

## Is DOE a Part of Lean?



**Perry K. Parendo**  
**651-230-3861**  
**Perry@PerrysSolutions.com**

## Agenda

- **Lean Basics**
- **DOE Basics**
- **Where is DOE used**
- **When is DOE used**
- **How to apply DOE in a Lean manner**

## Lean Basics

- **Waste**
  - Not of value to customer
- **Speed**
  - Quickest when less complexity and less waste
- **Cost performance is a natural output of improving these areas**
- **Applicable to manufacturing, product development and office processes**

## Waste (lack of value)

- **Garbage Can**
  - Inventory
  - Defects
  - Excessive rework
  - Over-analysis
  - Vague surveys



## Waste (lack of value)

### ■ Garbage Truck

- Design with low process capability
- Product does not meet customer needs
  - But could meet requirements...



## Speed

### ■ Garbage Can

- Rework
- Repair
- Cleaning
- Curing
- Develop a second source for supply
- Re-entry of data
- Inspection/ Review



## Speed

### ■ Garbage Truck

- Rebuild
- Redesign
- Retest
- Lack of product performance understanding
- Resistance to adoption of new technology or tools



## DOE is...

### ■ Design of Experiments

- An efficient technique to collect an adequate amount of usable data with the least amount of effort
- Can be used with hardware, computer simulations, and surveys
  - Product or process development
  - Technical and business applications
- The Three Ps of DOE
  - Predict, prove, and perform

*Who has previous exposure to DOE?  
What functional areas are represented?*

## Tool Comparison / Typical Equations

**OFAT typical output (main effects)**

$$y = z + a*A + b*B + c*C$$

**Factorial typical output (main and interactions)**

$$y = z + a*A + b*B + c*C + d*A*B + e*A*C + f*B*C + g*A*B*C$$

**Response Surface typical output (main, interactions, quadratic)**

$$y = z + a*A + b*B + c*C + d[A]^2 + e[B]^2 + f[C]^2 + g[AB] + h[AC] + i[BC] + j[ABC] + p[A]^3 + q[B]^3 + r[C]^3 + s[A^2B] + t[AB^2] + u[A^2C] + v[AC^2] + w[B^2C] + x[BC^2]$$

More information  
(fine tuning) is  
achieved as  
progress to more  
rigorous tools

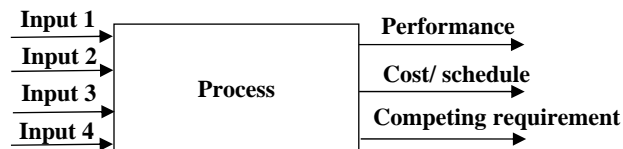
## Where is DOE used?

- Process design/ Manufacturing
- Product development
- Basic research
- Marketing/ sales
- Purchasing
- Office processes

## When is DOE used?

- Do not understand something
- Approach almost works, but needs to overcome a particular challenge
- Ability to predict performance for a variety of conditions
- Need to prove performance to customer
- Any time you test
  - Some say this... but is not true
  - Many potential areas, but they are not applicable all of the time

## What is a process?



Have had up to  
80 potential inputs

Business  
Manufacturing  
Product

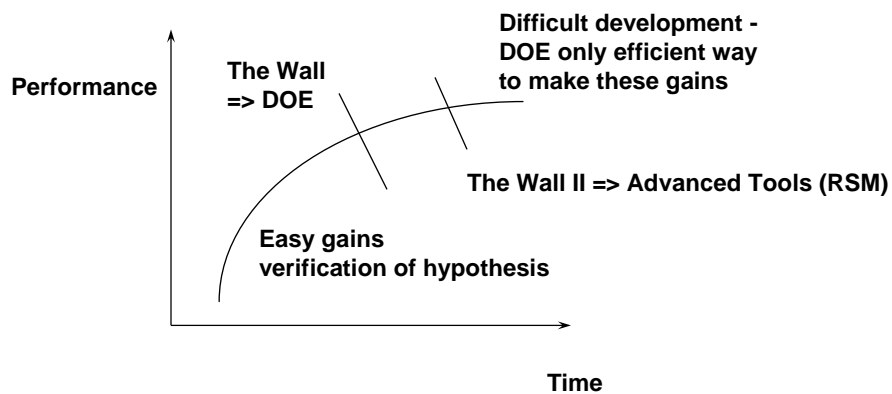
How can you simultaneously  
compare these things?

## Types of Testing in Design Process

- Thought Experiments \* (concepting stage, simulations, decision analysis and trade studies)
- Development \* (subsystem, components)
- Verification (composite system or subsystem, hypothesis testing)
- Qualification (composite system or subsystem)
- Problem Resolution \* (manufacturing, and post-implementation field issues)

\* These are the areas where DOE is used

## Design Stages



## DOE within Lean

### ■ Lean concerns with Waste or Speed (using DOE)

- Should have known the answer (hindsight)
- Could have found the answer another way
- Other solutions could have been available that did not require DOE



## DOE within Lean

### ■ Lean concerns with waste or speed (not using DOE)

- Hit "the wall" for too long
- Unneeded features or processes used because they "might" help
- Can't deliver
- Deliver wrong thing



**Do the best you can with the information available**



## DOE within Lean

### ■ Speed

- Less prototype cycles
- Quicker ECO process
- Equipment ready for production sooner
- Improved throughput time
- Timely results from marketing efforts
- New vendor on board quicker
- Important quality characteristics identified



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## DOE within Lean

### ■ Value

- Higher performing system when you have competing requirements
- Less errors or defects
- Second source available
- Reduced cost
- No excess features/unnecessary variable levels



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## Questions to Ask

- Understand customer needs?
- Prioritized options and right type of test?
- Have you “hit the wall” of performance improvement?
  - Or competitively, could you use higher performance?
  - Remember: predict, prove or perform (the 3 Ps of DOE)
- Do you have raw theoretical knowledge?
- Do you have a handbook that tells you what to do?
- Do you trust either of the above two resources?
  - Do you need to prove yourself to a 3rd party?
- Does someone else have this information?
  - Can you get it from them and does it provide adequate proof?
- Is the knowledge in an easy to use format (to predict)?

## Summary

- DOE does not have to be the answer, but it should not be withdrawn from consideration because “it sometimes is not useful”
- While there should be the potential for cost benefit, I have never run a DOE test that did not provide useful learning.
- Evaluate and prioritize more potential factors and discover deeper effects (interactions) more cost effectively than traditional methods
- Structured method gathers data quickly with higher confidence level in results