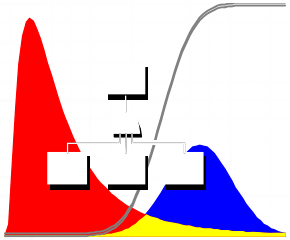
Tolerance Analysis Tools, Techniques and MBE Training

DMDII 15-11.



DMDII MODEL-BASED ENTERPRISE

MBE Summit

Dr. Andreas Vlahinos
andreas@aes.nu

Hosted by NIST
Sponsored by DMDII and Lockheed Martin
April 12, 2016
Gaithersburg, Maryland

This project has not yet been officially awarded by DMDII and is subject to pending negotiations.

Team Members

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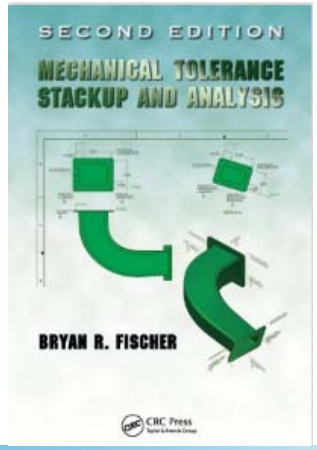

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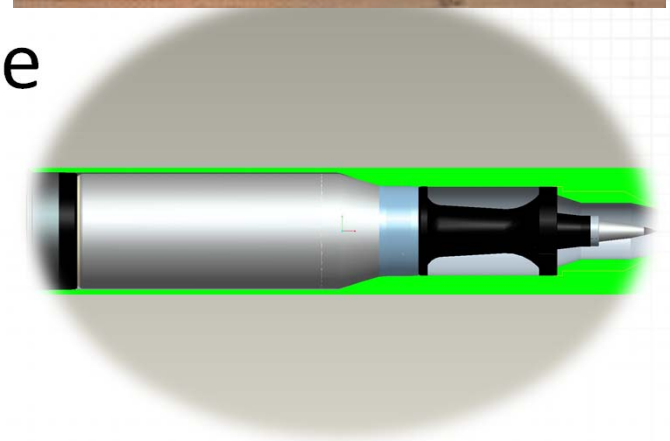
Motivation

- DOD Quality performance requirements
- Reliability and Materiel availability metrics as KPP
- Demonstration of compliance with virtual prototypes
- Immediate feedback during development process
- TDP Requires MBD
- TA -Design for Assembly (DFA)



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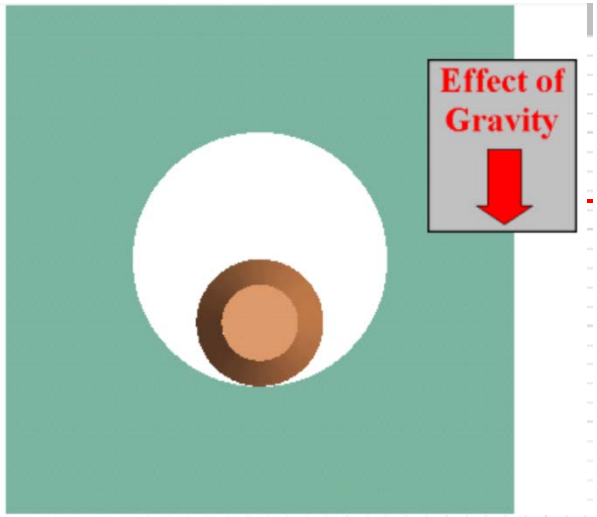
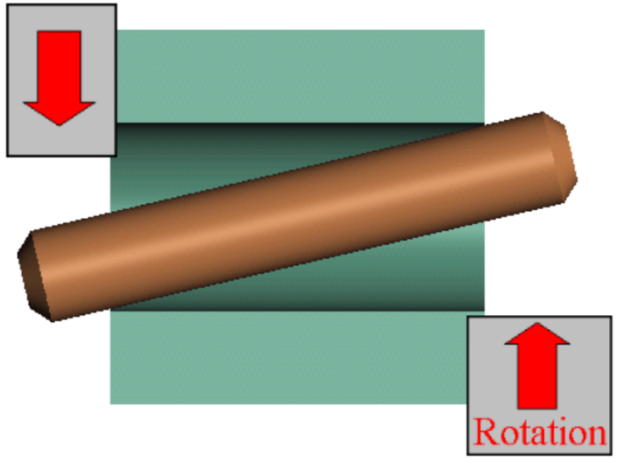
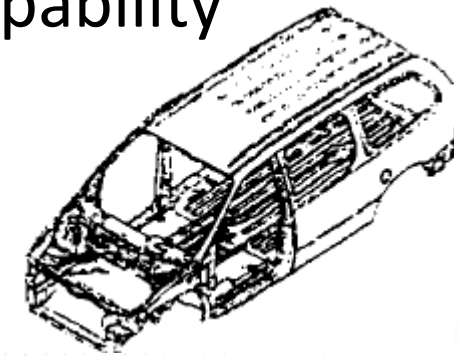
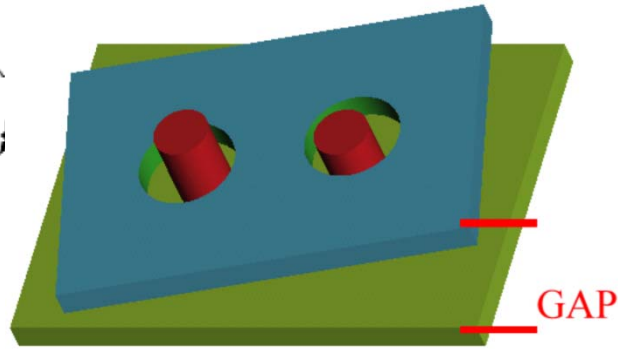
Challenges in Traditional Tolerance Analyses

- Multiple CAD Systems
- Luck of MBD in TDP
- Gravity Loading - Applied Forces
- Interference fits
- Component flexibility (components can deform & changing the dimensions during assembly)
- Differential thermal expansion
- Manufacturing process capability
- Humidity









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List of Tasks for Sigmetrix

- A tolerance analysis tool allowing the user to perform multiple tolerance analyses on part and assembly geometry definitions originating from multiple popular CAD systems. The user would not require access to the source CAD systems in order to be able to perform the tolerance analyses.
- Investigate the feasibility of using STEP AP242 as the CAD-neutral PMI-rich data format through the tolerance analysis function, both as the input format carrying PMI information from the source CAD systems as well as the output format containing additions and modifications to the PMI information resulting from the tolerance analysis activities.

