Introduction to 6σ

Statistical Quality Control

Monday, October 30, 2006

Do you have a Herbie?

How do Six Sigma & Lean differ from TQM, CQI, and other '90s bizfads?

- A focus on variation reduction in processes
- Greater intellectual rigor in the methods
- Application of real business metrics
- Bigger payoffs for committed participants
- Bigger sanctions for avoiders
- More management attention
- Real results that clearly make the business more competitive

Learning Objectives

- Describe quality control methods
- Understand the use of statistical process control
- Describe & apply control charts
- Distinguish x-bar, R, p and c-charts
- Define process capability
- Describe & apply capability indexes
- Define six-sigma capability

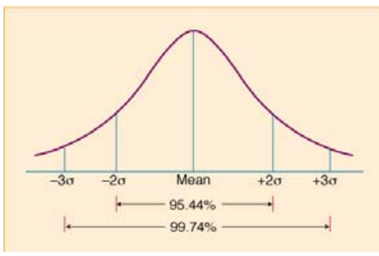
Quality Control Methods

- Descriptive statistics:
  - Used to describe distributions of data
- Statistical process control (SPC):
  - Used to determine whether a process is performing as expected
- Acceptance sampling:
  - Used to accept or reject entire batches by only inspecting a few items

Descriptive Statistics

- Mean (x-bar):
  - The average or central tendency of a data set
- Standard deviation (sigma):
  - Describes the amount of spread or observed variation in the data set
- Range:
  - Another measure of spread
  - The range measures the difference between the largest & smallest observed values in the data set

The Normal Distribution



Equations

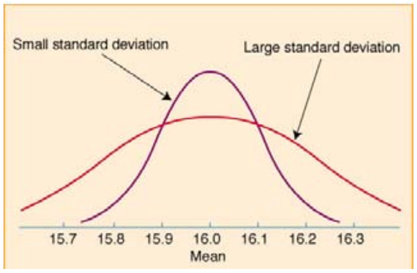
- Mean:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

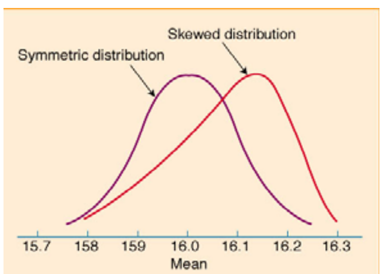
- Standard deviation:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \overline{X}\right)^2}{n-1}}$$

Impact of Standard Deviation



Skewed Distributions
(One Form of Non-Normal Distribution)



Causes of Variation

What prevents perfection? ***Process variation...***

Natural Causes	Assignable Causes
❑ Inherent to process ❑ Random ❑ Cannot be controlled ❑ Cannot be prevented ❑ Examples • weather • accuracy of measurements • capability of machine	

Toyota Root Cause Analyses

Why Why Why Why Why?

Causes of Variation

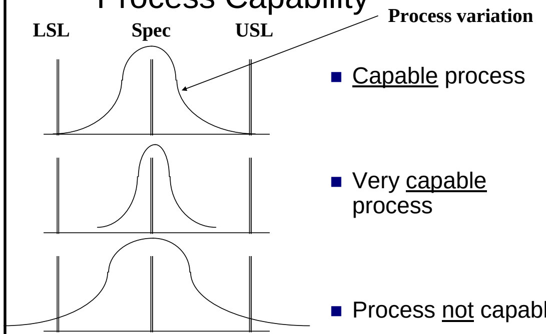
What prevents perfection? ***Process variation...***

Natural Causes	Assignable Causes
Inherent to process	Exogenous to process
Random	Not random
Cannot be controlled	Controllable
Cannot be prevented	Preventable
Examples • **weather** • **accuracy of measurements** • **capability of machine**	Examples ◦ tool wear ◦ "Monday" effect ◦ poor maintenance

Product Specification and Process Variation

- Product specification
  - desired range of product attribute
  - part of product design
  - length, weight, thickness, color, ...
  - nominal specification
  - upper and lower specification limits
- Process variability
  - inherent variation in processes
  - limits what can actually be achieved
  - defines and limits process capability
- *Process may not be capable of meeting specification!*

