Six Sigma Quality: Concepts & Cases- Volume I (Statistical Tools in Six Sigma DMAIC process with MINITAB Applications

Chapter 1

Introduction to Six Sigma, Lean and Design for Six Sigma (DFSS)

Chapter Highlights

This chapter introduces the field of Six Sigma and related quality programs. After completing this chapter, you should be able to understand the following concepts related to Six Sigma, Lean Six Sigma, and Design for Six Sigma.

1. *Lean Six Sigma and what it can do for your company*
2. *How to use Six Sigma to quantify the critical quality issues in your company*
3. *Statistical basis of Six Sigma — comparing a three-sigma to a six sigma process*
4. *Integrating the principles of business, statistics/ variation, and engineering to improve quality*
5. *Meeting and exceeding customer expectations by addressing the voice of customer (VOC) and critical to quality (CTQ) issues*
6. *Meeting and exceeding customer expectations through process improvement.*
7. *Transform process improvement opportunities into clearly defined Six Sigma projects.*
8. *Six Sigma and its relation to Process Capability*
9. *Achieving quality, reducing cost, and cycle time (or, delivery) through variation reduction and improving process capability*
10. *Six Sigma methodology: Define, Measure, Analyze, Improve, and Control (DMAIC) and the statistical tools used in DMAIC process*
11. *Quantifying and reducing the cost of poor quality*
12. *Implementing Six Sigma methods that ensure long term improvements*
13. *Concepts of Lean Six Sigma and Design for Six Sigma*
14. *Difference between Six Sigma, Lean Sigma, and Design for Six Sigma*
15. *Combining Lean, Six Sigma, and Design for Six Sigma to get results*

Chapter Outline

Six Sigma

What is Six Sigma?
Business Success of Six Sigma
Six Sigma Costs and Savings
Six Sigma Current Trends
Statistical Basis of Six Sigma
Comparing a Three Sigma to a Six Sigma Process
Percent Conforming in a Three Sigma and a Six Sigma Process
Metrics and Measurements in Six Sigma
Relationship between Six Sigma and Process Capability Indices Cp and Cpk
Relationship between Cp and Cpk
What Percent of the Specification Band does the Process use?
How are Cp and Cpk Related to Six Sigma?
Conducting a Process Capability Study
Service Successes of Six Sigma
Six Sigma Methodologies
Six Sigma Define Phase
- *Six Sigma Project Organization and Management*
- *Six Sigma Project Selection*
- *Factors Affecting Project Selection*
- *Quality Costs*
- *Project Definition*

Critical to Quality Characteristics
Six Sigma Measure Phase

Chapter 2

Introduction to MINITAB Statistical Software: Getting Started with MINITAB

Chapter Highlights

This chapter deals with the details of MINITAB statistical software used widely in Six Sigma. After completing this chapter, you will become familiar with MINITAB and its major features. The following topics are discussed in this chapter:

1. *Introduction to Minitab and getting started with the software*
2. *The main features of the software, and how to perform data analysis using Minitab*
3. *Entering data, data types, data formats, and analyzing data*
4. *Graphing and editing data using the features such as, Scale, Labels, Data View, Multiple Graphs, and Data Options to edit graphs*
5. *The descriptive and statistical analysis tools for Six Sigma using Minitab*
6. *Simple to advanced analysis tools in Minitab*
7. *An interactive session and a tutorial to learn Minitab*

Chapter Outline

Chapter 3

Visual Representation of Data: Charts and Graphs for Six Sigma

Chapter Highlights

This chapter will enable you to master the techniques of summarizing and describing data using charts and graphs. In this chapter you will learn to:

1. *Construct a frequency distribution from a set of data*
2. *Calculate relative frequency, cumulative frequency, and relative cumulative frequency from a frequency table and interpret their meanings*
3. *Construct different types of graphs using quantitative data including histograms, frequency polygons, ogives, stem-and-leaf plots, dot plots, box plots and interpret these plots*
4. *Construct bar charts and pie charts using qualitative data and their applications*
5. *Construct other types of charts and graphs including time series plots and scatter plots*
6. *Construct matrix plots and three dimensional plots*
7. *Understand the applications of these visual techniques in Six Sigma*

