

Ballbar Viewer Users Guide

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Introduction

The Ballbar Viewer utility was written to allow users the ability to display and analyze ball bar measurement data when performing interim checks on their CMM. Interim checks are necessary to ensure that the machine is running properly and also used to verify that changes to the machine, such as a software upgrade, have not adversely affected the accuracy of the machine.

The Ballbar Viewer utility can display data from three different file formats. The first two formats are currently in use where the third format is the new style defined by SCI and the default output format for all ballbar programs included with this or future utility programs. This utility is cross platform compatible and can be run on GNU/Linux, OSX, and Windows.

Overview

The Ballbar Viewer utility is a single dialog window with three tabs that have specific functions. The default view is the model tab that shows a graphical representation of the measurements. The analysis tab shows a text and histogram of the measurement data where the third tab is used to set the tolerance for the allowed variation in length from the ballbar measurements.

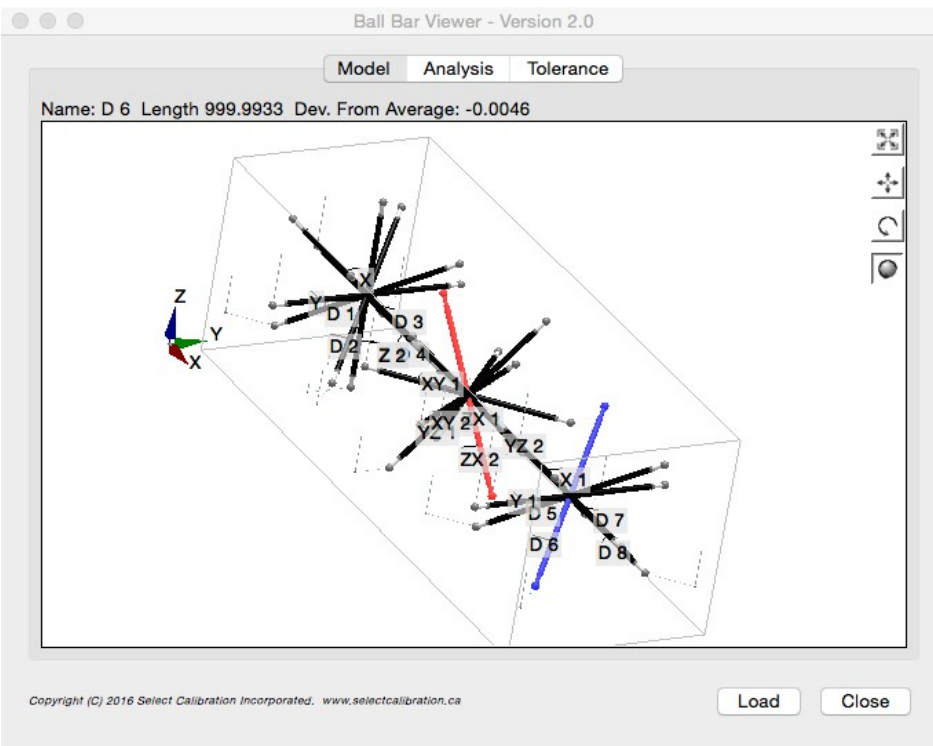


Illustration 1: Ballbar Viewer utility showing the model of the ball bar measurement positions.

Adding Measurement Data

Measurement data can be added to this program by one of two methods:

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- Drag and Drop the measurement file onto the Ballbar Viewer utility program.
- Press the Load button at the bottom of the Ballbar Viewer program and select the input file.

The input files usually have a *DAT* extension but files with any extension can be used provided the contents are one of the expected formats.





Model View

The model view shows the measurement data in 3D along with an outline of the measurement volume and axis directions for reference. Measurements that are outside of tolerance are shown in red and a selected ballbar is shown in blue.

Measurement uncertainty is not considered for when deciding if a result is inside or outside of specification. This is the traditional method when performing a ballbar measurement test so this method was also used by the Ballbar Viewer utility program. Including measurement uncertainty when deciding if a measurement set is inside or outside of specification is the preferred method.

