An Introduction to Design for Six Sigma concepts

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Product Excellence using 6 Sigma Module

Objectives of the session

• History of Six Sigma
• Describe the Six Sigma Philosophy
• Introduce DFSS
• Key points in DFSS
• DFSS background
• DFSS process
• Differences between DFSS and Six Sigma
Introduction to Six Sigma

• Six Sigma is:
  – A business process
  – Proactive approach to designing and monitoring key activities
  – Philosophy
  – Methodology
  – A process that is customer focussed and profit driven

• It works by:
  – Being adopted by the whole company;
  – Creating an internal infrastructure within the company;
  – Using metrics to measure processes and changes to processes
  – Using scientific methods, changing the working culture and introducing business process management
Six Sigma Background

• Motorola employee investigating variation in various processes
• Acted on results using tools to reduce variation
• Improved the effectiveness and efficiency of the processes
• Engaged CEO
• GE is the company that made SIX Sigma a management philosophy

What is six sigma performance?

Sigma (σ) is a statistical metric that corresponds to dpm (defectives per million)

2σ 308,537 dpm
3σ 66,807 dpm
4σ 6,210 dpm
5σ 233 dpm
6σ 3.4 dpm
### DMAIC

**Define**
- Define business objectives
- Set Up project team, establish the charter and develop project plan
- Review customer requirements
- Map process

**Measure**
- Data collection plan
- Confirm starting and targets
- Validate measurement system

**Analyse**
- Data analysis
- Root cause analysis
- Process analysis

**Improve**
- Solution generation, selection and implementation

**Control**
- Launch new improvements
- Monitor controls and track defect reduction
- Design and implement audit plan

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### Product life cycle

1. **Concept and definition**
2. **Design and development**
3. **Manufacturing**
4. **Installation**
5. **Operation and maintenance**
6. **Disposal**

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*Continuous assessment*
Introduction to DFSS

- Systematic methodology for designing or redesigning products or services according to customer requirements and expectations.
- Optimises design process to achieve six sigma performance
- Get it ‘right first time’

What is Design For Six Sigma?

- Companies who had seen the success of Six Sigma for problem solving using DMAIC wanted to apply data driven tools and techniques to the design of new products, processes & services
- Typically, after 2 years of DMAIC, Design For Six Sigma programmes were launched
- Applied in both Manufacturing and Service industries in technical and non-technical environments
- Used to define and/or supplement the ‘design’ process
When to Use DFSS

- Creating a new product, process, or service
- Incremental improvement cannot close the gap between the current process capability and customer requirements
- Should spend time understanding the faults of existing systems before you embark on a redesign methodology

Generic ‘Design’ Process

Requirements Flow down

Define Project → Identify Requirements → Select Concept → Develop Design → Implement Design

CTQ Flow up
The DFSS Opportunity

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<table>
<thead>
<tr>
<th>Product Stage</th>
<th>Research</th>
<th>Design</th>
<th>Development</th>
<th>Production</th>
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<td>Relative Cost to Impact Change</td>
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"Classic" Six Sigma focuses here

DFSS focuses here

"Design in" quality when costs are lowest

Effect of design phases on life cycle

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<table>
<thead>
<tr>
<th>Cost vs impact</th>
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<tr>
<td>Potential is positive Impact &gt; cost</td>
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<tr>
<td>Potential is negative Impact &lt; cost</td>
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"Design in" quality when costs are lowest
The Vision of DFSS

Reactive Design Quality  DFSS  Predictive Design Quality

From
• Evolving design requirements
• Extensive design rework
• Product performance assessed by “build and test”
• Performance and producibility problems fixed after product in use
• Quality “tested in”

To
• Disciplined CTQ flow-down through requirements management
• Controlled design parameters
• Confidence in product performance
• Designed for robust performance and manufacture
• Quality “designed in”

DFSS Methodology

• DMADV
  – Define, Measure, Analyse, Design and Verify

• PIDOV
  – Plan, Identify, Design, Optimise and Validate.
DFSS Process

Plan → Identify → Design → Optimise → Verify

Define → Measure → Analyse → Design → Verify

Develop project plans → VOC – CTQ → Prioritise CTQ → Generate, evaluate, select and review concepts → Detailed design and optimise performance → Demonstrate satisfies requirements

