

“Working Together - Designing Together - Thinking Together”

How Better Thinking is Leading to Better

NASA-JPL New Design Paradigms Workshop

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Agenda

- Objective
- Assumptions
- Thinking Together
- The Role of Better Thinking
- The Need for Change
- Better Thinking and Better Designs

Objective

Introduce the *potential energy* of
integrating the management theories

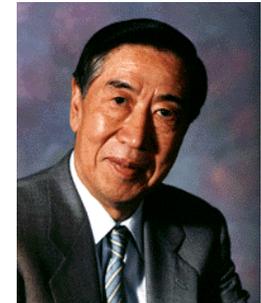
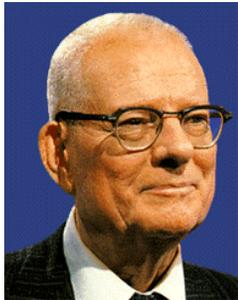
of

Dr. W. Edwards Deming
and

Dr. Genichi Taguchi

and others...

into the design process



Quality Loss

“Quality is the (minimum of) loss a product causes to society after being shipped, other than losses caused by its intrinsic functions.”

Genichi Taguchi

Source: *Introduction to Quality Engineering*, Genichi Taguchi

Perception & Thinking

“How the world we perceive works depends on how we think.

The world we perceive is a world we bring forth through our thinking.”

H. Thomas Johnson

Utilization of Thinking

- Where are we going ?
- Where does this fit in ?
- Where did this come from ?
- What is my role ?
- What is this part of ?
- Where should we invest ?

Assumptions

- A better way to operate an organization is to invest resources with the ability to delight customers
- Better investment results from discovering opportunities to invest
- The discovery of opportunities for investment is limited by how thinking is conditioned

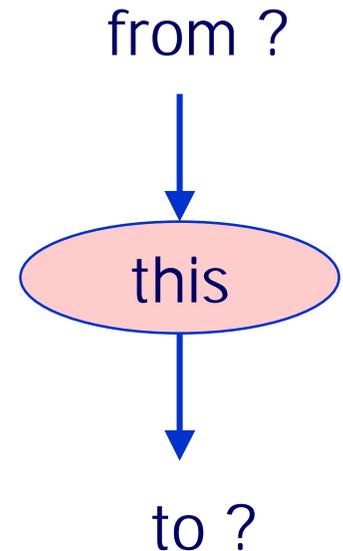
What is needed ?

Thinking that
promotes
better
discovery

Water and Rock Logic

- Water Logic**
- *What is this a part of ?*
 - *Where did this come from ?*
 - *What will this lead to ?*

- Rock Logic**
- Event focussed
 - Part focussed
 - Piece focussed



Source: *Water Logic*, Edward de Bono, 1994

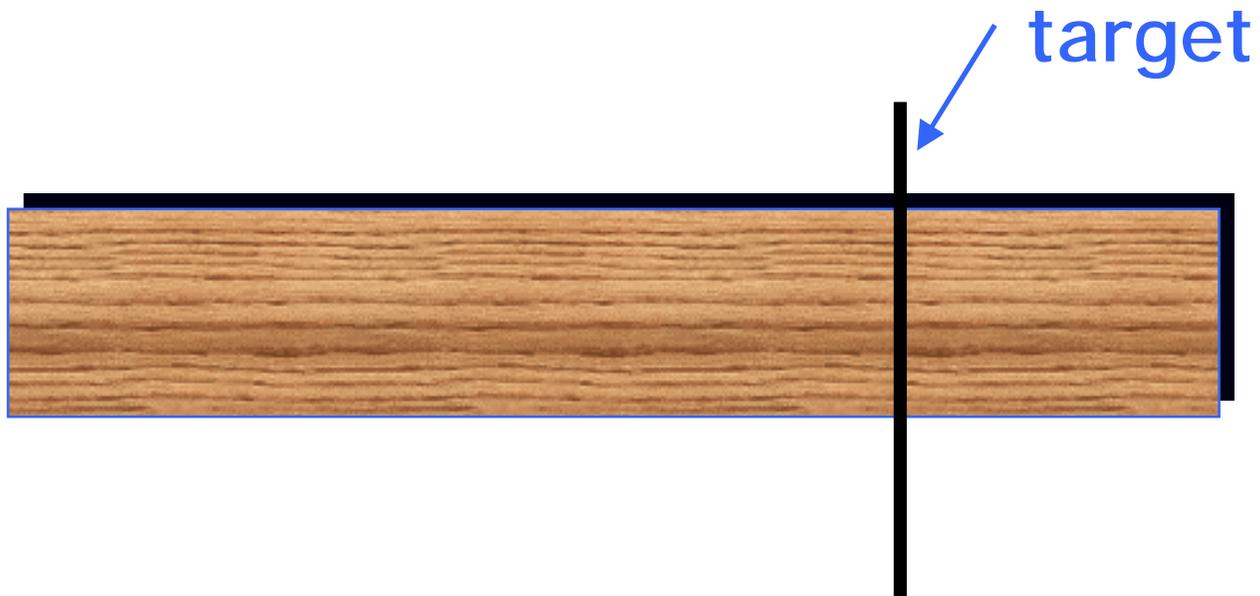
Question: Cutting Wood

Given a piece of wood that will be cut into 2 pieces....

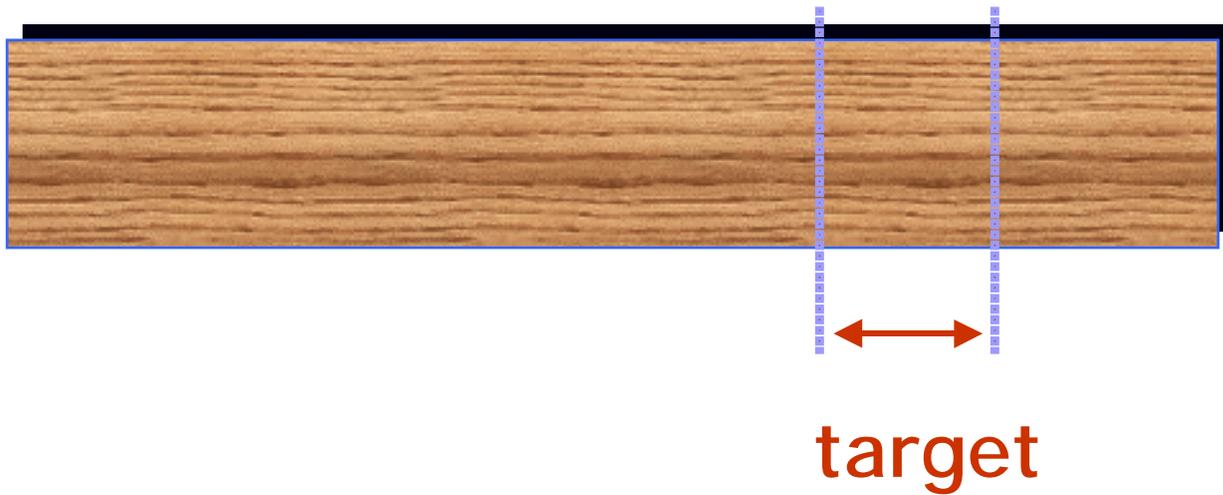


how many lines will be drawn across the top face before the cut is made ?

