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Application Note

# Machine Tool Alignment

## Multiturn Machining Centers

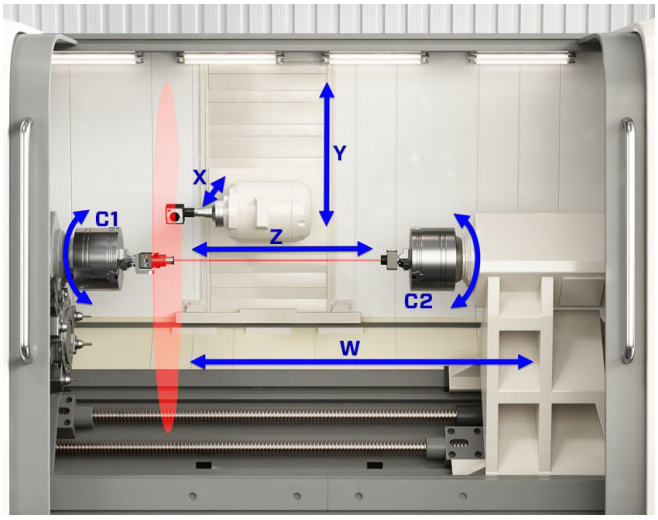
## Part 1 - Laser Setup & Measuring Machining Axes

*System Recommendations:*
*L-702SP 5-Axis Machine Tool Alignment System*

## How it Works - Laser Setup & Measuring Machining Axes

The following section is describes how the L-702SP is used to measure straightness, flatness, squareness, and parallelism on a 6-axis multiturn machine.

### Bucking-In (Setting Up) the Laser




When setting up the laser to measure either straightness or flatness, you must first position the laser beam or plane so that they are parallel to the reference points on the machine. This process is called “bucking in” the laser.

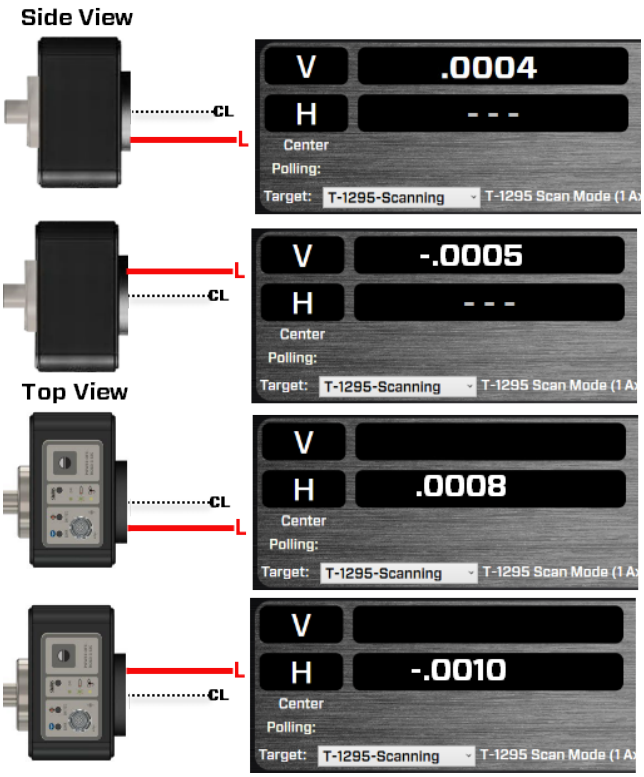
- For measuring rotation axis alignment, 1 reference axis is needed
- For measuring vertical or horizontal axis straightness, 2 reference points are needed.
- For measuring plane flatness, 3 reference points are needed, or in the case of the L-702SP, one of the 2 buckins above can be used since the laser plane is square to the beam, so an additional setup is not needed.

In this procedure, we’ll be bucking-in to 2 references:
1. The main spindle axis (C1); and
2. Y axis

Once the laser has been set up to its reference axis or reference points, the targets can be moved to measure the various lines of motion for deviation from (or alignment to) the references.

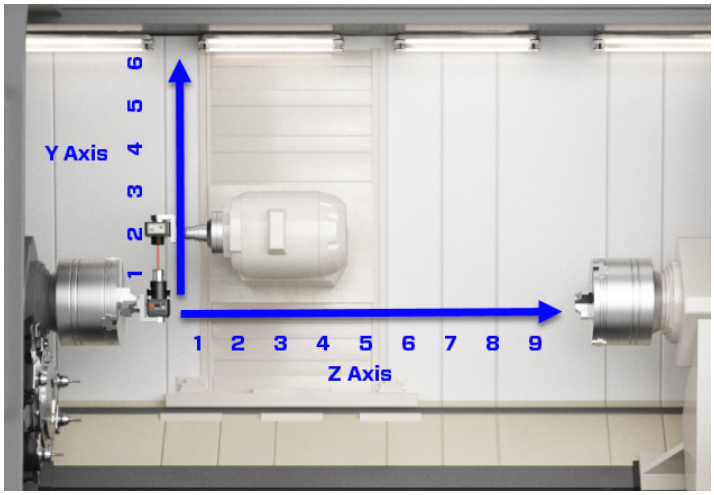
A quick note on how to interpret the signs (+/-) for the data values relative to the target centerline (CL):

- V+ reading means the target CL is higher than the reference points/rotation axis;
- V- reading means the target CL is lower than reference points/ rotation axis;
- H+ reading means the target CL is to the right of reference points/rotation axis (when looking into the target);
- H- reading means the target CL is to the left of reference points/rotation axis (looking into the target);



# 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 to the right for an example of how the data points should be taken.