Process for DFSS - DMADV

**Define**
Initiate, scope and plan the project

**Measure**
Understand customer requirements and generate specification

**Analyse**
Develop design concepts and high level design

**Design**
Develop detailed design and verification plan

**Verify**
Demonstrate compliance and launch product
Tollgates and phases

- Stopping point within the flow of phases
  – A thorough assessment of deliverables
  – A thorough review of the project management plans for the next phase

- Checklists
  – Summary statements of tools and best practices required to fulfil gate deliverable

- Scorecards
  – Summary statements from specific application of tools and best practice

DMADV

Define
DMADV - Define

Elements of a Charter

- Problem Statement
- Opportunity Statement
- Importance
- Expectations/Deliverables
- Scope
- Schedule
- Team Resources
Develop Project Plans

- Project schedule and milestones
- Organizational change plan
- Risk management plan
- Review schedule

Risk Management Plan

- Design projects face a number of risks
- The team’s job is to anticipate where the key risks of failure are and to develop a plan to address those risks
- In Define, the team should:
  – Identify known and potential risks for the project
  – Indicate when and how the risks will be addressed
Project Reviews

- Regular reviews are key for successful projects and should be included in the project schedule
- There are several levels of review:
  - Milestone or tollgate reviews; weekly reviews; daily reviews
- In addition, design projects have three unique reviews:
  - Concept review; High-level design review; Detailed design review

Key Outputs of DEFINE Phase

- Project team
- Project business case
- Project objective
- Project plan (GANNT chart)
- Document control systems
- Risk reduction plan
DMADV

Measure

DMADV - Measure

• **Goals:**
  – Collect Voice of the Customer data
  – Translate VOC into design requirements (CTQs)
  – Identify the most important CTQs
  – Develop the measurement system for each CTQ
  – Develop a design scorecard
  – Revise project objective if necessary

• **Output:**
  – Prioritized CTQs
Measure: Tools

- Data collection plan
- Customer segmentation
- Customer research
- Voice of Customer table
- Kano model
- Affinity diagram
- Benchmarking
- QFD (Quality Function Deployment)

Measure: Key Activities

1. Understand Voice of the Customer
2. Translate VOC Needs Into Requirements (CTQs)
3. Prioritize CTQs
4. Reassess Risk
What is the Voice of the Customer?

- The term Voice of the Customer (VOC) is used to describe customers’ needs and their perceptions of your product or service.
- It includes all forms of interaction between customers and your organization.

Use of Kano analysis

Critical to Quality Characteristics

- A quality characteristic that specifies how the customer need will be met by the product/service to be designed.
- A quantitative measure for the performance of the quality characteristic.
- A target value that represents the desired level of performance that the characteristic should meet.
- Specification limits that define the performance limits that will be tolerated by customers.
- Several CTQs will exist for each need.
- Use QFD to transfer VOC data into CTQs.
Develop and Validate a measurement system

- Review data requirements
- Review how to capture data
- Review applicable analysis methods
  - e.g. compare voice of the process with voice of the customer – SPC and capability analysis
- Decision criteria to determine acceptance
- Establish validity of the measurement system

Develop a design scorecard

Used to help the team to:

- Establish nominal values and specification limits for each CTQ
- Predict output of the voice of the process with respect to stability (SPC)
- Highlight problems and risks of CTQs
- Track CTQs throughout the entire life of the product
### Generic design scorecard

<table>
<thead>
<tr>
<th>Scorecard Part A (Voice of the customer)</th>
<th>Scorecard Part B (Predicted Voice of the process)</th>
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<tbody>
<tr>
<td>CTQ</td>
<td>Target</td>
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### Reassess Scope and Risk

- How difficult do we predict it will be to meet all the target values of the most important CTQs?
- Is it necessary to adopt a phased approach to meet the target?
- What are the risks associated with not meeting the CTQs now?
- What are the risks associated with dropping some of the less important CTQs from consideration?
Measure: Tollgate Review

• This tollgate review focuses on
  – Customer segmentation strategy
  – Top 10-15 customer needs
  – Top 8-10 CTQs and targets
  – Summarized benchmark information
  – Platform management matrix
  – CTQ achievement matrix

• The review can lead to the following steps:
  – Proceed to Analyse
  – Redo parts Measure
  – Stop the project

DMADV

Analyse
DMADV - Analyse: Key questions

- Important processes/functions that must be designed to meet the design requirements?
- Key inputs and outputs of each process?
- Processes for which innovative new designs are required to maintain a competitive advantage?
- Different solutions available for designing each process?
- What criteria do we use to evaluate these design alternatives?
- Collect information on these criteria for evaluation?

