

# Introduction to Design for Six Sigma (DFSS)

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# Introduction to Design for Six Sigma (DFSS)

- In this session, we will discuss:
  - The motivation for DFSS
  - How DFSS differs from Lean Six Sigma
  - The DFSS roadmap/methodology
  - Key players and roles in DFSS
  - DFSS projects and studies
  - DFSS Certification
- A list of supplemental material and additional practice/review questions for this session are provided at the end of this presentation
- You can download the pdf of this presentation, along with any supporting data files, on the site where you are accessing this course

Take  
Note

## True or False?

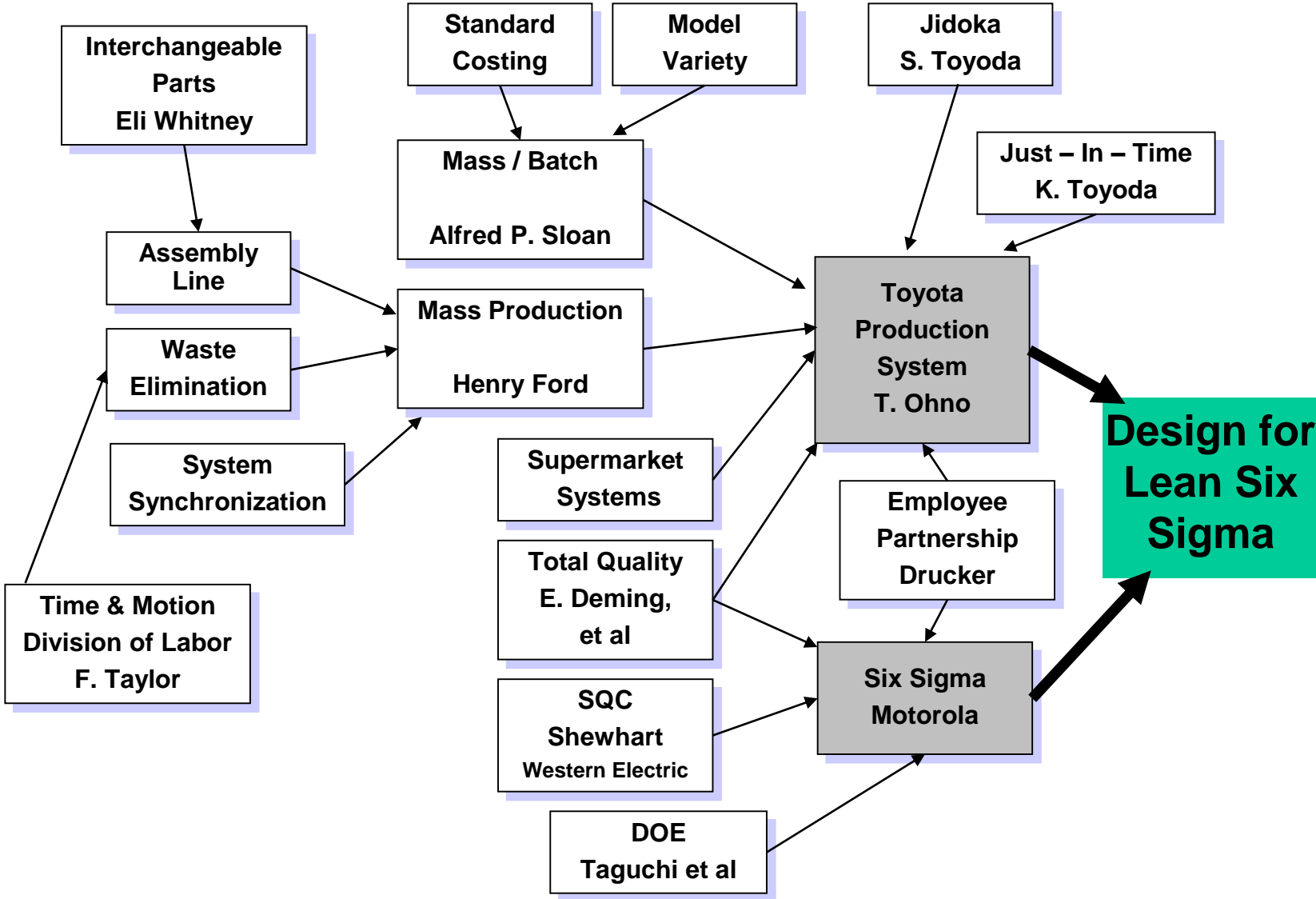
**The systems and products that deliver value to our customers are perfectly designed to achieve the results we are getting today.**

# What is Design for Six Sigma (DFSS)

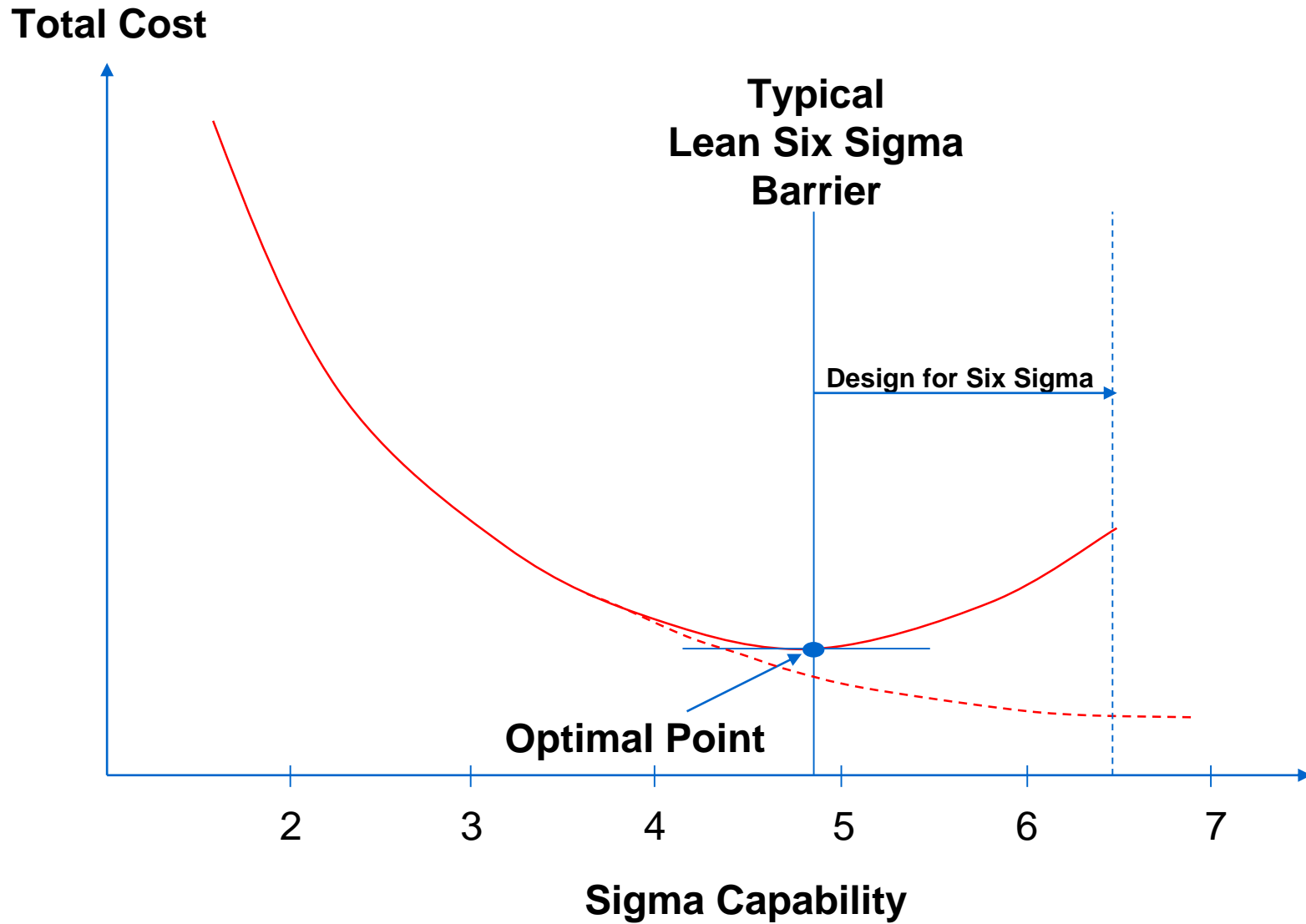
- Also known as Designing for Successful Systems
- It is the natural evolution of Lean Six Sigma (LSS)
- It is a methodology with a distinct roadmap called IDOV
- It has some unique tools that extend the LSS repertoire of tools
- Leverage talent and
- Develops systematic innovation
- Deliver **greater value to the customer and the business**

