Integrated Development

Impact of Measurement Uncertainty on the Development Cycle

Michael Fletcher

Agenda

- Concept Overview
  - Quality as an accumulation of error
  - Sources of Error
  - Flow of Error in System
  - Impact of MU on development cycle outputs
    - Quality
    - Cost
    - Time to Market
- Example
- Conclusions
- Questions

Integrated Development

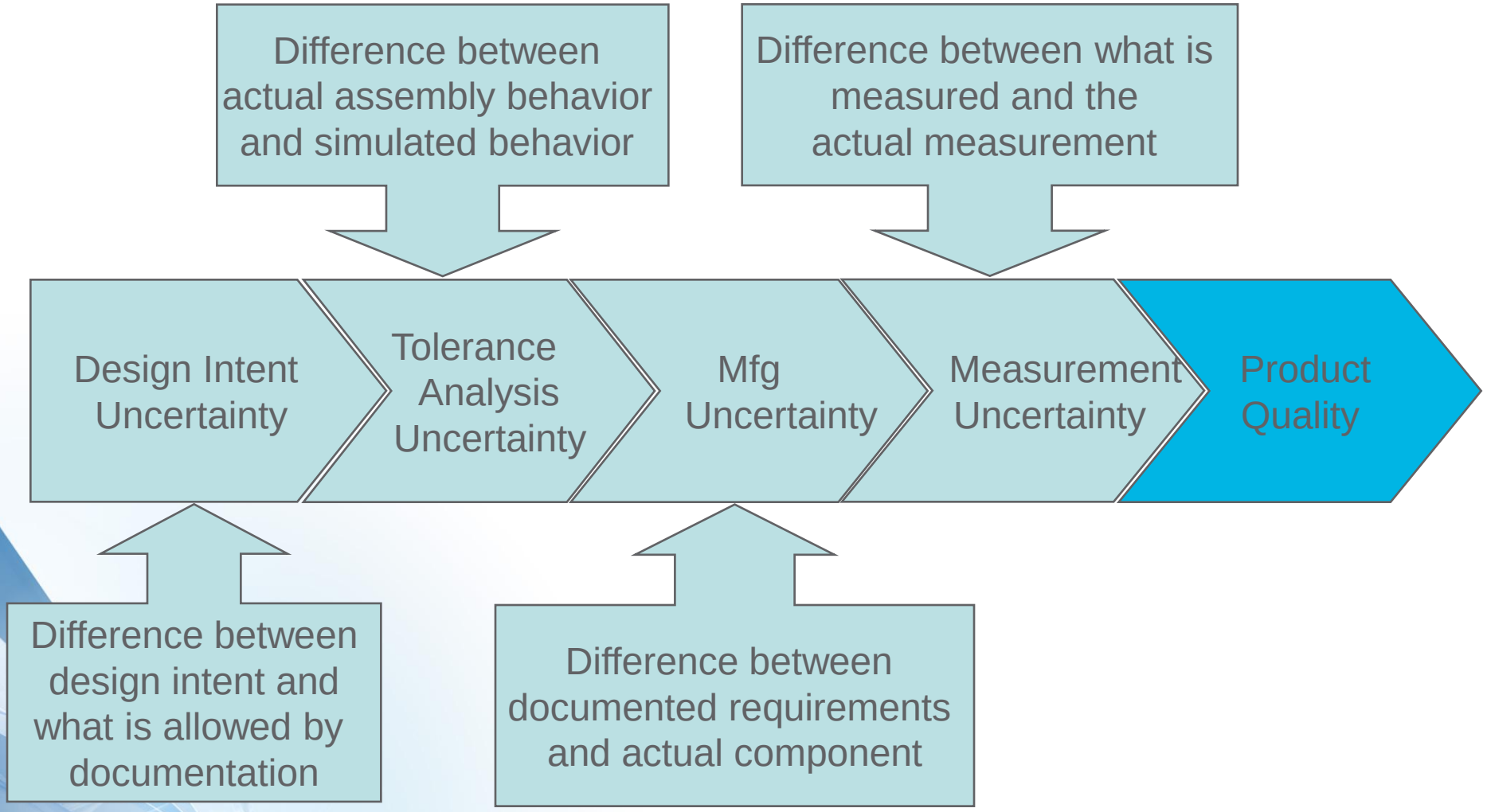
Concept Overview

Integrated Development Environment - Background

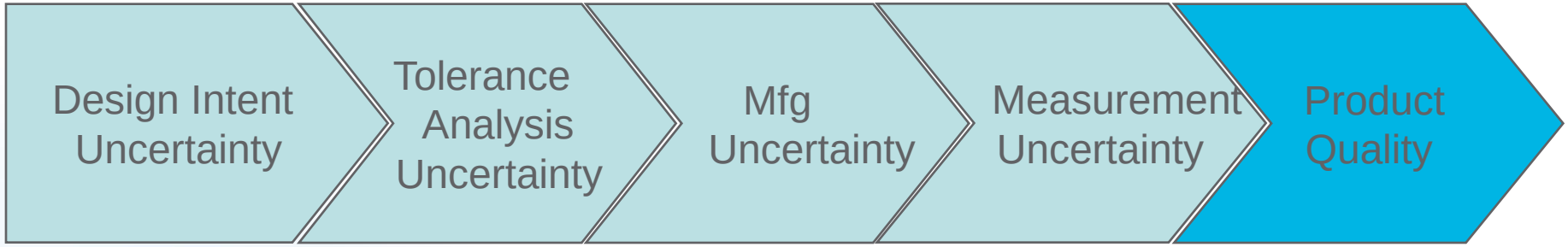
Integrated Development Environment

- Quality
- Time to Market
- Cost

Quality: A Function of Uncertainties

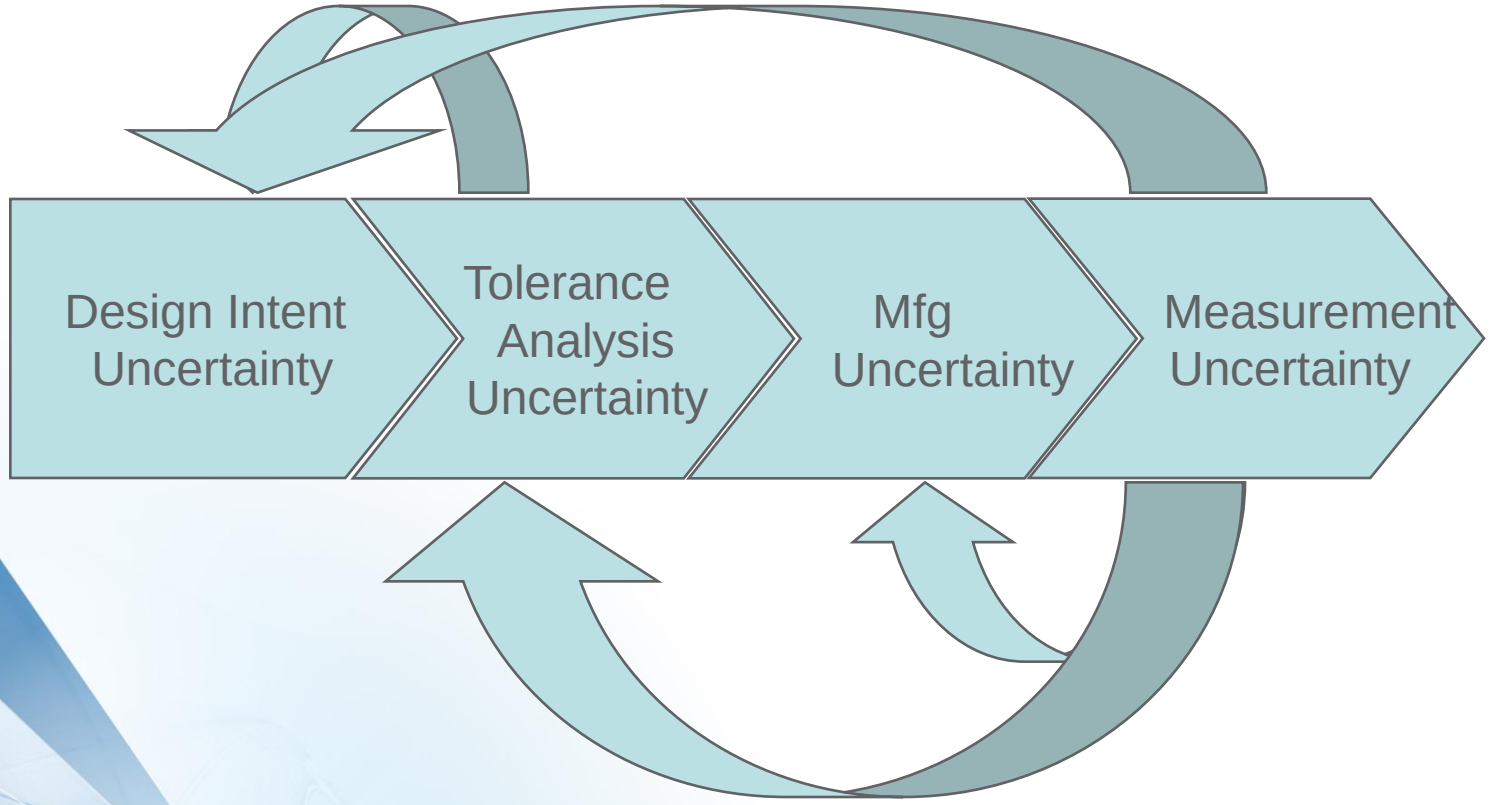


