Deflection Simulator Users Guide

Table of Contents

Deflection Simulator Users Guide

Purpose

The *Deflection Simulator* shows the effect of deflection compensation from different vendors on a horizontal arm CMM with a kinematic of XZY. The input parameters for the different deflection models match those of the vendor and the output shows a series of horizontal and vertical length measurements that would be observed with a laser. Measurement gauges can be added anywhere inside the measurement volume in order to see the impact on length.

The graphical representation shows the correction shape from the input parameters for the different correction models. The error of the graphical representation can be multiplied in order to show the effect of the correction.

The methods used by vendors to compensate for deflection are not standardized. Some vendors such as BnS and DEA use lookup tables for deflection compensation where vendors such as Renishaw and LK use correction constants.

The deflection models created for the different vendors is based on available information and may not match the actual model used by the vendor.

User Interface

The user interface of the deflection simulation utility is shown in illustration 1.

Option:

Option	Description
Measurement Editor	A dockable widget that can be used to add or edit gauge measurements anywhere in the volume of the horizontal arm CMM.
Deflection Model	Deflection model used by the vendor. The number and type of the input parameters are matched to the selected deflection model.
Y Range	Length of the Y axis of the simulated CMM.
Z Range	Length of the Z axis of the simulated CMM.
Input parameters	Up to four input fields associated with the selected deflection model.
Exaggeration	Multiplier for the simulation display error.
File – New	Delete all measurements are reset the active deflection model to reasonable values.
File - Init	Reset the active deflection model to reasonable values. Unlike File-New this does not delete the measurement data.
View – Measurement Editor	Show or hide the Measurement Editor dialog.
Help – About	Report the version of the deflection editor utility.