- **Better** products and services
- Produced **Faster** at **Lower cost**
- **Earlier market entry and faster market growth**
- **Lower total lifecycle costs**

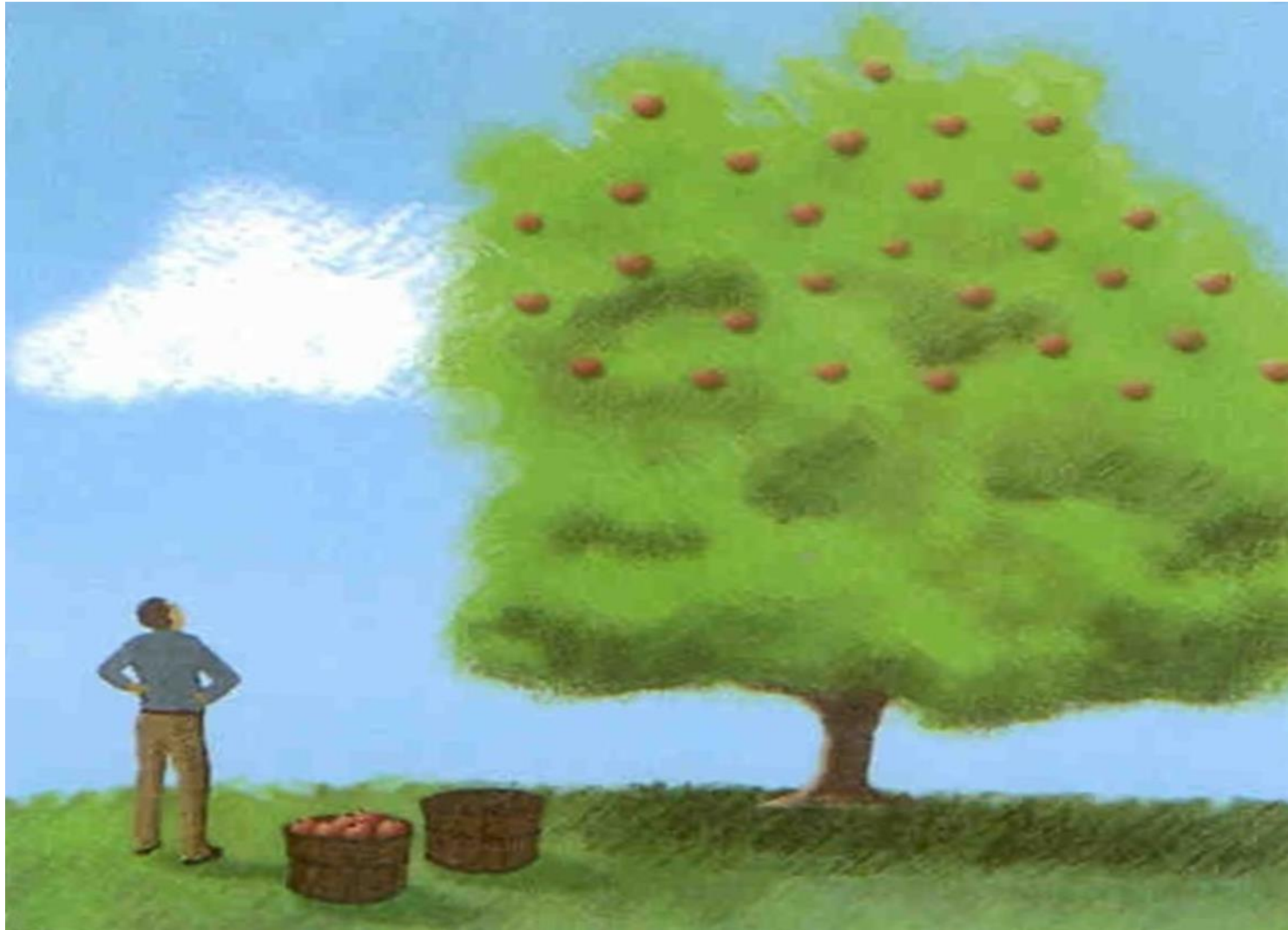
# Where Did It Come From?



