Three Dimensional GD&T: A CheckMate Dimensional Metrology Application

The example illustrated in this article is a support structure from the sphere that supports detectors used in the GRETINA project. The measurement and subsequent GD&T evaluation imposes demanding requirements not only due to its size of 4 feet in diameter but primarily due to the three dimensional aspect of the GD&T callouts. The callouts were constructed to ensure that the axis of all detectors mounted on the outside planar surfaces of the sphere, pointing inwards converge at the center of the sphere.

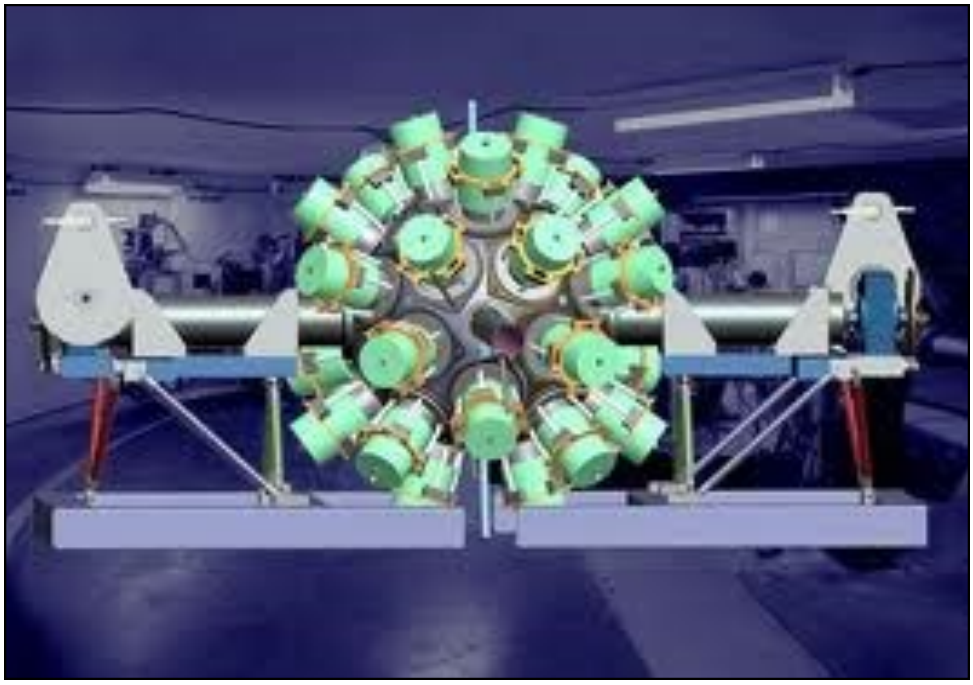

Fig. 1

Fig 1. shows the virtual mock up of the completed unit with the detectors mounted on the sphere.

Fig. 2 is the CAD representation of a structural component that forms one half of the sphere with planar surfaces for mounting each of the detectors. Fig. 3 is the basic datum structure which was used for CMM alignment .