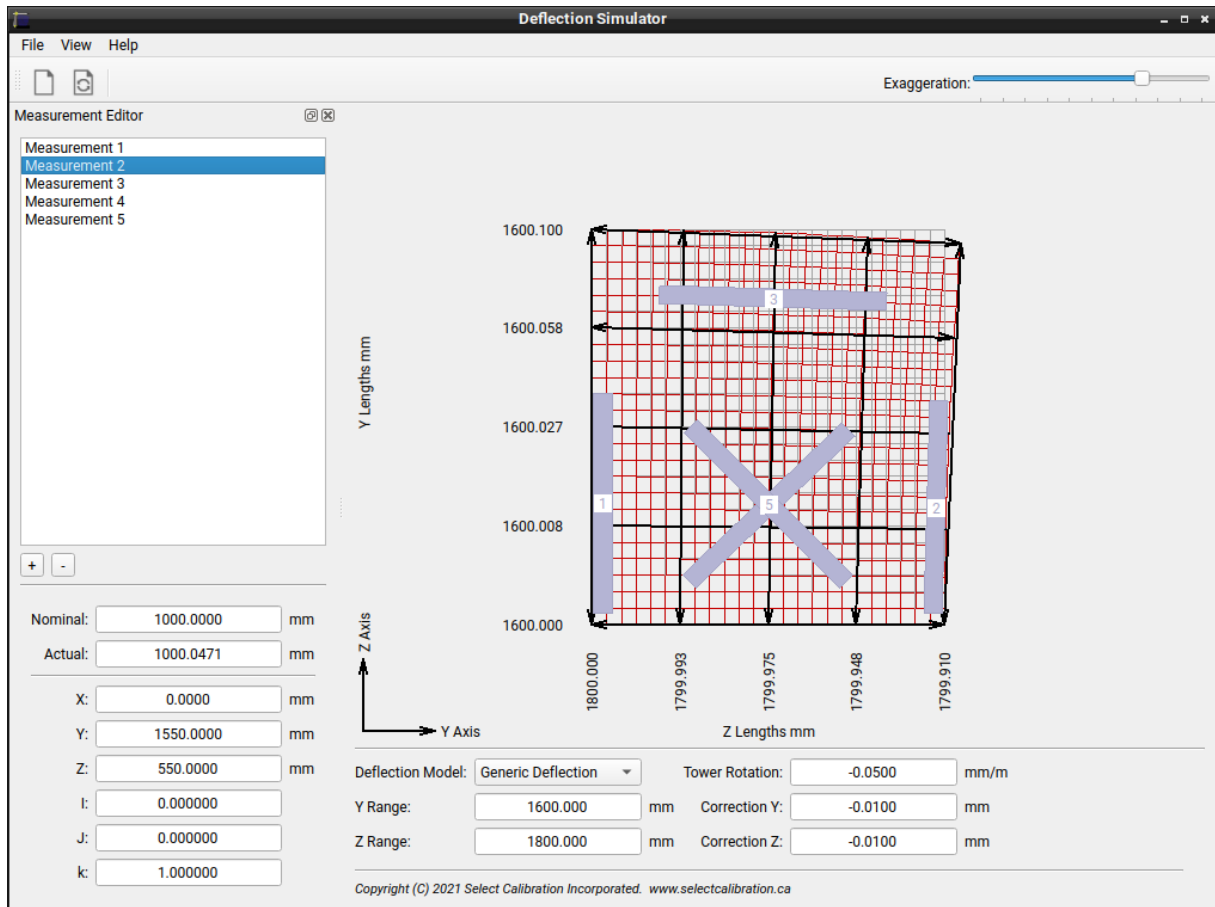# Deflection Simulator Users Guide

Illustration 1: Deflection simulator main window.

The coordinate system of the simulated horizontal arm CMM has the YZ zero at the bottom left with positive Y to the right and positive Z up. This reference point matches the mechanical origin of a typical CMM.

Measurement Editor

The measurement editor is a dockable widget that can be used to create or edit gauge block measurements anywhere relative to the volume of the horizontal arm CMM. Illustration 2 shows the measurement editor with an active measurement.
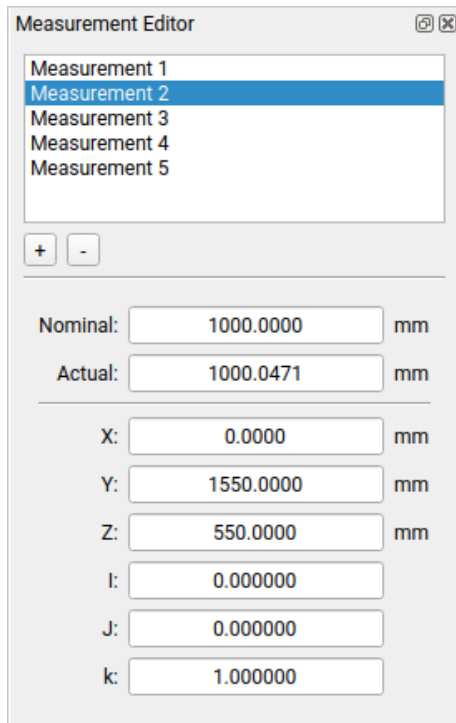
Illustration 2: Measurement editor widget.

Option	Description
Measurement List	Shows the list of all available measurements. Selecting a specific measurement will enable the measurement editor and show the expected measurement length.
Nominal	The nominal length of the measurement gauge block.
Actual	The actual length of the measurement gauge block.
X	X position of the center of the gauge block. This field is read only and always zero.
Y	Y position of the center of the gauge block.
Z	Z position of the center of the gauge block.
I	Orientation vector along the X axis. This field is read only and always zero.
J	Orientation vector along the Y axis.
K	Orientation vector along the Z axis.

The actual length of the gauge block is based on the active deflection values, the nominal length, and the position of the block. The actual length is updated automatically when any of these fields are modified.

Deflection Model

The deflection model allows selection of the method used for deflection compensation of a horizontal arm CMM. The deflection model ideally matches the method used by the vendor.

