Maximum Added Value Through Optimized Tolerances Right From The Start In The Design Process

Plus Important Market Trends

Ed Walsh
Vice President of Global Sales
Sigmetrix

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

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Sigmetrix Product Portfolio – 25 Years Experience

CETOL 6σ

Variation Analysis Software for Robust Assembly Design

- 3-D tolerance analysis tool
- Works with Creo, SOLIDWORKS, CATIA, and NX
- Evaluate worst-case and statistical results with Six Sigma metrics

EZtol

Tolerance Analysis Made Easy

- 1-D Tolerance stack-up tools:
  EZtol works with CATIA, Creo, Inventor, NX, & SOLIDWORKS files
  TAE add-in for Creo
- Shows worst-case, RSS, and statistical results with Six Sigma metrics

Sigmetrix Services

Global Experts for Training, Consulting, & Outsourcing

Consulting Services
- Tolerance Analysis
- GD&T
- Integration & Best Practices

Training
- GD&T
- Sigmetrix Software
- Tolerance Analysis

GD&T ADVISOR

Fast, Easy, Accurate, GD&T Creation

- Available for Creo and embedded within Inventor 2018
- Easily apply GD&T annotations
- Ensures GD&T is correct and complete
- Help content to easily answer GD&T questions

Better Products Through Mechanical Variation Analysis

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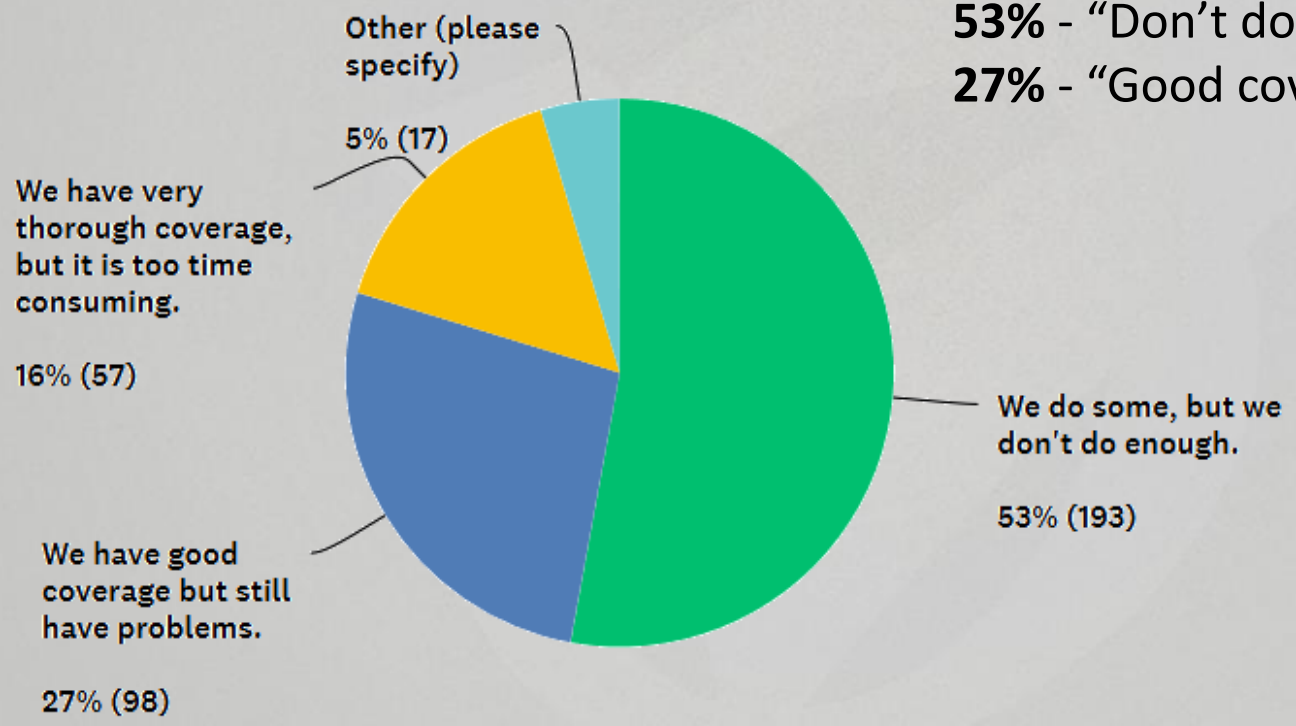
The State of Tolerance Analysis 2019

How companies rate themselves at tolerance analysis?

Which best describes your current tolerance analysis coverage?

Answered: 365 Skipped: 12



53% - “Don’t do enough”
27% - “Good coverage but still have problems”

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Top reasons cited for investigating Model Based Tolerances Analysis solutions

