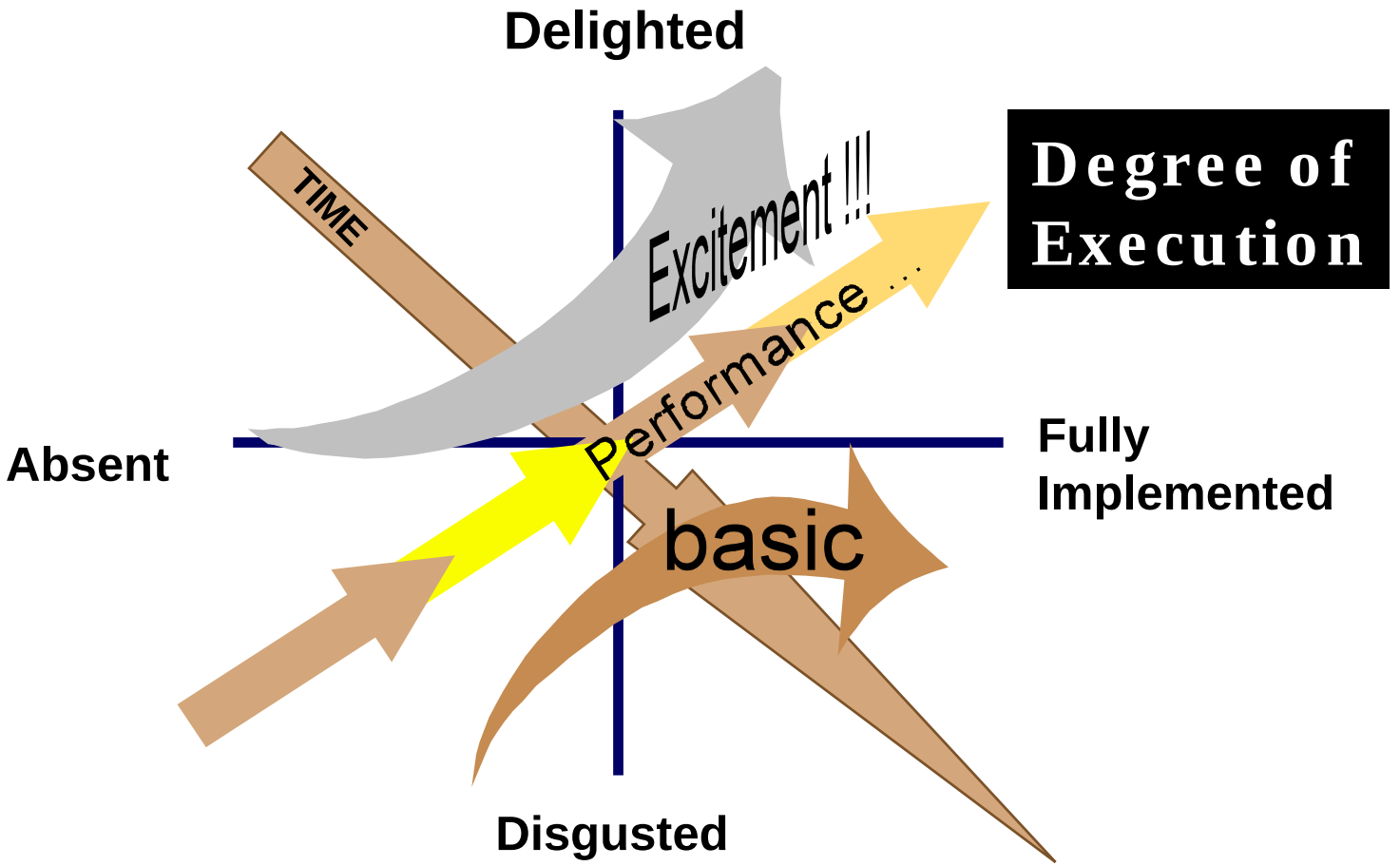
# SIX SIGMA "EXECUTIVE OVERVIEW"

*Prof. Prasad Chakrabarti,* *M.Tech(IIT) ,ACMA, CPIM, CSCP*
*Datamatics Consulting*

# Kano Customer Need Model



# Dimensions of Service Quality

RELIABILITY: consistency, error-free dependability

RESPONSIVENESS: willingness to help the customer

TANGIBLES: environment for the service presented

COMPETENCE: the right skills and knowledge required

COURTESY: supplier's behavior

SECURITY: freedom from danger or risk

ACCESS: ease of making contact

COMMUNICATION: understandable to the customer

EMPATHY: adopting the customer's viewpoint

# *Why Six Sigma in DL :*

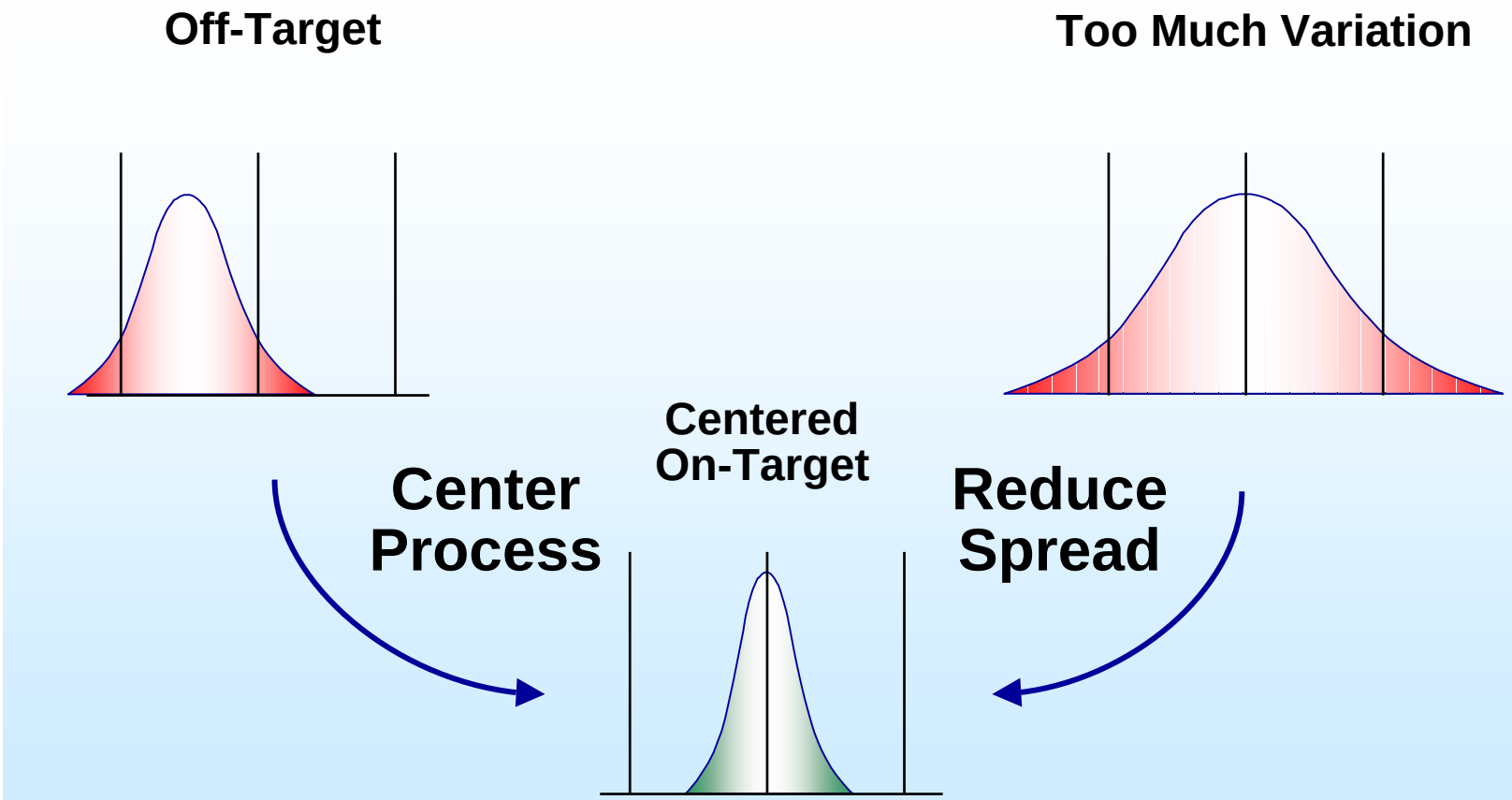
A company's **overall strategy** in any project is to:

- Delight the Customer
- Involve the Customer where possible
- Accelerate improvements in **all** processes, products & services
- Reduce cost of poor quality by eliminating waste and reducing defects and variations
- Celebrate and Promote Achievements

