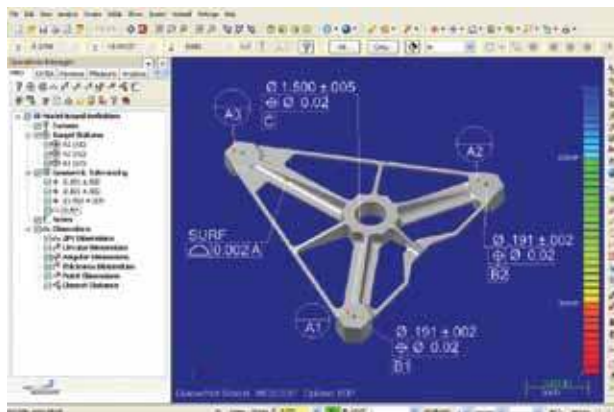# How To Close the Loop on the Digital Manufacturing Workflow

CAD-Based inspection software helps CAD, GD&T (Geometric Dimensioning and Tolerancing) datums, and measuring devices work together to ensure design intent and eliminate the need for 2D inspection drawings, while closing the loop on digital workflow. These are all important considerations when moving towards a Model-Based Definition (MBD) environment. CAD-Based inspection is a good practical first step toward the goal of a complete MBD environment. The central concept embodied in MBD is that the 3D CAD model provides all of the detailed product information necessary for all aspects of the product life cycle. Engineers have wanted to harness the power of MDB for years.

In a 2005 presentation, Terrence McGowan of Boeing, stated, **"The 3D model should contain everything needed from design to manufacturing, in particular, GD&T."** What this means for manufacturing and inspection is that they pull all dimensions and tolerances from the 3D CAD model instead of a 2D paper drawings. Making the CAD model the authority removes ambiguity, conflict and doubt that arise when drawings and models co-exist. With authority bestowed on the CAD model, MBD eliminates errors that result from referencing an incorrect source and makes processes more efficient. No more searching to determine correct revision levels.
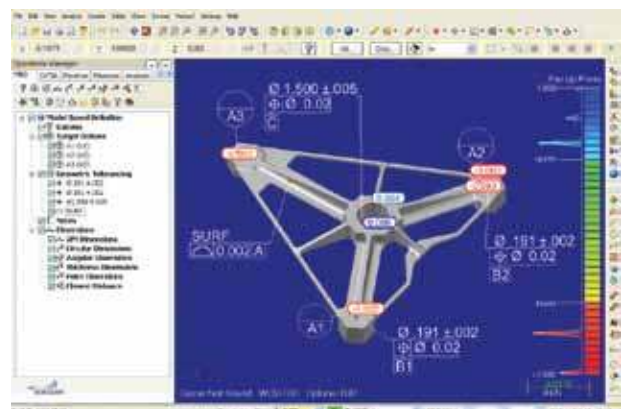
In the context of the enterprise, the benefits are many and diverse. MBD is the single information source to build and maintain products, and it integrates into processes from cradle to grave. Providing definition for operations throughout the product lifecycle, there are simply too many benefits to name. Yet, to summarize MBD's impact, one only has to look at the goals of leading aerospace companies when they began their pursuits of MBD:

- Improve quality
- Accelerate time-to-market
- Decrease time and expense

GD&T and CAD-based inspection is a great place to start when moving towards MBD. It moves the CAD model from design to a manufacturing orientation. It opens the door to many advantages where software can automate and validate steps in the simulation, manufacturing and inspection processes.

CAD-BASED INSPECTION AND GD&T

A necessary component of CAD-based inspection and the MBD approach to product design is GD&T, a universal symbolic and tolerancing language. Last updated in 2009, GD&T has been rigorously studied and applied by thousands of manufacturers around the world. It is often considered essential for communicating design intent — that is, that parts from technical drawings have the needed form, fit, function, and interchangeability. The recent update includes changes in feature design, datum references and degrees of freedom, surface

Verisurf X CAD-Based inspection software uses ASME Y14.5-2009 GD&T symbols as part of its CAD interface. CAD-based GD&T annotations can be imported as part of the CAD file if supported by the program, or added to the CAD model with Verisurf X.


Verisurf X illustrates high and low tolerance deviations on associated CAD model GD&T specs.

boundaries and axis methods of interpretation, profile tolerances, the symbols and modifiers tools.