Quality: A Function of Uncertainties



- **Determines Design Predictability**
- **Crosses Organizational Boundaries**

The Flow of Uncertainty



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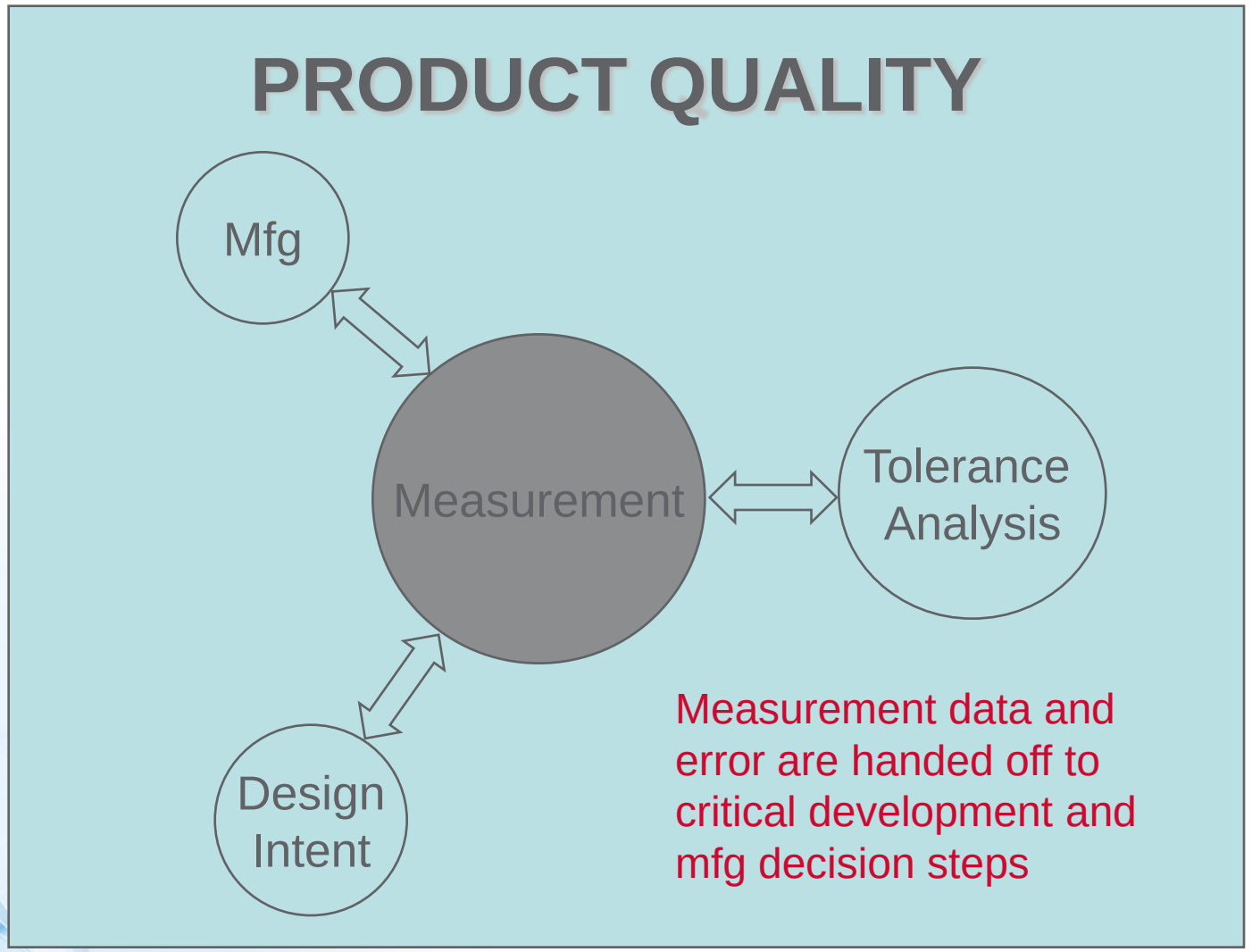
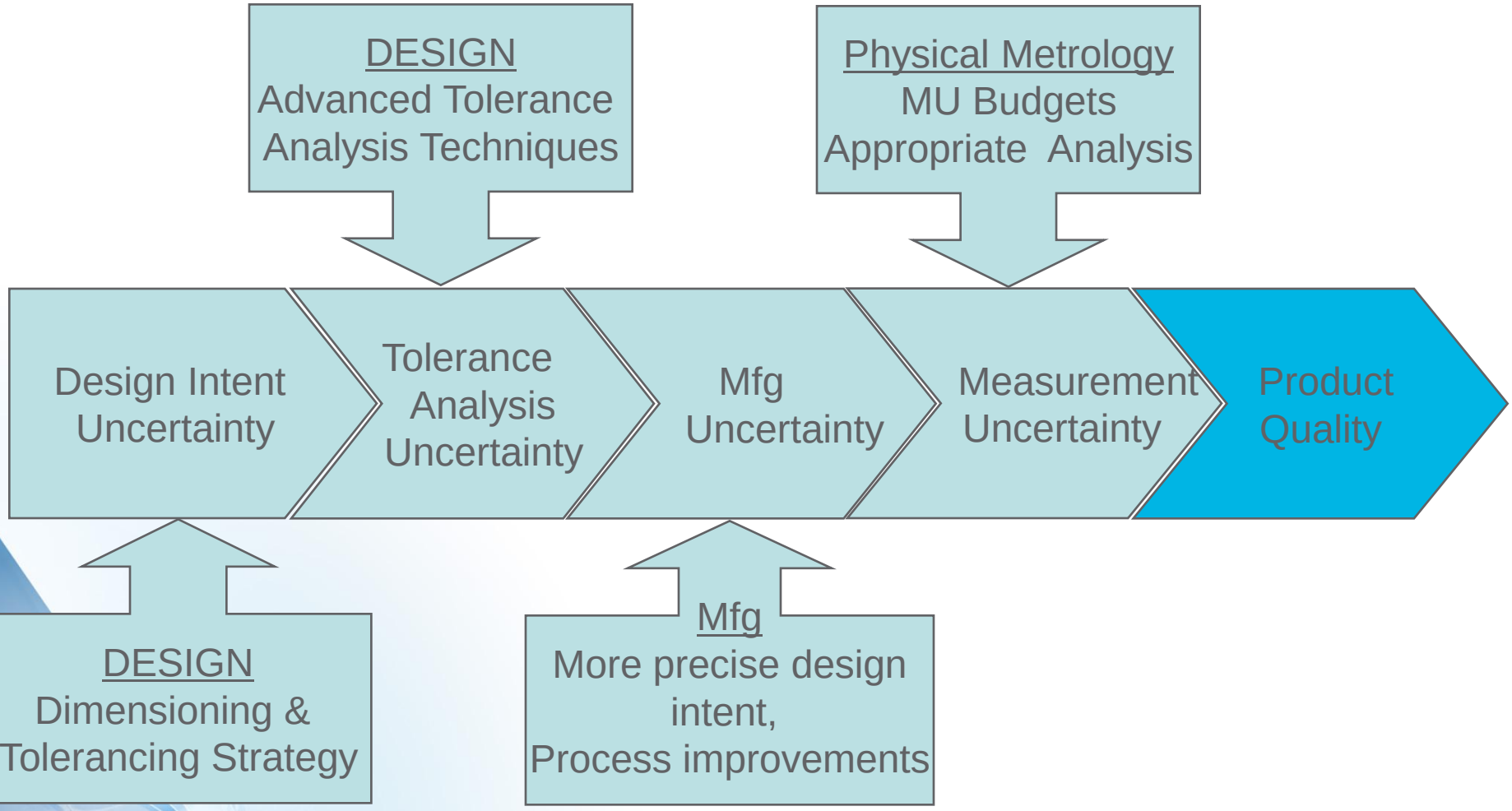
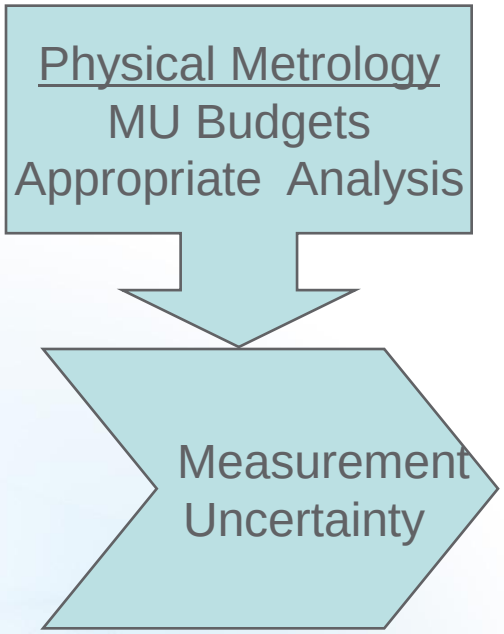


