SIX SIGMA
OVERVIEW
PM SIMPLIFY
Table of Contents

- History of Six Sigma
- Introduction to Six Sigma
- Definition of Six Sigma
- Variability
- Difference: 3 Sigma and 6 Sigma
- Perspective: 3 Sigma and 6 Sigma
- What is 6 Sigma
- Philosophy + Process + Statistics
- Growth of 6 Sigma
- 6 Sigma at GE
- Positives and Negatives
- Barriers to implementation
- Focus of 6 Sigma
- Critical Success Factors
- Key Elements of 6 Sigma
- Levels of 6 Sigma
- Key Terminologies
- DMAIC
- DMADV
- Similarities: DMAIC and DMADV
- Differences: DMAIC and DMADV
History of Six Sigma

- US DOD introduces FMEA
- Walter A. Shewhart - control chart I special vs. common cause variation >> process problems.
- Wilfred Pareto introduces 80/20
- 1896
- 1924
- 1941
- 1949
- 1960
- 1970’s
- 1986
- 1994
- 1995
- 1997
- Larry Bossidy Launches 6sigma @ allied Signal
- WIPRO - India
- Kano Model
- Ishikawa Diagram
- Bill Smith - 6Sigma @ Motorola
- Jack Welch - GE
- Gauss Uses Normal Curve for error analysis, probability
- De Moivre Creates normal Curve
- Alex Osborn of BBDO sets “brainstorming” definitions
Introduction to Six Sigma

- It is a methodology for continuous improvement
- It is a methodology for creating products and processes that perform at high standards.
- It is a Quality Philosophy & a Management Technique
- It leverages application of statistical tools within a structured methodology
- Repeated application of strategy to individual projects
Definition of Six Sigma

- Six Sigma is the measure of quality that strives for near perfection. It is a disciplined, data-driven methodology focused on eliminating defects.
- A Six Sigma defect is defined as anything that falls out of a customer’s specifications.
Variability

The world tends to be bell-shaped

- Even very rare outcomes are possible
- Fewer in the "tails" (lower)
- Most outcomes occur in the middle
- Fewer in the "tails" (upper)
- Even very rare outcomes are possible
Difference between 3 Sigma and 6 Sigma
# 3 Sigma and 6 Sigma: A perspective

## 3 SIGMA
1. 20,000 lost mails per hour
2. 200,000 wrong drug prescriptions each year
3. 5000 incorrect surgical operations per week
4. 2 short or long landing at major airports daily.

## 6 SIGMA
1. 7 lost mails per hour
2. 68 wrong drug prescriptions each year
3. 1.7 incorrect surgical operations per week
4. 1 short or long landing at major airports every five years.
Six Sigma: 3.4 defects per million

Path to Six Sigma

Sigma levels and Defects per million opportunities (DPMO)

- 6 Sigma: 3.4 Defects
- 5 Sigma: 233 Defects
- 4 Sigma: 6,210 Defects
- 3 Sigma: 66,807 Defects
- 2 Sigma: 308,537 Defects
Philosophy + Process + Statistics

**Philosophy**

- Anything less than ideal is an opportunity for improvement
- Defects costs money
- Understanding processes and improving them is the most efficient way to achieve lasting results

**Process**

- To achieve this level of performance you need to: Define, Measure, Analyze, Improve and Control

**Statistics**

- Six Sigma processes will produce less than 3.4 defects per million opportunities
The Growth of Six Sigma
Six Sigma at GE

- Where has GE implemented Six Sigma?
- Approving a credit card application
-Installing a turbine
-Lending money
-Servicing an aircraft engine
-Answering a service call for an appliance
-Underwriting an insurance policy
-Developing software for a new CAT product
-Overhauling a locomotive
History of Six Sigma at GE

- In 1995 GE mandated each employee to work towards achieving 6 sigma
- The average process at GE was 3 sigma in 1995
- In 1997 the average reached 3.5 sigma
- GE’s goal was to reach 6 sigma by 2001
- Investments in 6 sigma training and projects reached 45million US$ in 1998, profits increased by 1.2Billion US$

“The most important initiative GE has ever undertaken”.