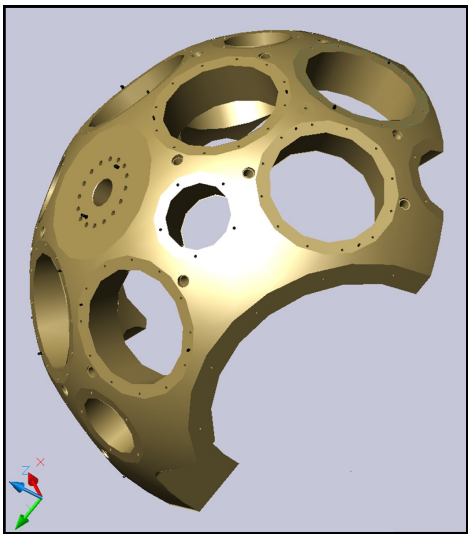

Fig. 2

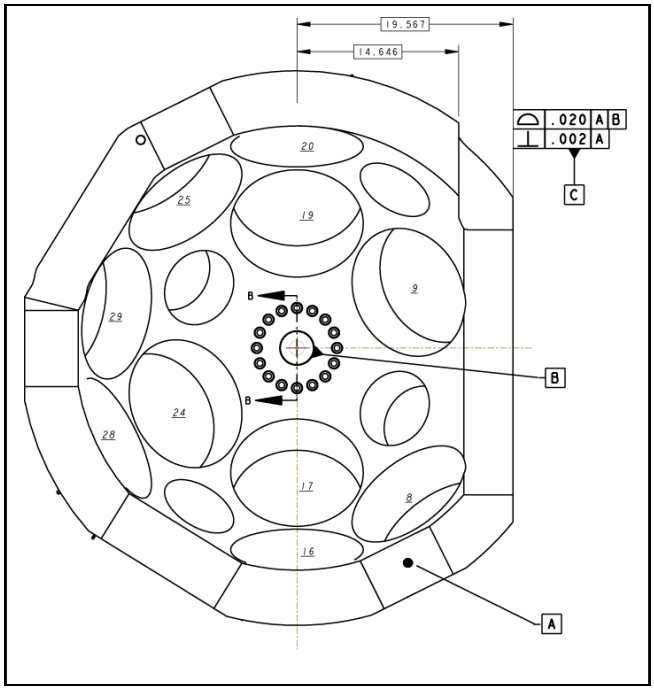

Fig. 3

Fig. 4 shows the GD&T callouts controlling the attitude of the planar surface and the pins used to locate the detectors.

The "10X SIM. REQ." for the position of each of the pins and the profile of the planar surface stipulates that when each feature and their respective tolerance parameters are evaluated they must be done simultaneously with their corresponding feature on each of the 10 planes of the structure.

The simultaneity requirement brings into play the three dimensional aspect of this requirement.

Any translation or rotation (wiggle) available from the tolerance band of each of the three features is only valid when all features in all 10 planes are evaluated simultaneously.

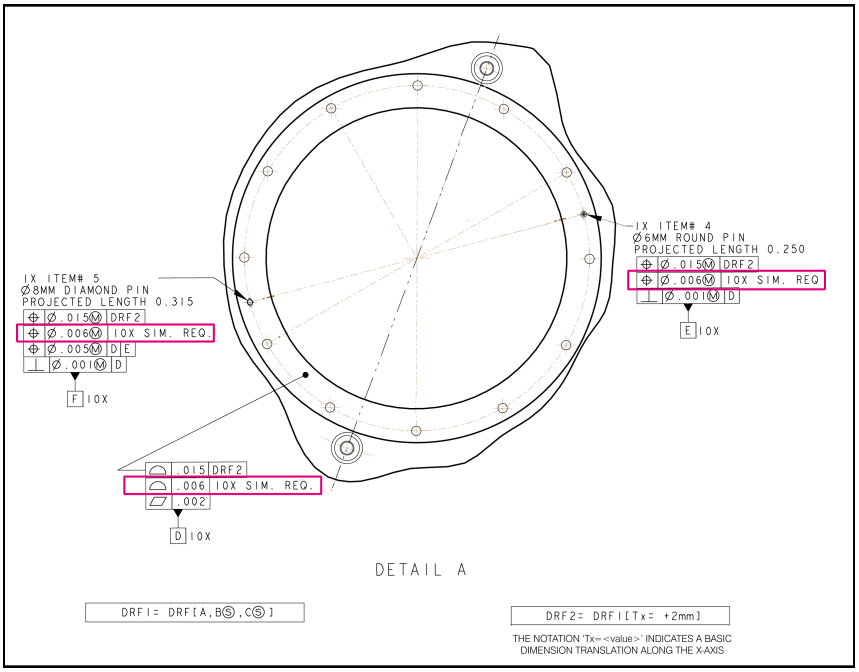

Fig. 4

In order to meet this requirement the software must;

1. Be 3D capable as dictated by the 10 x simultaneity callout, 2D fits in a plane do not cut it here.
2. Handle a mix of surface profile and true position simultaneously.
3. Manage the true tolerance condition, which is not possible with a least squares (LSQ) fit.