# What Have We Learned from LSS?

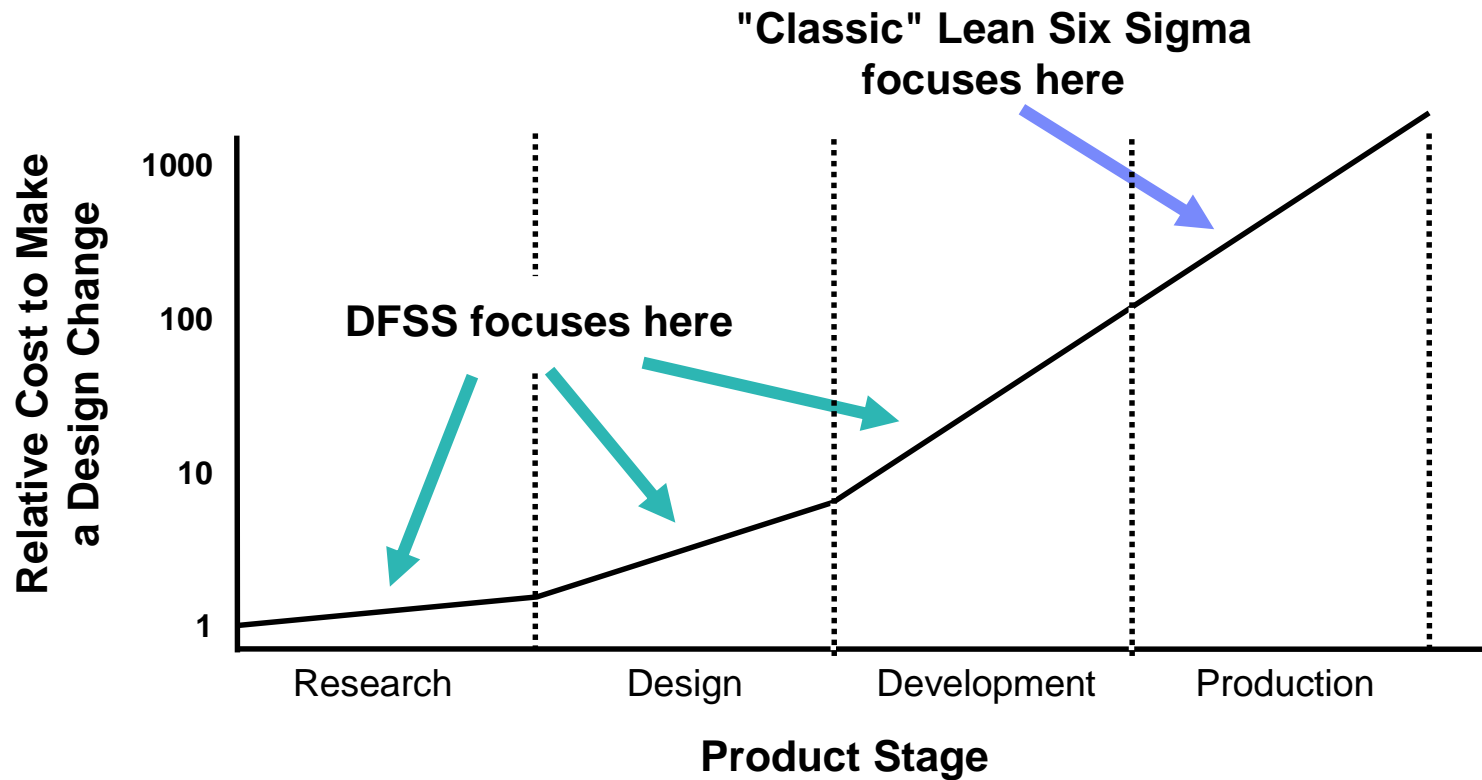


# DFSS: Getting to the Next Level





# Why DFSS

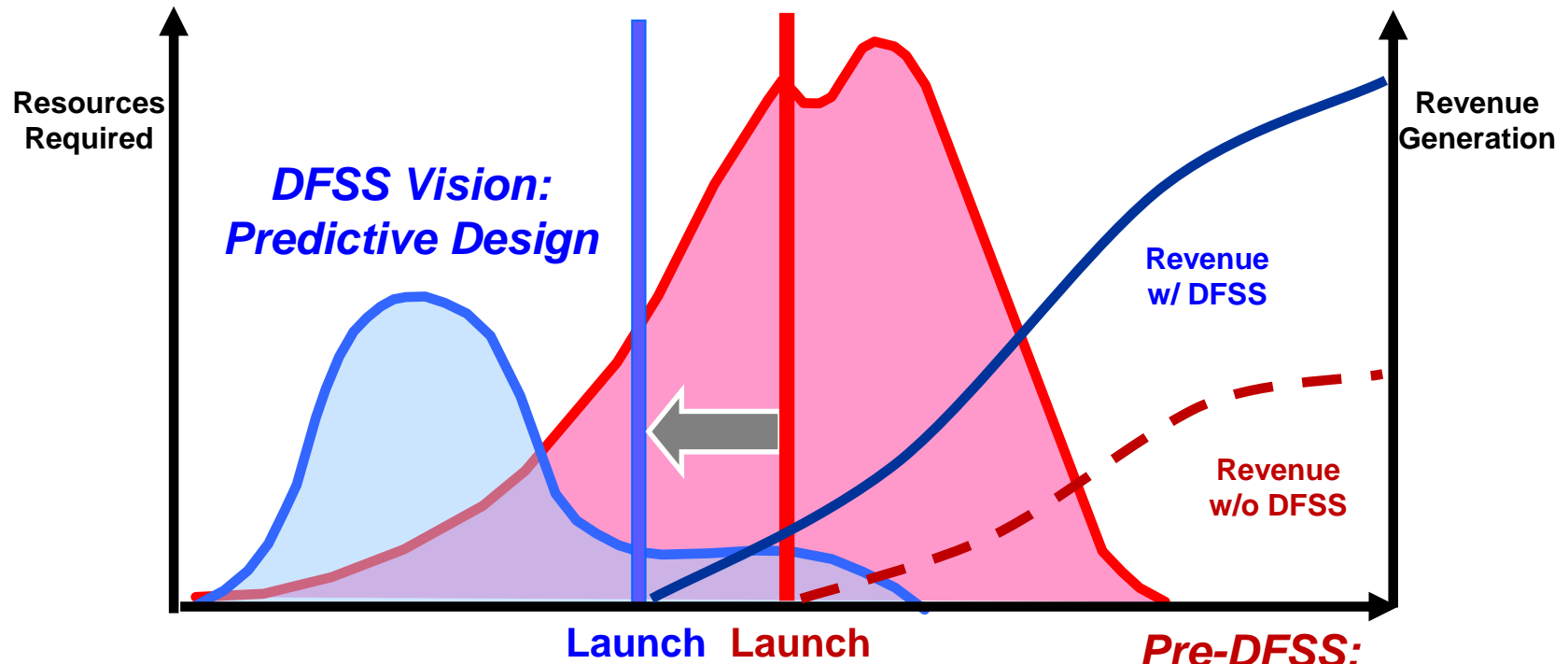


- Gain knowledge when costs are lowest
- Design in quality right from the start

# The Goals of DFSS

- Reduce Cycle Time in the Design and Development Process
- Reduce the Time to Money (TTM)
- Reduce the Cost of Poor Quality
- Improve Predictability of QCD (Quality, Cost, Delivery)

# The Benefits of DFSS



- Early problem identification; solution when costs low
- Faster market entry: earlier revenue stream, longer patent coverage
- Lower total development cost
- Robust product at market entry: delighted customers
- Resources available for next game-changer

## *Pre-DFSS: Reactive Design*

- Unhappy customers and employees
- Unplanned resource drain
- Skyrocketing costs
- Next product compromised

- **Upfront investment is most effective and efficient**
- **Show customers high quality products right from the start**

# General Electric Testimonial (Dr. Norm Kuchar\*, GECRD, Oct 2003)

- Quality increases of at least  $+1\sigma$  at launch over previous designs
- Time to Market decrease by at least 25% over previous launches
- Cost savings due to total resources utilized in the 20-40% range

\* Norm was responsible for the worldwide deployment of GE's DFSS initiative.

