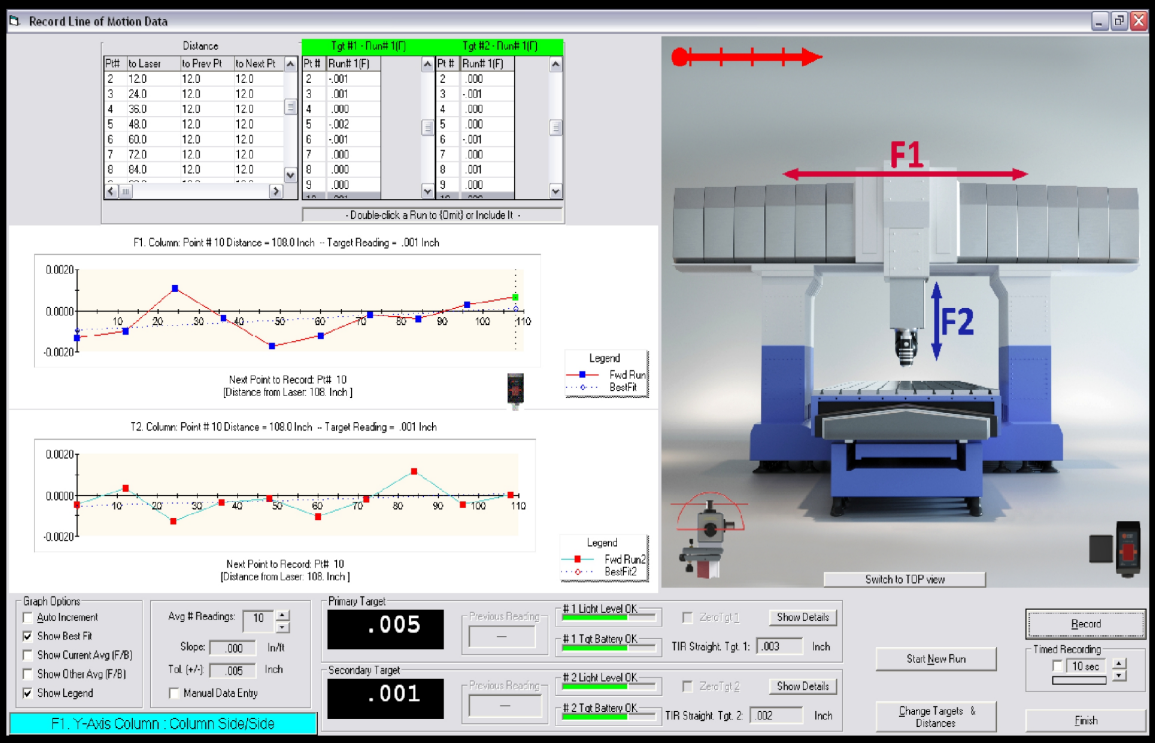

Operations Manual

Machine Tool Geometry (3D Plot)

February 2019

HAMAR LASER®

HAMAR LASER INSTRUMENTS, INC.
www.hamarlaser.com

Five Ye Olde Road, Danbury, CT 06810
Phone: (800) 826-6185 Fax: (203) 730-4611

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Introducing the Machine Tool Geometry Program

Hamar Laser's Machine Tool Geometry program (also known as 3DPlot) is Windows-based software for machining center alignment. The program is used with continuously rotating lasers and a compatible target (or targets) to measure and analyze the lines of motion of a machine's main axes and to verify that they are within required tolerances for squareness, straightness and parallelism. Data are recorded at specified points along an axis or axes and displayed graphically to show where the laser beam is striking the target. Hamar Laser's wireless targets, such as the A-1519, send data directly to the alignment software via an IR Receiver.

Program Features

- Multiple machine graphics for customized data taking and display. User-generated graphics may also be used.
- Records and analyzes flatness, straightness, squareness and parallelism misalignment data for each line of motion using *one* program.
- Real-time graphs show data *as it is recorded* for each line of motion.
- Can customize axis labels (i.e., W, X, Y, Z, etc.) for individual machine types.
- Save and print recorded data and recall previously saved machine data for comparison to existing alignment conditions.
- User-definable tolerances for each line of motion and squareness and parallelism between axes.
- Alignment graphs simultaneously show up to 4 lines of motion for straightness/flatness, squareness and parallelism.
- Graphs show TIR, high and low points, tolerance bands, squareness and parallelism errors in English or metric units. Zoom in on straightness, squareness and parallelism graphs as well as choose one line of motion as the datum. Select either "forward" or "backward" lines of motion.
- Reports print the analysis graphs as well as all backup data.
- Supports manual data entry.

Program Summary

The Machine Tool Geometry program consists of five major screens:

The **MACHINE CATALOG** screen displays front, side and top views of the machine tool, with the lines of motion for each view. A user may choose a machine configuration from a list of predefined machine tools, and the label of each main axis can be customized to the individual machine type.

On the **SETUP** screen, the user specifies company information, machine information, program parameters such as units of measure and the number of decimal places to be used, and tolerances for each line of motion.

On the **SPECIFY TARGETS AND DISTANCES** screen, the user specifies the length, number of points and distance between the points for each line of motion. The type of target, target orientation, direction of measurements and interface to be used in the measurement are also selected on this screen.

The **RECORD LINE OF MOTION DATA** screen displays the live target data in a readout box and updates the data graph *as it is recorded.* After each point is recorded, the cursor automatically moves to the next point and the least squares, best-fit line is calculated. Multiple measurement "runs" and bi-directional data can also be recorded for each line of motion.

The **VIEW PLOT** screen displays a graph of each line of motion for a given view (such as top view). Many viewing choices are available, including tolerance bands, TIR with high and low points, and squareness and parallelism angles (slope of best-fit line) between axes. Any line of motion can also be chosen as the datum and the other axes are re-plotted to reflect the new reference. The angles and graphs can be zoomed in or out, and a forward-run average, backward-run average or an overall average can also be graphed. In addition, a previously recorded set of data may be compared to the newly recorded data on the **VIEW PLOT** screen.

Getting Started

If the Machine Tool Geometry program 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 CD in the appropriate drive.
2. Click **Start** and select **Run**.
3. Type *Drive name*:\Setup, (where *Drive name* is the letter of the drive where you program CD is located) and click on **OK**. Follow the instructions on your screen. You will be required to enter the serial number provided with the software.

Note: *The minimum recommended screen resolution for running the Machine Tool Geometry program is 1024x768.*

Starting the Program

To begin using the Machine Tool Geometry program, double click the 3DPlot 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. The program may be run using the Random Data mode if no hardware is connected. Click **OK** or press Enter to begin using the program.

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 will 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 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.

Hardware Overview

A-1519 Type II Universal Wireless Target

The A-1519 Type II Universal Wireless Target incorporates new features and provides greater capabilities than previous wireless targets offered by Hamar Laser. In single axis scanning mode, the target can be used with Hamar Laser's continuously sweeping lasers for measuring the flatness, straightness, squareness and parallelism of both machine tools and rolls. Features include:

- Built-in radio transceiver, available in either 900 MHz or 2.4GHz ISM band
- Internal Li-Polymer rechargeable battery with twice the capacity of previously offered targets
- Rechargeable through a plug-in power supply or an optional charging station/cradle
- Field-Programmability: System ID and Target Network ID programmable via rotary DIP switches. Firmware Updates, Calibration and Other Parameters configurable through the USB Port, using the Configuration Utility.
- Three data communication modes: Wireless (Radio), RS-485 and USB
- Auxiliary Port for future expansion, such as a numerical display or external temperature sensor
- Improved Background light noise suppression
- Internal dampening by averaging of 2 to 64 laser position scans
- The target requires the R-1310 PDA Receiver or the A-910 Computer Radio Base Station (900 MHz or 2.4 GHz) to display target data in single-axis mode. Both radio transceivers have frequency hopping to minimize interference from other devices using the same or similar frequencies. Targets can change channels within their frequency range so two or more independent systems can be used in the same working area without interfering with each other.

Identifying Target Features

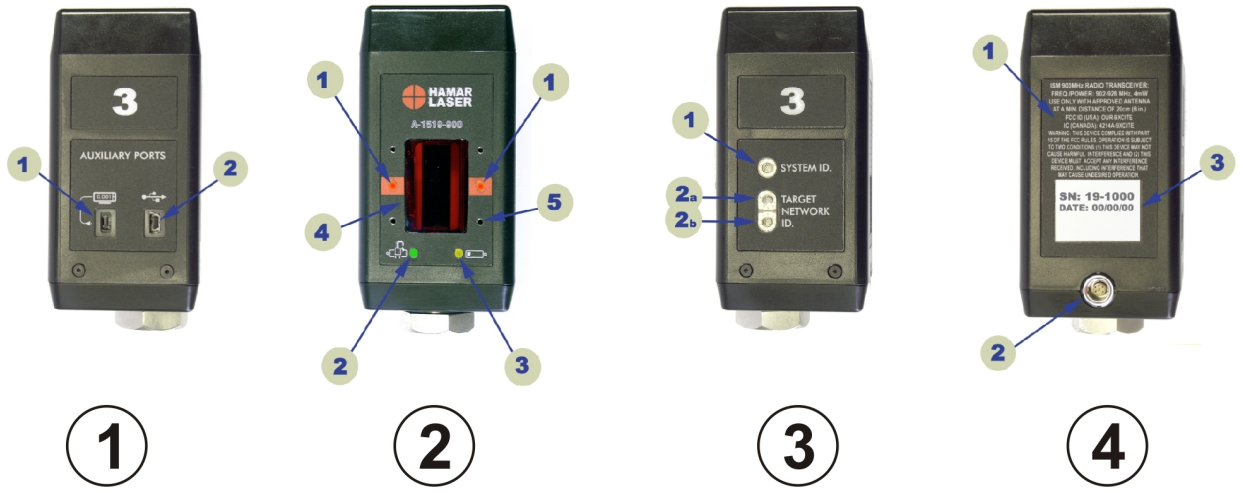


Figure 1 – *Target Features Chart*

(1) Right Side (Auxiliary Ports)

1-1 Auxiliary Port, Expansion Port

1-2 USB Port (used to updated target firmware, upload calibration data, configure operating parameters and run diagnostics. Can also be used as a Data I/O port compatible with standard applications).

(2) Front View

2-1 Target status LEDs. Steady when the laser scanner is detected and all conditions are normal. Blinks at different rates when an abnormal condition is detected.

2-2 Battery charging indicator.

2-3 Low battery indicator.

2-4 Position sensor, aperture window.

2-5 Optional light shield mounting holes (4x)

(3) Left Side (ID Switches)

3-1 System ID rotary switch (used to get the system ID group number 0-9).

3-2 Target Network ID (used to set the target network ID from 01 to 99).

(4) Rear View

4-1 Radio regulatory information.

4-2 RS-485 and plug-in power supply connector.

4-3 Serial Number label.

Using the Zigbee® Radio Utility

Pre-installing the Common USB Port Driver (A-910-2.4ZB)

This driver is required for the A-910-2.4ZB Transceiver and to communicate with targets via the computer's USB port. The driver creates a virtual COM Port that is recognized by the applications as a standard serial port.

Note: *You must pre-install this driver prior to connecting the device(s) to the computer through the USB port.*

Installing the Driver

1. Insert the A-910-2.4ZB Radio Programmer CD in the CD ROM drive.
2. Select **My Computer**, locate the CD ROM icon and click to open it.
3. Select the USB Drivers folder.
4. Select the correct Operating System installed on your computer (Windows 2000, Windows XP, etc.) and open the folder.
5. Locate the **CP210x_VCP** icon and click to initiate the installation process. The **Install Driver** dialog box displays.
6. Click **Browse** to select an installation folder different from the default folder (optional).
7. Click **Install** to continue. Once the installation is complete, the **Installation Successful** message displays.

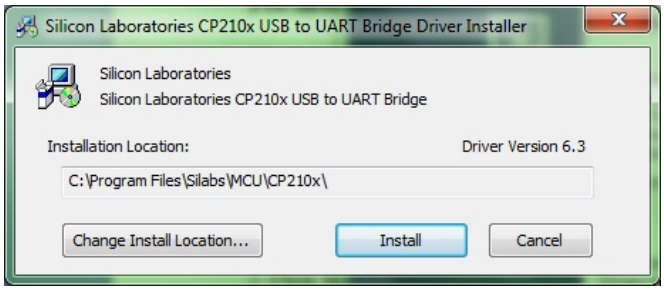


Figure 2 - *USB Common Driver Install*

Installing the A-910 Utility Software

1. Insert the A-910-2.4ZB Radio Programmer CD in the CD ROM drive.
2. Select **My Computer**, locate the CD ROM icon and click to open it.
3. Locate the **Setup** icon and click to initiate the installation process. Click **NEXT** to continue.
4. Click **Browse** to select an installation folder different from the default folder (optional).
5. Click **Next** to continue. Once the installation is complete, the **Installation Complete** message displays. Select **Close.**

Configuring the Hardware and Utility Settings

1. Insert the A-910 ZB dongle into any unused USB Port (see Figure 3). The computer should automatically assign a COM port number to the dongle.
2. Start the A-910 Utility Software. The software should display the COM port assigned to the Zigbee Dongle (see Figure 4). If the utility does not automatically detect the COM port, it must be manually selected (see **Manually Selecting a COM Port** on Page 8).
3. The Target System ID or R-1307 CH (channel) is the number associated with the A-1519/1520 targets or R-1307 Readout. If using both the A-1519/1520 targets and an R-1307 Readout, both need to be set to the same system ID and channel (see Figure 5).

Figure 3 – *A-910 Zigbee Dongle*

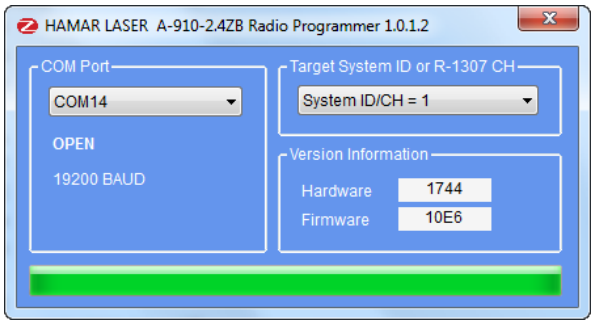


Figure 4 – *A-910 Utility showing the COM Port, System ID and Channel settings*

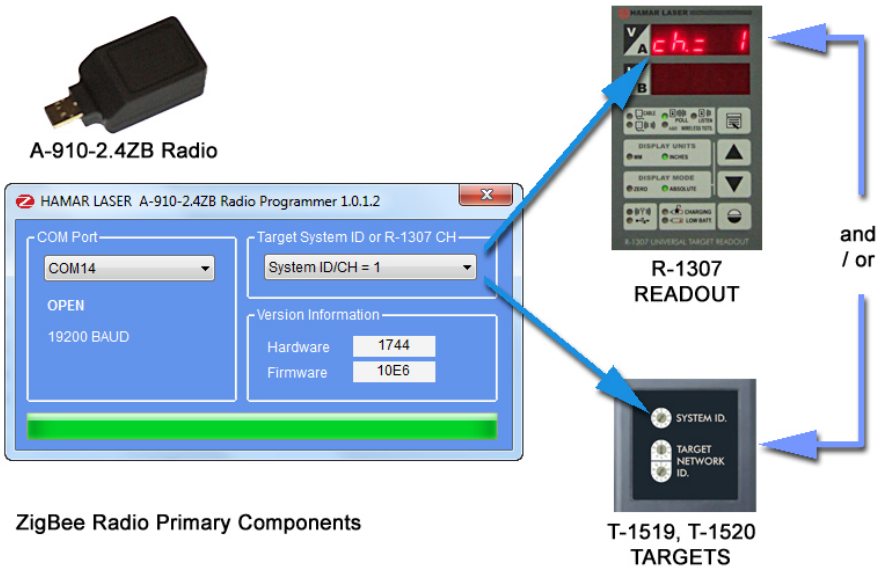


Figure 5 – *System ID Setup*

Manually Selecting the COM Port

The A-910 Utility should automatically detect the COM Port upon startup. If not, use the following steps to locate the correct COM Port.