Display 3D Controls

The 3D model display is not fixed and can be manipulated in a variety of ways. The model is displayed on the idea of a projection frustum to mimic the relative size of objects based on the distance away from the viewer to provide a slightly more realistic rendering of the volume of the data.

<i>Image</i>	<i>Description</i>
	Scale to fit. Adjusts the scale of the OpenGL Projection matrix to fit the visible data into the display viewport.
	Pan Mode. When enabled a right mouse button click and drag will move the position of the displayed model. For systems with a single mouse button use Ctrl + Mouse.
	Rotate 2D Mode. When enabled a right mouse button click and drag will rotate the model around the center of the viewport. For systems with a single mouse button use Ctrl + Mouse.
	Rotate 3D Mode. When enabled a right mouse button click and drag will rotate the model around the click position on the displayed model. For systems with a single mouse button use Ctrl + Mouse.

Selection Data

The ballbar measurements shown in the model view window can be individually selected with a left mouse button click. When a ball bar has been selected information about the measurement will appear at the top of the model window and the selected ballbar will be highlighted in blue. The selection data includes the name, actual length, and deviation from the average length of all measured ballbar positions.

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Probe Information

The probe data is drawn graphically above the first sphere of every ball bar measurement. An example of the probe data display is shown in illustration 2.

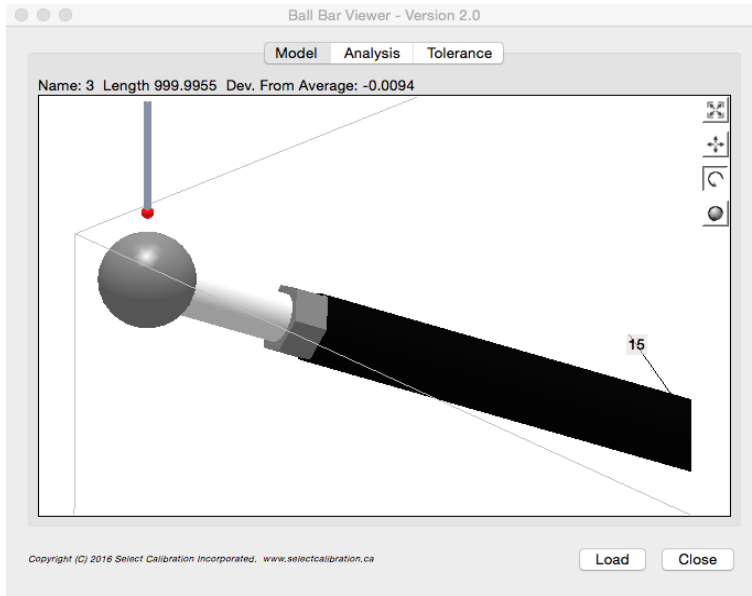


Illustration 2: View of a ballbar measurement showing the probe data above the first measured sphere.

OpenGL

The graphical view of the measurement is drawn using OpenGL. Starting with version 2.0 of the Ballbar Viewer a newer base class for rendering 3D data is used. The computer must have at least OpenGL version 2.x or higher in order to run this utility program with a visible model window.

Using the newer base class solves a number of problems such as the opaque (or nonexistent) zoom window. The newer OpenGL widget is also more suitable for using modern features such as vertex shaders. The Ballbar Viewer program will be eventually updated with the newer OpenGL features and methodologies and moving to the new widget is the first step.

The advantage of the older OpenGL base class was compatibility with legacy systems. Version 1.x of the Ballbar Viewer utility would work on computers that only supported OpenGL 1.x.

Running the Ballbar Viewer program on computers that only support OpenGL 1.x the graphics window is automatically disabled and replaced with an information window. An example of this information window is shown in illustration 3.