# MultiTurn10 Step 1: Machine Setup

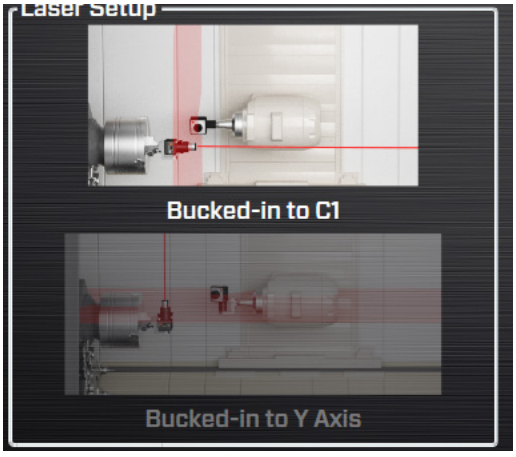
## 1. MultiTurn10 Step 1 - Machine Setup

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 C1 (main spindle rotation axis) - use this to measure:
   ii. Z & W straightness (in X & Y),
   iii. X squareness to Z
   iv. Y squareness to Z
   v. X straightness in Z
   vi. Parallelism of Z to W
   vii. Parallelism of C1 to Z

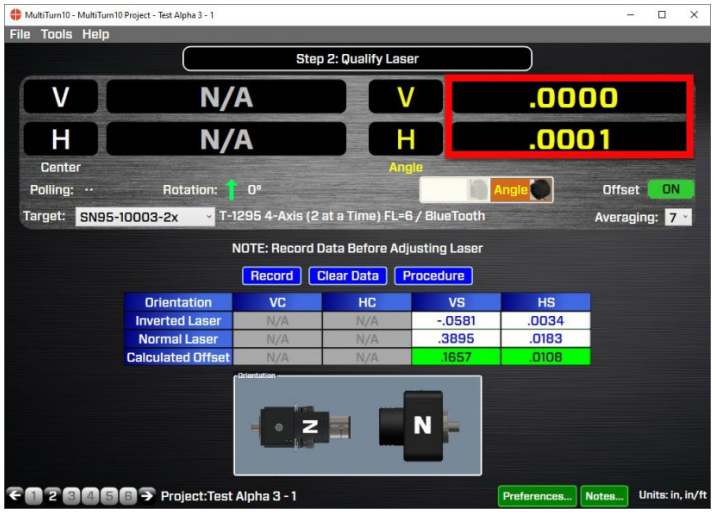
b. Laser bucked-in to Y axis - use this to measure:
   i. Y axis straightness (in X & Z)
   ii. X Axis straightness in Y.
   iii. X squareness to Y.

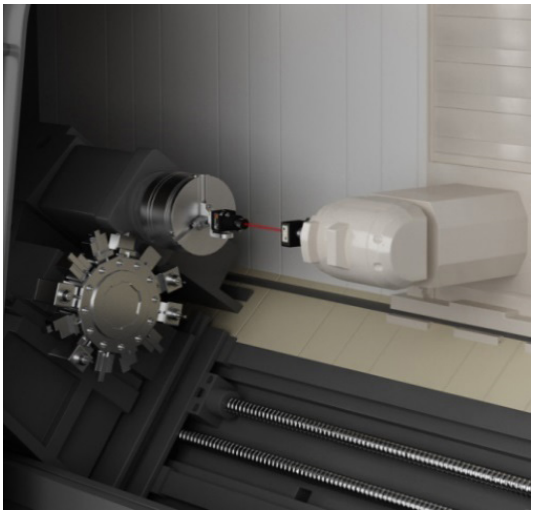
***Note:*** *this is only for clarification. Selecting the wrong setup will not affect any results.*

## 3. MultiTurn10 Step 2 - Buck-In (Align) L-702SP Beam to Spindle Rotation Axis.

First we need to align the laser beam to the C1 rotation axis. This is done by installing the L-702SP into the C1 spindle and the T-1295 Target into the machining spindle or the C2 spindle. The buck-in is done by installing the angle-measuring lens into the target and taking 2 sets of measurements: 1) with the L-702SP/spindle in the NORMal position; and 2) with the L-702SP/spindle in the INverted position. The results are averaged to create a Set Point. The laser beam is steered to that Set Point using the angular adjustments, which aligns the laser to the rotation axis. This is repeated a second time to confirm the setup is good. When confirmed, the L-702SP is left in the NORMal position and data can be taken.