The deflection models created for the different vendors is based on available information and may not match the actual model used by the vendor.

Deflection Model	Input Options	Units	Comments
Generic Deflection	Tower Rotation	mm/m	Angle measured at base of tower at top of Z from Y zero to Y extended.
	Correction Y	mm	Proportional correction of Y axis over the Y and Z axis range.
	Correction Z	mm	Proportional correction of Z axis over the Y and Z axis range.
Renishaw Deflection	Tilt	mRad/m	Angle measured at base of tower at top of Z from Y zero to Y extended.
	Bend2	mm/m2/m	Correction of YZ. Z correction is 2x Y correction. Correction is non-linear.
	Bend3	mm/m3/m	Correction of YZ. Z correction is 3x Y correction. Correction is non-linear.
LK Deflection	ZCRS.R1.C1	mm/mm	Correction in the Y axis scaled to the inverted length of ZCRS.R2.C1.
	ZCRS.R2.C1	mm/mm	Inverted length for correction ZCRS.R1.C1.
	ZCRS.R3.C1	arcsec	Angle measured at based of tower with Z at top from Y zero to Y extended scaled to a length of 1 mm.
	ZCRS.R4.C1	mm/mm	Inverted length for correction ZCRS.R3.C1.

Generic Deflection

The generic deflection model is not from any vendor but based on observations of actual machines in the field. The bulk of the correction is handled by the tower rotation parameter and further tweaked using the YZ linear correction fields.

Renishaw Deflection

The Renishaw deflection model treats the tilt as an X roll parameter so, unlike the generic model, this provides no correction along the Z axis and must be combined with one or both bend parameters to fully describe the error. The two bend parameters provide non-linear corrections in the YZ where Bend2 corrects twice Z relative to Y and Bend3 corrects three times Z relative to Y.

Deflection Simulator Users Guide

LK ZCRS Deflection

The ZCRS.DAT file used by LK contains the deflection information along with other parameters. An example of this file is shown below:

```
   .0000500000        .0000000000        .0000000000
   .0006250000        .0000000000        .0000000000
  -.0080572004        .0000000000        .0000000000
   .0005000000        .0000000000        .0000000000
.0000000000E+00    .0000000000E+00    .0000000000E+00         .00       .00
.0000000000E+00    .0000000000E+00    .0000000000E+00         .00       .00
```

The first column of four values contains the deflection information. The entries names in the *Deflection Simulator* utility are based on the name of the file, row number, and column number. For example, ZCRS.R3.C1 is the value in the file ZCRS.DAT, Row 3, Column 1.