Question: Cutting Wood



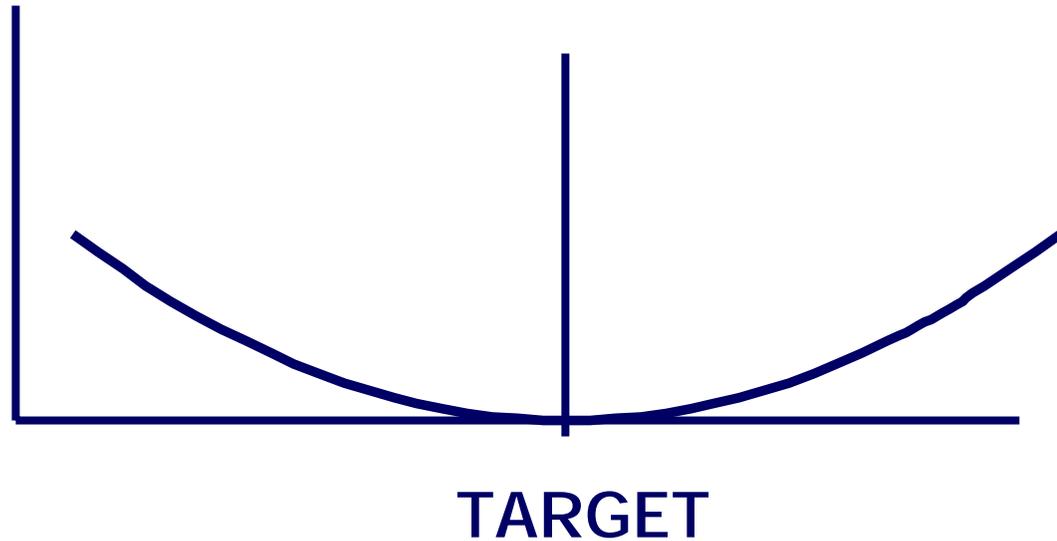
Question: Cutting Wood



Relationships



Cumulative
Negative
Impact to
Others
Downstream



Investment Thinking

- Seeing connections
- Spending \$ to save \$
- Spending time to save time
- Spending resources to save resources
- Examples
 - ✓ college education, roof repair, time with kids

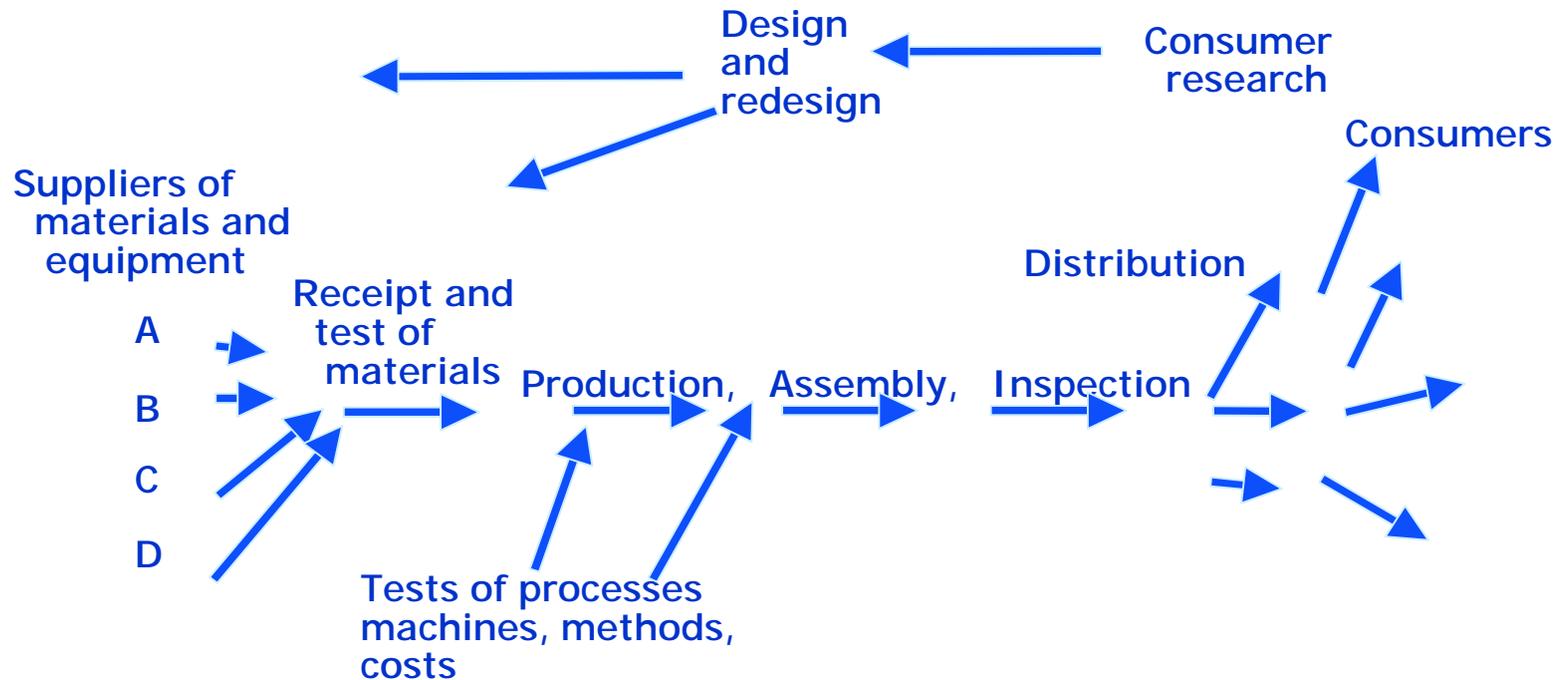
Picking Up Nails

Spending time (yours)
to
Save time (others)

*Minimizing Loss to
Society*

Seeing Organizations as Systems

The Process View ("work with")