Process Capability



- Capable process
- Very capable process
- Process not capable

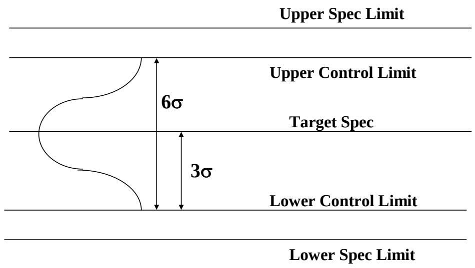
Example: Process Capability

Process Control Charts

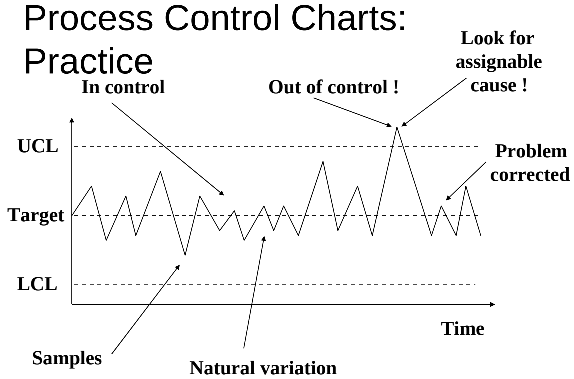
Statistical technique for tracking a process and determining if it is going "out to control"

- Establish *capability* of process under normal conditions
- Use normal process as benchmark to statistically identify abnormal process behavior
- Correct process when signs of abnormal performance first begin to appear
- *Control the process rather than inspect the product!*

Process Control Charts
Theory I

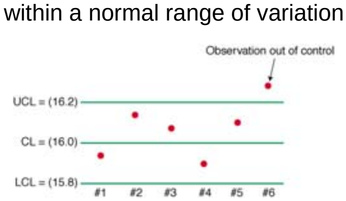


Process Control Charts: Practice

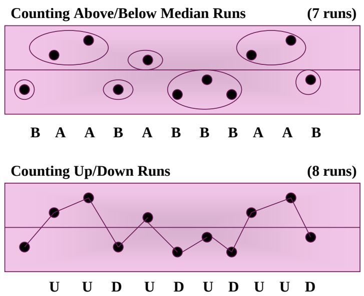


SPC Methods

- Control charts
  - Use statistical limits to identify when a sample of data falls within a normal range of variation



Counting Runs

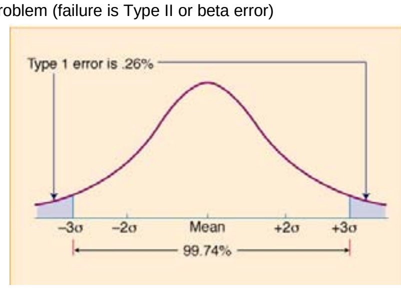


Above and Below Center Line

- Like 'flipping a coin"
- You suspect a loaded coin when you have 10 heads in a row

Setting Limits Requires Balancing Risks

- Control limits are based on a willingness to think something's wrong, when it's actually not (Type I or alpha error), balanced against the sensitivity of the tool - the ability to quickly reveal a problem (failure is Type II or beta error)

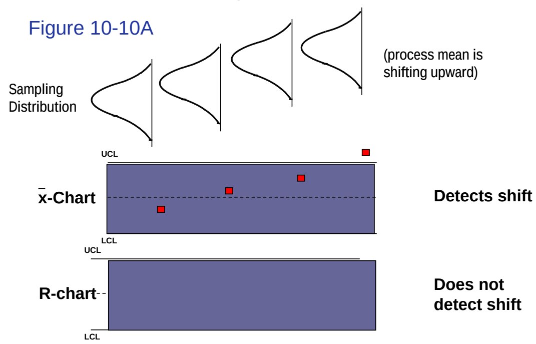


Control Charts for Variable Data

- Mean (x-bar) charts
  - Tracks the central tendency (the average value observed) over time
- Range (R) charts:
  - Tracks the spread of the distribution over time (estimates the observed variation)

