U.S. Army Research, Development and Engineering Command

Introduction to **Key Parameter Development and Management (KPD&M)**

19th Annual NDIA Systems Engineering Conference

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Agenda

- Background
- What/Why/How
- Focus Area
- Process
- Example
- Questions

Background

Continued “fire-fighting” throughout production because the following are not understood:

- Design factors impacting desired performance
- System interactions impacting desired performance
- External, deteriorative and manufacturing variations impacting desired performance
- Which characteristics to focus resources on

This led to the development of Key Parameter Development and Management

Key Parameter Development and Management (KPD&M)

- **What is KPD&M**
  - Structured process that integrates Engineering best practices to guide product development and process control efforts to areas of greatest impact
- **Why KPD&M**
  - Focuses time and money on the important characteristics from design through ongoing production
  - Develops and documents the technical information required to produce best value products
  - Provides the essential data to justify tolerances
- **How**
  - Focusing on Moderate to High Technical Risks
  - Understanding of Functions and Parametric relationships
  - Concentrating on Physics
  - Emphasis on Robust Design

Puts Engineering back into Systems Engineering

What does the word "Key" mean?

Something that is…

- **New**
  - Totally new to you, no one has fulfilled the requirement(s) or controlled the parameter(s) before – no experience!
- **Unique**
  - The requirement(s) or parameter(s) have been fulfilled or controlled by others but not by you!
- **Difficult**
  - The requirement(s) or parameter(s) are extreme & their fulfillment or control is very high in risk