The example ZCRS data is for a horizontal arm CMM with a Y axis range of 1600 mm and a Z axis range of 2000 mm. The Z measurement length error of -0.100 mm at Y=1600 and Y (residual) measurement length error of 0.100 mm at Z=2000 mm. The following images show the different parameters in the *Deflection Simulator utility* using the ZCRS entries shown above:
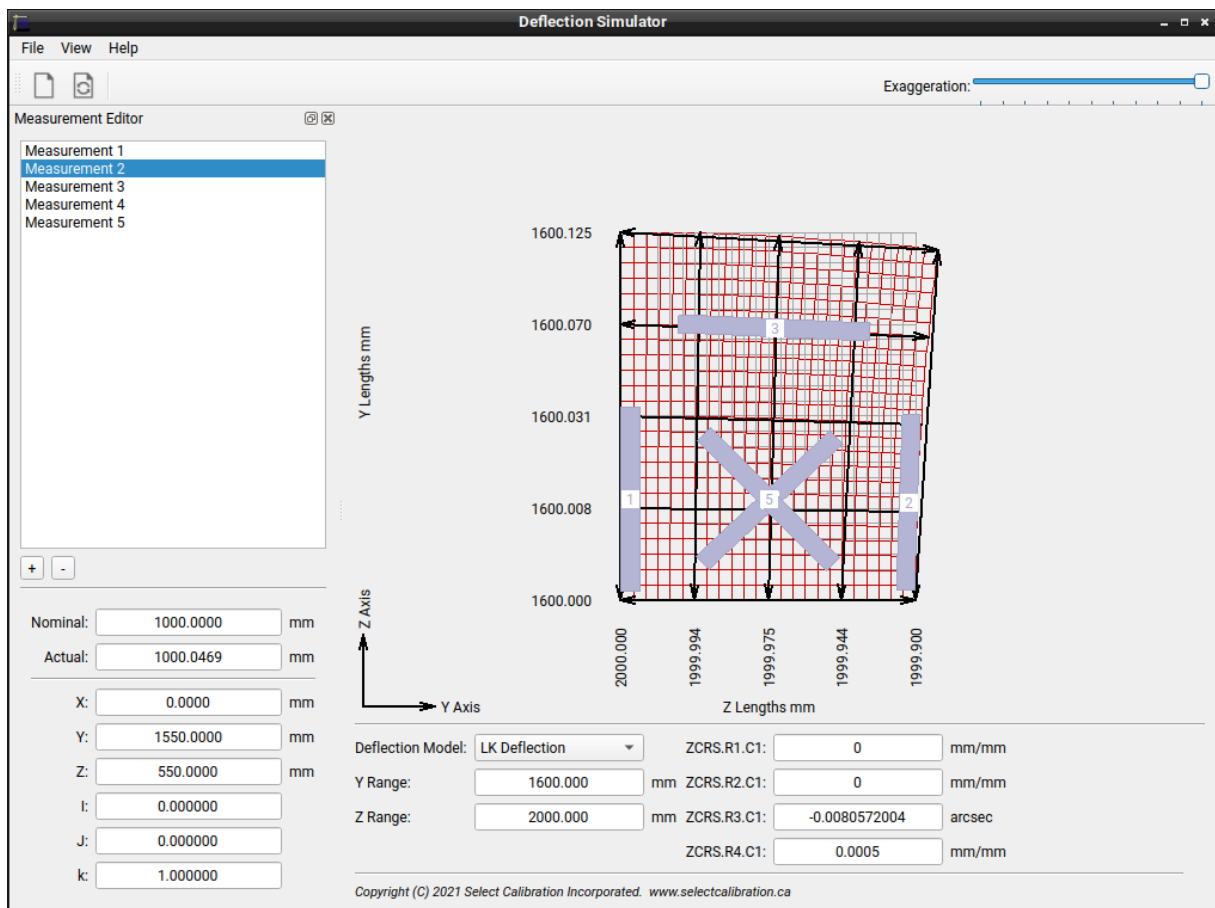

Illustration 3: Effect from ZCRS.R3.C1 and ZCRS.R4.C1 parameters.

Illustration 3 shows the effect from the angular correction (ZCRS.R3.C1/ZCRS.R4.C1). As the

