Introduction to Six Sigma

Applying Statistical Analysis to Business Issues
Objectives

- Understand Six Sigma
- Gain a high-level understanding of the tools methods and application of Six Sigma
- Learn the basic vocabulary of Six Sigma
- Understand the roles and responsibilities of Six Sigma practitioners
- Identify the benefits of Six Sigma as a business improvement methodology
Agenda

• Introduction
• Methodology
• Roles and Responsibilities
• Why Six Sigma
• How to Implement Six Sigma
Introduction

• What Six Sigma means
• What Six Sigma is
• The concept of variation
• Performance and defects
What Six Sigma Means

“Past definitions of quality focused on conformance to standards, as companies strived to create products and services that fell within certain specification limits.” -Mikel Harry and Richard Schroeder
What Six Sigma Means

“...this Six Sigma journey will change the paradigm from fixing products so they are perfect to fixing processes so that they produce nothing but perfection, or close to it.” - Jack Welch
What Six Sigma is

- Goal
- Metric
- Benchmark
- Philosophy
- Value
- Vision
- Symbol
- Method
- Tool
The Concept of Variation

Variety may be the spice of life but, for customers, consistency is King!
The Concept of Variation

Every repeatable process exhibits variation
We measure variation using standard deviation ($\sigma$).
Performance and defects

Reducing Variability Is The Essence of Six Sigma

Reducing Variability Is The Essence of Six Sigma
## Performance and Yield

<table>
<thead>
<tr>
<th>$\sigma$</th>
<th>Defects per Million opportunities</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>308,537</td>
<td>69.20%</td>
</tr>
<tr>
<td>3</td>
<td>66,807</td>
<td>93.32%</td>
</tr>
<tr>
<td>4</td>
<td>6,210</td>
<td>99.38%</td>
</tr>
<tr>
<td>5</td>
<td>233</td>
<td>99.98%</td>
</tr>
<tr>
<td>6</td>
<td>3.4</td>
<td>99.99%</td>
</tr>
</tbody>
</table>

$3\sigma$ to $6\sigma$ – 20,000 X Improvement...A True Quantum Leap
Performance in Context

--- 99% Good (3.8 Sigma) ---

- 20,000 lost articles of mail per hour
- Unsafe drinking water for almost 15 minutes each day
- 5,000 incorrect surgical operations per week
- 340 Passengers with Misplaced Luggage every day
- 200,000 wrong drug prescriptions each year

--- 99.99966% Good (6 Sigma) ---

- Seven articles lost per hour
- One unsafe minute every seven months
- 1.7 incorrect operations per week
- 6 Passengers with Misplaced luggage each month
- 68 wrong prescriptions per year
Methodologies

• Two distinctly different methodologies

• DMAIC
  – Define
  – Measure
  – Analyze
  – Improve
  – Control
  When a process needs to be improved

• DMADV
  – Define
  – Measure
  – Analyze
  – Design
  – Verify
  When a process needs to be invented
  (aka. DFSS-Designed For Six Sigma)
The Improvement Methodology

Define

Control

Measure

Improve

Analyze
**Define**

**Deliverables**

1. Identify customer wants
2. Project charter
3. High-level process map
Identify Customer Wants

- Who are your customers?
  - Internal vs. external customers

- Collect VOC - Voice Of Customer data
  - Interviews
  - Surveys
  - Complaints
  - Focus groups

- Define CTQs - Critical To Quality measures
  - How does the customer judge your product or service?
Project Charter

- Project scope
- Business case
- Cost benefit
- Roles & responsibilities
- Milestones
- Deliverables
High-level Process Map

**INPUTS**
1) Part Request
2) Physical Inventory
3) Call Transfers
4) Parts
5) Customer/Equipment data

**PROCESS**
- Create Part Request
- Action Part Request
- Receive Part into WIP
- Use / Consume Part
- Fulfill & Ship Part to Vendor / NPC

**SUPPLIERS**
1) Technicians
2) Buyers
3) NPC
4) Refurb
5) Vendors
6) NSC

**CUSTOMERS**
1) Finance
2) Technicians
3) Buyers
4) NPC
5) Vendors

**SIPOC / COPIES**
OUTPUTS
1) Part Usage
2) Inventory
3) Credit/Debit to P&L
4) Part
5) Part Removed from WIP
Measure

Deliverables
1. Identify CTQ characteristic
2. Collect data
3. Calculate sigma
Identify CTQ Characteristic

• Getting down to the thing that the project will target using tools like:
  – Detailed process mapping
  – QFD-Quality Functional Deployment
  – Cause & effect analysis
  – FMEA-Failure Modes & Effects Analysis
Measure

Identify CTQ Characteristic

Some Technicians update part receipt through Antenna.