NUD

Key Parameters are associated to NUD requirements

Things that are not "Key"…

Something that is…

- **Easy**
- **Common**
- **Old**

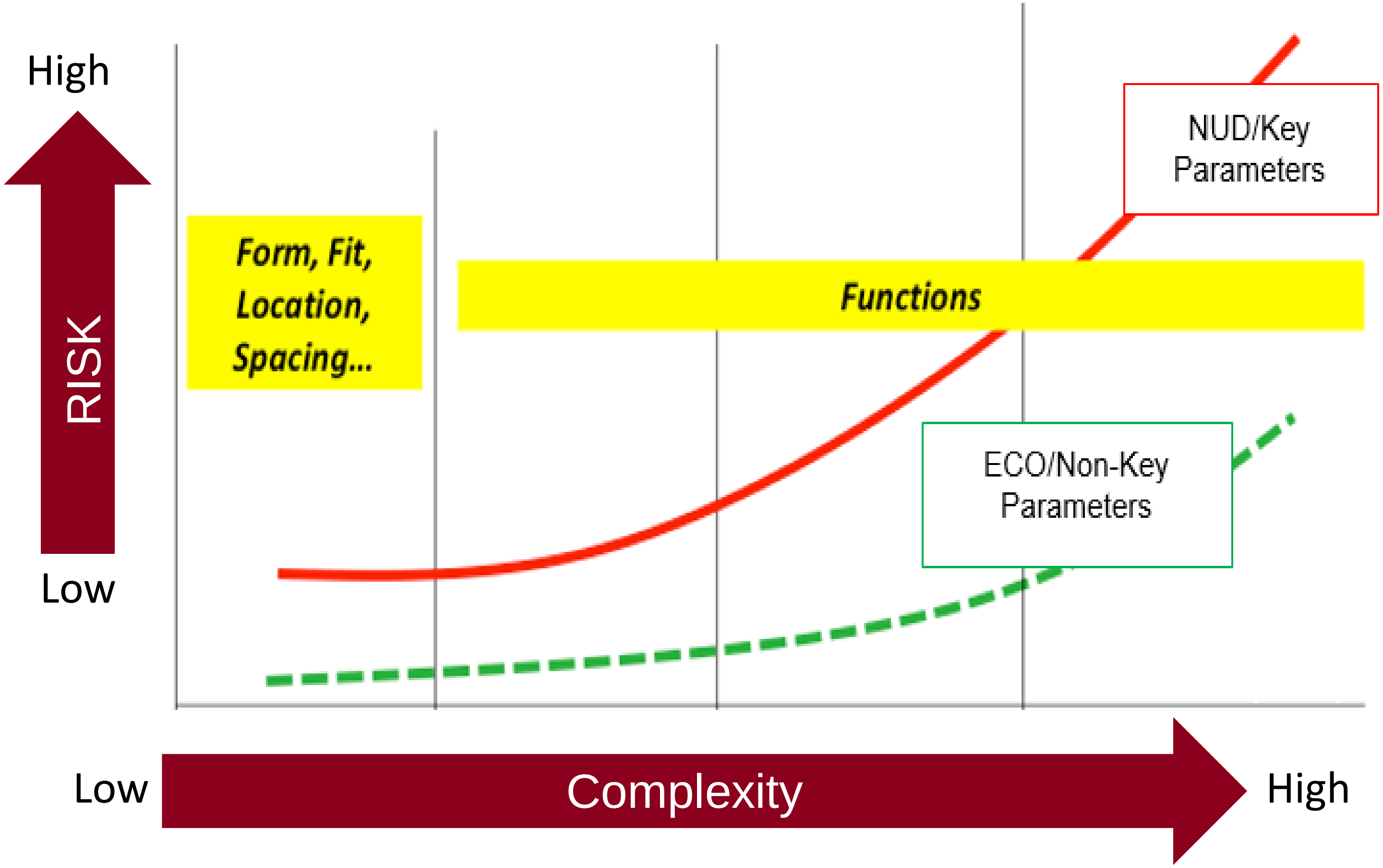
ECO

These are functions, part specifications and manufacturing parameters that we place under normal quality control metrics

- Little or no investment to monitor or maintain
- Capability is checked periodically
- Use Six Sigma to react to problems in this area

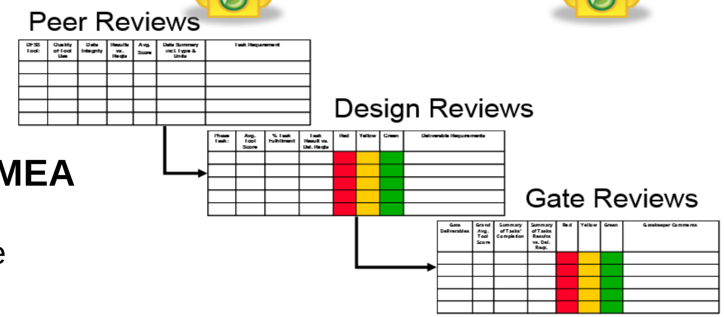
Just because it is ECO does not mean it is not important.