Driving Down Uncertainty



Impact of Measurement Uncertainty On Development



Misclassification

- Single value vs. capability

Measurement Uncertainty : Scenario 1

Classify unacceptable capability as acceptable

- Move ahead with Development
  - Component Qualifications
  - Development Builds and Testing
  - IQ/OQ/PQ
  - Design Verification Builds and Testing
- Fail at some point in these processes

Scenario 1: Impact

- Delay Product Launch (Lost Revenue)
- Tool Changes (Cost)
- Repeat Development work (Delays resources and impact to other developments)

Measurement Uncertainty: Scenario 2

Classify acceptable capability as unacceptable

- Do one of the following
  - Change Tool
  - Change design and perform tolerance analysis
- Act of changing tool or design likely created MU scenario-1

Integrated Development

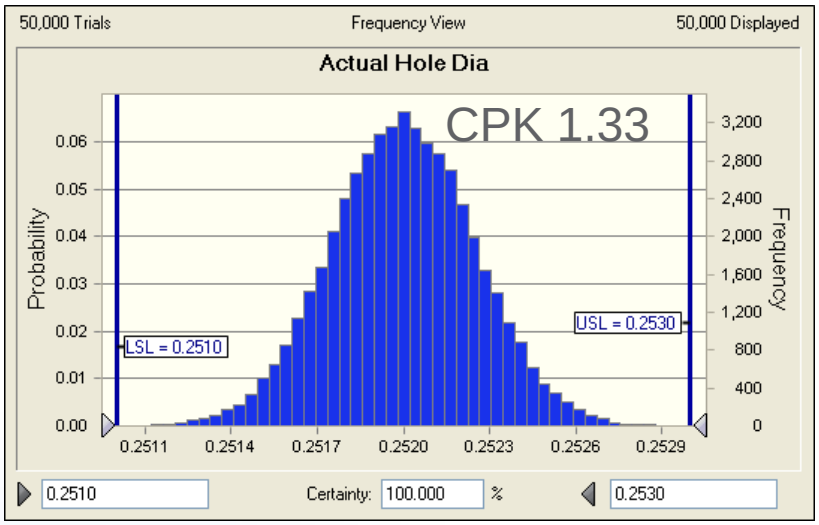
Metrology Impact on Development

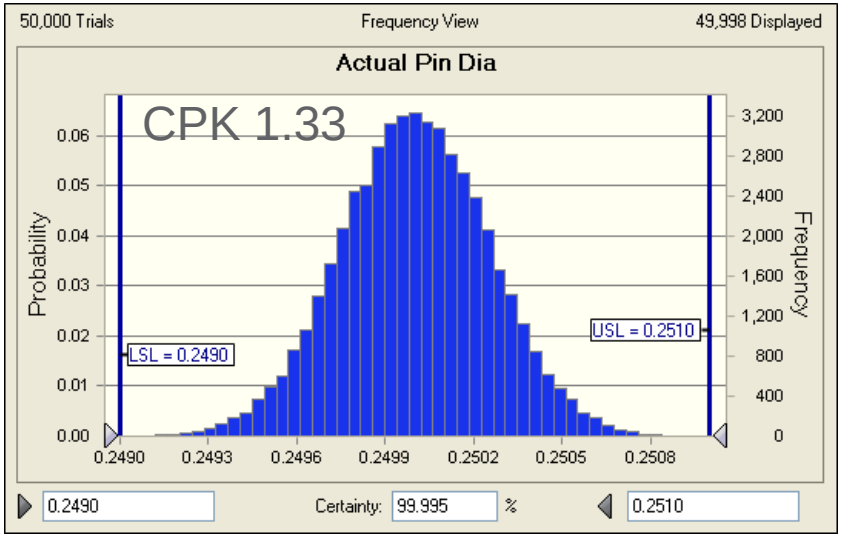
Pin and Hole Simulation - Design

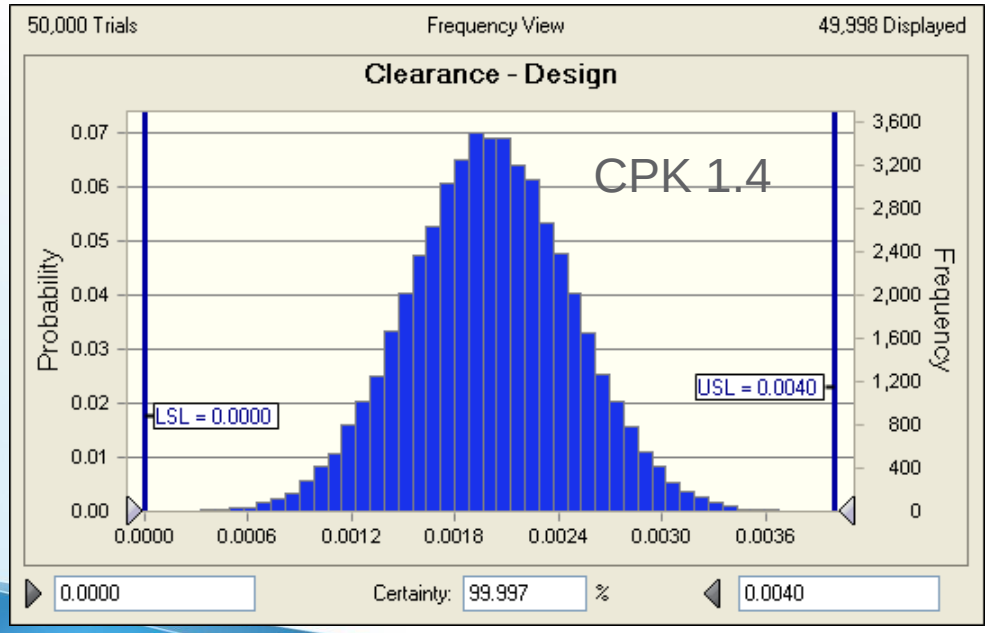
- Hole DIA : .252 +/- .001 : Min Cpk 1.2
- Pin DIA : .250+/- .001 : Min Cpk 1.2 (Strength and fit into assembly)
- Clearance Requirement: .000 - .004 : Min Cpk 1.33 (Fit and Wobble)

- Method – Monte Carlo
- Tools – Crystal Ball and Minitab
- Assumptions
  - Measurement Error is the same for each component
  - Measurement Uncertainty is Composed of Bias and GR&R
  - GR&R is normally distributed: 25% of Tolerance Zone
  - Bias = .0005”
  - Actual parts are perfect (Normally distributed, Centered on Nominal with Cpk = 1.33)

Pin and Hole - Simulation







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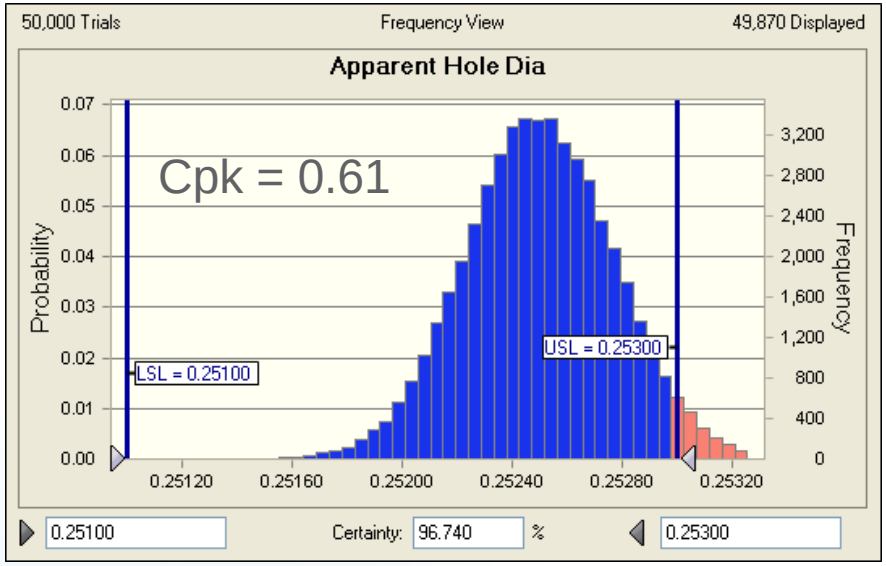