DMADV - Analyse

Identify Key Functions → Prioritize Functions → Generate Concepts → Evaluate and Analyze → Concept Review
Generate Concepts

- Concepts are generated using two approaches:
  - Creative idea-generation techniques that focus on analogy, connections, extrapolations and creative visualization to develop new ideas
  - Benchmarking techniques that study similar designs in competing and non-competing businesses

Design Review

- Process for objectively evaluating the quality of a design at various stages of the design process
- Opportunity for voices external to the design team to provide feedback on the design, as the product and service is being developed
- Helps to ensure that the design will satisfy customers, and that the design process will function effectively to produce a high quality product or service
When to conduct a design review

- Concept Review: Conducted after two to three key concepts have been identified and their feasibility has been determined.
- High Level Design Review: Conducted after a selected concept has been designed to some level of detail and tested, and before detailed design begins.
- Pre-pilot Design Review: Conducted when the detailed design is complete and the product/service is ready to be piloted.

Design for X

- Design for manufacture
- Design for assembly
- Design for reliability
- Design for testability
- Design for service
- Design for quality
- Design for reusability
- Design for environment
Analyse: Tollgate Review

• This tollgate review focuses on:
  – List of key functions
  – List of top concepts
  – Pugh Matrix
  – Concept review outputs
  – Risk analysis update

• This review can lead to the following steps:
  – Proceed to High Level Design
  – Redo work on concepts, concept review and tollgate review
  – Stop the project
DMADV - Design

High Level Design → Detailed Design

From Concept to Design

- Less Detail /Many Alternatives
- More Detail/Few Alternatives
- Most Detail/Single Alternative

Redesign
Design: Goals and Outputs

• Goals:
  – Develop high level and detailed design
  – Test design components
  – Prepare for pilot and full scale deployment

• Outputs:
  – Tested high level design
  – Tested detailed design
  – Plans for process control
  – Completed design reviews

Design: Tools

• QFD
• Simulation
• Rapid prototyping
• Weibull analysis
• SPC and process capability
• Detailed design scorecards
• FMEA
• Reliability testing and qualification testing
• Design reviews
Tollgate review

The pre-pilot detailed design tollgate review focuses on:

• Developed design
• Completed FMEA/simulation analysis
• Design solutions for vulnerable elements
• Organizational Change Plan updates
• Process management system variables
• Process management system details

DMADV

Verify
DMADV - Verify

Steps in the Verify phase

- Build a prototype
- Pilot test the prototype
- Conduct design reviews using design scorecards
- Decide if the process is meeting business objectives
- Close DMADV project
- Transfer lessons learned from the project
Verify: Goals and Outputs

• Goals:
  – ‘Stress-testing’ and de-bugging of prototype
  – Implementation and team closure

• Outputs:
  – Working prototype with documentation
  – Plans for full implementation
  – Process owners using control plans to measure, monitor and maintain process capability
  – Project closure and documentation completed
  – Ownership transition from sponsor to operations management, and from design team to process management team(s)
  – Lessons learned

Completion Checklist

• Completed project documentation that summarizes results and learnings
• Recommendations (supported by updated information, if possible) for the next generation of this design
• Plans for (or results from) communicating your achievements to the rest of the organization
• Plans for celebrating your success
Advantages of DFSS

- Provide structure to development process
- Anticipate problems and avoid them
- Reduce life cycle cost
- Improve product quality, reliability and durability
- Cultural change
- Minimise design changes
- Improve communication between functions

Difference between SS and DFSS

<table>
<thead>
<tr>
<th>DMAIC</th>
<th>DFSS</th>
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<tbody>
<tr>
<td>reactionary</td>
<td>proactive</td>
</tr>
<tr>
<td>detecting and resolving problems</td>
<td>preventing problems</td>
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<tr>
<td>Existing products or services</td>
<td>Design of new products, services or processes;</td>
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<td>Financial benefits quantified</td>
<td>Financial benefits long-term</td>
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<tr>
<td>quickly</td>
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<tr>
<td>Mainly manufacturing processes</td>
<td>Marketing R&amp;D and design</td>
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<td>DFSS team cross-functional</td>
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DFSS Summary

• Rigorous approach to design
• Primarily used for new product design
• Structured approach
• DMADV and PIDOV
• Tailored for each company
• In conjunction with product introduction
• Pushes key issues up front – design for reliability and design for manufacture