***Note:*** *the centering of the laser to the rotation axis is not critical since we'll be doing another NORMIN when taking data for C1 to C2 spindle alignment. Any centering errors are eliminated by this process.*

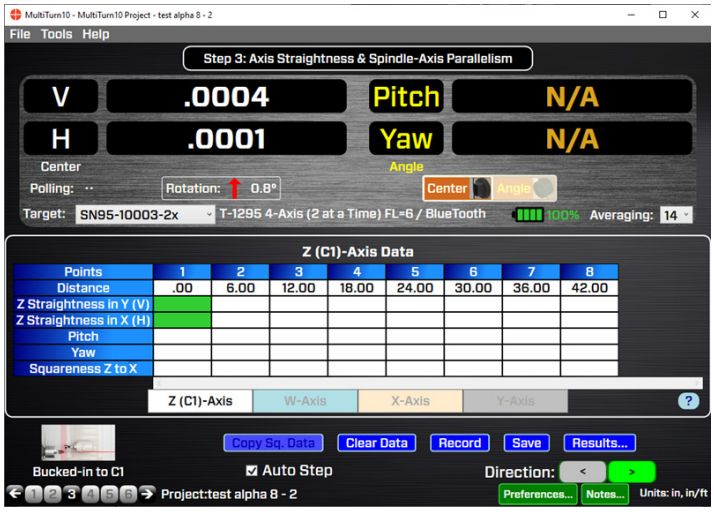


## 4. MultiTurn10 Step 3 - Measuring Axis Straightness

Next we go to **Step 3: Measure Axis Straightness** and click On "Center" to switch the display mode to Center values, and, **important!**, remove the lens from the T-1295/1296 and install the light shield.


Lens Light Shield



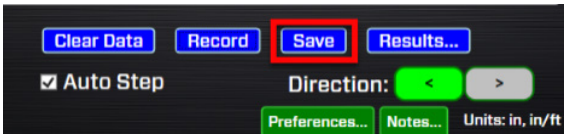
# Z Axis Straightness Data

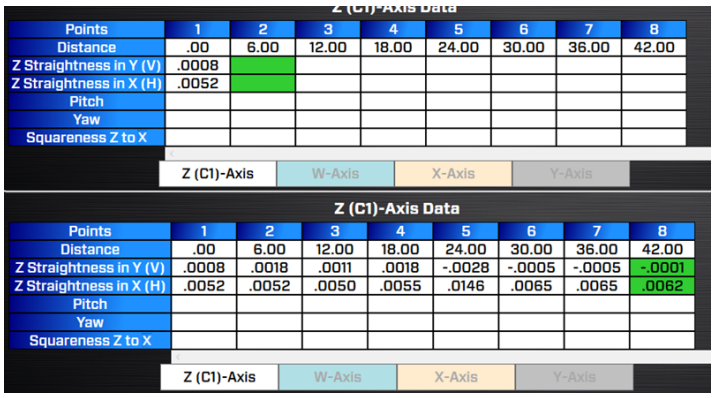
## 5. Select Z-Axis Tab and Record 1st Point

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.

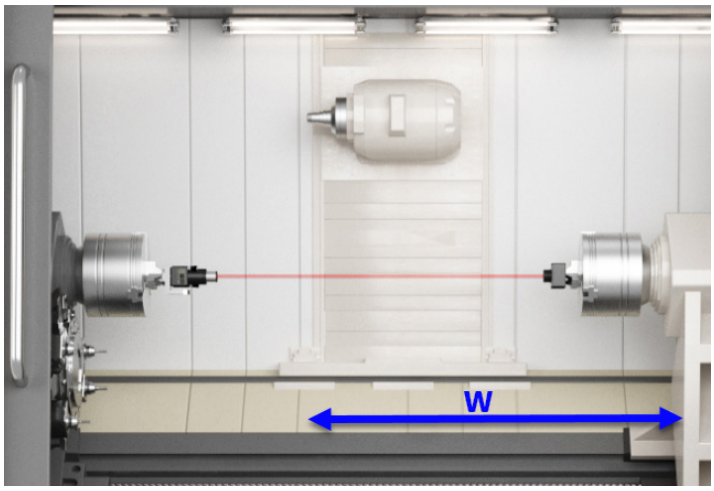



# W Axis Straightness Data

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

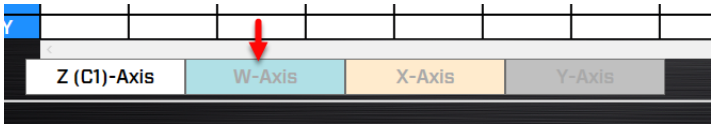
If it's not there already, move the T-1295 Target to the C2 spindle and chuck it up. Make sure the top of the target in the NORMal position (control panel is at 12:00).