Windows XP

1. Right-click My Computer.
2. Click **Properties** and then select the **Hardware** tab.
3. Click **Device Manager**.

Windows 7

1. Click **Start** and select **Control Panel**.
2. Click the **System** icon.
3. In the **System** window, click on the Device Manager link located under the **System** heading.
4. In Device Manager, scroll down to **Ports.** Expand the listings under **Ports** to reveal all the ports installed.
5. Locate **SILICON LABS CP210x USB to UART Bridge (COM x)** (see Figure 6**).**
6. Note the COM Port listed and select that COM Port in the A-910 Zigbee Utility software using the drop-down arrow (see Figure 6).

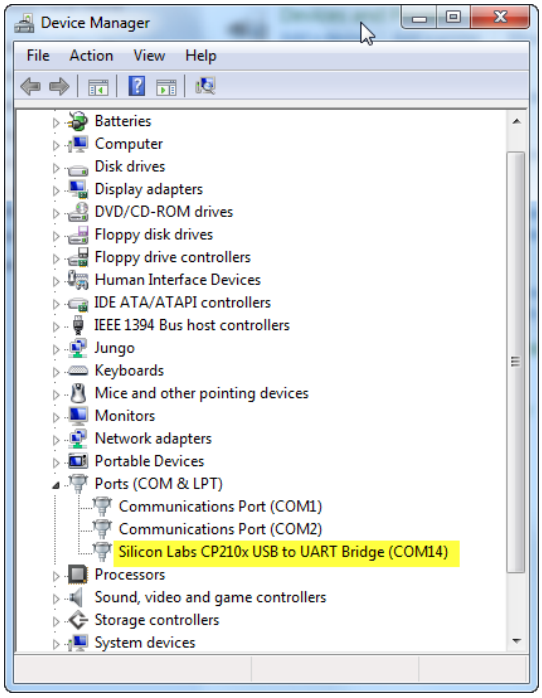


Figure 6 – *Device Manager showing COM Port for A-910 Dongle*

Setting the Target System ID and Target Network ID

The System ID is a Radio Network Address that is used by the Radio Communications Protocol to filter unwanted data from other radio transceivers and targets using a different address. Only targets and radio transceivers that are set to a matching System ID can communicate with each other.

Because no two targets with the same System ID can transmit simultaneously, it is necessary for each target to be programmed to respond only when it is being addressed. The Target Network ID is the target address on the communications network. Under Host (computer) control, the radio transceiver transmits a message called a *polling request* that contains the Target Network ID of one specific target. All targets receive all polling requests, but only the target with a Network ID matching the ID contained in the polling message will reply (Transmit Data to the Host).

There are three rotary DIP switches located on the right side of the target, shown in Figure 7:

- The uppermost switch sets the System ID.
- The two lower switches are used to set the target network ID.

Setting the System ID

Note: *Before selecting a System ID, ensure that it is not already in use by another system within the radio coverage area.*

Using a small screwdriver, rotate Switch 1 to align the arrowhead with the System ID number (0-9). Figure 7 shows the System ID switch set to 1.

Figure 7 – *Unitarget ID Switch set to1*

Using the Machine Tool Geometry Program

The Machine Tool Geometry Program consists of a series of screens that prompt the user for information corresponding to the physical setup of the laser, target and machine to be aligned. Options for selecting and calibrating specific targets are included, or **Manual/Random Data** may be selected to familiarize the user with the program before performing an alignment. The user may make on-screen adjustments to agree with the alignment setup.

Once the alignment setup is determined, the user specifies a number of points to be recorded and the distance between these points. As the target is moved along the axis, the software records the readings for these specified points, providing a graph of each line of motion. Each graph can be viewed and analyzed individually (for straightness) or in comparison with graphs from other lines of motion (for squareness and parallelism).

The Machine Catalog Screen

The Machine Catalog Screen allows the user to specify the line or lines of motion to be analyzed. Data for either a single line of motion or for an entire *view* can be collected, the latter showing all aspects of a machine's lines of motion to be compared.

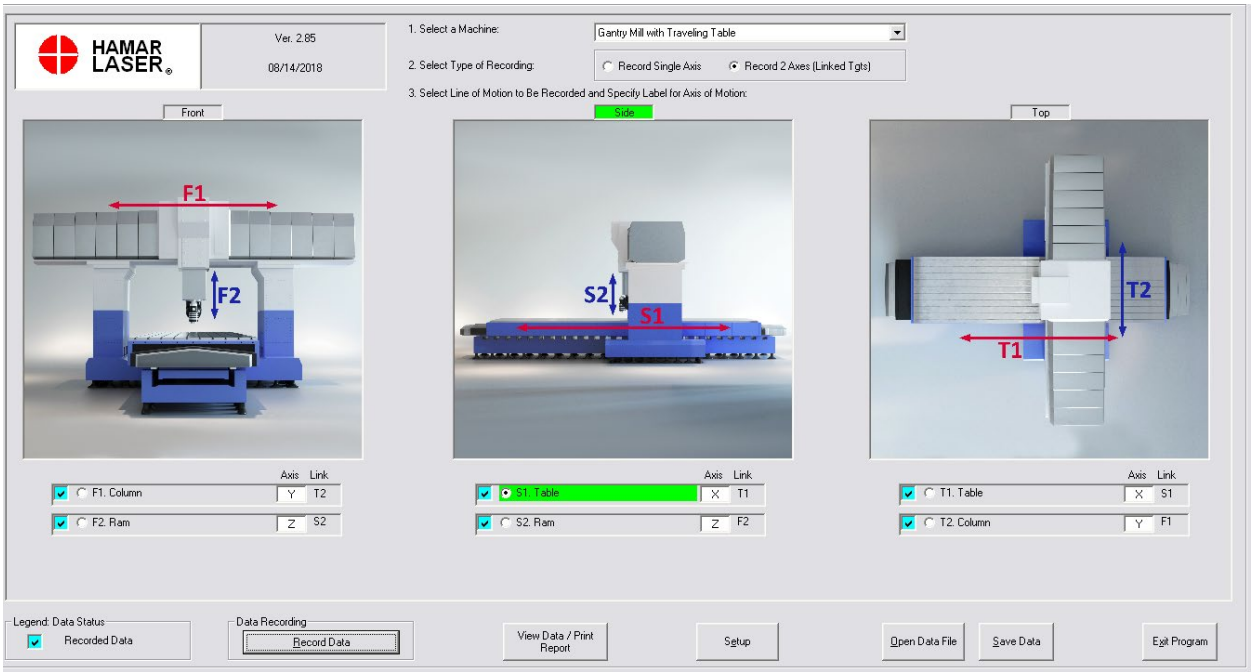


Figure 8 – *Machine Catalog Screen*

The following actions are performed from the Machine Catalog Screen (see Figure 8):

Select a Machine

Specify a machine type by clicking on the down arrow and selecting from one of the predefined machines on the list. These include **Gantry Mill**, **Horizontal Machining Center 1**, (shown in Figure 8) **Lathe**, **Vertical Machining Center 1** and **Vertical Machining Center 2**. You may edit any of these machine styles or create a new machine by selecting **Create/Edit Machine** from the dropdown menu (see Appendix B, starting on Page 31, for the full procedure).

Select Type of Recording

Specify whether a single target (**Record Single Axis**) or multiple linked targets (**Record 2 Axes Linked Tgts**) will be used (see Figure 9). One target allows the user to record a single axis. When two targets are placed perpendicular to each other, 1 target reads the *horizontal* plane and the other reads 1 of the 2 *vertical* planes.

Note: When "Record 2 Axes" is selected, only the first linked target of each linked pair is selectable, since both axes will be recorded simultaneously. In the example below, F1 is linked to T1, but only F1 is selectable. Both F1 and T1 will be recorded at the same time.

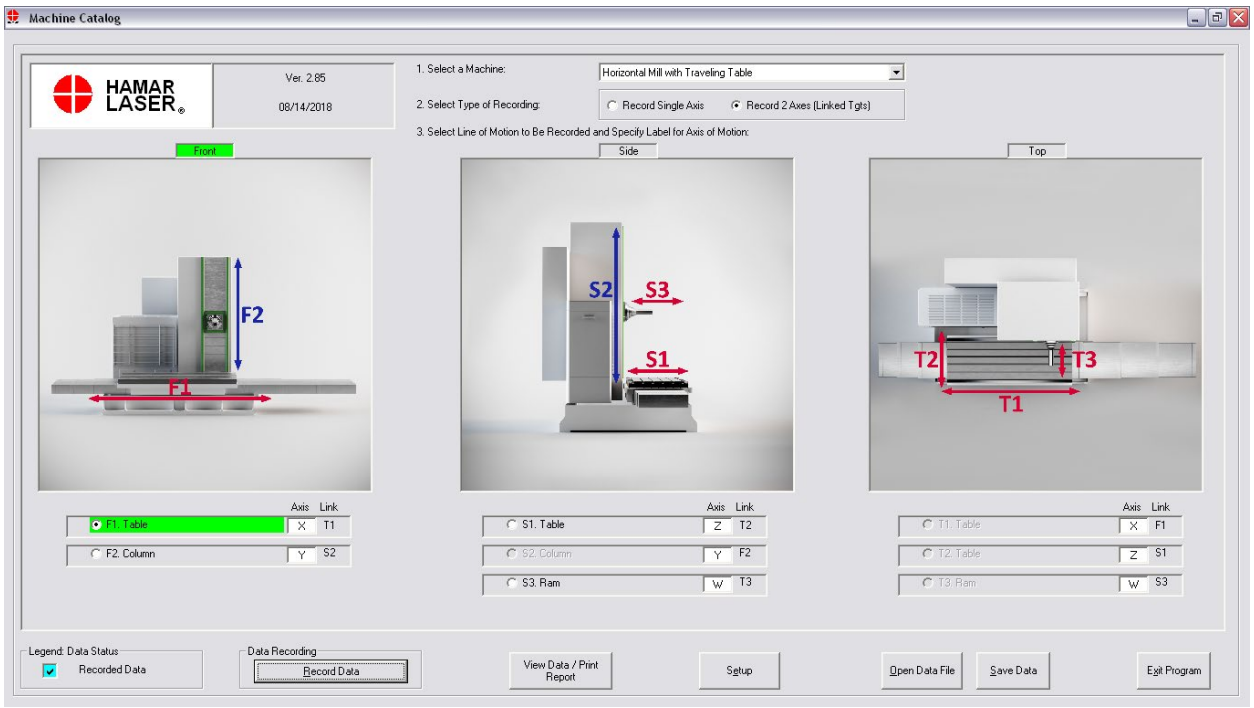


Figure 9 – *Machine Catalog Screen Showing Record 2 Axes (Linked Tgts) Option*

Select Line of Motion to be Recorded and Specify Label for Axis of Motion

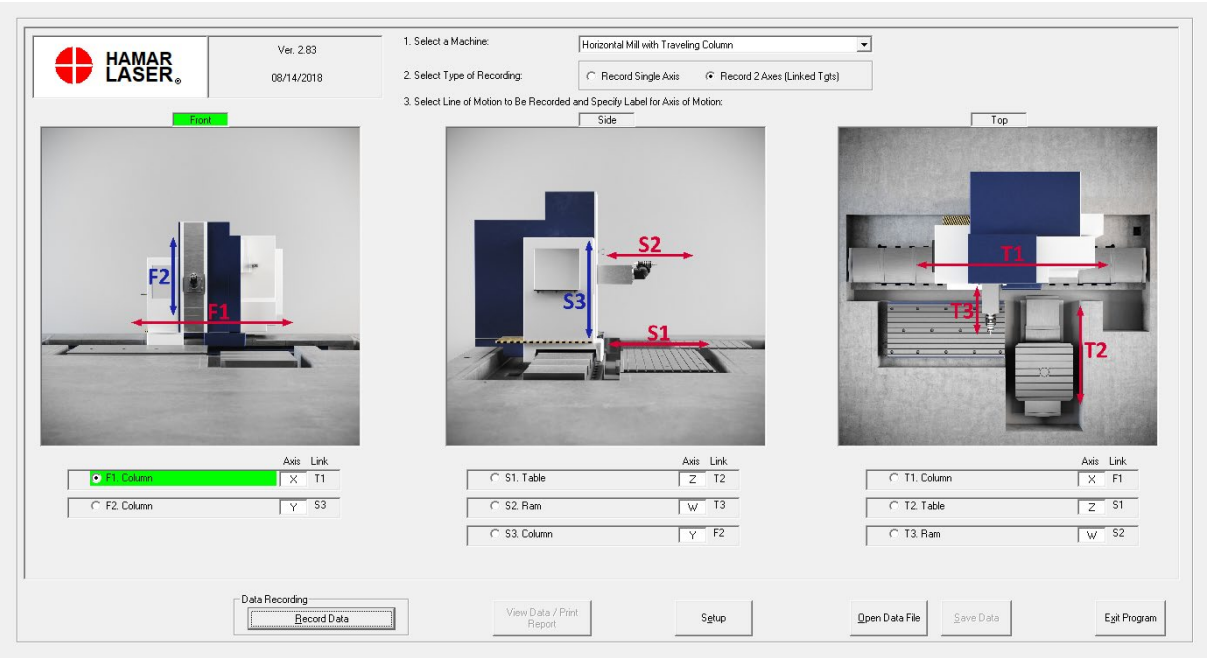


Figure 10 – *Selecting a Line of Motion*

Select the line of motion to be recorded for a *particular* view (Top, Side, or Front). When the desired line of motion is selected, the corresponding view is highlighted. When all data are collected for that view, the lines of motion can be compared. When data for a *single* line is desired, select the number that corresponds only to that line of motion. Each line of motion is labeled in the graphic for that view.