In manufacturing the direction of CAD is to 3D, however not all CAD programs provide intelligent GD&T data. Here, "intelligent" means computer readable, thereby capable of feeding downstream applications. There are two GD&T definition-data formats. Potentially confusing, both are labeled "3D annotation," but one format is purely for display, while the other provides intelligence back to the CAD model.

The distinction is that in the display format, Tolerancing associated to the model is in the form of text. In other words, humans must interpret the GD&T information, opening the door to potential errors. The display or presentation format is similar to typing a math equation in Microsoft Word. It conveys information, but the computer cannot use it in calculations. In conversation, this approach is commonly referred to as "decorating the model."

What makes the effort of applying GD&T to 3D models worthwhile? As part of the MBD approach, it helps users leverage data throughout product development, cutting time from processes and improving them, while avoiding investment in 2D drawings. It can even be said that 3D GD&T data provides a form of "artificial intelligence" for manufacturing and inspection.
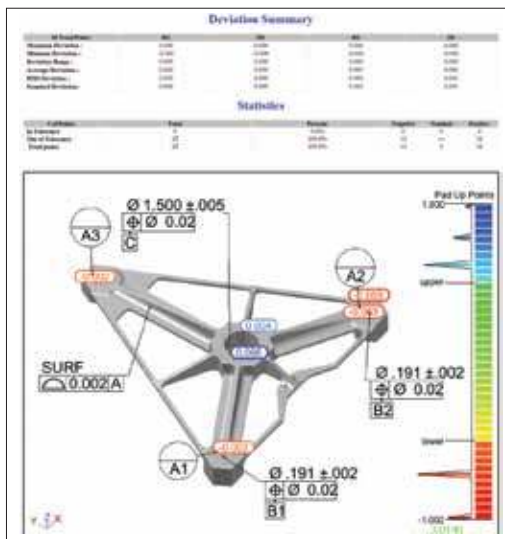
Verisurf X uses the CAD model as the nominal definition to generate custom reports in industry standard formats, including GD&T constraints and color deviation maps. A Database Write feature in the program formats and sends inspection information to SPC applications and PLM databases used by major manufacturers. The feature also supports Microsoft Access and SQL Server database formats for combining Verisurf inspection data with numerous enterprise databases.
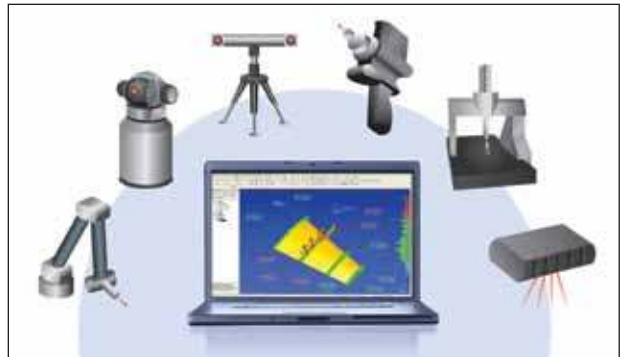
Verisurf X provides a common software platform to drive all digital metrology devices. Benefits include, reduced training time across multiple devices, consistent reporting formats, and support for upstream enterprise databases.

3D CAD-BASED INSPECTION

GD&T defines quality requirements, and inspection then confirms these requirements are being met. For CAD-based inspection to occur, there must be GD&T representation and the inspection software must be able to import the data from the native CAD software. When intelligent GD&T data is not available, users must be able to add it to the CAD model in the inspection software.

CAD-based inspection involves inspecting physical part measurements against the CAD model. This process can be dependent or independent of how or where Tolerancing is defined on the CAD Model. Consider, for example, inspection software such as Verisurf X from Verisurf Software Inc. It connects to and controls measuring devices such as scanners and laser trackers as well as stationary and portable coordinate measuring machines (CMMs). It also accommodates both presentation and intelligent GD&T specs from CAD models. Intelligent GD&T datums are imported directly from the native CAD software with the 3D model and provide nominal dimensions. For presentation annotations, the quality or manufacturing engineer uses Verisurf to add GD&T specifications to the 3D model. Importing information from a native CAD package as a 3D CAD model with GD&T representation is a good example of moving towards an MBD environment.

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