# Xerox Testimonial

## (Jeff Koff, DFLSS Global Deployment Leader)

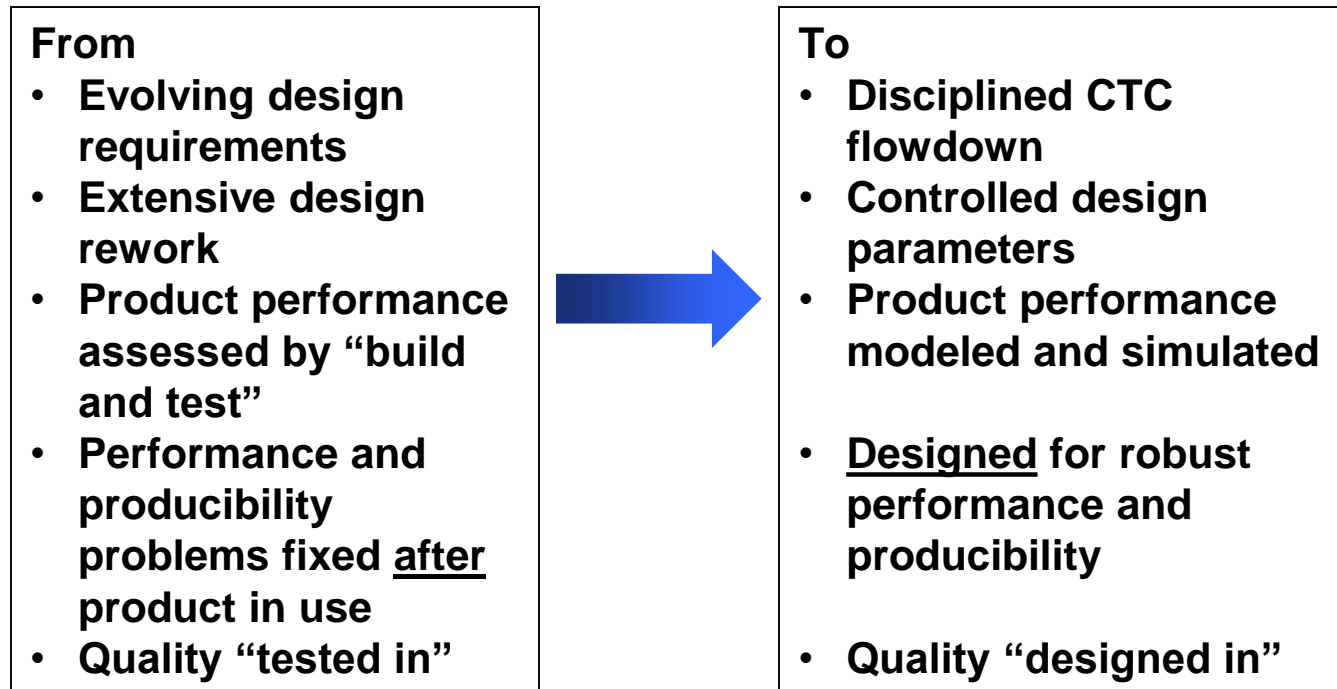
- “We have multiple products that we would have been absolutely unable to commercialize without DfLSS.”
- “We have multiple products that have been developed faster than previously.”
- “We have multiple products that have been launched with better and more predictable reliability and performance than previously.”

# Intuit Testimonial

## (Scott Cook, CEO, January 2015, HBR)

- “We developed D4D (Design for Delight) which clearly articulated Intuit’s approach to design thinking, based on deep customer empathy, idea generation, and experimentation.”
- “D4D is vital because it provides the entire company with a common framework for building great products.”
- “Today we are really a customer-focused, design-driven technology company. And by 2020 we’ll be even better.”

# The Vision of DFSS



- Lean Six Sigma (DMAIC) fixes known problems.
- ***DFSS prevents unknown problems from occurring.***

# Sigma Ratings Measure Process Capability

Sigma ( $\sigma$  Capability is a measure of quality. It compares the Voice of the Process with the Voice of the Customer and is correlated to the defect rate. It is computed from DPMO.

Yield is the probability that whatever we are producing (manufactured part, PO, shipped part, etc.) will pass through the entire process without rework and without defects.

$\sigma$ Capability*	DPMO*	RTY
2	308,537	69.1%
3	66,807	93.3%
4	6,210	99.4%
5	233	99.97%
6	3.4	99.99966%

Process  
Capability

Defects per Million  
Opportunities

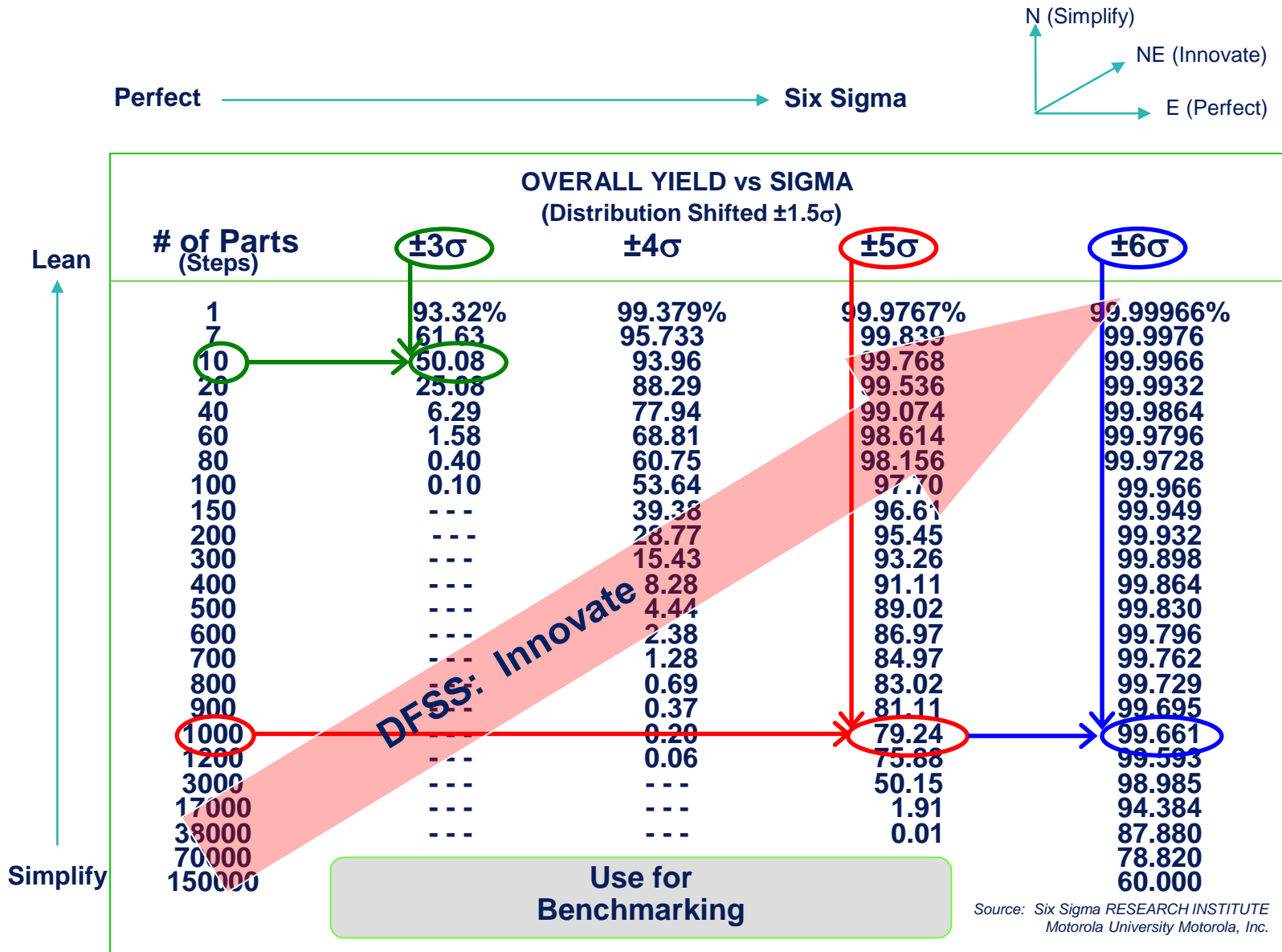
Rolled Throughput  
Yield

**Six Sigma is a standard of Excellence.  
It means less than 4 Defects per Million Opportunities.**

\* Assumes a 1.5 sigma shift in average if the performance measure is normally distributed