For example, in Figure 10 *Horizontal Mill with Traveling Column* is the selected machine. The lines of motion are defined as follows:

F1 Column – X-axis "vertical" straightness (flatness) of the column travel (left/right), perhaps with a target mounted vertically on the quill
F2 Column – Y-axis "horizontal" straightness of the ram traveling up/down the column, perhaps with a target mounted horizontally on the side of the ram.
S1 Table – Z-axis "vertical" straightness (flatness) of the table travel (in/out), perhaps with the target mounted vertically on the table.
S2 Ram – W-axis "vertical" straightness (flatness) of the ram travel (in/out), perhaps with a target mounted vertically under the ram.
S3 Column – Y-axis "horizontal" straightness of the ram traveling up/down the column, perhaps with a target mounted horizontally on the face of the ram.
T1 Column – X-axis "horizontal" straightness of the column travel (left/right), perhaps with a target mounted horizontally on the face of the ram.
T2 Table – Z-axis "horizontal" straightness of the table travel (in/out), perhaps with a target attached horizontally to side of the table.
T3 Ram – W-axis "horizontal" straightness of the ram travel (in/out), perhaps with the target attached horizontally on the side of the ram.

The letter designation for an axis may be changed for each selection as setup needs require.

Record Data

Click **Record Data** or press **Alt-R** to access the Record Line of Motion Data Screen and begin recording data. If you are using the program for the first time or if you haven't opened a file containing previously saved data, the Specify Targets and Distances Screen will display to allow target and data recording selections. See Page 15 for more information about the Specify Targets and Distances Screen.

View Data/Printer Report

Click **View Data/Print Report** to view or print information you have collected during the alignment process. If no data has been recorded, this button will be grayed out.

Open Data File

To open a previously saved file, click **Open Data File** or press **Alt-O**. The default filename for the first saved data file is **PLOT0001.plt**. Each time data are saved, the number for the new filename increments by one (**PLOT0002.dat**, **PLOT0003.dat**, etc.). Note that saving a file with an existing filename will overwrite the existing file.

When a previously saved file containing recorded data is in use, the **Legend: Data Status** box displays in the lower left-hand corner of the Machine Catalog screen (see Figure 11). When you are ready to record data, the Record More Data for This Line of Motion Screen displays with the following options to allow maximum flexibility:

Continue With Current Run	Record more data for current run
Ready to Start a New Run	Same direction for new run/Change direction for new run
Change This Line of Motion	Go back to change targets or distances for this line of motion

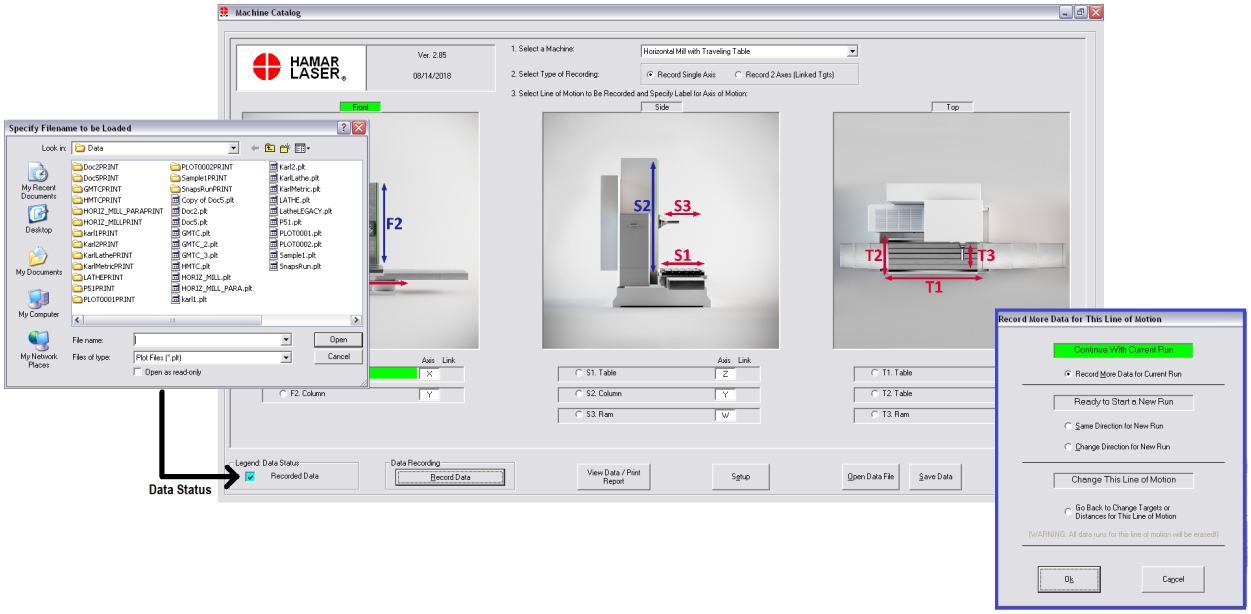


Figure 11 – *Opening and Using a Previously Saved Data File*

The Setup Screen

Activate the Setup Screen by clicking **Setup (Alt-E)** from the Machine Catalog Screen. This screen is used to enter company and machine data, to specify units of measure and the number of decimal places to be used for readings, and to enter tolerance values.

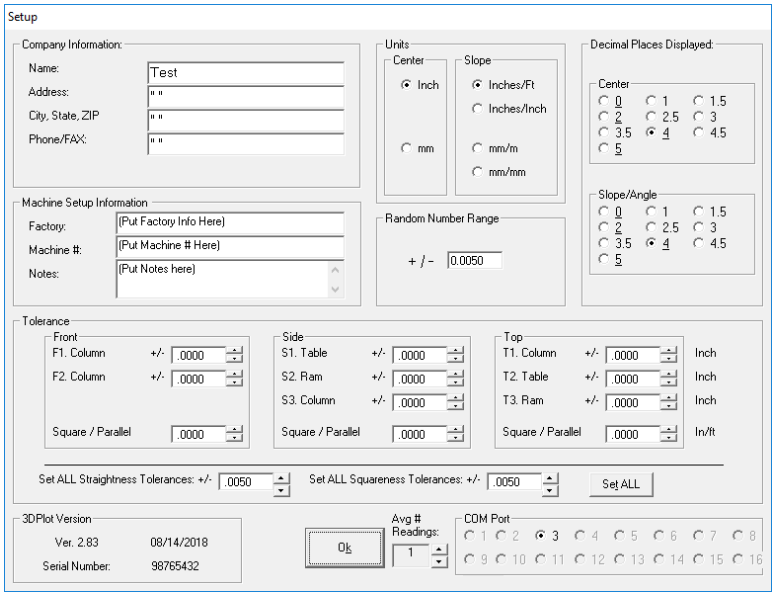


Figure 12 – *Setup Screen*

Company Information

Enter your company information to personalize the Machine Tool Geometry software. The program uses this information as part of a report header when printing reports. To move among the fields, either press the Tab key or position the mouse cursor in each field and click.

Machine Setup Information

Enter factory and machine information, as well as any additional notes on a particular machine setup. This information is also incorporated into the header of printed reports. To move among the fields, either press the Tab key or click in each field. When the text of a note fills the **Notes** box, click on the up or down arrows to the right of the box to see the entire text of the note.

Units

Select either English or Metric units for the **Center** value. When English units are selected, you may specify **Inches/inch** or **Inches/ft.** for the **Slope** value. When Metric units are selected, you may specify **mm/m** or **mm/mm**.

Decimal Places Displayed

Select the number of decimal places to be displayed for both **Center** and **Slope** readings.

Tolerances

Enter the tolerance values according to your machine specifications. Note that the tolerances used by the program are *overall* tolerances, not point-to-point. Tolerance values can be changed by clicking the up and down arrows or by highlighting the existing value and typing a new one. For example, in Figure 12 the tolerance value indicates that the *straightness* of the quill along the Z-axis should not deviate by more than .005 in. over the entire range of the line of motion. The value for *squareness* indicates that the two lines of motion being compared must be perpendicular or parallel to each other by .005 in/ft (the unit of measure selected).

In addition, *all* tolerance values for either center or squareness can be set to the same number by entering a value in the boxes marked **Set ALL Center Tolerances** or **Set ALL Squareness Tolerances** and clicking **Set All (Alt-T)**.

When all Setup selections are made, click **Ok (Alt-K)** to return to the Machine Catalog Screen.

The Specify Targets and Distances Screen

If you are working with new data or running the Machine Tool Geometry program for the first time, the Specify Targets and Distances Screen displays automatically when you click **Record Data (Alt-R)** from the Machine Catalog Screen. If you are working with a previously saved file, the target information and data recording settings that were specified previously are saved with the file. To make changes to this information, access the Specify Targets and Distances Screen by clicking **Change Targets & Distances** or pressing **Alt-C** from the Record Line of Motion Data Screen.

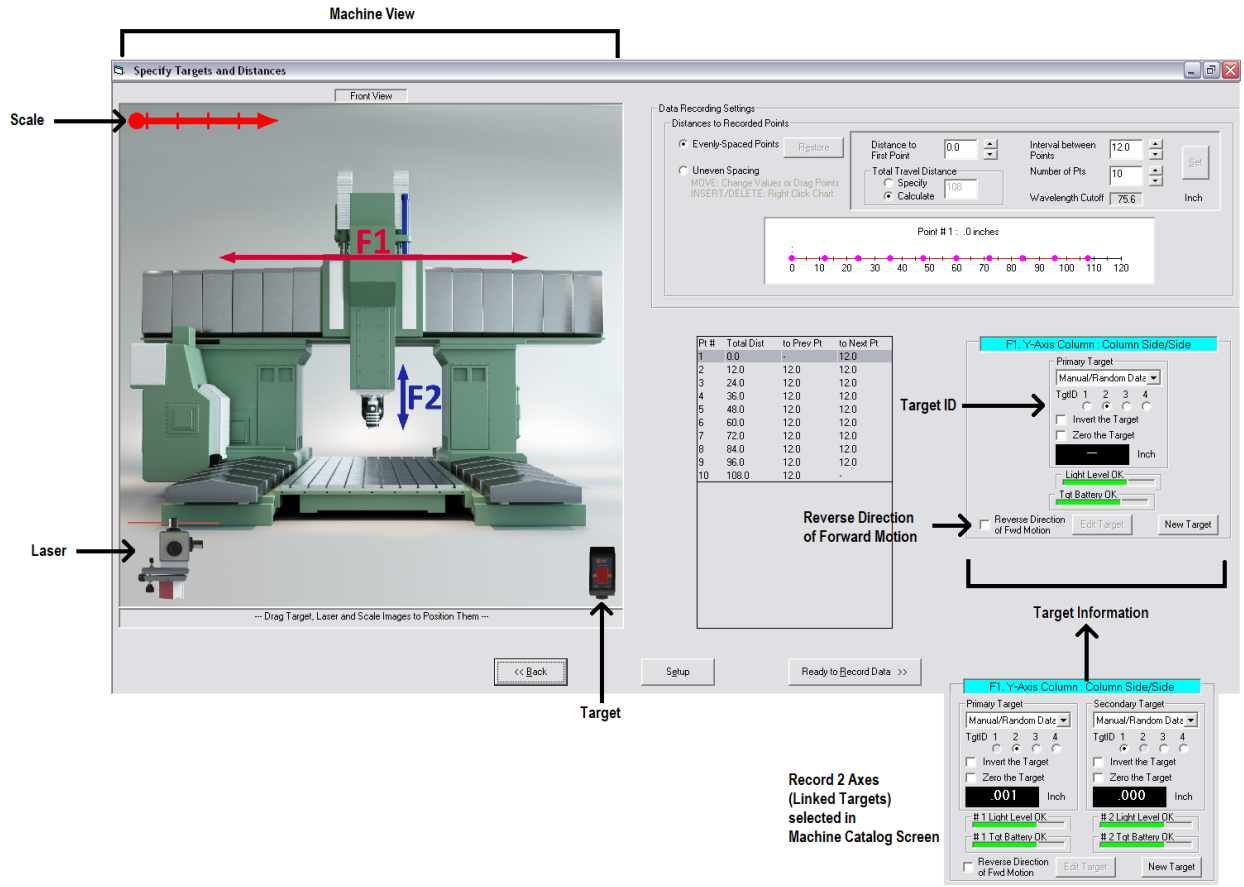


Figure 13 – *Specify Targets and Distances Screen (Machine View and Target Information)*

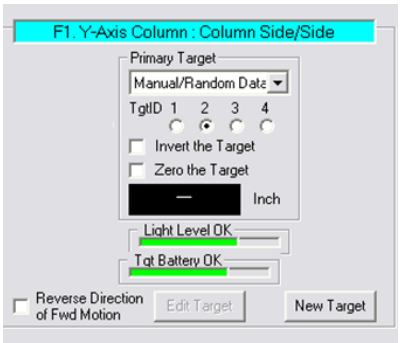
This screen contains three sections as shown in Figure 13: Machine View, Target Information and Data Recording Settings. Depending on the machine or the machine view you have selected and the number of targets being used, the placement of each section may differ slightly on your screen.

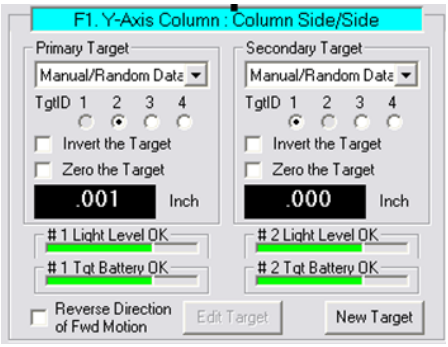
View

This section of the screen reflects the machine view that is currently selected in the Machine Catalog Screen. Modifications can be made to this screen to reflect your physical setup by moving the cursor over the graphic of the laser, target, or scale bar until it becomes a hand. Hold down the left mouse button and slide the graphic to the proper position. To change the direction of the scale bar, click **Reverse Direction of Forward Motion** (see Figure 13).

Target Information

Click on the down arrow of the **Primary Target** box to select the target you are using from the list, or select **Manual/Random Data** to run the program with software-generated random numbers. This allows familiarization with the software without connecting to an actual target.





Note*: Actual target data being received are ignored when* **Manual/Random Data** *is selected.*

If **Record 2 Axes (Linked Tgts)** is selected in the Machine Catalog Screen, selection boxes for both **Primary Target** and **Secondary Target** will display on the Specify Targets and Distances Screen (see Figure 13).

If a target is purchased with a complete alignment system, all the information for that target, including the calibration factors (usually cal factors are stored inside the target and don't need to be entered here), will be entered for you in the Machine Tool Geometry Software. If a *new* target is added to the system, the target name must be added.

Target ID

In the **Tgt ID** area, select the Target ID to match the side of your A-1519-2.4ZB or A-1520-2.4ZB Targets. Note is using **Record 2 Axes,** you will have to select the ID for both targets. Note: *You will see if Target 1 is selected in* ***Primary Target****, then it will be disabled for the Secondary Target. If you don't match the target ID here to the one on the side of the target, the target data will not appear in the live displays*.

Invert the Target

Select this option if the target is to be used in an inverted position. This will cause all readings in the software to switch their sign. Therefore, if a target is used underneath a ram upside down and **Invert Target** is selected, if the ram starts moving down as it travels out, the readings will start to go negative and the software will display the axis slope going down, which is correct. If **Invert Target** is *not* selected, then for the same scenario, the software will show the axis sloping up. It will still be an accurate calculation, but the direction of the travel will be wrong.