Some Technicians call NSC to have part receipt updated.

Some Technicians continue on call W/O updating part receipt.

Technician Performs service.

Was part used?

Was part used?

Was part used?

Part received by NPC/branch logistics (A)

Return part to NPC/branch logistics.

Return part direct to vendor.

Part received by NPC/branch logistics.

Technician advises P/E or Logistics of part return.

Part received by NPC/branch logistics.

Physically ship part w/ no update, part still in WIP.

Technician advises P/E or Logistics of part return.

Part received by NPC/branch logistics.

(A) NPC/branch logistics fulfill part from WIP.

Consumable Dispose of part, part out of WIP.

Non-Consumable.

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?

X-ship?
### Identify CTQ Characteristic

#### Quality Functional Deployment (QFD)

<table>
<thead>
<tr>
<th>Customer Reqmts</th>
<th>Priority</th>
<th>Product Design Reqmts</th>
<th>Interactions</th>
<th>Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cust. envelope/Interface</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Weight 160 lbs.</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleed air 75 lbs/min</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine containment</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elect pwr. 40 KYA</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliable</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support oil-cooled gen.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Evaluation</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Difficulty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance Rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Measure** - Identify CTQ Characteristic

http://www.npd-solutions.com
Measure Identify CTQ Characteristic

Environment
- Vibrations
- Humidity
- Temperature

Method
- Production Rate
- Manufacturing Instructions
- Material
- Steel Type
- Solder Type
- Vendor

People
- Training
- Self
- Internet
- Systems
- Shift
- Experience Level
- Scrap Rate

Measurement
- Gauge2
- Gauge1
- Method B
- Method A

Maintenance
- Monthly
- Weekly
- Daily

Machine
- Machining
- Maintenance
- Heat Treating
- Cleaning

Cause & Effect Analysis, or Fishbone, or Ishikawa diagram
# FMEA-Failure Modes & Effects Analysis

## System Design Verification Process

### Potential Failure Mode and Effects Analysis (Design FMEA)

<table>
<thead>
<tr>
<th>Item / Function</th>
<th>Potential Failure Mode(s)</th>
<th>Potential Effect(s) of Failure</th>
<th>Severity</th>
<th>Potential Cause(s)/Mechanism(s) of Failure</th>
<th>Probability</th>
<th>Current Design Controls</th>
<th>Detection</th>
<th>RPN</th>
<th>Recommended Action(s)</th>
<th>Responsibility &amp; Target Completion Date</th>
<th>Action Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer sends in a quote request for product.</td>
<td>System, Software, Integration and Shipping requirements overlooked by</td>
<td>Customer needs not fully met by delivered system.</td>
<td>7</td>
<td>Human error</td>
<td>1</td>
<td>Design configuration tool.</td>
<td>3</td>
<td>21</td>
<td>Use configuration tool when available.</td>
<td>Closed 10/21/99</td>
<td>[ ]</td>
</tr>
<tr>
<td>Requirement entered and verified by Inside Sales in config. tool.</td>
<td>Data entry error</td>
<td>System compatibility requirements not evaluated by config. tool.</td>
<td>3</td>
<td>Human error</td>
<td>1</td>
<td>Order verified by a configuration tool.</td>
<td>3</td>
<td>9</td>
<td>Continue order verification by configuration tool.</td>
<td>Closed 10/21/99</td>
<td>[ ]</td>
</tr>
<tr>
<td>Sales identifies need for CII or SHC</td>
<td>Specific packing, labeling and shipping requirements may not be</td>
<td>On time delivery and integrity of the product may be compromised.</td>
<td>7</td>
<td>Requirements Overlooked.</td>
<td>3</td>
<td>Customer Inspection Instruction/ Special Handling Codes Process</td>
<td>3</td>
<td>63</td>
<td>Publish comprehensive procedure for the 1st Article Process.</td>
<td>Jun-00</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