Source: *The New Economics*, W. Edwards Deming, 1993

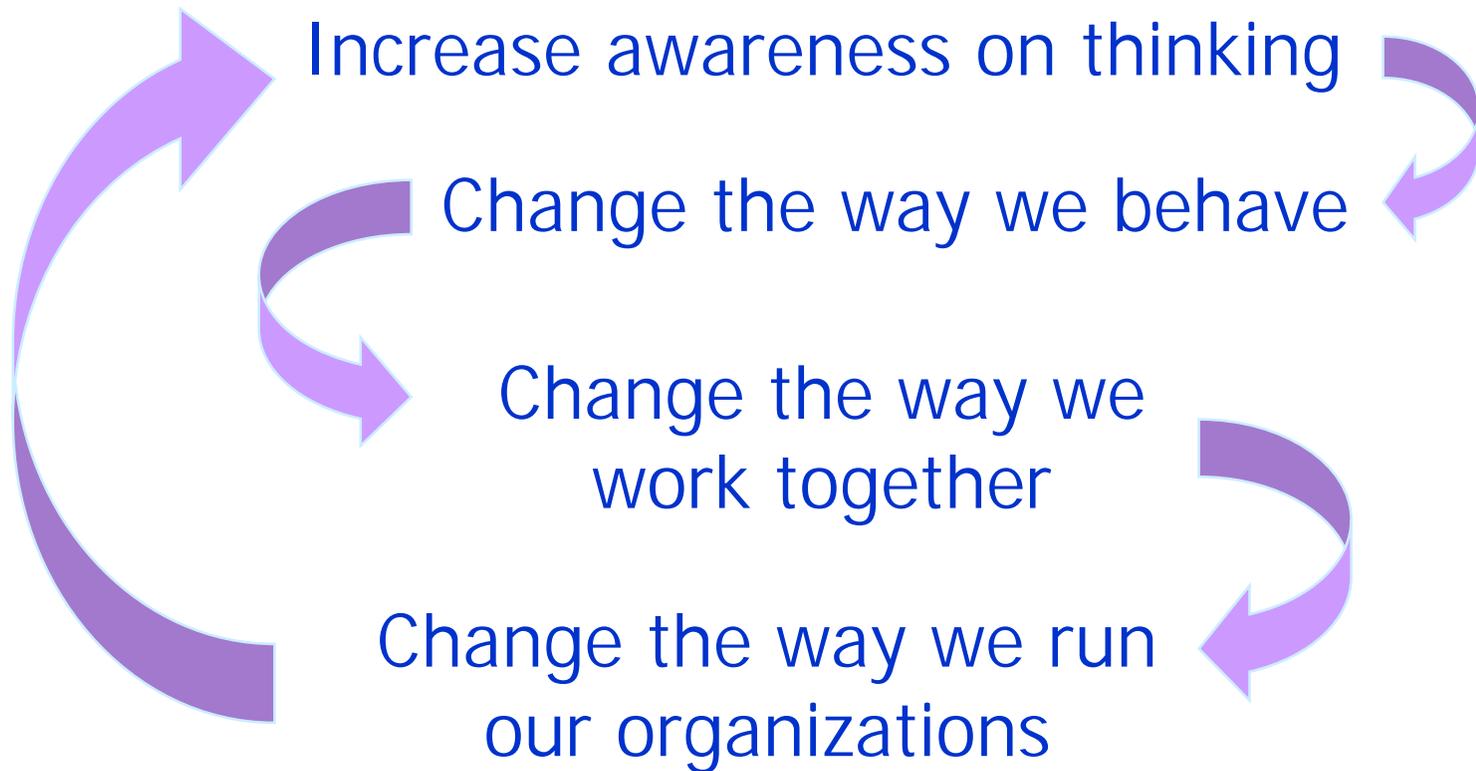
Utilization of Thinking

- Where are we going ?
- Where does this fit in ?
- Where did this come from ?
- What is my role ?
- What is this part of ?
- Where should we invest ?

“Boomerang Karma”



The role of better thinking...



The Need for Change In a Rocket Engine Sales

- Increased global competition for launch business
- Reduced overall funding levels
- Time-to-market pressure
 - Short time between business model closure and first launch requirement
- Ability to provide customizable rocket engine systems on demand

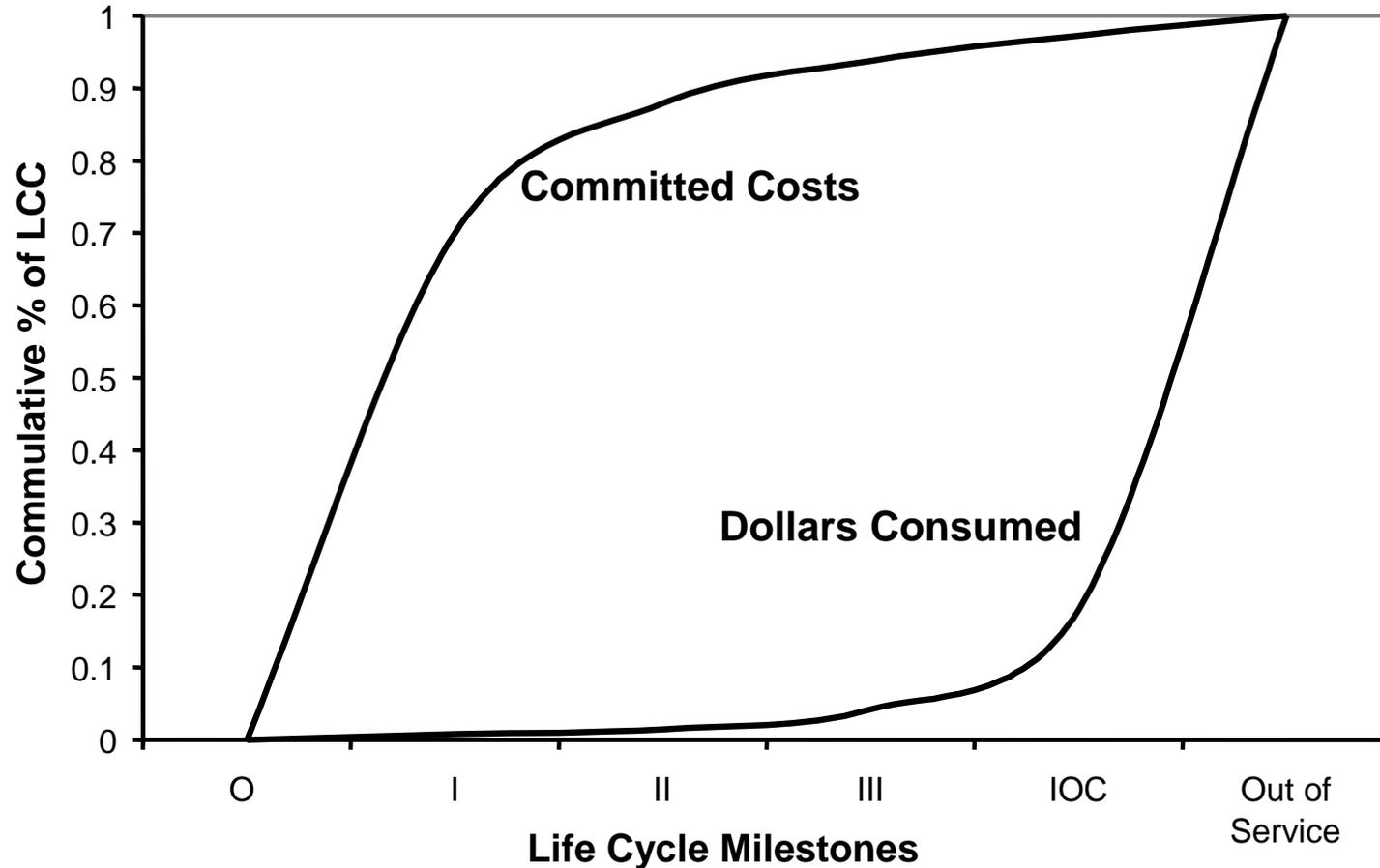
Strategy - Provide Better Value

- Design, develop and manufacture “End Item Products” that meet / exceed target performance, schedule, price and quality

By what method?