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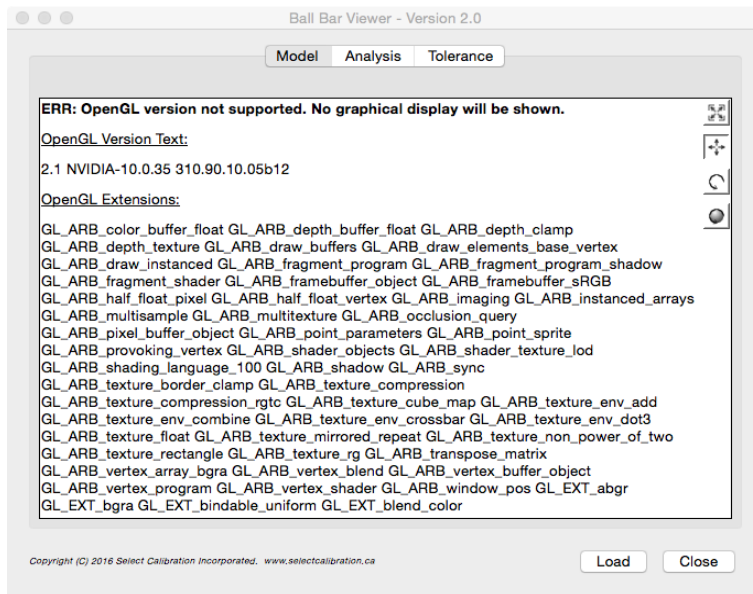


Illustration 3: Information screen that is displayed with unsupported OpenGL versions.

In the event the model view of the data is disabled the rest of the program will continue to work as expected.

Analysis View

The analysis view of the data shows the measurements in a distribution histogram and all the numerical results in a text window. The analysis is intended to help identify results which are not typical of the overall measurements. The analysis text view summarizes the measurement data with the following information:

```
Measurement Volume
-----
Start X:    -0.0347 mm
End X:     1000.0019 mm
Range X:    1000.0366 mm
Start Y:    -0.0118 mm
End Y:     2000.0498 mm
Range Y:    2000.0616 mm
Start Z:   -1000.0151 mm
End Z:      0.0065 mm
Range Z:    1000.0216 mm

Measurement Statistics
-----
Measurement Count:      22
Minimum Length:        999.9900
Maximum Length:        1000.0207
Range Length:           0.0307
Average Length:         1000.0049
Median Length:          1000.0053
StdDev Length:          0.0085
Tolerance:              0.0270

Estimated Range for 99% of Measurements: 0.02544
```

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Number Outside of Estimated Range: 4

Individual Measurement Results

```

-----
Position Name           Length      Deviation  Sph1 Form  Sph2 Form
-----
BallBar 1.2.1 - 1     1000.0207    0.0158    0.0012    0.0023
BallBar 1.2.1 - 2     1000.0038   -0.0011    0.0007    0.0038
...
  
```

<i>Parameter</i>	<i>Description</i>
Measurement Volume	Describes the area of the machine as a cube with values that contain all of the ballbar measurements. The volume is based on the center positions of all measured spheres.
Measurement Count	Total number of ball bar measurements.
Minimum Length	The length of the shortest ball bar measurement.
Maximum Length	The length of the longest ball bar measurement.
Range Length	Difference in length between the shortest and longest ball bar measurement.
Average Length	The average length of all ball bar measurements.
Median Length	The middle length between the shortest and longest measurement. If fliers exist in the measurements this will often be very different from the average length.
StdDev Length	The standard deviation of the length measurements.
Tolerance	The current working tolerance. This value is defined by entering a tolerance expression in the tolerance tab and calculated from the average ballbar length.
Estimated Range for 99%	The range of three standard deviations of the data.
Number Outside Estimated	The total number of length measurements that fall outside the estimated range of the length data.
Individual Measurements	A list of all the individual measurements that were used for the calculations.

The sphere form error should be considered when reviewing measurement data. Measurements that show a large sphere form error for one or both spheres should not be trusted.