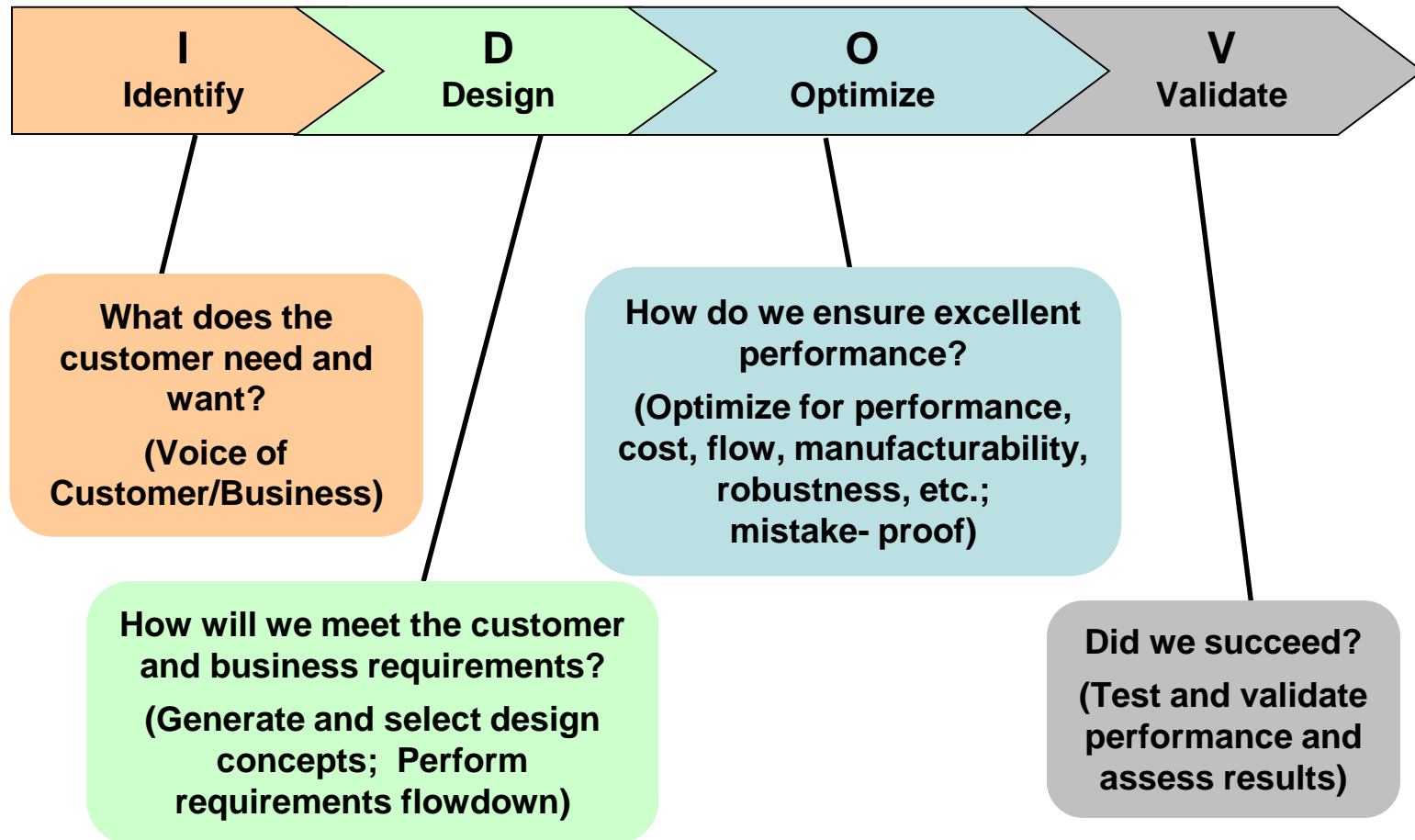


# Relationship Between Lean, Six Sigma, and DFSS



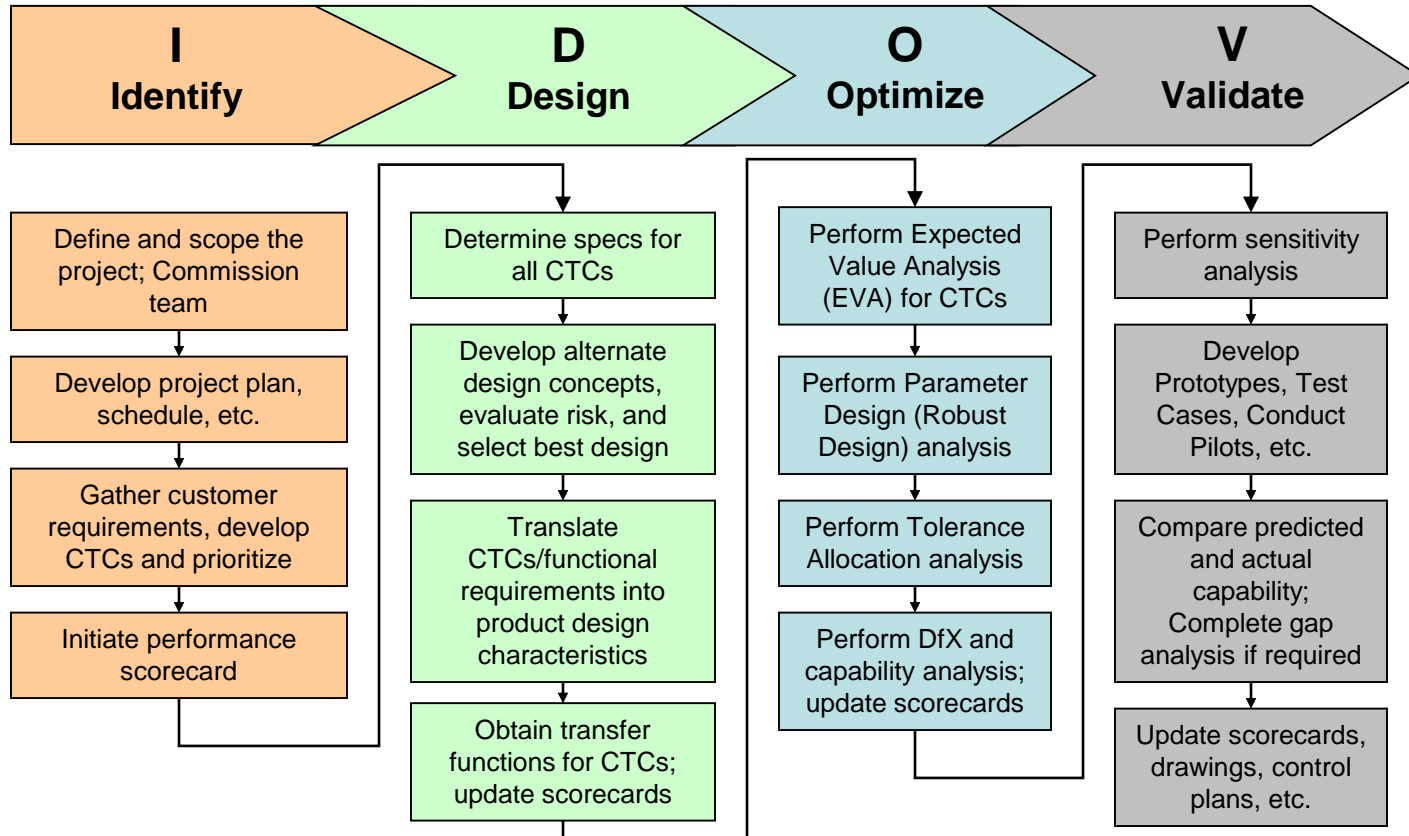


# The DFSS Roadmap



\* The **IDOV** four-phase DFSS process originated with Dr. Norm Kuchar at GE CRD and is used with permission.

# Break Points in the IDOV Journey



## Key Deliverables:

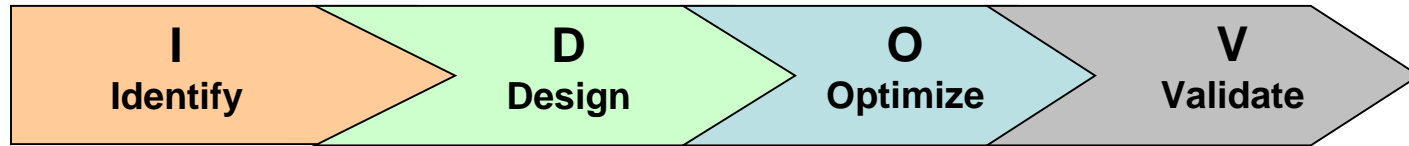
- strategic plan
- benchmarking results
- customer requirements; prioritized, measurable CTCs (HOQ #1)
- Initial performance scorecard

- Design concepts and selection results
- Requirements flowdown
- Prioritized product design characteristics (HOQ #2)
- Design risk assessments
- Transfer functions
- Updated scorecards

- Capability and reliability studies
- X-ability assessment
- Optimized design
- Capability analysis
- Tolerances for key Xs
- Updated scorecards (capability flowup)

- Sensitivity analysis
- Pilots / prototypes and capability analysis
- Validated processes and products
- Updated scorecards
