setting on the target, which is usually labeled on the side of the target.

Figure 32 - Defining a new target.

- **Calibration Date**: The date that this target was last calibrated. It is for information purposes only, and not used by the program but does appear in the report.
- **Calibration Factors**: This not needed for the A-1519-2.4ZB Target
- **Target Notes**: Text of any information that you wish to save.

Preferences: Axis Names

Axis / Data Grid Options: Axis names used in this program default to industry standards. However, you can change these to reflect your own environment.

Note: *MultiTurn Axis names have a maximum of only 2 letters or numbers. The Lathe Axis names have a maximum of 9 characters.*

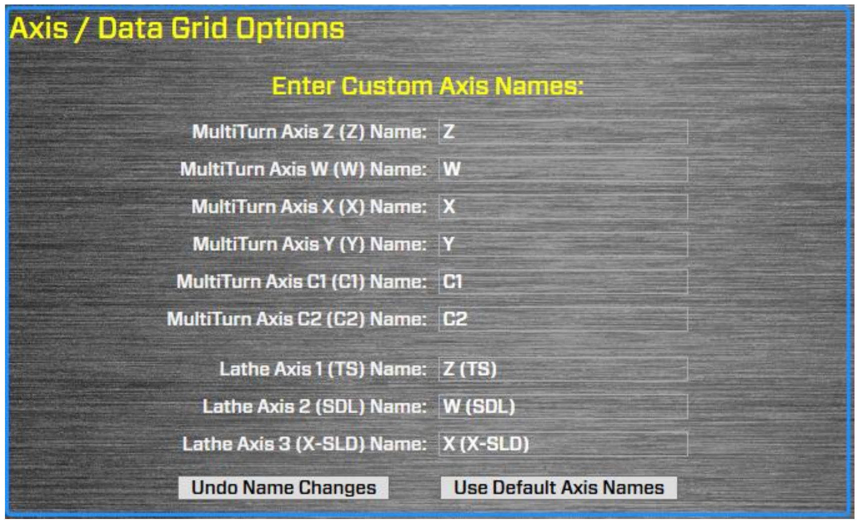


Figure 33 - Preferences - Entering Custom Axis Names.

Tools Menu - Print Report

This function allows printing a report of collected data.

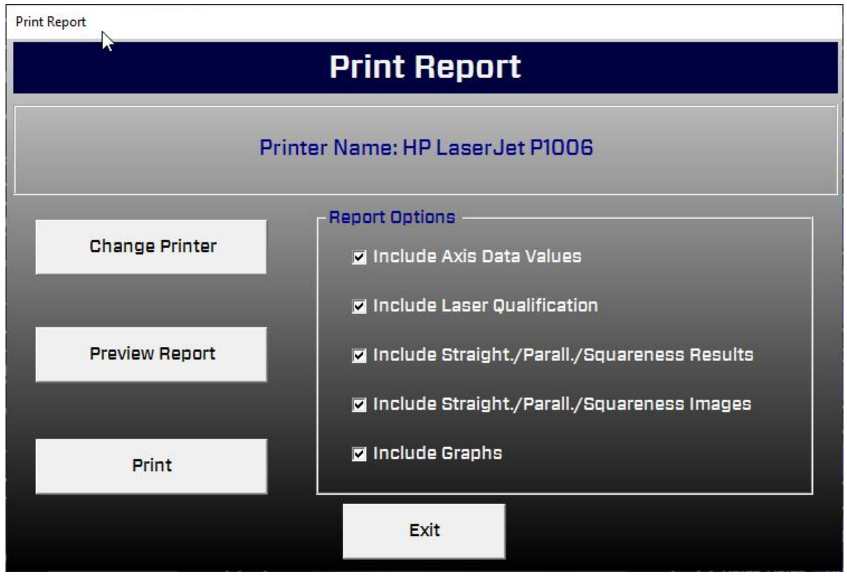


Figure 34 - Print Report Menu

What the Print Buttons Do

- ***Change Printer*** – This opens the Windows printer dialog box where you can select either your printer or print the report to a .pdf file for emailing.

  Note: *Hamar Laser can supply its own PDF printer that will print the report directly to a PDF document for emailing or printing later.*

- ***Preview Report*** – Click to open a preview window of the report. The preview window default shows one page at a time.

  You can show multiple pages at a time by clicking the buttons at the top of the screen.

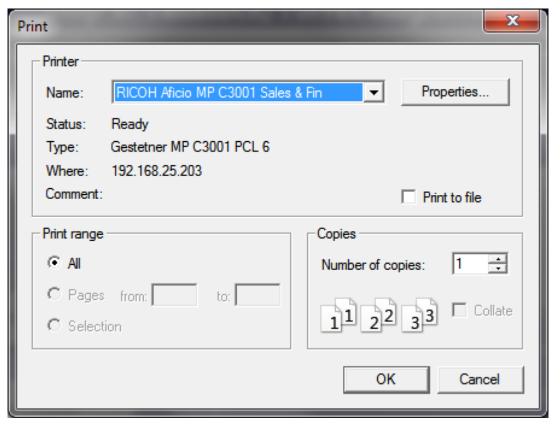
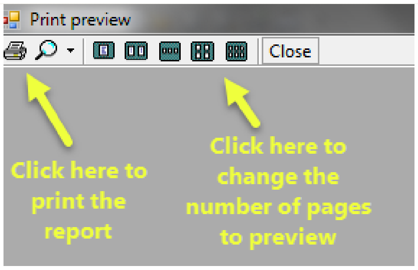


Figure 35 - Print Menu - Change Printer menu.



Clicking the magnifying glass will zoom in on the pages.

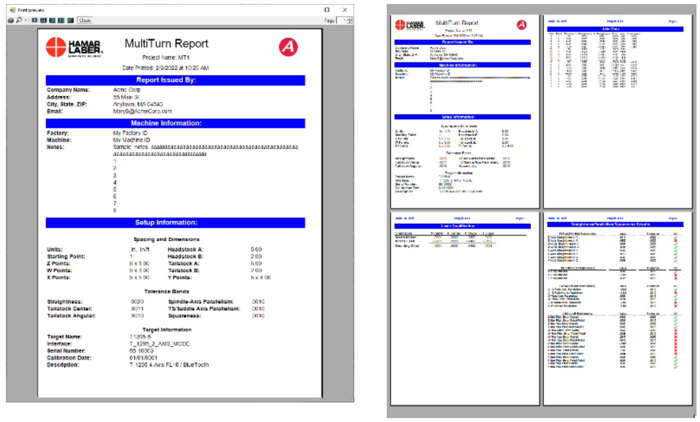
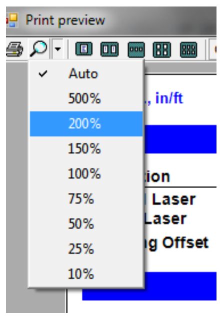


Figure 36 - Print Report preview.



- ***Print*** – Skips the preview and prints the report to the previously selected printer.

- ***Exit*** – Closes the popup and returns to the Lathe9 screen.

Excluding Sections on the Report

To hide a section, uncheck it in the **Report Options** list.

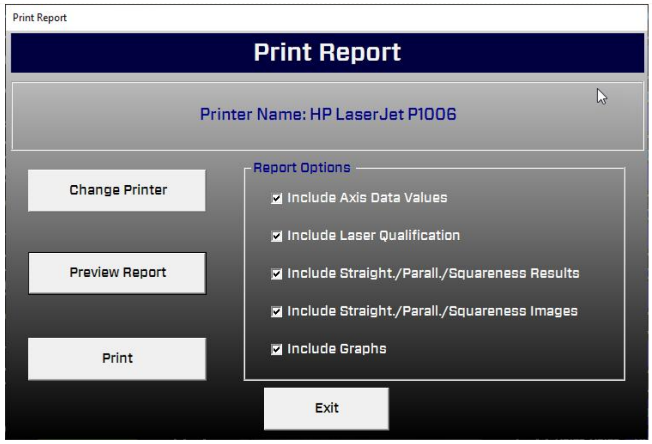
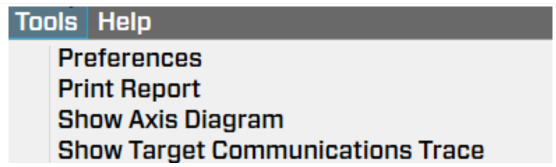


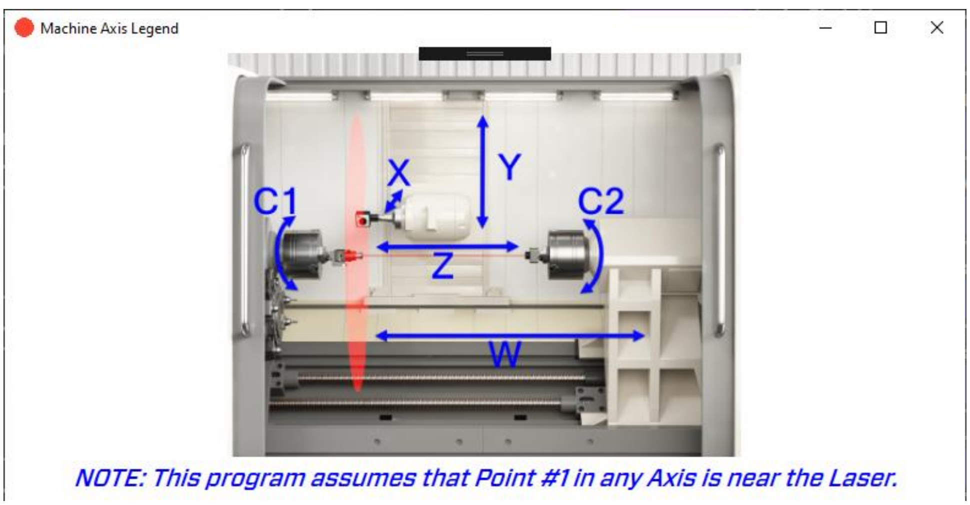
Figure 37 - Print Report - Include or exclude a section.

Tools Menu - Show Axis Diagram



This will display an image of a generic machine, with the various axis names (as currently defined in Preferences).

***Note**: to keep the signs for squareness and parallelism consistent, it is highly recommended to always start the data taking by assuming that point #1 is near the laser. In other words, where the laser is mounted is considered to be X,Y,Z = 0.*



.

Figure 38 - Show Axis names for reference.

Show target Communications Trace:

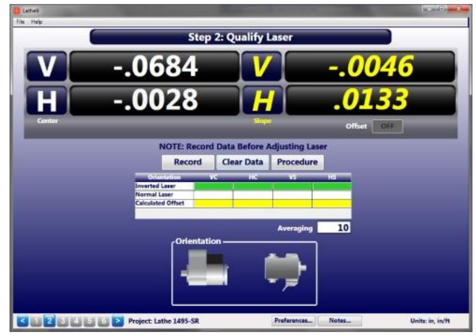
This function is used for debugging various target communications anomalies. It displays the actual conversation between the PC and the target. This is only used when talking to Support to troubleshoot communications issues.

Interpreting the Plus and Minus Signs in Software Live Displays

The signs of the data displays indicate the position (high/low or left/right) of the target is relative to the laser beam when "standing" *behind* the laser and looking *into* the target. See the interpretation below.

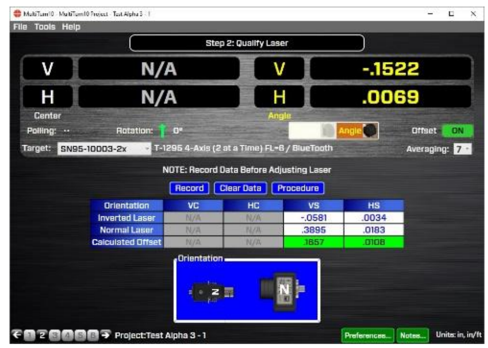
Note the *T-261 Target* provide 4 simultaneous axes:

- Vertical Center
- Horizontal Center
- Vertical Angle
- Horizontal Angle



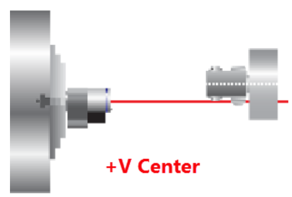
The *T-1295/T-1296 Targets* provide 4 axes but 2 at a time.

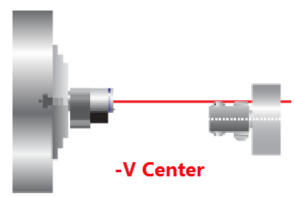
- Vertical Center
- Horizontal Center
- Vertical Angle
- Horizontal Angle

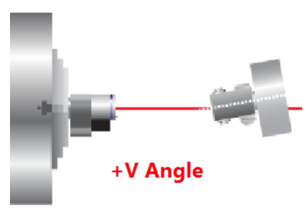


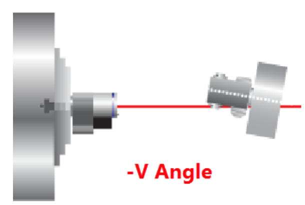
Vertical Axis (side view)

A **+V** *center* value indicates that the target is higher than the laser beam.
A **+V** *angular* value indicates that the back of the target is *higher* than the front of the target.
A **–V** *center* value indicates that the target is lower than the laser beam.
A **-V** *angular* value indicates that the back of the target is *lower* than the front of the target.









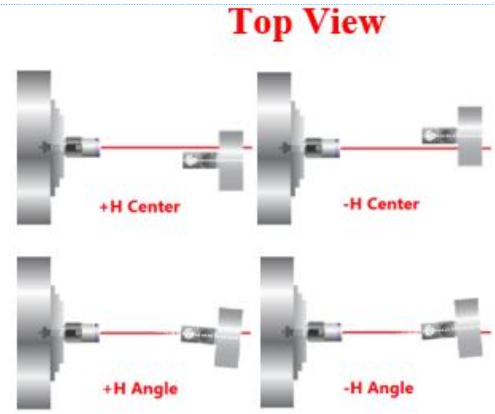
Horizontal Axis (top view)

A **+H** *center* value indicates that the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

A **+H** *angular* value indicates that the back of the target is to the *right* of the front of the target when looking from the laser *into* the T-261 target.

A **–H** *center* value indicates that the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

A -H *angular* value means that the back of the target is to the *left* of the front of the target when looking from the laser *into* the T-261 target.



Step 1 – Machine Setup

Figure 39 - Step1: Machine Setup

Data Points: This section defines which machine axes enabled for data taking in *Step 3: Axis Straightness*. By clicking the checkbox "*Include…Axis*", a tab will be enabled in Step 3 to record the data for that axis (see **Figure 40**).

Figure 40 MultiTurn10 Step 3 – showing all tabs enabled.

Number of Points: Specify how many equally spaced readings will be made for this axis.

Starting Point Number: Choose one or zero.

Spacing Increment: Specify the distance between each reading for this axis.

Headstock / Tailstock: Enter the dimensions between the bolt holes in the headstock and the tailstock or subspindle, using the graphic image to ID where to take the measurements. These dimensions will be used in Step 3: Move Screen to calculate shim values to re-align the headstock to the tailstock or saddle guideways. The dimensions will also be used to calculate shim values to re-align the tailstock or subspindle in Step 6 - Tailstock/Turret Alignment. *Note: The dimensions should be taken to an accuracy of ± 1/8, if possible, to ensure the accuracy of the shim calculations*.

Laser Setup: This section allows specification of the laser/target relationship. It is informational only, and is displayed in Step 3 as a reminder.

Tolerance Bands:

MultiTurn10 uses the least-squares, best-fit algorithm to determine the overall straightness of a set of axis data. The Straightness and Center tolerance values are set up as a ± band around zero. In the Alignment Results Summary in **Steps 3** and **4**, a green √ or red **X** indicates if the measured value is within or outside of the tolerance band. For example, for a ±.0005 in. straightness tolerance, MultiTurn10 looks at the absolute of all the values relative to the *Best Fit* line, and if any of those values are higher than .0005, then it will be *out* of tolerance. Therefore, if the maximum of all the *positive* values is .0004 and the *minimum* of all the negative values is -.0003, then the straightness would be *in* tolerance. However, the overall *TIR Straightness* will be .0007.

In this case, the laser was level to earth but the surface was not level. By using the Least-Squares, Best-Fit analysis, which calculated a line that "best fits" the data and then compared the data points to the line, we can see that the Best-Fit (true) TIR flatness error is significantly less than the raw flatness error and is "in-tolerance".

Angular tolerances are specified as "within" (w/in) and are the result of subtracting the slope of the best fit (BF) line for one axis from the BF slope of the other axis. The tolerance is applied to the result.

Enter alignment tolerances for the following:

- **Straightness** – this is the overall straightness ± for each axis based upon the max-min of the data relative to its Best Fit line.
- **Spindle Center** – this is the *center* ± tolerance for the alignment of the sub-spindle's rotational axis *center* relative to the headstock rotational axis center.
- **Spindle Angular** – this is the *angular* tolerance for the alignment of the sub-spindle's rotational axis angle relative to the headstock rotational axis center.
- **Spindle Parallelism –** this is the *angular* tolerance for the parallelism of the headstock rotation axis relative to the tailstock guideways.
- **Squareness** – this is the angular tolerance for the squareness between each of the linear machining axes and also relative to the rotation axes.
- **Pitch/Yaw** – This is a tolerance for the maximum slope value of the angular measurements for Pitch and Yaw of a linear axis. The *Overall* tolerance is the maximum angular error for the whole set of data. The *Point-Point"* tolerance is the maximum angular value for any 2 points.

Step 2: Qualify Laser – Spindle Axis

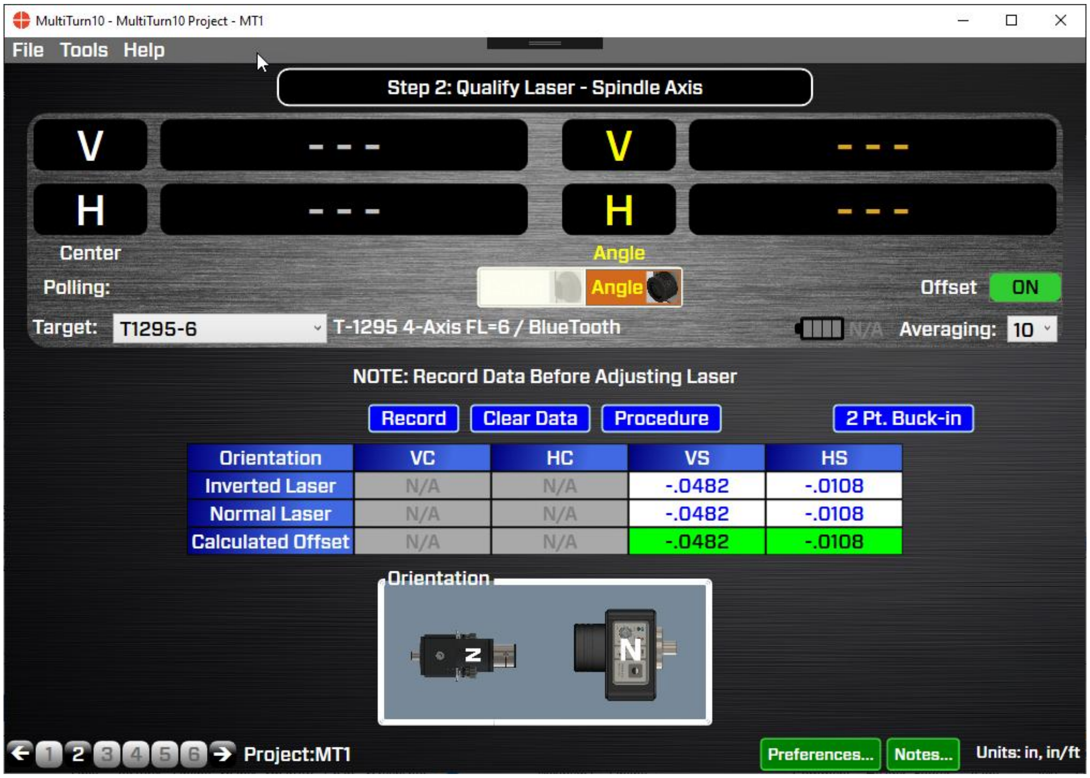


Figure 41 - Step2 - Qualifying Laser

In this step, we will be aligning the laser beam to the Spindle axis of rotation (AOR). This is a very simple procedure that records 2 data points and applies display offsets, so you simply adjust all the axes to zero and the laser beam is aligned to the headstock AOR.

> **Note:** *It is much more important to the alignment to align the laser's* ***angular*** *values to the headstock AOR rather than the* ***center*** *values. This is because the closer the laser is aligned in angle to the headstock axis, the more accurate the measurement of the parallelism to the tailstock guideways or saddle guideways. Conversely, when measuring centers, the NORMIN procedure can subtract out any remaining centering errors of the laser beam to the spindle AOR.*
>
> *Also, the best that you will be able to align the laser to the headstock spindle axis depends on how well the spindle itself repeats. Any center or angular runout in the spindle cannot be subtracted out by this program. This represents the limit of how accurately the alignment can be done.*

What the Buttons Do

Record – click or press **Record** or press the spacebar to record the data point.

Note: *The values in the displays are recorded instantaneously, so if the values are still updating, you must wait for them to stop changing before recording the point.*

Clear Data – this clears the data from the table, removes the display offsets and moves the cursor to the top to be ready to record data.

Procedure – this opens a PDF section of the manual with the basic procedure to qualify the laser.

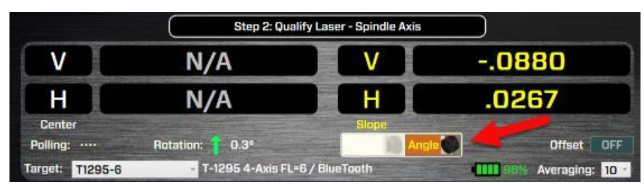
2 Pt. Buck-In. – Click on **2-Pt. Buck-In** to open a window that is used for our 2-point buck-in procedure to align the laser to 2 points along an axis. This may be used with the L-702SP-RA Right Angle fixture to align the laser to 2 points along the X axis for checking its straightness.

Averaging – enter values from 1 to 99 and this will change the number of samples Multiturn10 uses to average for each of the display values. The default is 10.