Why focus on NUD's

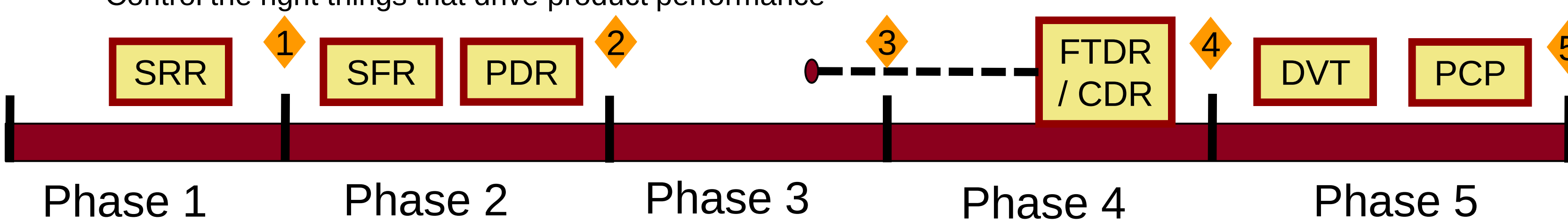


NUD's pose the greatest risk to the program

The KPD&M Process



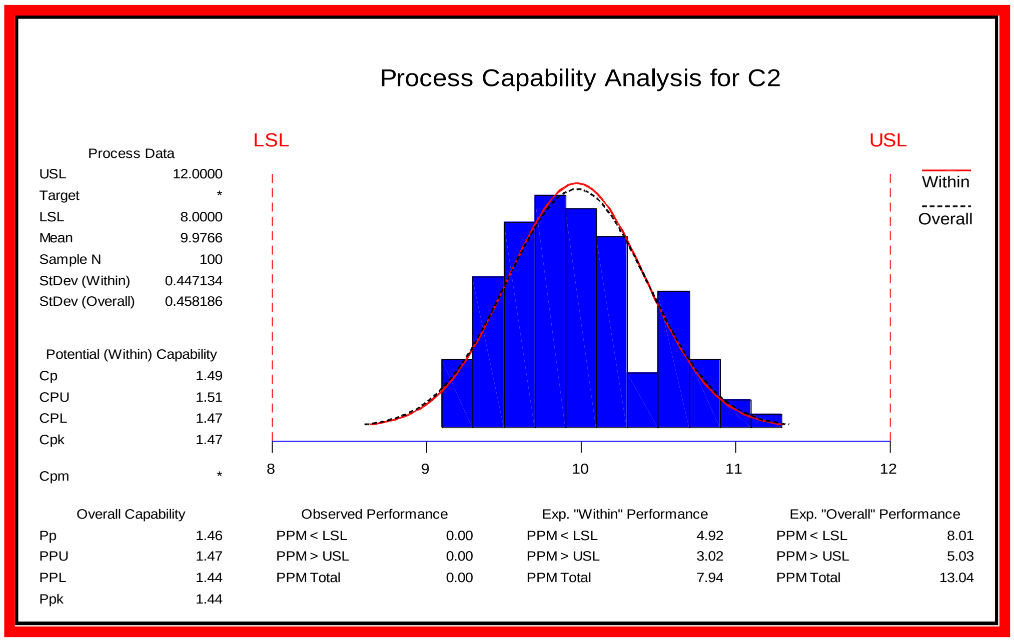
- **Phase 1: Requirements and NUD Analysis**
  - Understand design objectives
  - Prioritize effort on only the technical risk areas
- **Phase 2: Concept, Architecture, System Diagrams and DFMEA**
  - Develop robust concepts
  - Establish traceability between requirements, functions and hardware
  - Establish relationships for developing transfer functions
  - Identify areas for stress testing and product improvement
- **Phase 3: MSA, Screening, Modeling, Noise and Robust DOE’s**
  - Identify design parameters that have a major influence on performance
  - Identify interrelationships between design parameters that have negative impact on performance
  - Desensitize technologies/products to factors causing variability and aging
- **Phase 4: System Stress Testing and Tolerance Design**
  - Establish and verify tolerance ranges to ensure desired performance under all operating conditions
  - Validate system capability
- **Phase 5: MSA, DOE’s, Capability Studies and Process Control Plan**
  - Identify process parameters that have a major influence on performance
  - Control the right things that drive product performance`



KPD&M Metrics

Capability is the metric that we use to make decisions related to requirements…

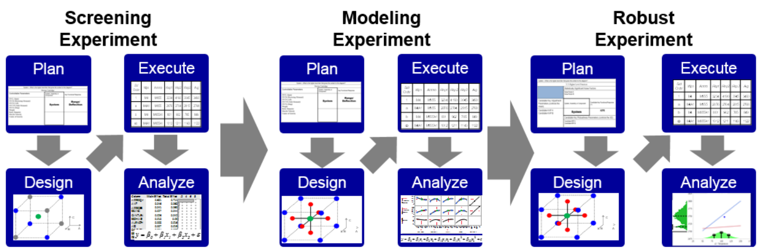
It links the Voice of the Customer (VOC) to the Voice of Physics (VOP)



