Are you getting the full benefit from MBD?

Stephen Werst, Director of Customer Success & Product Strategy

Sigmetrix
- Global Experts in GD&T and Mechanical Variation

- Over 25 years of Mechanical Variation experience

- Tolerance Analysis Software Solutions work with CATIA V5-6, Autodesk Inventor NX, PTC Creo, and SOLIDWORKS
  - Analysis models utilize native CAD data files for geometry and PMI
  - OEM provider of 1D stackup and GD&T authoring solutions to PTC Creo and Autodesk Inventor

- Training in ASME GD&T & ISO GPS, Fundamentals of Tolerance Analysis, MBD/MBE, and our software solutions

- Consulting & Integration Services

Customers worldwide supported either directly in North America or through distributors internationally
A few definitions courtesy of Wikipedia with some simplification

• **Model-based enterprise (MBE)** is a strategy where an annotated digital three-dimensional (3D) model of a product, instead of drawings, serves as the authoritative information source for all activities in that product's lifecycle. There are two prerequisites to implementing MBE:
  1. Creation of necessarily annotated 3D models, known as a Model-based Definition
  2. Transformation of CAD data into forms usable by downstream lifecycle activities (i.e. production)

• **Model-based definition (MBD)** - the practice of using 3D models (such as solid models, 3D PMI, and associated metadata) to define product. Types of information included are geometric dimensioning and tolerancing (GD&T), component level materials, assembly level bills of materials, engineering configurations, design intent, etc.

• **Product Manufacturing Information (PMI)** - conveys non-geometric attributes in 3D computer-aided design (CAD) and Collaborative Product Development systems necessary for manufacturing product components and assemblies. PMI may include geometric dimensions and tolerances (GD&T), 3D annotation (text) and dimensions, surface finish, and material specifications.
The flow of information in the MBE

- MBE enables efficient communication throughout the organization

- FEA
- Tolerance Analysis

- CNC Instructions
- Automated Manufacturing Plan

- CMM Instructions
- Closed Loop inspection feedback

- Human Readable Formats

MBE enables efficient communication throughout the organization.
MBD Concerns addressed by various software solutions

- CAD data conversion
- Geometry validation & healing
- Simplification for CAE
- Semantic PMI validation
- CAM & CMM usage
- Light weight derivatives
- Data reuse
- Archiving
- Human readability
... but how much potential savings go unrealized if the information is wrong?
Dimensional Management MBD Recommendations

1. **Use** tolerance analysis to determine what values should be specified in the dimensional annotations.

2. **Use Geometric Tolerances** (GD&T or GPS internationally) to **avoid ambiguity** associated with the more common/traditional dimensioning and tolerancing methods.

3. Ensure the **authors** of GD&T/GPS annotations **know the language** well and have access to tools that help provide “spell-check” and “grammar-check” type of functionality.
Industry transition to MBD – informal survey results from 376 respondents

Does your company have any initiatives to move to Model-Based Definitions (where the model is the master instead of the drawing) in the next year? In the next 5?

- No: 25.38%
- Not in the next year, but probably in the next 5: 49.24%
- Yes, we are working on MBD projects this year: 25.38%
The State of Tolerance Analysis
Which best describes your current tolerance analysis coverage?

**MBD in next year**
- We have very thorough coverage, but it is too time consuming: 19% (16)
- We do some, but we don’t do enough: 56% (47)
- We have good coverage but still have problems: 21% (18)
- Other (please specify): 4% (3)

**MBD in 2-5 years**
- We have very thorough coverage, but it is too time consuming: 13% (22)
- We do some, but we don’t do enough: 52% (85)
- We have good coverage but still have problems: 30% (49)
- Other (please specify): 4% (7)
Top reasons cited for investigating tolerances analysis solutions

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1. Improved efficiency for performing the analysis – 84%

2. Reduction in manufacturing problems caused by tolerance issues – 76%

3. Improved integration of analysis tool(s) and data within CAD models – 70%
   Note: 80% of respondents use spreadsheets today for their tolerance analysis studies

4. Improved coverage that we are unable to do today because of cost, schedule, etc. – 34%

5. Reduction in field problems caused by tolerance issues – 34%

6. Reduction in time required in pre-production phase – 33%
1D Stackup Analysis

- Quickly define multiple stackups on the CAD geometry
- Analyses automatically update when CAD nominal change
- Dashboard provides overview of all studies
- Quickly generate reports with loop diagrams
The Importance of GD&T for MBD
*(Hint: it’s not about the bonus tolerances)*
Which best describes your company’s GD&T/GPS usage?

MBD in next year

- never use it: 5.95% (5)
- less than ¼ of new parts: 22.62% (19)
- ¼-⅓ of new parts: 13.10% (11)
- ⅓-⅔ of new parts: 9.52% (8)
- more than ¾ of new parts: 48.81% (41)

MBD in 2-5 years

- never use it: 1.84% (3)
- less than ¼ of new parts: 17.79% (29)
- ¼-⅓ of new parts: 19.02% (31)
- ⅓-⅔ of new parts: 21.47% (35)
- more than ¾ of new parts: 39.88% (65)
Dimensions with +/- Tolerance are Ambiguous

What do the dimensions on this drawing mean?

- $25 \pm 1$
- $50 \pm 1$
- $25 \pm 1$
- $50 \pm 1$
- $20 \pm 0.5$
- $Ø10 \pm 0.5$
Dimensions with +/- Tolerance are Ambiguous

Is the hole being controlled to the sides? Are the sides being controlled to the hole?

Possibly Creates a 2mm Square Tolerance Zone

2mm Wide Tolerance Zone

"Axis" of Hole
“Real-world” variation adds additional complexity

How does inspection determine the measurement direction on the actual parts?

![Diagram showing two variations of a part with a hole and tolerance zone.](image_url)
How does inspection determine the measurement origin on the actual parts?

As-Produced Hole

As-Produced Part

2mm X 2mm Tolerance Zone

As-Produced Surface

As-Produced Part

As-Produced Hole

Measuring Tape

±1 Tol Zone

Two-Point Measurement

"Real-world" variation adds additional complexity
• The hole is being controlled relative to a coordinate system defined by three datum features labeled A, B, and C. This is DRF A|B|C.
• The axis of the hole must fall within a cylindrical tolerances zone having a diameter of 2.8 mm and located 25 mm from both datums B and C as defined by DRF A|B|C.
GD&T is a language

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• To “speak” it properly requires:
  • Education
  • Application
  • Practice

• For authors, don’t feel obligated to use all things covered in the standards. A subset of the standard will carry you far.

• Like any language, no two people will speak it identically.
  • It is possible to converge on similar definitions with standard processes.
The State of GD&T Authoring
Where are tolerances first defined?

MBD in next year

- Don't know: 3.57% (3)
- We do a mix of both: 39.29% (33)
- Drawings only: 40.48% (34)
- Models: 16.67% (14)

MBD in 2-5 years

- Don't know: 2.45% (4)
- We do a mix of both: 31.29% (51)
- Drawings only: 58.90% (96)
- Models: 7.36% (12)
GD&T Authoring tools help with the definition - demo

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GD&T Advisor

- Quickly add semantic GD&T

- GD&T applied per governing ASME or ISO standards

- Recommendations made to help provide consistency

- Visual feedback about status of control of each surface
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