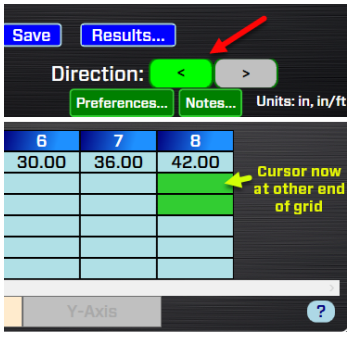



## 7. Select W Axis Tab and Change Data Direction

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.

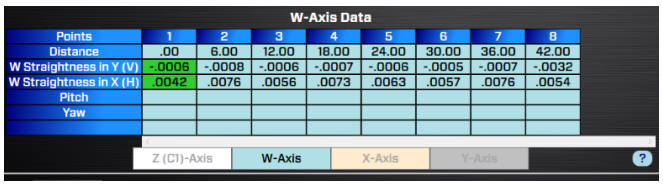
***Note** – don't worry so much about the actual value of the target when you insert it into the W axis. While this value is an indication of the alignment it is incomplete and not the full picture of the C1 to C2 alignment. To see this alignment, go to Step 5: Record Sub-spindle/Turret Rotation Axis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



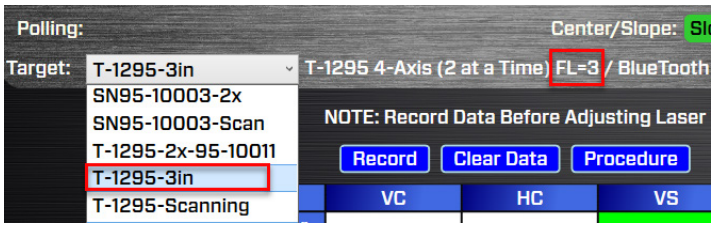

## 8. Record W Axis Data

Continue recording data for W Axis.



## 9. Record Z & W Axis Pitch/Yaw Data

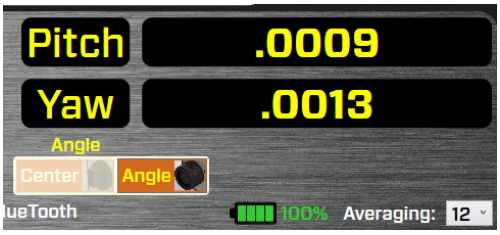
Set Z axis at the same location as in Step 5. Insert the lens into the T-1295/1296 Target. Make sure the lens focal length (FL=?) matches the target type in the drop-down list in Step 3. There is an overlay on the lens identifying the focal length.





## 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).



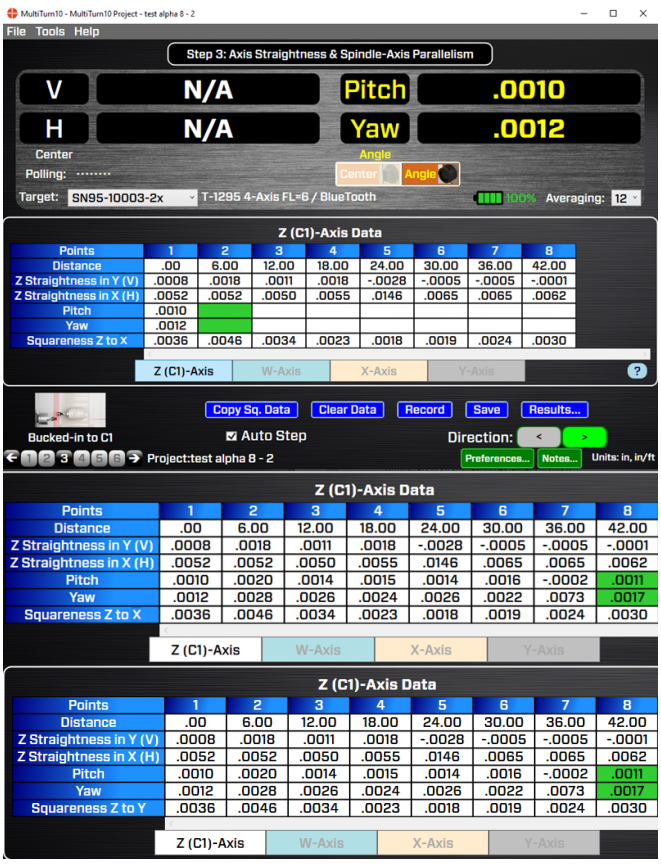

## 11. Record Pitch/Yaw Data

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.