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%**

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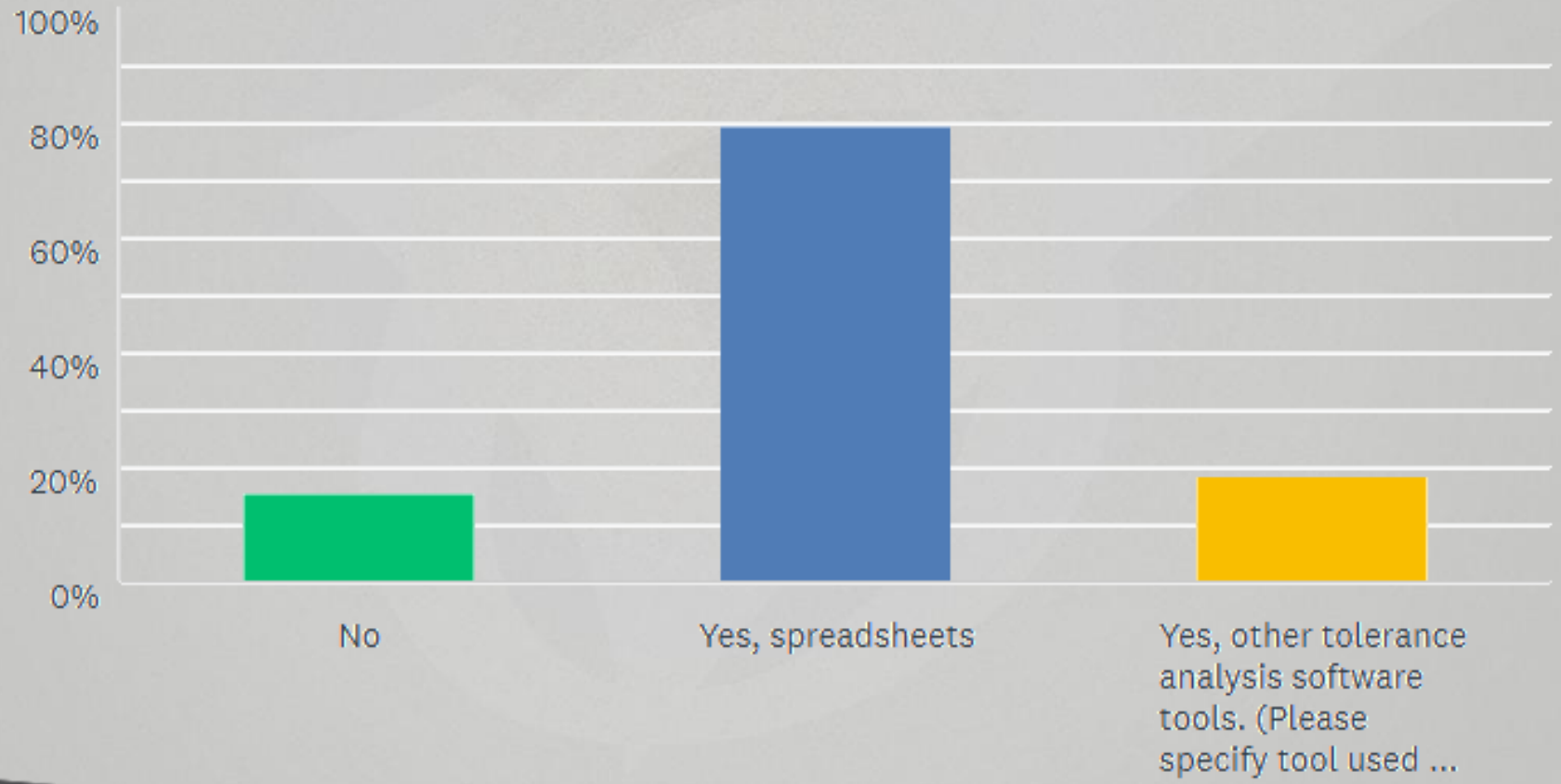
What is the market-leading solution for tolerance analysis?

Do you use spreadsheets or other tolerance analysis tools?

Answered: 365 Skipped: 12



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Problems with Spreadsheets for Tolerance Analysis:

1. Spreadsheets not associative to design
2. Each analysis is typically treated independently from the others.
3. Manual creation of report graphic
4. Math for true statistical treatment (as opposed to just RSS) and GD&T becomes complex.
5. Only provide results, usually WC and RSS
   - Contributions not identified
6. Not easy to change assembly assumptions (shift/bias across features of size)
7. Not obvious if more efficient tolerancing method is available
8. No indication that things may be more complex than they appear
9. Angular variation is hard to calculate for 2D problems, almost impossible for 3D

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Sigmetrix Revenue Timeline

See Live Presentation for Detail

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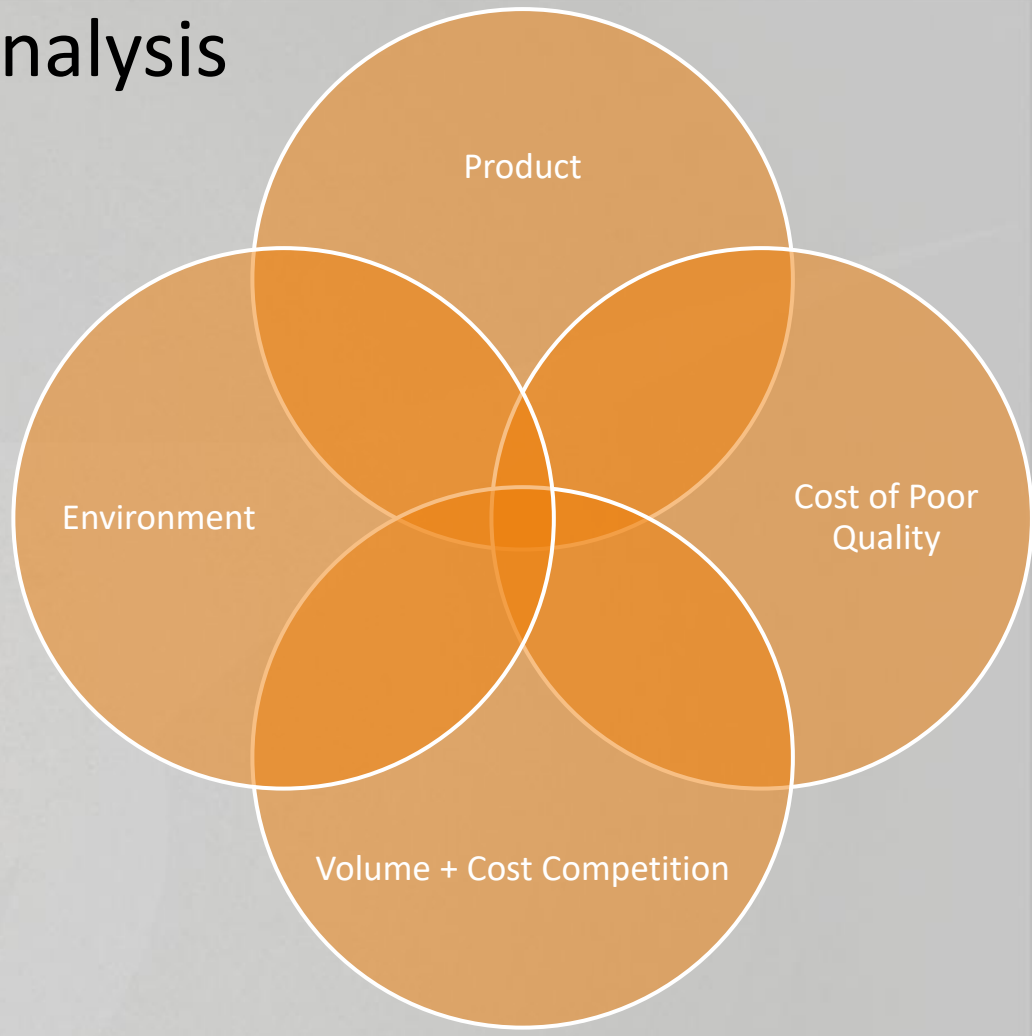
Why is the Tolerance Analysis Market Growing?