# *What is Six-Sigma?*

- Management mandated and directed improvement program focused on ***breakthroughs*** in financial performance and customer satisfaction
- Focused on core business and Customer needs
- A systematic method for process and product improvement
- A metric for evaluating performance quality
- A standard of excellence (3.4 defects per million opportunities)

# Reduce Process Variation & Defect Rates




***The objective is to understand customer requirements and reduce process variation and defects***

| | *Defects/million* | *Error-free Rate* |
|---|---|---|
| • ***Six Sigma*** | ***3.4*** | ***99.9997%*** |
| • *Five Sigma* | *233* | *99.977%* |
| • *Four Sigma* | *6,210* | *99.4%* |
| • *Three Sigma* | *66,810* | *93%* |

# Why is Six Sigma Important?

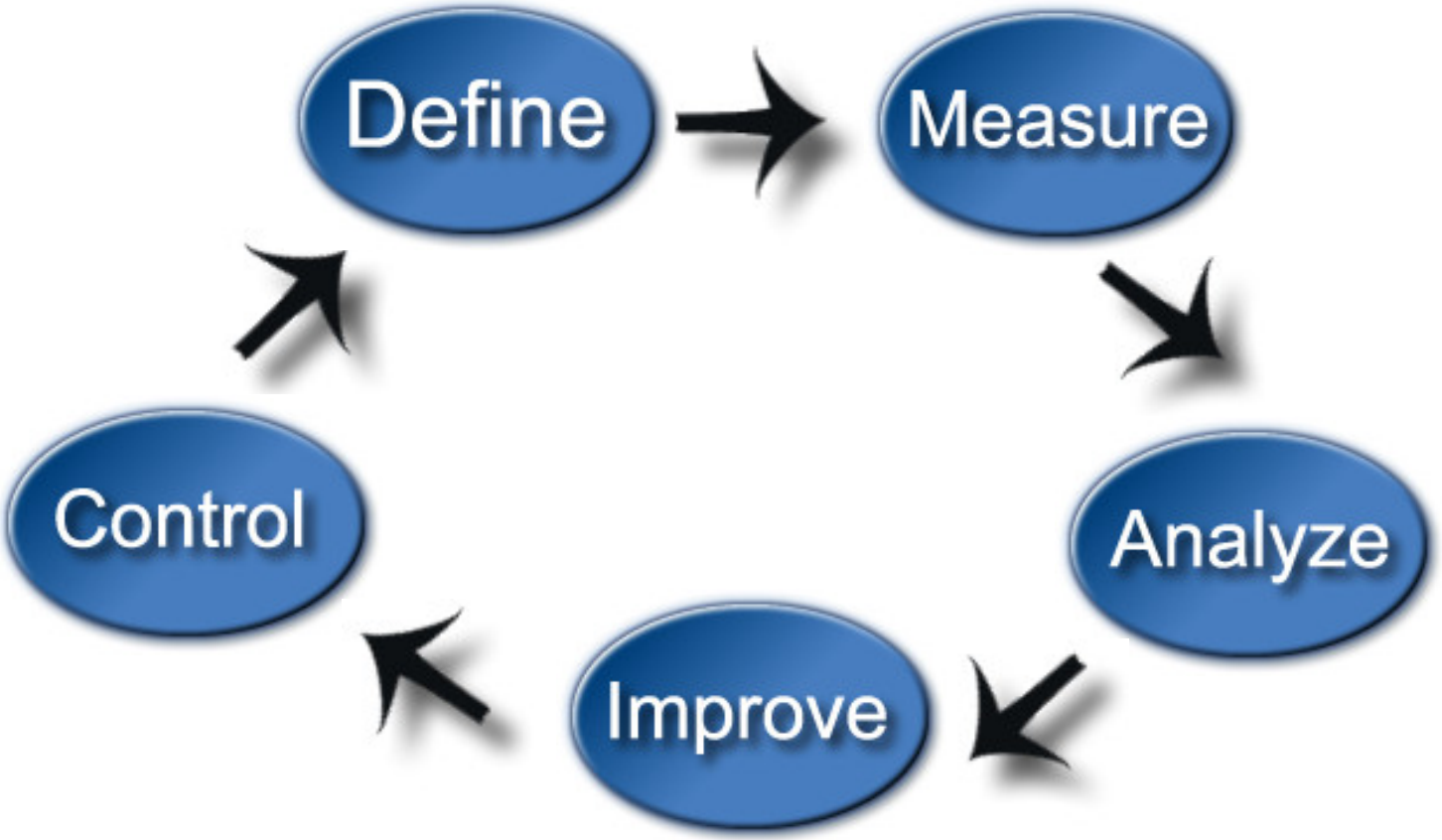
**Cost of Poorly Performing Processes**

| σ level | DPMO | CP[3] |
|---|---|---|
| **2** | 308,537 | Not Applicable |
| **3** | 66,807 | 25%-40% of sales |
| **4** | 6,210 | 15%-25% of sales |
| **5** | 233 | 5%-15% of sales |
| **6** | 3.4 | < 1% of sales |

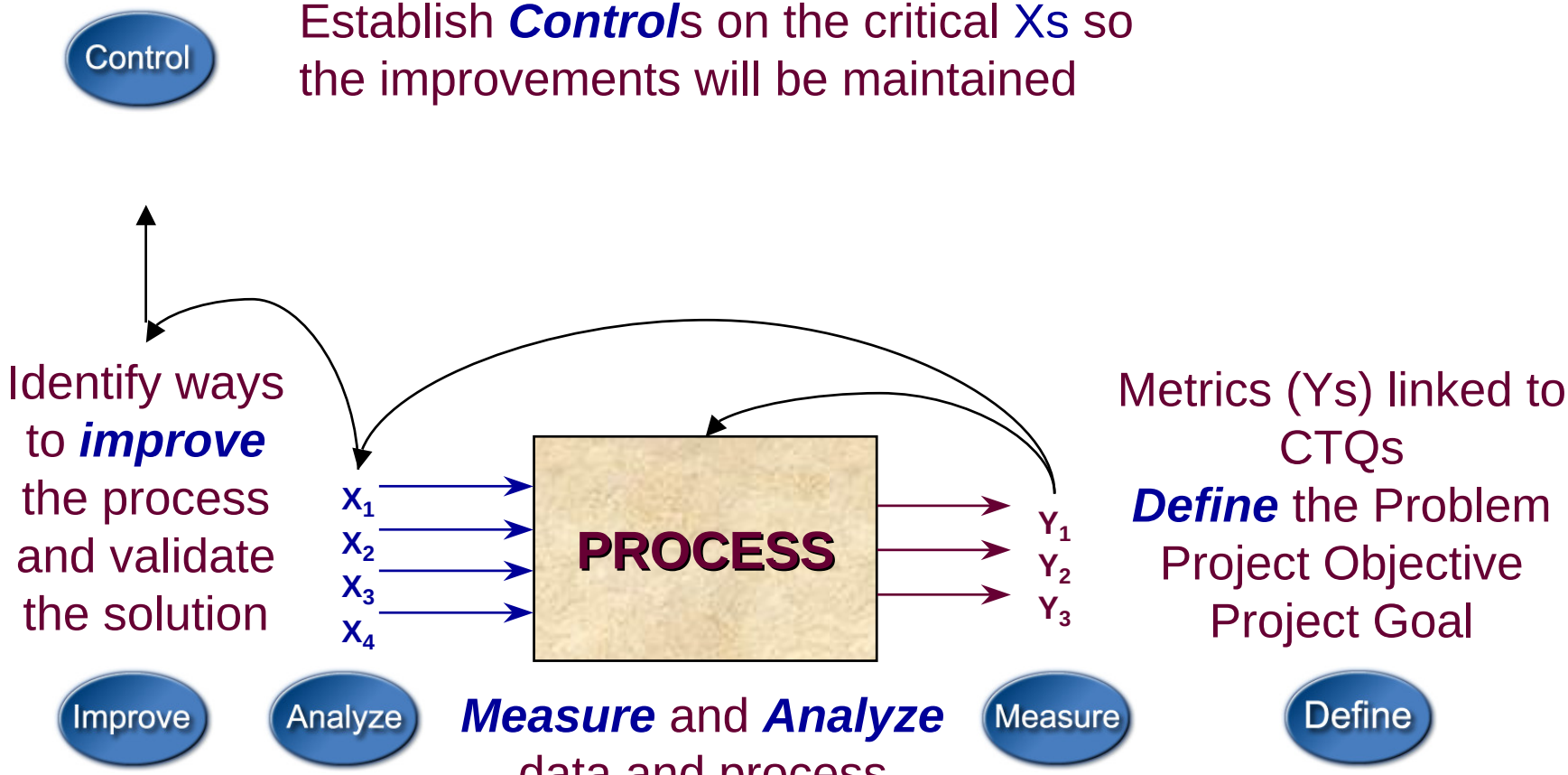
Use this **method** to solve problems:

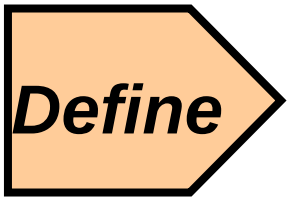

- **Define** problems in processes
- **Measure** performance
- **Analyze** causes of problems
- **Improve** processes -- remove variations and non value-added activities
- **Control** processes so problems don't recur

# *DMAIC Process Improvement Methodology*



# DMAIC Process






**Purpose:** Define the project goals and customer (internal and external) deliverables.

## Deliverables

Define Customers and requirements (CTQs)

Develop Problem Statement,Goals and Benefits

Define Resources

Evaluate Key Organizational Support

Develop Project Plan and Milestones

Develop High Level Process Map

## Tools Used

Project Charter

Process Flowchart

SIPOC Diagram

Stakeholder Analysis

CTQ Definitions

Voice of the Customer Gathering


**Purpose:** Measure the process to determine current performance; quantify the problem

### Deliverables

Define Defect, Opportunity, Unit and Metrics

Detailed Process Map of Appropriate Areas

Develop Data Collection Plan

Validate the Measurement System

Collect the Data

Begin Developing Y=f(x) Relationship

Determine Process Capability and Sigma Baseline

### Tools Used

Process Flowchart

House of Quality (QFD)

Failure Modes and Effects Analysis (FMEA)

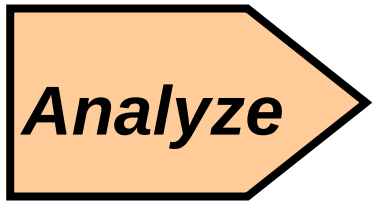
Data Collection Plan/Example

Benchmarking

Measurement System Analysis/Gage R&R

Voice of the Customer Gathering

Process Sigma Calculation




**Purpose:** Analyze and determine the root cause(s) of the defects/variation/waste Y=f(x)

**Deliverables**

Define Performance Objectives

Identify Value/Non-Value Added Process Steps

Identify Sources of Variation

Determine Root Cause(s)

Determine Vital Few x's, Y=f(x) Relationship

**Tools Used**

Histogram/Pareto Chart

Time Series/Run Chart

Scatter Plot

Regression Analysis

Cause and Effect/Fishbone Diagram

5 Whys/ Process Map Review and Analysis

Statistical Analysis/ Hypothesis Testing (Continuous and Discrete)

Non-Normal Data Analysis


**Purpose:** Improve the process by eliminating defects/variation/waste per project goals

## Deliverables

Perform Design of Experiments

Develop Potential Solutions

Define Operating Tolerances of Potential System

Assess Failure Modes of Potential Solutions

Validate Potential Improvement by Pilot Studies

Correct/Re-Evaluate Potential Solution

## Tools Used

Brainstorming

Mistake Proofing

Design of Experiments

House of Quality (QFD)

Failure Modes and Effects Analysis (FMEA)

Simulation Software


**Purpose:** Control future process performance, institutionalize the improvement, and ensure ongoing monitoring

## Deliverables

Define and Validate Monitoring and Control System

Develop Standards and Procedures

Implement Statistical Process Control

Determine Process Capability

Develop Transfer Plan, Handoff to Process Owner

Verify Benefits, Cost Savings/Avoidance, Profit Growth

Close Project, Finalize Documentation

Communicate to Business, Celebrate

## Tools Used

Process Sigma Calculation

Control Charts (Variable and Attribute)

Cost Savings Calculations

Control Plan

# Six Sigma DMAIC Road Map

## Define

- Identify Project, Champion and Project Owner
- Determine Customer Requirements and CTQs
- Define Problem, Objective, Goals and Benefits
- Define Stakeholder/Resource Analysis
- Map the Process
- Develop Project Plan

## Measure

- Determine Critical Xs and Ys
- Determine Operational Definitions
- Establish Performance Standards
- Develop Data Collection and Sampling Plan
- Validate the Measurements
- Measurement Systems Analysis
- Determine Process Capability and Baseline

## Analyze

- Benchmark the Process or Product
- Establish Causal Relationships Using Data
- Analysis of the Process Map
- Determine Root Cause(s) Using Data

## Improve

- Design of Experiments
- Develop Solution Alternatives
- Assess Risks and Benefits of Solution Alternatives
- Validate Solution using a Pilot
- Implement Solution
- Determine Solution Effectiveness using Data

## Control

- Statistical Process Control
- Determine Needed Controls (measurement, design, etc.)
- Implement and Validate Controls
- Develop Transfer Plan
- Realize Benefits of Implementing Solution
- Close Project and Communicate Results

## Key Analytical Tools

Process Mapping and Modeling

Measurement Systems Analysis & Process Capability

Statistical Tests, Modeling & Root Cause Analysis

Brainstorming
Design of Experiments, FMEA, & Validation

Statistical Process Control

# Define the problem and customer requirements.

## *Define Activities*

Define Problem, Objective, Goals and Benefits
Define Stakeholder/Resource Analysis
Map the Process
Develop Project Plan

## *Define Quality Tools*

Project Charter and Plan
CTQ tree Diagram , SIPOC Chart
Effort/Impact Analysis
Process Mapping
Dollar Estimate

# Steps-DEFINE

**A. Detailed Assessment of Customer Needs and Identify project CTQs: what does the customer think is essential?**

**B. Team Charter with the *business case* for the project.**

**C. Define and build a process map that relates measurable internal processes to customer needs.**

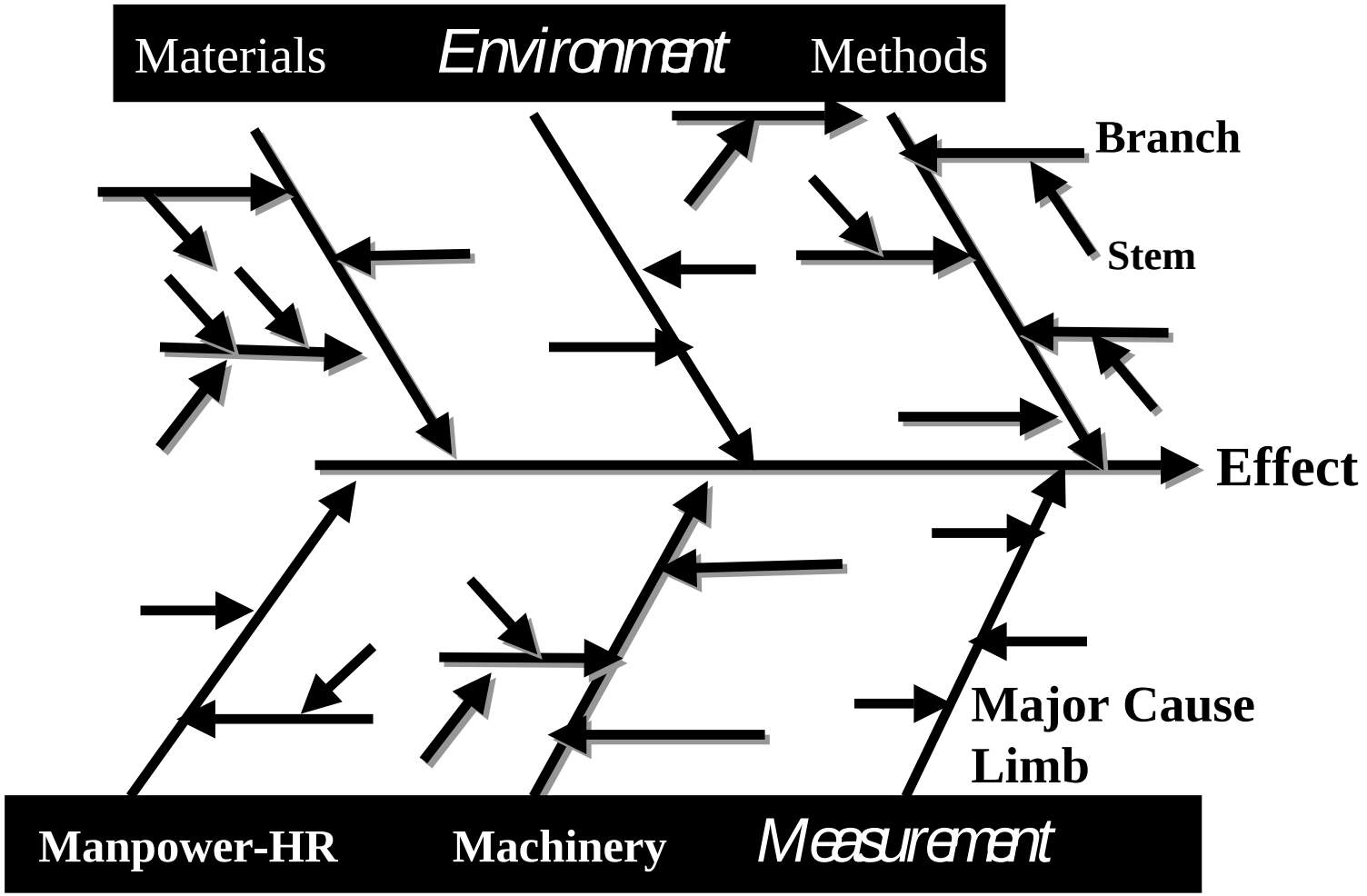
- Problem & Goal Statements Should be:

  **S**pecific, **M**easurable, **A**ttainable’**R**elevant , **T**ime-Bound

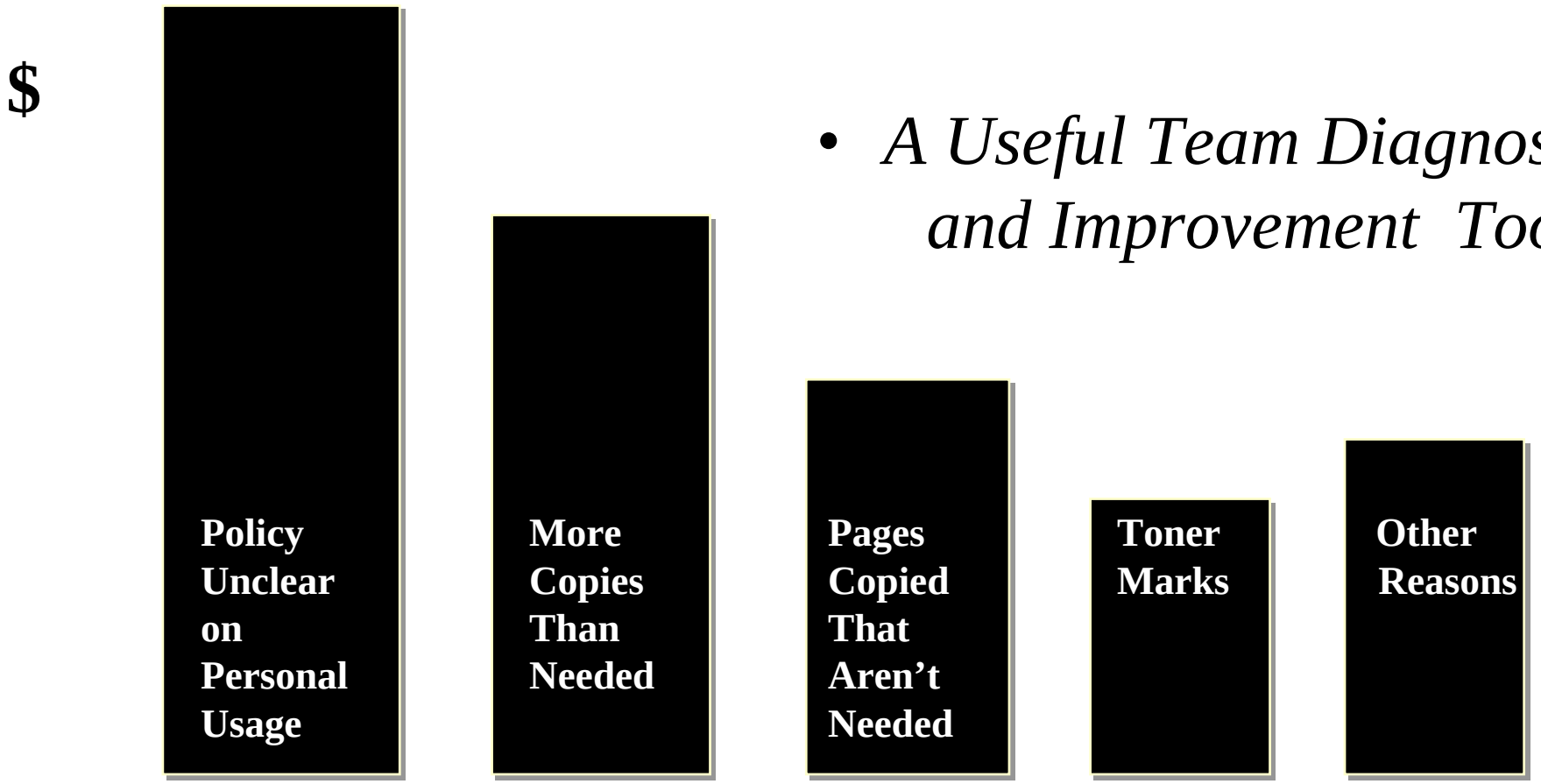
# MEASURE

# Cause-and-Effect Diagram

Also called a *fishbone* or *Ishikawa* diagram

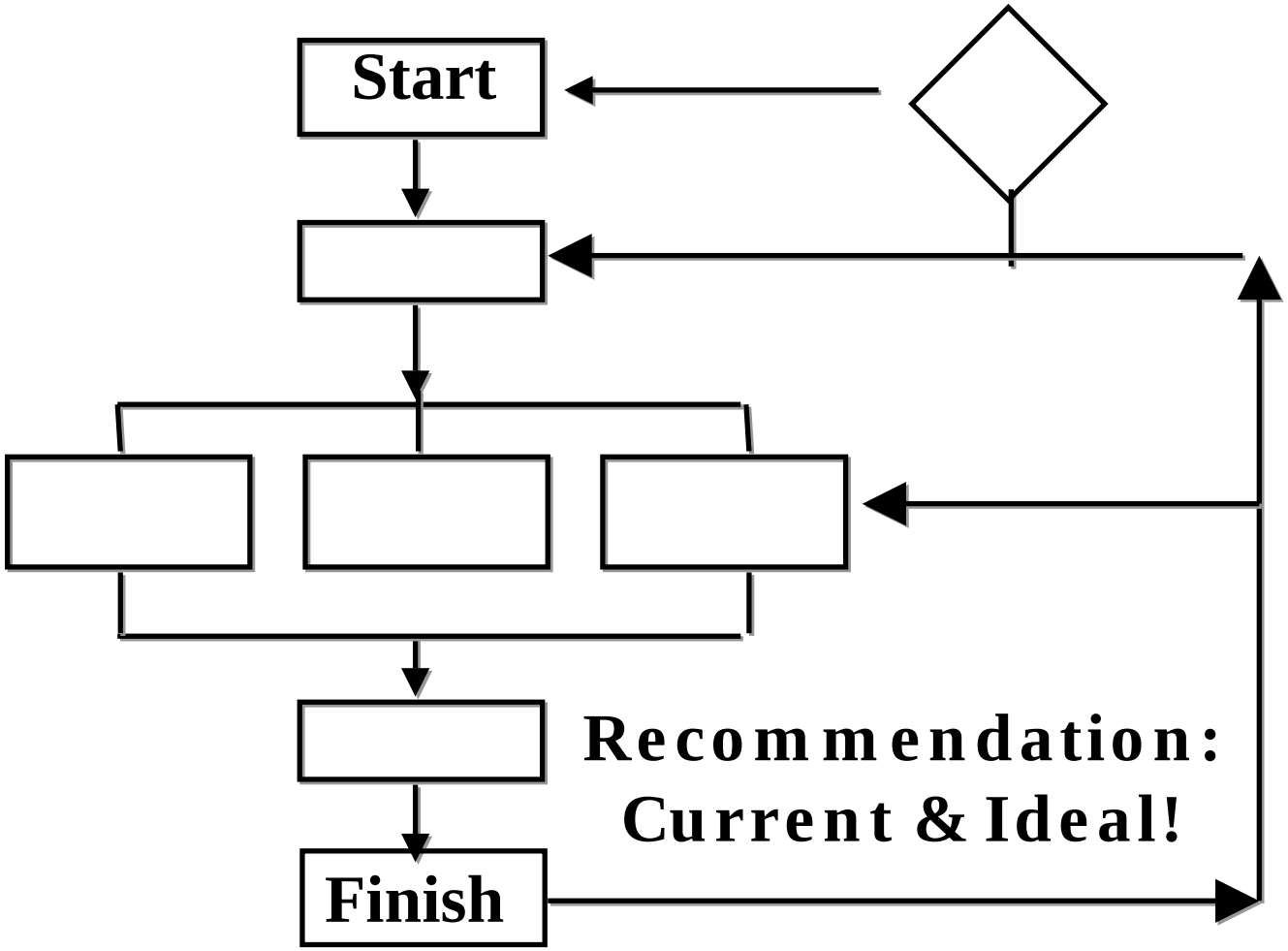


# Pareto Analysis for Process Improvement

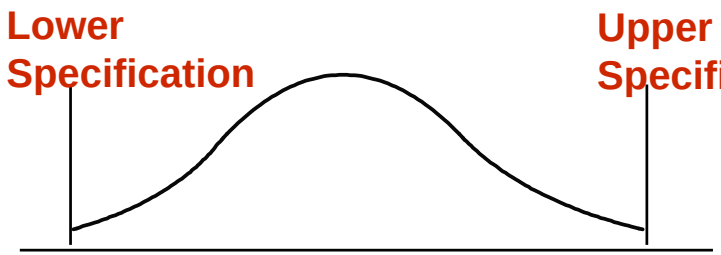



- *A Useful Team Diagnostic and Improvement Tool*

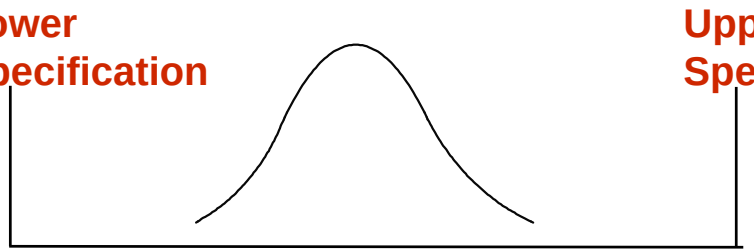
# Process Flow Diagrams



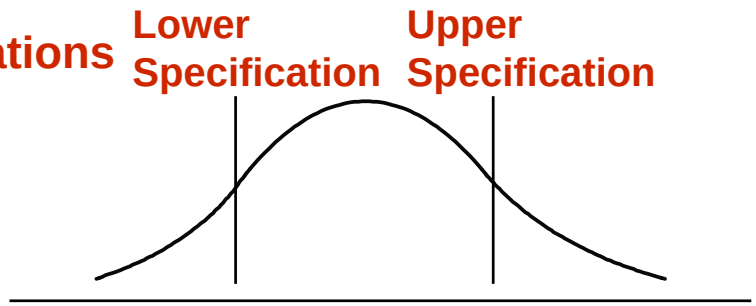
# *Process Capability*




**A. Process variability matches specifications**

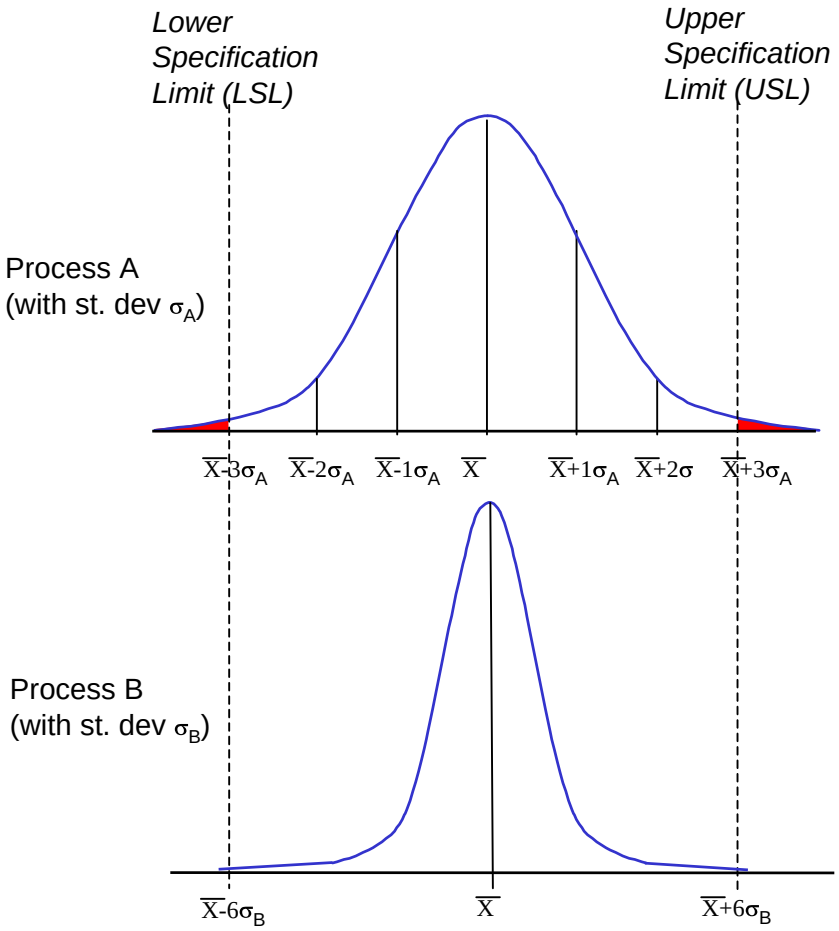