Zero the Target

Select this option to zero the target display (stores the current target reading as the zero offset). This feature is used when you want to zero a target on a reference position and then measure other points for deviation. A non-zero measured reading means that point is either high or low relative to the reference point.

Target Displays

The black boxes below **Zero the Target** are target displays that show the live target readings. These numbers can be magnified for easier viewing by placing the cursor over the numbers. Click when the cursor changes to a magnifying glass. If a zero offset has been applied, the magnified view reflects that information. Click **Hide** to close the window.

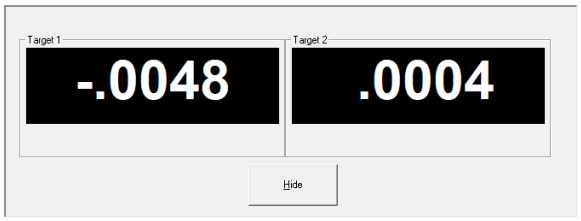


Figure 14 – *Target Pop-Up Window*

Background Light Level and Battery Status Indicators

If you are using wireless targets, the **Light Level** and **Target Battery Level** indicators show the background light level (the amount of background light from sunlight or overhead lights) and its effect on the target, and the battery strength of the target (see Figure 15).

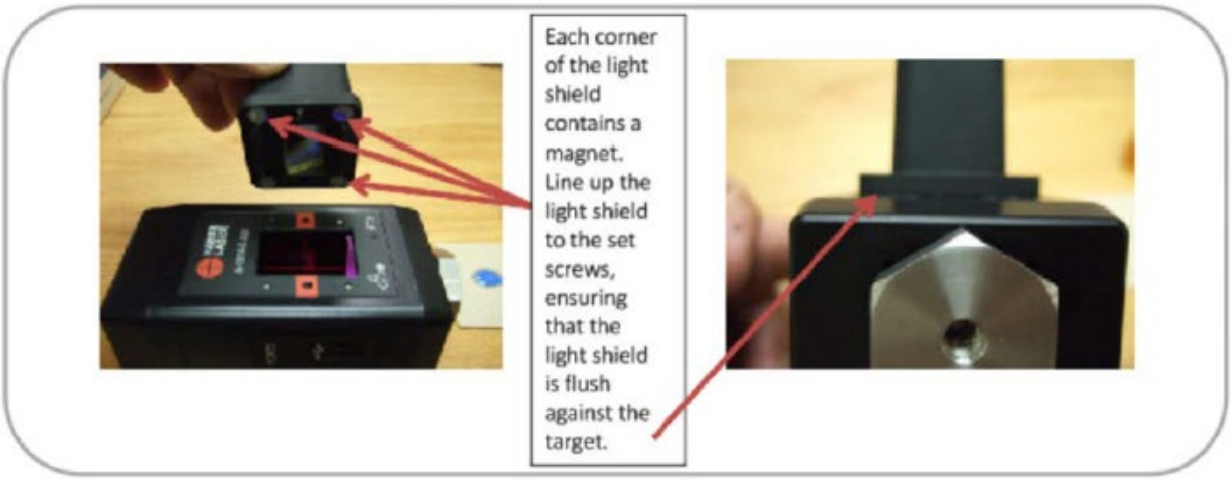
Figure 15 -- *Target battery and light level status indicators*

Light Indicator

Message	Color	Condition
Light Level OK	**Green**	Acceptable light level.
Light Level High	**Yellow**	High level of background light. This could also mean weak laser power.
Light Level Warning	**Red**	Too much background light. Target may provide invalid readings.

Note: *Both* Light Level Warning (Red) and Light Level High (Yellow) *conditions may produce invalid target readings. When either of these conditions display on the Light Level Status Indicator, reduce the amount of background light reaching the target. The A-1519-2.4ZB Targets come with light shields that can help this condition . See below or the A-1519-2.4ZB Target Manual.*

Install the light shield to the target



Battery Indicator

Message	Color
Target Battery OK	**Green**
Target Battery Weak	**Yellow**
Target Battery Bad	**Red**

Defining a New Target

If no targets have been selected previously or if you wish to add a target, do the following:

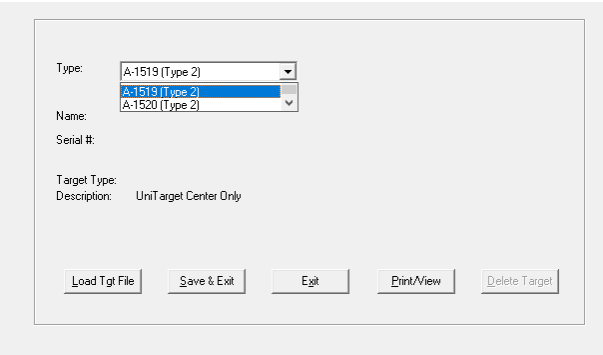


Figure 16 – *New Target Screen*

1. **Click New Target to display the New Target screen (**see Figure 16**).**
2. **Select a target from the list.**
   Click on the down arrow in the Type list box to view the list of target types. Enter a name for the target in the Name field, (or keep the default model number as a name) and the target serial number (optional) by clicking in the field and typing the information. The Tab key may also be used to navigate within the New Target screen.
3. **Load the Target File (Alt-L).**
   Note: *Loading a target calibration file is necessary only for older, discontinued Hamar Laser targets such as the A-517. If you're using one of Hamar Laser's wireless targets, calibration takes place within the target.*
   Load the file containing the target information using **Load Tgt File**. Hamar Laser provides this file when a target is purchased.
4. **Save the information.**
   Click **Save** (**Alt-S**) on the New Target screen when the target is selected and the information from the target file is loaded. Click **Print/View** or press **Alt-P** to view or print this information.

Editing Target Information

To change information that has been saved for a target, select the name of the target from **Target 1** or **Target 2** and click **Edit Target** to display the Edit Target Screen (see Figure 17). From this screen, selected targets can be deleted from the list and saved information can be modified or printed.

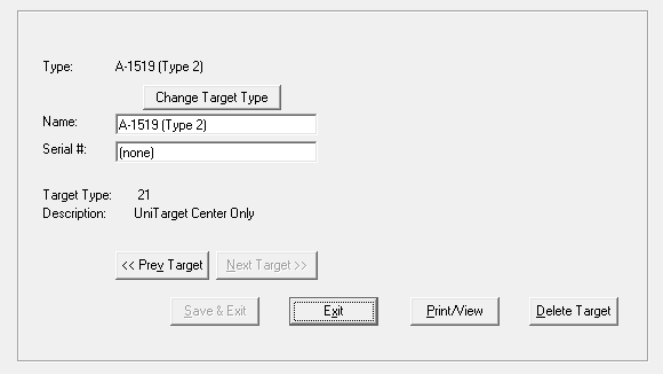


Figure 17 – *Edit Target Screen*

Data Recording Settings

Select **Evenly-Spaced Points** when the points to be measured are *evenly spaced* along the line of motion from the laser or any other reference point (see Figure 18). The user may select the total number of points to measure and the interval between those points (the software then calculates the total travel distance) or the user may select the total number of points to measure and the total travel distance (the software then calculates the interval between points).

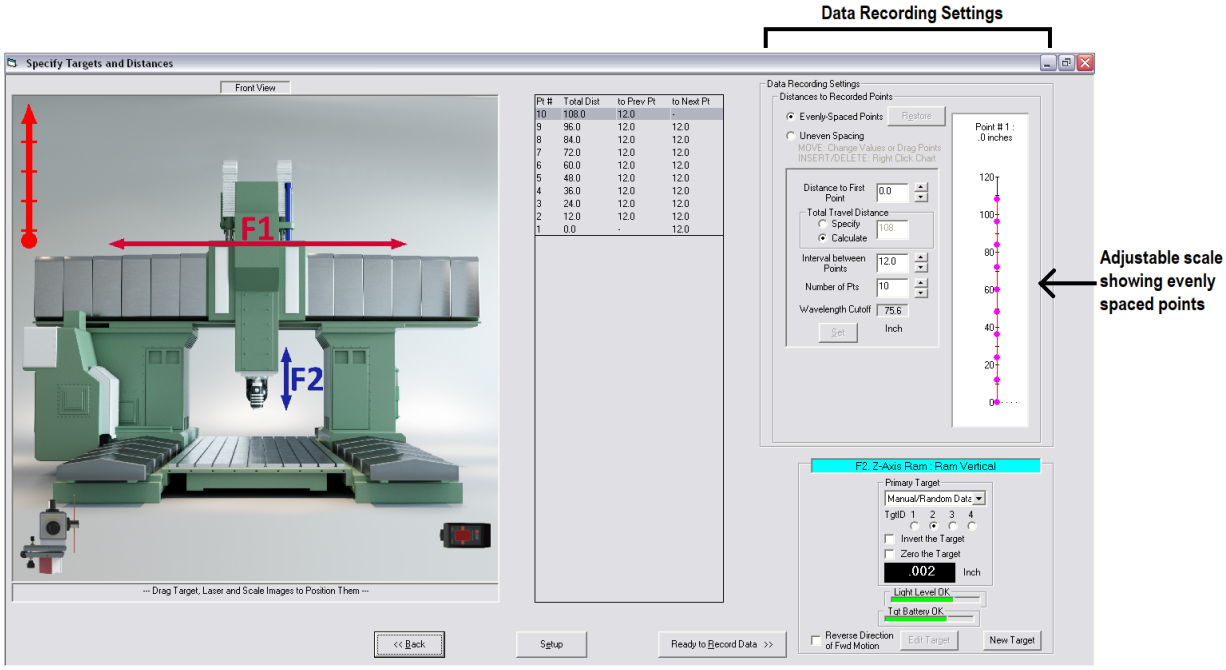


Figure 18 – *Specify Targets and Distances Screen (Data Recording Settings/Evenly spaced points)*

Distance to First Point

Enter a number in this box to reflect the starting distance from the laser to the first point. For example, if the original distance from the laser to the target is 12 in., enter the number 12 in the **Distance to First Point** field.

Total Travel Distance

This is the total travel of the machine tool being aligned (refer to the machine documentation). Enter the total distance and the total number of data points to be recorded or click on the up or down arrows to change the value. The **Interval Between Points** will be automatically calculated and displayed.

– or –

Calculate Total Travel Distance

Enter the **Interval Between Points** and the **Number of Points**. The **Total Travel Distance** will be automatically calculated and displayed.

Number of Points

Enter the total number of points to be measured or click on the up or down arrows to change the value. Select **Uneven Spacing** when the points to be measured are *not* spaced an equal distance along the line of motion (see Figure 19). When this option is selected, you can *move* the points on the adjustable scale by dragging a point with the right mouse button, or information can be entered manually in the **Total Distance from Laser** (**Previous Point** or **Next Point**) box. You can also *delete* a point from the graph by *right clicking* on that point. *Add* a point by *right clicking* on the graph (but not on a point) and specifying the distance at which a new point should be located.

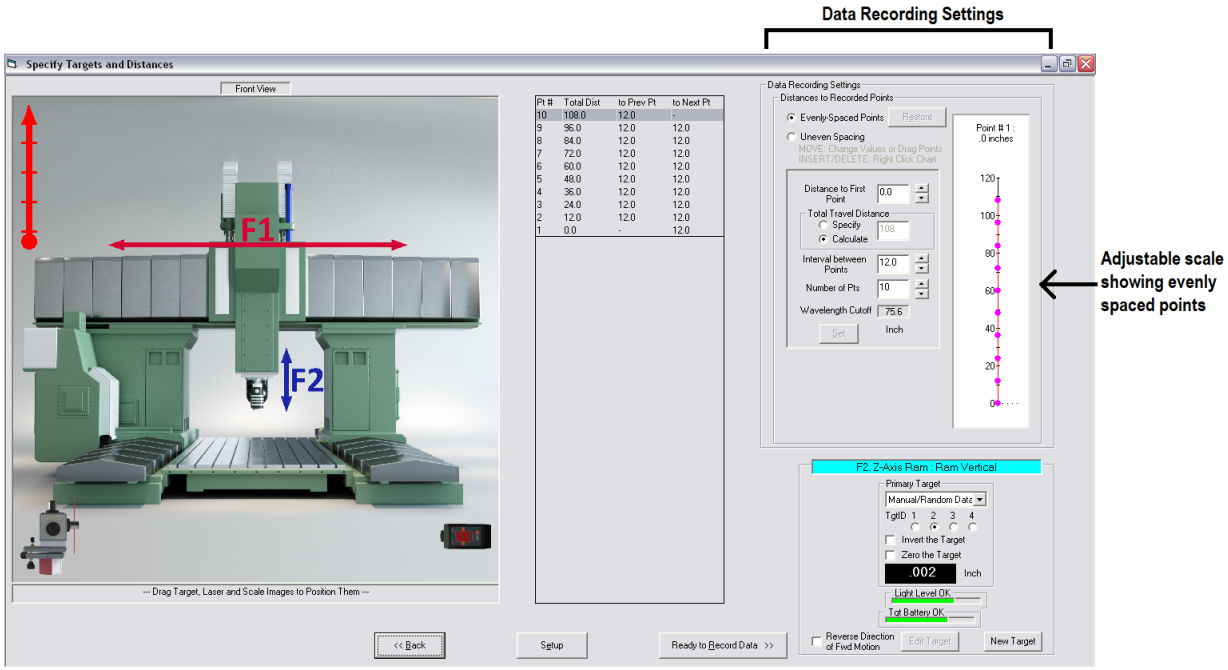


Figure 19 – *Specify Targets and Distances Screen (Data Recording Settings/Unevenly spaced points)*

When all values are entered, click **Ready to Record Data** or press **Alt-R** to begin recording data.

The Record Line of Motion Data Screen

The Record Line of Motion Data Screen is used to collect data. The screen displays the live target data and straightness tolerance for the selected line of motion in graph format. You may record data points in any order if **Auto Increment** is turned off. Click on a point and then record data for that point.