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List of Tasks for AES

- Establish and validate a technique to **add flexibility to a parametric CAD model** with slender components. The components will “bend” as a response to “Loading Parameters” entered in the CAD model. Perform TA
- Establish and validate a technique that links the parametric CAD model to the CAE model. The CAE model will understand the CAD parameters and rebuilds automatically the FEA model with the new set of parameters. Perform TA
- An effort will be made to use a **Multiphysics simulation**. For example it can be a combination of thermal model to find temperature distributions, and a structural model to find the deformation due to the determined temperatures.

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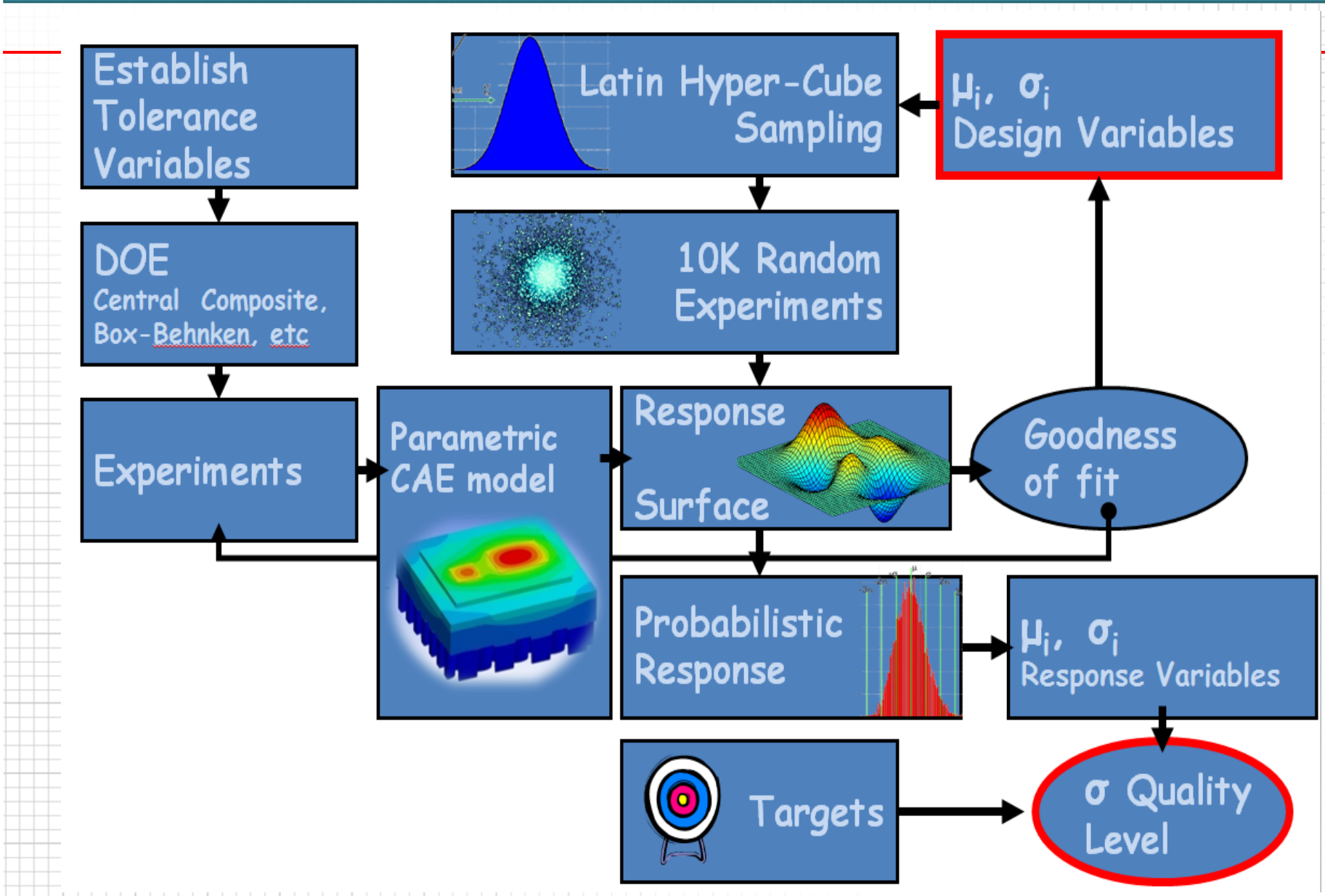
Workflow for Tolerance Analysis of Flexible Assemblies



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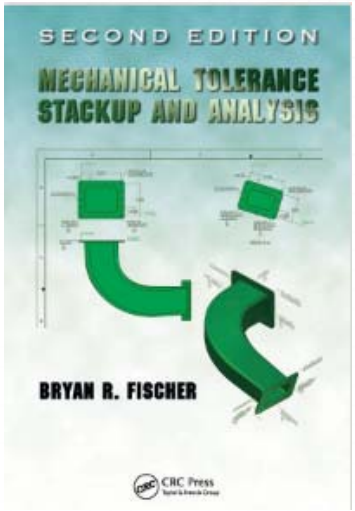
List of Tasks for MBE360

MBE360 will provide the following Training Courses and Workshops:

- Two 20-hour **Level 1 GD&T Fundamentals Course**
- Two 20-hour **Level 2 GD&T Applications Course**
- Two 16-hour **Level 3 Advanced GD&T Course**
- Two 20-hour **Level 4 Tolerance Analysis Course**
- Five 8-hour 3D **MBx Overview, Culture Change and Using MBD in the Workflow**
- Five 8-hour **3D MBD and Product Definition Data Practices Overview Workshops**



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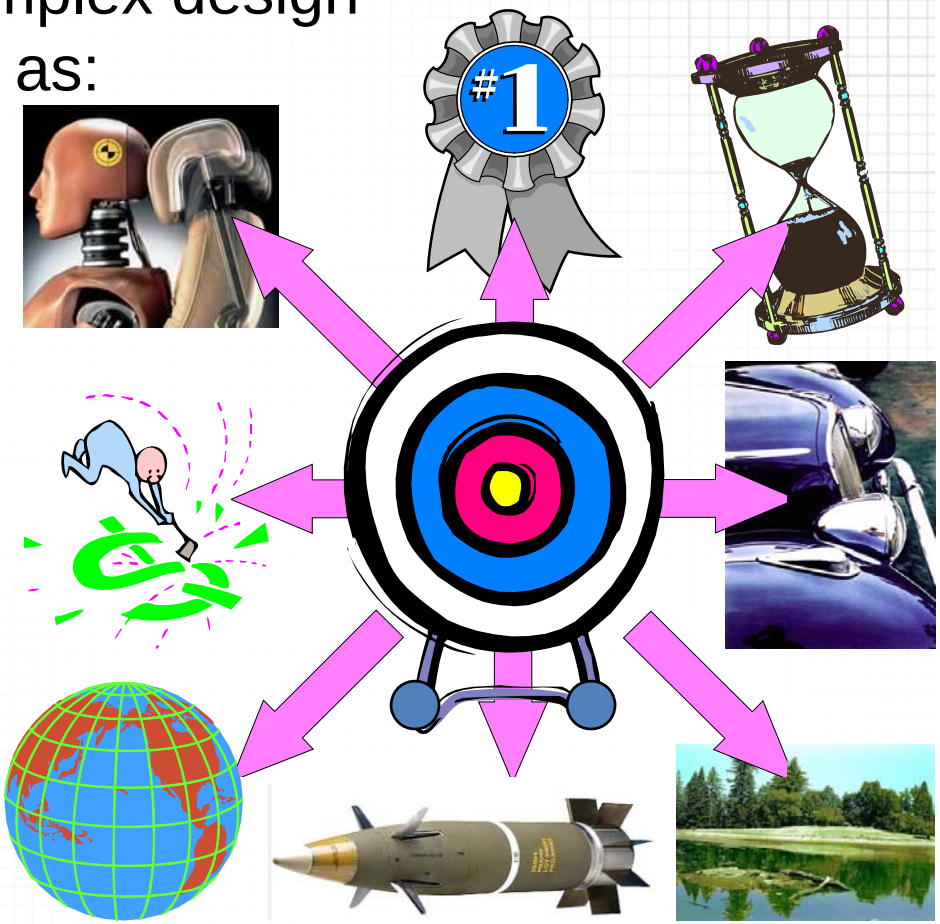
Where are we today?

The need for innovative tools & MBE is apparent now more than ever as more complex design requirements are surfacing such as:

- Cost
- Performance & safety
- **Time to Quality**
- Short life cycle
- Environmental impacts
- Aesthetics (wow, lust for the product, I got to have it ...)
- Major Changes in Industry's Business Model
- Lack of MBD



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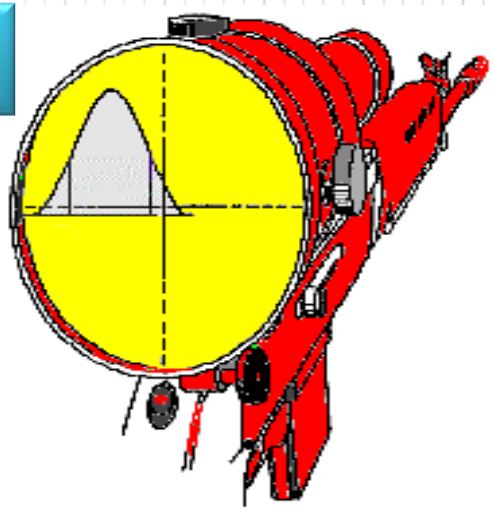
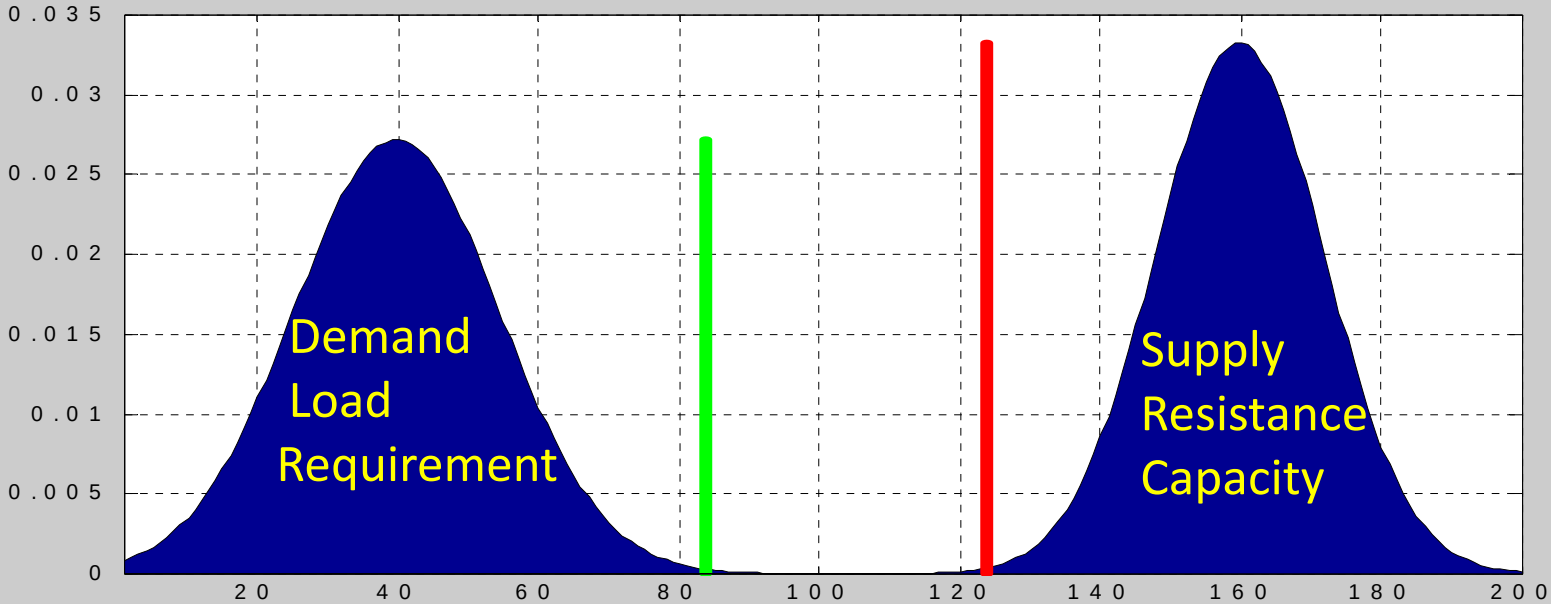
Traditional Deterministic Approach