Note: *The higher the averaging value, the more noise fluctuations will be dampened out, but also the slower the response time for movements in the laser position. The data updates at 13 readings per second, so with an averaging value of 24, the data takes about 2 seconds to update after the laser beam position has started moving.*

Changing Angle & Center Displays

The T-1295/T-1296 Targets can measure in 4 axes but only 2 at a time. So Multiturn10 needs to put the data in the correct displays. To view the Center values, click on the Center/Angle Graphic just below the data displays.



When the displays are set to *Center Mode*, the values will show up in the left-side displays and the font color is *white*. You will also see that the Angle button has been greyed out.

When the displays are set to *Angle Mode*, the values will show up in the right-side displays and the font color is *yellow*. You will also see that the Center button has been greyed out.

***Important Note** – You must install the angular lens into the target to get the proper results.*

Figure 42 - T-1295 Target: Inserting Angular Lens

Qualifying the Laser Beam to a Spindle AOR
L-700, L-703 & L-702SP Lasers

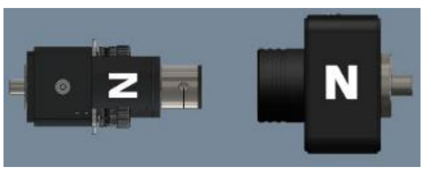
In spindle alignments on lathes and turning centers, it is important to ensure that the laser beam is aligned, or qualified (bucked-in), to the axis of rotation (AOR) of the spindle. This is so the alignment of the headstock to the machine's guideways can be checked.

This procedure describes how to align the laser beam to the spindles' AOR.

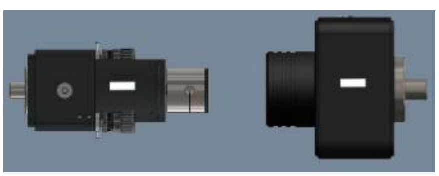
The NORMIN Method

The NORMIN method is a way of canceling mounting errors. The word is a contraction of "NORMal-INverted," which briefly describes the method.

To take NORMIN readings, the laser and target fixtures are set in the NORMal position (cable down or switch panel facing toward you) and the readings are recorded. Then the laser or target fixture is rotated 180 degrees to the INverted (cable up or switch panel on the bottom) position and a second set of readings is obtained. With a quick calculation, the 2 sets of readings are averaged to cancel out both laser and target mounting errors (center and angular) and provide a very accurate result. For a complete discussion of the NORMIN method, see *Appendix A*, beginning **on page 78**



NORMIN Reading
L-702SP Laser NORMal,
T-1295 Target NORMal



NORMIN Reading
L-702SP Laser INverted,
T-1295 Target INverted

Figure 43 - Taking NORMIN Readings

To qualify or buck-in a laser, error correction readings are taken to cancel out mounting and other errors, and MultiTurn10 calculates what we call *Set Points*. The laser beam is then adjusted to the *Set Points*, making it parallel to/coincident with the desired axis of rotation.

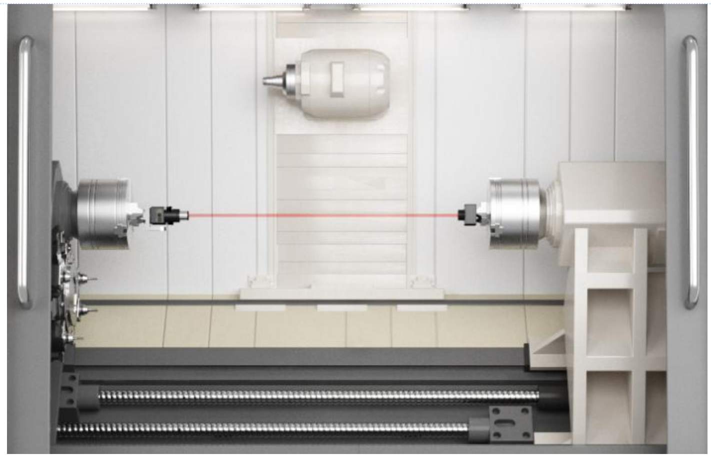
Procedure for Qualifying the Laser to a Spindle's Rotation Axis T-1295/T-1296 and MultiTurn10

The following procedure explains how to qualify (buck-in or align) the L-702SP laser to the spindle's rotation axis using the T-1295/T-1296 4-axis Target and MultiTurn10 software.

1. **Install the L-702SP & T-1295/T-1296 into headstock and sub-spindle/tailstock chuck.**
   Mount the laser in the headstock spindle and the target in the sub-spindle or tailstock or the T-242 Target Stand. Both the laser and target should be in the *NORMal* position. The *NORMal* position for the laser is with the switch panel facing *toward* you.

L-702 Switch Panel

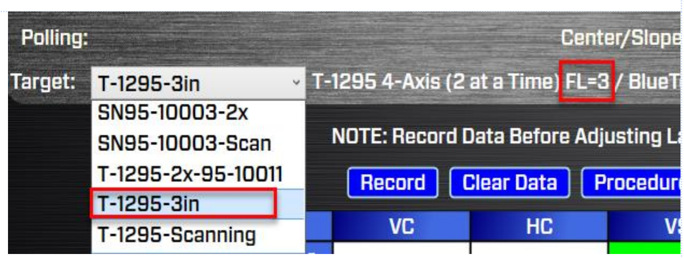
L-702 A/C Adapter Connector



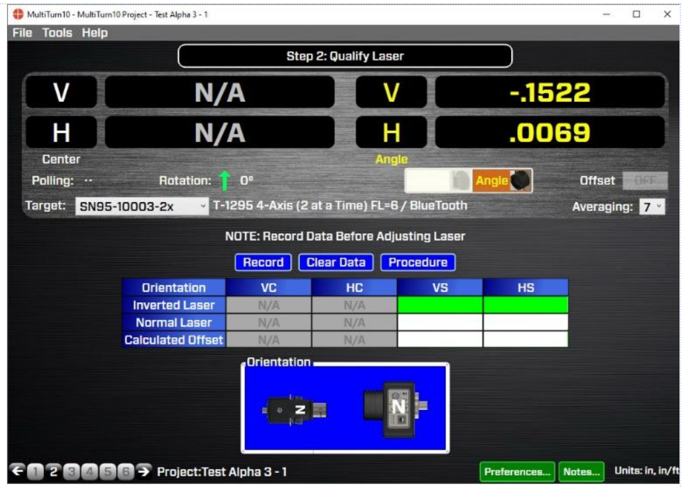
2. **Alignment Tolerance**
   The goal is to align the laser to the spindle's AOR to ±-.0001 in/ft (0.012 mm/m) in angle.

3. **Open MultiTurn10**
   Open MultiTurn10 using either a saved file or enter a new file name.
   See the *MultiTurn10 Software Manual* for details on how to set up the T-1295/T-1296 Targets.

4. **Go to Step 2: Qualify Laser**
   Go to Step 2: Qualify Laser and ensure you are getting readings in the **Angle** displays. Make sure to install the T-1295-A-3 (or A-6) Lens and ensure that the target description has a matching focal length. ***FL=3*** should be selected for the T-1295-A-3 lens and ***FL=6*** should be selected for the T-1295-A-6 lens. See the MultiTurn10 Manual for instructions on how to set up a new target.

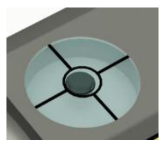


Note*: for the L-702SP/T-1295 Target there is no centering adjustment, so you will only be adjusting the V & H angular axes.*

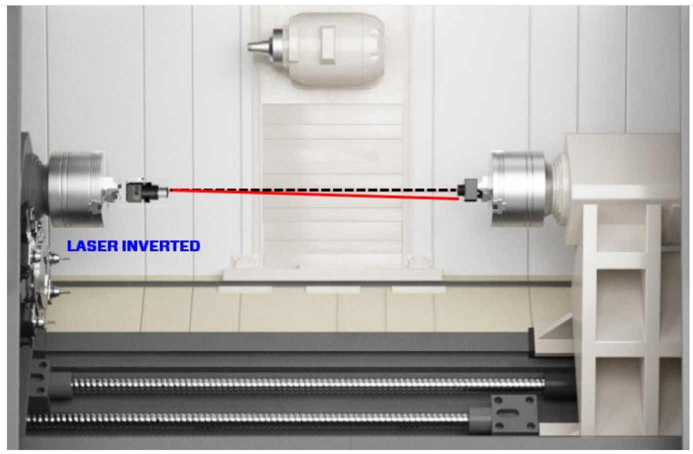


5. Rotate the spindle/L-702SP to the INverted Position.

Rotate the spindle/L-702SP to the *INverted* position (A/C connector panel is facing *toward* you), with the target in the *NORMal* (cable down) position. Ensure the bubble level is in the center of the circle. Wait for the readings to stabilize (approximately 5 seconds).

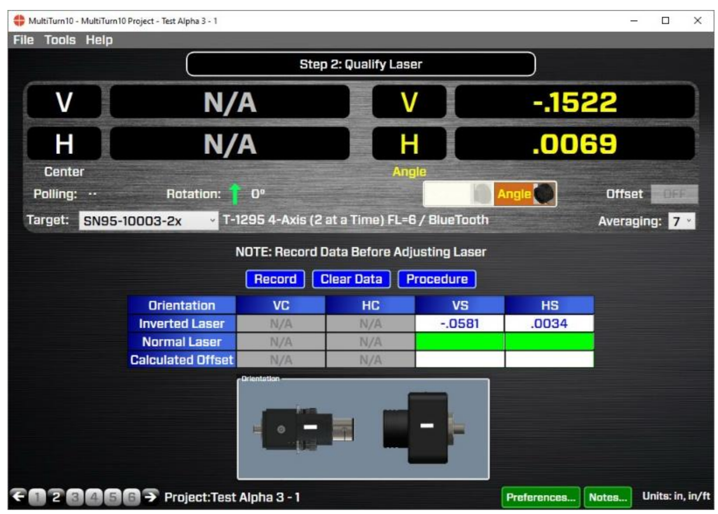


Note: *Do NOT rotate the laser in the chuck. Always rotate the laser and spindle TOGETHER as one unit.*



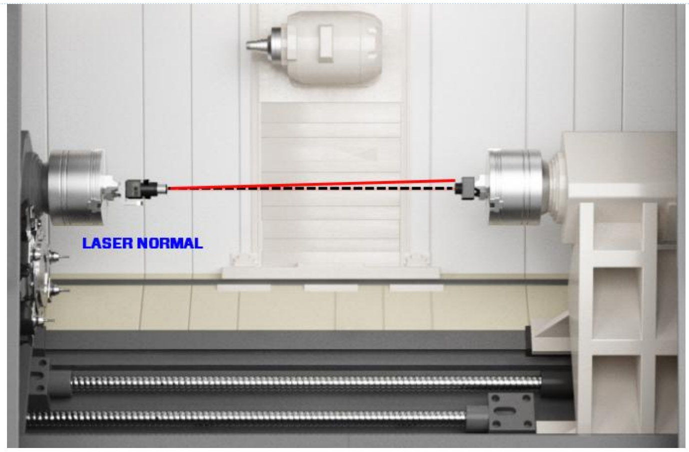
6. Click RECORD.

Click or tap **Record** (or the spacebar on a laptop) to record the INverted value. The V & H angular values will be recorded in the table.



7. Rotate the spindle/laser to the NORMal position.

Rotate the spindle/L-702SP to the *NORMal* position (switch panel facing *toward* you with the level vial leveled), with the target in the *NORMal* position (cable down) and wait for the readings to stabilize (approximately 5 seconds). Ensure the bubble level is in the *center* of the circle.

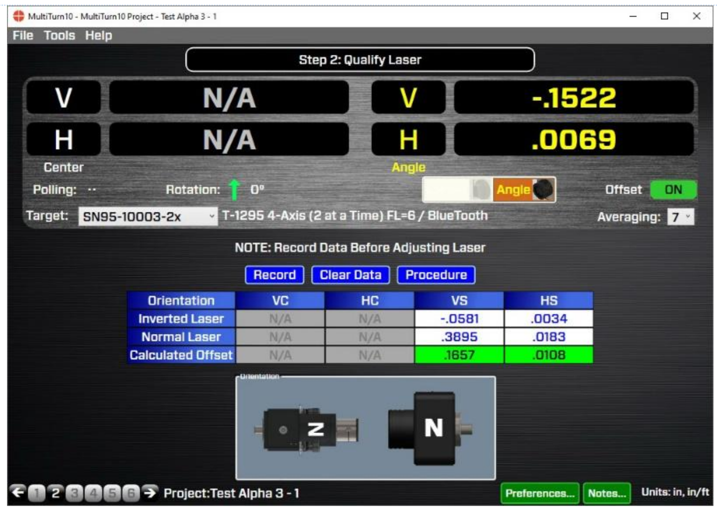


8. Click RECORD.

Click or press **Record** to record the NORMal value.

MultiTurn10 records the NORMal value and automatically calculates display offsets so you can adjust the 2 *angular* adjustment axes to *zero* instead of the calculated Set Point.

Note: *While it is not recommended, if you want to see the raw values, click the* **Offset** *button to turn the offsets off (the green* **ON** *button will turn gray). Click* ***Offset*** *again to turn them back on.*

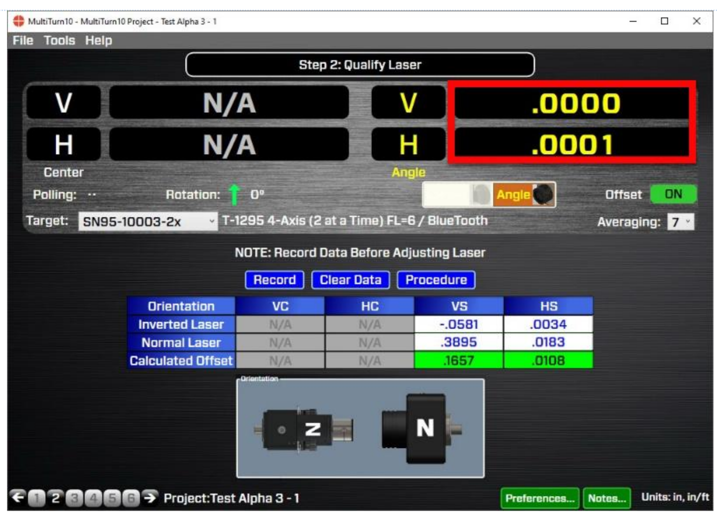


9. Adjust the V and H Angular (slope) Adjustments

Turn the Pitch and Roll adjustment knobs until the Angle values in the Step 2 display are within ±.0001 in/ft (0.012 mm/m) of zero. Use the coarse adjustments first and then the fine adjustments when the coarse adjustments can't get the value to the recommended tolerance.

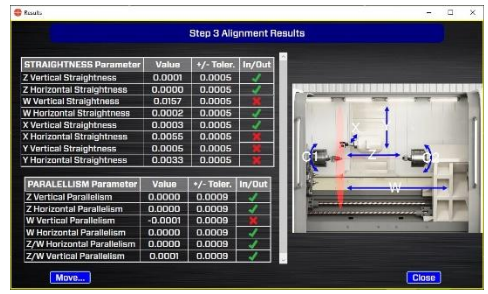
In the image here are the L-702SP V and H *Angular* (*Slope)* values in or close to tolerance.

Note: *There are no center adjustments with the L-702SP, since any small centering errors will be averaged out by using the NORMIN procedure in Step 5.*



10. Repeat Steps 6-10 to verify the laser is aligned to the spindle rotation axis.

11. The laser is now bucked into the C1 axis and the straightness for the Z and W axes can be recorded in Step 3. See the MultiTurn10 Manual for more information.



Procedure for Qualifying the Laser to a Spindle's Rotation Axis
T-261 and MultiTurn10 Software

The following procedure explains how to qualify (buck-in or align) the L-702SP laser to the spindle's rotation axis using the T-261 4-axis Target and Lathe9 software. This is nearly identical to using MultiTurn10, so we included the procedure here.

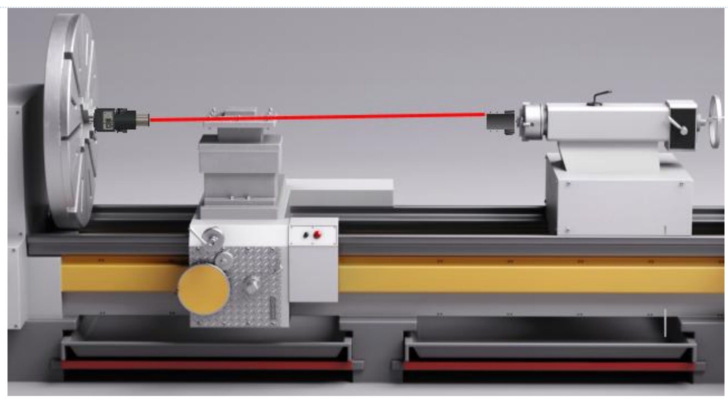
1. **Connect the T-261 Target to the R-358 Computer Interface.**
   Connect the T-261 to the R-358 and use the mounting screws to hold the target connector in place. Connect the serial cable to the USB/Serial adapter cable and plug it into the laptop or desktop computer.

Note*: You must install the software driver for the USB cable BEFORE plugging in the USB cable into your computer. Please see Page* *Error! Bookmark not defined.* ***for details on how to install the driver.*

2. **Install the L-702/T-261 into the headstock and tailstock spindles.**
   Mount the laser in the headstock spindle and the target in the tailstock or the T-230 Target Stand. Both the laser and target should be in the *NORMal* position. The *NORMal* position for the laser is with the switch panel facing *toward* you.

L-702 Switch Panel

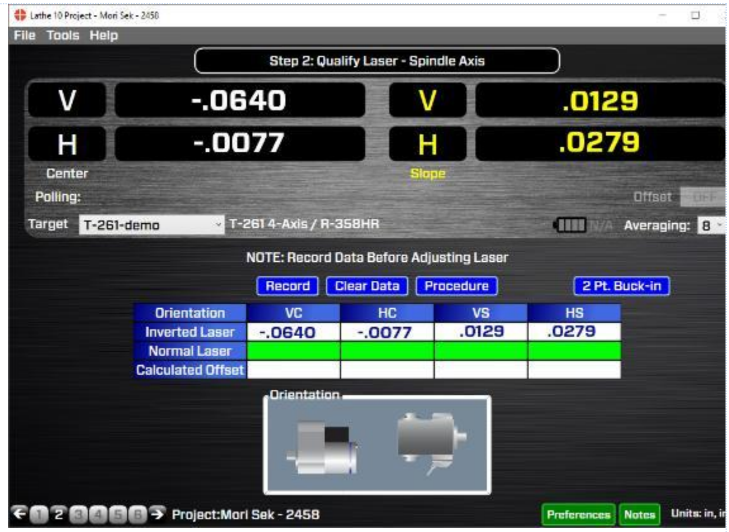
L-702 A/C Adapter Connector



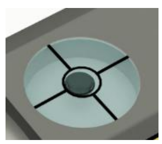
3. **Alignment Tolerance**
   The goal is to align the laser to the spindle's AOR to ±-.0001 in/ft (0.012 mm/m)

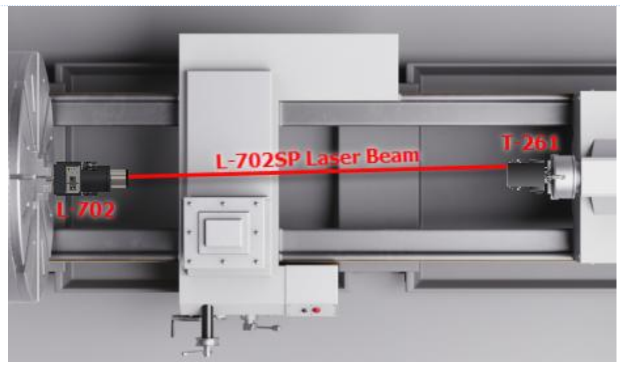
4. **Open Multiturn10**
   Open Multiturn10 using either a saved file or enter a new file name.

5. **Go to Step 2: Qualify Laser**
   Go to Step 2: Qualify Laser and ensure you are getting readings in all four displays.



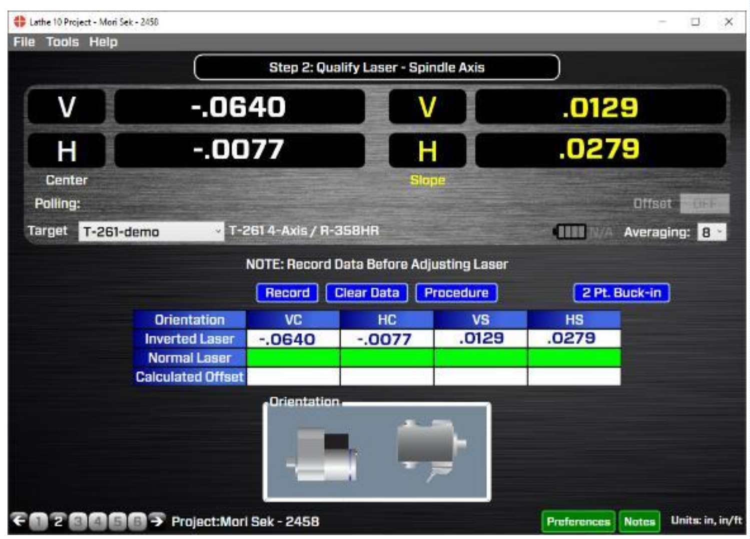
6. **Rotate the spindle/L-702SP to the INverted Position.**
   Rotate the spindle/L-702SP to the *INverted* position (A/C connector panel is facing *toward* you), with the target in the *NORMal* (cable down) position and ensure the bubble level is in the center of the circle. Wait for the readings to stabilize (approximately 5 seconds).