**B. Process variability well within specifications**




**C. Process variability exceeds specifications**

# The Statistical Meaning of Six Sigma



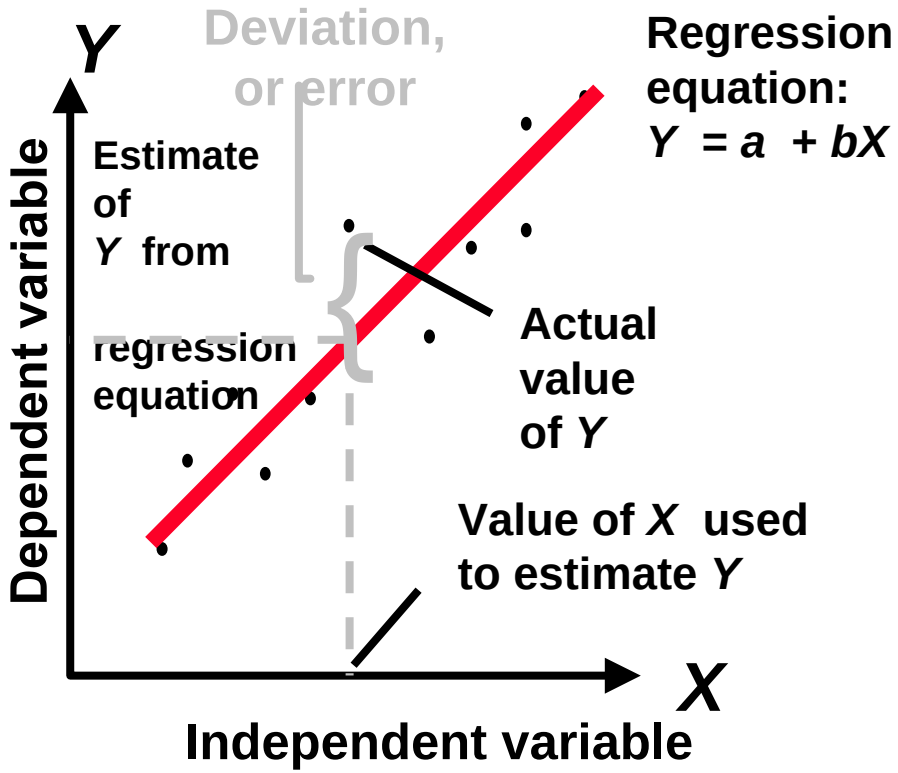

**Process capability measure**

$$C_p = \frac{USL - LSL}{6\hat{\sigma}}$$

| xσ | $C_p$ | P{defect} | ppm |
|---|---|---|---|
| 1σ | 0.33 | 0.317 | 317,000 |
| 2σ | 0.67 | 0.0455 | 45,500 |
| 3σ | 1.00 | 0.0027 | 2,700 |
| 4σ | 1.33 | 0.0001 | 63 |
| 5σ | 1.67 | 0.0000006 | 0,6 |
| 6σ | 2.00 | $2x10^{-9}$ | 0,00 |