- Control plan

# Extending the LSS Tools



Project or Study Charter  
 Strategic Plan  
 Cross-Functional Team  
 Voice of the Customer  
 Customer Retention Grid  
 Benchmarking  
 KANO's Model  
 Questionnaires  
 Focus Groups  
 Interviews  
 Internet Search  
 Historical Data Analysis  
 Design of Experiments  
 Quality Function Deployment  
 Pairwise Comparison  
**Analytical Hierarchy Process**  
 Performance Scorecard  
 Flow Charts  
 FMEA  
**Visualization**

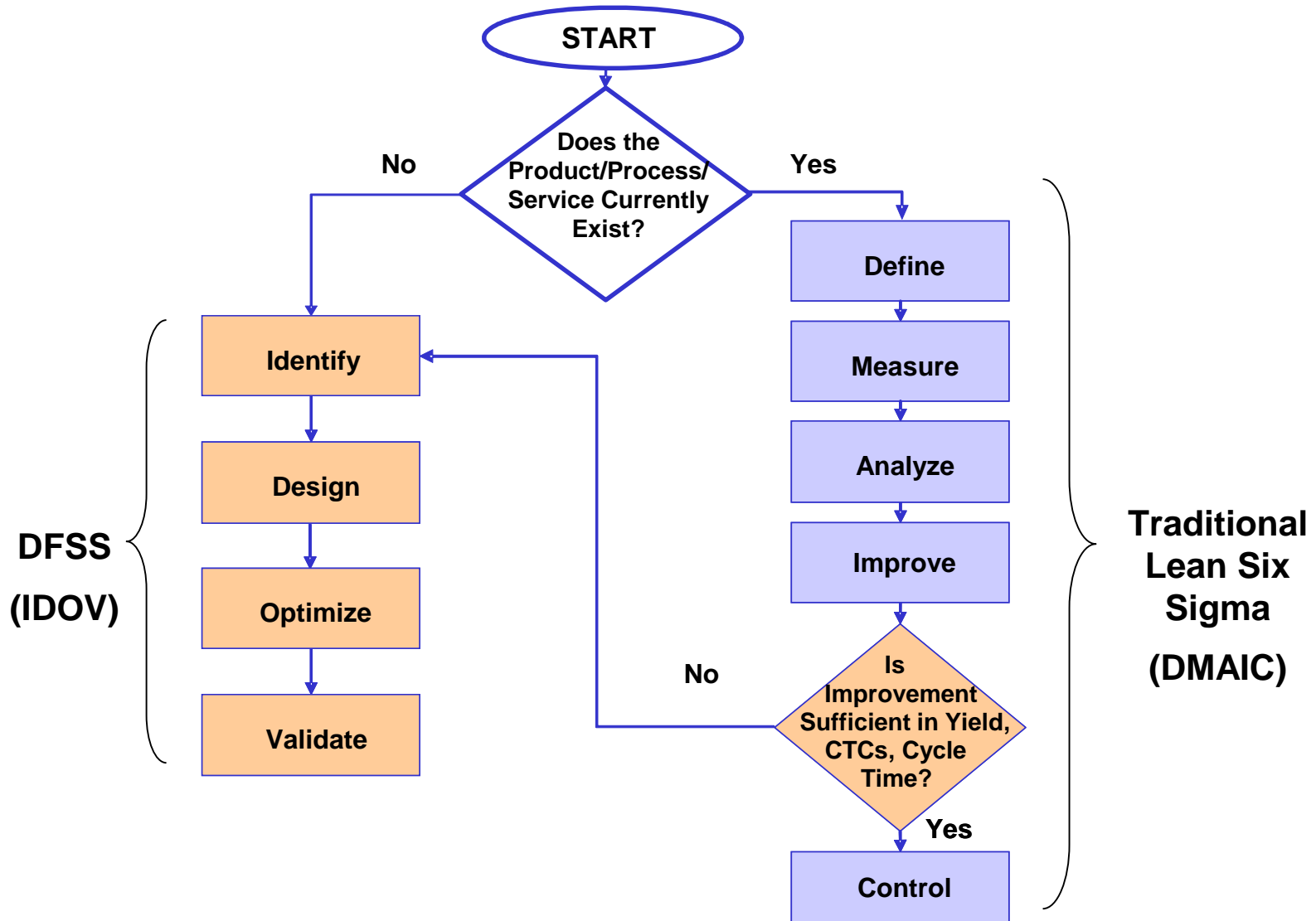
**\*Unique to DFSS**

Assign Specifications to CTC's  
**Axiomatic Design**  
 Customer Interviews  
 Formulate Design Concepts  
**Pugh Concept Generation**  
**TRIZ**  
 FMEA  
 Fault Tree Analysis  
 Brainstorming  
 QFD  
 Scorecard  
**Transfer Function**  
 Design of Experiments  
**Deterministic Simulators**  
**Discrete Event Simulation**  
 Confidence Intervals  
 Hypothesis Testing  
 MSA  
 Computer Aided Design  
**Computer Aided Engineering**