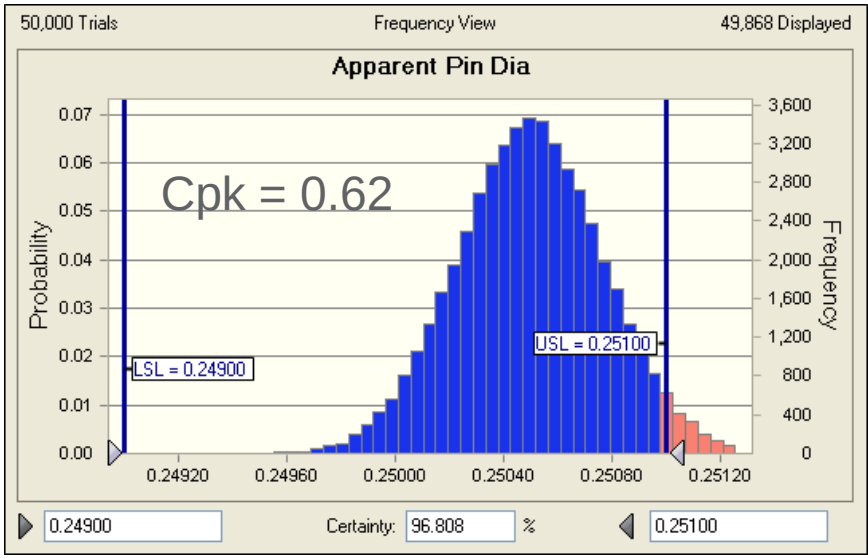

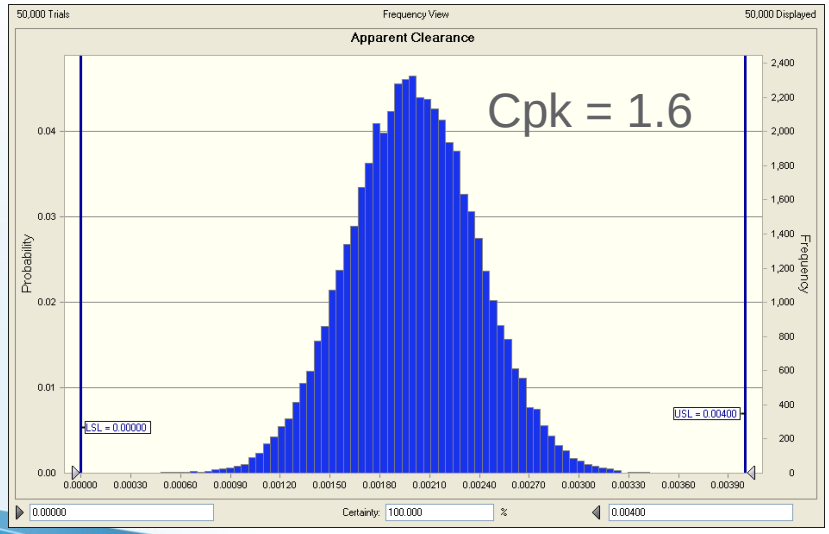

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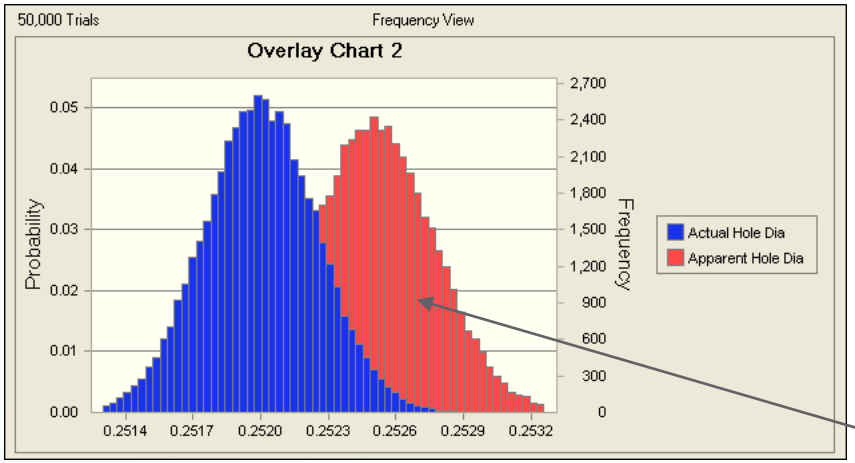
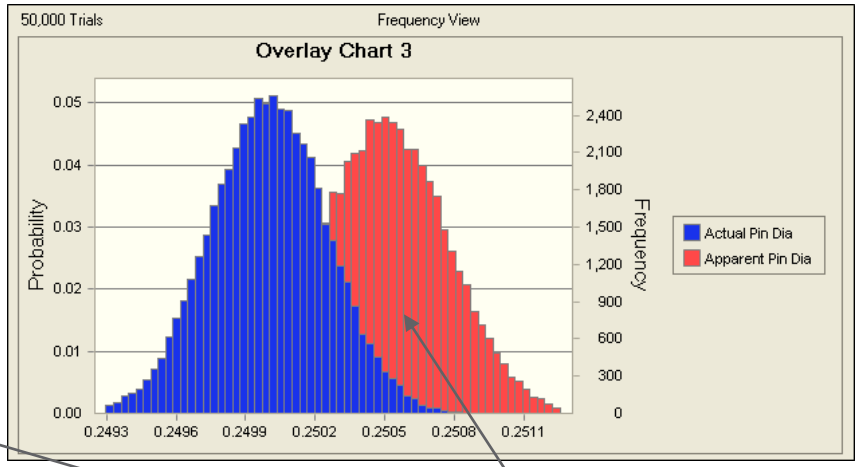
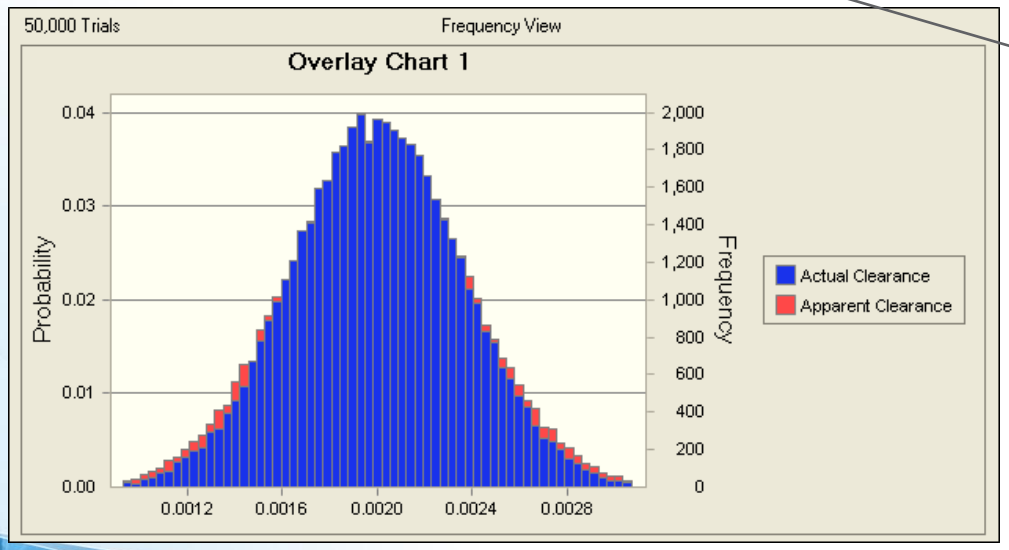