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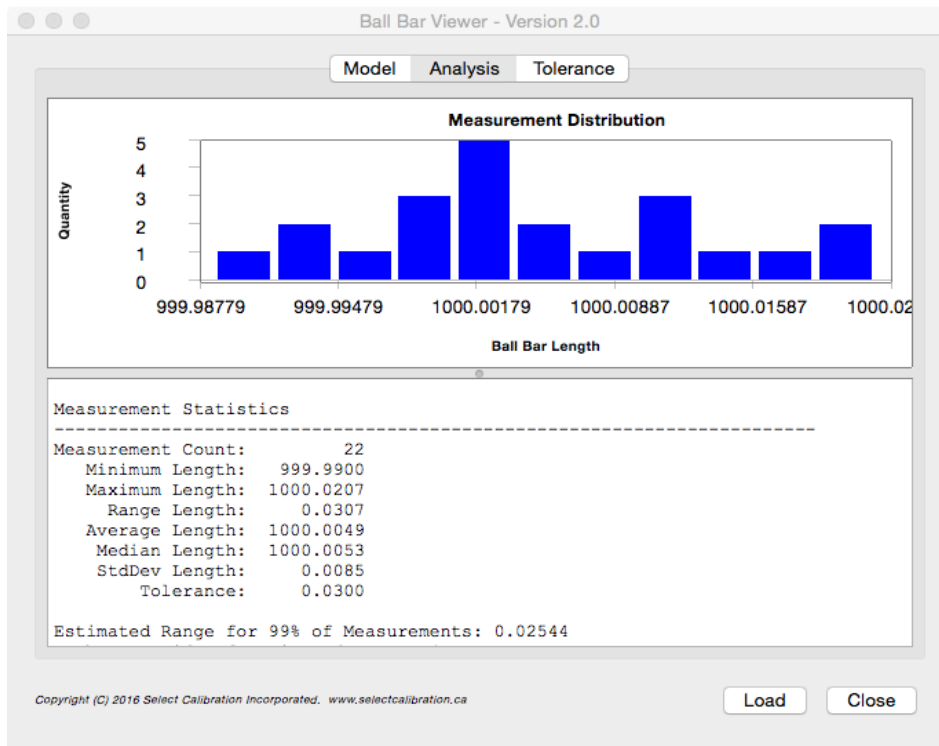


Illustration 4: Example of how ballbar measurement data is displayed in the analysis tab of the Ballbar Viewer utility.

Tolerance View

The tolerance view of the Ballbar Viewer utility program allows the user to enter an upper limit for the variation in ballbar measurement lengths when performing an interim test of the machine.

The method used to determine if a measurement is outside or inside the specification is to find the upper and lower measurement limits from the average. Any measurements that fall outside of this range are considered to be outside of tolerance. The method defined by the ASME B89.4.1:1997 standard is to compare the range of the length measurements to the specification. For this reason it is possible that measurements may appear out of tolerance but still have a measurement range that is inside specification.

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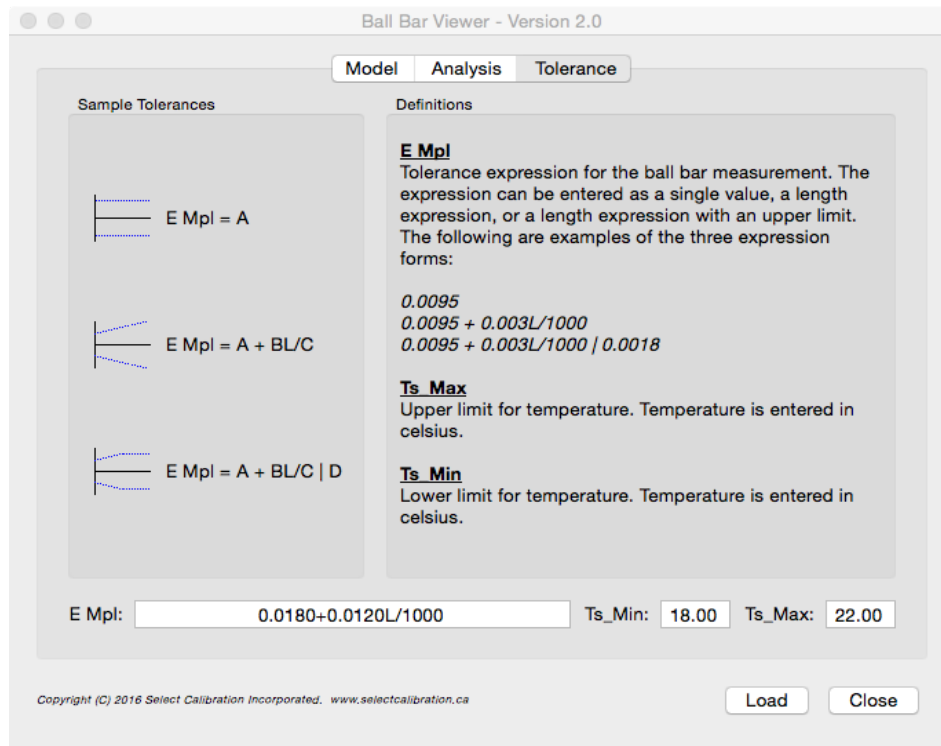