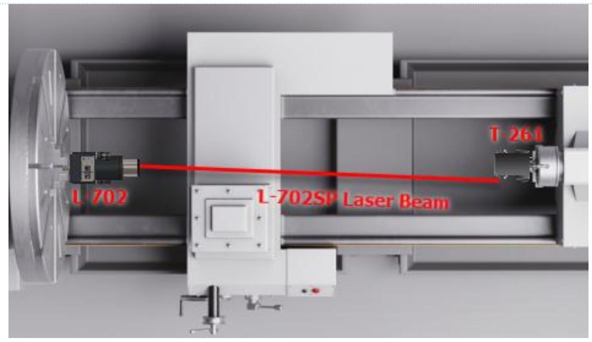


   Note: *Do NOT rotate the laser in the chuck. Always rotate the laser and spindle* ***TOGETHER*** *as one unit.*

7. **Click RECORD**.
   Click or press **Record** to record the INverted value.



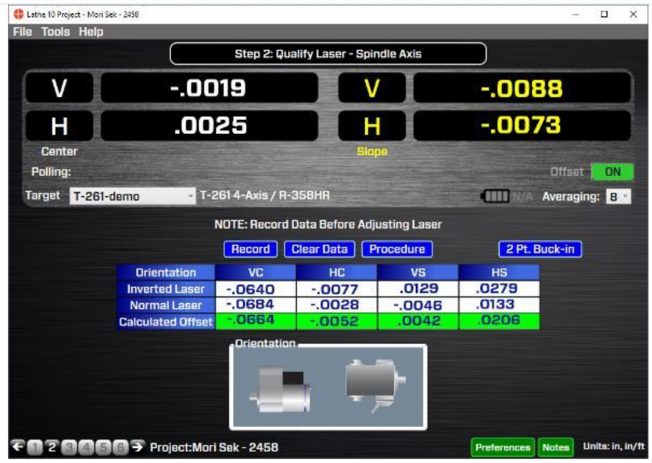
8. **Rotate the spindle/laser to the NORMal position.**
Rotate the spindle/L-702SP to the *NORMal* position (switch panel facing *toward* you with the level vial leveled), with the target in the *NORMal* position (cable down) and ensure the bubble level is in the *center* of the circle. Wait for the readings to stabilize (approximately 5 seconds).



9. **Click RECORD.**
Click or press **Record** to record the NORMal value.

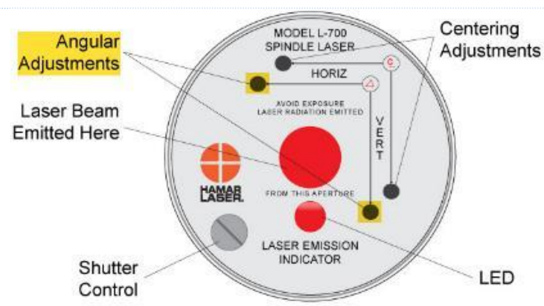
Lathe9 automatically calculates display offsets so you can adjust the two *angular* adjustment axes to zero instead of the calculated Set Point.

Note: *While it is not recommended, if you want to see the raw values, click the* **Offset** *button to turn the offsets off (the green* **ON** *button will turn gray). Click* ***Offset*** *again to turn them back on.*



10. **Adjust the V and H Angular (slope) adjustments**
Turn the Pitch and Roll adjustment until the Slope values in the Step 2 display are within ±.0001 in/ft (0.012 mm/m) of zero.

If you run out of range, this is most likely due to the fixturing not being done properly. QC the fixtures to make sure the mounting hole/rotation axis is perpendicular to the axis you are trying to align to.

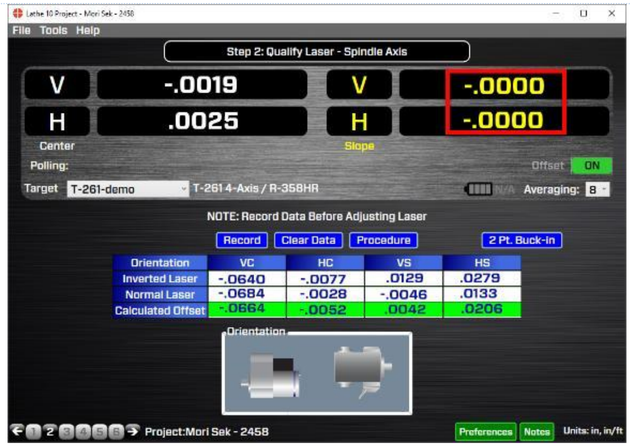


Warning!!

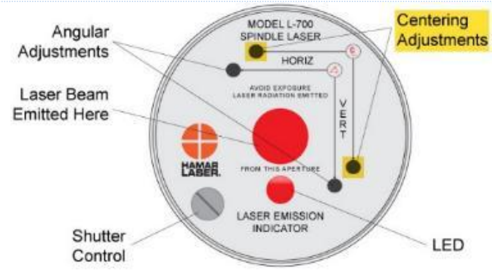
If the adjustments start getting tight or very loose, STOP! You might cause some damage to the laser adjustments if you turn them too far. The adjustments have about 3 full turns in either direction before they run out of range.

Here are the L-702SP V and H *Angular* (*Slope)* values in or close to tolerance.

Note: *There are no center adjustments with the L-702SP since any small centering errors, will be averaged-out by using the NORMIN procedure in Step 5.*



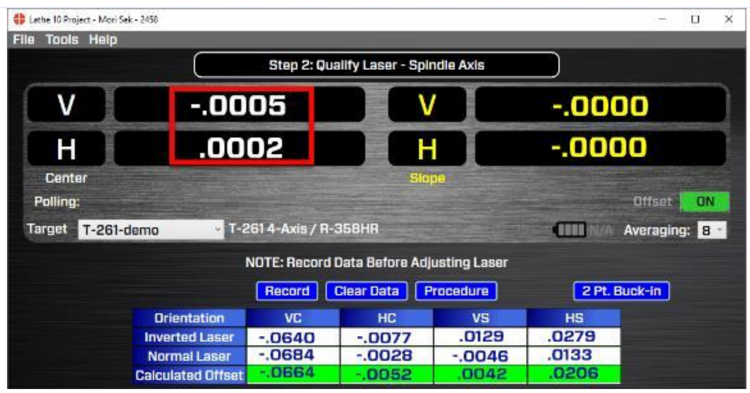
11. **Adjust the V and H *Center* adjustment on L-700 Laser until the *Center* values in the display are within ± .001 in/ft (0.025 mm) of zero.**



12. **Here, the L-700 V & H *Center* values are in tolerance.**

Since the *Center* values were adjusted, the *Angular* values should not change (or should change very little).

Note: *If you have a large center offset to adjust out, this will probably change the angular values enough to need to be tweaked back into tolerance*



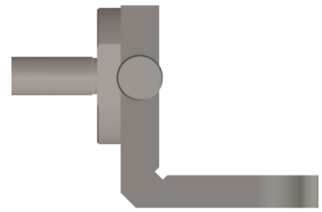
Two-Point Buck-In Procedure for T-1295/T-1296 and MultiTurn10

To measure the straightness of all the axes of a multiturn or machining center, it is necessary to do a 2-point buck-in to one of the axes, usually to the Y Axis. Here is a procedure for bucking-in to the Y Axis on a multiturn machine using the L-702RA Right-Angle Mounting Fixture.

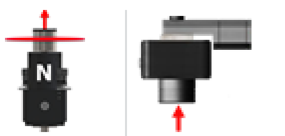
1. **Insert L-702SP into L-702RA Right-Angle Mounting Fixture.**
   Insert L-702SP into L-702RA Right-Angle Mounting Fixture and tighten the thumb screw very tight. Insert the mounting stud into the spindle and clamp with a chuck or collet.

   Rotate the spindle so the L-702SP is at the 12:00 position. Lock the spindle if possible.

   Make sure the turret set screw is flipped so the beam is coming out the *top* of the turret.



2. **Insert the T-1295 Target into another L-702RA and insert that into the machining head.**
   Insert the T-1295 Target into another L-702RA and insert that into the machining head, so the target is pointed down and the top of the target is pointed to the *left* (see the graphic below).

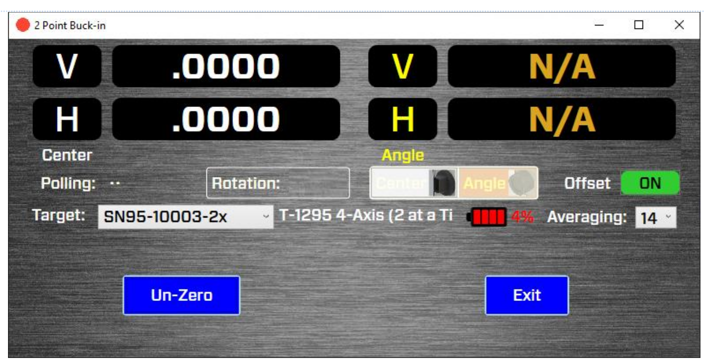


   ***Note**: you can also use the T-243 Target Stand to hold the target.*

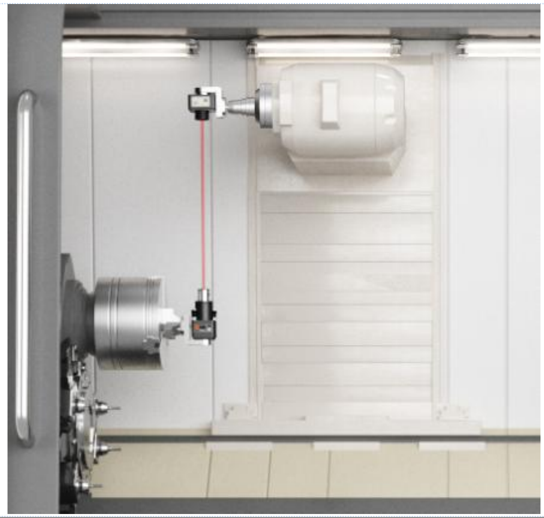
   Remove the Angular Lens if it's installed and install the light shield.

3. **Move the Machining Head Near the Laser and Zero the readout**
   Move the machining head down to be near the laser (*Near Position*). Go **to Step 2: Qualify Laser** and click on **2-Point Buck-In**. Make sure you are getting readings. If so, then click on **Zero** to zero out the reading.

   To re-zero the value, click on the **Un-Zero** button and then click on **Zero** button again. If you just want to toggle the display offset on/off (keeping the recorded zero offset) then click on the **Offset On/Off** button.

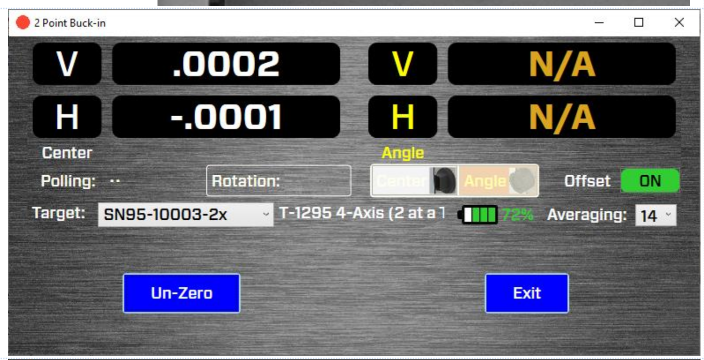


4. Move the Machining Head to the top of the travel
Move the machining head to the top of its travel (Far Position).



5. Adjust the Pitch/Yaw Axes on L-702SP
Adjust the Pitch/Yaw adjustment knobs until the displays read zero or within ±.001 in. (0.025 mm) of zero.

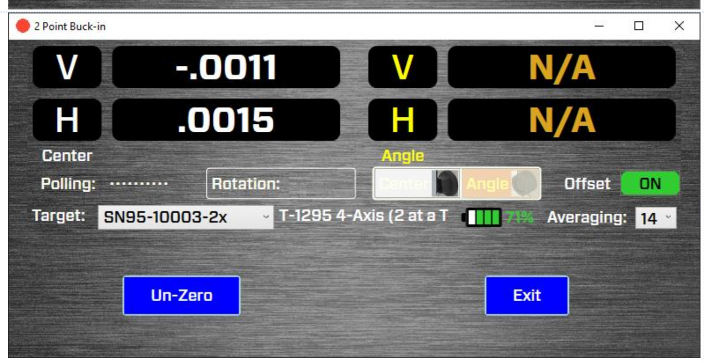
Note: If you have a Remote Buck-in situation, then see ***Page 78*** *for Remote Buck-In - Calculating a Set Point. We strongly recommend using this formula for L1/L2 ratios > 0.1.*



***6.* Move back to the close position and note the display values.**
If the top and bottom values are close to .001 in. (0.025 mm), then the buck-in is done and you can hit Zero. If not, then repeat Steps 3-6 until the values are near .001 in. of each other.

Note*: to measure the straightness of Y, we recommend getting the top & bottom values to approximately .001 in. (0.025 mm) of each other. The last remaining slope error in the laser beam will be removed from the data by the MultiTurn10 when it analyzes the data.*

See Appendix A – Remote Buck-In Formula & Set Points *(on page 78) for a detailed explanation on the math behind this 2-point buck-in wizard.*

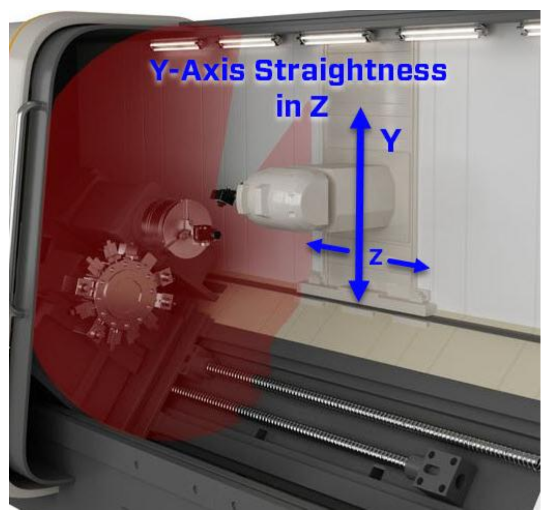


Step 3 – Axis Straightness & Spindle-Axis Parallelism

Figure 44 - Step 3 Data Collection Screen

This step allows collecting data for all active axis's.

Note: when collecting squareness data for an axis, the L-702SP uses the scanning plane to measure one of the 2 straightness values of an axis. For example, if the L-702SP is aligned to the C1 spindle and the Z-axis data was measured with the laser beam, we can then use the perpendicular scan plane to measure the X and Y axes for squareness to Z. In the example to the right, the scan plane is measuring both the straightness of Y in Z and the squareness of Y to Z, but the data will be recorded in the Squareness Row.

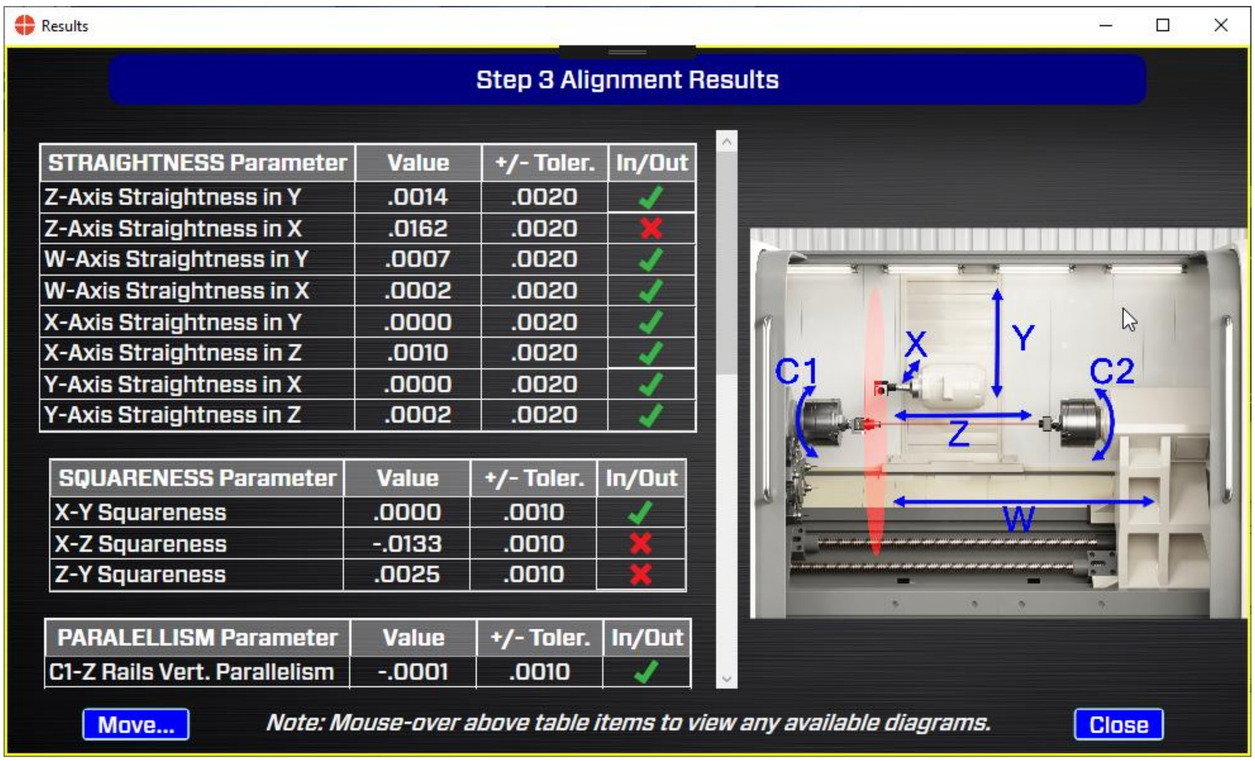


What the buttons do:

- **Copy Sq. Data** – (Copy Squareness Data) Depending on the axis currently selected, this allows copying of the collected squareness data, which will be input into the straightness row of a linear axis. You can hover over the button to reveal a tooltip that will give the specific axis ID that the data will be transferred to.

- **Clear Data** – This clears data from the currently selected axis.
  Important note on clearing data *- If the displays are set to* ***Center****, then clicking* ***Clear Data*** *will erase the straightness values for that axis. If the displays are set to* ***Angular****, then it will clear the* ***Pitch*** *and* ***Yaw*** *rows of data for that axis. If the T-1295 is in* ***Scanning Mode*** *and* ***Squareness*** *is selected, then the* ***Clear Data*** *button will clear the squareness row of data.*
- **Record** – Records the data point. The cursor will automatically move to the next point if Auto Step is checked.
- **Save** – Saves all currently collected data.
- **Results** - Calculates the straightness, parallelism, etc. values, and opens a window with the results.
- **Direction** - Click to reverse the direction of **Auto Step**. The default direction is left to right.

Alignment Results Screen



STRAIGHTNESS Parameter	Value	+/- Toler.	In/Out
Z-Axis Straightness in Y	.0014	.0020	✓
Z-Axis Straightness in X	.0162	.0020	✗
W-Axis Straightness in Y	.0007	.0020	✓
W-Axis Straightness in X	.0002	.0020	✓
X-Axis Straightness in Y	.0000	.0020	✓
X-Axis Straightness in Z	.0010	.0020	✓
Y-Axis Straightness in X	.0000	.0020	✓
Y-Axis Straightness in Z	.0002	.0020	✓

SQUARENESS Parameter	Value	+/- Toler.	In/Out
X-Y Squareness	.0000	.0010	✓
X-Z Squareness	-.0133	.0010	✗
Z-Y Squareness	.0025	.0010	✗

PARALELLISM Parameter	Value	+/- Toler.	In/Out
C1-Z Rails Vert. Parallelism	-.0001	.0010	✓

This screen displays the calculated results. The left-hand side of the screen shows the calculated values, the tolerances, **X** = out of tolerance, √ = in tolerance.

The right-hand side of the screen displays a context-sensitive image of relevant data. Mouse over the table to view any available diagrams.

Step 3: Move Screen

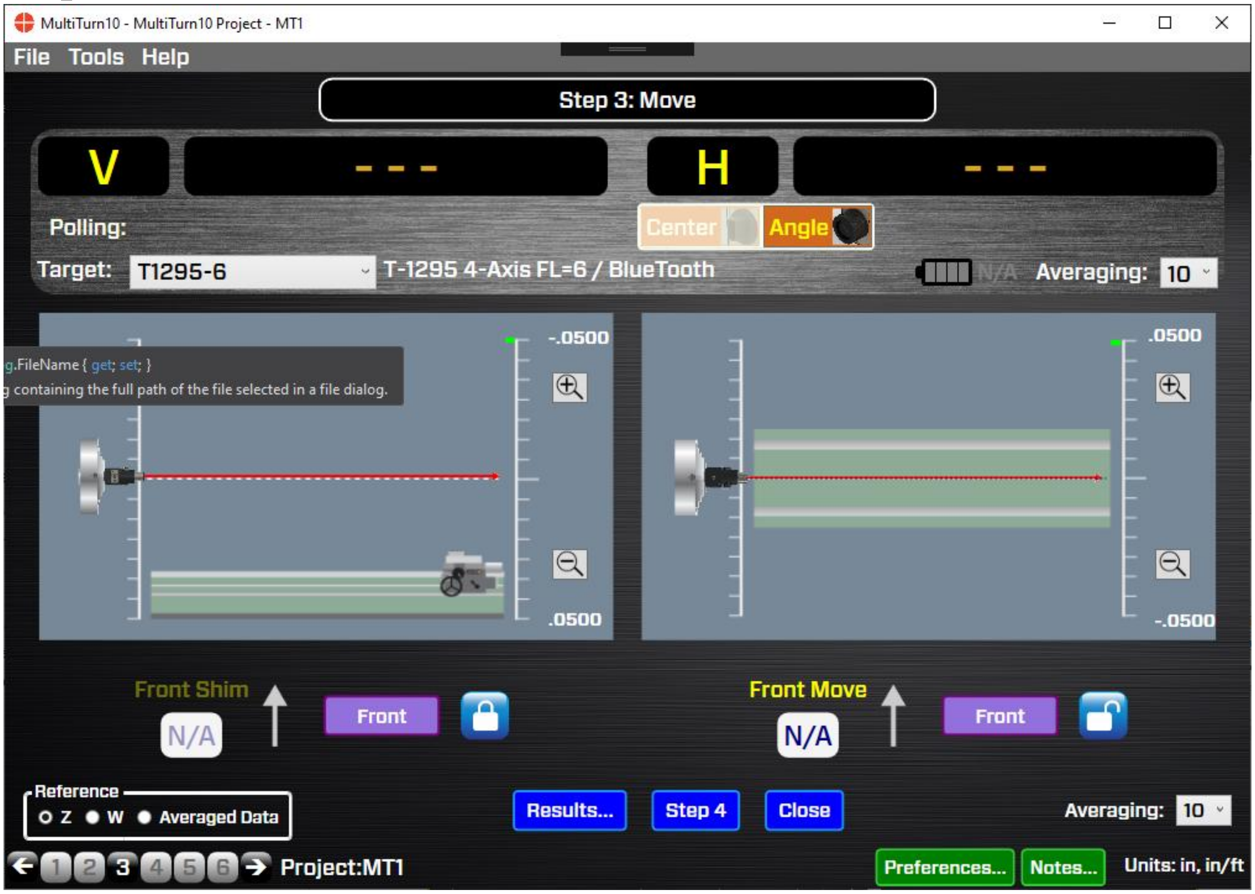


Figure 45 - Step 3 - Live Adjustment

If you find that the V or H headstock parallelism is out of tolerance, click the ***Move*** button from the **Step 3: Alignment Results** Popup. A live adjustment screen displays the parallelism values and a graphic depiction of the headstock AOR alignment relative to the guideways is shown. The display values update in real time and shim values are calculated for either the front or back feet to fix the angular error. Since we only need to fix the parallelism, shim the front *or* the back foot to fix the alignment.