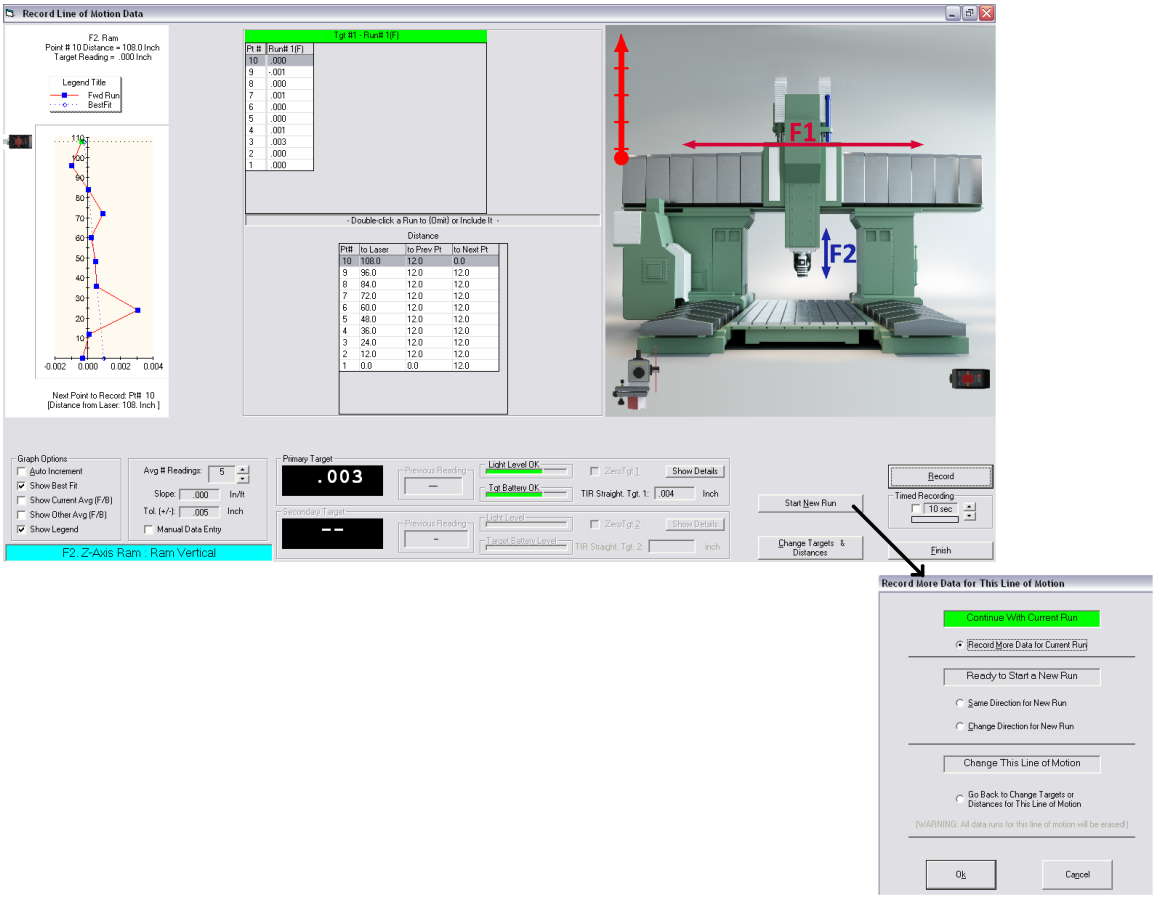


Figure 20 – *Record Line of Motion Data Screen*

Graph Options

Auto Increment

Click the **Auto Increment** box or press **Alt-A** to toggle the Auto Increment feature on and off. When Auto Increment is *on*, the cursor automatically advances to the next position when data are recorded. When Auto Increment is *off*, data will record at the same position and will overwrite the previous data recording. Disabling Auto Increment allows the user to move the target to a point where data has previously been recorded, select that point on the plot and retake the reading.

Show Best Fit

Click the Show Best Fit box to toggle the Best Fit line on and off. The Best Fit line is designated on the graph as a *red* broken line. When Show Best Fit is *on*, the Least Squares Best Fit line will be automatically drawn once the second data point has been taken, and it will be *redrawn* for each successive data point taken. The Least Squares Best Fit line is a mathematical line that "best fits" the slope of the data taken using linear regression analysis.

Show Current Average/Show Other Average
The program keeps separate averages at each point for all **(F)**orward runs and **(B)**ackward runs, as well as an overall total average for *all* runs. For example, it may be desirable to know if a machine is giving the same readings when it moves *forward* as when it moves *backward* to compare the two averages for this line of motion. To change the direction for a run, click **Start New Run (Alt-N)** and select **Change Direction for New Run (Alt-C)** (see Figure 20). Backward runs are designated on the graph by a *yellow* broken line, while a black broken line designates Forward runs.

Manual Data Entry
To enter data manually, click Manual Data Entry and then press the Spacebar. This displays a box to record the target reading.

Change Targets and Distances
Click **Change Targets & Distances (Alt-C)** to return to the Specify Targets and Distances Screen described on Page 15.

Record
Click Record (Alt-R) or press the spacebar to record data.

Start New Run
Click **Start New Run** or press **Alt-N** to record more data for the selected line of motion (see Figure 21). The user may record data from Point 1 by selecting **Same Direction** (**Alt-S**) or from the end point by selecting **Change Direction** (**Alt-C**). Averages are calculated for all forward runs, for all backward runs, and for all runs. These averages are displayed on the **View Graphs/Reports** screen.

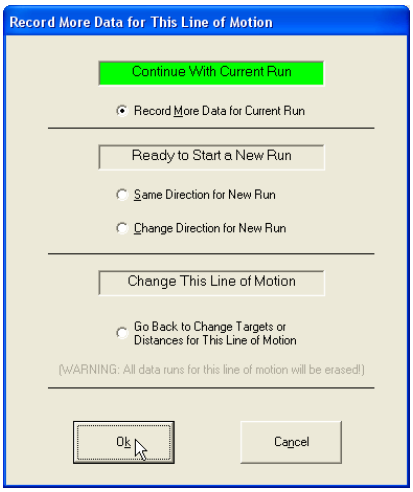


Figure 21 – *Start New Run*

Tolerance
Tolerance displays the tolerance value specified on the Setup Screen for this line of motion.

Slope
Slope displays the calculated slope of the best-fit line through the points recorded for the current run.

Average Number of Readings
Enter a value to specify the number of readings from the target to be averaged to measure each point. Averaging *more* readings at each point may "smooth out" readings that are varying slightly because of vibration. The default value of 3 should be reasonable for most cases.

Save
Click **Save** or press **Alt-S** to save a plot file (see Figure 22). The default filename for the first saved data file is **PLOT0001.plt**. Every time data are saved, the number for the new filename increments by one, for example, **PLOT0002.dat**, and **PLOT0003.dat**. You can provide a new filename or change the directory for the saved files.

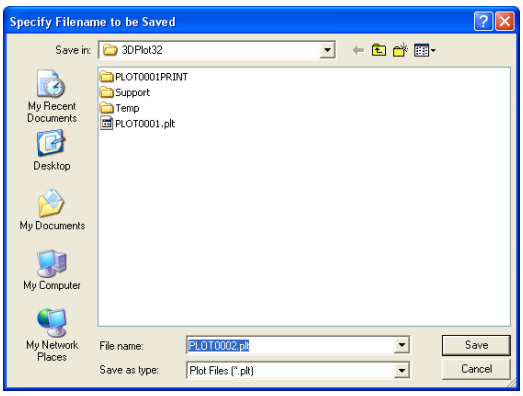


Figure 22 – *Save a Plot File*

Finish

Click **Finish** (**Alt-F**) to finish recording data for a particular line of motion and to return to the Machine Catalog screen. The lines of motion for which data have been recorded are indicated by check marks and the Legend: Data Status box will also contain a check mark to indicate that you are working with recorded data (see Figure 23). You may now either select another line of motion to record, select **Open Data File** to load previously recorded data for viewing or comparison with the current data, or select **View Data/Print Reports**.

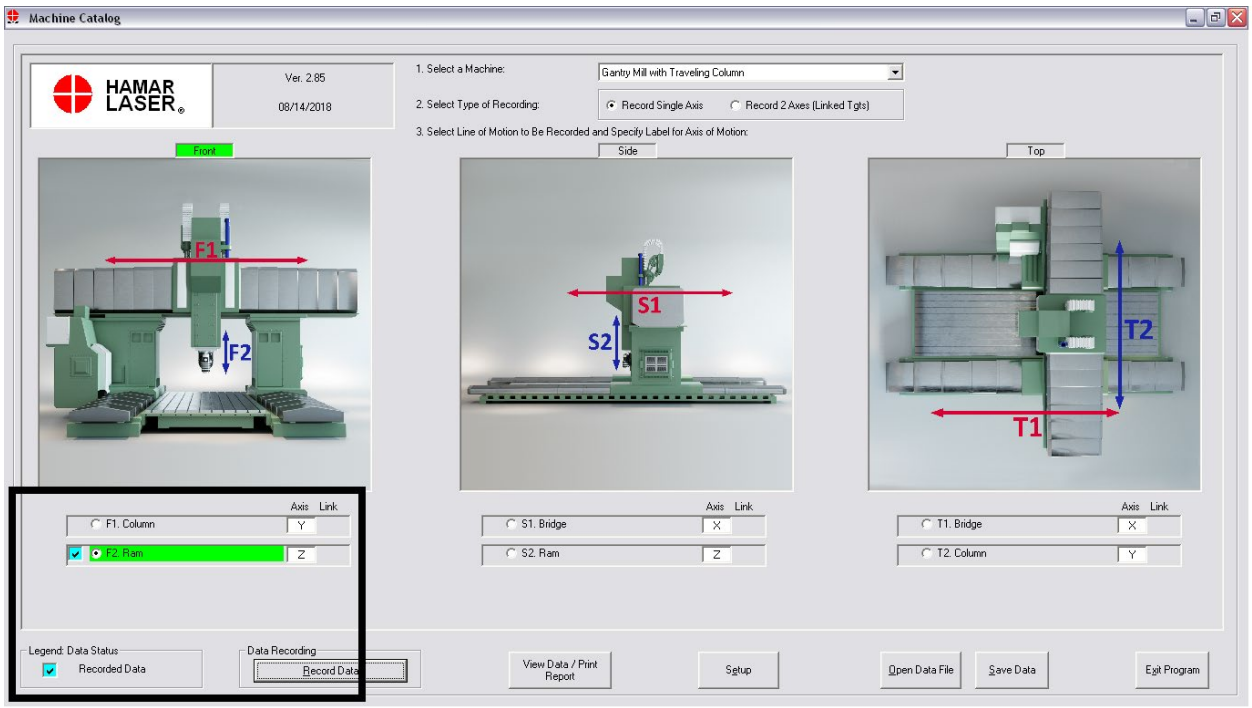
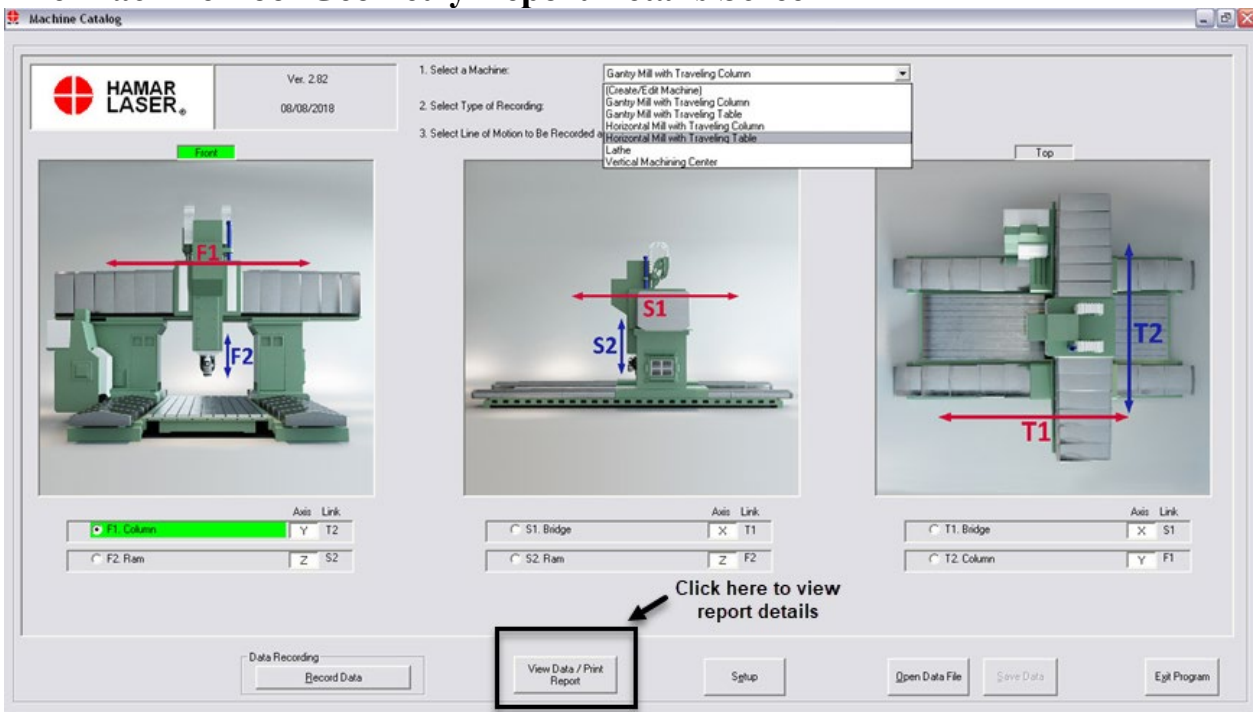


Figure 23 – *Machine Catalog Screen Showing Legend*

The Machine Tool Geometry Report Details Screen



The 3-DPlot Details Screen allows the user to display and analyze all recorded or loaded data for the currently selected view (Front, Side, or Top). Details of the selected line of motion and its squareness or parallelism to other lines of motion can be displayed, or a report of the data may be printed. Details for each line of motion may also be viewed, and each line of motion may be displayed or hidden.

In Figure 24, data for two lines of motion have been taken (Selections F1: Z-Axis Quill and F2: X-Axis Table, comprising the Front View of Horizontal Machining Center 1). The **Legend** is shown and the **Details** Screen for F1: Z-Axis Quill is below the 3DPlot View Plots Screen.

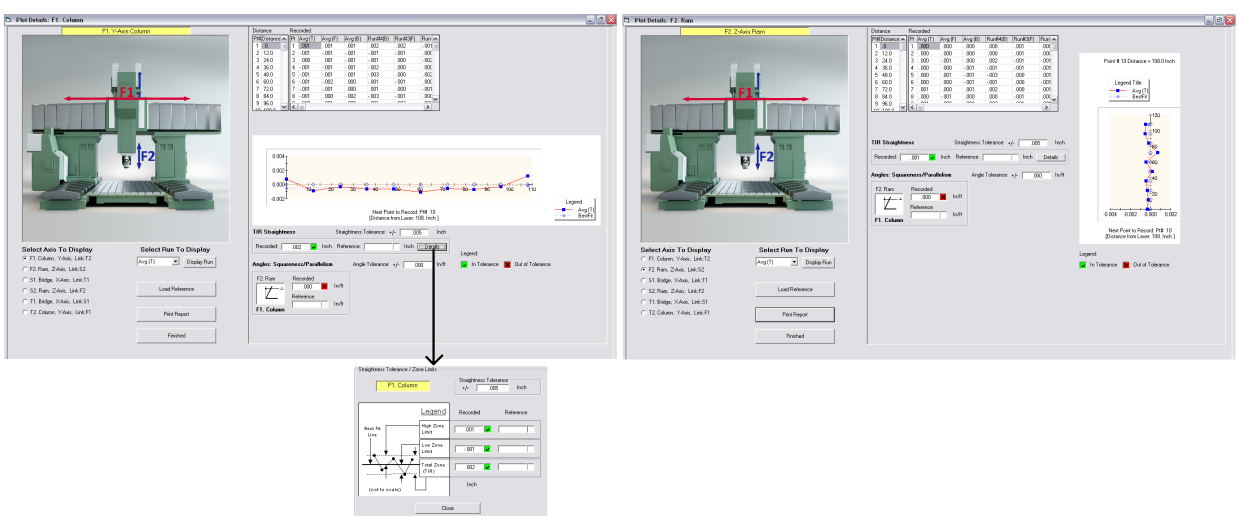


Figure 24 -- *Plot Screen Showing Legend and Details for F1*

Load Reference

To compare current alignment data with that taken during another alignment, click **Load Reference (Alt-L)** to bring up a list of previously saved files. When a second file is loaded for reference, a check also displays in the **Reference Data** box. By removing the check mark from a box, that line of motion will be hidden on the graph. Each **Line of Motion** box has its own scrollbar, which repositions the Best Fit line and data plot identifying that line of motion on the graph. Forward Runs, Backward Runs and All Runs can be viewed for an individual line of motion by clicking the appropriate button (**Fwd Runs**, **Bak Runs**, **All Runs**).