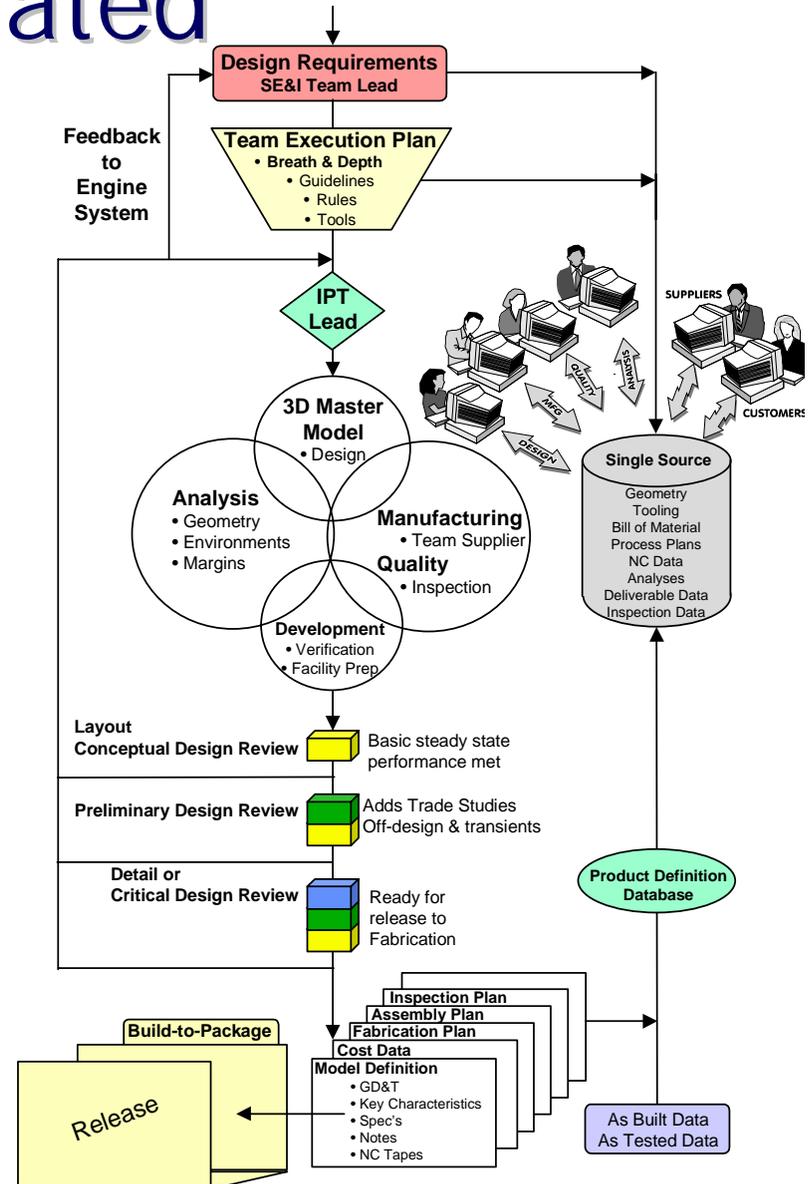
- Integrated model based design process
- Robust Design - Design for Capability