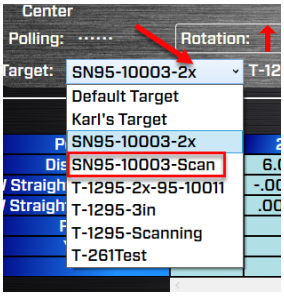



## 12. Record the W Axis Pitch/Yaw Data

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.

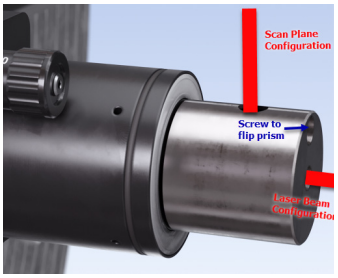
# X & Y Squareness to Z and Straightness of X-in-Z Data

## 1. Select Scan Mode in MultiTurn10



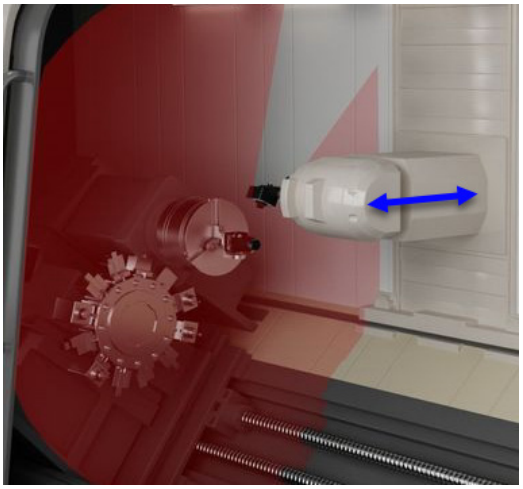

Without changing the setup, we can now take squareness data for X & Y to Z. So from the dropdown list in Step 3, select the Target serial number you are using with "-**Scan**" in the description, which is Scan Mode. There will be a popup window that gives you instructions on how to change the laser and target to Scan Mode (or see below).

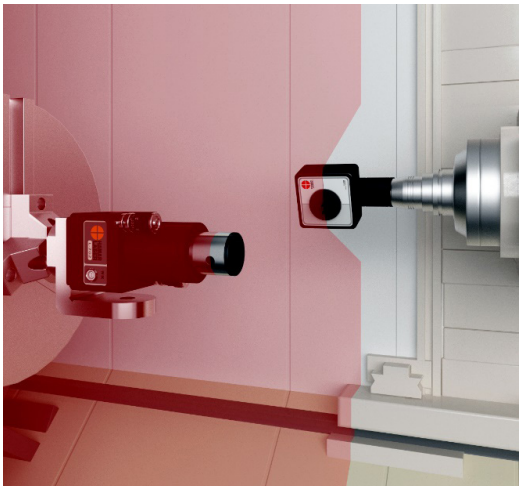
## 2. Switch L-702SP & T-1295/1296 into Scan Mode to Record X and Y Squareness


First switch L-702SP into Scan Mode by pressing the power button until the ***I/O*** LED is always on (the laser will not be blinking but on continuously). 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 or 26 of the manual). To start the spindle rotation, hit the **SCAN** button.

## 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.

***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 (or most retracted) position in its travel.

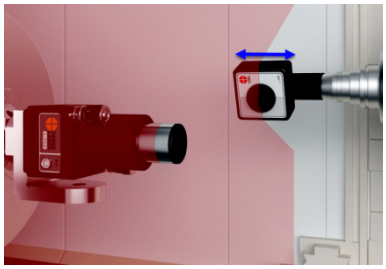
## 4. Change T-1295/T-1296 Target to Scan Mode

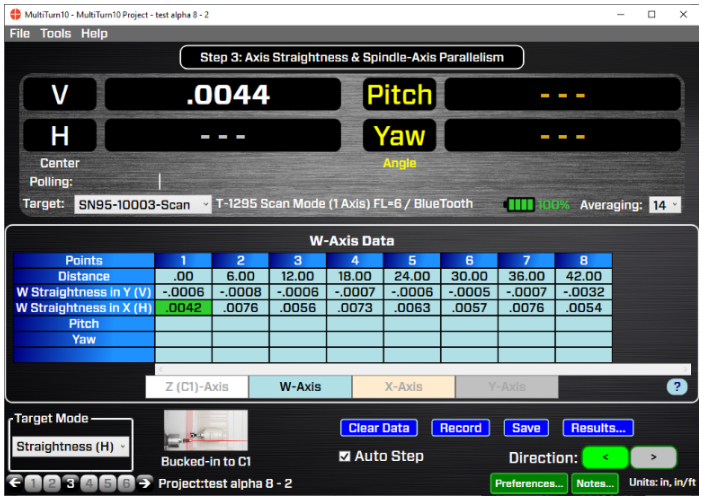
Change the target to Scan Mode by pressing and holding the power button until the ***On TGT*** LED starts blinking.