Environment for Model Based Tolerance Analysis

- Volume + Cost Competition (Margin)
  - -
  - -
- Product
  - Numbers of parts in an assembly/chain
  - 1D, 2D, 3D Effects
  - Interchangeable parts
  - *Rigid body
- Cost of Poor Quality or Product Failure
  - Failure of product could result in harm or death
  - Product my be hard to service
  - Customer competing to be high quality provider (reputation)
- Environment/Culture
  - High R&D to Revenue Ratio
  - Culture of Change and Learning
  - Possibility for Engineering/Manufacturing/Inspection to collaborate
  - Well developed processes and engineering technology



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Factors Driving Increase in Model Based Tolerance Analysis

- Greater skills, knowledge and process around Tolerance Analysis
- Change in where and how tolerance analysis is used
- Increase in use of Model Based Definition
- Increase in use of GD&T or GPS
- Market demands
  - Global Competition
  - New Competitors in the Market
  - Need for more innovative products
- Regulatory demands

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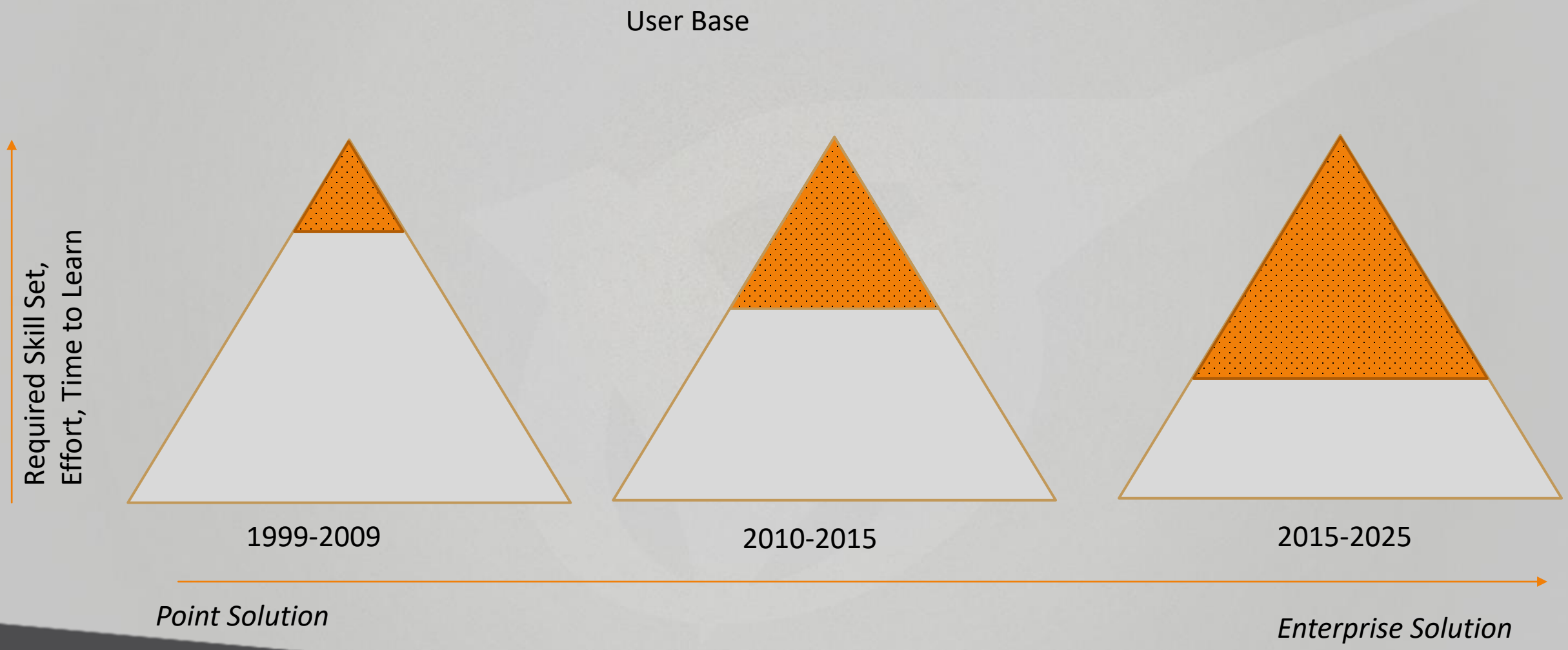
Customer End User Evolution