Jack Welch
Chief Executive Officer
General Electric
If you’re an average Black Belt, proponents say you’ll find ways to save $1 million each year

Raytheon figures it spends 25% of each sales dollar fixing problems when it operates at four sigma, a lower level of efficiency. But if it raises its quality and efficiency to Six Sigma, it would reduce spending on fixes to 1%

The plastics business, through rigorous Six Sigma process work, added 300 million pounds of new capacity (equivalent to a ‘free plant’), saved $400 million in investment and will save another $400 million by 2000
Negative quotations

- Because managers’ bonuses are tied to Six Sigma savings, it causes them to fabricate results and savings turn out to be phantom”

- Marketing will always use the number that makes the company look best …Promises are made to potential customers around capability statistics that are not anchored in reality

- Six Sigma will eventually go the way of the other fads
Barriers to Implementation

- Lack of commitment from leadership.
- Unable to change mindset from event-driven to process-driven.
- Engineers and managers are not interested in mathematical statistics.
- Statisticians have problems communicating with managers and engineers.
- Non-statisticians experience “statistical anxiety” which has to be minimized before learning can take place.
- Statistical methods needs to be matched to management style and organizational culture.
Focus of Six Sigma*

- Customer Focus!
- Accelerating fast breakthrough performance
- Significant financial results in 4-8 months
- Ensuring Six Sigma is an extension of the Corporate culture, not the program of the month
- Results first, then culture change!

*Adapted from Zinkgraf (1999), Sigma Breakthrough Technologies Inc., Austin, TX.
Six Sigma: Critical Success Factors

- Top management leadership & commitment
- A well-implemented customer management system
- The education and training system
- A well-developed strategic planning system
- A well-organized information and analysis system
- A well-implemented process management system
- A well-developed supplier management system
- Availability of tools
- A well-developed human resource management system
- A well-developed competitive benchmarking system
1. Key Elements
   - Customer
   - Process
   - Employees

2. Six Sigma Levels
   - Master Black Belt
   - Black Belt
   - Green Belt
   - Yellow Belt

3. Key Terminologies
   - COPQ: Cost of Poor Quality
   - CTQ: Critical to Quality
   - DO: Defect Opportunity
   - DPO: Defect Per Opportunity
   - DPMO: Defect Per Million Opportunity
   - CPK: Process Capability

4. Methodologies
   - DMAIC
   - DMADV
Key Elements
Key Elements

- **The Customer:** Customers define quality. They expect performance, reliability, competitive prices, on-time delivery, service, clear and correct transaction processing and more. Today, Delighting a customer is a necessity. Because if we don't do it, someone else will!

- **The Processes:** Defining Processes and defining Metrics and Measures for Processes is the key element of Six Sigma. Quality requires to look at a business from the customer's perspective, in other words, we must look at defined processes from the outside-in. By understanding the transaction lifecycle from the customer's needs and processes, we can discover what they are seeing and feeling. This will give a chance to identify weak areas within a process and then we can improve them.

- **The Employees:** The company must involve all employees in Six Sigma Program. Company must provide opportunities and incentives for employees to focus their talents and ability to satisfy customers. This is important to six sigma that all team members should have a well-defined role with measurable objectives.
Six Sigma Levels
Six Sigma Levels

- **Master Black Belt**
  - Mentor, trainer, and coach of Black Belts and others in the organization.

- **Black Belt**
  - Leader of teams implementing the six sigma methodology on projects.

- **Green Belt**
  - Delivers successful focused projects using the six sigma methodology and tools.

- **Yellow Belt**
  - Participates on and supports the project teams, typically in the context of his or her existing responsibilities.
Master Black Belt

- Enterprise Six Sigma expert.
- Permanent full-time change agent.
- Certified Black Belt with additional specialized skills or experience especially useful in deployment of Six Sigma across the enterprise
- Highly proficient in using Six Sigma methodology to achieve tangible business results.
- Technical expert beyond Black Belt level on one or more aspects of process improvement (for example, advanced statistical analysis, project management, communications, program administration, teaching, project coaching)
- Identifies high-leverage opportunities for applying the Six Sigma approach across the enterprise
- Coach / Mentor Black Belts
Black Belt