tower leans out at the top of the Z it affects both the Z and Y axis lengths. Note the Z length at Y=1600 shows and error of 0.1 mm which was one of the defining parameters. Also note the length in the Y axis at the top of the Z is 1600.125 (error of +0.125 mm) from the deflection of the tower.
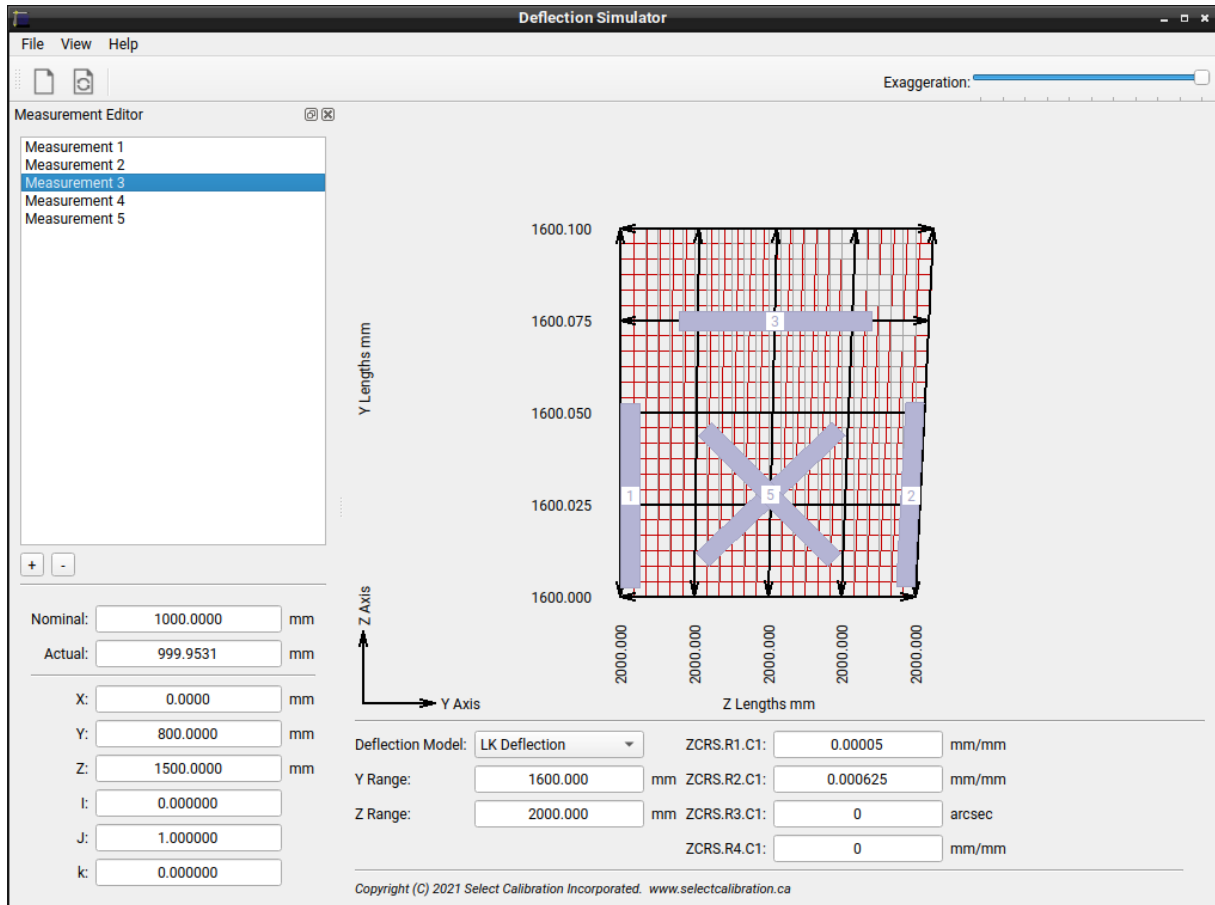

Illustration 4: Effect from ZCRS.R1.C1 and ZCRS.R2.C1 parameters.