How to Change Shim Values to Back Foot

The default shim calculation is for the front foot. To see the shim for the back foot, click the **Front** shim box and the value displays for the back foot.

What the Buttons Do

- ***Results*** – returns to the **Results** popup.
- ***Step 4*** – displays **Step 4: Bed Straightness Results** and provides a graph of the collected data.
- ***Close*** – returns to **Step 3**.

Changing the Scale

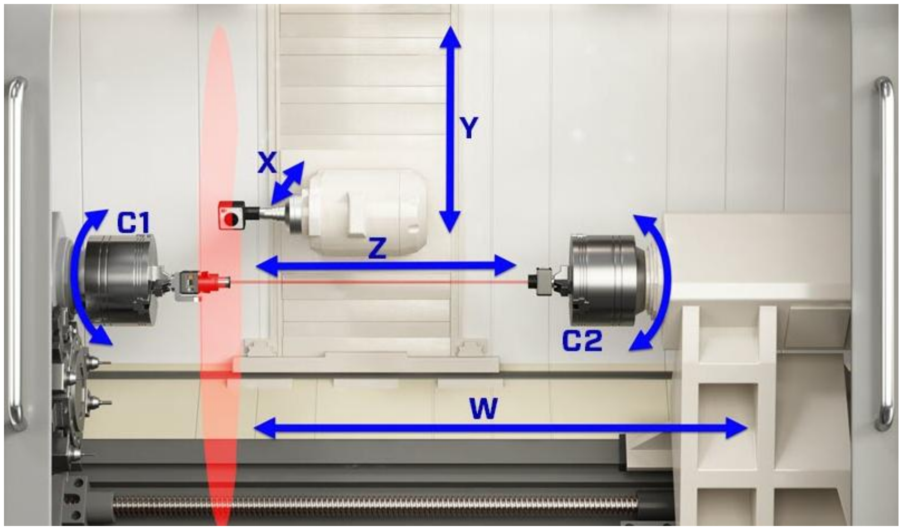
 

Click on the + or – icon to zoom the scale in or out on the graph.

Locking the Shim

The Vertical shim value is locked by default. To update the shim in real time, click on the lock icon to unlock it. The Horizontal move is unlocked by default but can also be locked by clicking on the lock icon for the H axis.

Measuring Straightness - Identifying Axis and Parameter Names



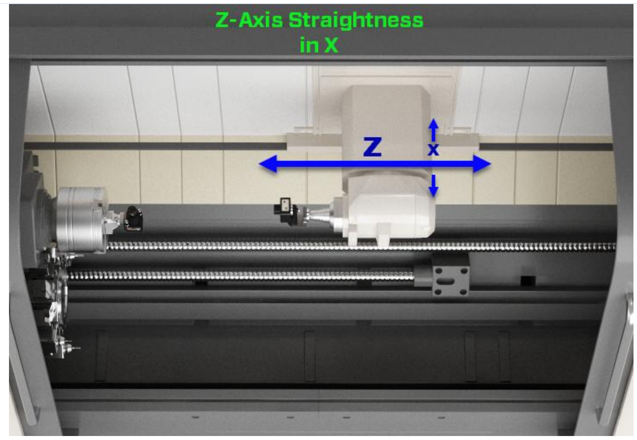
When taking geometric data for machine tools, it is important to identify what parameters you are measuring. This has always been somewhat complicated, especially on multiturn machines. We try to make it easy but there is only so much we can do.

To try to make it easier to understand, the labels of the axes can be used to describe what direction the geometric parameter is varying. So in the example below, for the Z axis straightness (some might call this flatness), we say it's the straightness parameter of the *Z Axis* in the *Y* direction or put more succinctly: *Straightness of Z in Y* or *Z-Axis Straightness in Y*. In other words, viewing from the front of the machine, this Z straightness error is the movement of the axis up/down (in the direction of Y) as Z traverses along its axis (left/right).

See more examples below.

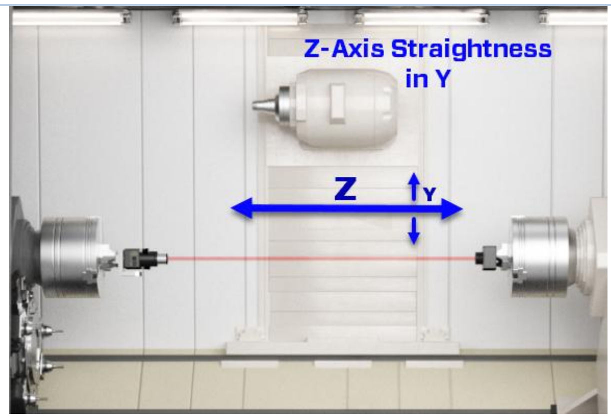
Z-Axis Straightness in X

This is what some might call "horizontal straightness". It is the straightness error of the *Z axis* in the direction of the X axis.



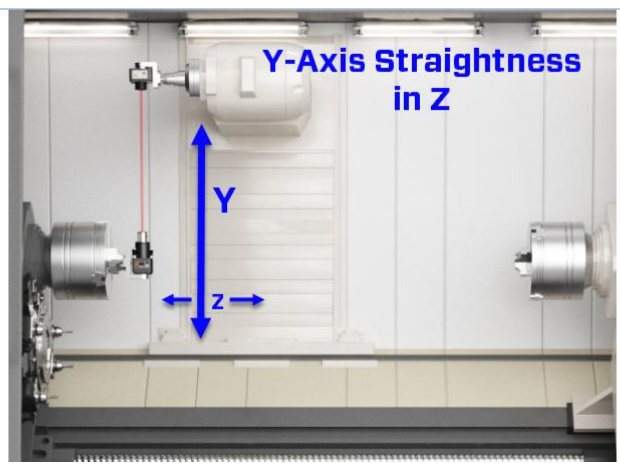
Z-Axis Straightness in Y

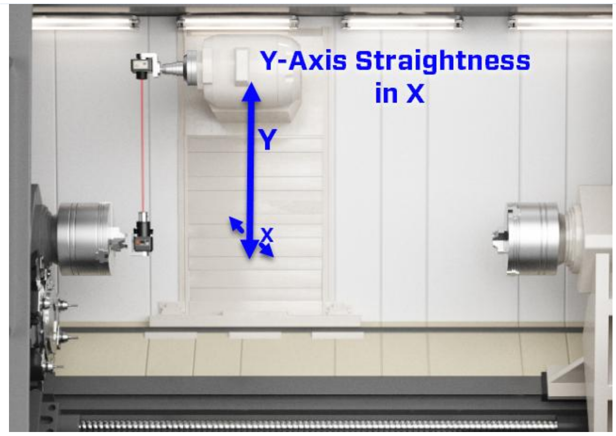
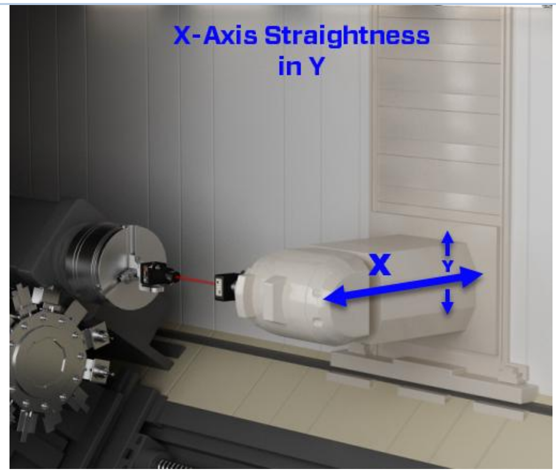
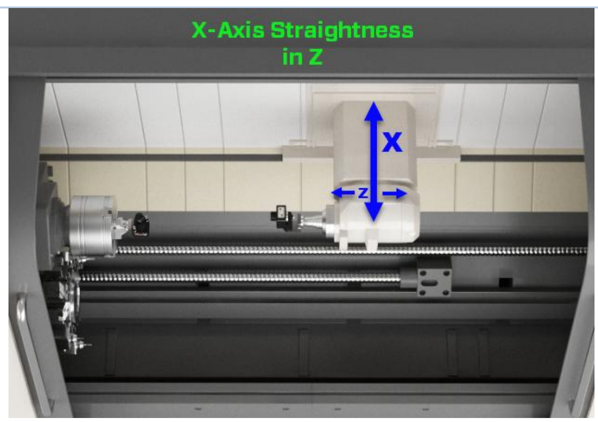
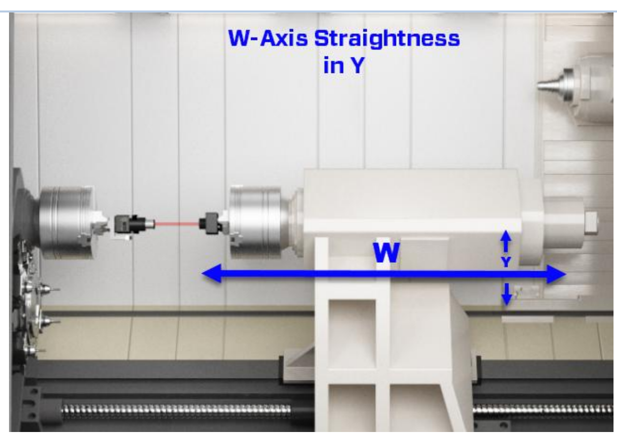
This is what some might call "vertical straightness" or "flatness". It is the straightness error of the *Z axis* in the direction of the Y axis.



Y-Axis Straightness in Z

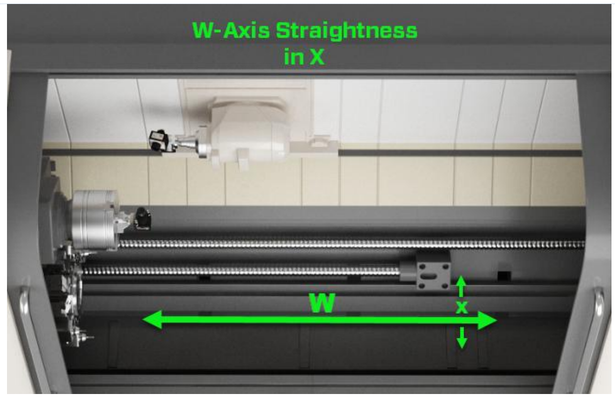
This is what some might call "horizontal straightness". It is the straightness error of the *Y axis* in the direction of the Z axis.



Y-Axis Straightness in X This is what some might call "vertical straightness" or "flatness". It is the straightness error of the *Y axis* in the direction of the X axis.	
X-Axis Straightness in Y This is what some might call "vertical straightness" or "flatness". It is the straightness error of the *X axis* in the direction of the Y axis.	
X-Axis Straightness in Z This is what some might call "horizontal straightness". It is the straightness error of the *X axis* in the direction of the Z axis.	
W-Axis Straightness in Y This is what some might call "vertical straightness" or "flatness". It is the straightness error of the *W axis* in the direction of the Y axis.	

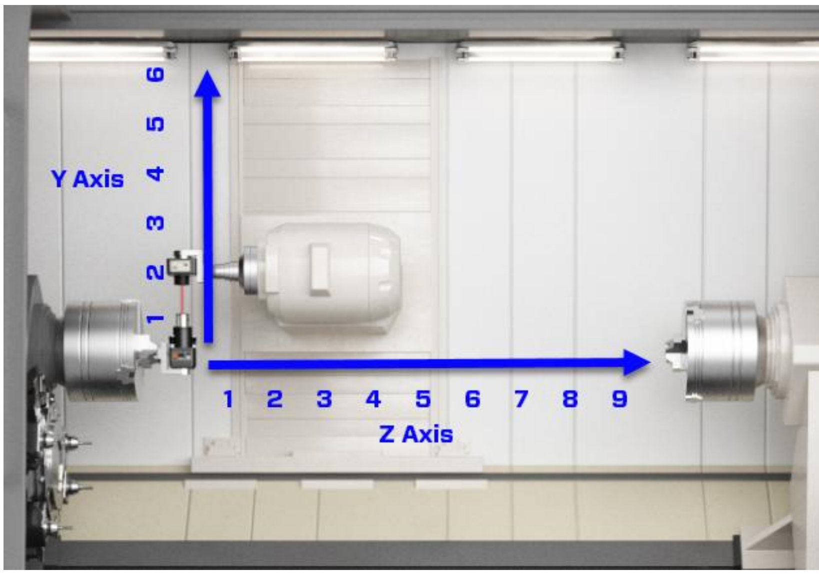
W-Axis Straightness in X

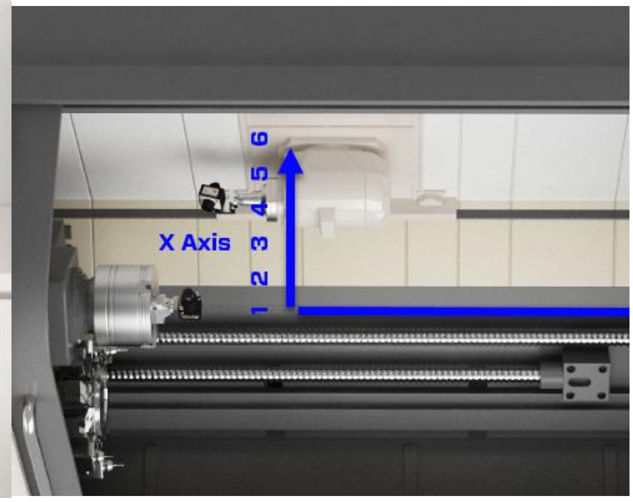
This is what some might call “horizontal straightness”. It is the straightness error of the *W axis* in the direction of the X axis.



Procedure to Measure MultiTurn Machines for Straightness and Squareness

Please note that MultiTurn10's measurement of the axes for straightness assumes that the first point of any axis is that one that is closest to the laser. It is important to follow this data-taking rule so that the direction of the tilt of the squareness and parallelism errors will be correct. If this is not followed, then the squareness/parallelism values will be correct but the interpretation of which direction the axis is tilted will be wrong. See below for examples of how the data points should be taken.





MultiTurn10 Axis Setup

1. MultiTurn10 Step 1 - Project Setup

Select which axes you want to measure, the number of points and the distance between the points. Also, choose the tolerances and laser setup.

*Note: if you do not click the "Include *" Axis checkbox, then that data-taking tab will not appear in Step 3.*

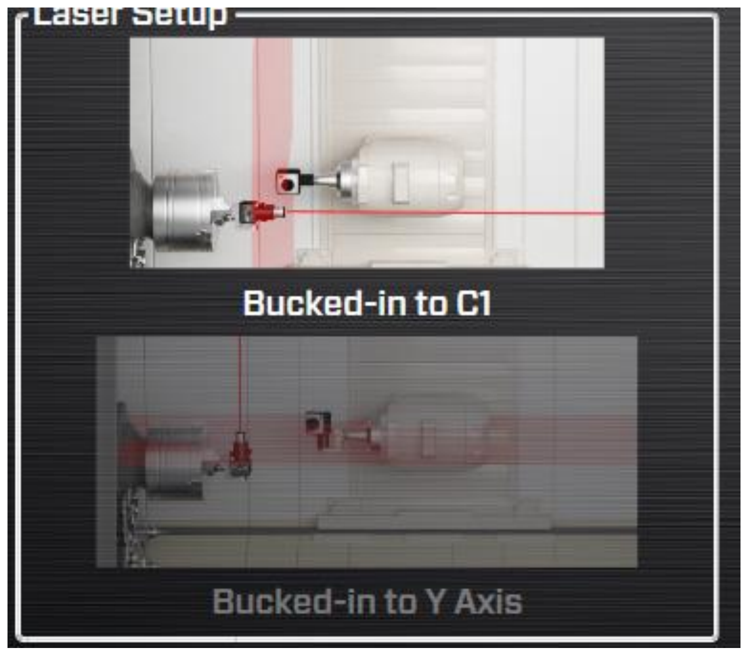
2. Choose the Laser Setup

Choose the laser setup you are going to use. Selecting one of the 2 setup images will change that image in Step 3 as a reminder of the laser setup needed for these parameters. There are 2 for a multiturn machine:

a. *Laser bucked-in to C*1 (main spindle rotation axis) - use this to measure:
   i. Z & W straightness (in X & Y),
   ii. X squareness to Z
   iii. Y squareness to Z
   iv. X straightness in Z
   v. Parallelism of Z to W
   vi. Parallelism of C1 to Z

b. *Laser bucked-in to Y axis* - use this to measure:
   i. Y axis straightness (in X & Z)
   ii. X Axis straightness in Y.
   iii. X squareness to Y.

***Note**: this setting is only for information. Selecting the wrong setup will not affect any results.*

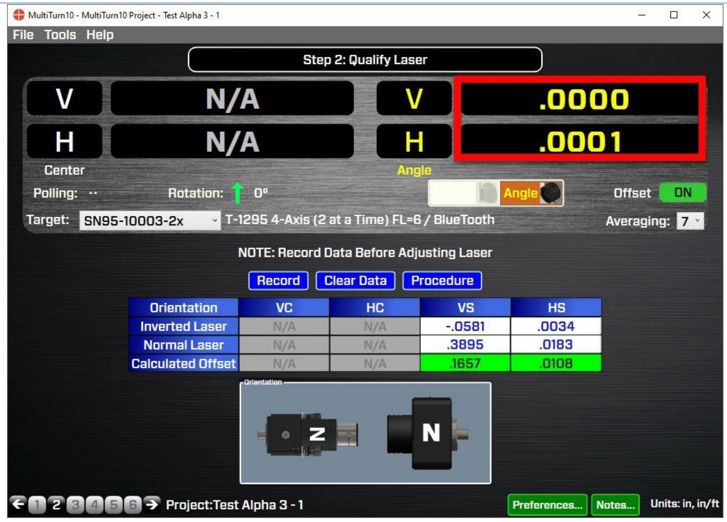


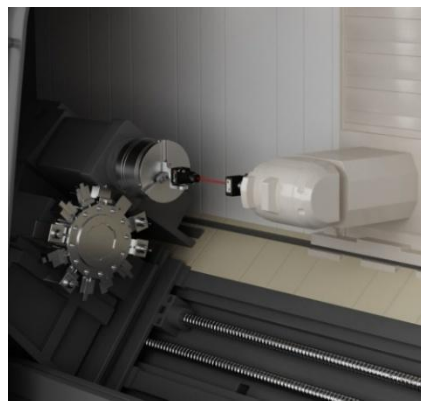
X, W & Z Axis Straightness Data – Laser Setup #1

3. **MultiTurn10 Step 2 - Align L-702SP Beam to Spindle Rotation Axis.**

   As shown in Qualifying L-702SP Laser on **Page 32**, align the L-702SP laser beam to the spindle rotation axis. Make sure to put the T-1295/1296 target into the machining axis spindle for the setup and also that it is mounted in the NORMal position.

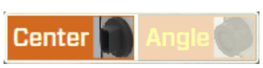
Figure 46 - T-1295 Target with Light Shield in Normal Position





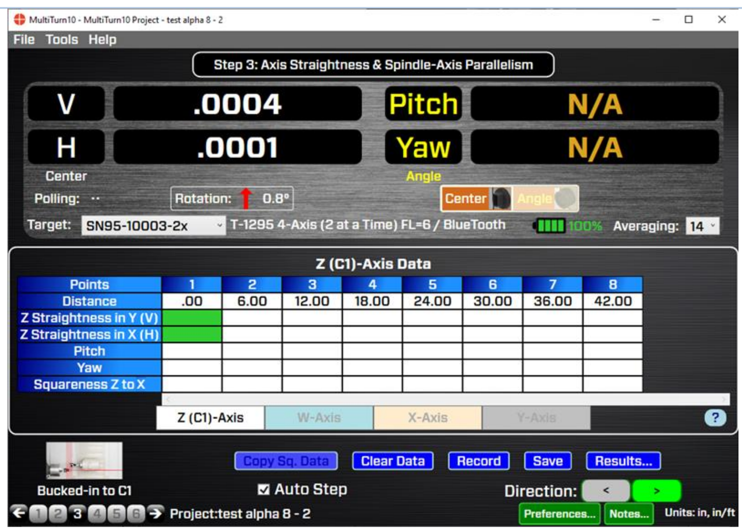
4. **MultiTurn10 Step 3 - Measuring Axis Straightness**

   Go to **Step 3: Measure Axis Straightness & Spindle Axis Parallelism**. Click On **Center** to switch the display mode to Center values.



   Important! Remove the lens from the T-1295/1296 and install the light shield.

Lens Light Shield



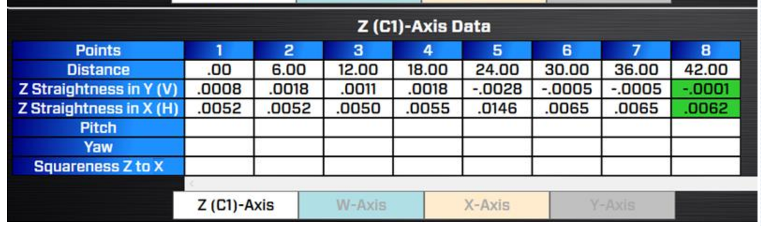
Z Axis Straightness Data

5. Select Z-Axis Tab and Record 1st Point

Select Z Axis Tab, move the Z axis to point #1 (nearest the laser) and hit **Record**. The data point will be recorded and the cursor "green boxes" will automatically move to the next point.

