# CheckMate Geometric Correction

Hit error is the error induced when the CMM measurement is taken and the probe is not in alignment with the nominal vector. This error is generally a factor of the effect of staircasing or other mechanical influences on the probe path. CheckMate has the capability of determining the hit error , calculating correct point and outputting it in the inspection report. Below is a definition of the applicable terminology followed by a study of of these calculations based on customer provided data.
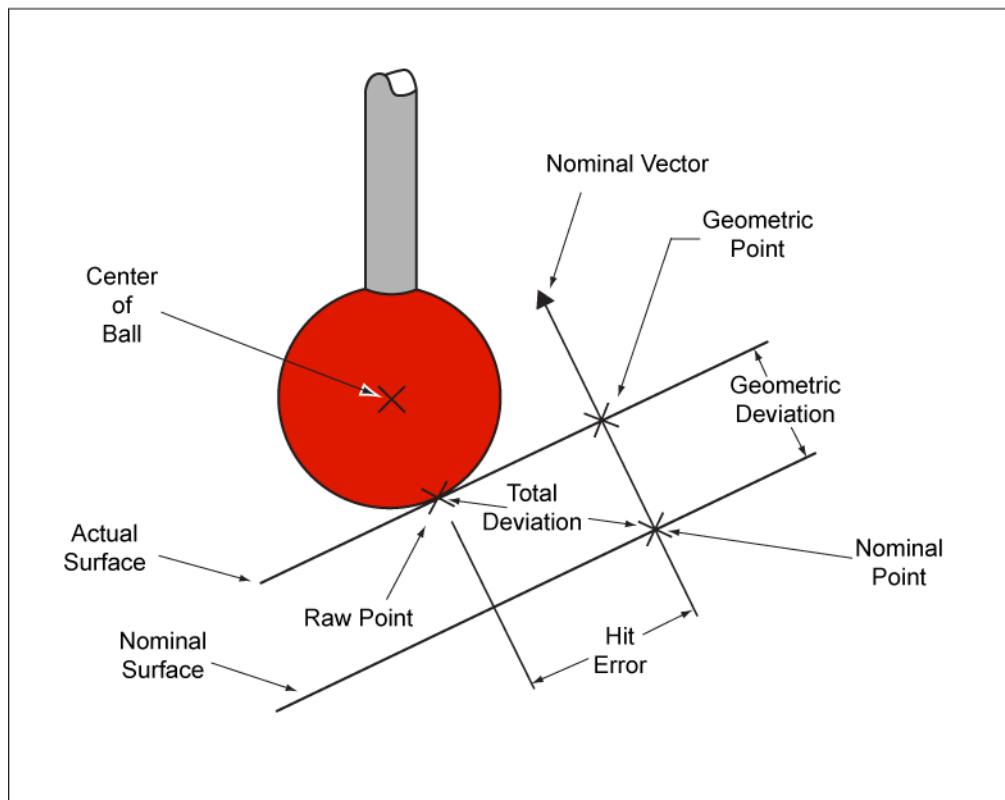
The diagram illustrates a measurement of a surface point on a surface with positive material.

Nominal Point
> This is the intended point for measurement.

RAW Point
> The actual point registered by the CMM at inspection.

Geometric Point
> The corrected point after calculations removing hit error. The point on the actual surface that would have been taken had the CMM travelled down the Nominal Vector, attempting to measure the nominal point.

CheckMate 3D Calculations versus Raw CMM Data

This document provides a short pictorial guide to CheckMate true position and vector deviation calculations based on real customer data. It should help clear up confusion on why the numbers in CheckMate reports don't appear to match those in the CMM report. The dimensions in the pictures were created from the raw loaded data in the reporting entity in two UCS's: the ZX plane and a UCS in the plane of the feature.