Software from conventional dimensional measurement equipment OEM's does not offer this level of GD&T complexity. CheckMate SoftFit Solver, mimicking the capabilities of a hard gauge not only handles this condition, it also determines what percentage of the available tolerance was used. This can be particularly useful to determine if a process is wandering on multi piece runs or whether or not measurement uncertainty could be cause for concern.

SoftFit Solver features a user friendly browser interface to organize data into functional groups, run the application and provide scripting capability to automate repetitive tasks.

The part was measured on a Zeiss CMM and the Calypso measurement definition and results files have been loaded and the data organized into functional groups corresponding to the GD&T callouts for fit processing as shown in Fig. 5. The raw measurement data as read in from the CMM and prior to fitting clearly indicates a number of features out of tolerance.

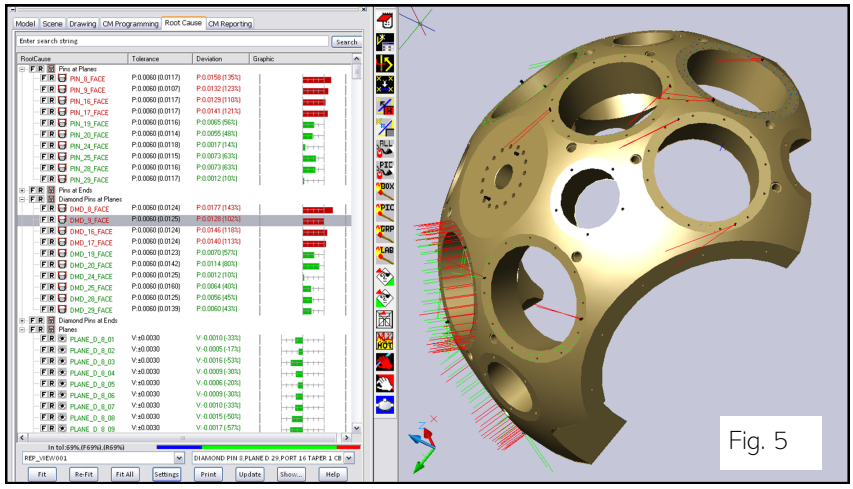

Fig. 5

As displayed here the tolerance for each feature and its (bonus), the deviation and what (percentage) of the it's tolerance band the deviation represents, and a graphic of the relative value of each deviation is shown.

In order to correctly evaluate the results as per the 10X SIM callout the mobility permitted by the absence of datums in the callout and the tolerance band of each feature must be taken into account.
CheckMate SoftFit Solver's robust control of fit algorithms, methods and degrees of freedom (Fig. 6) provides engineers with the functionality to handle the most demanding of dimensional metrology applications.

For this application only the "Fit method" , "Degrees of freedom" and "Data selection" have any relevance on the result.

The Gage simulation fit, with translation and rotation available in full 3D enables the mobility allowed by the callout.

With the Root Cause option for Data Selection selected, all features with the "F" turned on in the browser will be included in the fit.

With the processing of the gage simulation taking not much more than the blink of an eye the browser is automatically updated as illustrated in Fig. 7.