- Six Sigma technical expert
- Temporary, full-time change agent (will return to other duties after completing a two to three year tour of duty as a Black Belt)
- Leads business process improvement projects where Six Sigma approach is indicated.
- Successfully completes high-impact projects that result in tangible benefits to the enterprise
- Demonstrated mastery of Black Belt bod of knowledge
- Demonstrated proficiency at achieving results through the application of the Six Sigma approach
- Coach / Mentor Green Belts
- Recommends Green Belts for Certification
Green Belt

- Six Sigma Project originator
- Part-time Six Sigma change agent. Continues to perform normal duties while participating on Six Sigma project teams
- Six Sigma champion in local area
- Recommends Six Sigma projects
- Participates on Six Sigma project teams
- Leads Six Sigma teams in local improvement projects
Yellow Belt

- Learns and applies Six Sigma tools to projects
- Actively participates in team tasks
- Communicates well with other team members
- Demonstrates basic improvement tool knowledge
- Accepts and executes assignments as determined by team
Key Terminologies
List of Terminologies

- COPQ : Cost of Poor Quality
- CTQ : Critical to Quality
- DO : Defect Opportunity
- DPO: Defect Per Opportunity
- DPMO: Defect Per Million Opportunity
COPQ (Cost of Poor Quality)

- Underutilization
- Scrap / Rework
- Warranty Costs
- Lost Sales
CTQ (Critical-To-Quality)

- CTQ characteristics for the process, service or process
- Measure of “What is important to Customer”
- Six Sigma projects are designed to improve CTQ
- Examples:
  - Waiting time in clinic
  - Spelling mistakes in letter
  - % of valves leaking in operation
Defect Opportunity

- Number of defect opportunities relate to complexity of unit.
- Complex units – Greater opportunities of defect than simple units
- Examples:
  - A units has 5 part
  - in each part there are 3 opportunities of defects
  - Total defect opportunities are 5 x 3 = 15
DPO (Defect Per Opportunity)

- Number of defects divided by number of defect opportunities

Examples:
- In previous case (15 defect opportunities), if 10 units have 2 defects.
  - Defects per unit = $\frac{2}{10} = 0.2$
  - $DPO = \frac{2}{(15 \times 10)} = 0.0133333$
DPMO (Defect Per Million Opportunities)

- DPO multiplied by one million

Examples:
- In previous case (15 defect opportunities), if 10 units have 2 defects.
- Defects per unit = \( \frac{2}{10} = 0.2 \)
- DPO = \( \frac{2}{(15 \times 10)} = 0.0133333 \)
- DPMO = \( 0.013333333 \times 1,000,000 = 13,333 \)
Methodologies:
DMAIC & DMADV
DMAIC Model
### DMAIC Method

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEFINE</strong></td>
<td>Determines the scope and purpose of the project</td>
</tr>
<tr>
<td><strong>MEASURE</strong></td>
<td>The collection of information on the current situation</td>
</tr>
<tr>
<td><strong>ANALYZE</strong></td>
<td>Determines the root causes of defects and explore and organize potential cause</td>
</tr>
<tr>
<td><strong>IMPROVE</strong></td>
<td>The development of solution that are implemented to remove the root causes and then measured and evaluated for desired result</td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
<td>Standardizes the improvement process to maintain the gains</td>
</tr>
</tbody>
</table>
Define

- Who wants the project and why?
- The scope of project / improvement (SMART Objective)
- Key team members / resources for the project
- Critical milestones and stakeholder review
- Budget allocation

MEASURE

ANALYZE

IMPROVE

CONTROL
Measure

**DEFINE**

**MEASURE**
- Ensure measurement system reliability
  - Is tool used to measure the output variable flawed?
- Prepare data collection plan
  - How many data points do you need to collect?
  - How many days do you need to collect data for?
  - What is the sampling strategy?
  - Who will collect data and how will data get stored?
- What could the potential drivers of variation be?
- Collect data

**ANALYZE**

**IMPROVE**

**CONTROL**
Analyze

- **DEFINE**
- **MEASURE**
- **ANALYZE**
  - How well or poorly processes are working compared with
    - Best possible (Benchmarking)
    - Competitor’s
  - Shows you maximum possible result
  - Don’t focus on symptoms, find the root cause
- **IMPROVE**
- **CONTROL**
Improve

**DEFINE**

**MEASURE**

**ANALYZE**

**IMPROVE**
- Present recommendations to process owner.
- Pilot run
- Formulate Pilot run.
- Test improved process (run pilot).
- Analyze pilot and results.
- Develop implementation plan.
- Prepare final presentation.
- Present final recommendation to Management Team.