Illustration 5: Example of the tolerance view of the Ballbar Viewer utility program.

The tolerance is input as an expression in the field *E Mpl* and can be in one of these formats:

- A single value such as 0.010
- An expression based on the length such as $0.010 + 0.005L/1000$
- An expression based on the length with a hard limit such as $0.010 + 0.005L/1000 | 0.015$

Entry errors are shown when the background color of the input field is changed to red. Entry errors can be from an unrecognized input expression or from other unrealistic input data such as swapping the upper and lower temperature limits.

The temperature tolerance fields are currently not used by the Ballbar Viewer utility program.

Input File Formats

Ballbar measurement data that can be used by the Ballbar Viewer utility program can be in one of three formats. The format of the data is reasonably flexible but must meet the minimum requirements listed below:

Version 1 Format

- The first line in this file must be *BallBar_V1*
- Comment lines, if any, must start with a hash character #

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- The format of each line is: <name>, <length>, SPHERE1<X,Y,Z>, SPHERE2<X,Y,Z>, PROBE_OFFSET<X,Y,Z>
- The first field of each entry line can contain text or a numeric value with all additional fields numeric. The first entry is for the name of the measurement.
- Each ballbar sphere position is in machine coordinates without the probe offset.

Version 2 Format

- The first line in this file must be *BallBar_V2*
- Comment lines, if any, must start with a hash character #
- The format of each line is: <name>, <length>, SPHERE1<X,Y,Z>, SPHERE2<X,Y,Z>, SPHERE1 FORM, SPHERE2 FORM, PROBE_OFFSET<X,Y,Z>
- The first field of each entry line can contain text or a numeric value with all additional fields numeric. The first entry is for the name of the measurement.
- Each ballbar sphere position is in machine coordinates without the probe offset.

Version 3 Format

- The first line in this file must be *B89.4.1_Data:Version=1:Type=BallBar*
- Comment lines, if any, must start with a hash character #. The exception to this rule is a title line and underscore used to identify the columns of the data.
- The format of each line is: <name>, <length>, SPHERE1<X,Y,Z>, SPHERE2<X,Y,Z>, SPHERE1 FORM, SPHERE2 FORM, PROBE_OFFSET<X,Y,Z>
- The first field of each entry line can contain text or a numeric value with all additional fields numeric. The first entry is for the name of the measurement.
- Each ballbar sphere position is in machine coordinates and includes the probe offset. This is different from the first two input formats and is more in-line with other types of measurement file formats.

The third format is technically a new format with the data consistent with other utilities used by SCI. The output of this data is column aligned with a title block explaining the contents better than what was done in previous versions.

All three versions are similar in content but have differences that affect how the data is processed by the end software.

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Version 3 Format Example

The following is an example of a suitable ballbar measurement file, version 3:

B89.4.1_Data:Version=1:Type=BallBar

Note: Sphere locations include the probe offset.