Move the axis to point #2 and click **Record** and continue until all the points are recorded.
Hit Save Data.

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008							
Z Straightness in X (H)	.0052							
Pitch								
Yaw								
Squareness Z to X								



Z (C1)-Axis Data

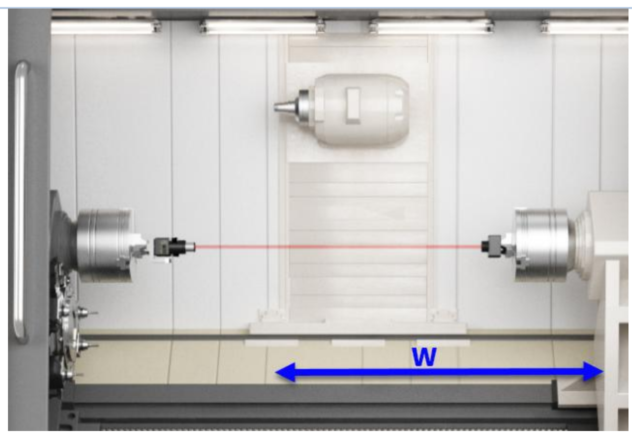
Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch								
Yaw								
Squareness Z to X								

W Axis Straightness Data

6. Move T-1295/1296 Target to C2 Spindle

Move the T-1295 Target to the C2 spindle and chuck it up. Make sure the top of the target is in the NORMal position (control panel is at 12:00).

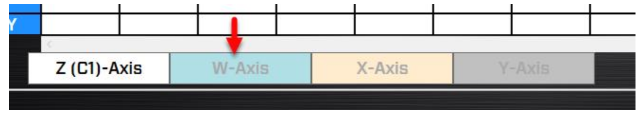
Figure 47 - T-1295 Target with Light Shield

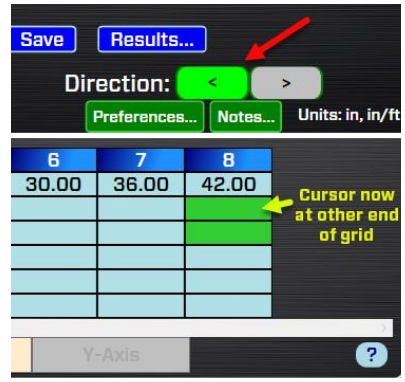


7. Select W Axis Tab and Change Data Direction

Click on the **W-Axis Tab** to bring up the W-Axis grid and then click the *left* **Direction** Arrow to move the cursor to the other end of the grid, so you can start with the *W Axis* at the far *right* side of the machine. When you hit **Record**, the value is recorded and the cursor moves to the left.

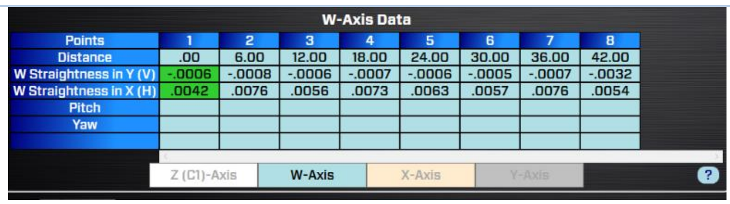
Note *– don't worry so much about the actual value of the target when you insert it into the W axis. While this value is an indication of the alignment, it is incomplete and not the full picture of the C1 to C2 alignment. To see this alignment, go to Step 5: Record Sub-spindle/Turret Rotation Axis Data.*





8. Record W Axis Data

Continue recording data for W Axis.

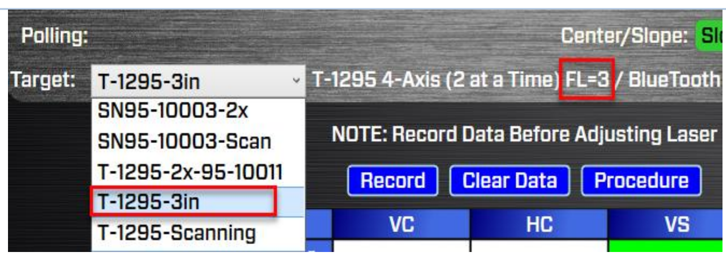


W-Axis Data

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
W Straightness in Y (V)	-.0006	-.0008	-.0006	-.0007	-.0006	-.0005	-.0007	-.0032
W Straightness in X (H)	.0042	.0076	.0056	.0073	.0063	.0057	.0076	.0054
Pitch								
Yaw								

9. Record Z & W Axis Pitch/Yaw Data

Set Z axis at the same location as in Step 5. Insert the lens into the T-1295/1296 Target. Make sure the lens focal length (FL=?) matches the target type in the drop-down list in Step 3. There is an overlay on the lens identifying the focal length.



10. Change the display to Angle Mode

Change the display to the Angle Mode (you should see the numbers in yellow in the displays on the right).

11. Record Pitch/Yaw Data

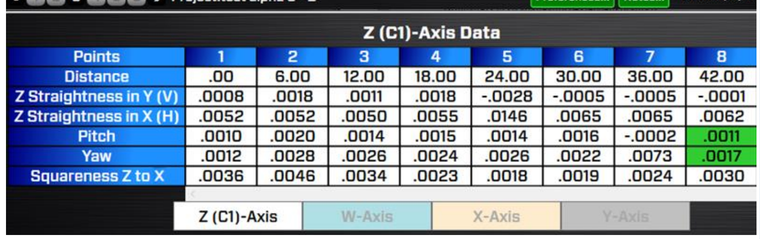
Click on the direction you want to take the data - with the machine head on the left click the right arrow so the green cursor is on the left.

Then hit **Record**.

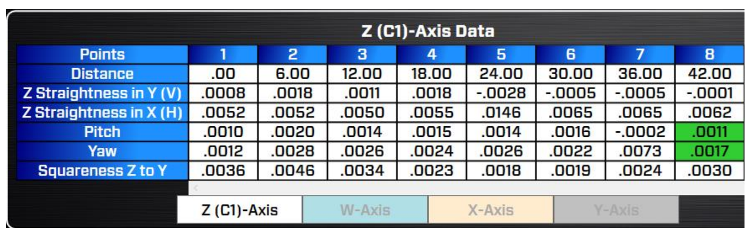
Move the axis to point #2 and click **Record** and continue until all the points are recorded.

Hit Save Data.

Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010							
Yaw	.0012							
Squareness Z to X	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030



Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010	.0020	.0014	.0015	.0014	.0016	-.0002	.0011
Yaw	.0012	.0028	.0026	.0024	.0026	.0022	.0073	.0017
Squareness Z to X	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030



Points	1	2	3	4	5	6	7	8
Distance	.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00
Z Straightness in Y (V)	.0008	.0018	.0011	.0018	-.0028	-.0005	-.0005	-.0001
Z Straightness in X (H)	.0052	.0052	.0050	.0055	.0146	.0065	.0065	.0062
Pitch	.0010	.0020	.0014	.0015	.0014	.0016	-.0002	.0011
Yaw	.0012	.0028	.0026	.0024	.0026	.0022	.0073	.0017
Squareness Z to Y	.0036	.0046	.0034	.0023	.0018	.0019	.0024	.0030

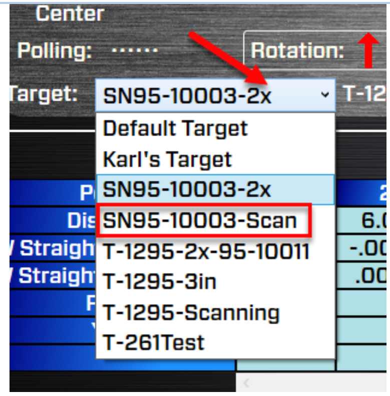
12. Record the W Axis Pitch/Yaw Data

Select the W Axis tab and repeat the data collection with the lens installed, as done in Step 11. See Step 7 for instructions on how to change the direction of the data taking.

X & Y Squareness to Z and Straightness of X-in-Z Data

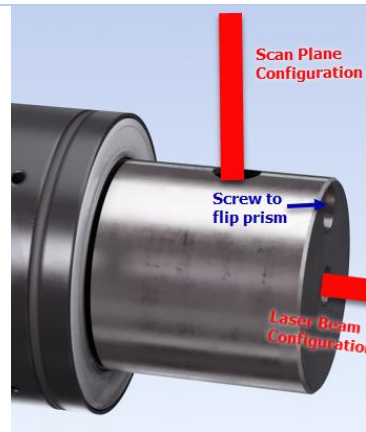
1. Select Scan Mode in MultiTurn10

From the dropdown list in Step 3, select the Target serial number you are using with "**-Scan**", which is Scan Mode. There will be a popup window that gives you instructions on how to change the laser and target to Scan Mode (or see below).



2. Switch L-702SP & T-1295/1296 into Scan Mode to Record X and Y Squareness

First, switch L-702SP into Scan Mode by pressing the power button until the ***I/O*** LED is always on. Flip the prism on the end of the L-702SP turret. Make sure the laser beam is coming out the side of the turret (see **Page 4)**.



3. **Attach the T-1295/1296 Target to the Machine Head**

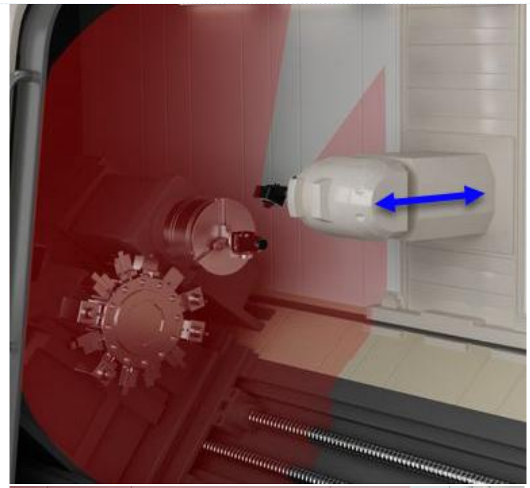
Attach the T-1295/1296 Target to the machine head spindle using custom fixturing or the magnetic base that comes with the target. Do NOT use the lens but the light shield.

Lens **Light Shield**

Note: *The top (Control Panel) of the target should be facing toward the C1 side of the machine. See image.*

Adjust the height of the target so the laser plane is in the middle of the window. You can rotate the laser turret by hand to see where the laser beam is hitting the window to easily adjust the post in the fixture or magnetic base.

Bring the X Axis to the most extended position in its travel, which is closest to the laser and is point #1 in MT10.



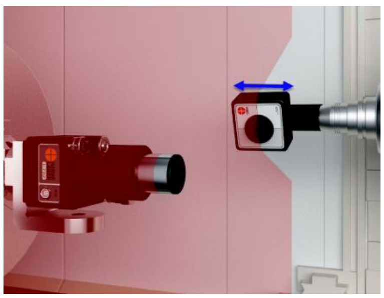
4. **Change T-1295/T-1296 Target to Scan Mode**

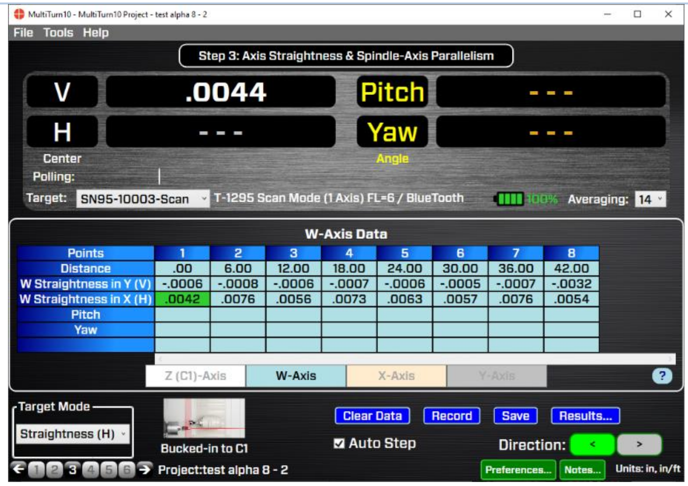
Change the target to Scan Mode by *pressing* and *holding* the power button until the ***On TGT*** LED starts blinking.

Note: *Before switching to Scan Mode, make sure the L-702SP laser beam is either turned off or blocked from hitting the T-1295/1296 Target. The easiest way to do this is to turn off the laser's Scan Button.*

5. **Turn on Scan Plane to Get Data & Adjust Target Height**

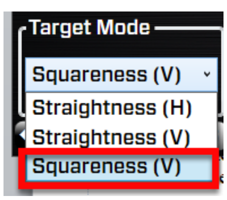
Turn on the scan plane and you should see a value in the V Center display. Adjust the target position to get the raw value below ±.025 in. (1.0 mm).

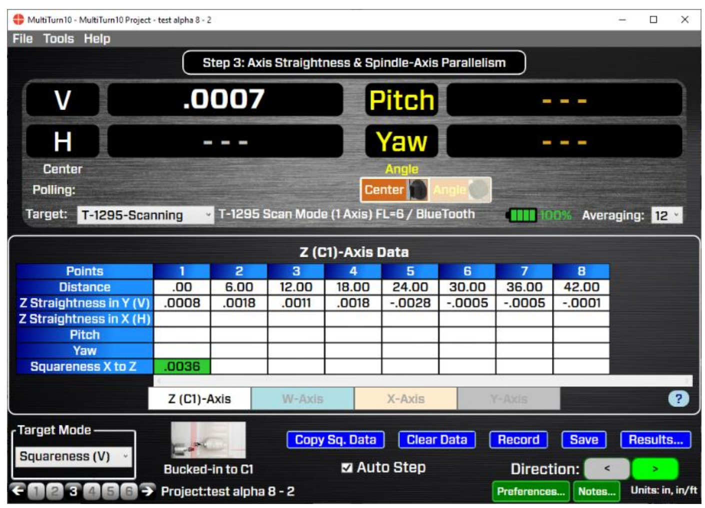




6. **Select Z-Axis Tab & Squareness (V) for Data Type**

Select the **Z-Axis** tab and **Squareness (V)** from the lower left corner dropdown list. This will enable a row in the grid for X-to-Z Axis squareness and ready the program to record the data. You will see the green cursor in the *Squareness X to Z* row.

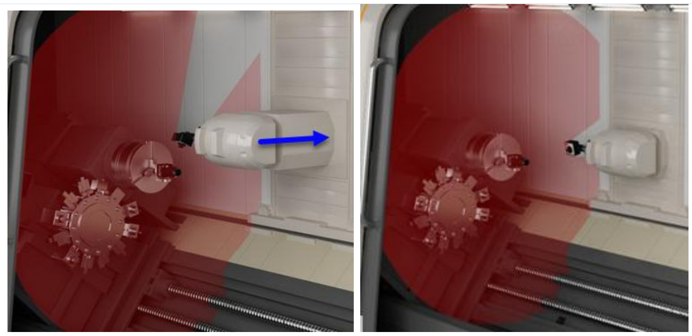




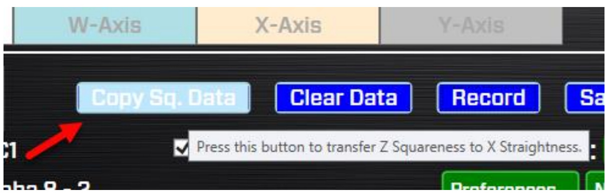
7. **Take Measurements for the X Axis Squareness**

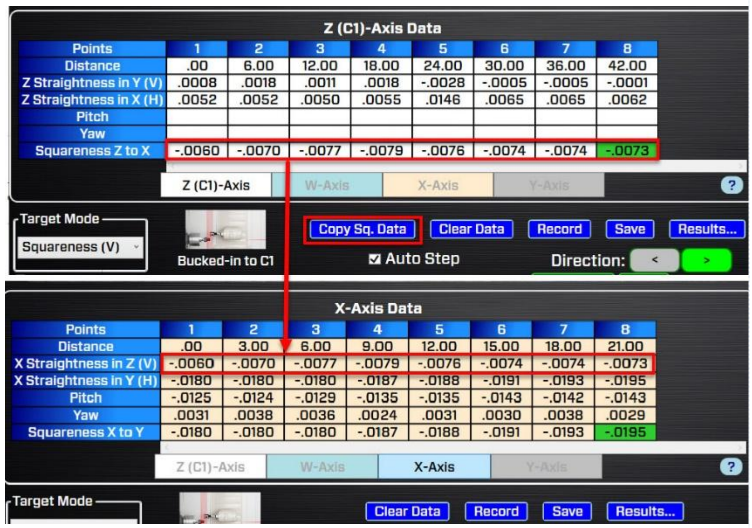
Hit **Record** to record the first data point. Move the X Axis to the next point and hit **Record** and continue to record all the points. You may have to rotate the target on the post to point it toward the laser.

Note: *Since the L-702SP scan plane is perpendicular to the laser beam, the laser is* *measuring the squareness of the X Axis to the Y Axis to within .00006 in/ft (0.005 mm/m). When analyzing the squareness data using the Least-Squares, Best-Fit algorithm, the straightness can also be calculated for the X Axis in the Z direction. All we have to do is transfer the data to the X Axis tab and MultTurn10 will calculate the straightness of X in the Z direction.*



Hit **Copy Data** button to transfer X-Axis Squareness data to *X Straightness in Z* row.

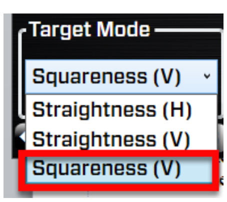


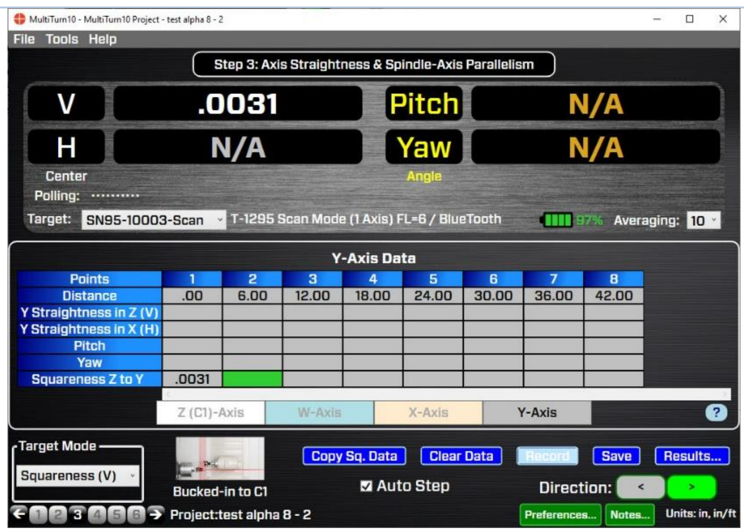


Z-to-Y Squareness Data

8. Select Y-Axis Tab and Squareness (V)

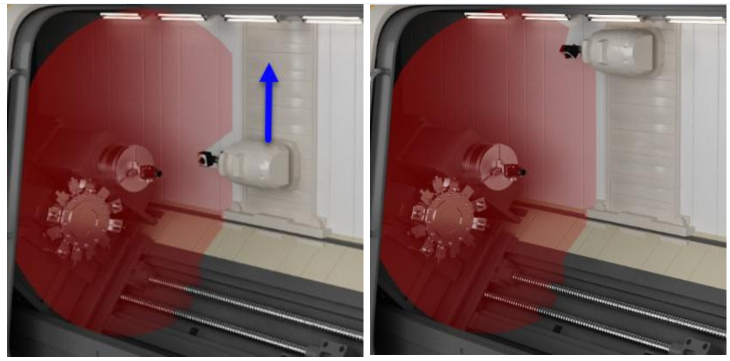
Make sure the T-1295/1296 is still in *Scan Mode* and the L-702SP is, too. Then, to measure the squareness of Y to Z, select the Y-Axis tab, and using the dropdown, select Squareness (V) as above. You will see the green cursor in the Squareness Z to Y row.

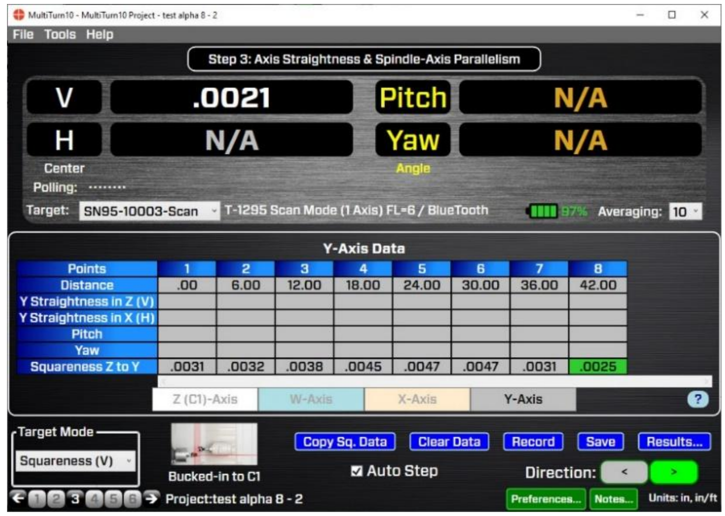




9. **Move the Y Axis to the Lowest Position**

With the T-1295/1296 attached to the spindle as described above in Step 11, move the Y axis down to its lowest position. Hit **Record** to record point #1. Move Y up to the next position and hit **Record** again and continue until all the points are recorded.



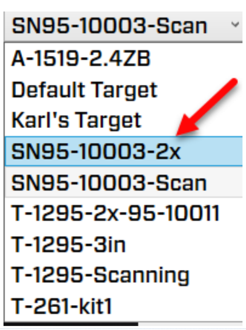


Y-Axis Straightness Laser Setup #2

10. **Buck-In Laser to Y Axis**

Go to **Step 2: Qualify Laser** and buck-in the L-702SP to the Y Axis. See **Page 39** for instructions.