***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 turn off the scan button.*


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

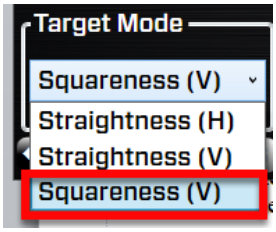
Turn on the scan plane by hitting the SCAN button and you should see a value in the V Center display. Adjust the target height to get the raw value below ±.010 in. (0.25 mm).

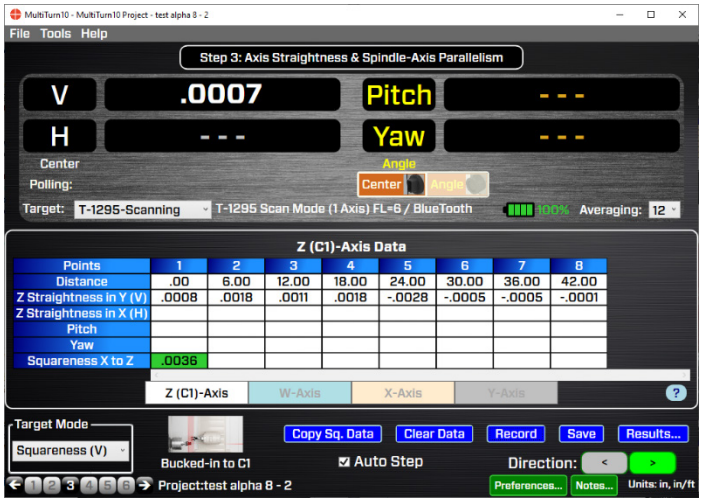






## 6. Select Z-Axis Tab & Squareness (V) for Data Type

Select the **Z-Axis** tab and **Squareness (V)** from the lower left corner *Target Mode* 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.



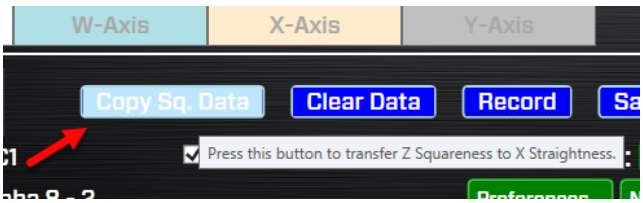



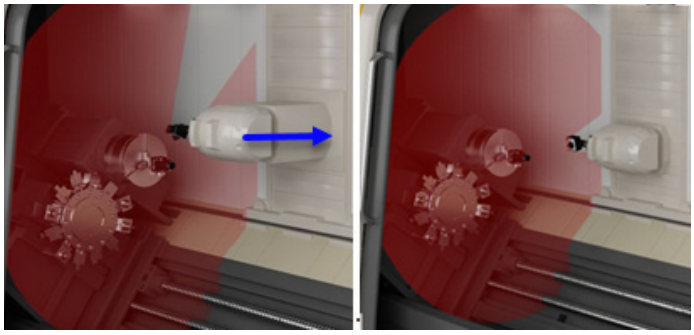
## 7. Take Measurements for the X Axis Squareness

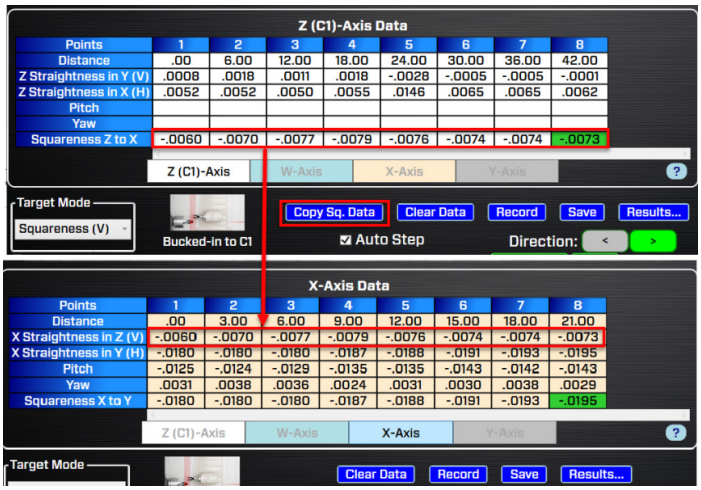
Hit **Record** to record the first data point. Move the X Axis to the next point and hit **Record** and continue to record all the points. You may have to rotate the target on the post to point it toward the laser.