Histogram  
**Distributional Analysis**  
**Empirical Data Distribution**  
**Expected Value Analysis (EVA)**  
**Adding Noise to EVA**  
 Non-Normal Output Distributions  
 Design of Experiments  
**Multiple Response Optimization**  
**Robust Design Development**  
**Using S-hat Model**  
**Using Interaction Plots**  
**Using Contour Plots**  
**Parameter Design**  
**Tolerance Allocation**  
**Design For Manufacturability and Assembly**  
 Mistake Proofing  
 Product Capability Prediction  
**Part, Process, and SW Scorecard**  
**Risk Assessment**  
**Reliability**  
**Multidisciplinary Design Optimization (MDO)**

**Sensitivity Analysis**  
**Gap Analysis**  
 FMEA  
 Fault Tree Analysis  
 Control Plan  
 PF/CE/CNX/SOP  
 Run/Control Charts  
 Mistake Proofing  
 MSA  
 Reaction Plan  
**High Throughput Testing**

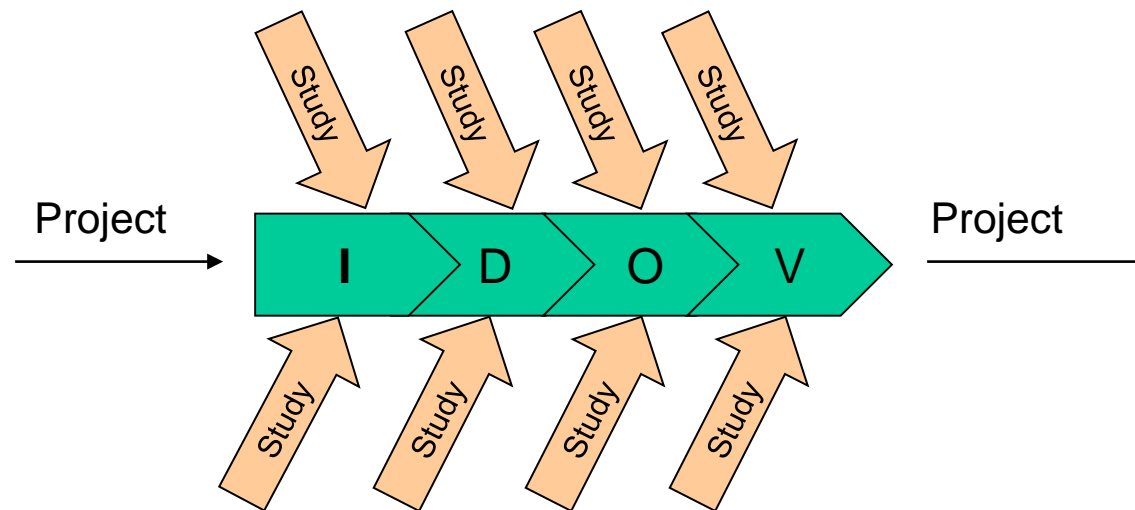
# DFSS (IDOV) vs LSS (DMAIC)



# Project vs Study

## Project

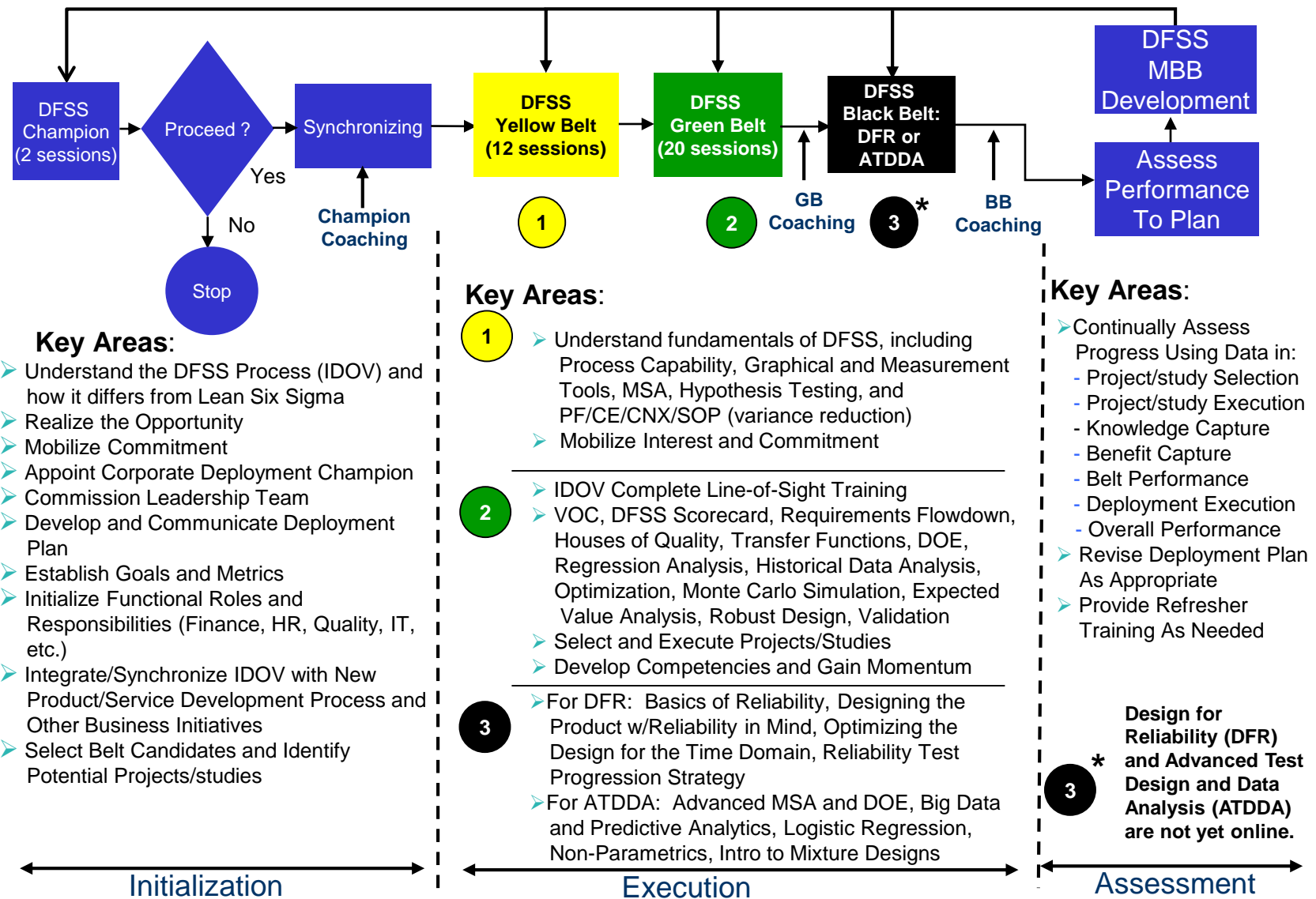
- This is an effort that results in the design of a sub-assembly, module or system. The design should proceed through all four stages of IDOV starting with the concept and customer requirements and ending with a validated design that has been delivered to manufacturing. The project must include a representative sampling of tools such as QFD, concept selection, DOE, etc.