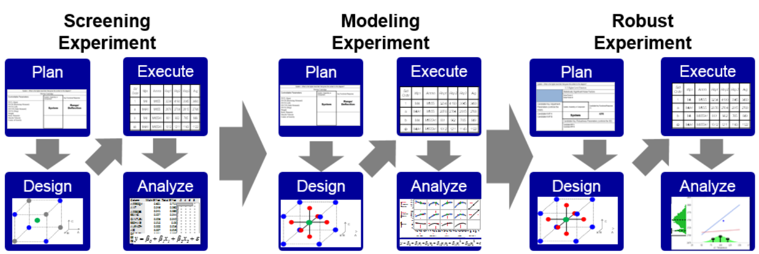
- **The KPD&M Metrics**
  1. Measurability
  2. Stability
  3. Adjustability
  4. Interactivity
  5. Sensitivity
  6. Robustness
  7. Capability

Knowledge Developed from Sequential Design of Experiments

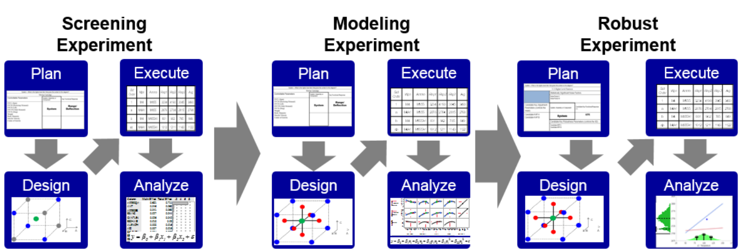
Sub-function 1: Spin



Sub-function 2: Restoring Moment



Sub-function 3: Drag