***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.



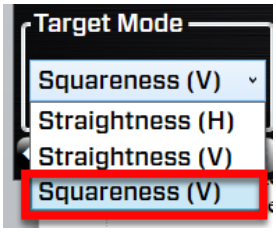



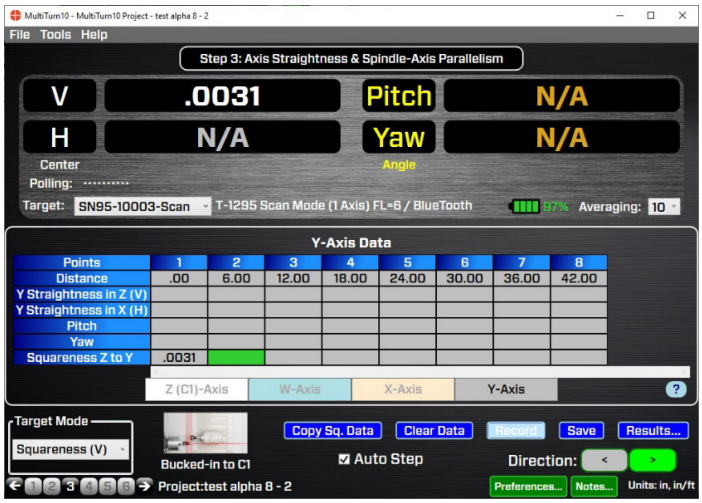



# Z-to-Y Squareness Data

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

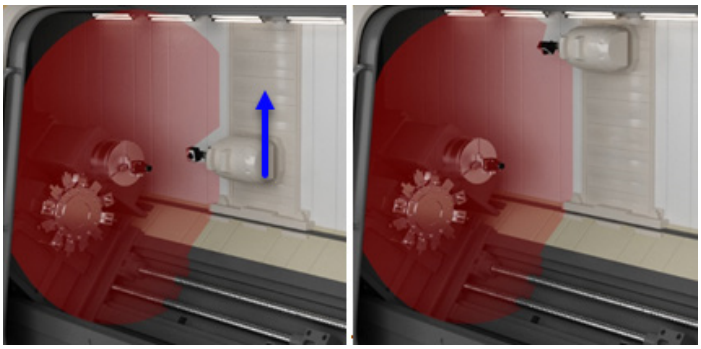
Make sure the T-1295/1296 is still in Scan Mode and the L-702SP is, too. Then to measure squareness of Y to Z, select the Y-Axis tab, and using the dropdown, select Squareness (V) as above. You will see the green cursor in the Squareness Z to Y row.

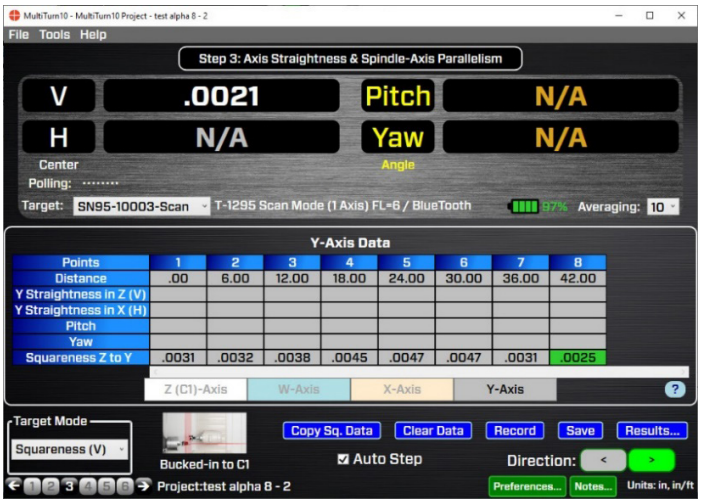


## 9. Move the Y Axis to the Lowest Position

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.



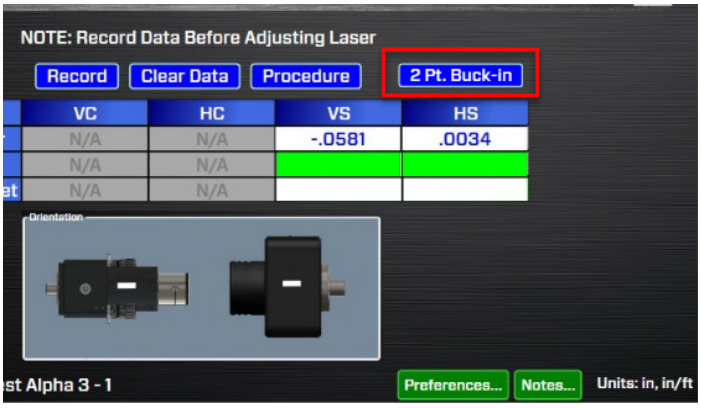



# Y-Axis Straightness Laser Setup #2

## 10. Buck-In Laser to Y Axis

Here we are going to change the laser setup to get the rest of the axis alignment data. First install the L-702RA Right-Angle fixture so we can point the laser up toward the Y axis. Then we bring the T-1295 in the machining spindle so that it is above the L-702SP Laser and then make sure the target is in 2x Mode (see the Target dropdown menu).

Then we go to Step 2 and select **2-Point Buck-In**. This is used to align the L-702SP to the end points of the Y axis to within ± .001 (0.025 mm) or so.