Early Design Decisions Significant Life Cycle Cost Impact



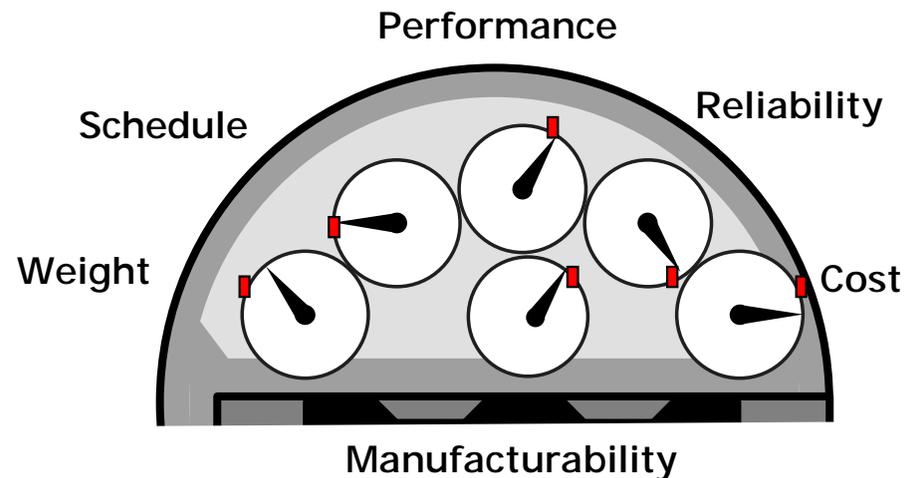
Horizontally Integrated Design Process

Product Data Management and Flow



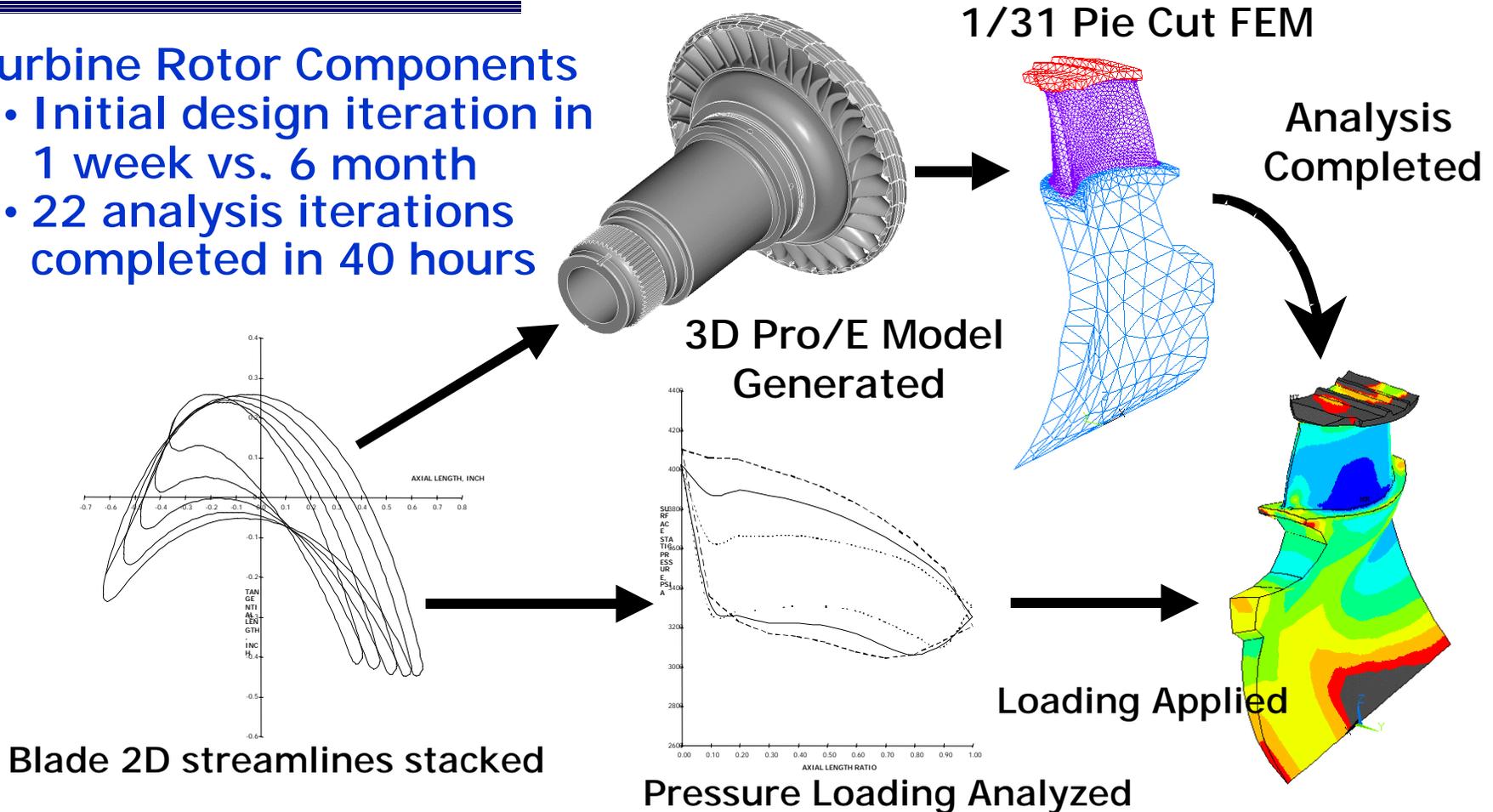
Integrated Product Teams

- Team responsible and accountable for
 - Performance
 - Schedule
 - Cost
 - Quality
 - Upstream and Downstream elements
- Composed of correct skill mix
 - Engineering
 - Manufacturing
 - Quality
 - Financial
 - Marketing



3D Model Centric Design Analysis Environment

- Turbine Rotor Components
 - Initial design iteration in 1 week vs. 6 month
 - 22 analysis iterations completed in 40 hours