Details

Click **Details** in any **Line of Motion** box to bring up the details for that line of motion and how it is related to other lines of motion. Figure 25 shows the **Details** Screen for S1: W-Axis Quill as it relates to S2: Z-Axis Column and S3: Y-Axis Table (Side View of Horizontal Machining Center 1).

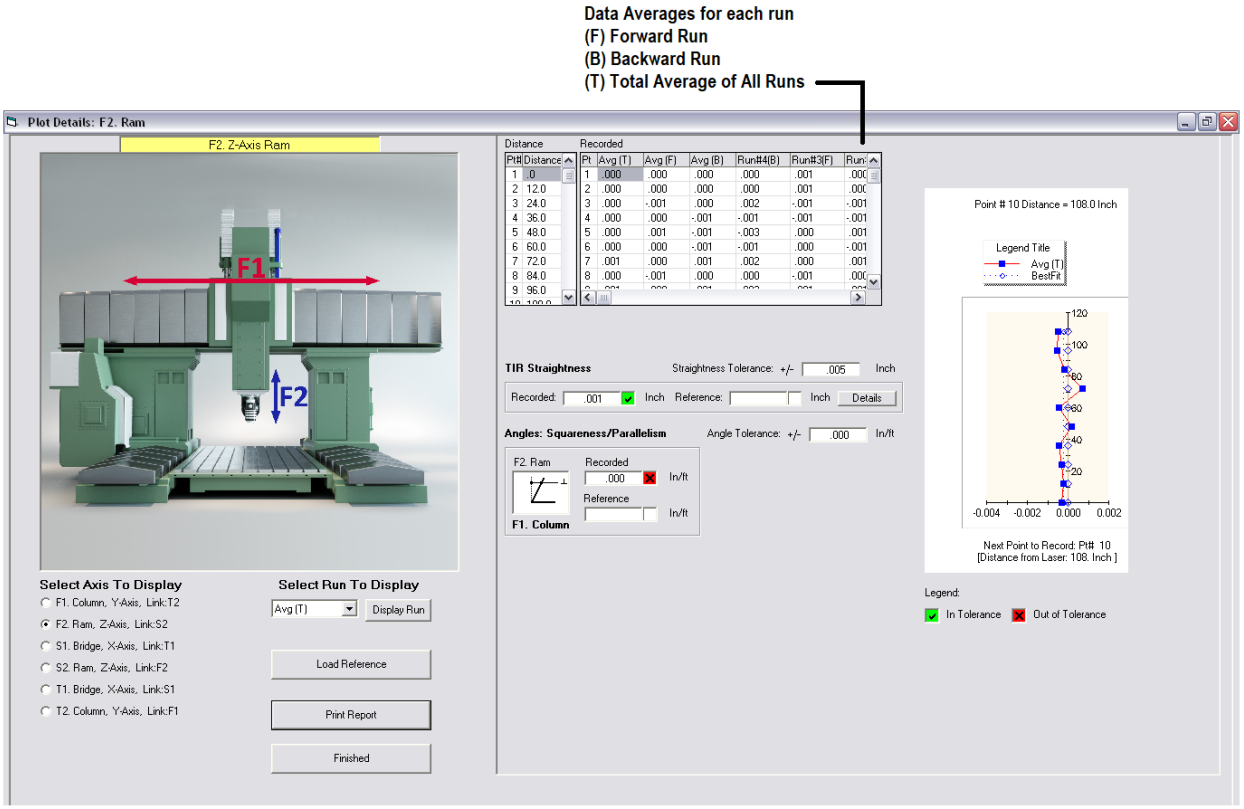
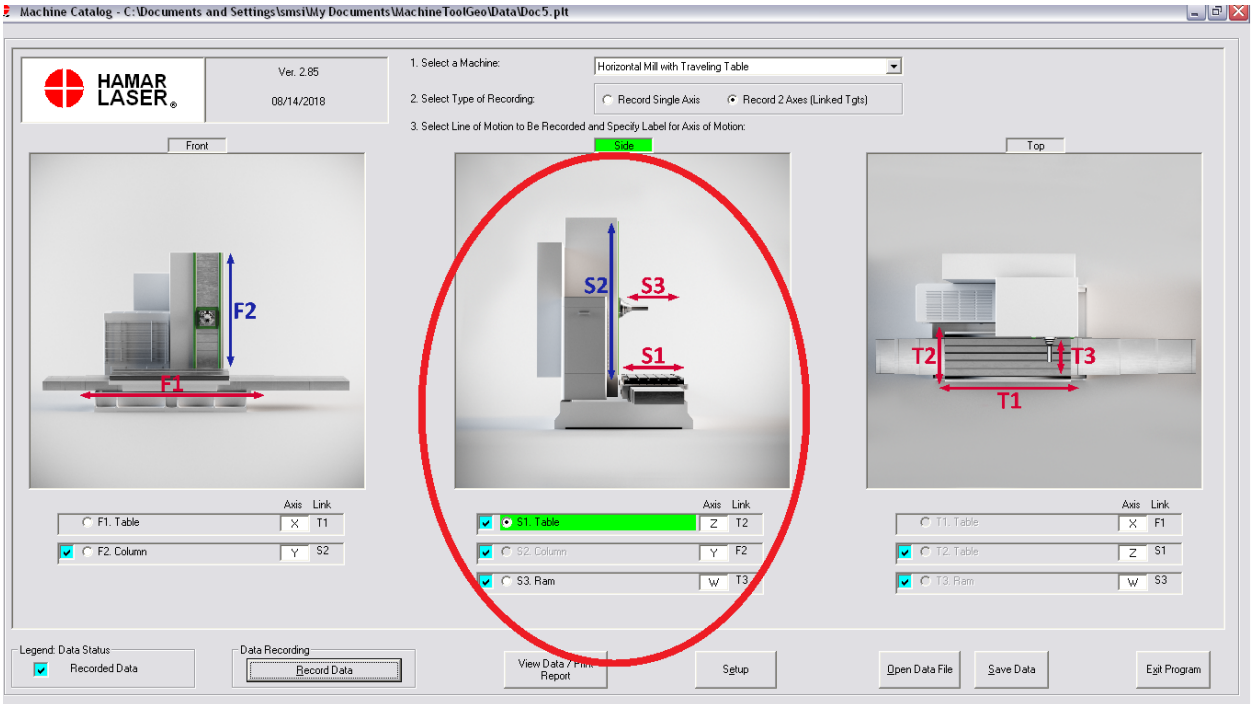


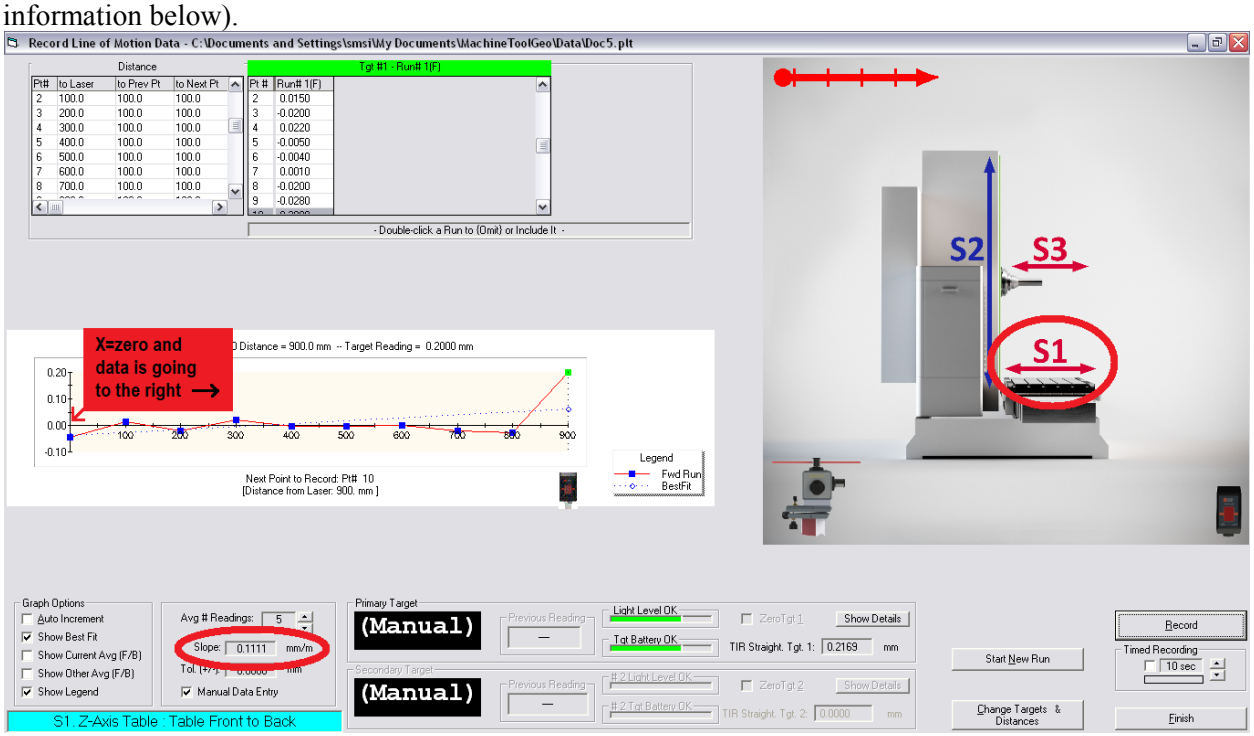
Figure 25 – *Details Screen for a Line of Motion (F2: Z-Axis Ram)*

Interpreting Graphs in Machine Tool Geometry Software

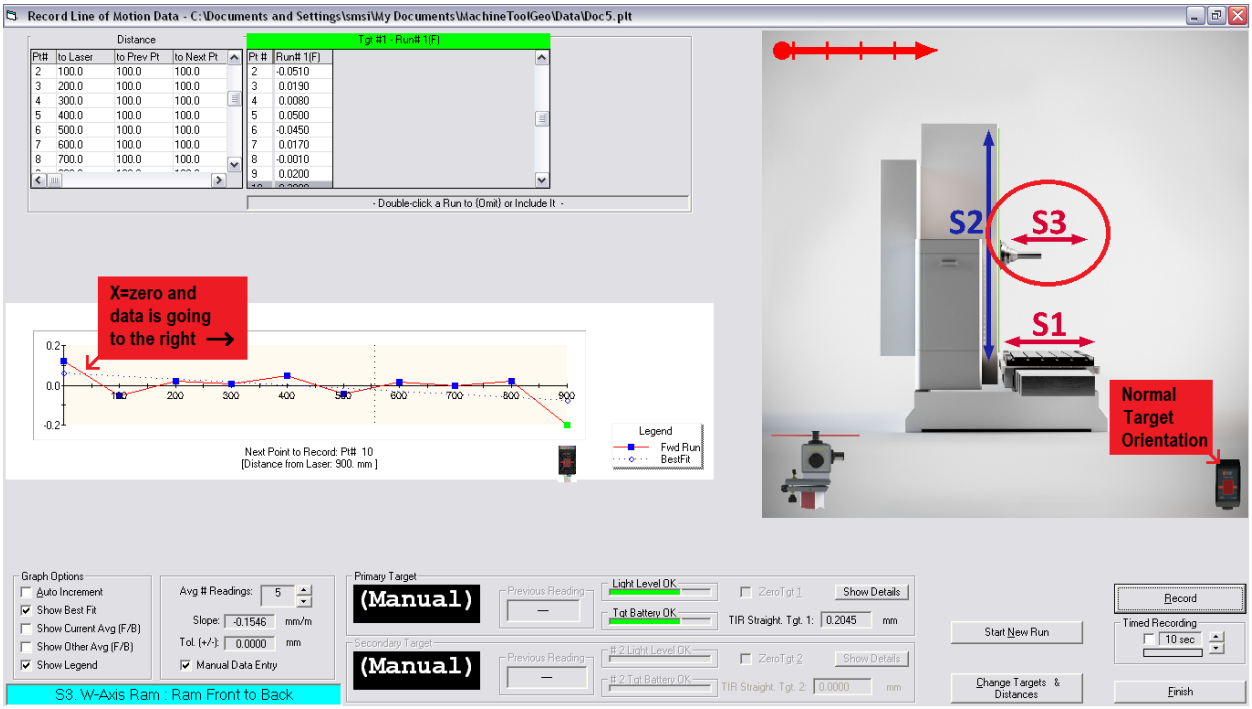
The following is a step-by-step illustration of parallelism for a horizontal floor mill.