- Accounts for uncertainties through the use of empirical Safety factors:
  - Are derived based on past experience
  - Do not guarantee safety or satisfactory performance
  - Do not provide sufficient information to achieve optimal use of available resources



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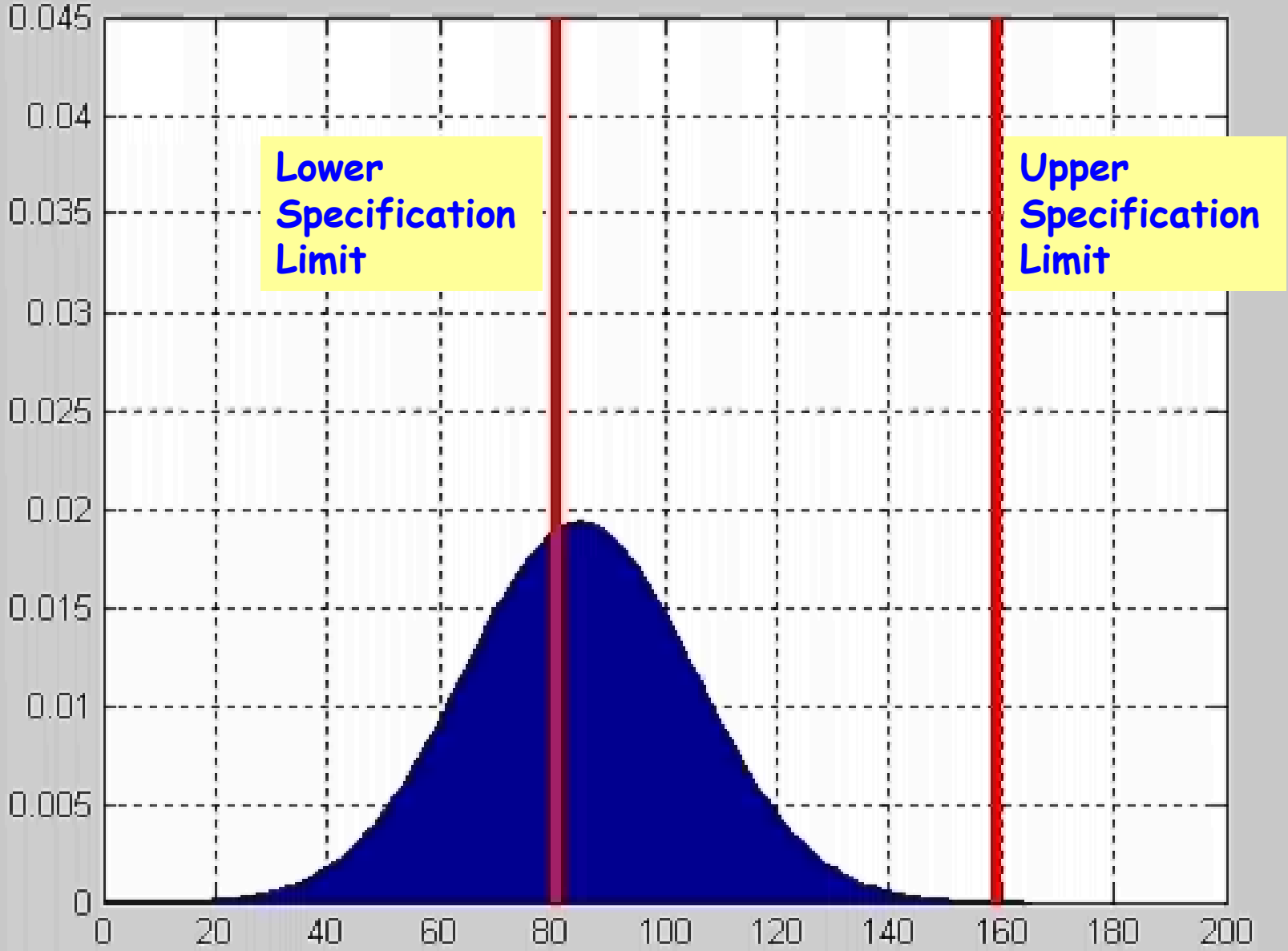
Shift and Shrink