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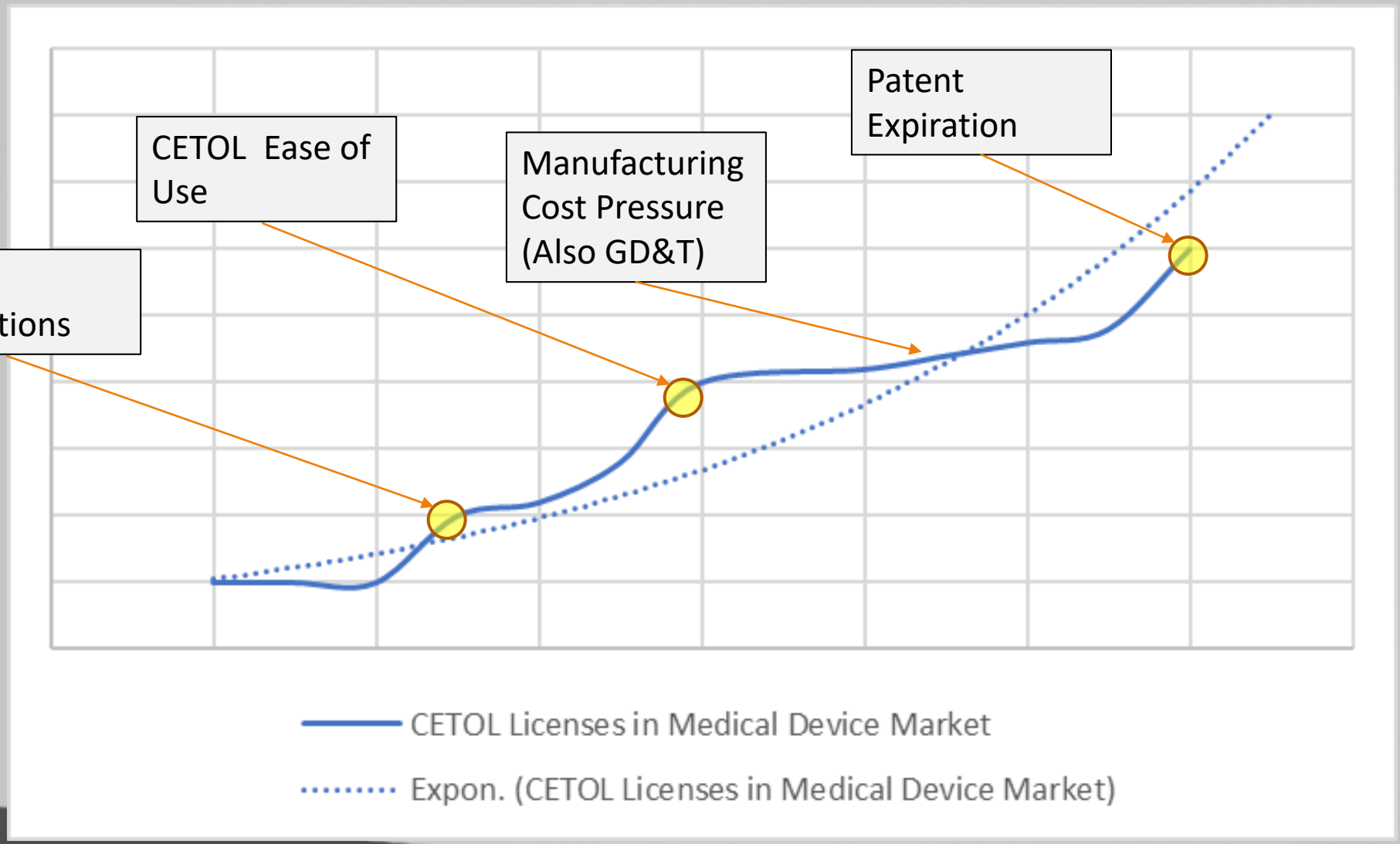
CETOL Use in Medical Device History



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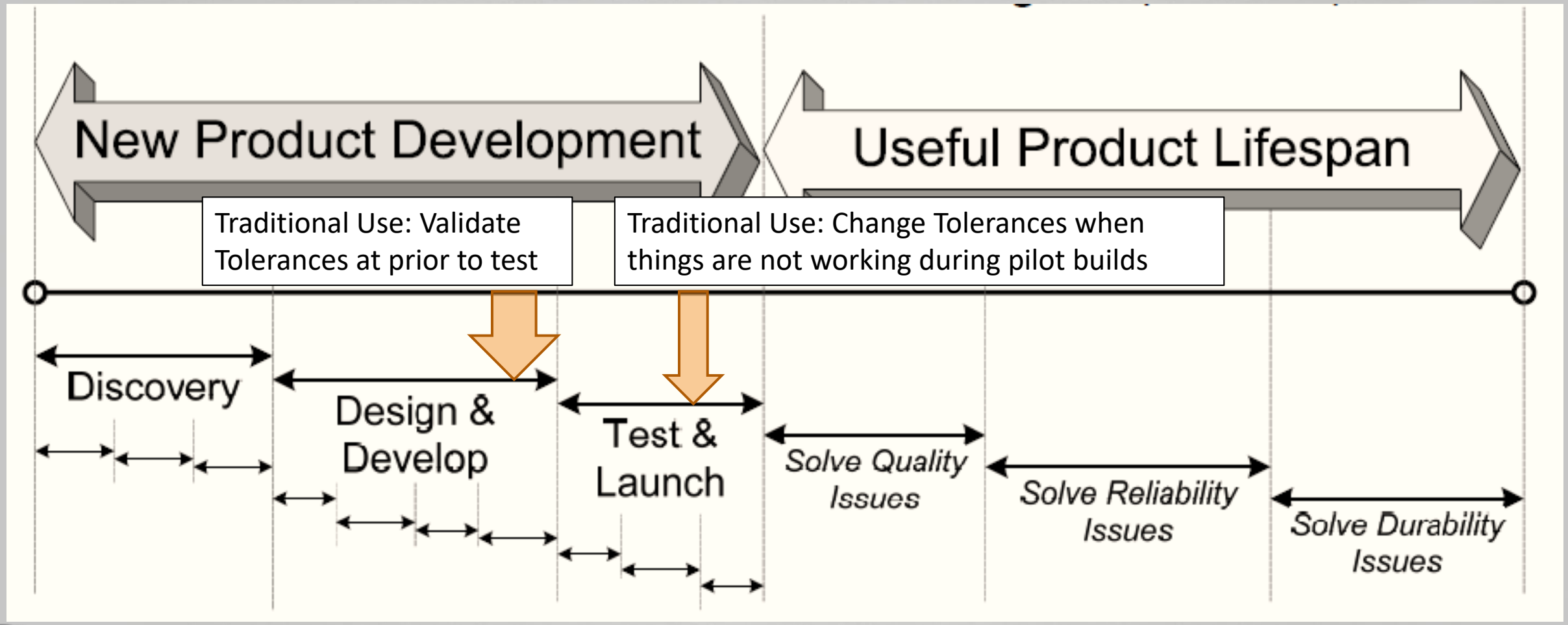
When are people using tolerance analysis?