Name	Length	Sph1 X	Sph1 Y	Sph1 Z	Sph2 X	Sph2 Y	Sph2 Z	Sph1 Form	Sph2 Form	Probe X	Probe Y	Probe Z
D 1,	1000.00500,	1261.30930,	961.32416,	-1188.66594,	1838.65725,	1538.67653,	-611.30680,	0.00000,	0.00000,	150.00000,	150.00000,	-200.00000
D 2,	999.99334,	1838.65014,	961.32659,	-1188.65894,	1261.30996,	1538.67212,	-611.30537,	0.00000,	0.00000,	-150.00000,	150.00000,	-200.00000
D 3,	1000.00724,	1261.30236,	1538.68030,	-1188.66199,	1838.66191,	961.32521,	-611.31329,	0.00000,	0.00000,	150.00000,	-150.00000,	-200.00000
D 4,	999.98609,	1838.64067,	1538.68141,	-1188.65114,	1261.31382,	961.32121,	-611.31148,	0.00000,	0.00000,	-150.00000,	-150.00000,	-200.00000
X,	999.98925,	1049.98609,	1249.99970,	-899.98854,	2049.97534,	1250.00336,	-899.98145,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000
Y,	1000.00450,	1549.98474,	749.99865,	-899.98864,	1549.97545,	1750.00315,	-899.97885,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000
Z 1,	999.99900,	1549.97477,	1250.00462,	-1399.98714,	1549.99130,	1249.99909,	-399.98814,	0.00000,	0.00000,	200.00000,	0.00000,	-50.00000
Z 2,	1000.00100,	1549.97413,	1250.00310,	-1399.98498,	1549.98966,	1249.99657,	-399.98398,	0.00000,	0.00000,	0.00000,	200.00000,	-50.00000
ZX 1,	1000.00693,	2196.41325,	1250.00791,	-1253.53423,	2903.52836,	1250.00517,	-546.42597,	0.00000,	0.00000,	0.00000,	0.00000,	-200.00000
ZX 2,	999.98232,	2903.51118,	1250.01528,	-1253.53275,	2196.42793,	1250.00030,	-546.42745,	0.00000,	0.00000,	0.00000,	0.00000,	-200.00000
YZ 1,	1000.00413,	2549.96874,	896.45473,	-1253.53830,	2549.97350,	1603.55636,	-546.42053,	0.00000,	0.00000,	0.00000,	150.00000,	-200.00000
YZ 2,	1000.00112,	2549.95738,	1603.56594,	-1253.52784,	2549.98236,	896.44765,	-546.43099,	0.00000,	0.00000,	0.00000,	150.00000,	-200.00000
XY 1,	999.99406,	2196.42449,	896.44934,	-899.98513,	2903.51357,	1603.56543,	-899.97320,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000
XY 2,	999.99969,	2903.52492,	896.45547,	-899.98490,	2196.41564,	1603.55930,	-899.97592,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000
D 5,	1000.00500,	3261.28780,	961.34149,	-1188.66178,	3838.63575,	1538.69386,	-611.30263,	0.00000,	0.00000,	150.00000,	150.00000,	-200.00000
D 6,	999.99334,	3838.62864,	961.34969,	-1188.66054,	3261.28846,	1538.68368,	-611.29543,	0.00000,	0.00000,	-150.00000,	150.00000,	-200.00000
D 7,	1000.00725,	3261.27509,	1538.69764,	-1188.65205,	3838.64618,	961.34253,	-611.31489,	0.00000,	0.00000,	150.00000,	-150.00000,	-200.00000
D 8,	999.98608,	3838.61339,	1538.70451,	-1188.64697,	3261.29810,	961.33277,	-611.30731,	0.00000,	0.00000,	-150.00000,	-150.00000,	-200.00000
X 1,	999.98925,	3049.96459,	1250.01202,	-899.97937,	4049.95384,	1250.02569,	-899.98228,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000
Y 1,	1000.00450,	3549.96824,	750.01598,	-899.98947,	3549.94895,	1750.02048,	-899.96968,	0.00000,	0.00000,	0.00000,	0.00000,	-250.00000

The column formatting is not critical. The column title lines can be omitted if necessary.

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Revision History

<i>Date</i>	<i>Version</i>	<i>Changes</i>
Nov 6, 2016	1.0	New Program
Nov 7, 2016	1.1	Bug fix. OpenGL Z clipping for some input data. Added machine volume information. Improved ability to select ball bar measurements from model.
Nov 28, 2016	1.2	Additional improvements to ballbar selection. Changed selection display from a floating dialog to a text line at the top of the model view window. Added the option to show the selected ballbar when viewing data.
Dec 14, 2016	2.0	Switched to newer OpenGL base class. Added option to detect minimum usable OpenGL version and disable sections of the program that are not compatible.