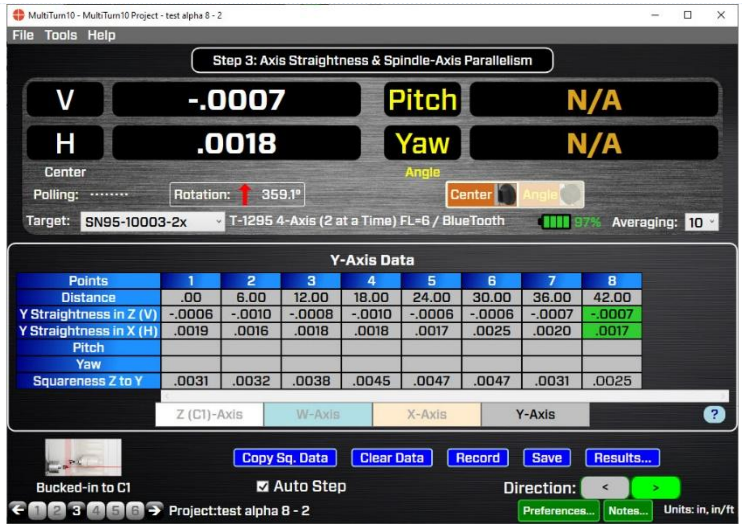
Important Note *- Make sure the target is in 2x Mode. Also, make sure the T-1295 Targets are in 2-axis mode by turning it off and turning it back on again.*



11. Go Back to Step 3 and Click Y Axis Tab

Go back to *Step 3* and click on the *Y-Axis Tab*. Make sure the display is set to **Center Mode** (white numbers, left display).

Make sure the Y axis as at the *Near Point* from the 2-point buck-in procedure and click **Record**. Move the Y axis to Point #2 and click **Record** and continue until all the points are collected.

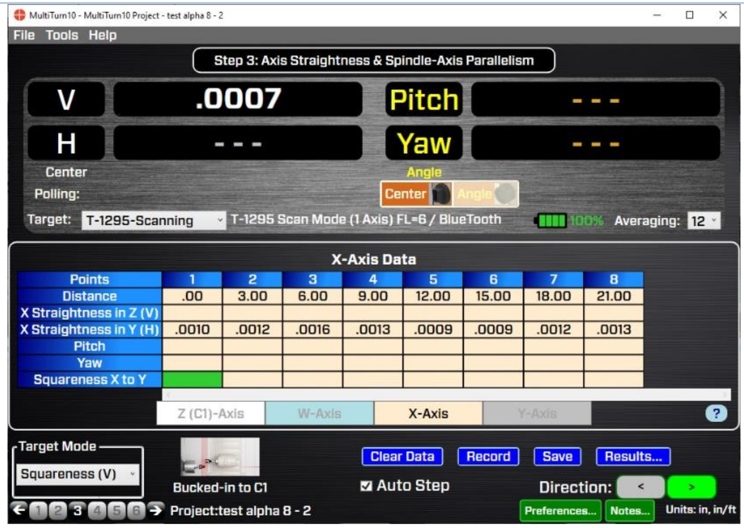


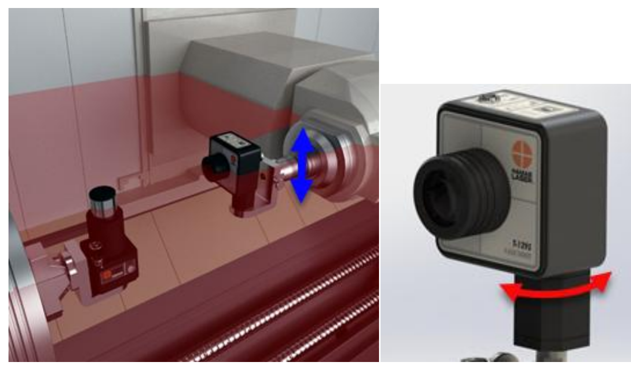
Y-to-X Squareness Data

12. Install T-243 Fixture and Switch to Scan Mode for X-Axis Squareness

Click on the X-Axis Tab. Switch the L-702SP and T-1295/1296 target into **Scan Mode** (see Page 6-8). Install the T-1295/1296 Target into the T-243 Laser Scanning Stand and the L-102RA as shown (or with other custom fixturing). The T-243 stand allows the target to pivot on the mounting stud without changing the flatness value by more than ±.00004 in. (±0.001 mm).

Adjust the Y axis up or down so the laser plane is going inside the window.

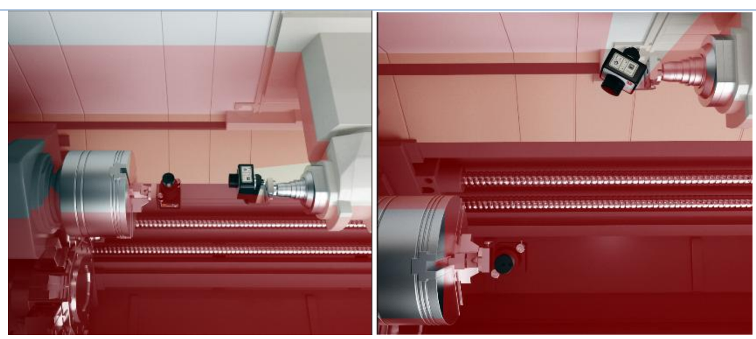


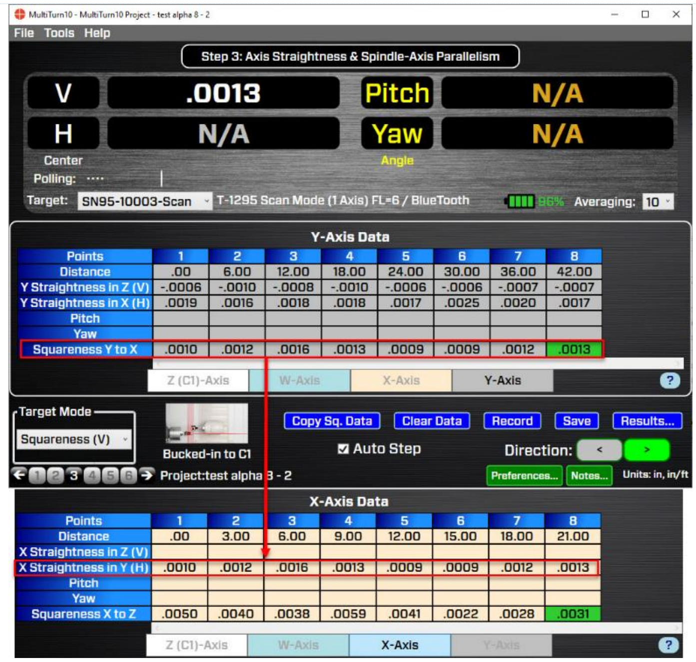
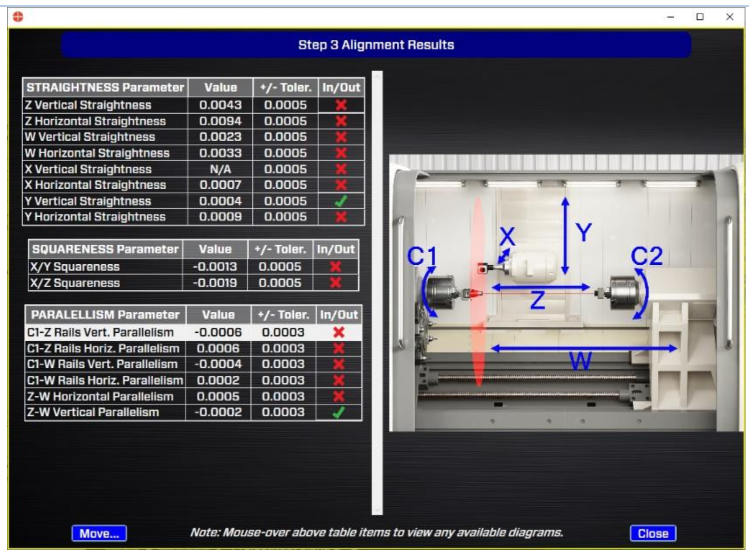


13. Move the X-Axis to the End of Its Travel and Record Data

Move the X-Axis to the end of its travel (extended out closest to the laser) and hit **Record.** Move the head to point #2 and hit **Record**. Repeat to take all the data for X.

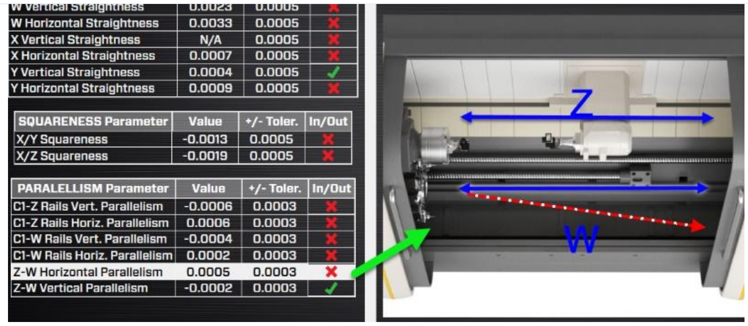
Note: *As you move the X Axis in toward the back of the machine, you will need to periodically rotate the target head to make sure it's pointing at the laser.*

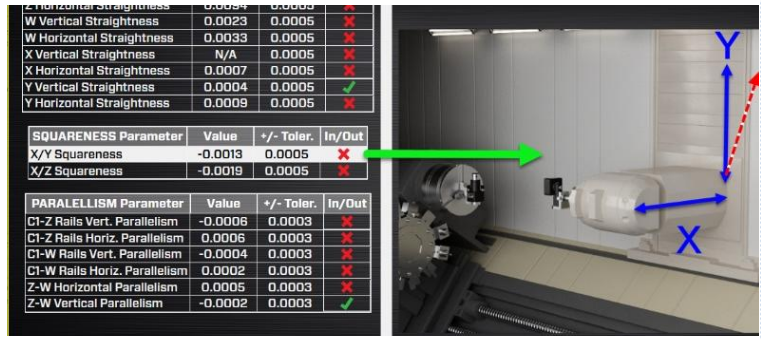


14. Hit Copy Data to Transfer Data to X Axis Straightness in Y row. By taking this squareness data for X relative to Y, the straightness of the X Axis can also be recorded. MultiTurn10 records the same data in the X Straightness in Y row. The straightness of the X will be calculated in the Results Screen.	
15. Click Results to Analyze the Data Click on **Results** to pop up the Results	

16. Hover the Mouse Over Squareness/Parallelism Parameter to See the Direction

Hovering over a squareness or parallelism parameter will show which direction the axis is sloping relative to the datum axis. In this case, the W axis is sloping to the right relative to the Z axis when the W axis is moving from left to right.





Step 4 – Bed Straightness Results

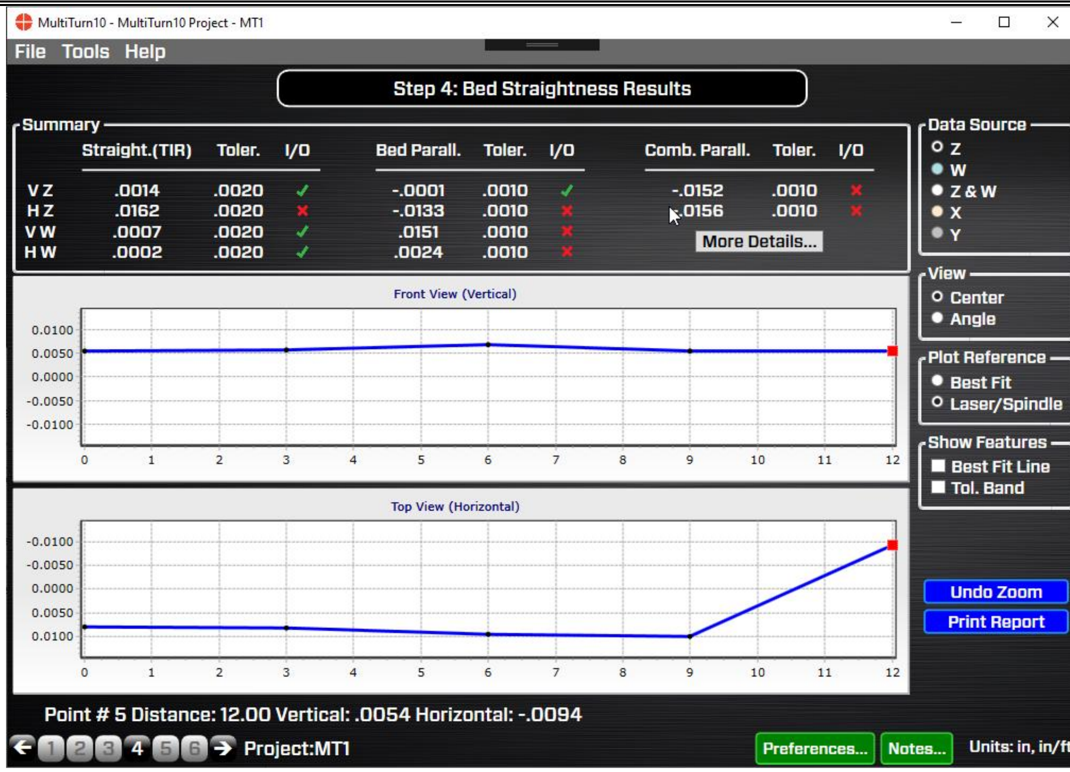
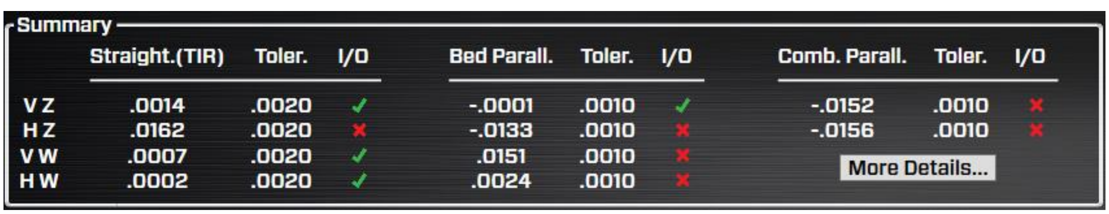


Figure 48 - Step 4: Bed Straightness Results screen

This step displays a summary of the alignment data taken in **Step 3**, as well as graphing the straightness data. There are several options to graph the data and you can print the alignment report from here.

Results Summary



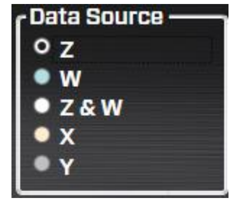
Summary

	Straight.(TIR)	Toler.	I/O	Bed Parall.	Toler.	I/O	Comb. Parall.	Toler.	I/O
V Z	.0014	.0020	✓	-.0001	.0010	✓	-.0152	.0010	✗
H Z	.0162	.0020	✗	-.0133	.0010	✗	-.0156	.0010	✗
V W	.0007	.0020	✓	.0151	.0010	✗	More Details...		
H W	.0002	.0020	✓	.0024	.0010	✗			

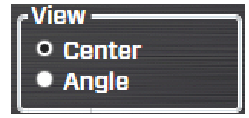
Straightness (TIR): This is the total straightness error (max minus min) using the least-squares, best fit algorithm, expressed in inches or mm. TIR = Total Indicated Runout.

- **Toler**. – Tolerance for the various axes as defined in Step 1.
- **I/O** – **X** = out of tolerance, √ = in tolerance
- **Bed. Parallel**. – Parallelism of the headstock rotation axis relative to the tailstock guideways (assuming you used C1 Main Spindle to mount the L-702SP). This also equals the slope of the best-fit line. Expressed in in/ft or mm/m or mm/100 mm.
- **Comb. Parallel** – This is the combined parallelism of the Z-Axis AOR relative to an average of: a) the Z-Axis parallelism, and b) the W-Axis parallelism, which is the average of the two best-fit slopes. The data is expressed in in/ft or mm/m or mm/100 mm. This would be used in cases where there is a large error in the parallelism for both sets of guideways, and you want to align to the average of both.

Data Source – Selects which axis to display:



View:



- **Center**: Plots the V & H *Center* values (default).
- **Angle**: Plots the V & H *Angular* (Slope) values.

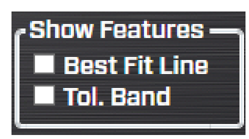
Plot Reference:

- **Best Fit:** The straightness data is corrected by subtracting the slope of the Best-Fit line from each data point and then determining maximum and minimum values that deviate from zero. The difference between the max and min values is the overall TIR straightness for that set of data. The data is then plotted with the X Axis line (zero line) being equal to the best-fit line. The straightness tolerance values are set up as a ± band around zero.

  In the **Summary** table, a green √ or red **X** will indicate if the measured value is within or outside of the tolerances entered in Step 1. For example, for a .0005 in. straightness tolerance, this program will look at the absolute value of all the values relative to the Best Fit line and if any of those values are higher than .0005, it will be out of tolerance. Therefore, if the maximum of all the positive values is .0004 and the minimum of all the negative values is -.0003, then the straightness would be *in-tolerance*. However, the TIR Straightness will be .0007.

- **Laser/Spindle:** Select this to plot the raw data relative to the laser beam (which was aligned to the spindle's rotation axis) and the Best-Fit line is drawn through the data. The slope of the Best-Fit line shows which direction and by how much the spindle's rotation axis is tilting relative to the lathe bed.

Show Features:



- **Best Fit**: For the *Laser/Spindle Plot Reference*, checking this will show the Best Fit line on the graph. The slope of the Best-Fit line shows you how far the headstock AOR is tilted relative to the bed.
- **Tol. Band**: If checked, draws *Tolerance bands* in green. While the tolerance bands can be drawn for the *Laser/Spindle Plot Reference*, it is recommended that they be turned off since the raw data's first point might not be near zero, so the tolerance band would be meaningless.

Zooming in on the Graph

For situations with many data points, you can zoom into a section of the graph to look more closely at the data. Click and drag the mouse over a section of the report and it zooms in to that part of the graph. To undo the zoom, click ***Undo Zoom***.

Step 5 – Record Subspindle/Turret Rotation Axis Data

In this step, the coincidence (in 4 axes) of the headstock rotation axis to the tailstock centerline (the subspindle rotation axis or turret tool-holder centerline) is recorded. Once the data is recorded, the laser and target mounting errors for the 4 alignment axes are calculated and subtracted from the raw data. The actual alignment results are displayed, along with Side View and Top View spindle graphics to illustrate the direction of the misalignment. The tolerances entered in Step 1 are then applied to see if the results are in or out of tolerance.

To calculate the results, 6 data points are needed. Click Procedure to open a popup providing instructions. See **Page 72** below for a step-by-step procedure. On-screen graphics show how to orient the headstock spindle and tailstock/subspindle/turret to take the data.

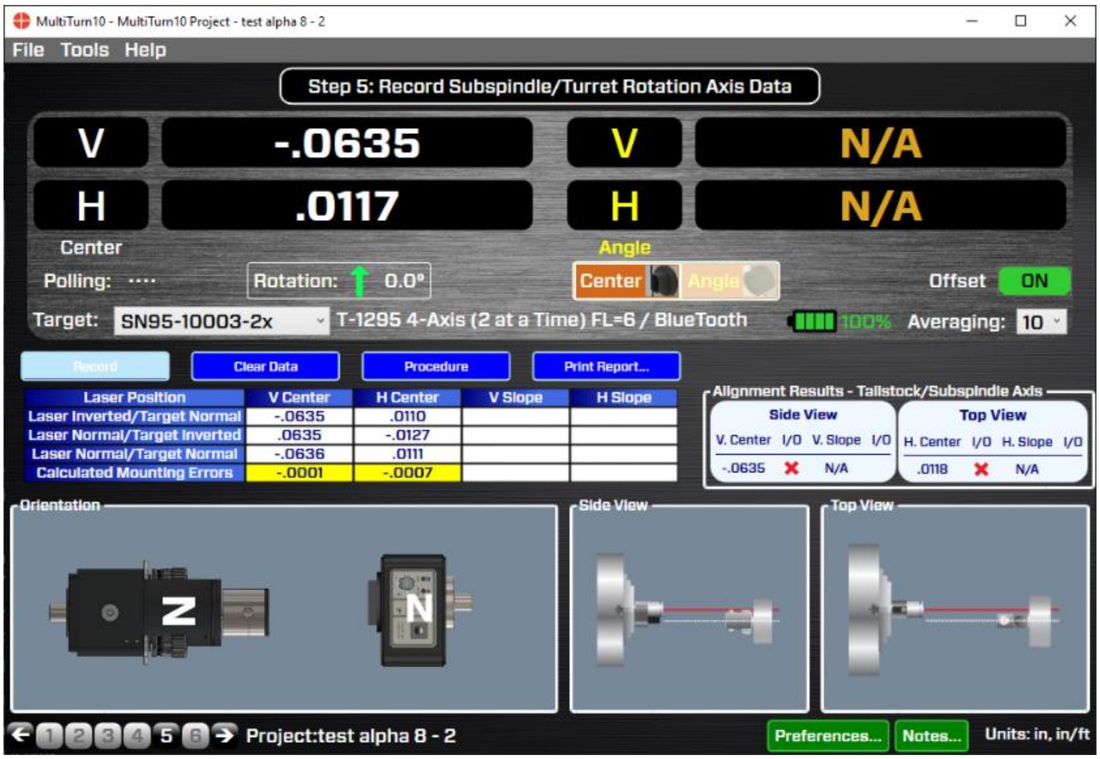


Figure 49 - MultiTurn10 – Step 5 Record Subspindle/Turret Data

What the Buttons Do:

- ***Record*** – Records the 2 axes of data for each point in the procedure. The green "cursor" automatically advances to the next point and updates the laser/target graphics to indicate how they should look when taking the *next* data point.
- ***Clear Data*** – Clears the data from the table with a request for confirmation.
- ***Procedure*** – Click to see a summary of the data-taking procedure.
- ***Print Report*** – Click to print the report. You can also print from **Step 4**, or from the Tools Menu.