---

**Identify CTQ Characteristic**

- **System**
- **Subsystem**
- **Component**
- **Design Lead**
- **Core Team**

*Prepared By: Houston Mayer*

*FMEA Date: 22/10/1999*

*Revision Date: 21/08/2000*

*See Project III R1 Report*
Collect Data

- Create a data collection plan
- Perform a MSA
  - Measurement Systems Analysis
    - Gage R & R
    - Attribute R & R
    - Test re-test study
- Collect data
Calculating Sigma

- Calculate process capability
  - Short term ($Z_{ST} = \sigma_{ST}$)
  - Long term ($Z_{LT} = \sigma_{LT}$)
  - The 1.5 Shift
Deliverables

1. Identify possible causes
2. Narrow down to root cause
3. Confirm the benefit
Identify Possible Causes

- Identify sources of variation using:
  - Process map analysis
  - Graphical analysis
  - Brainstorming
Narrow To Root Causes

- Confirm statistically significant factors through:
  - Hypothesis testing
  - DOE-Design Of Experiment

Regression Plot

\[ Y = 1026.02 + 98.0500X \]
\[ R-Sq = 87.9\% \]

P value = 0.000
Confirm The Benefit

- Ensure that the effort needed to rectify the issues identified are financially feasible
  - Basic ROI-Return On Investment or cost benefit analysis
Deliverables
1. Generate and select solution
2. Implement solution
3. Confirm results
Generate & Select Solution

- Solution generation through structured brainstorming
- Solution Selection based upon viability and trade-offs

<table>
<thead>
<tr>
<th>Key Criteria</th>
<th>Importance Rating</th>
<th>Benchmark Option</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
<th>Alternative 4</th>
<th>Alternative 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria 1</td>
<td>4</td>
<td>+</td>
<td>S</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Criteria 2</td>
<td>2</td>
<td>S</td>
<td>-</td>
<td>S</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Criteria 3</td>
<td>3</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Criteria 4</td>
<td>2</td>
<td>+</td>
<td>S</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Criteria 5</td>
<td>5</td>
<td>S</td>
<td>-</td>
<td>S</td>
<td>S</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Criteria 6</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Criteria 7</td>
<td>10</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Criteria 8</td>
<td>8</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sum of Positives</th>
<th>Sum of Negatives</th>
<th>Sum of Sames</th>
<th>Weighted Sum of Positives</th>
<th>Weighted Sum of Negatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria 1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Criteria 2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Criteria 3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Criteria 4</td>
<td>16</td>
<td>13</td>
<td>16</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Criteria 5</td>
<td>9</td>
<td>13</td>
<td>9</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Totals</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

**Concept Selection Legend**
- Better +
- Same S
- Worse -
Implement Solution

• Comprehensive pilot planning
  – Detailed process maps
  – SOP-Standard Operating Procedures
  – Monitoring plans
  – Contingency planning
  – Risk management plan
Confirm Results

- Ensure that an improvement has been made and is consistent with expectations
  - Learn and adapt
  - Re-assess measurement systems
  - Adjust improvements as required
  - Re-calculate sigma
  - Confirm improvement is statistically significant
Control

Deliverables
1. Standardization and documentation
2. Process monitoring and control
3. Closing the project
Control

Standardize and Document

• Rollout confirmed solution across business with updated information from pilot
  – Detailed process maps
  – SOP-Standard Operating Procedures
  – Monitoring plans
  – Contingency planning
  – Risk management plan
Monitoring and Control

- Ensure project x’s and y’s remain in statistical control
  - SPC - Statistical Process Control
Close the Project

- Complete project documentation
- Complete project sign-off
- Handoff documentation to process owner
- Celebrate!