Here is data from a CMM report for a hole measurement and a trim measurement:

```
**** SH054 **
10 N0793 Pos. X      -504.989    0.000  -504.831    0.158 $$$$$$$$$$$$
                      0.000              0.158
10 N0793 Pos. Y      -629.429    0.000  -628.841    0.588 $$$$$$$$$$$$
                      0.000              0.588
10 N0793 Pos. Z       328.700    0.000   328.718    0.018 $$$$$$$$$$$$
                      0.000              0.018
10 N0795 Diameter       6.999    0.200     7.143    0.144 -----***---
                      0.000
10 N0797 Position     328.700    0.444   328.718    0.318     *****-
             -504.989    0.300  -504.831

**** RM057 Edge Measurement (-Z direction)
59 N0828 Pos. X      -531.119    0.000  -531.116    0.003 $$$$$$$$$$$$
                      0.000              0.003
59 N0828 Pos. Y      -633.046    0.000  -632.462    0.584 $$$$$$$$$$$$
                      0.000              0.584
59 N0828 Pos. Z       323.610    0.000   324.319    0.709 $$$$$$$$$$$$
                      0.000              0.709
```

And here are filled labels in CheckMate for the same data (labels ballooned with LABEL+SIG and filled with GEO compensation.

SH054 ⊕	0.84	ⓜ 0.30	*
	NOM	ACT	DEV
X	−504.99	−504.83	0.16
Z	328.70	329.00	0.30
∅	7.00	7.14	0.14

+0.14 (top), +0.20 / −0.00 (right of ∅ row)

RM057 V	−0.92	± 0.80 *
	NOM	ACT	DEV
Z	323.93	324.64	0.70

For the Hole
The actual values for the hole XZ coordinates in the label match the report (lucky, really, they can change as the hole is projected to the nominal surface with GEO compensation). ***QUESTION1***: Why is the true position out-of-tolerance in the label at 0.84 but in-tolerance at 0.318 in the CMM report?

For the Trim
The actual value for the trim Z coordinate is a little different in the label than in the report (due to GEO compensation, if RAW had been used all XYZ values would match). ***QUESTION2***: The CMM used to generate the report does not report the vector deviation but the question still arises why if the Z deviation is 0.70, is the vector deviation –0.92 in the label?

CheckMate 3D Calculations versus Raw CMM Data, continued

ANSWER: For the Hole

The answer to both questions arises from the 3D nature of CheckMate's calculations. "A picture is worth ten thousand words" so here is the situation with the hole from the CMM perspective: looking down on the ZX plane:
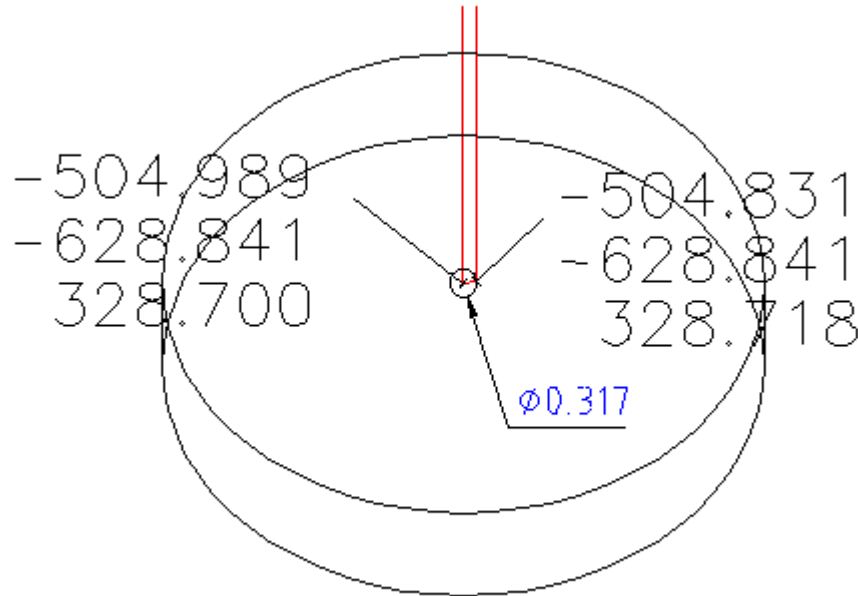
In the picture the reporting entity is red, the actual XYZ is to the left and the nominal XYZ to the right. The diametrical true position in this obviously skewed view is shown as a circle with a diameter of 0.317, the value from the CMM report.
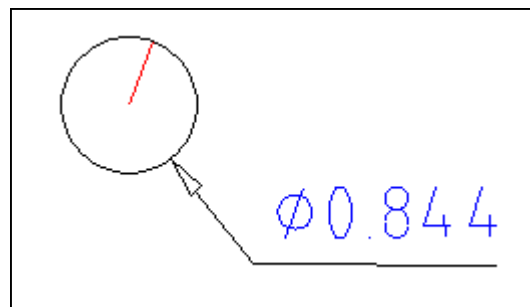