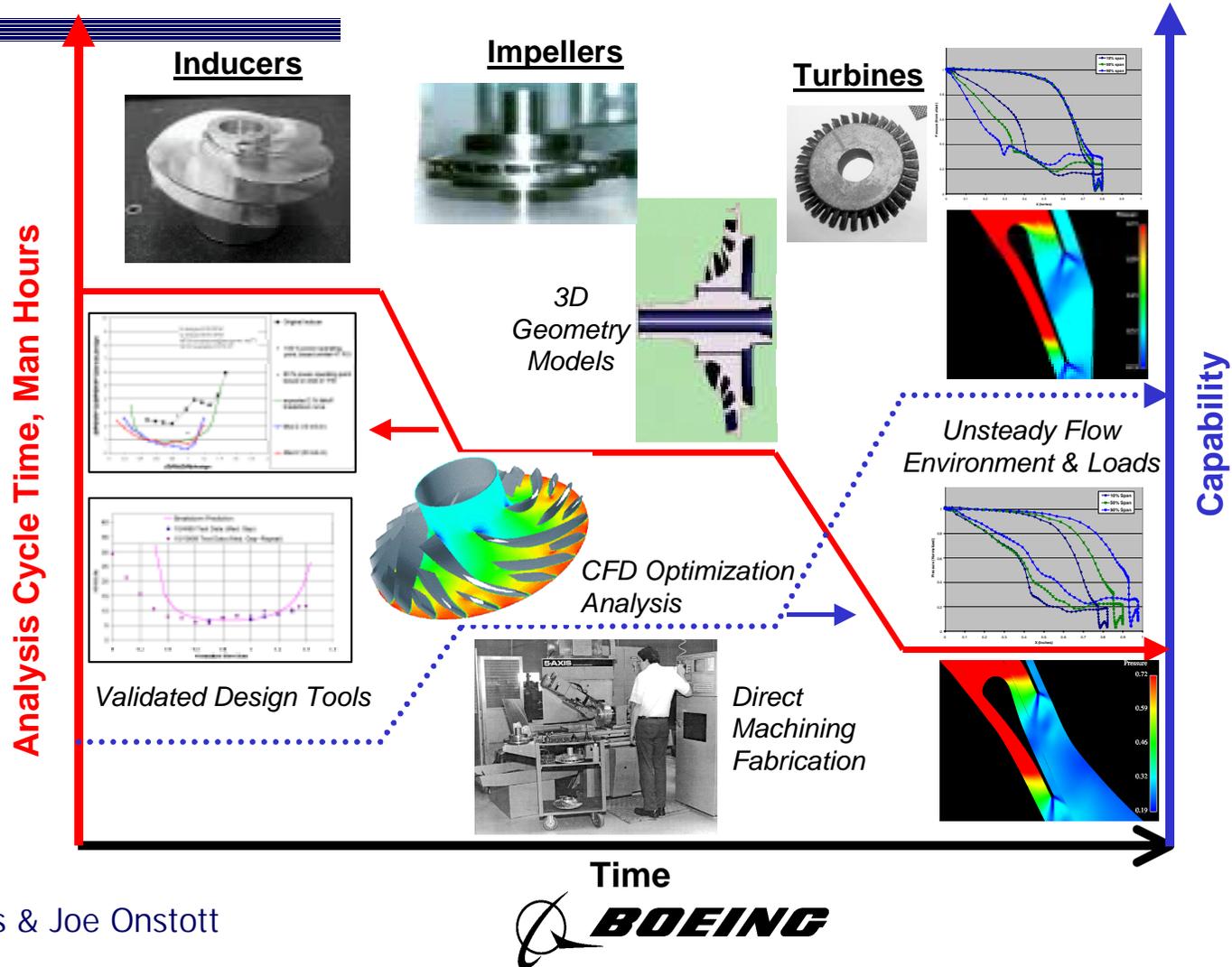


Blade 2D streamlines stacked

Pressure Loading Analyzed

Analysis Tool Development

Increased Analysis Scope



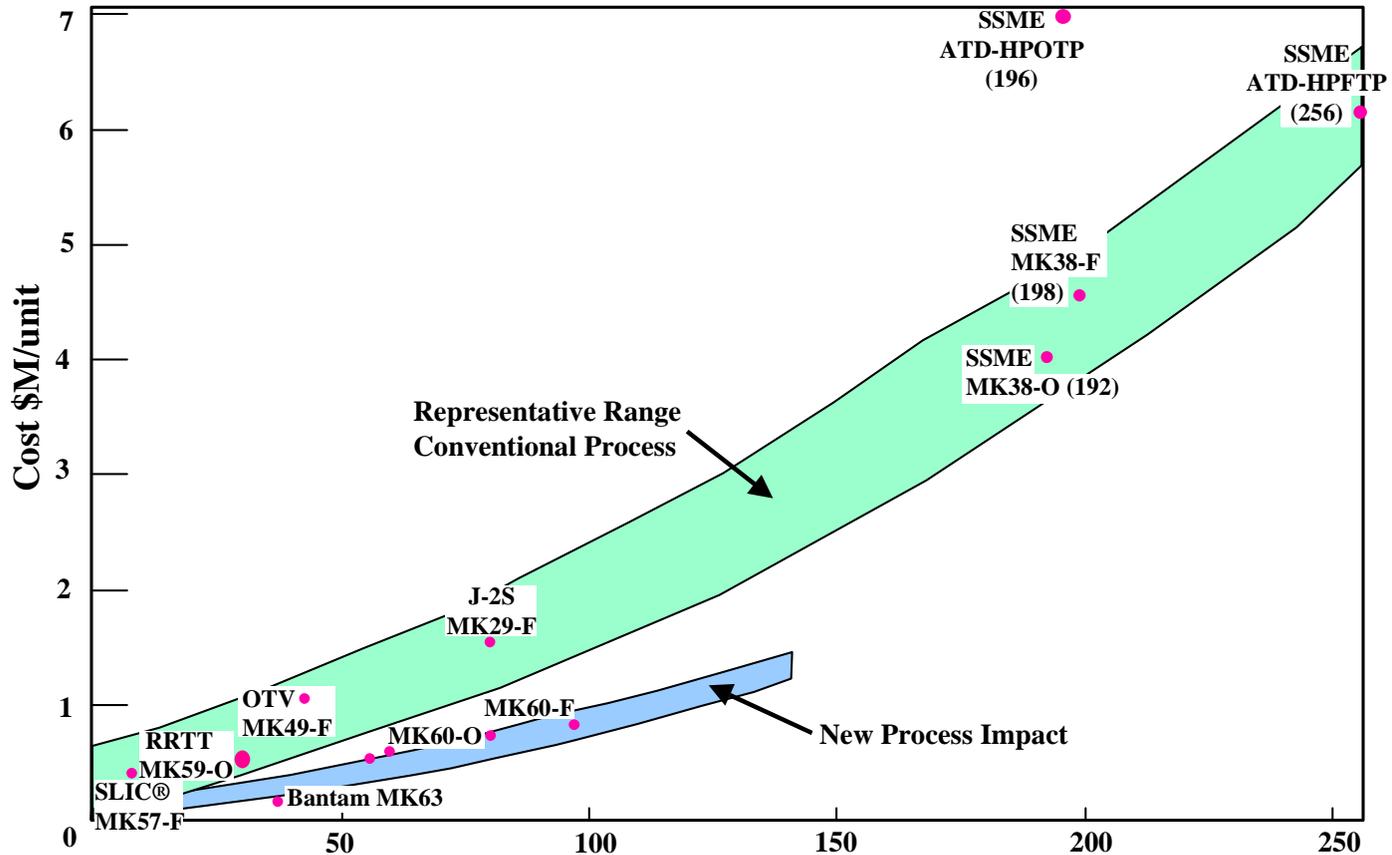
Rapid Prototyping

Integration of Design and Fabrication



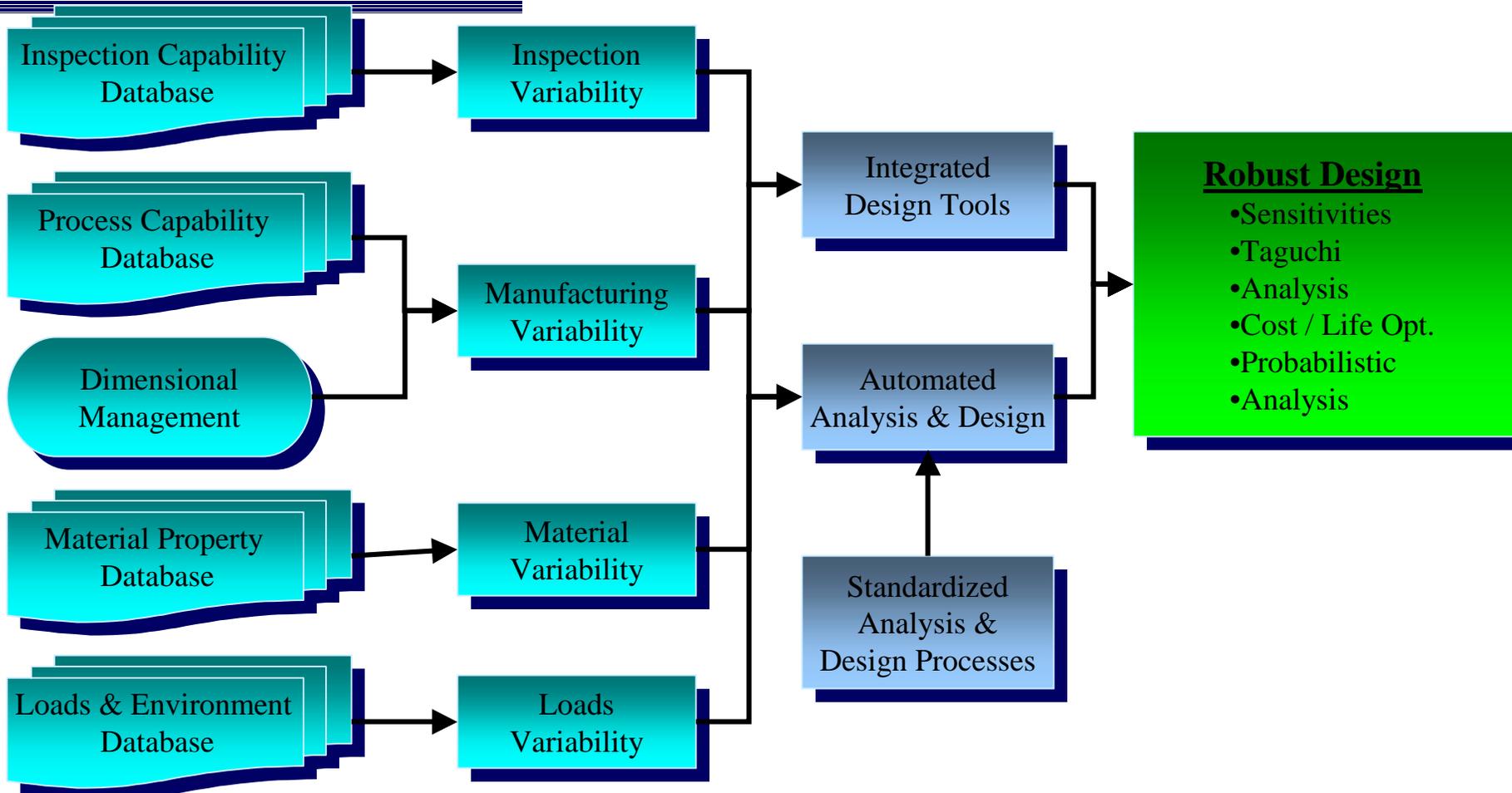
Part Count Management

Design Integration Decreases Costs



(Unique Part = 1 Drawing Number)