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

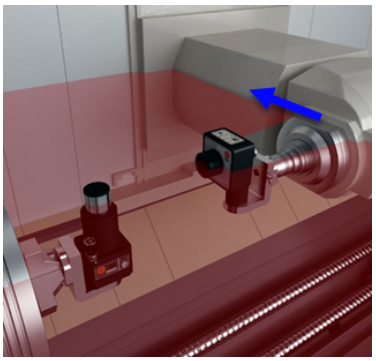
With the buck-in completed, go back to **Step 3** and click on the Y-Axis Tab. Make sure the display is set to Center Mode (white numbers, left display).

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.


## 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 pg. 36-37). 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).

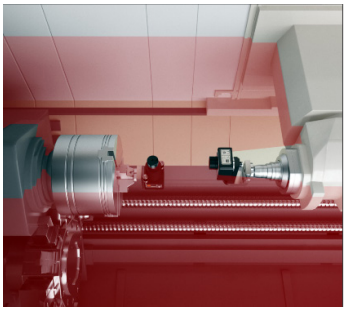
Adjust the Y axis up or down so the laser plane is going inside the window.

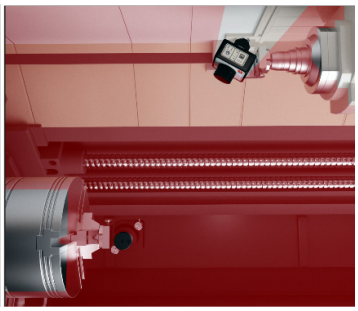



## 13. Move the X-Axis to the End of its Travel and Record Data

Move the X-Axis to the end of its travel (extended out – this is pt. #1) and hit **Record**. Move the head to point #2 and hit **Record**. Repeat to take all the data for X.

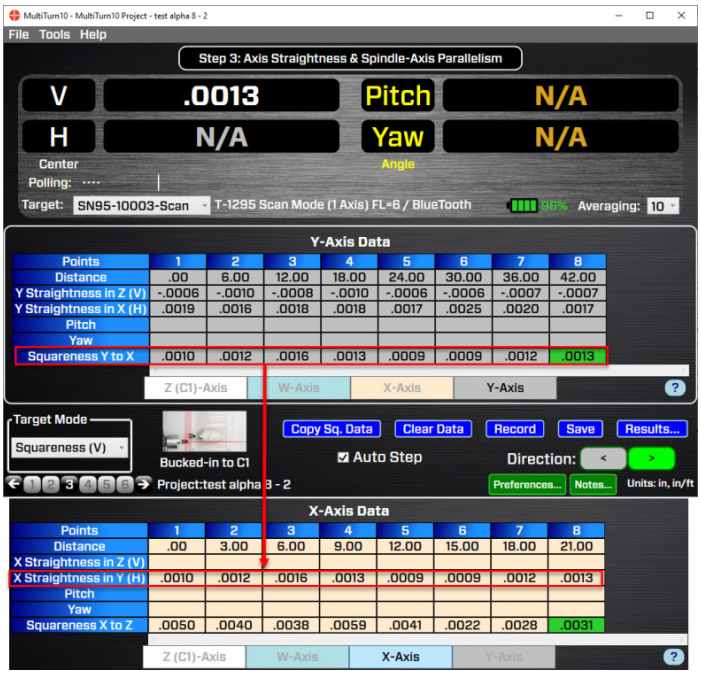
***Note:*** *as you move the X Axis in toward the back of the machine, you will need to periodically rotate the target head to make sure it's pointing at the laser.*





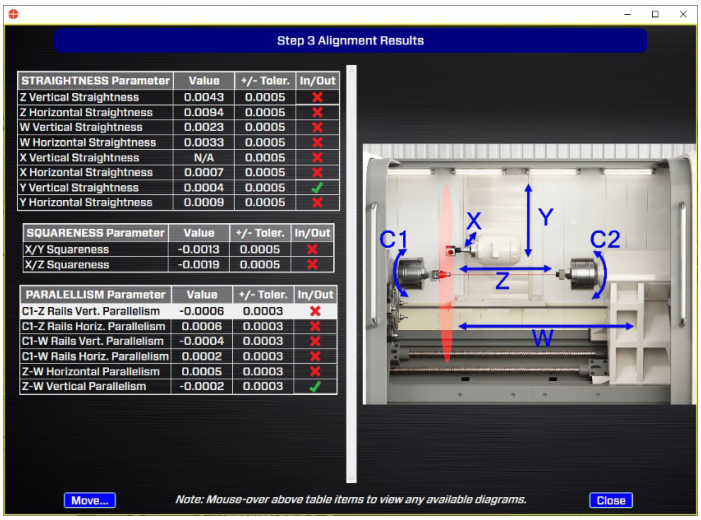
## 14. Hit Copy Data to Transfer Data to X Axis Straightness in Y row.

By taking this squareness data for X relative to Y, the straightness of the X in Y 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 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.