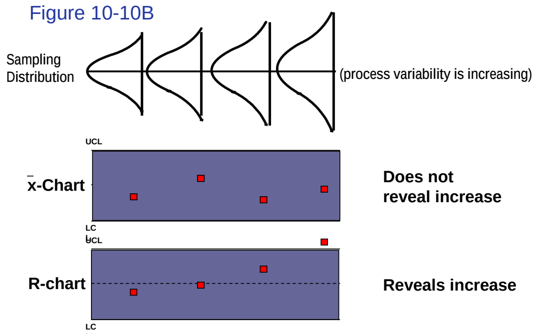
Mean and Range Charts

Figure 10-10A

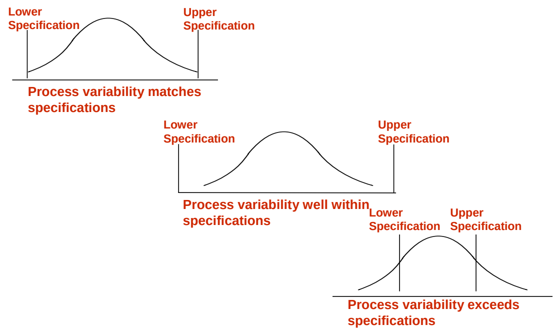


Mean and Range Charts

Figure 10-10B



Process Capability



Six Sigma: What is it?

Specifically –

• Customer-focused, fact and data-based decision making driving out waste and defects which creates value for our customers.

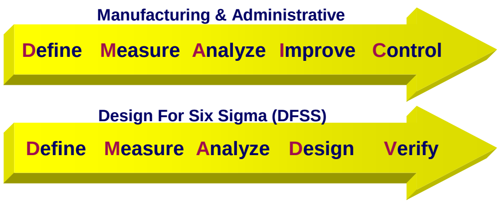
It is NOT just Supply Chain or Manufacturing

Six Sigma continued

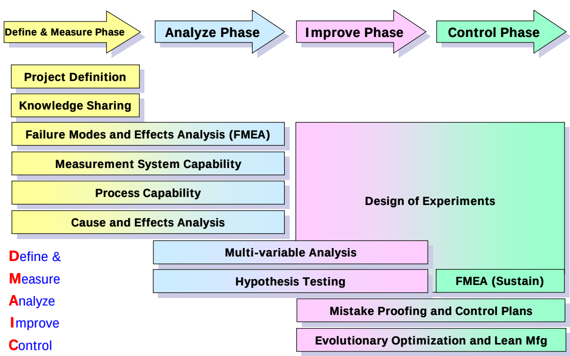
- What is it ? **Aviation Week & Space Technology, September 2002**
  - **"Six Sigma, in a business context, is a methodology consisting of analytical-based practices and procedures aimed at eliminating defects and variability from any process. The term Six Sigma itself is a statistical measure of extraordinarily high quality. At Six Sigma, only 3.4 defects per 1 million opportunities will occur. The overall quality at most companies - including those in the aerospace industry - is at best, Three Sigma. That's equal to 66,807 defects for every 1 million opportunities."**
  - ***"At companies that are exploiting the methodology's full potential, Six Sigma is less about statistical tools than about creating a business management system to deliver greater value to customers."***

Why Six Sigma?

- Six Sigma embraces both continuous improvement and breakthrough performance. The process includes models for manufacturing, design and administrative services



Six Sigma Problem Solving Approach

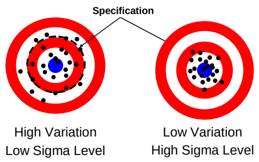


What is Sigma?

σ

Sigma - the lower case Greek letter that denotes a statistical unit of measurement used to define the standard deviation of a population. It measures the *variability* or spread of the data.

Definition of Sigma Level



σ	PPM
2	308,537
3	66,807
4	6,210
5	233
6	3.4
Process Capability	**Defects per Million Opportunities**

Sigma Level: The business metric used to measure the performance of a process to a customer specification.

The Goal: Near Perfection

6σ: 3.4 defects per million opportunities (over the long term)

PPM: Parts per million defective

(Distribution Shifted $\pm 1.5\sigma$)

Four Sigma quality

- 20,000 lost articles of mail *every hour.*
- Power outages seven hours *each month.* .
- 5,000 incorrect surgical procedures *each week* for a major healthcare provider.
- Unsafe drinking water nine minutes *every day.*
- Two long / short airport landings *every day*.