$$\hat{\sigma} = \bar{R}/d_2$$

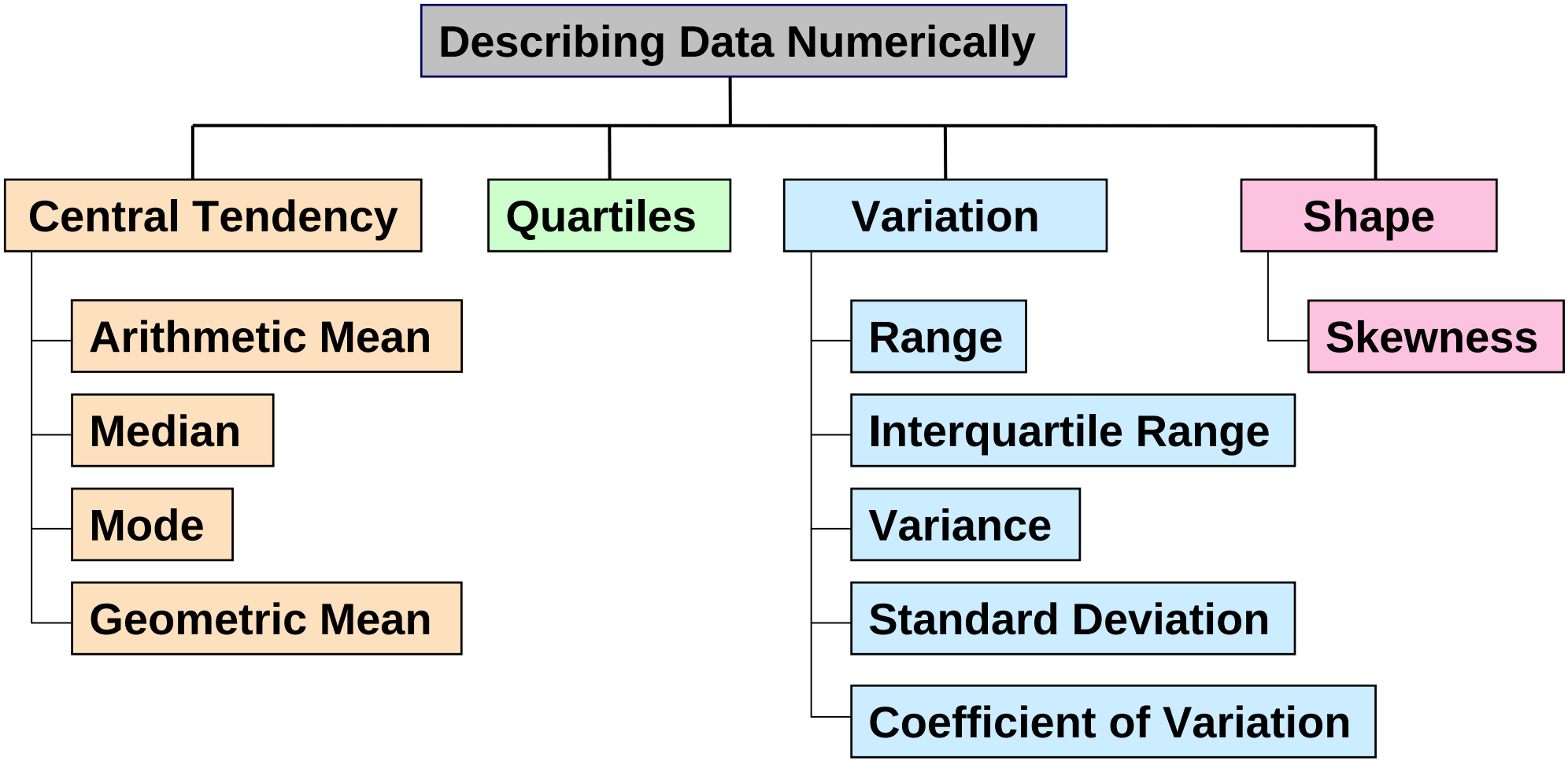
# Causal Methods
# Linear Regression




| Month | Sales (000 units) | Advertising (000 $) |
|---|---|---|
| 1 | 264 | 2.5 |
| 2 | 116 | 1.3 |
| 3 | 165 | 1.4 |
| 4 | 101 | 1.0 |
| 5 | 209 | 2.0 |

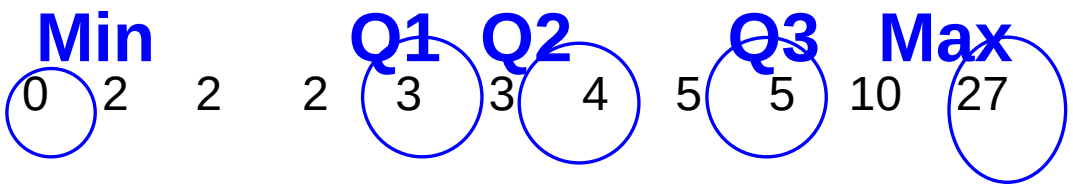
$$a = \bar{Y} - b\bar{X} \qquad b = \frac{\Sigma XY - n\bar{X}\bar{Y}}{\Sigma X^2 - n\bar{X}^2}$$

# Summary Measures



# Box-and-Whisker Plot Example

Below is a Box-and-Whisker plot for the following data:




The data are right skewed, as the plot depicts

# The Seven New Tools

Affinity Diagrams

Interrelationship Diagrams

Tree Diagrams

Matrix Diagrams

Matrix Data Analysis

Process Decision Program Charts

Arrow Diagrams

# The Thinking Hats (Edward Bono's Lateral Thinking)

White Hat (neutral, objectivity)

Hard data. Facts and figures. Questions/suggestions about what data to collect.

Red Hat (emotional, intuitive)

Hunches. Feelings. Soft data.

Black Hat (logical negative)

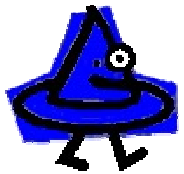
Caution. Rationale for not doing something, failure predictions, legal limits, etc.

Yellow Hat (logical positive)

Savings. Benefits. Advantages. Usually forward thinking.

Green Hat (creative)

Proposals, suggestions, ideas, alternatives, provocations.

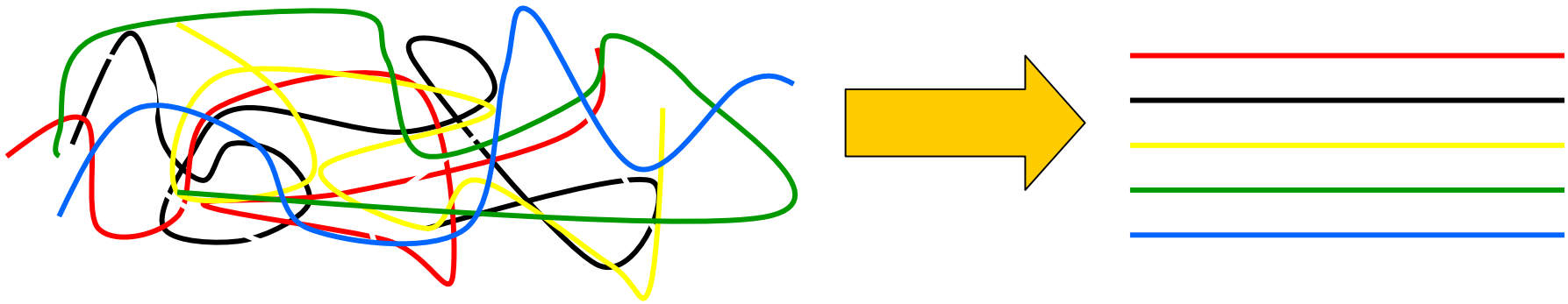


Blue Hat (meta-hat)

Control, organization of the discussion process and use of the other hats.

# Benefits

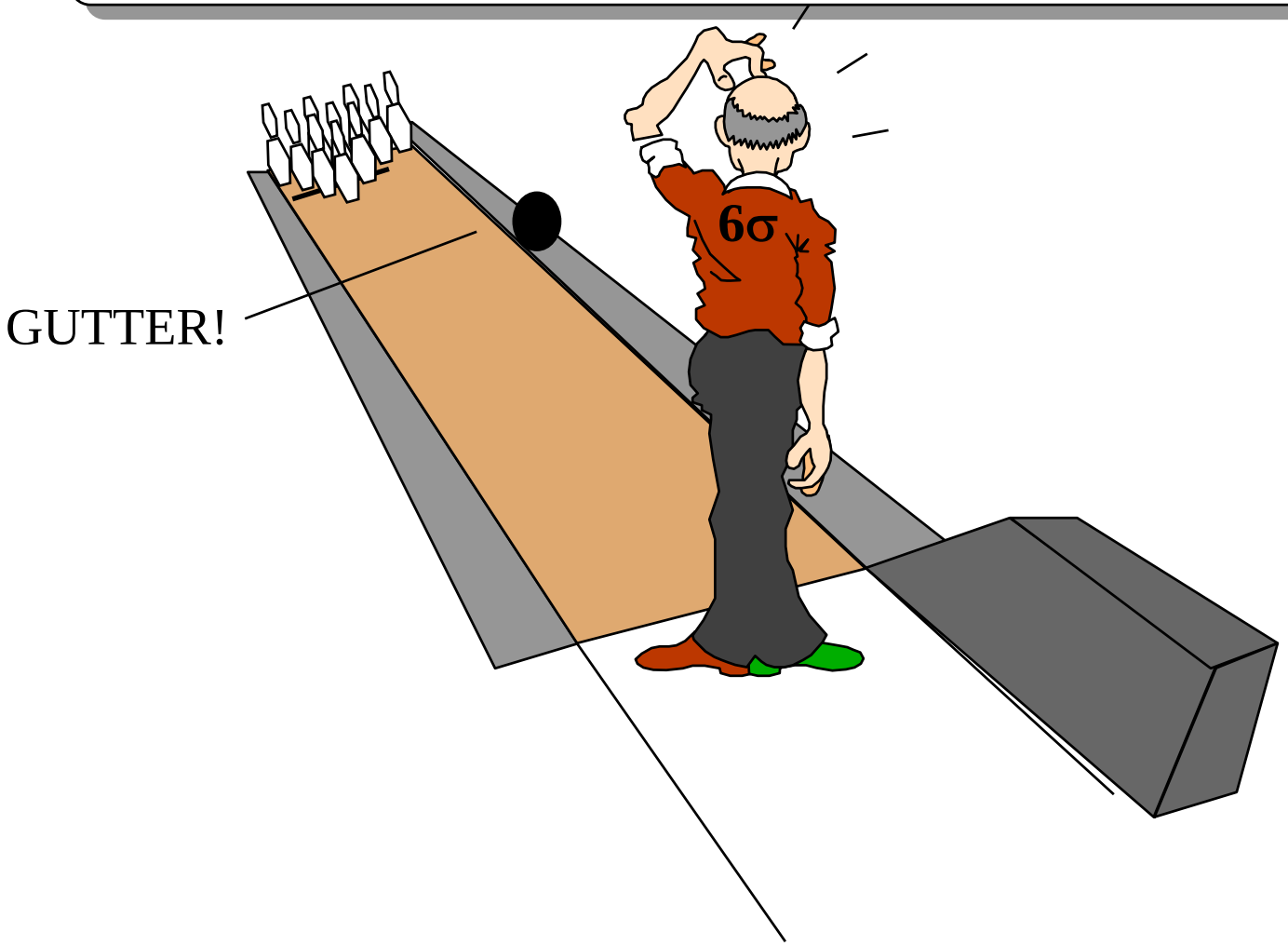
- Puts all participants on same level
- Side steps the ego-reduces conflict
- Edward de Bono created this system to encourage “Lateral Thinking” (creativity)
- Limits black hat discussions
- Structures thinking