Tolerance Analysis in the Product Lifecycle - Traditional



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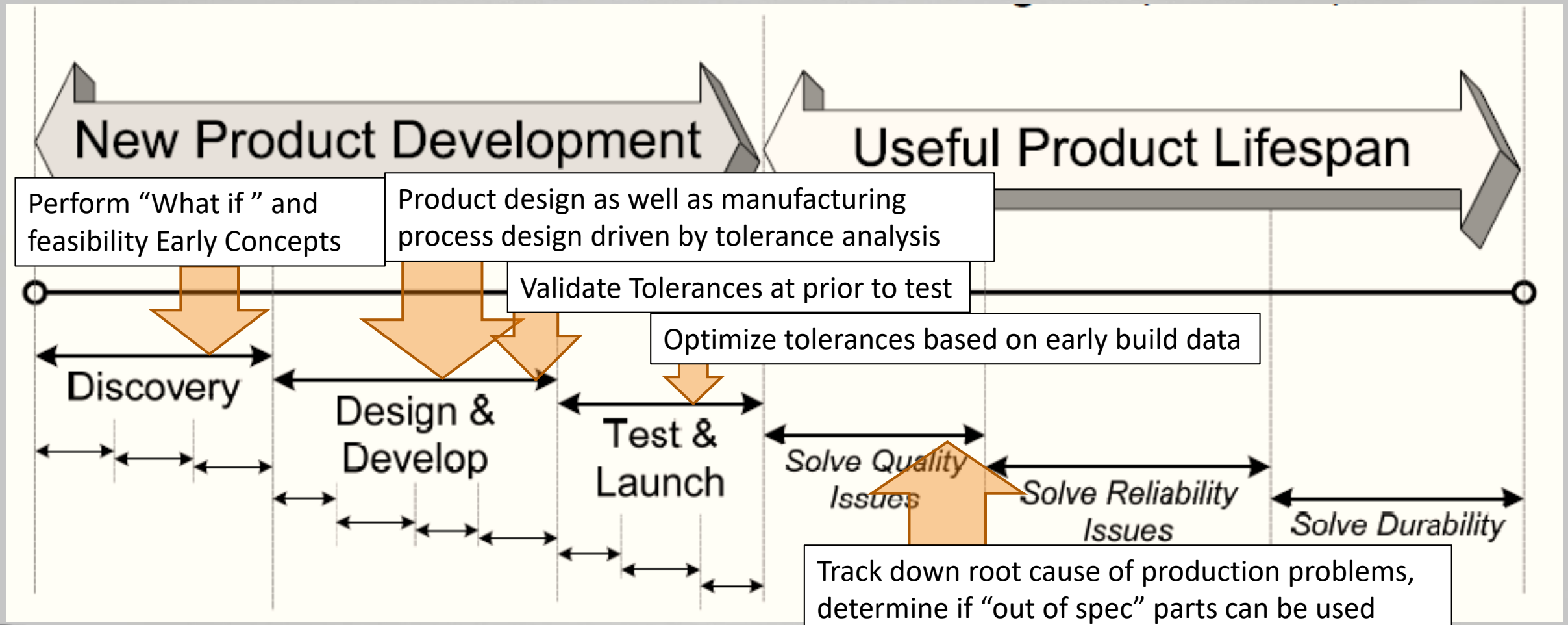
Tolerance Analysis in the Product Lifecycle – Current Trends



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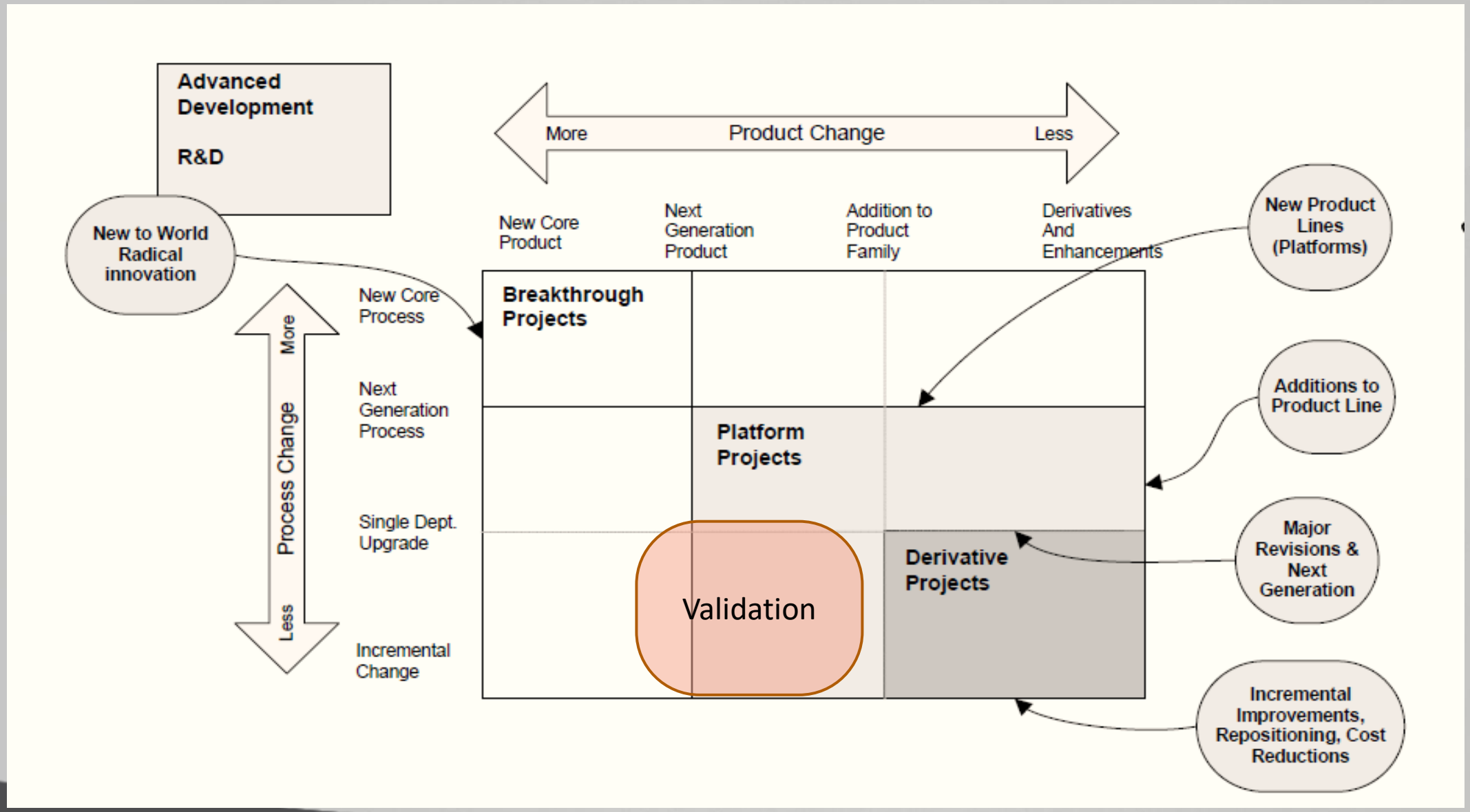
Tolerance Analysis in Types of Development - Traditional