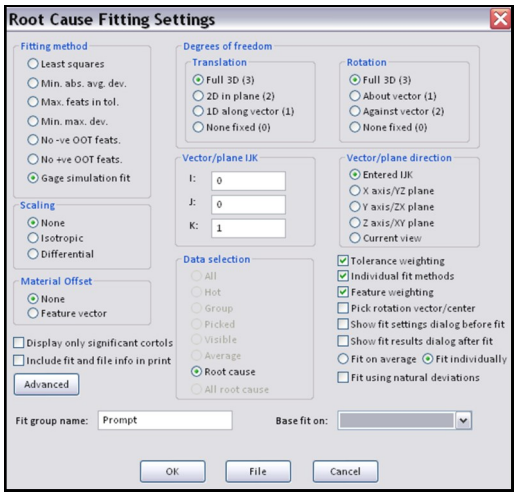

Fig. 6

The features have been evaluated in 3D as dictated by the 10XSIM callout and with the mobility afforded by the fact the callout is independent of the datums, and the tolerance band on the individual features , SoftFit Solver has shown the part to meet the specified requirement .

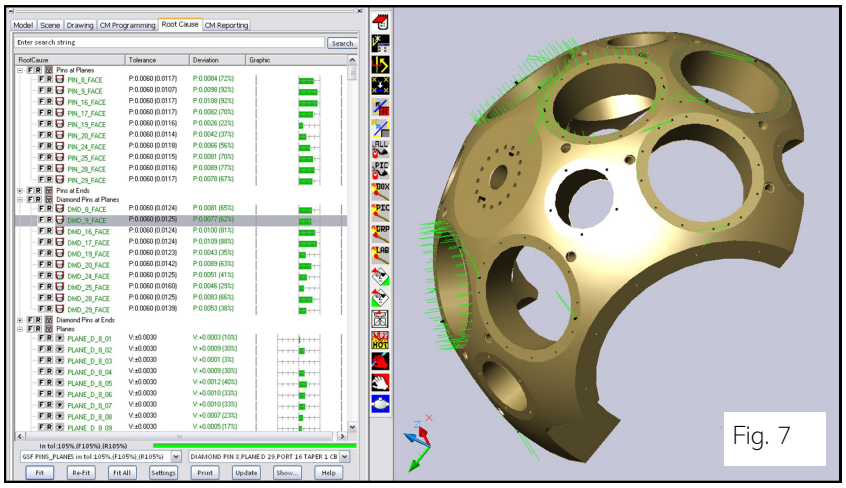

Fig. 7

For the purposes of this publication it was not practical to display the complete data set for all of the features within the browser in Fig. 5 & 7, representing the before and after state of this evaluation. Fig. 8 however does provide a summary of results indicating the before and after state of the number of features out of tolerance and the rotation and translation required to attain this result.

SoftFit Solver provides the unique capability to meet complex requirements as this, removing the need and expense of using hard gages.

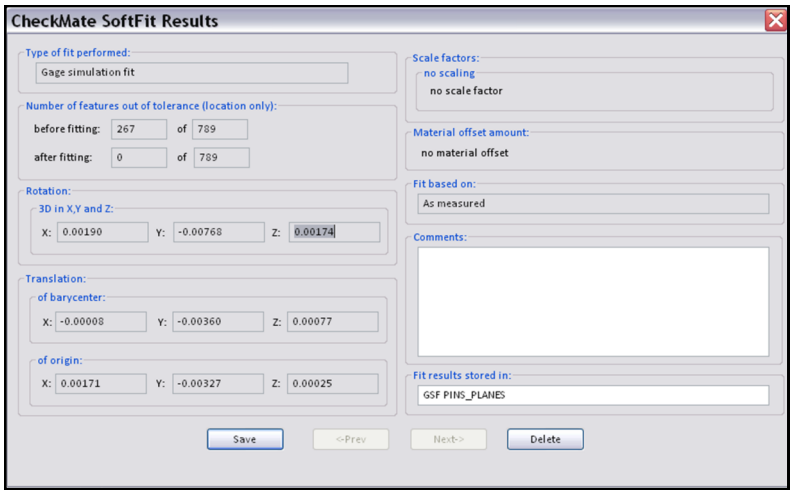

Fig. 8