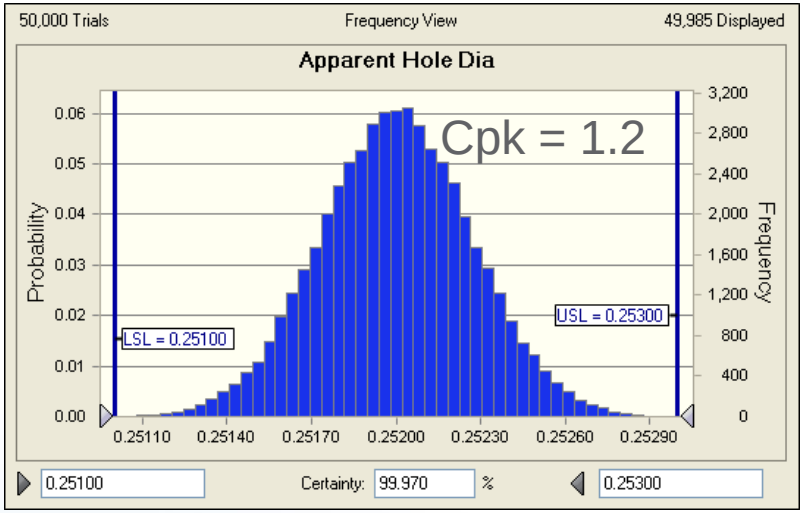




Scenario 1 – Led to believe good parts are bad

Instruct Mfg to move process mean -.0005”

Pin and Hole – Simulation



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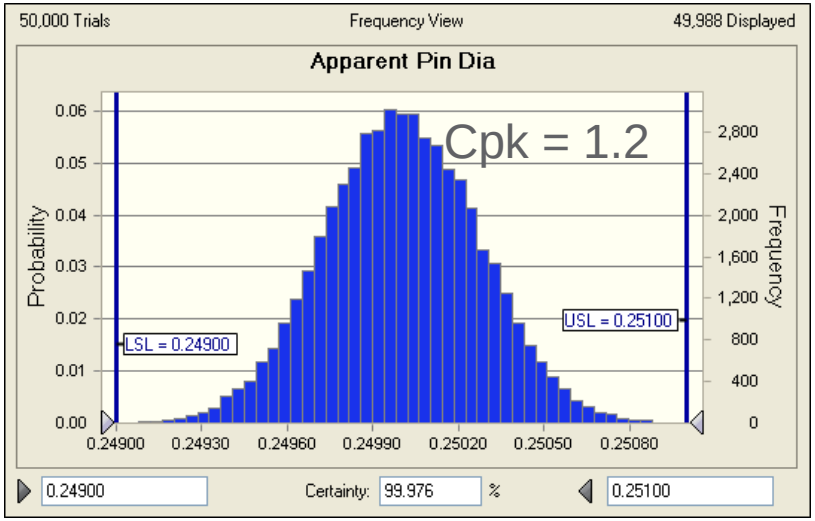

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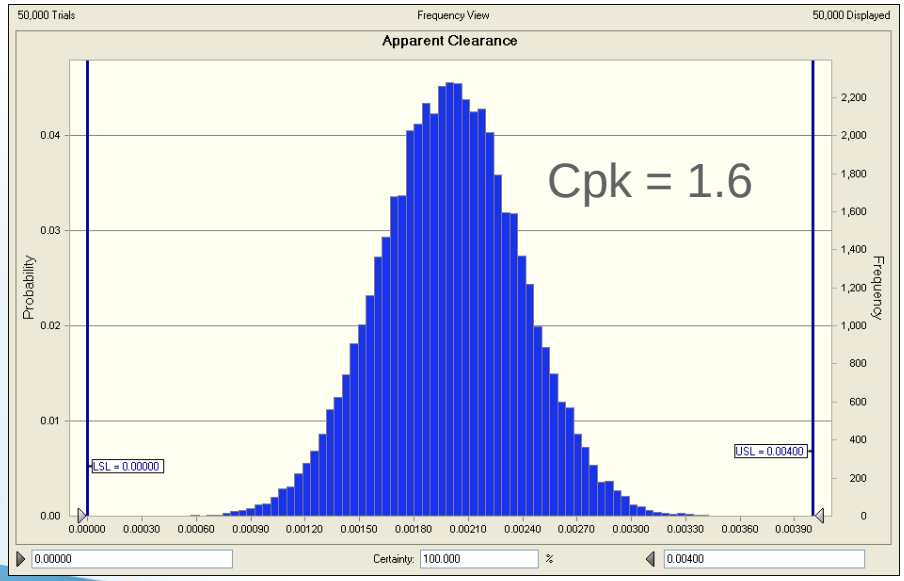