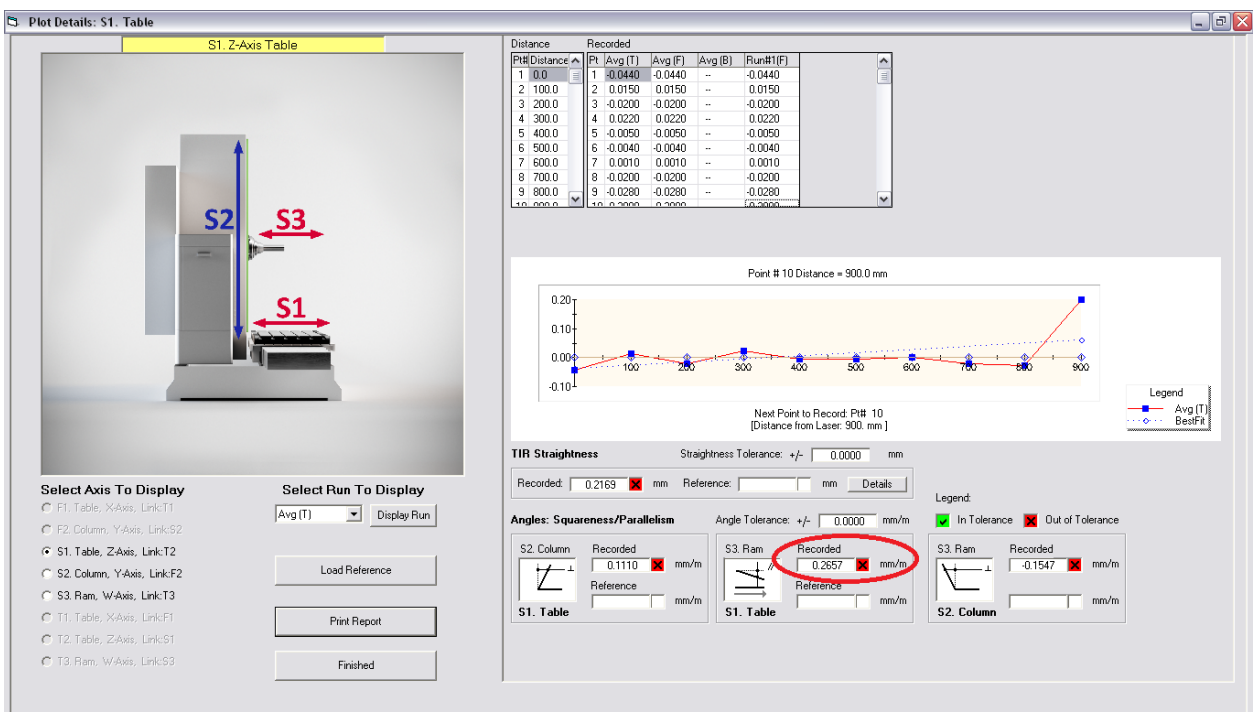
For this horizontal mill, the S1 and S3 lines of motion were measured (see the individual axis information below).



S1 indicates that the slope of the Best Fit line is +0.111 mm/m, sloping up and to the right.



For the S3 data, the slope of the Least-Squares Best Fit line is – 0.1546 mm/m and is sloping down.



The report indicates that the parallelism for S3 to S1 is +0.2657 mm/m, which was calculated by subtracting S3 Best Fit Slope from the S1 Best Fit Slope (0.111 - -0.1547 = +0.2657 mm/m). This is an *open* angle, since the result of the subtraction got larger. If the result is smaller, then it is a *closed* angle. This is also correct if two vertical axes are used.

Print Report

Click **Print Report** (**Alt-P**) to print a report of the data. The **Print** menu allows the selection of a Summary Report or Detail Report, (including the header defined in the Setup Screen and all details for each line of motion) along with page formatting and print preview options (see Figure 26).

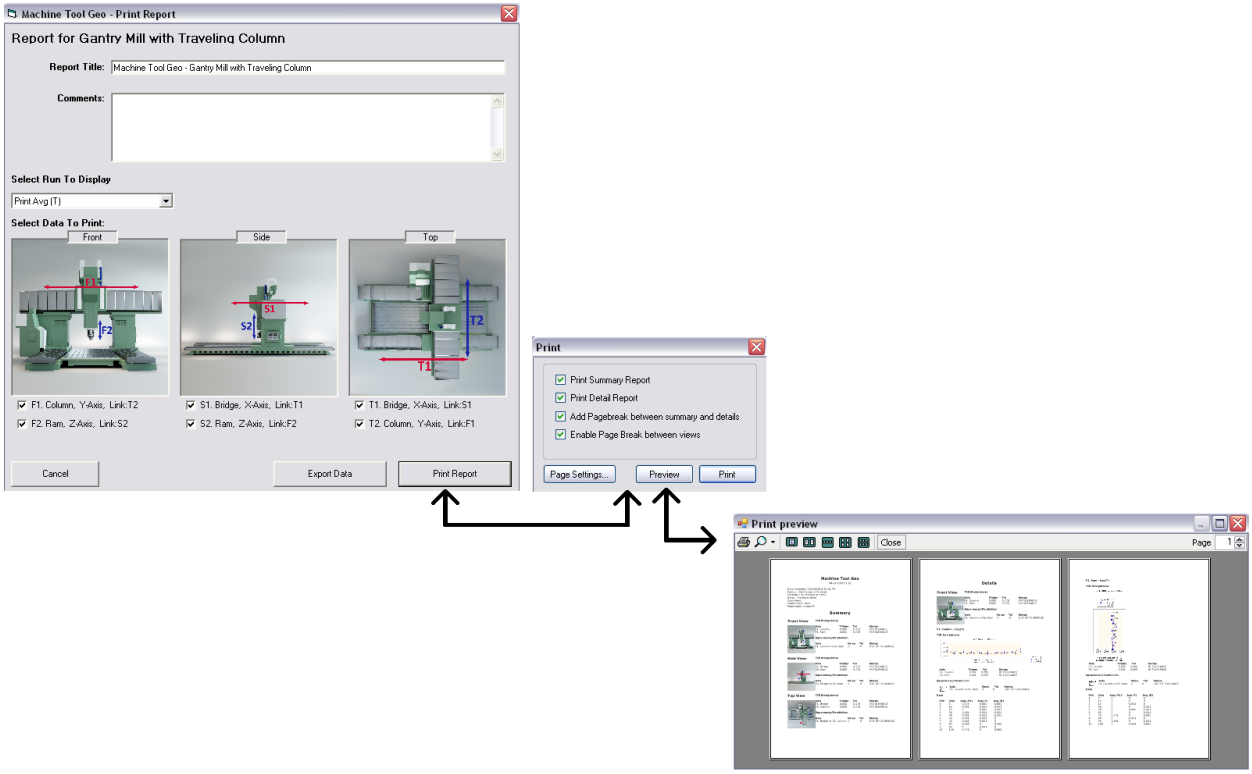


Figure 26 – *Print Report Screen*

Finish

Click **Finish** (**Alt-F**) to return to the **Machine Catalog** screen.

Appendix A – Using the A-910 Radio Transceiver/Hub

Hamar Laser's A-1519/1520 Type II Universal Wireless Targets incorporate a built-in radio transceiver, available in 900 MHz or 2.4 GHz ISM band. Operating through the A-910 Radio Transceiver/Hub, up to 99 Type II Targets may be connected as a Target System Group, and up to ten Target System Groups consisting of 99 targets per group may be used at one time. Power is supplied by a 3.5-volt lithium ion, rechargeable battery or by the computer's USB port. When connected to the USB port, the battery charges automatically.

Figure 27 – *A-910 Radio Transceiver/Hub*

Front Panel Features

1. **Power ON indicator and Low Battery indicator**
2. **Internal backup battery charging indicator and USB LINK ESTABLISHED indicator**
3. **TX indicator:** blinks when device is transmitting data to the target(s)
4. **RX indicator:** blinks when the device is receiving data from targets or other transceivers.
5. **System ID setting switch:** set to the same number as the R-1307's CH (Channel) number.

Figure 28 – *The A-910 Radio Transceiver/Hub FRONT PANEL*

Rear Panel Features

1. **Not used**
2. **USB/Data I/O Port**
3. **Power Switch**
4. **External power supply:** required only for computers that cannot provide adequate power (5V, 400 mA) through the USB port.
   Note: *When using the USB Extender™ cable extension kit, plug the A-910-2.4 into an A/C power supply.*
5. **Antenna**

Figure 29 – *The A-910 Radio Transceiver/Hub REAR PANEL*

See Appendix C for radio specification details.

MODEL NUMBER	PRIMARY FREQUENCY
A-910-900	**900 MHz**
A-910-2.4	**2.4 GHz**

Setting the Target Network ID and System ID for the R-1307 Readout

To make the unit visible to all other radio-enabled devices, you must set the Target Network ID and the System ID for the readout.

1. **Set the Local Readout/Target Network ID**

   Press **MENU** until the *upper* display shows id=nn (nn is also equal to the R-1307 number) and the matching target number with the current target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID.

   Press MENU button again until the lower display shows id=nn, with the current target ID (nn) blinking. Use the UP and DOWN arrow keys to set the Target ID to the same value as that of the upper display's Target ID.

2. **Set the System ID (Radio Channel)**

   Press **MENU** until the upper display shows ch = nn, with the current System ID (nn) blinking. Use the UP and DOWN arrow keys to set the System ID.

   Note that nn must be set to the same number as the channel switch setting of the A-910 radio transceiver.

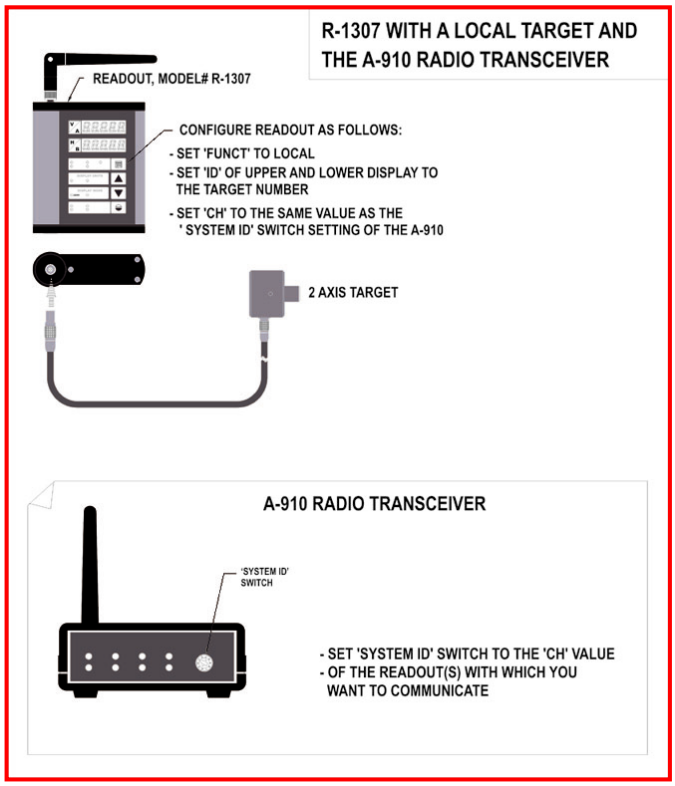


Figure 30– *R-1307 with Cabled (Local) Target and A-910 Radio Transceiver*

Miscellaneous Display Messages

-HLI-	
r 1.00	Startup Message. Lower Display shows firmware Revision Number.
. . .	Three moving dots. Wireless target is not responding to a polling request from Readout. Check ID and Channel settings. Check Target(s).
- - -	3 dashes. Target detected but the laser is not on target. Check laser.
ch.=no	
rAd io	Radio channel cannot be selected because no Radio is present or detected. Standard message for R-1307C. For Models R-1307 or R-1307W, this message indicates a fault in the radio module.
FAuLt	
PSd	Indicates a problem with the connection to the Cabled (Local) Target's Position Sensing Device (PSD). Check plugs and cable(s).
tGt.n	
UncAL	Target 'n' descriptor does not contain target calibration data.

Appendix B – Create/Edit a Machine

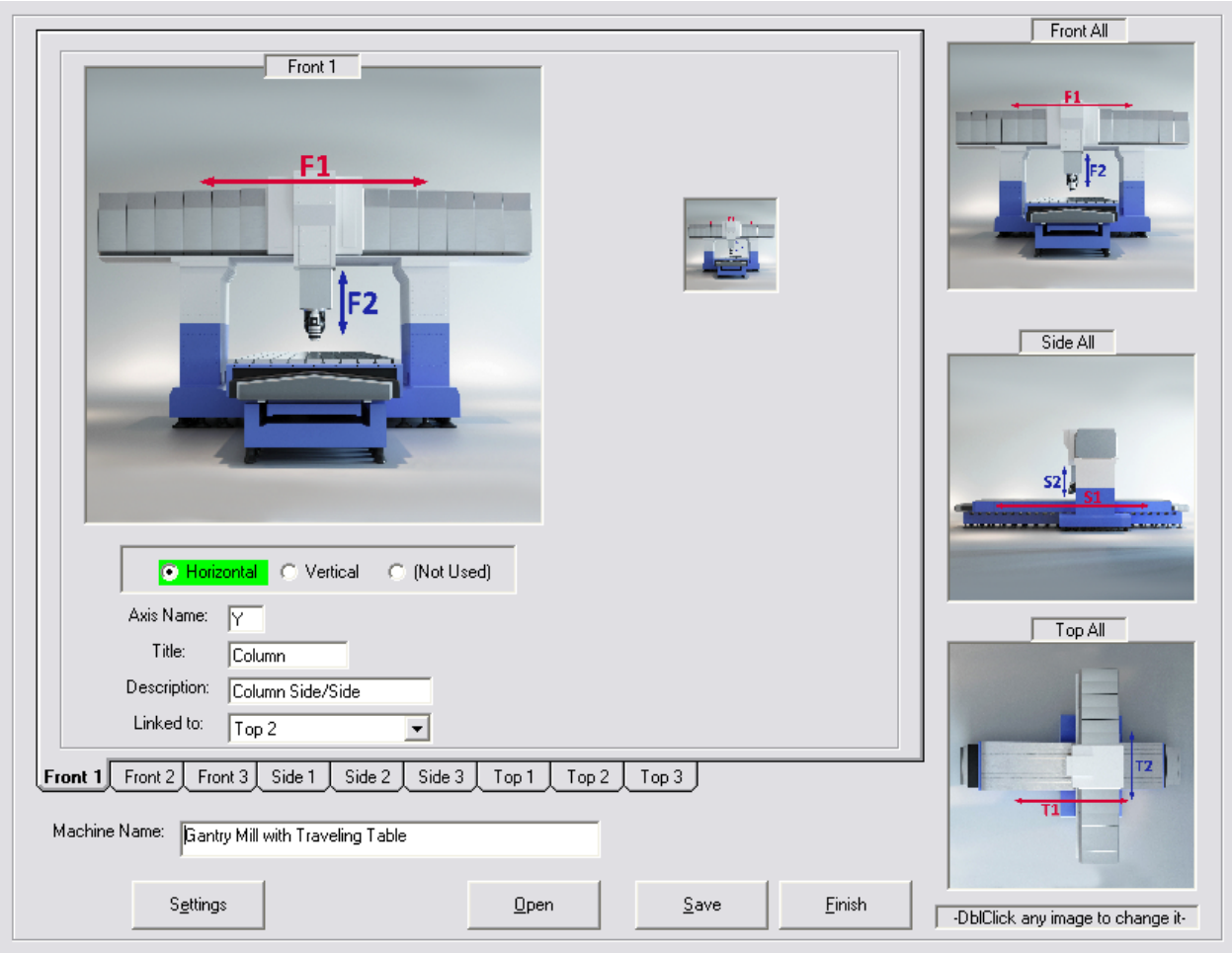


Figure 31 – *Create/Edit Machine Catalog File*

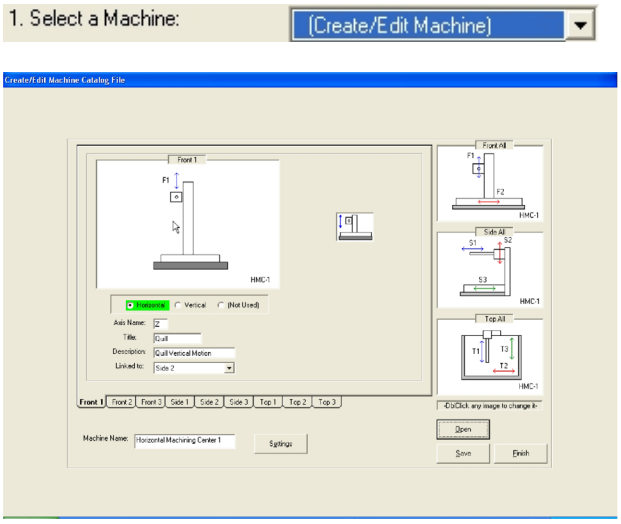
A .CAT file, located in the 3D Plot directory on your computer, defines each machine on the list. These files contain the images required for each view (front, side and top) and for each line of motion (Front1, Front2, etc.). Each line of motion has an axis name, (Z, X, etc.) a description, a direction (vertical or horizontal) and a *linked* line of motion when two targets are being used simultaneously.