You can no longer see the vectors on the reporting entity because we are looking straight on and now the diametrical true position is shown as a circle with a diameter of 0.844, the value in the filled CheckMate label.

The 3D true position (actually 2D but in a canted plane) is not always bigger than the 2D true position in the nearest major plane. Depending on the feature vector, measurement depth, surface deviation, and actual deviation, the 3D calculation of true position can either be larger or smaller than the 2D major plane calculation. The CheckMate filled label (and other CheckMate reports) can be forced to show the deviation from the report by using the DEV modifier with /#SFO (on the menu these are the "with deviations from report" choices).

CheckMate 3D Calculations versus Raw CMM Data, continued

ANSWER: For the Trim
Looking at the trim measurement in the XZ plane and dimensioning the Z deviation we get this picture:
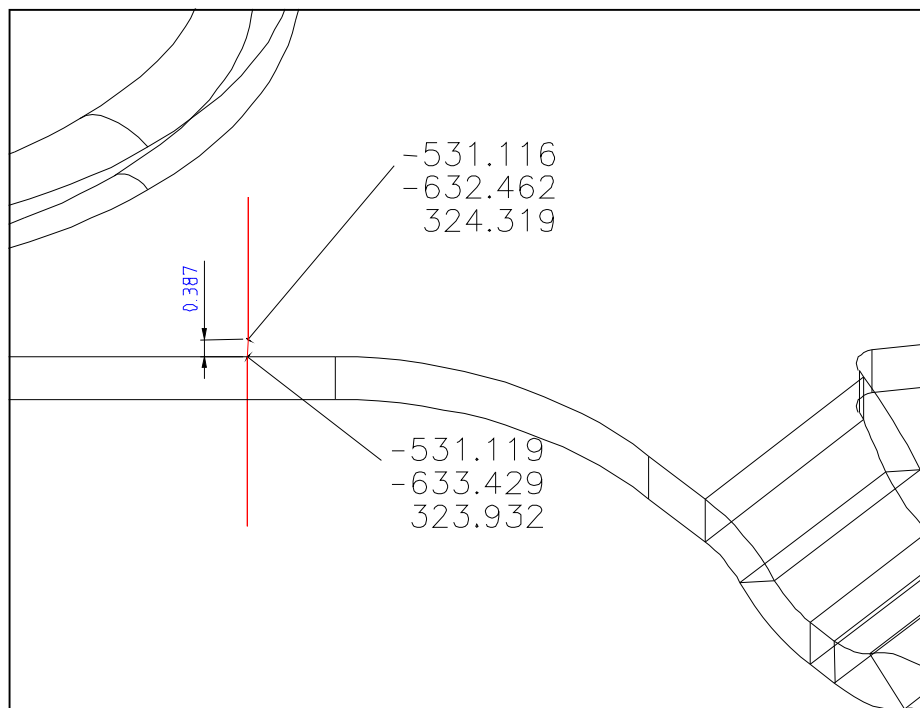
Again the reporting entity is in red. The nominal XYZ values are shown at the bottom and the actual XYZ values at the top. The deviation in this view doesn't appear to match anything. The reason is the difference between RAW and GEO compensation. Also, in the picture we see the RAW actual which matches the CMM report but the nominal is at the CAD surface, the nominal in the CMM report is at the depth of measurement.

All becomes clear if we look straight down on the edge in the diagram to the right:

Looking straight down on the edge the depth of either the nominal or the actual no longer matters, the difference between actual and nominal is 0.918 which matches the filled CheckMate label. It is a negative value in the label (and other CheckMate reports) because the probe "hit too late" when measuring the edge, in other words there is material missing.