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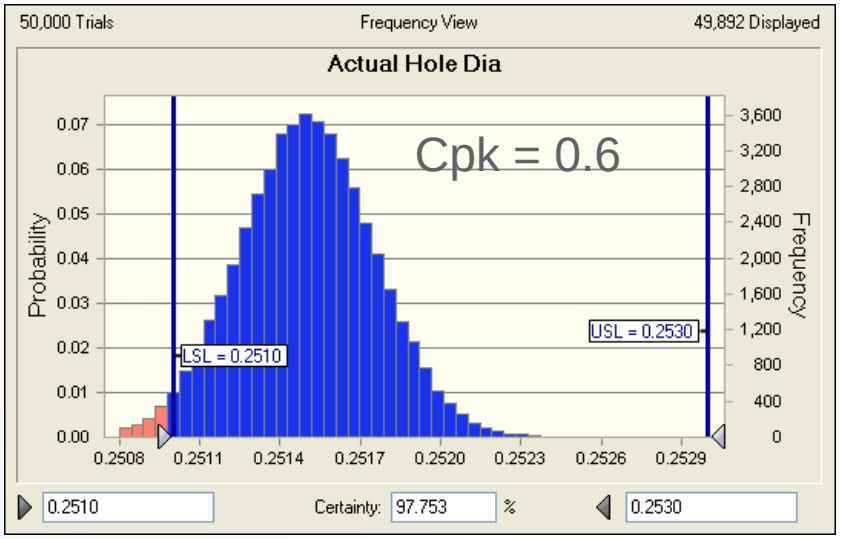

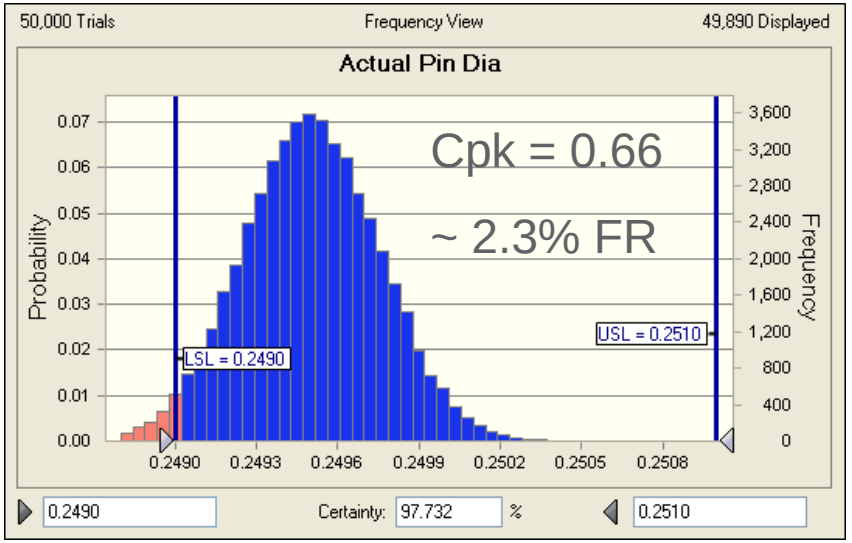

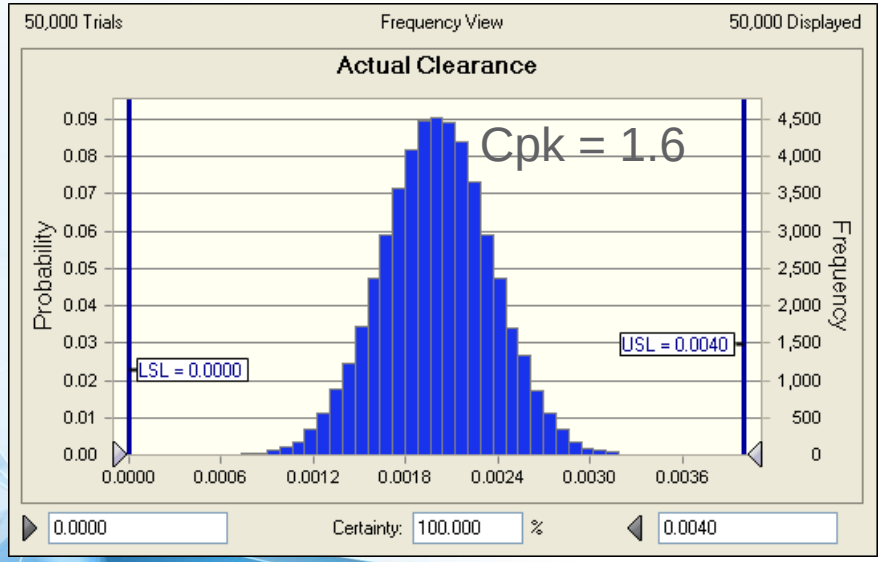

2.3% Failure rate may not be caught Testing; Likely show up in the field

Pin and Hole - Summary

- Good parts were made to look bad by way of Measurement Uncertainty
- Process mean was changed to move the distribution “into spec”
- Now bad parts were made to look good
- Bad parts were used in Development
- Two Possible Outcomes:
  - Get lucky and see a 2% failure rate in development testing
  - Go to production and field issues once sufficient volumes are reached
- Responding mostly to Bias Error

Key Take-Aways

- Capability of component distributions are more important than ever because of the *predictive design* goals
- Error sources in distribution estimates cut across all disciplines and must be quantified
- All sources must be controlled if predictive goal is to be reached
- Bias (as a percentage of tolerance) has the larger impact on misclassification than %GR&R and should be quantified

Thank You

Continuing Work