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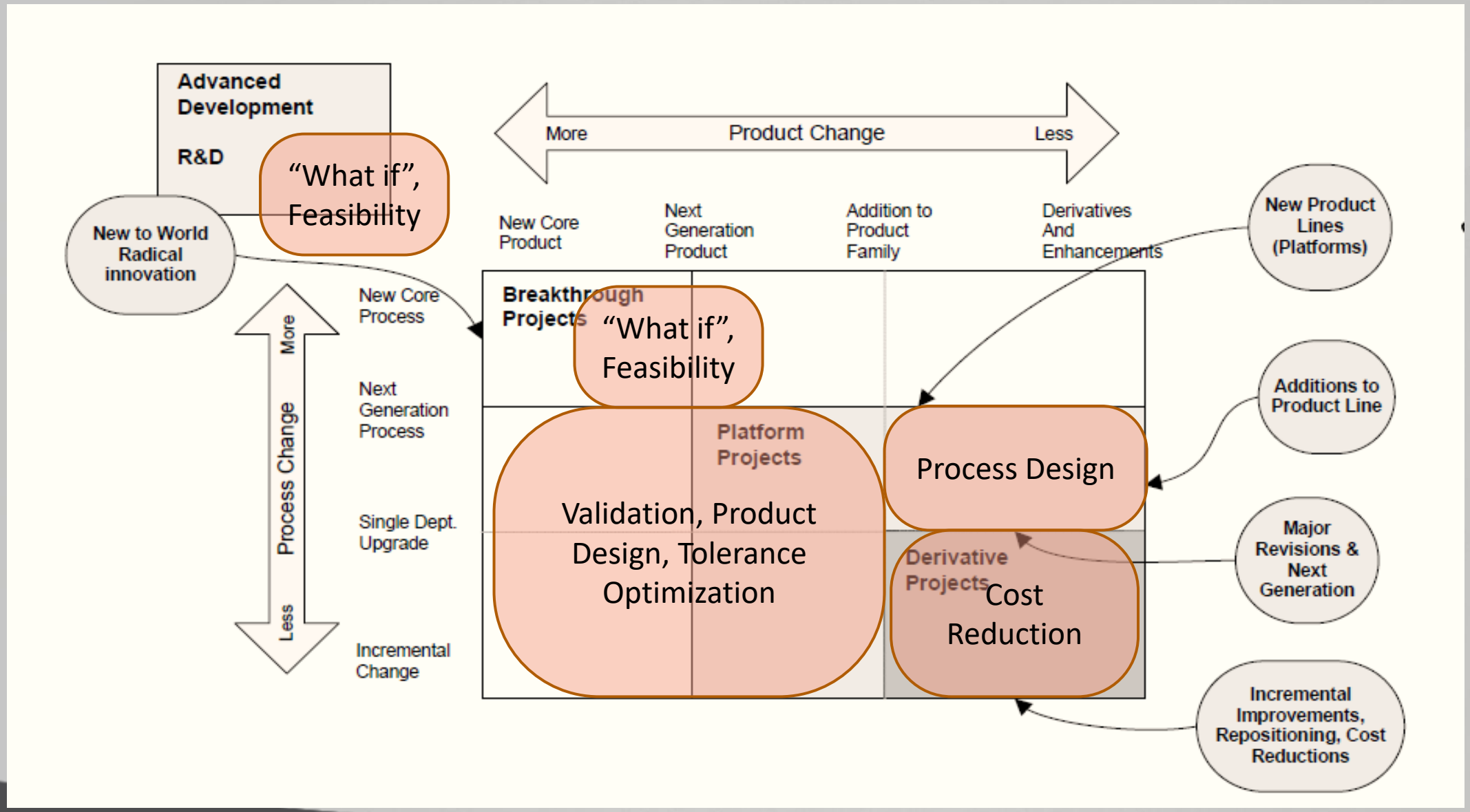
Tolerance Analysis in Types of Development - Current Trends



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GD&T / GPS

GD&T Situation in North America and Europe

- GD&T (GPS in EMEA and Asia)
  - Aerospace & Defense leads the way – Raytheon has the most number of GD&T Senior level individuals
  - Automotive next, though not as extensively used as in Aerospace
  - Medical, Consumer Appliances, and Consumer Electronics are a distant 3rd, but growing quickly
- Factors that are driving an increase in GD&T
  - Need for supplier flexibility on global scale
  - Competition for production cost
  - Demand for fast manufacturing
  - Demand for more modular manufacturing
  - Automated GD&T programming by manufacturing and inspection equipment
  - Overall increase in skill levels

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GD&T Survey Data

- Poor dimension & tolerance practices is a significant quality issue
  - Significant number of ECNs are dimension & tolerance related
- GD&T is seen as a means to address this quality issue
  - 51% have quality initiatives that specifically include GD&T
  - 59% provide some kind of GD&T training.
  - 78% plan to increase usage of GD&T
  - Many companies only teach GD&T to design, not manufacturing and inspection
- GD&T is still not well utilized
  - 92% of companies use GD&T, but 52% say they don't use it effectively
  - 47% employ design checkers to ensure GD&T quality

"We estimate that 80% of our manufacturing issues are directly related to improper use of GD&T."