Rotation Sensor – TDC Correction

The T-1295/1295 Targets have a rotation sensor built into them. The rotation angle value is displayed in the display area next to "**Rotation:**". In general, it is recommended that when taking data either with the spindle in the NORMal position (~0°.) or in the INverted position (~180°.) to get the rotation angle fairly close to 0° or 180°. However, it is not critical because MT10 uses a trigonometric correction routine (we call it a *TDC Correction* – TDC is Top Dead Center) to adjust the center values so they read what they would read if the spindle & target were directly at 0° or 180°. This makes the data recording more accurate and allows the user not to worry so much about how close the spindle is to 0° or 180°.

Taking Data

A simple 6-step procedure is used to take the spindle alignment data.

Note: *When rotating the laser and target, it is very important to rotate the spindle itself (with the laser in it), not the laser or target within the spindle chuck. In other words, never loosen the collet or chuck when taking alignment data of a rotating spindle (be it the headstock spindle or subspindle) during this procedure – unless, of course, it does not rotate. For the tailstock chuck or turret fixturing, loosen the chuck or the fixture to rotate the target. By rotating the spindle and laser together, you are measuring the axis of rotation (AOR) of the spindle, which is the most important reference to use when aligning a lathe. If we just rotate the laser in the chuck, then we would only be measuring the alignment of the centerline as defined by the chuck jaws (or collet), not the spindle AOR.*

Interpreting the Results

After recording the third point, the program calculates the mounting errors of the laser and target and subtracts them from the raw data, applying display offsets to the four real-time data displays. These values are the actual alignment values of the tailstock chuck centerline, the turret tool holder centerline or the subspindle AOR relative to the headstock AOR.

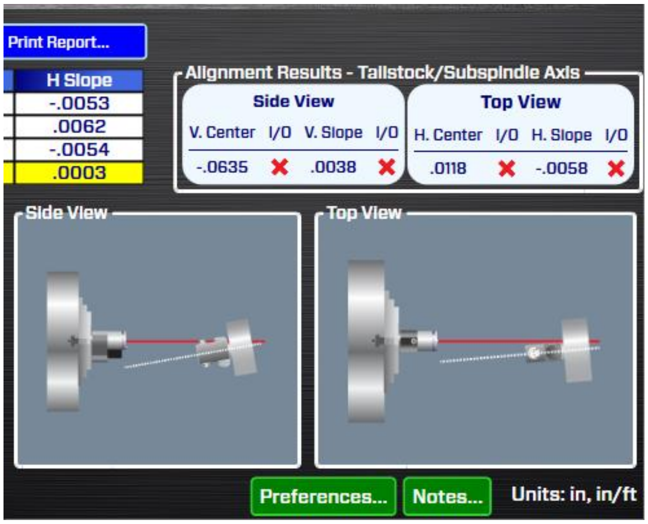


Figure 50 - MultiTurn10 – Step 5 Record Subspindle/Turret Data - Data Recorded

Alignment results are also shown in the **Alignment Results – Tailstock/Subspindle Axis** area of the screen. The tailstock *Center* and *Angular* tolerances from **Step 1** are applied to the data. An **X** indicates out of tolerance and a green check √ indicates in tolerance.

Static spindle graphics show a *Side View* and *Top View* of the Tailstock/Turret/Subspindle relative to the headstock AR.

Out of Tolerance

If the alignment of the Tailstock/Turret/Subspindle is out of tolerance, click **Step 6** to go to **Step 6: Tailstock/Turret Alignment**.

Checking C1 to C2 Alignment - Procedure

After checking the machining axes of the multiturn, we need to now focus on the main spindle alignment (C1) to the sub-spindle (C2) in 4 axes. Here is a procedure to get that data and to align them, if necessary.

1. **MultiTurn10 Step 1 - Project Setup**

   Select the tolerance for the alignment:

   - **Sub-Spindle (C2) – Center** – this is the allowable centering error between the C1 spindle and the C2 spindle.
   - **Sub-Spindle (C2) – Angular** – this is the allowable angular error between the C1 spindle and the C2 spindle.

   Enter the dimensions between the mounting bolts and the target location so MultiTurn10 can calculate shim values.

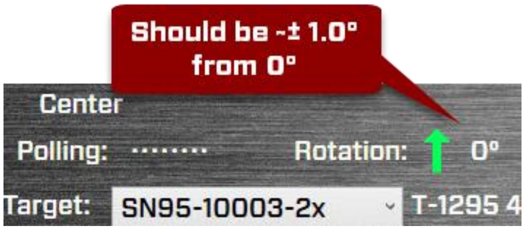
2. **Go To Step 5: Record Sub-spindle/Turret Rotation Axis Data**

   Go to Step 5 to record the rotation axis data of the 2 spindles. You will need to take a total of 6 data points, 3 for Center and 3 for Angle. Start with the Center.

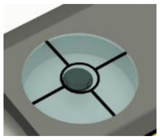
   ***Note**: when taking data in Step 5, you must always turn the spindle and the target together to ensure you are measuring the rotation axis and not the center of the chuck's jaws.*

   First, make sure the T-1295/1296 Target is in the NORMal position (~± 1.0° from 0°).

   Next, rotate the C1 spindle+laser to the inverted position (A/C Adapter plug facing you), level the bullseye level and hit **Record**.



L-702 A/C Adapter Connector

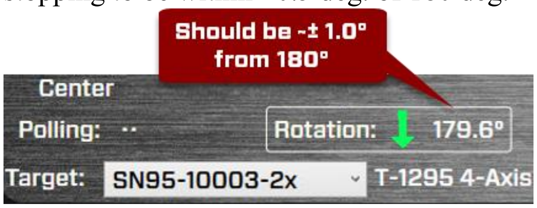


3. Rotate the Laser Back to NORMal and Rotate Target to INverted Position

Rotate the laser back to the NORMal position (L-702 Switch Panel facing you) and level it.

L-702 Switch Panel

Rotate the C2 spindle+T-1295/1296 to the INverted position, watching the rotation axis sensor and stopping to be within ±0.5 deg. of 180 deg.



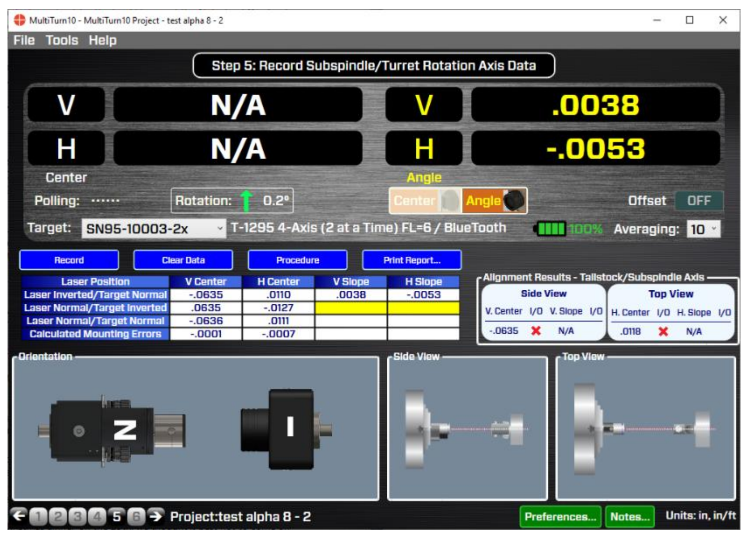
Click **Record**. The data for the Center parameters has been taken.

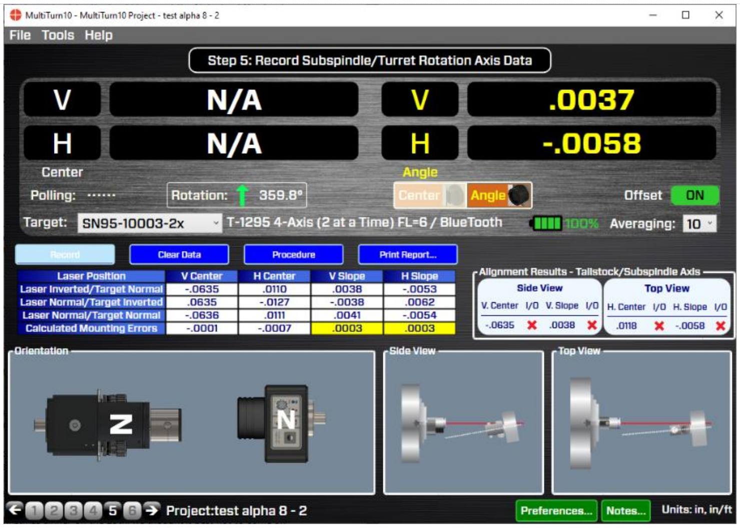
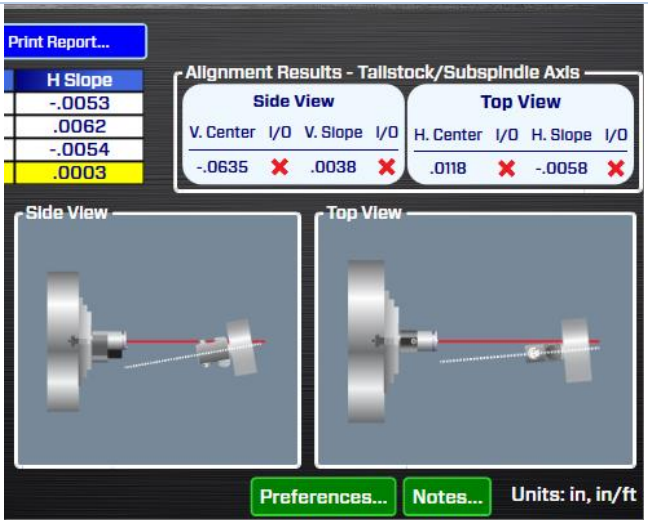
4. Insert Lens, Switch to Angle Mode and Record First Point

The center values are recorded, so now record the angular values. First, insert the lens into the target and switch the display to Angle Mode. The H & V angular values will display in the right-hand displays with yellow numbers.

Note: make sure the target type selected matches the lens. "FL=3" is the 3 in. (76 mm) lens.

Invert the Laser/Spindle, make sure the bubble is leveled, make sure the Target Rotation indicator is at 0 deg., and hit **Record.**



5. Rotate Laser to NORMal position and Target/C2 Spindle to INverted position. Rotate Laser+C1 Spindle to NORMal position and Target+C2 Spindle to INverted position, making sure the Rotation indicator is set to 180 degrees and the laser bubble level is leveled. Hit **Record**. Rotate the target back to 0 degrees and hit **Record** again.	
6. View Results The data has now been taken and MultiTurn10 calculates mounting errors and subtracts them from the raw display data to produce the alignment Results, which are displayed in the **Alignment Results – Tailstock/Sub-spindle Axis** – area of the screen. It also indicates if the results are in or out of tolerance by a red X (out) or green check mark (in). Below the table of results are graphics that illustrate the 4 alignment parameters. V Center (offset) V Slope (angle) H Center (offset) H Slope (angle) In the example to the right, the C2 spindle rotation axis is below the C1 spindle and tilted down. It is also to the right of C1 rotation axis and pointed to the left.	

Step 6: Subspindle/Turret Axis Alignment

This step provides a real-time, 4-axis display of the 4 alignment values. A Target graphic is used to interpret the values for the Vertical and Horizontal axes of the tailstock centerline or subspindle rotation axis. The target graphic will update with changes in the alignment values, so you can watch the tailstock/subspindle come into alignment as you adjust it. Tolerance bands indicating the values entered in **Step 1** are displayed and are color-coded to indicate if the values are in or out of tolerance.

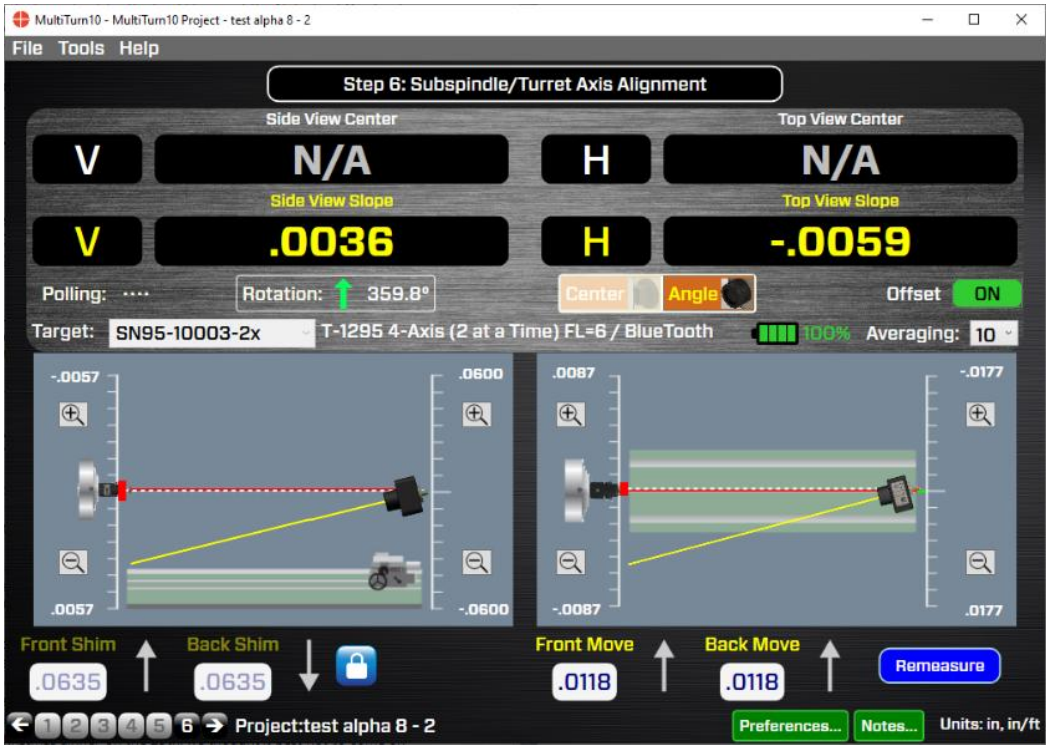


Figure 51 - Step 6: Subspindle/Turret Axis Alignment screen

What the Buttons Do

- ***Remeasure*** - After you add shims and perform moves, click **Remeasure** to return to **Step 5**, which clears the values from the table so you can retake the spindle data to verify it is aligned.

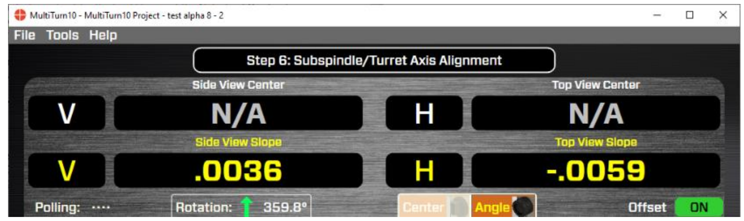
- ***Offsets*** –This button turns the mounting-error display offsets calculated in **Step 5** on or off. These offsets are applied to the raw target values to remove the mounting errors and display the actual alignment in the 4 real-time displays. The default setting is **ON** and normally it is not turned off.

-  - Click to "zoom in" (decrease) the scale on the graph to magnify the graphic depiction of the alignment center offset and angle. There are separate Zoom buttons for the *angle* graphics and the *center* graphics

-  Click here to "zoom out" (increase) the scale on the graph to decrease the graphic depiction of the alignment offset and angle. There are separate Zoom buttons for the *angle* graphics and the *center* graphics.

Interpreting the Plus and Minus Signs in the Live Displays

The signs of the data displays will tell you what position (high/low or left/right) the target is relative to the laser beam. See the interpretation below.



Vertical Axis

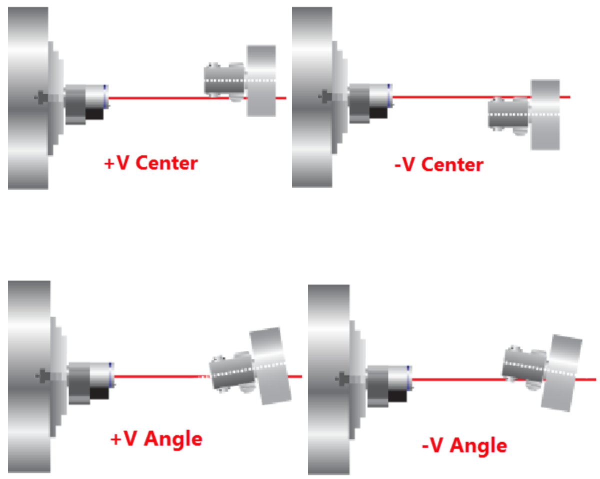
A **+V** *center* value indicates that the target is higher than the laser beam.

A **+V** *angular* value indicates that the back of the target is *higher* than the front of the target.

A **–V** *center* value indicates that the target is lower than the laser beam.

A **-V** *angular* value indicates that the back of the target is *lower* than the front of the target.

Side View



Horizontal Axis

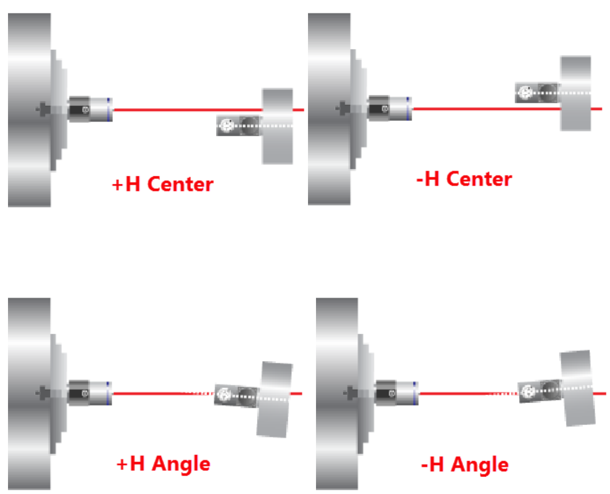
A **+H** *center* value indicates that the target is to the right of the laser beam when looking from the laser *into* the T-261 target.

A **+H** *angular* value indicates that the back of the target is to the *right* of the front of the target when looking from the laser *into* the T-261 target.

A **–H** *center* value indicates that the target is to the *left* of the laser beam when looking from the laser *into* the T-261 target.

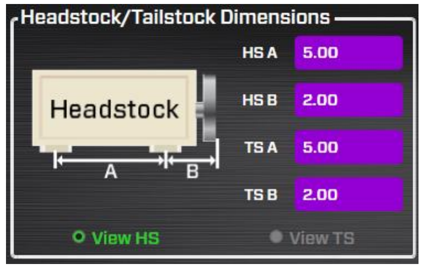
A **-H** *angular* value means that the back of the target is to the *left* of the front of the target when looking from the laser ***into*** the T-261 target.

Top View



Shim Values

The program automatically calculates shim values (for the Vertical axis) and move values (for the Horizontal axis) to re-align the tailstock, subspindle or turret. The shim values are calculated using the dimensions entered in **Step 1**.



The *Shim* values are locked while the *Move* values update with changes in the H-axis alignment values.

 The Lock Icon will unlock or lock the *Shim* values. Default is *locked*.

Arrows next to the shim/move displays indicate whether to add or remove shims and in which direction to move the "feet" of the tailstock/subspindle.

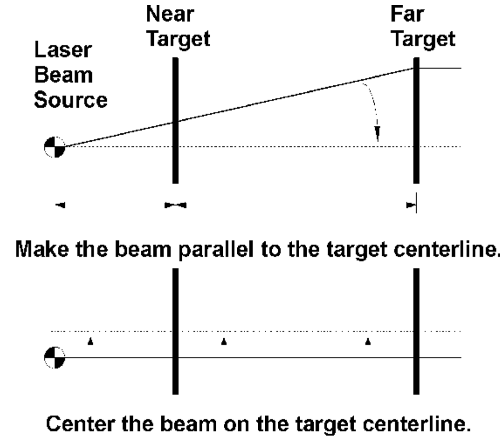
Printing Reports

See ***Page 25*** to see how to print the alignment report.

Appendix A – Remote Buck-In Formula & Set Points

Remote Buck-In – Calculating Set Points

Note: Use this formula if L1/L2 > 0.1 (see below for definitions)



As the distance between the laser and the near target increases with respect to the distance between the 2 targets, bucking in by the normal method becomes nearly impossible. A special ***Remote Buck-In Procedure*** has been developed for these situations. The Remote Buck-In uses simple geometry to make the laser beam parallel to the centerline of the 2 targets, and then centers the beam on that line. Figure xx52xx illustrates how the remote method works.

Unlike the normal *buck-in*, where the laser is pointed ***to*** zero on the far target, the *Remote Buck-In* procedure has the laser point (tilted) ***through*** zero to a point called the "Set Point." The set distance is the offset between the parallel laser beam and the target centerline.

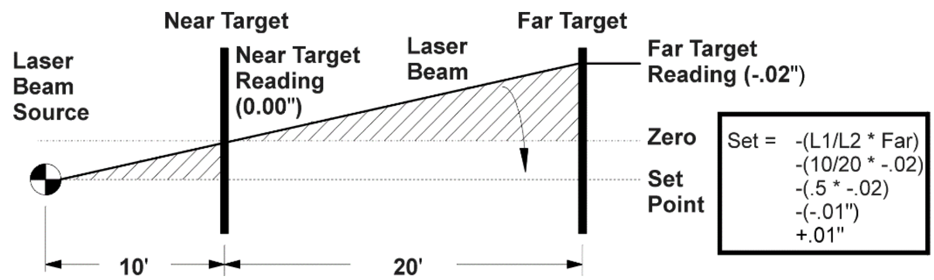


Figure 53 - Calculating the Set Point

The theory behind this is as follows: The uncorrected laser beam, the offset parallel beam and the set distance form a triangle. The uncorrected laser beam, the target centerline and the distance between the far target center and the far reading form a second triangle. The two triangles have the same three angles and are therefore geometrically identical.

A relationship between these two triangles can be stated in the formula, "The Set Point is to L1 as the far reading is to L2." Stated mathematically, the ratio is:

***Set Point*/L1 = Far/L2**

If L1, L2, and the far reading are known, then the **Set Point Formula** can then be determined by the following formula:

***Set Point* = -1 * (Far reading * L1/L2)**

(**Note:** *This is a simplified formula for cases where the laser beam is zeroed on the near target*).