Following is a brief description of the process to *edit* one of the existing machines on the list, or to *create* your own machine. Detailed steps are provided in

1. Select a machine type *similar* to the one to be measured from **Select a Machine** on the Machine Catalog Screen.
2. When the machine parameters display, select the **Create/Edit Machine** from **Select a Machine**. The existing machine information can be modified and user-generated graphics can be used to replace existing graphics by clicking on an image and specifying the filename of the new graphic.
3. When modifications are complete, type a new name in the **Machine Name** box and click **Save** to save the file.

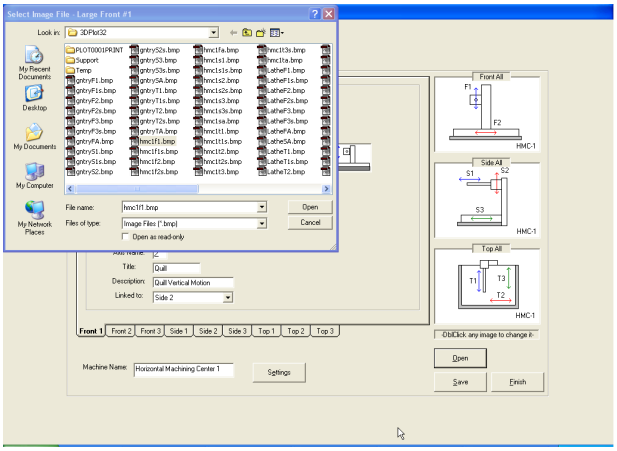
To Edit an Existing Machine

1. Using the dropdown menu for Select a Machine , select the machine to be edited. When the machine graphics display, select Create/Edit Machine.

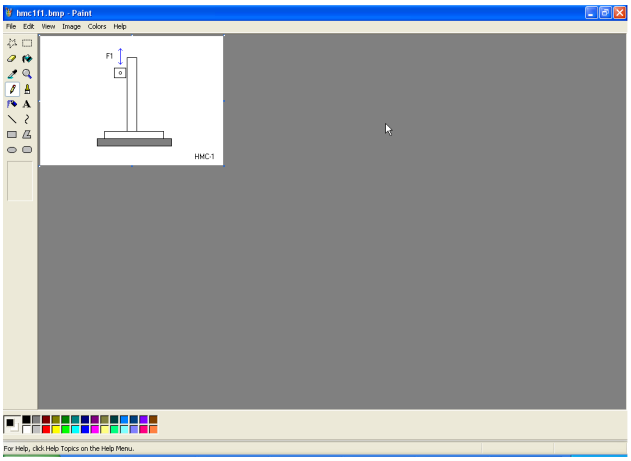


2. Note that there are three tabs each for Front View, Side View and Top View. In each view, the Axis Name, Title and Description, as well as Link to Another View (when using linked targets) may be edited. To edit an image, double-click on it.

3. The Select Image File dropdown list displays, containing the file names of all the images that are cataloged. Right click on the file name of the image to be edited and select **EDIT** from the list. For example, a *front* image for Horizontal Machining Center 1 would be named **hmc1f1.bmp** or **hmc1f2.bmp**. A *front all* image for the same machine would be named *hmc1fa.bmp*. *Side* images would be named **hmc1s1.bmp, hmc1s2.bmp** and **hmc1s3.bmp** or **hmc1sa.bmp** for *side all*. The small insert image would be **hmc1f1s.bmp**.



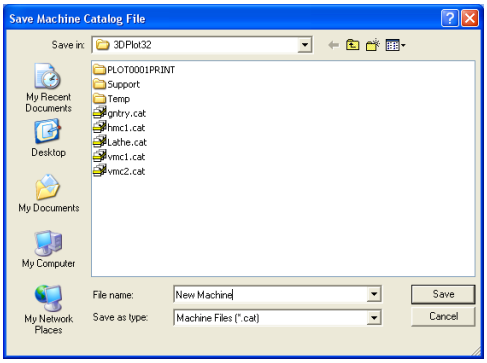
4. Microsoft Paint opens the image for editing. Edit the image as necessary and then click **Edit > Save As** to give the file a new name.

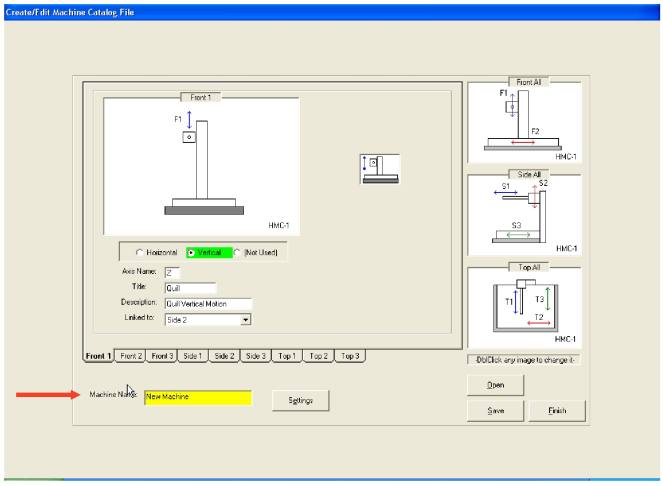


5. Close the Select Image File dropdown list. Double-click the image again and the updated Select Image File dropdown list displays with the newly-created file name. Double-click on the new file name and the new image replaces the one previously displayed in the image window.

6. Repeat the editing process for all the images that need to be edited.

7. When completed, type a new name in the Machine Name box and click **Save.** The Save Machine Catalog file dropdown list displays. Type the new machine name and click **Save.**

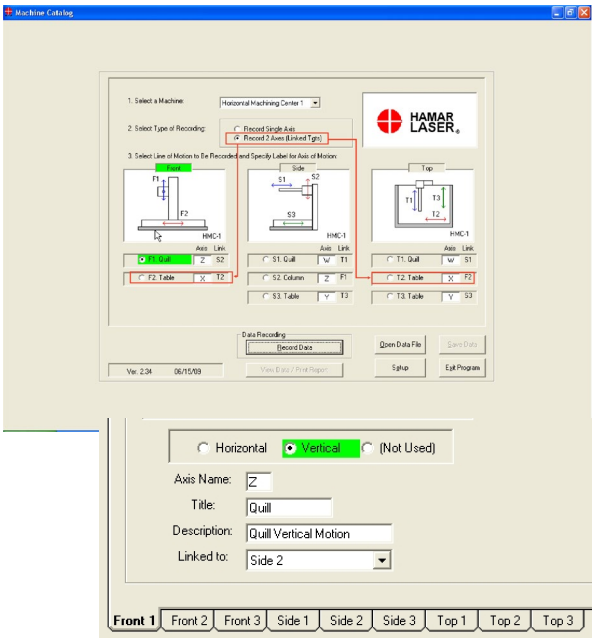




Linking Axes

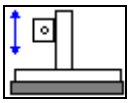
Linking axes allows 3D Plot to read two targets simultaneously in order to record the vertical and horizontal readings of a single axis. It is *not* possible to read two axes at the same time, but rather one axis in two directions. The *squareness* of two axes cannot be recorded using linked targets.

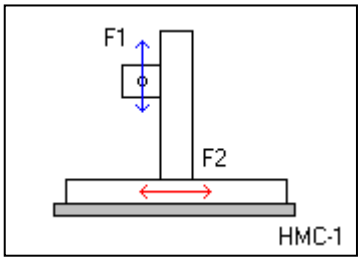
You may link axes when using two targets so that both targets may be read simultaneously. **Record 2 Axes (Linked Tgts)** must be selected as the Type of Recording. In the example shown, Axis Name: Z on Front 1 is linked to Axis Name: Z on Side 2.



For example, Horizontal Machining Center 1 is the selected machine. The lines of motion are defined as follows:
F1 Quill – Z-axis line of motion straightness relative to the Y-axis, with a target mounted horizontally on the quill
F2 Table – X-axis line of motion vertical straightness, with a target mounted vertically on the table
S1 Quill – W-axis line of motion straightness relative to the Y-axis, with the target mounted vertically on the quill
S2 Column – Z-axis line of motion straightness relative to the X-axis, with a target mounted horizontally on the column
S3 Table – Y-axis line of motion vertical straightness, with a target mounted vertically on the table
T1 Quill – W-axis line of motion straightness relative to the X-axis, with a target mounted horizontally on the quill
T2 Table – X-axis line of motion horizontal straightness, with a target attached horizontally to the table
T3 Table – Y-axis line of motion horizontal straightness, with the target attached horizontally to table
The letter designation for an axis may be changed for each selection as setup needs require. For more information, see Select Type of Recording on Page 11.

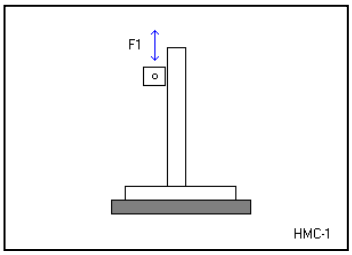
To Create a New Machine
When creating images for a new machine, ensure that the image size is 300 x 212 pixels. The small insert image must be 60 x 45 pixels.

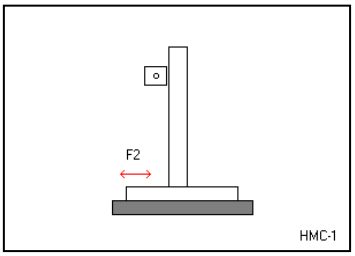


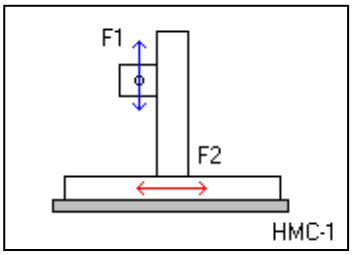


Using a drawing program, create the machine images for Front, Side and Top if needed for your machine. Also create Front All, Side All and Top All images, as illustrated on Page 35. Once you have created your images, save or copy them to the 3D Plot folder located in C:\Program Files.

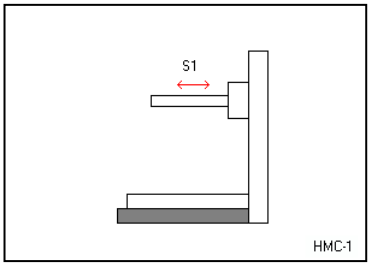
Horizontal Machine Center – Front Images

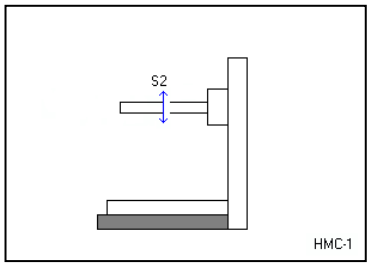


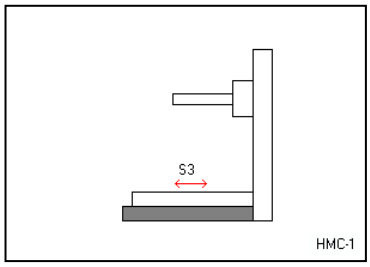


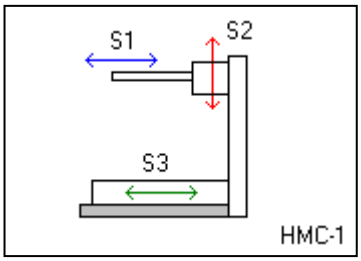


Horizontal Machine Center – Side Images

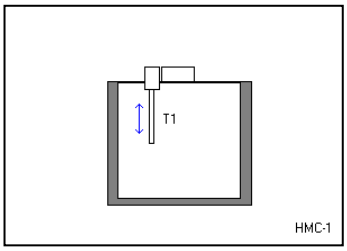


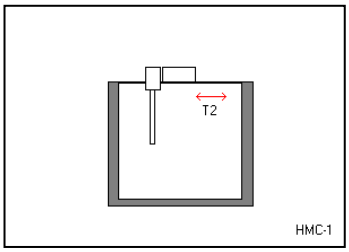


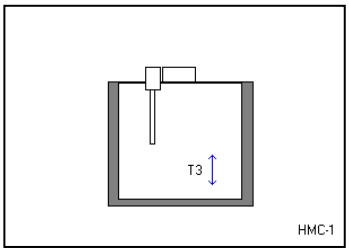


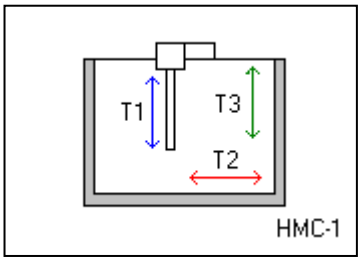


Horizontal Machine Center – Top Images









Appendix C – Agency Certifications

Agency Certifications for the 2.4 GHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-24XSTREAM
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ RF EXPOSURE WARNING: This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended

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IC (Industry Canada) Certification

Contains Model 24XStream Radio (2.4 GHz), IC: 4214A 12008
Complies with IC ICES-003

CE ⓘ

Complies with ETSI. *France – France imposes restrictions on the 2.4 GHz band. Go to www.art-telecom.Fr or contact MaxStream♦ for more information. Norway – Norway prohibits operation near Ny-Alesund in Svalbard. More information can be found at the Norway Posts and Telecommunications site (www.npt.no).*

Since the 2.4 GHz band is not harmonized throughout Europe, other restrictions may apply to your country.

Technical Data:
- OEM radio transceiver, model number: 24XStream
- Frequency Band: 2400.0 – 2483.5 MHz
- Modulation: Frequency Shift Keying
- Channel Spacing: 400 kHz
- ITU Classification: 400KF1D
- Output Power: 100 mW EIRP max.
- Notified Body Number: 0891

♦ The radio Transceiver contained in the A-1519/A-1520 Type II Universal Wireless Targets is manufactured by MaxStream®. For more information pertaining exclusively to the Radio Transceiver please contact MaxStream at 1.801.765.9885 or visit their web site: http://www.maxstream.net

Agency Certifications for the 900 MHz Radio Transceiver

FCC (United States of America) Certification

Contains FCC ID: OUR-9XCITE
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

⚠ RF EXPOSURE WARNING: This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended

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IC (Industry Canada) Certification

Contains Model 9XCite Radio (900 MHz), IC:4214A-9XCITE