**CONTROL**
Control

DEFINE

MEASURE

ANALYZE

IMPROVE

CONTROL

- Don’t be too hasty to declare victory.
- How will you maintain the gains made?
  - Change policy & procedures
  - Change drawings
  - Change planning
  - Revise budget
  - Training
DMADV Model
<table>
<thead>
<tr>
<th>DMADV Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEFINE</strong></td>
</tr>
<tr>
<td><strong>MEASURE</strong></td>
</tr>
<tr>
<td><strong>ANALYZE</strong></td>
</tr>
<tr>
<td><strong>DESIGN</strong></td>
</tr>
<tr>
<td><strong>VERIFY</strong></td>
</tr>
</tbody>
</table>
Like in DMAIC, the first phase of the DMADV process is the define phase. In this phase the goal of the process is designed. At the same time, internal goals for the company working on the DMADV are also set up.
The critical to quality aspects are identified and measured.
The product capabilities and risks are also identified and quantified.
This helps in better understanding of the goal of the customer.
• The data gathered and quantified is analyzed.
• This analysis is used for developing and designing alternatives.
• High level design is created with the analysis.
• The capability of the design its stability are tested.
• Using the test results, the best of the alternatives from the design are chosen.
The design is optimized further.
A verification plan is set up which helps in analyzing the design.
The aim of this phase is to ensure that the right process is chosen.
• Once the optimum design has been chosen it is verified.
• Simulation may be used for verifying the design.
• Test runs are carried out to verify that the process works fine and is able to meet the target.
• Once the results are positive, the process is implemented and handed over to the customer.
Similarities of DMAIC & DMADV

- Both the methodologies are used for reducing the number of defects to less than 3.4 per million opportunities available for such defects to occur.

- Both the methodologies use facts and statistical tools for finding solutions to common problems, related to quality.

- Both the methodologies require the services of Green Belts, Black Belts and Master Black Belts during the implementation stage.

- Both concentrate on achieving the financial and business objectives of an organization.

- Both the methodologies require support from a Champion and Process Owner during the implementation stage.
## DMAIC vs DMADV

<table>
<thead>
<tr>
<th>DMAIC</th>
<th>DMADV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated with defining a business process and its applicability</td>
<td>Helps in defining customer needs in relation to a product or service</td>
</tr>
<tr>
<td>Used for measuring the current performance of a business process</td>
<td>Used for measuring the customer needs and specifications</td>
</tr>
<tr>
<td>Business process is analyzed to find the root cause of a defect or recurring problem</td>
<td>Business process is analyzed for finding options that will help in satisfying the customer needs and specifications</td>
</tr>
<tr>
<td>Improvements are made in the business process for eliminating or reducing defects</td>
<td>An appropriate business model is designed that helps in meeting customer requirements</td>
</tr>
<tr>
<td>Control systems are put in place to keep a check on future performance of a business process</td>
<td>The suggested business model is put through simulation tests for verifying efficacy in meeting customer needs and specifications</td>
</tr>
</tbody>
</table>
References

Walter A. Shewhart : http://en.wikipedia.org/wiki/Walter_Shewhart


Mikel J. Harry :

List of Six Sigma Companies : http://en.wikipedia.org/wiki/List_of_Six_Sigma_companies

Six Sigma: http://en.wikipedia.org/wiki/Six_Sigma

Control Chart: http://en.wikipedia.org/wiki/Control_chart

Toyota Production System: http://www2.toyota.co.jp/en/vision/production_system/

Seven Basic Tools of Quality: http://en.wikipedia.org/wiki/Seven_Basic_Tools_of_Quality


Engineering Statistics Handbook, National Institute of Standards and Technology (NIST) -
http://www.itl.nist.gov/div898/handbook/