# Design of Experiments :

**Improve** the process and remove defect causes.

**What Do I need to do to <u>improve</u> my Game?**



# Improve:

The goal of the **improve** phase is to test sources of variation to determine which of these actually cause process variation in the customer CTQ.

**A.** Screen / Identify Causes of Variation.

**B.** Discover Variable Relationships.

**C.** Estimate Operating Tolerances & Pilot Solutions.

# *Design of Experiments (DOE)*

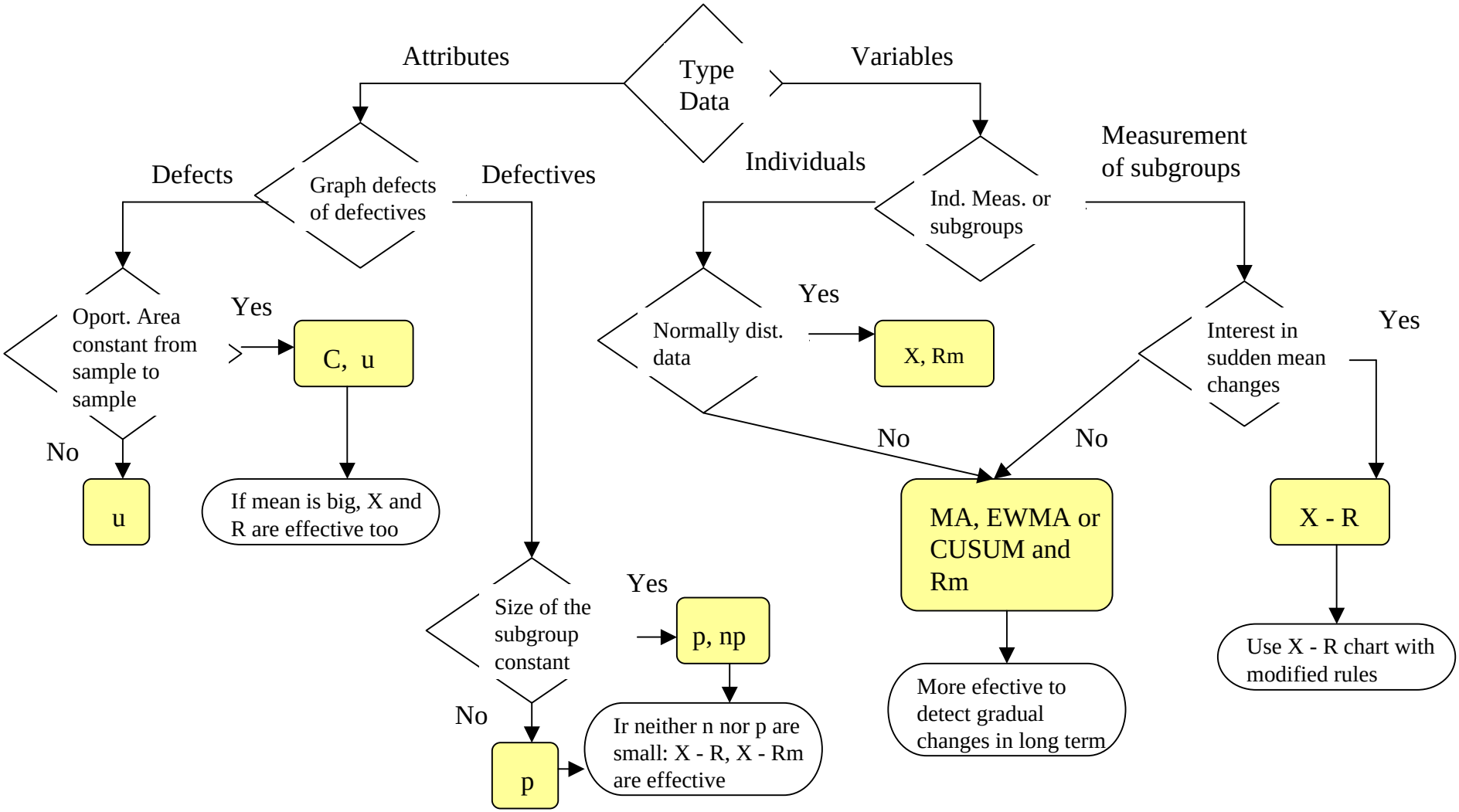
To estimate the effects of independent Variables on Responses.


Terminology

- Factor – An independent variable
- Level – A value for the factor.
- Response - Outcome

# *The Control Phase*

# How do we select the correct Control Chart:



| Sample | Defect | Proportion Defective |
|---|---|---|
| 1 | 6 | .06 |
| 2 | 0 | .00 |
| 3 | 4 | .04 |
| . | . | . |
| . | . | . |
| 20 | 18 | .18 |
| | 200 | 1.00 |