Come celebrate with us!
Roles and Responsibilities

- Champions
- Green Belts
- Quality Leader & BQC
- Master Black Belts
- Black Belts
# Champions & Master Black Belts

<table>
<thead>
<tr>
<th>Champions</th>
<th>Master Black Belts</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Create the vision of Six Sigma</td>
<td>• Understand the big business picture</td>
</tr>
<tr>
<td>• Define the path to implement Six Sigma across the organization</td>
<td>• Develop and deliver training to various levels of the organization</td>
</tr>
<tr>
<td>• Carefully select high-impact projects</td>
<td>• Assist in the identification of projects</td>
</tr>
<tr>
<td>• Develop a comprehensive training plan for implementing the Six Sigma strategy</td>
<td>• Coach and support Black Belts in project work</td>
</tr>
<tr>
<td>• Ask Black Belts and Green Belts many questions to ensure that they are properly focused</td>
<td>• Participate in project reviews to offer technical expertise</td>
</tr>
<tr>
<td>• Make sure that project opportunities are acted upon by organization’s leadership and the finance department</td>
<td>• Take on leadership of major programs</td>
</tr>
<tr>
<td>• Recognize people for their efforts</td>
<td>• Facilitate sharing of best practices across the corporation</td>
</tr>
</tbody>
</table>
# Black Belts & Green Belts

<table>
<thead>
<tr>
<th>Black Belts</th>
<th>Green Belts</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Act as Six Sigma experts</td>
<td>• Function as Green Belts on a part-time basis</td>
</tr>
<tr>
<td>• Lead and direct teams in project execution</td>
<td>• Participate on Black Belt projects as content experts</td>
</tr>
<tr>
<td>• Coach and Mentor Green Belts</td>
<td>• Lead Green Belt projects</td>
</tr>
<tr>
<td>• Ensure that the results are sustained</td>
<td>• Identify potential Six Sigma projects</td>
</tr>
<tr>
<td>• Identify potential barriers to project completion</td>
<td></td>
</tr>
<tr>
<td>• Report progress of both BB and GB projects to appropriate leadership</td>
<td></td>
</tr>
</tbody>
</table>
Return on Investment

- In 2000 GE’s gross annual benefit was $6.6 billion.
- CEO Larry Bossidy brought AlliedSignal back from the verge of bankruptcy. Cumulative benefits $2 billion in direct savings.
- Raytheon improved its cost of doing business by more than $1 billion annually in 2001.
- Average financial benefit per project $120,000
- Motorola claims a Six Sigma ROI of between 10:1 & 50:1
Performance Improvements

• Increased profits
• Decreased operating costs
• Improved customer satisfaction
• Decreased cycle-time in processes
• Increased employee morale
How To Implement Six Sigma

• Factors for success
  – Leadership
  – Communication
  – Rewards & recognition
  – Training
  – Launching the initiative
  – Implementation
  – Sustaining the effort and return
Leadership Buy-in

• Clear, unwavering direction on deploying Six Sigma
• Development of a strategy for deployment
• Personal involvement
• Willingness to revise company policies and procedures to be supportive
• Insistence on tangible results
Communication

- Clear and precise communication when launching the initiative
- Frequent updates on initiative status
- Consistent communication plan
Rewards and Recognition

• Rewarding Green Belts for project completion
• Recognizing team members for working on projects
• Recognizing major milestones in project progress
Training

Awareness

Green Belt

Champion

Black Belt
Launching the Initiative

1. Set vision and goals for Six Sigma initiative
2. Develop deployment plan
3. Develop clear implementation plan
4. Develop Six Sigma budget
5. Train Champions and BQC members
6. Select Green Belts for first round of training
7. Select Six Sigma Leader
Implementation

1. Select first round of projects
2. Develop reward and recognition strategy
3. Train Green Belts
4. Develop project review system
5. Identify potential Black Belts within the organization
Continue Momentum

- Well defined training strategy
- Monitoring system to ensure gains are sustained
- Management review of Initiative
- Continue to have projects ready to start
- Recruit and train Black Belts
Sustaining the Return

- Continue to budget for Six Sigma
- Constant communication strategy
- Continuous training and improvement
Information Sources

ASQ

International Society of Six Sigma Professionals

International Quality Federation

Six Sigma Software

MINITAB

Making Data Analysis Easier

SigmaFLOW

Process Analysis and Design

RSD

Statit Software