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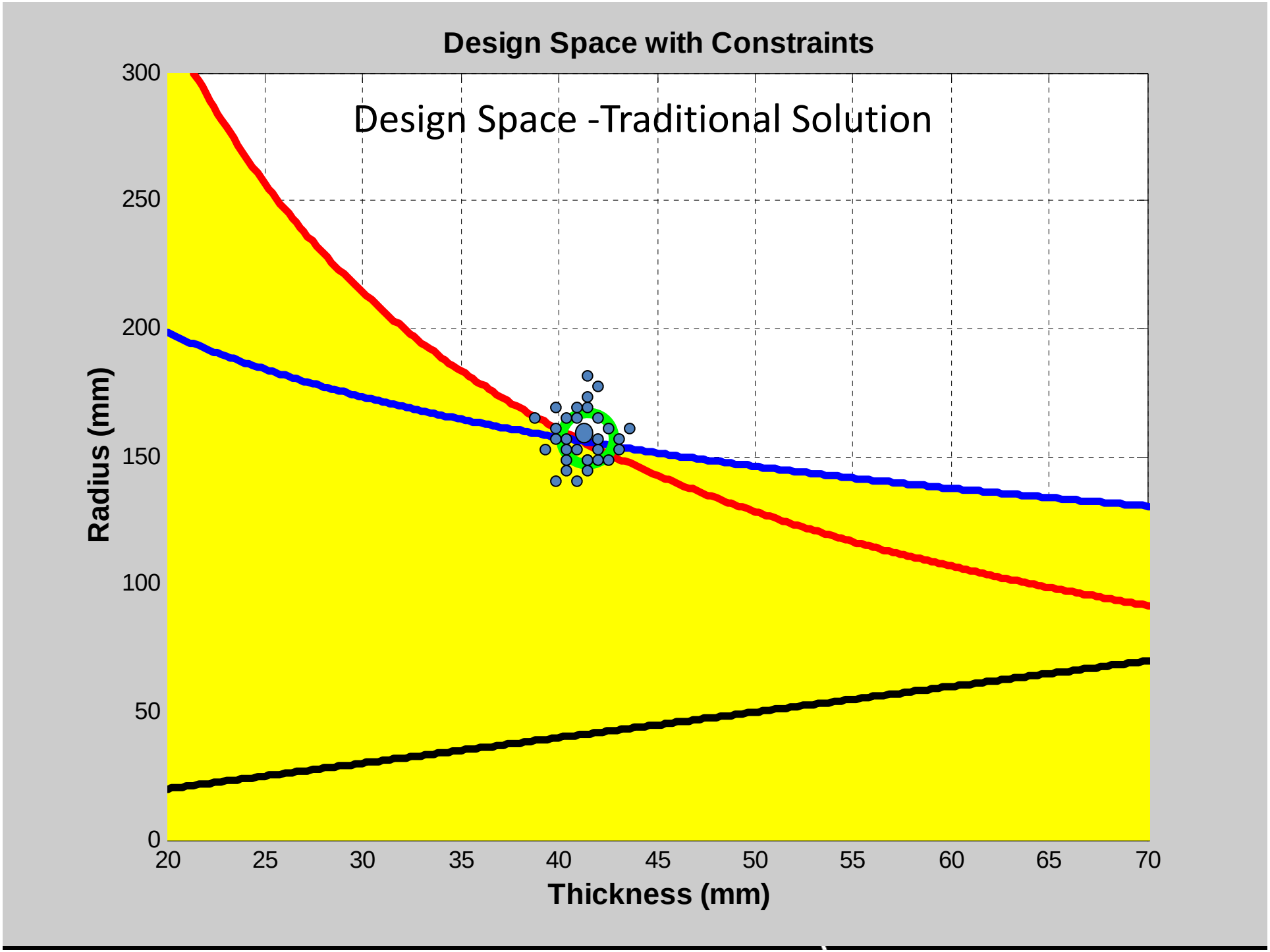

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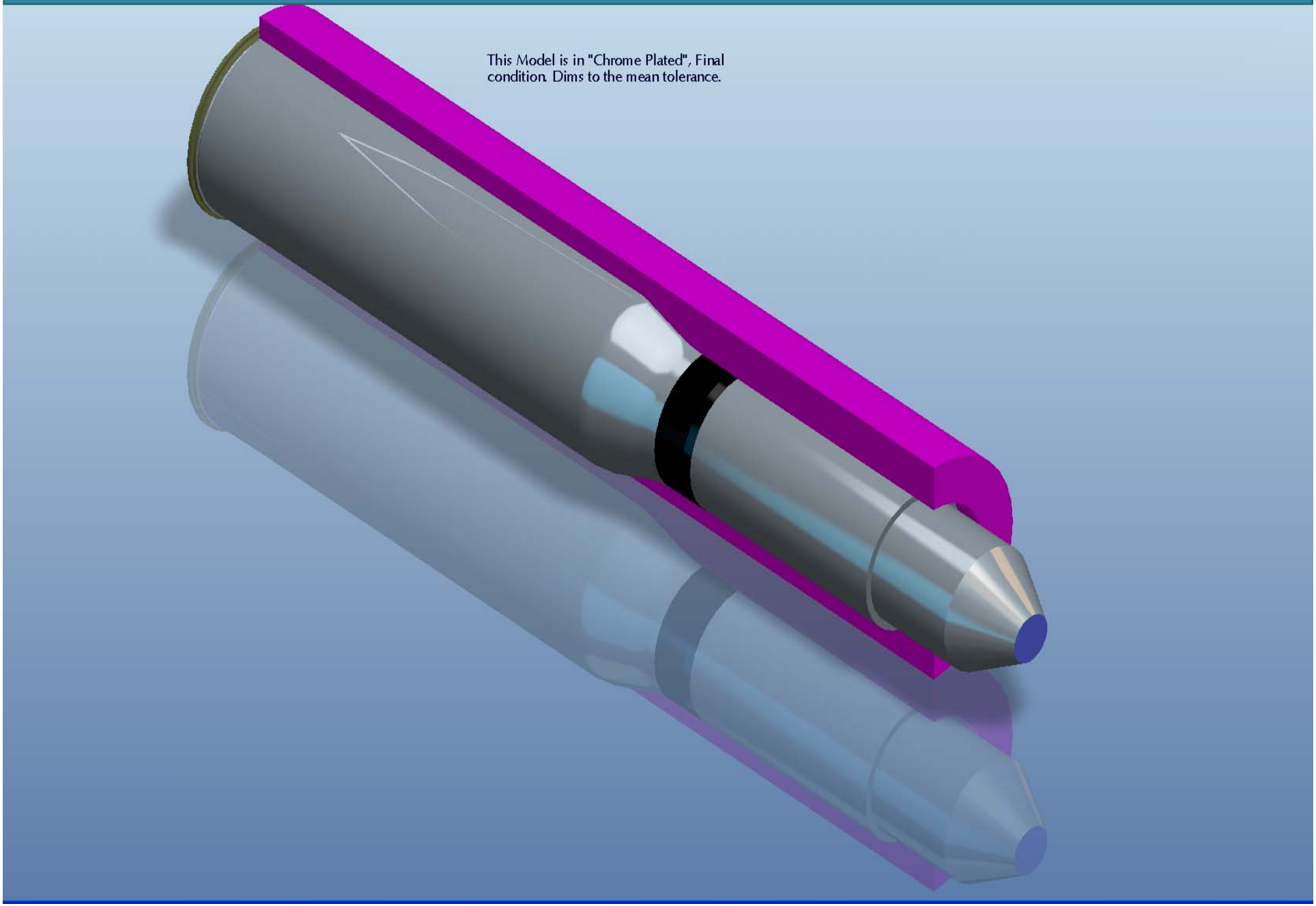
ICD Solid Model