Chapter Outline

Chapter 4

Using Statistics to Summarize Data: Concepts and Computer Analysis

Chapter Highlights

This chapter deals with the basic tools of data analysis used in Six Sigma. The primary objective of this chapter is to enable you to master the techniques of describing data using numerical methods, and use these methods to compare and draw meaningful conclusions from data. The topics in this chapter will enable you to:

1. *Calculate and apply the measures of central tendency for both ungrouped and grouped data.*
2. *Calculate the measures of position — percentiles and quartiles, interpret their meaning, and their applications in data analysis.*
3. *Calculate and apply various measures of variation— range, interquartile range, variance, and standard deviation for both grouped and ungrouped data.*
4. *Understand the concept and importance of variation in Six Sigma.*
5. *Compare the mean, median, mode, and standard deviation to draw meaningful conclusions from the data.*
6. *Relate the mean and standard deviation using the Chebyshev's and Empirical rules and understand the importance of Empirical rule in statistics and data analysis.*
7. *Calculate and apply the measures of measures of central tendency, measures of variation, measures of shape (skewness and kurtosis), and measures of position to learn about the data*
8. *Describe the relationship between two variables — covariance and coefficient of correlation.*
9. *Learn the applications of the numerical methods in this chapter as they apply to Six Sigma and Lean Sigma.*

Chapter Outline

Descriptive Statistics: Numerical Methods
Measures of Central Tendency or Measures of Location
- *Mean*
- *Median*
- *Mode*

Comparing Mean, Median, Mode

Chapter 5

Quality Tools for Six Sigma

Chapter Outline

This chapter deals with the quality tools widely used in Six Sigma and quality improvement programs. The chapter includes the seven basic tools of quality, the seven new tools of quality, and another set of useful tools in Lean Six Sigma that we refer to –"beyond the basic and new tools of quality." The objective of this chapter is to enable you to master these tools of quality and use these tools in detecting and solving quality problems in Six Sigma projects. You will find these tools to be extremely useful in different phases of Six Sigma. They are easy to learn and very useful in drawing meaningful conclusions from data. In this chapter, you will learn the concepts, various applications, and computer instructions for these quality tools of Six Sigma. This chapter will enable you to:

1. *Learn the seven graphical tools - considered the basic tools of quality. These are:*
   - *(i) Process Maps*
   - *(ii) Check sheets*
   - *(iii) Histograms*
   - *(iv) Scatter Diagrams*
   - *(v) Run Charts/Control Charts*
   - *(vi) Cause-and-Effect (Ishikawa)/Fishbone Diagrams*
   - *(vii) Pareto Charts/Pareto Analysis*
2. *Construct the above charts using MINITAB*
3. *Apply these quality tools in Six Sigma projects*
4. *Learn the seven new tools of quality and their applications:*
   - *(i) Affinity Diagram*
   - *(ii) Interrelationship Digraph*
   - *(iii) Tree Diagram*
   - *(iv) Prioritizing Matrices*
   - *(v) Matrix Diagram*
   - *(vi) Process Decision Program Chart*
   - *(vii) Activity Network Diagram*
5. *Learn the construction and applications of some other quality tools including the stem-and-leaf and box plot.*
6. *Learn a set of powerful tools beyond the basic and new tools of quality that include multi-vari charts, symmetry plots, and variations of scatter plots.*
7. *Learn how to construct the symmetry plots, and multi-vari charts using MINITAB.*

Beyond the New Tools of Quality

1. **Bivariate Data: Measuring and Describing Two Variables**
   Variations of Scatter Plots

Scatterplots with Histogram, Box-plots and Dot plots
Scatterplot with Fitted Line or Curve
Scatterplot Showing an Inverse Relationship between X and Y
Scatterplot Showing a Nonlinear Relationship between X and Y
Scatterplot Showing a Nonlinear (Cubic) Relationship between X and Y

2. **Multi-Vari Charts**
    1. *A Multi-vari Chart for Two-factor Design*
       Main Effects and Interaction Plots
    2. *Another Multi-vari Chart for a Two-factor Design*
       Box Plots, Main Effects Plot, and Interaction Plot
    3. *Mult-vari chart for a Three-factor Design*
       Multi-Vari Chart, Box Plots, and Main Effects Plot
    4. *Multi-vari Chart for a Four-factor Design*
       Multi-Vari Chart, Box Plots, Main Effects and Interaction Plots
       Determine a Machine-to-Machine, Time-to-Time variation
       Part-to-Part Variation in a Production Run using Multi-vari Plots
3. **Symmetry Plots**