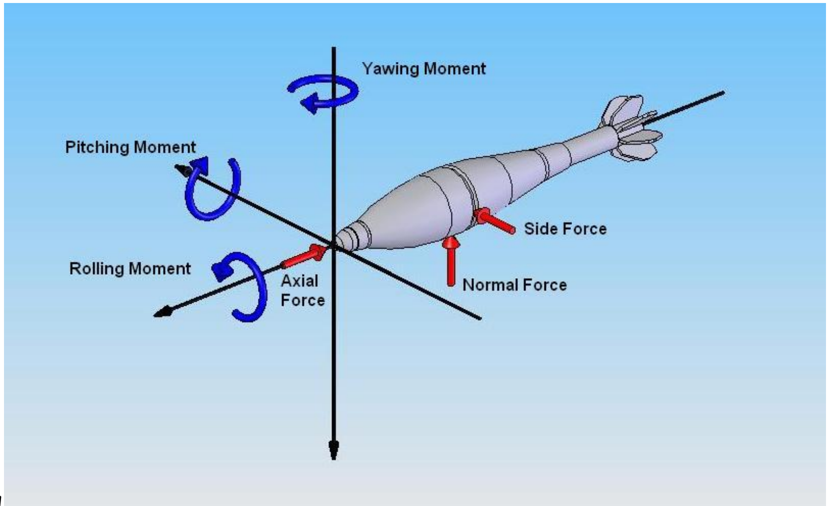


Y Becomes X

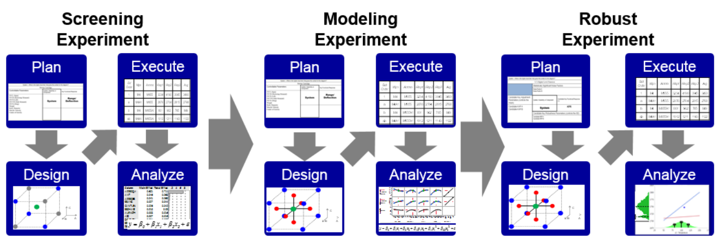
Y Becomes X

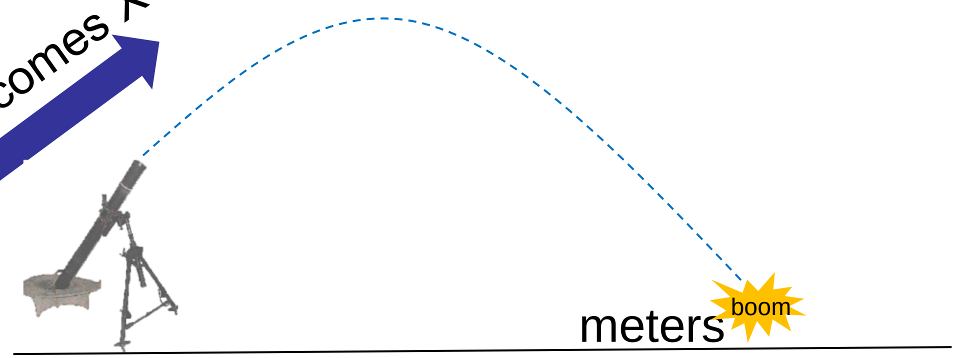
. . .

Y Becomes X



Range/Deflection





Phase 3 - subsystem-level testing

Phase 4 - system integration testing

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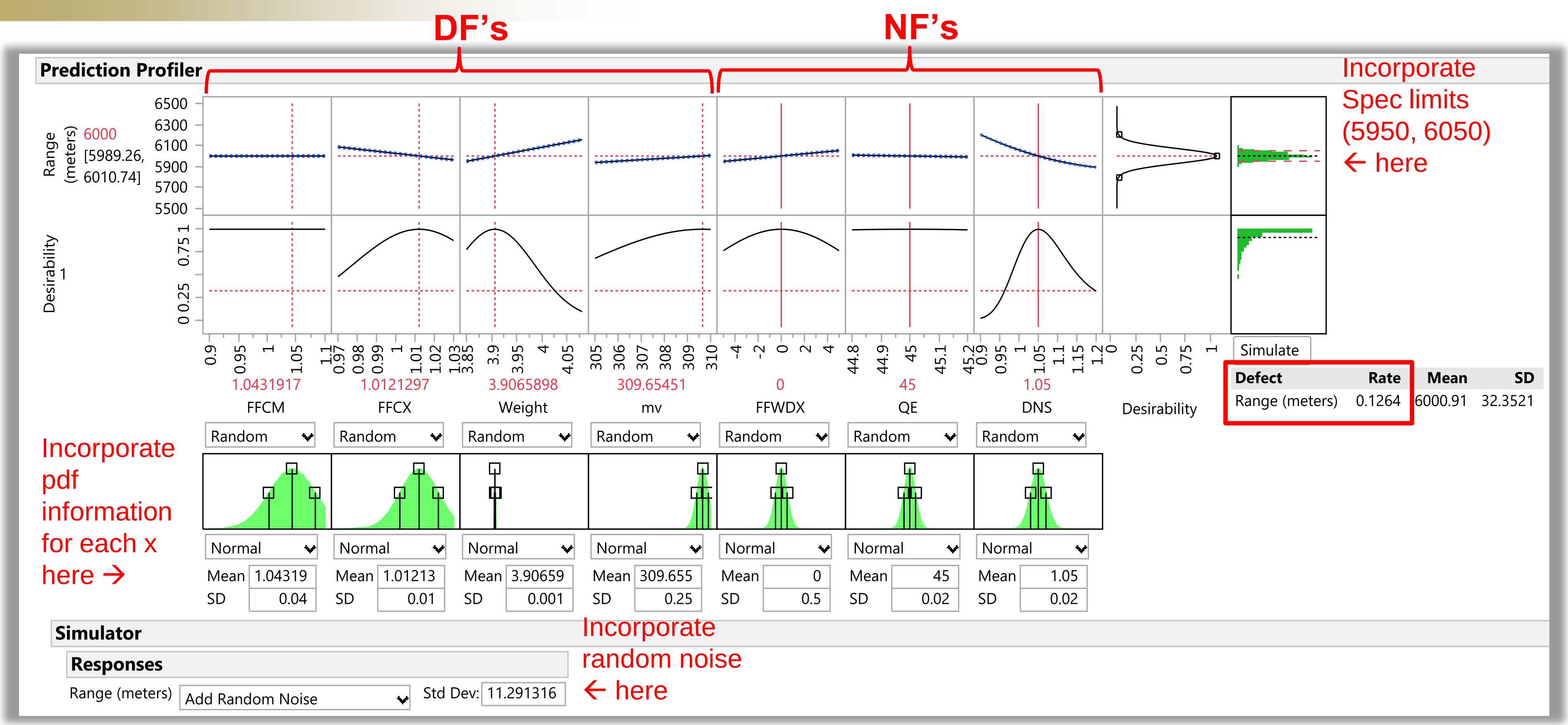
Tolerance Design