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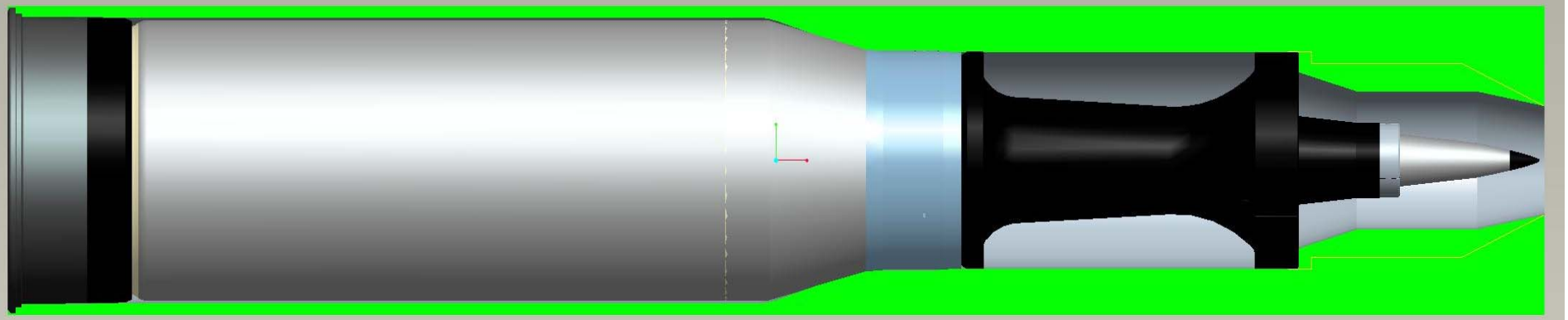
Gun section and ICD Solid Model



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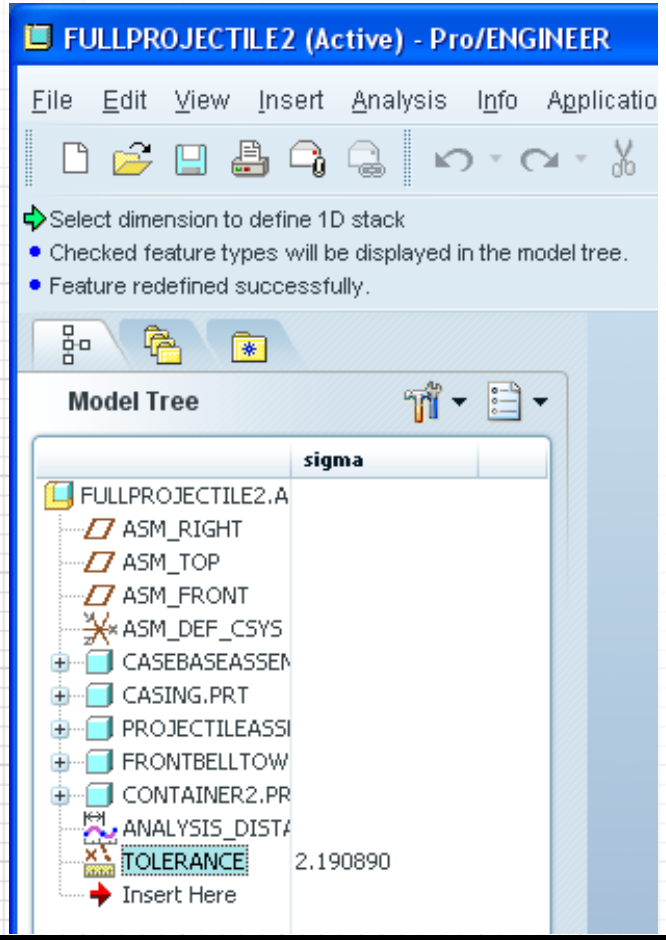
CAD Integration



Tolerance Analysis Report

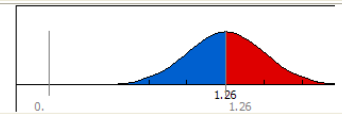
Report Generated On Fri July 16 2010 @ 08:20:35 pm
Analysis Report By: Maiki Vlahinos
Company : GD OTS