## Study

- This is the execution and completion of work which utilizes one of the DFSS tools / methods as part of an assignment to meet unit objectives. A DOE, a QFD, a MSA, and a tolerance study are examples.

# Rolling Out DFSS Online





# Definition of a “Champion”

- **Champion:** “one that defends, fights for, or supports a cause”  
(source: The American Heritage Dictionary)
- **DFSS Champion:** one who defends, fights for, or supports the cause of DFSS; that is, one who, by his or her actions and behavior, is a strong advocate of DFSS
- **DFSS Deployment Champion:** one who is responsible for deploying and implementing DFSS throughout an organization
- **DFSS Project/Study Champion (a.k.a. DFSS Project/Study Sponsor):** one who is responsible for chartering, sponsoring, and supporting a DFSS project or study, ensuring that it crosses the finish line

# Responsibilities of a DFSS Champion

- Know the what and why of DFSS
- Identify and define key projects/studies that can best benefit the organization
- Identify belt candidates and make sure their projects/studies align with their current work
- Provide financial and organizational resources to train and equip belts to accomplish project goals
- Create and maintain project or study momentum
- Ask the right questions and review the answers
- Break down barriers to project completion and push the project across the finish line
- Recognize and reward success
- Propagate success stories to generate cultural change
- Raise the level of effectiveness of new product/process development throughout the entire organization

# 12 Sessions for Yellow Belt (DFSS Fundamentals)

- Introduction to DFSS (also DFSS Champions)
- PF/CE/CNX/SOP
- VSM with IPO and SIPOC
- Basic Statistics
- Process Capability
- Graphical and Measurement Tools
- Measurement System Analysis
- Confidence Intervals and Sample Size
- Hypothesis Testing
- Statistical Process Control
- Introduction to Regression Analysis
- Introduction to DOE

# 20 Additional Sessions Needed for DFSS GB

DFSS Foundations  
(8 sessions)

- Full Factorial Designs (2 levels)
- Fractional Factorial and Screening Designs (2 levels)
- 3-Level Designs
- DOE Rules of Thumb
- Mixed Factor - Mixed Level Designs
- Multiple Response Optimization
- Residual Analysis
- Historical Data Analysis

DFSS IDOV  
(12 sessions)

- Project and Study Definition
- DFSS Scorecard
- Voice of the Customer (VOC and HOQ 1)
- Concept Generation and Selection
- Detailed Design (HOQ 2)
- Failure Mode and Effects Analysis (FMEA)
- Expected Value Analysis (EVA)
- Robust Design
- Tolerance Allocation and Sensitivity Analysis
- Design for X-ability (DFX)
- Probability Distributions
- DFSS Summary (also DFSS Champions)

# DFSS GB Certification Criteria

1. Successfully complete the DFSS GB course curriculum:
  - DFSS Fundamentals (aka Yellow Belt): 12 sessions
  - DFSS Foundations: 8 sessions
  - DFSS IDOV: 12 sessions
  - “Successful” completion means completing each session’s 5-question MC quiz with at least 4 of the 5 questions answered correctly. Multiple tries are allowed without penalty.
  - An electronic course certificate will be awarded after successfully completing all quizzes. This is a certificate of course completion, NOT certification as a DFSS GB.
2. Candidate must complete two online 30-question MC exams covering the Foundations and IDOV portions of the GB material, scoring at least 70% on each exam.
3. Candidate must complete a project or 3 studies. See next page for examples.
4. Candidate must demonstrate the ability to communicate the results to others:
  - Oral briefing(s) to their own internal team of leaders/managers
  - Written report(s) to Air Academy Associates for final approval
5. Candidate must demonstrate competency to an Air Academy coach\* in the areas shown on page 29. Competency is the key to certification.

\*If Air Academy does not do the coaching, then both an additional comprehensive written exam and an oral certification review will be required.

# Potential Areas for DFSS Studies

- Establishing and Populating a DFSS Scorecard (Identify)
- Understanding the True Voice of the Customer (Identify)
- Translating the Voice of the Customer: Requirements Flowdown (Design)
- Transfer Functions (Design)
- Robust and Optimized Designs that can be produced efficiently and with high quality (Optimize)
- Rolling up the Results/Validating the Design (Validate)

# DFSS GB Competency Areas

- VOC Gathering and Requirements Generation and Analysis
- DFSS Scorecard Generation and Analysis
- Concept Generation and Selection
- Detailed Design Strategy
- Measurement System Analysis (MSA)
- Failure Mode and Effect Analysis (FMEA)—risk analysis
- Statistical Tools and Analysis (hypothesis testing, regression, etc.)
- Design of Experiments (Screening, Modeling, and Validation Designs)
- Analytical Modeling and Simulation
- Robust Design and Optimization Methods
- Tolerancing and Specifications
- Design for X (manufacturability, testability, serviceability, etc.)
- Design and Process Capability

# Key Takeaways



- As a review, you may want to pause the video at this point and summarize the key learnings from this session, at least from a high-level view. When you are finished, you may resume the video and complete the session.



# Key Takeaways

- Design for Six Sigma (DFSS) means all of the following:
  - Better products and services produced faster and at lower cost
  - Earlier market entry
  - Faster market growth
  - Reduction in total lifecycle costs
  - A framework for systematic improvement and innovation
  - A vision
- DFSS expands the toolset of LSS to include tools that must be used earlier in the lifecycle of a product or service
- Certification is based on competency

Are you ready to learn and apply the details of DFSS?

# Supplemental Material



- Suggested Reading:
  - ***Design for Six Sigma: The Tool Guide for Practitioners*** by Reagan and Kiemele (pp. 1-5, 11-18)
  - ***Knowledge Based Management*** by Kiemele, Pollock and Murrow (pp. 186-213)
  - ***Lean Six Sigma: A Tools Guide*** by Adams, Kiemele, Pollock, and Quan (pp. 147-154)
  - ***Reversing the Culture of Waste: 50 Best Practices for Achieving Process Excellence*** by Pollock and Kiemele
  - Air Academy's app: ***Six Sigma Quick Tools***



- Recommended software from [sixsigmaproductsgroup.com](http://sixsigmaproductsgroup.com):
  - SPC XL™
  - DOE PRO XL™
  - Quantum XL™
  - Pro-Test™
- The data files for this session can be downloaded from the site where you are accessing this course.

# Additional Practice / Review Questions



- 1) What are some of the benefits of DFSS?
- 2) Explain the synergy of Lean, Six Sigma, and DFSS.
- 3) What are the 4 major phases of the DFSS Roadmap or Methodology?
- 4) What is the difference between a DFSS project and a DFSS study?
- 5) Name some of the key roles and their responsibilities in building a DFSS infrastructure.
- 6) What is the key to certification in DFSS?
- 7) To be certified as a DFSS GB or BB from Air Academy Associates, what are the required steps?

# We can help...

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There are times when help outside your organization is needed. When that time comes, benefit from a partner that is experienced, tested, and trusted.

Expert coaching is one of the Top Five Best Practices for generating step change in project execution, as well as enhanced return on investment. We can work remotely with your organization to provide coaching support.

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