- **Tolerances are established starting at the system level**
  - Allocate tolerances to sub-system functions
  - Follow the same process until design features tolerances are established

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Robustness

➢What is robustness

- A product or process is said to be robust when it is insensitive to the effects of sources of variability, even though the sources themselves have not been eliminated

➢What opportunities are there for robustness

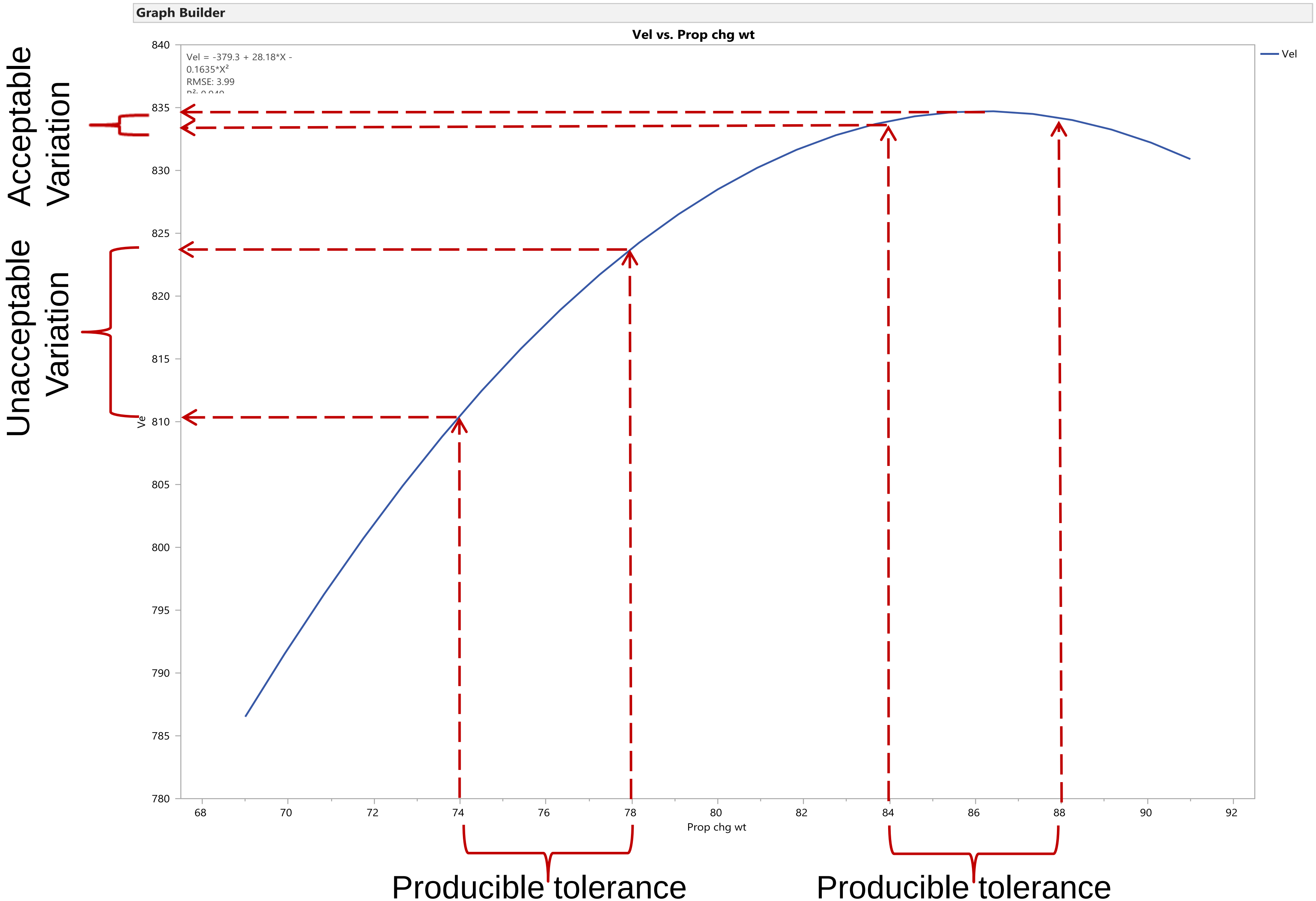
- ✓ Interaction between Design Parameters and Noise Parameters
- ✓ Higher Order behavior caused by a Design Parameter (undesired)