Designing for Capability Managing Variation



Design for Manufacturing

A Traditional Approach

- **Producible Design definition:**

An “End Product” that is manufacturable, testable, inspectable, and supportable using standard processes with minimum variability, requiring minimum tooling, meets high quality, ensures rapid cycle time, and is minimum cost

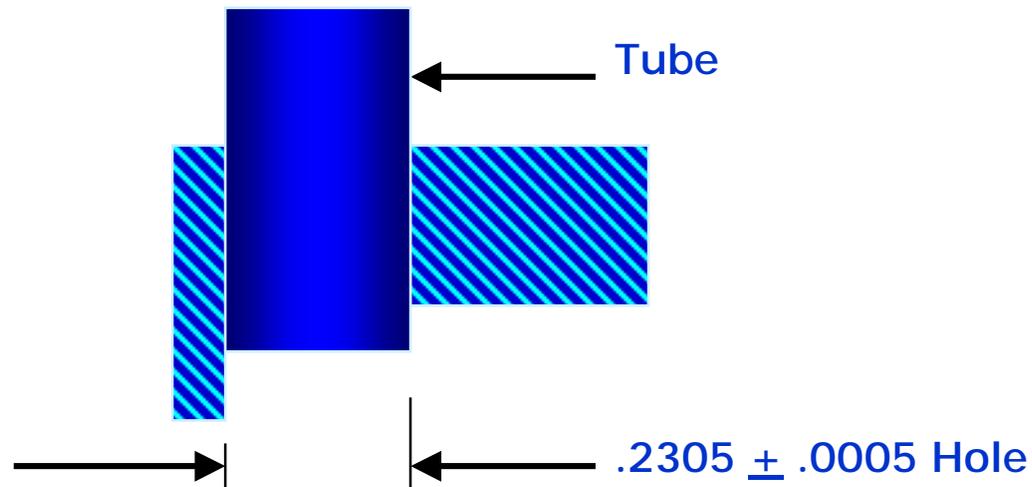
Design for Manufacturing

A Better Approach

- Design “End Products” to process capability
 - Manage variation
- Develop processes to meet design needs
 - Process control vs. inspection
- Maximize customer delight by using:
 - The right amount of parts
 - The right amount of tooling
 - The right investment of time
 - The right amount / investment of...

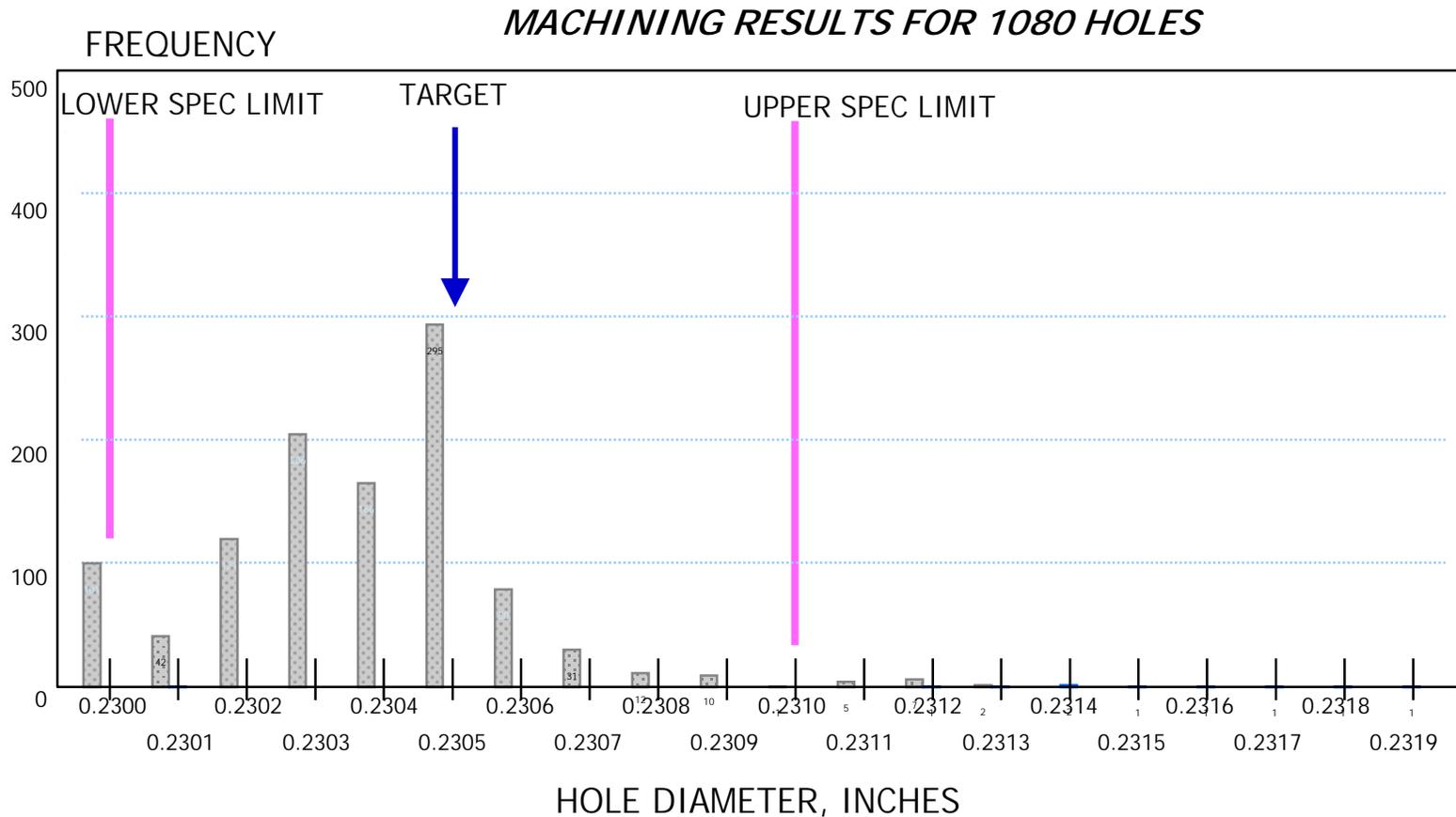
Design for Manufacturing Tubes & Holes

Consider a tube fit into a hole:



Design for Manufacturing

Drilled Hole Data



SOURCE: Dave Dettly
10/2/92

HOLE3-2

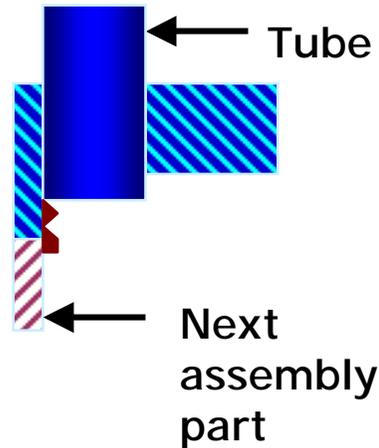
Design for Manufacturing

Tube in Hole, Next Assembly

Rock Logic

Traditional Approach

- Ream/ rework holes
- Braze flow thru holes
- Crack welds
- Add grind operation
- Add etch operation
- Add better etch operation