Measurement Details

Pro/E Model	FULLPROJECTILE2.asm
Tolerance Analysis Measurement	CETOL_2
Design Specification	1.26/0.00
Solved Nominal	1.26

Measurement Results

Derivative-Based Statistical Analysis

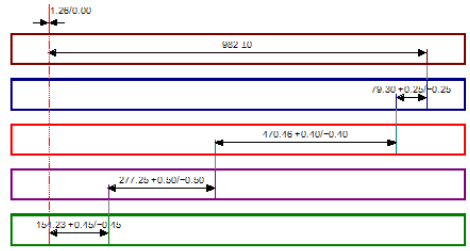


Sigma = 0.6745
% Yield = 49.9998
DPMU = 500,002

Dimension Details

Name:	Dim./Tolerance:	Cp	Sensitivity	Variance/Contribution Statistical
PROJECTILEASSEMBLY:d1	277.25 +0.50/-0.50	1.00	-1	37.04%
FRONTBELLTOWINDSHIELD:d1	154.23 +0.45/-0.45	1.00	-1	30.00%
CASING:d1	470.46 +0.40/-0.40	1.00	-1	23.70%
CASEBASEASSEMBLY:d1	79.30 +0.25/-0.25	1.00	-1	9.26%
CONTAINER2:d6	982 ±0	1.00	1	0.00%

Dimension Loop Diagram



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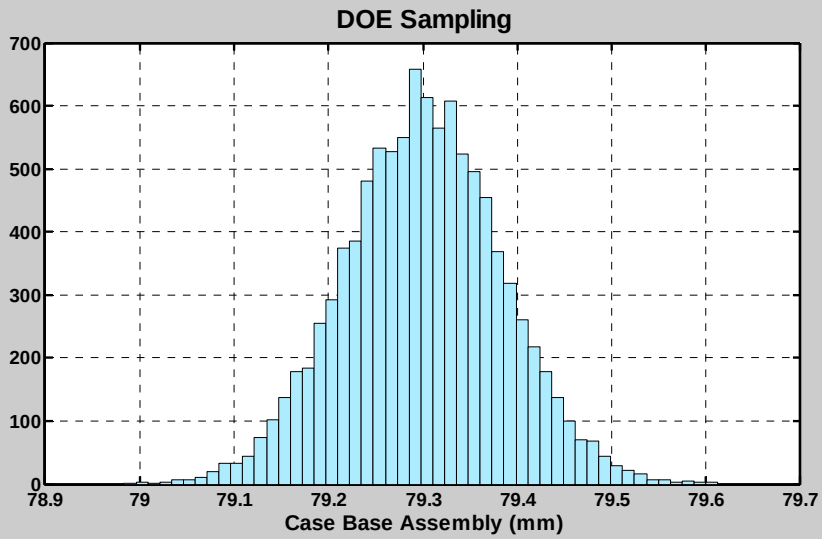
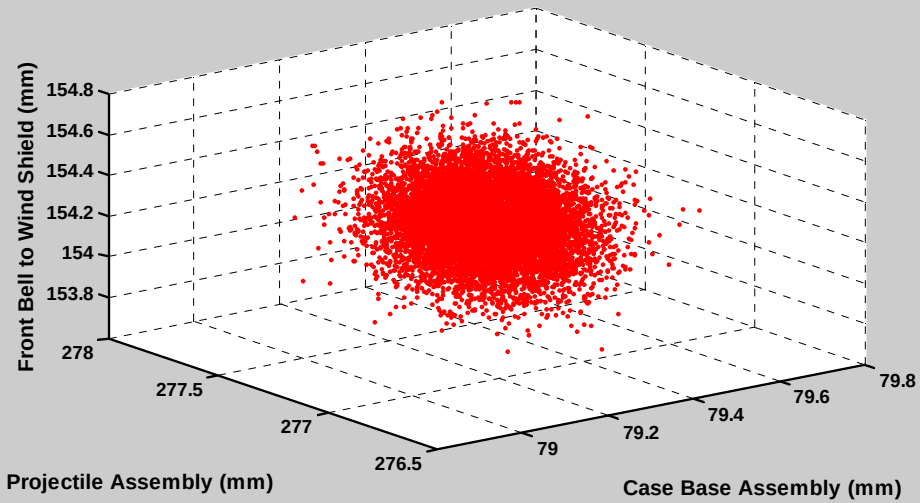
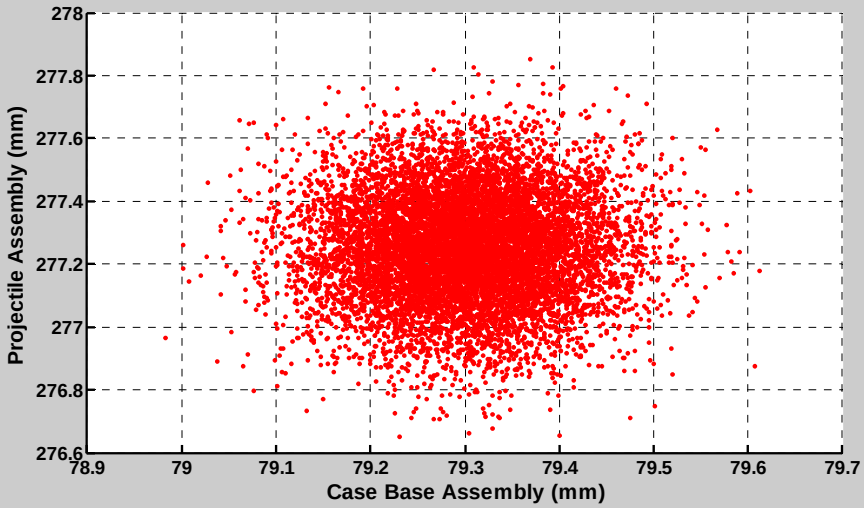
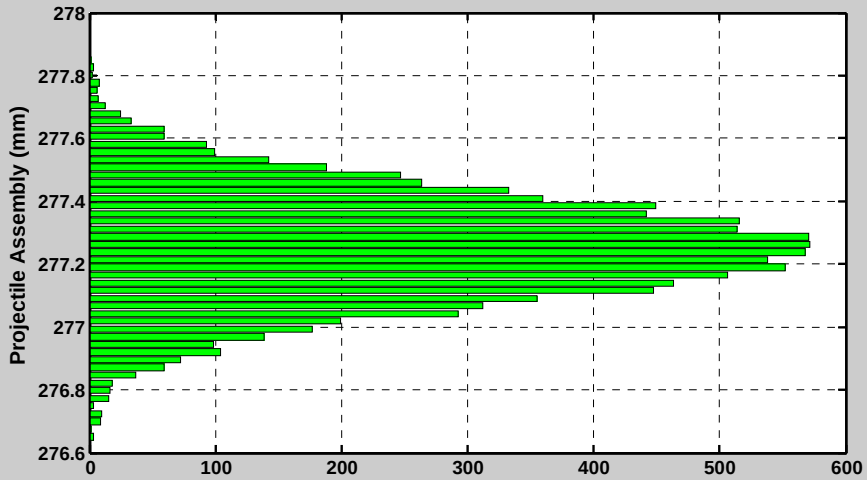
Sampling in Stack-up Tolerance Example