Chapter Summary and Applications

Chapter 6

Process Capability Analysis for Six Sigma

This chapter deals with the concepts and applications of process capability analysis in Six Sigma. Process Capability Analysis is an important part of an overall quality improvement program. Here we discuss the following topics relating to process capability and Six Sigma:

1. *Process capability concepts and fundamentals*
2. *Connection between the process capability and Six Sigma*
3. *Specification limits and process capability indices*
4. *Short-term and long-term variability in the process and how they relate to process capability*
5. *Calculating the **short-term** or **long-term process capability***
6. *Using the process capability analysis to:*
    - *assess the process variability*
    - *establish specification limits (or, setting up realistic tolerances)*

- *determine how well the process will hold the tolerances (the difference between specifications)*
- *determine the process variability relative to the specifications*
- *reduce or eliminate the variability to a great extent*

7. *Use the process capability to answer the following questions:*
   - *Is the process meeting customer specifications?*
   - *How will the process perform in the future?*
   - *Are improvements needed in the process?*
   - *Have we sustained these improvements, or has the process regressed to its previous unimproved state?*
8. *Calculating process capability reports for normal and non-normal data using MINITAB.*

Chapter Outline

Chapter 7

Measurement System Analysis: Gage Repeatability & Reproducibility (Gage R &R) Study

Chapter Highlights

The chapter discusses the importance of measurement and measurement system analysis (MSA) in Six Sigma. It is critical to assess the accuracy of the measurement process before collecting data. Overlooking the measurement process can be expensive as it may divert the effort in fixing the wrong problem. This chapter deals with the following concepts related to measurement system.

1. *Terms Related to the Measurement Systems Analysis : Systematic Errors, Random Errors, Metrology, Gage, Bias, and Resolution*
2. *Accuracy, Precision, Repeatability, and Reproducibility*
3. *Graphical Analysis of Gage Study: Gage Run Charts*
4. *Quantitative methods of Gage analysis - Examples*
5. *Analytical Gage Study: Gage R & R*
6. *Elements of the Measurement Process: equipment, operators, and parts*
7. *Gage Repeatability and Reproducibility (Gage R&R) study with cases*
8. *Computer analysis of gage study including*
   Gage R&R Study (Crossed) – X-bar/R Method and ANOVA

Gage R & R Study (Nested)
Gage Linearity and Bias Study
Attribute Gage Study (Analytical Method)

Chapter Outline

Introduction

Terms Related to the Measurement Systems Analysis

Systematic Errors *Random Errors*
Metrology *Gage*
Bias *Resolution*

Accuracy, Precision, Repeatability, and Reproducibility

Accuracy and Precision *Gage Linearity*
Bias *Stability*
Repeatability *Reproducibility*

Estimating Measurement Error: Some Measurement Models

Classification of Measurement Errors

Graphical Analysis of Gage Study: Gage Run Chart

Gage Run Chart - Example 1
Gage Run Chart - Example 2
Gage Run Chart - Example 3
Gage Run Chart - Example 4
Summary of Examples 1 through 4

Analytical Gage Study: Gage R & R

Case 1: Determining Gage Capability (1)
Case 2: Determining Gage Capability (2)
Case 3: Gage R & R Study (Crossed): X-bar and R Method:
Case 4: Gage R & R Study (Crossed): ANOVA Method Using Case 3 Data:
Case 5: Comparing the Results of Gage Run Chart, Gage R & R: X-bar and R method, and Gage R & R: ANOVA Method
Case 6: Another Example on Comparing the Results of Gage Run Chart, Gage R & R: X-bar and R Method, and Gage R & R: ANOVA Method
Case 7: Gage R & R Study (Nested): ANOVA Method Determining the Bias and Linearity
Case 8: Gage Linearity and Accuracy (Bias) Study 1
Case 9: Gage Linearity and Accuracy (Bias) Study 2
Comparing Two Measuring Instruments for Precision and Accuracy
Case 10: Comparing the Precision and Accuracy of Two Measuring Instruments: 1