In Remote Buck-Ins, steer/tilt the laser plane ***through*** zero until the display reading is equal to the Set Point. By doing this, the sign of the number (negative or positive) will be reversed. **Error! Reference source not found.** illustrates this by taking sample readings and showing how the Set Point is derived. Notice the far reading is a negative number and the Set Point is positive as you go "through zero," resulting in a laser beam parallel to the target centerline but offset by the set distance.

An example:

Let say we have the following situation:

L1 = 8 in.
L2 = 30 in.
Far reading is +.012 in.

So the Set Point would be:

SP = -1 * 8/30 * .012
= -1 * 2667 * .012
- .0032

Notice the sign changed, so you would steer the laser beam using angular adjustment until the value is -.0032. Now if you move back to the Near Position, you should see the same value of -.0032. This means you are Bucked-in and ready to take data.

Appendix B – The NORMIN Method (Bore and Spindle)

The NORMIN method was developed by Hamar Laser Instruments as a way of compensating for laser or target mounting errors in bore or spindle work. The word is a contraction of "NORMal-INverted," which briefly describes the method. It is similar to the four clock readings taken with dial indicators but uses a laser and a target instead. The NORMIN method is used in conjunction with simple fixtures and targets that allow inexpensive, precision measurement. The target/fixture is set in the bore or spindle in the NORMal position (cable down) and the readings are recorded. Then the target/fixture is rotated 180 degrees to the INverted (cable up) position, and a second set of readings is obtained. The two sets of readings cancel out centering errors and provide a very accurate result.

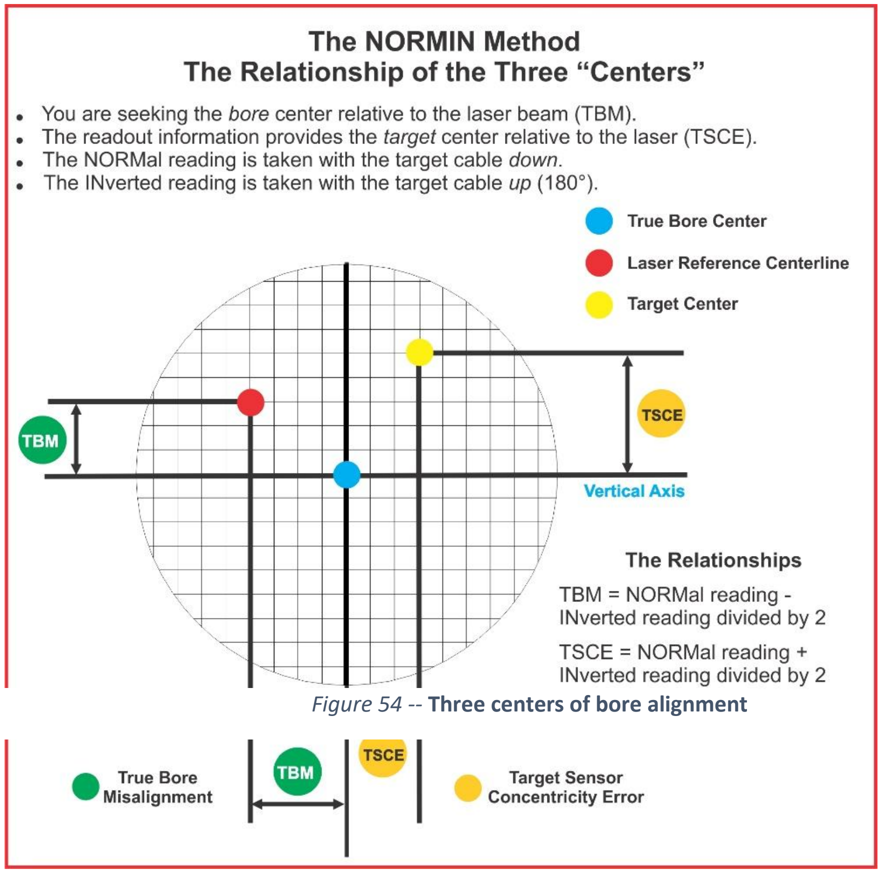


Figure 54 -- **Three centers of bore alignment**

There are three centers involved in bore alignments: True Bore Center, Target Center, and Laser Reference Centerline. If mounting fixtures were perfect, the Target Center would be located at the True Bore Center, and if perfectly aligned, the True Bore Center would be located at the laser beam center. However, they seldom line up. An example of the three centers with respect to one another is shown in Figure 54.

Two relationships can be calculated from these three centers and two sets of NORMIN readings: Target Sensor Concentricity Error (TSCE) and True Bore Misalignment (TBM). The True Bore Misalignment (TBM) is used when it is desirable to know the true bore centerline position relative to the laser beam center without fixture errors. Usually, the laser beam center is where a bore center *should* be located, and the TBM shows its *actual* location. The Target Sensor Concentricity Error (TSCE) is used if the operator wants to place the laser beam center exactly in the middle of a bore.

The general rule is buck-in to the TSCE and measure the TBM.

The readout always shows the displacement between the Target Center and the Laser Beam Center. When the Target Center is not on the True Bore Center, the numbers and the signs on the readout will change when the target is rotated because the Target Center is moved to a different location in relation to the laser beam.

Figure represents the target in the NORMal position, with the cable *down*. If each square represents .001", the Target Center is .002 in. higher than the Laser Beam Center (+.002 in.) and is .007 in. to the right of the Laser Beam Center (+.007 in.).

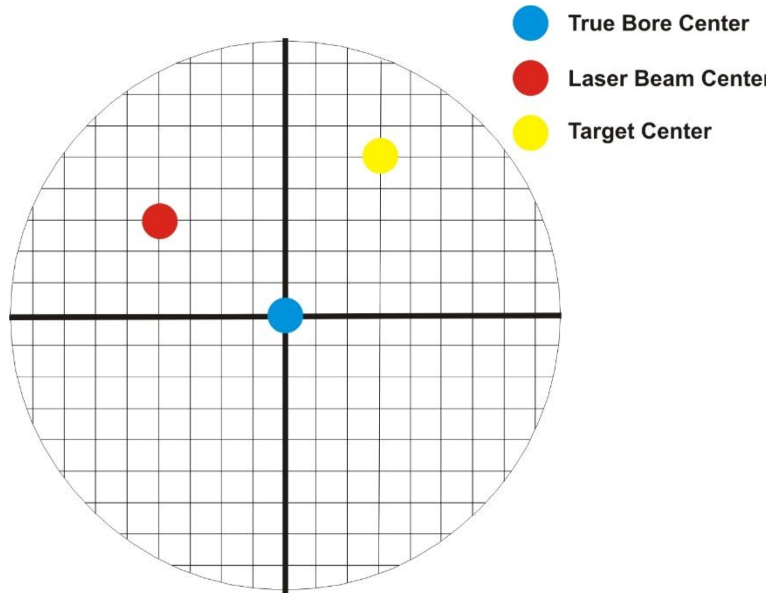


Figure xx – *Target in the NORMal position*

Figure represents the target in the INverted position, with the cable *up*. When the target is rotated, the *signs* on the readout are also rotated. Therefore, although the Target Center appears to be to the right of and lower than the Laser Beam Center in Figure the vertical readings are positive, and the horizontal readings are negative. When the vertical TCE is calculated, (Normal Inverted divided by 2) the Target Center is .004 in. higher and .003 in. to the right of the True Bore Center in the NORMal position.

The table below shows the calculation of the vertical and horizontal TSCE values.

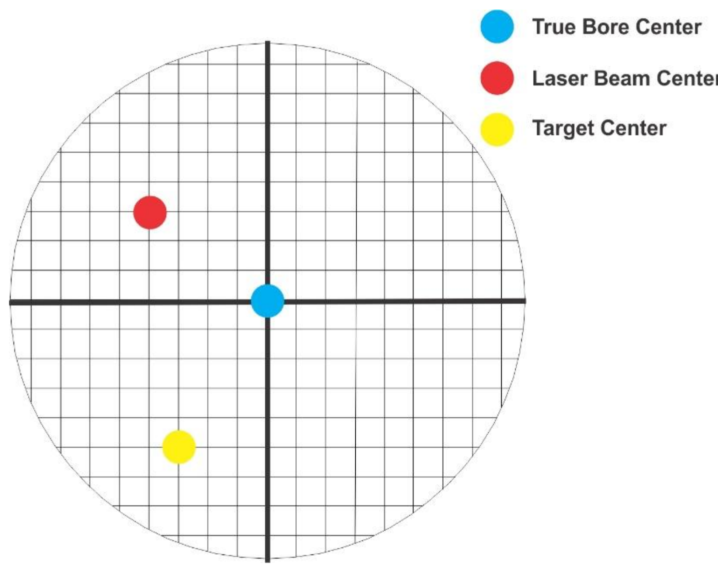


Figure xx – *Target in the INverted position*

NORMal Vertical Reading	+.002 in.		NORMal Horizontal Reading	+.007 in.
INverted Vertical Reading	+.008 in.		INverted Horizontal Reading	-.001 in.
Total	+.010 in.		Total	+.006 in.
Divide by 2 = **Vertical TSCE**	**+.005 in.**		Divide by 2 = **Horizontal TSCE**	**+.003 in.**

If you place the Laser Beam Center exactly on the True Bore Center with the target in the NORMal position, the readings will show Vertical +.005 in. and Horizontal +.003 in.

Note: All cross-references, Table of Contents, and Table of Figures have been prepared. Please press Ctrl+A then F9 in Word to fully update all dynamic fields.

Appendix C – Target Calibration – T-261 Target Using Read8

Before a new target can be used, it should be calibrated. If the target is purchased as part of a system, it will be calibrated at the factory and the resulting calibration factors will be included with the target, that can be uploaded into the software, such as Multiturn10 – see page 33-35 to see how to upload target calibration factors.

If the user wants or needs to calibrate a target, the process involves moving or tilting a target a known amount from center or zero and observing the actual readings. The calibration factors are then calculated and used by the software to adjust the actual target reading to match the actual target displacement.

Four calibration factors (+V, -V, +H, -H) must be set for each 2-axis target. A 4-axis target (T-261, T-266, T-267 and T-212) requires eight factors (+V, -V, +H, -H, for center *and* for slope). Calibration factors may be entered manually, or calibration may be done automatically by the program.

Note*: the T-1295/1296 Targets are new and can only be calibrated at the factory. Check back soon for a procedure to use the A-807 for these targets.*

Calibration Setup

1. Mount the laser and target.

Note: *Error! Reference source not found. shows the target mounted in the Hamar Laser A-807 fixture stand. In order to take a dvantage of the automated calibration features available with the Read8 software, this fixture stand must be used for calibrating center and slope targets. Mount the laser in the non-adjustable hole on the fixture. Mount the target in the tilt plate with both the target and laser in the normal position (cord down).*

An appropriate target stand with micrometer stage, such as the Hamar Laser T-230, or any calibrated x-y slide, may be used when calibrating center-only targets (see **Figure 56***).*

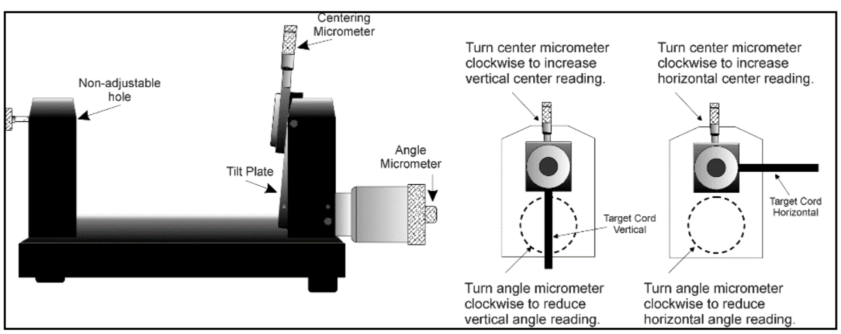


Figure 55 - Model A-807 Calibration Mounting Fixture

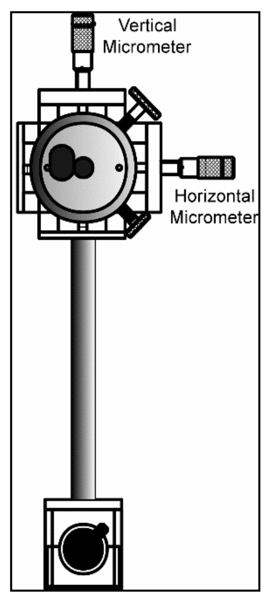


Figure 56 - T-230 Target Stand

2. **Check all connections.**
   Connect the target to the interface, making note of the port to which it is connected, and make sure the interface is connected to the computer. Turn on the laser power supply.

3. **Start the Read8 program and select Target Setup from the Setup Screen.**
   Click the **New Target** button. The New Target screen displays (see **Figure 57**).**Error! Reference source not found.**Click the down arrow next to the **Type** list box to see a list of targets. Select the target you want to add. You may enter a new name for the target and the target serial number.

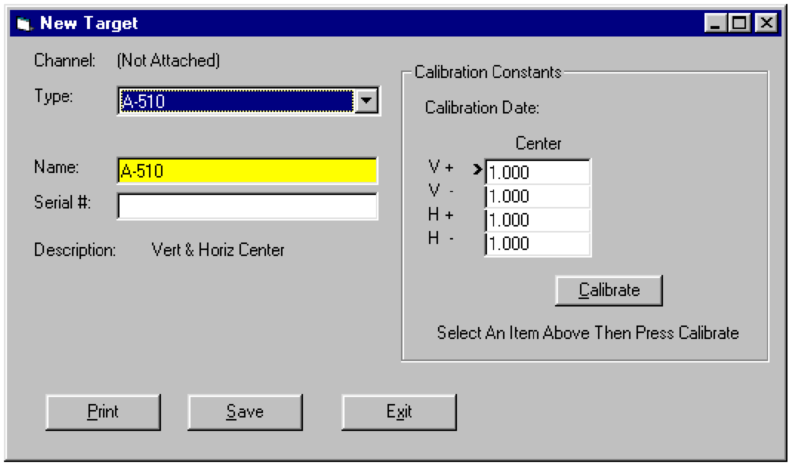


Figure 57 - New Target Screen – 2-axis Target

4. **Select the calibration factor from the list in the Calibration Constants menu, (+V, -V, +H, -H) then click the Calibrate button or Press Alt-C.**

   Note: *The preferred procedure is to calibrate the vertical axes, both center and slope if appropriate, then rotate the target in the fixture 90 degrees and calibrate the horizontal axes. If working with a fixture that has a horizontal micrometer, there is no need to rotate the target.*

   The Select Channel/Port for Target menu displays (see **Figure 58**). Select the channel or the port to which the target is attached and click **OK**. The Calibration Screen displays and indicates the Port or Channel selected (see right arrow in **Figure 59**).

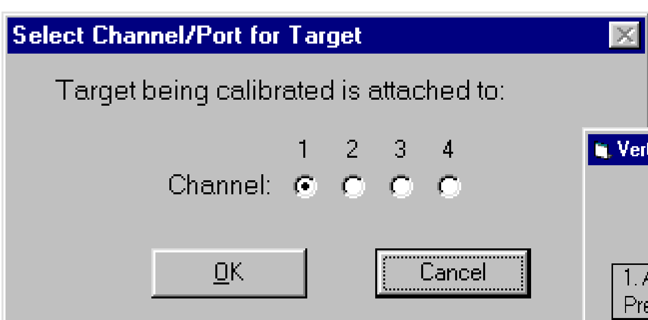


Figure 58 - Channel/Port Selection Screen

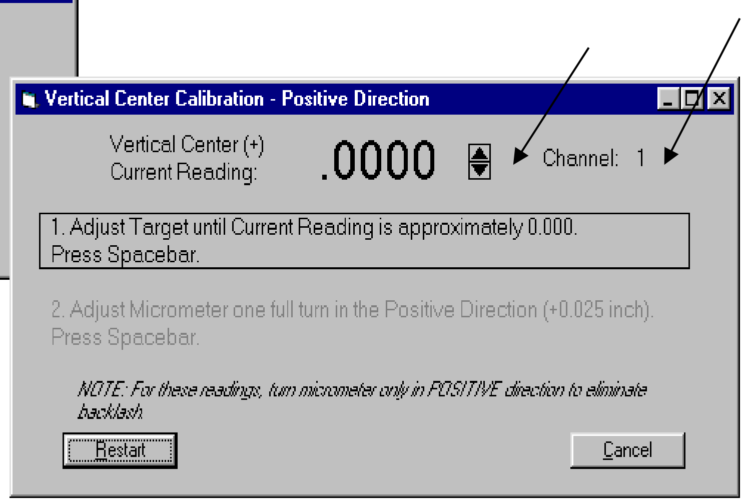


Figure 59 - Calibration Screen

Notes:

- *Once the first calibration factor is recorded, the program adds the calibration date to the Calibration Constants screen.*
- *The double arrows next to the reading are visible only in Manual Data mode and are not available when actual targets are being read (see left arrow in* ***Error! Reference source not found.****).*
- *Ensure that you perform each step slowly so that the values have time to register correctly before you press the spacebar.*

Calibrating a Center-Only Target

1. **For the first reading (in this case V+), center the target using the centering micrometer. This corresponds to Step 1 on the Calibration Screen (see** Figure 57**).**
   The display should read close to 0.000 (within ±.005 in.). Center in such a way as to remove the micrometer backlash; that is, for a *positive* calibration reading, approach zero from a *negative* reading by adjusting the micrometer in a positive direction.
2. **Press the spacebar to record the reading.**
3. **Read the micrometer on the selected axis and move it exactly .025 in. (one full turn), moving in the same direction as Step 1. This corresponds to Step 2 on the Calibration Screen.**
   The displayed reading should be close to +.025 for the positive factors and close to –.025 for the negative factors.
4. **Press the spacebar to record the reading.**
5. **Re-zero the target.**
   Turn the micrometer .025 in. (one full turn) in the direction *opposite* that in **Step 3**. You are now ready to record the next calibration factor.

   Note: *If using the Model A-807 Calibration Mounting Fixture (see* **Figure 55***), then the target must be rotated 90° before performing a horizontal calibration. If the calibration fixture you are using has two centering micrometers, such as the T-230, the horizontal centering micrometer may be used and there is no need to rotate the target.*
6. **Select the next calibration factor from the Calibration Constants menu, and click the Calibrate button or Press Alt-C.**
   Follow Steps 1-5 to obtain the next calibration factor. Repeat this procedure until all the necessary calibration factors have been obtained.
7. **Save the calibration information.**
   When the calibration procedure is completed, click the **Save** button to save the target profile. This target name will now display in the Select Targets to Use section of the Target Setup Screen.

Calibrating a Center-and-Slope Target

In order to use the automated features of the Read8 software, calibration for a center-and-slope target must be performed with the target mounted in the A-807 calibration mounting fixture (see **Figure 55**). This fixture is equipped with both a centering micrometer and an angle micrometer.

The Calibration Constants menu for center-and-slope targets requires that four calibration factors for center and four calibration factors for slope be entered (compare with **Figure 57).** The procedure is the same as that for calibrating a center-only target, however, the calibration factors for slope are obtained by using the angle micrometer.

1. **For the first reading, (in this case V+), center the target using the centering micrometer. This corresponds to Step 1 on the Calibration Screen (see** Error! Reference source not found.**).**
   The display should read close to 0.000 (within ±.005 in.). Center in such a way as to remove the micrometer backlash; that is, for a *positive* calibration reading, approach zero from a *negative* reading by adjusting the micrometer in a positive direction.
2. **Press the spacebar to record the reading.**
3. **Read the micrometer on the selected axis and move it exactly .025 in. (one full turn), moving in the same direction as Step 1. This corresponds to Step 2 on the Calibration Screen.**
   The displayed reading should be close to +.025 for the positive factors and close to –.025 for the negative factors.
4. **Press the spacebar to record the reading.**
5. **Re-zero the target.**
   Turn the micrometer .025 in. (one full turn) in the direction *opposite* that in **Step 3**. You are now ready to record the next calibration factor.

   Note: *If using Model A-807 Calibration Mounting Fixture (see* Figure 55*), the target must be rotated 90° before performing a horizontal calibration. If the calibration fixture you are using has two centering micrometers, such as the T-230, then the horizontal centering micrometer may be used and there is no need to rotate the target.*
6. **Select the next calibration factor from the Calibration Constants menu, and click the Calibrate button or Press Alt-C.**
   Follow Steps 5-9 to obtain the next calibration factor. Repeat this procedure until all the necessary calibration factors have been obtained. ***Ensure that the calibration factors for slope are obtained by using the angle micrometer.***
7. **Save the calibration information.**
   When the calibration procedure is completed, click the **Save** button to save the target profile. This target name will now display in the **Select Targets to Use** section of the Target Setup Screen.

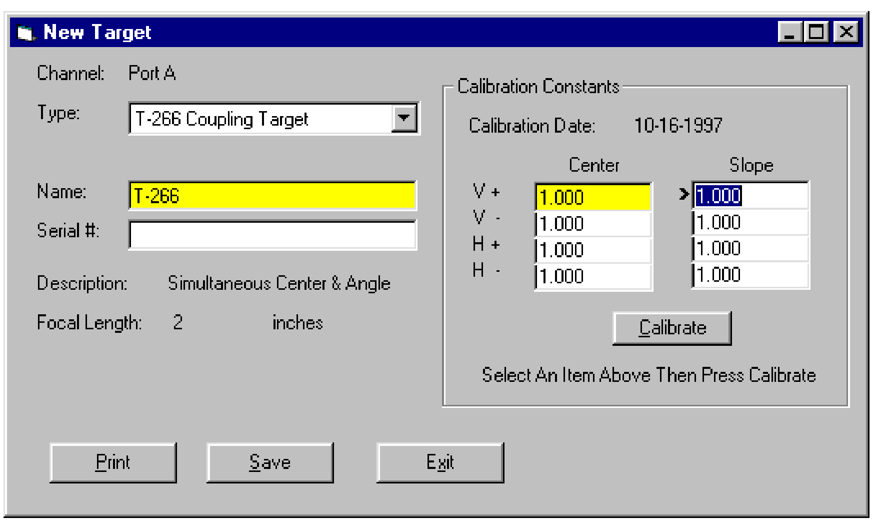


Figure 60 - New Target Screen – 4-axis Target