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GD&T Advisor Statistics

- Top 10 Subscribers have between 27 and 330 licenses each
  - 7 Defense Contractors
  - 1 Automotive Supplier
  - 1 Communications Equipment Supplier
  - 1 Postage Equipment Supplier (*Government*)
- Note: Data isn't balanced as only 1 CAD system, PTC Creo, is represented
  - Much CATIA and NX in Automotive
  - Many Medical Device companies use SOLIDWORKS

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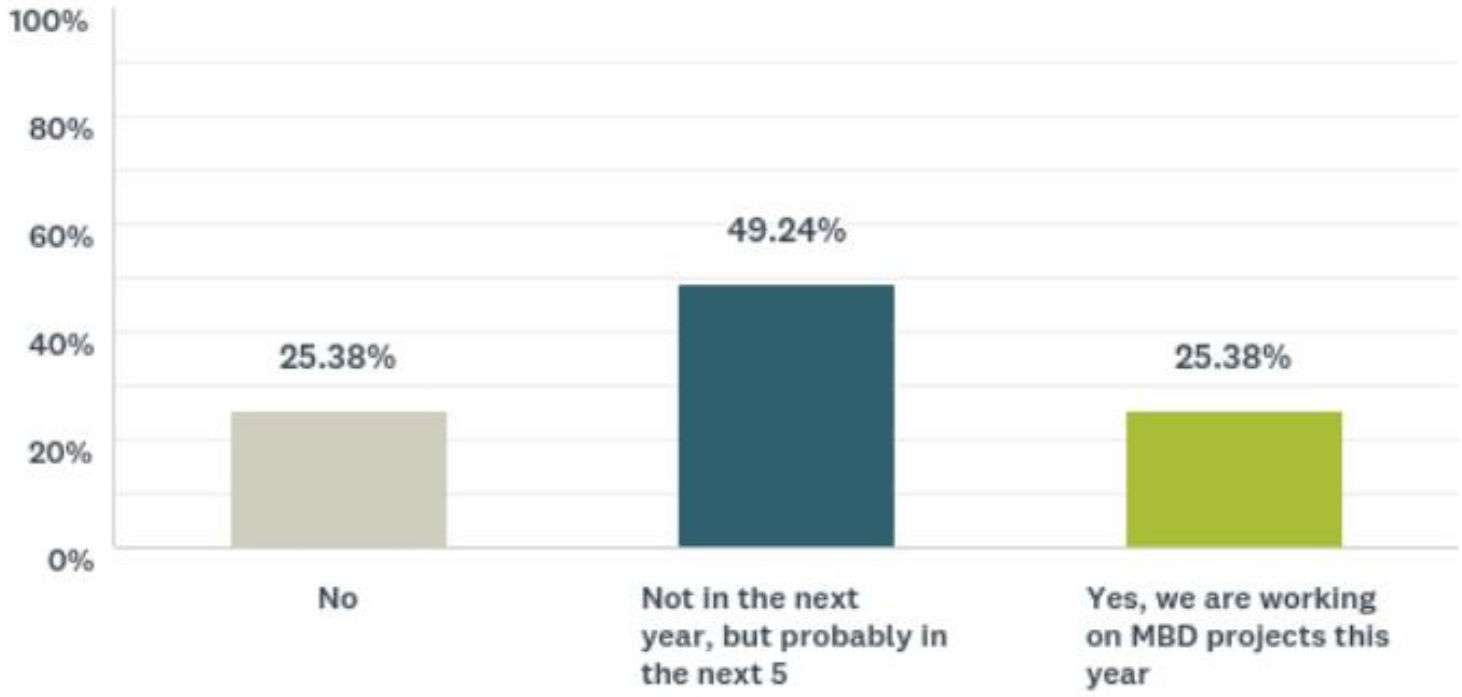
Model Based Definition

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?