Water Logic

Better Approach

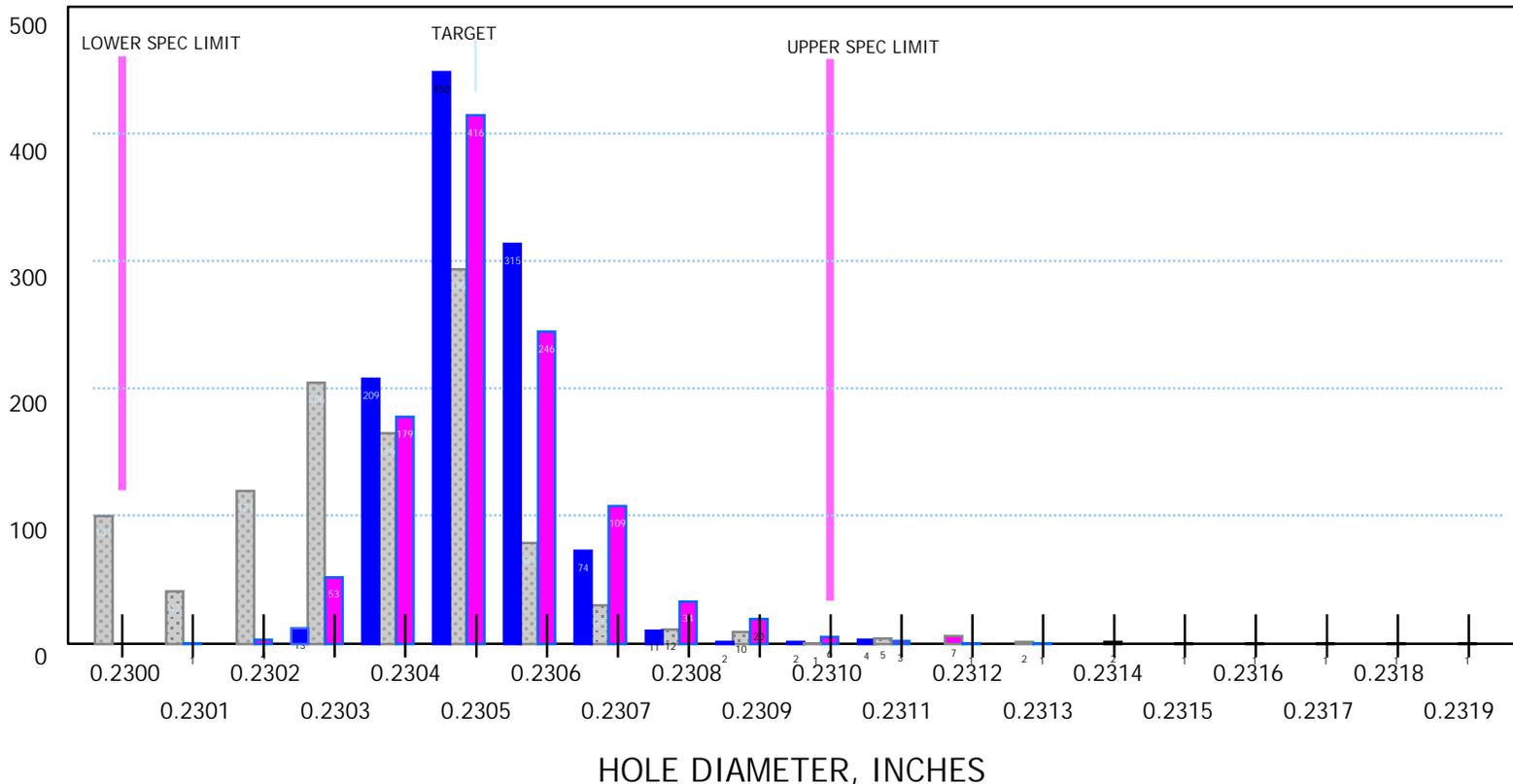
- Improve hole drilling
 - To target
 - Better distribution
- Assembly snap fit
- Successful braze

Design for Manufacturing

Drilled Hole Data, Post Taguchi Experiment

FREQUENCY

MACHINING RESULTS FOR 1080 HOLES - "BEFORE" & "AFTER"



SOURCE: Dave Deilly
10/2/92

"BEFORE"
 "AFTER #1"
 "AFTER #2"

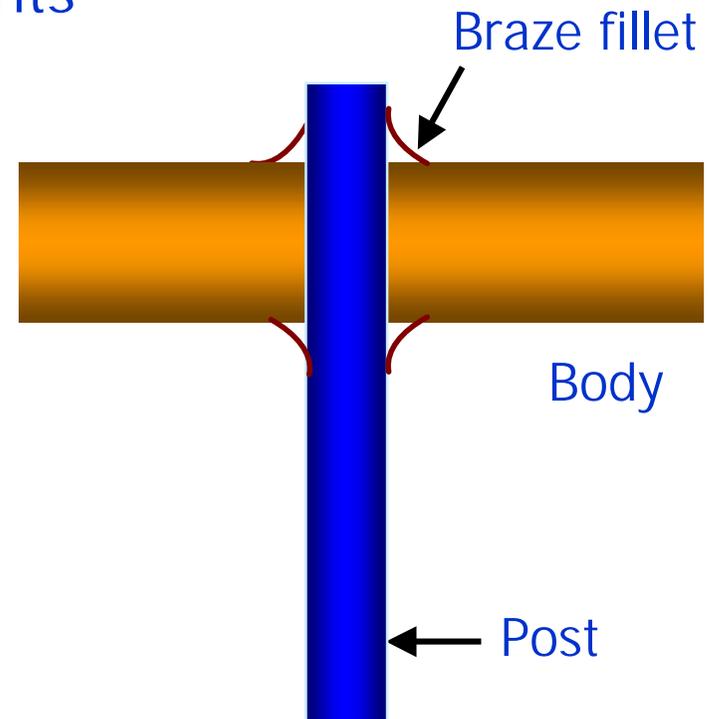
HOLE3-2

Design for Manufacturing Component Brazing

Major component braze joints

628 posts /joints

1256 braze fillets



Design for Manufacturing Brazing

“Two-line” thinking:

- All within spec the same
- Maximum Material Condition best
 - Can be reworked

Results:

- Two braze cycles
- \$30,000

“One-line” thinking:

- Target is best
- Loss increases as feature moves away from target value
- Design within capability of process

Results:

- One braze cycle
- \$9,000

Summary

Working, Learning, and Thinking Together

- Better Value Products from Better Thinking
 - Water Logic - Seeing Systems
 - Quality Loss - “One-Line” Thinking
 - Thinking Together - Integrated Teams & Tools
 - Design for Capability - Managing Variation
- Demonstrated Success
 - Reduced “End Product” Cycle Time
 - Reduced “End Product” Cost
 - Improved “End Product” Quality