➢Why is Robustness desirable

- Desensitization of function to unwanted sources of variation
- Key driver to improving capability
- Significantly improves reliability and performance
- Improves the cost effectiveness of technology and products

Product Development is the only time the system has an opportunity to be robust to variation

Robustness to Manufacturing Variation



Key Parameter Identification

Candidate Key Parameters

ANOVA

Not Statistically Significant

Statistically Significant

Regression/ Transfer Functions

Not Practically Significant

Practically Significant

Important Parameter

Key Parameter Identification (cont.)

Important Parameter

Engineering, Regression, ANOVA, Functional Capability Models

Capable

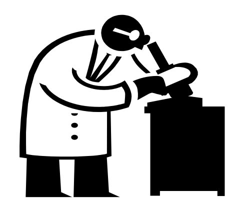
Process Capability Studies

- High Manufacturing Capability
- Low Manufacturing Capability

Not Capable

- Difficulty adjusting mean to target
- Anti-synergistic interactivity (2 Xs)
- Hypersensitivity (Xs and Ys)
- Poor Robustness to Noise (Xs and Zs)

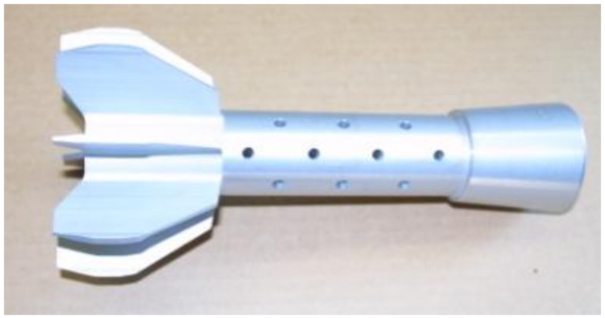
Key Parameter →



manufacturing

KPD&M Example

Description:



➢ M31 Fin Assembly is used on the Mortar 120MM Family of Munitions to provide flight stability and transfer energy for propulsion

Results:

➢ Identified previously undefined characteristic that impacted safety and performance

➢ Increased the design tolerance for the angle between blades (doubled the tolerance)

➢ Eliminated 7 characteristics

➢ Reduced sampling rates for 39 characteristics

➢ Developed new acceptance methodology that will reduce the inspection of **68 characteristics** to monitoring **16 characteristics** and inspecting **4 characteristics** (in process of being piloted)

Background:

➢ Historically, malfunction investigations have revealed the design has been built to the TDP and still does not meet the performance or safety requirements

➢ Historically, the angle between blade requirement has limited the amount of suppliers that are willing to extrude the fin blanks

➢ Roughly 75% of the design characteristics are currently being tested/inspected

Benefits:

➢ Reduced the risk of performance and safety issues

➢ Increased the potential supplier base

➢ Eliminated non-value inspections and reclassified more than 57% of the characteristics

➢ Will be reducing the amount of inspection by more than 70%

➢ Will be implementing process controls which is the DOD preferred method of acceptance

➢ Developed validated aeroballistics model that can be used to evaluate future RFV's or malfunctions

Significantly improved quality, reliability, producibility and cost effectiveness of item

Questions?

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