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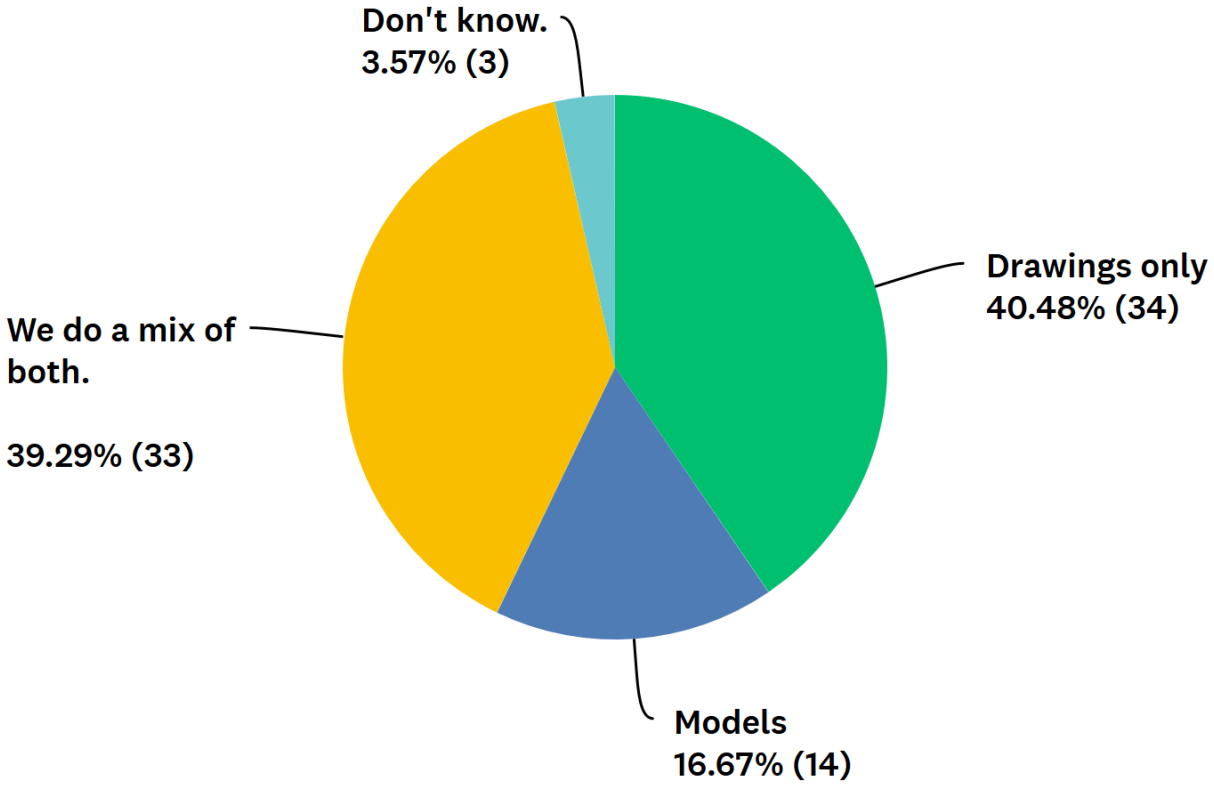
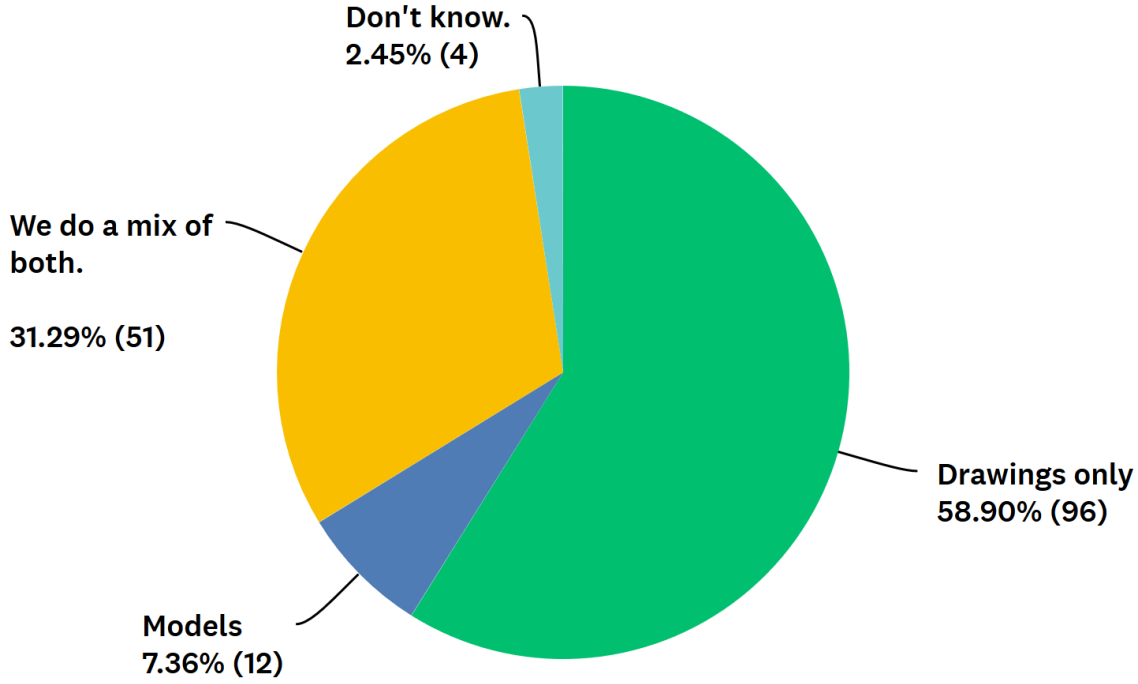
When do companies expect to define GD&T in CAD model (vs print)?

Next year



2-5 years



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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.

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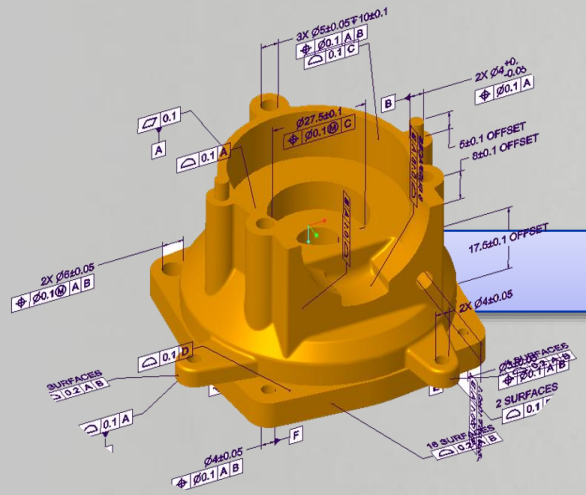
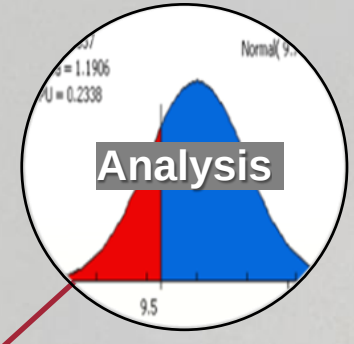
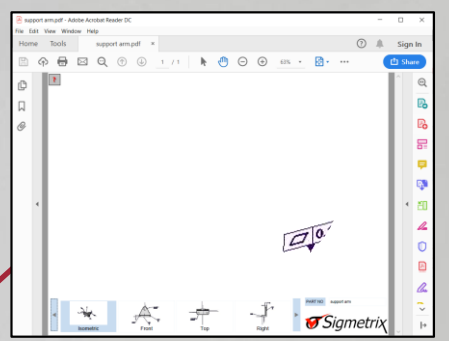
The flow of information in the MBE

- **MBE enables efficient communication throughout the organization**





- FEA
- Tolerance Analysis



- Human Readable Formats

Digital Thread

- CNC Instructions
- Automated Manufacturing Plan

- CMM Instructions
- Closed Loop inspection feedback

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MBD Situation in North America and Europe

- MBD
  - Aerospace & Defense leads the way for the application of GD&T to models
    - The U.S. Government is trying to move it's contractors to MBD
    - Most common applications include airframe/structural components and powerplants
  - Automotive 2nd in terms of implementation
    - Many use their own internal rules rather than relying completely on standards
    - Few have an entire product line or sub-assembly defined using MBD only
    - Asian auto makers have benchmarked themselves against European automakers and have determined that they are behind in skill and implementation
  - Medical, Power Distribution, Consumer Products, Consumer Electronics are 3rd, but growing most quickly due to complex shapes and use of additive manufacturing processes

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