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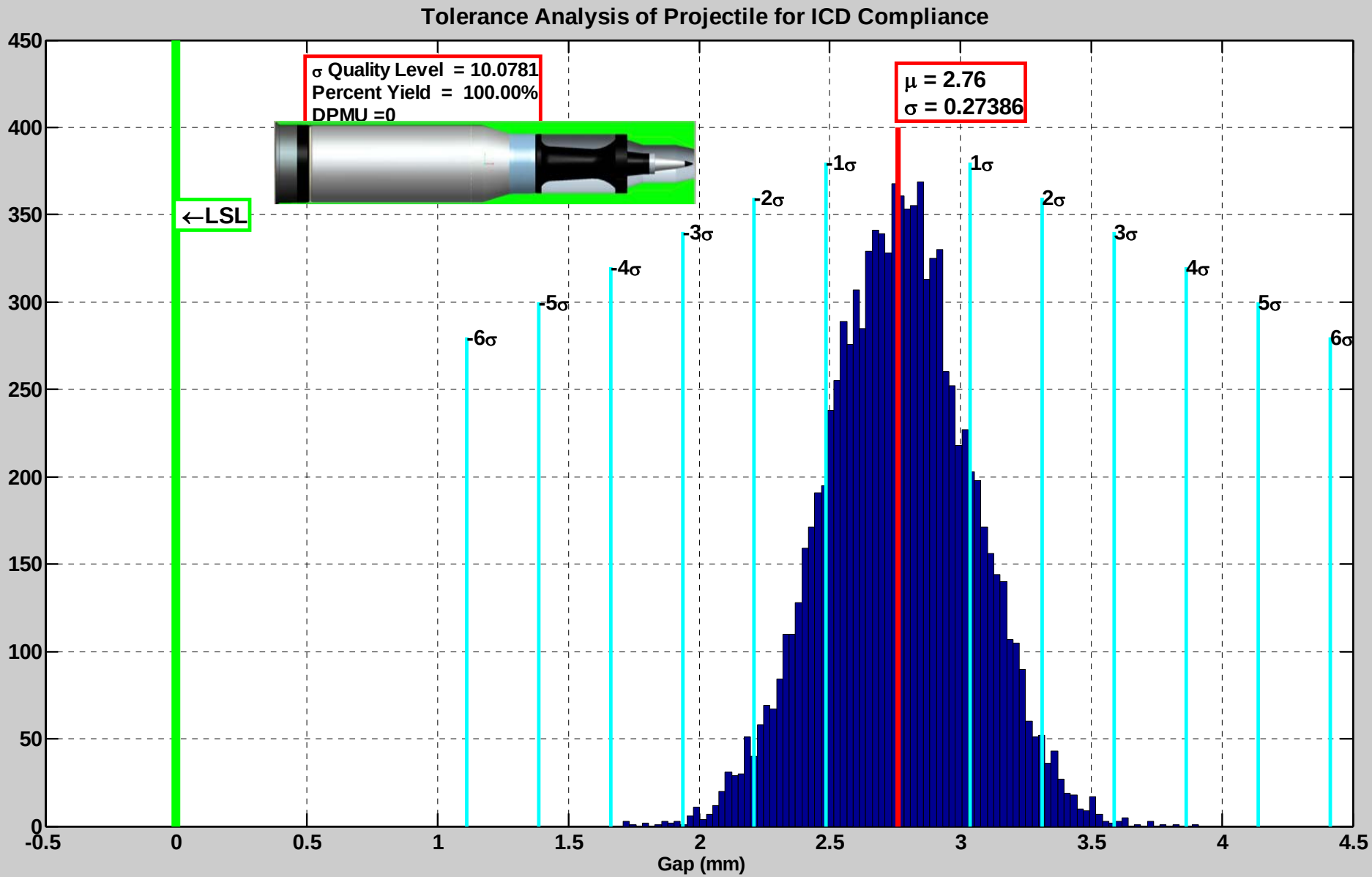
Typical Results of Tolerance Analyses



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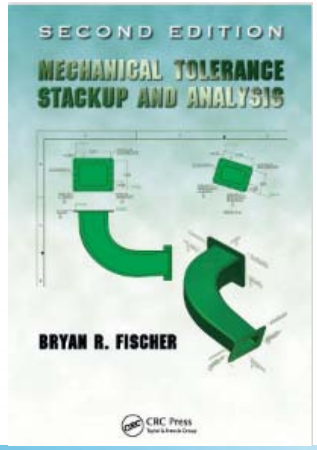

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