Illustration 4 shows the effect from the linear correction in the Y axis (ZCRS.R1.C1/ZCRS.R2.C1). Note the Y length at Z=2000 shows and error of 0.1 mm which was one of the defining parameters.
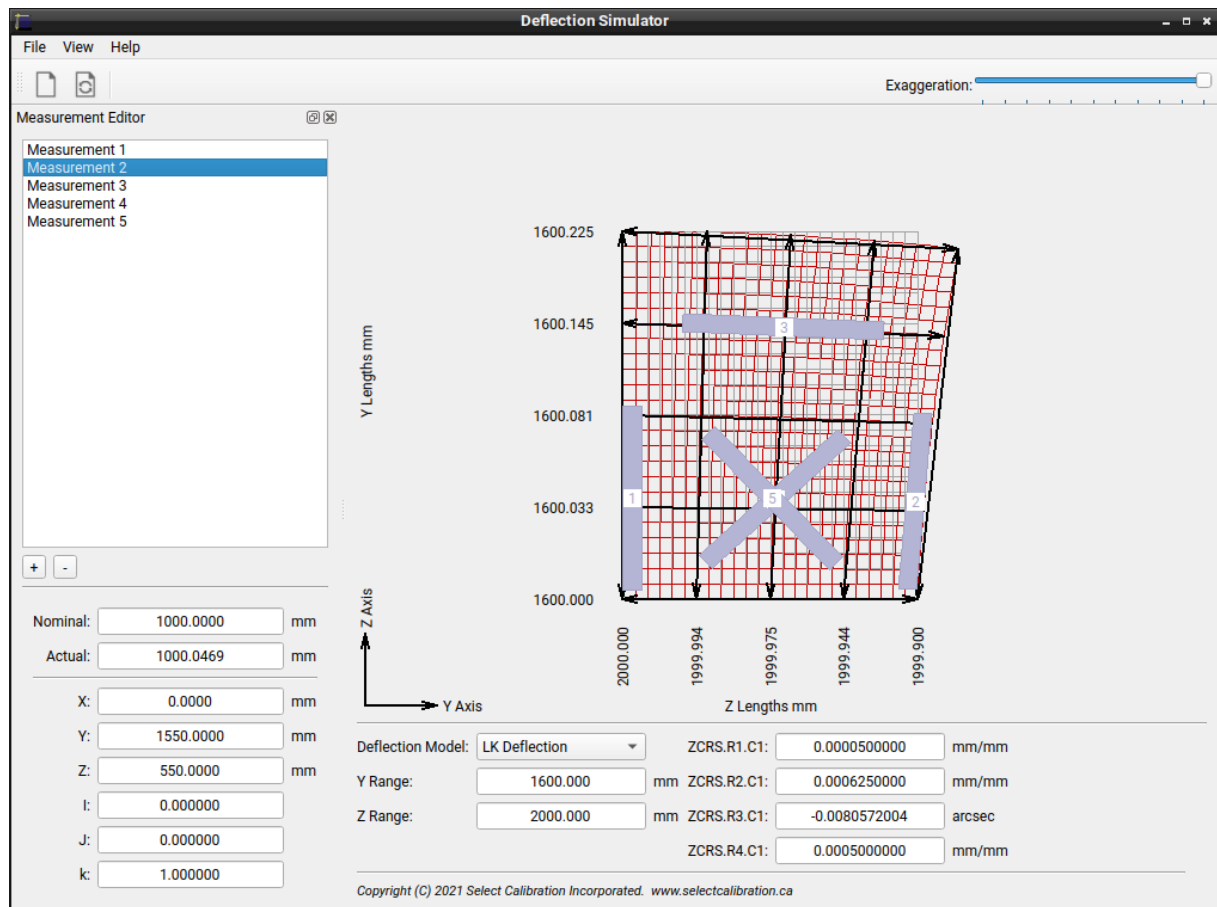
Deflection Simulator Users Guide

Illustration 5: Effect from all ZCRS parameters.

Illustration 5 shows the effect of all corrections from the ZCRS data file. Note the error in the Y axis length at the top of the tower is 0.225 mm which is the sum of the angular correction of 0.125 mm and the Y axis correction of 0.100 mm.

Deflection Simulator Users Guide

Revision History		
Date	*Version*	*Changes*
Jul 30, 2021	1.0	Initial release.
Aug 6, 2021	1.1	Added fourth deflection input parameter. Improved LK simulation. Locked simulation width / height aspect ratio. Added length mode option.
Sep 15, 2021	1.2	Update of Renishaw model Interpretation of mRad incorrect. Comparable to mm/m not um/m.
Sep 23, 2021	2.0	Changed interface. Added menu, toolbar, and dock widget. Added ability to add or edit gauge block measurements.