100 data in each sample

$$\bar{p} = \frac{\text{total defectives}}{\text{total sample observations}}$$

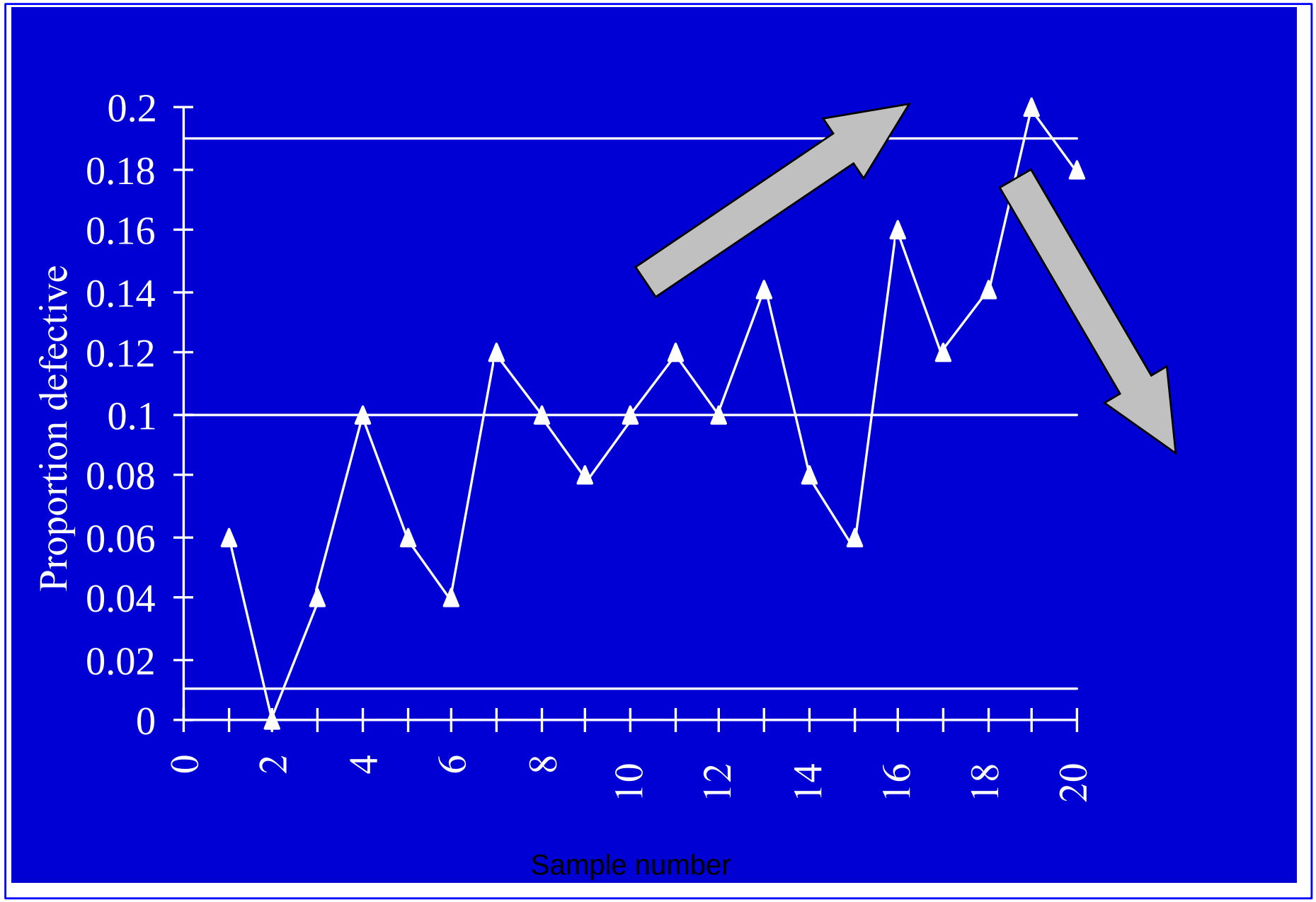
$$= \frac{200}{20\ (100)} = \mathbf{0.10}$$

$$UCL = \bar{p} + 3\sqrt{\bar{p}(1-\bar{p})\ /n}$$

$$= 0.10 + 3\sqrt{0.10\ (1-0.10)\ /100}$$

$$= \mathbf{0.190}$$

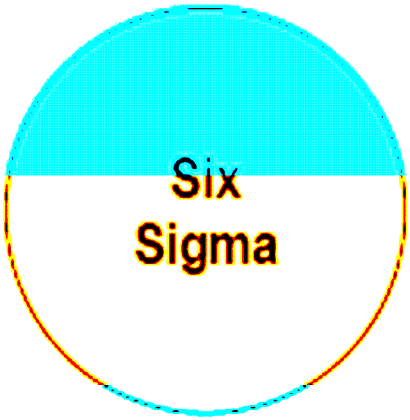
$$LCL = \mathbf{0.010}$$


Proportion defective
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
16
18
20
Sample number

# PMBOK – Six Sigma

## Conceptual Comparison


- Large Project Orientation
- Focused on Coordination and Management (in addition to Results)
- Management and Control Methods
- Foundation for Planning, Organizing, Managing, and Controlling Projects

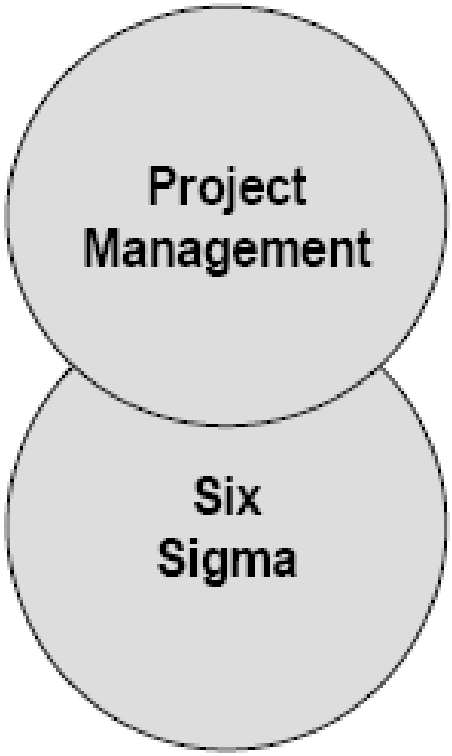



- Small Project Orientation
- Focused on Results
- Systematic Data-Driven Methods
- Incorporate PM Concepts

Observation: Shades of Difference

# PMBOK – Six Sigma

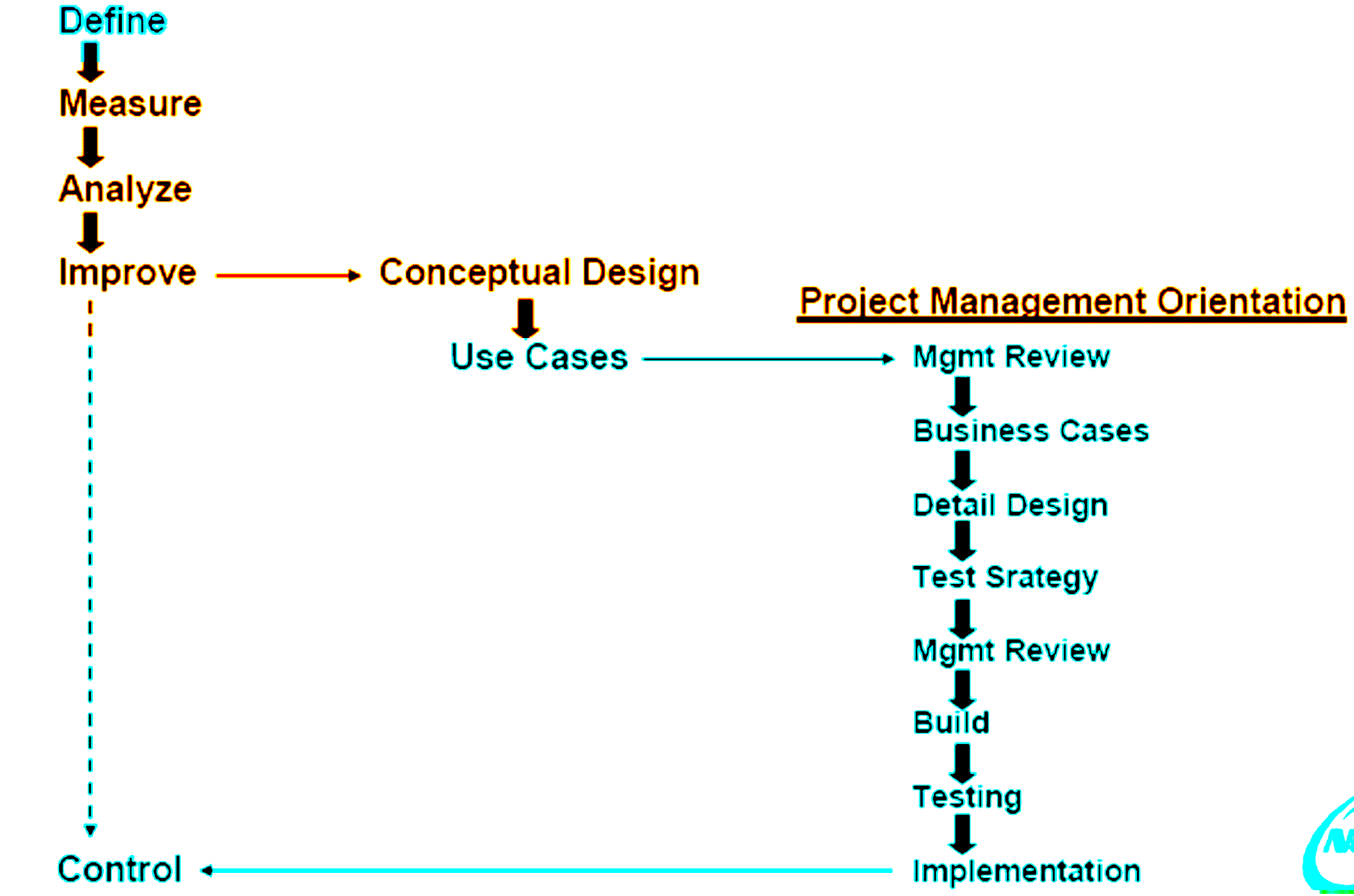
Pragmatic Comparison




- Mutual Leveraging of Concepts and Methodologies
  - -- Six Sigma uses PMBOK Planning, Organizing, Managing, and Controlling Methodologies
    - -- Project Management applies Six Sigma Data-Driven Techniques
      - o Improved Scope Management
      - o Improved Quality Planning and Control
- Achievement of Common Goals
  - -- Reduce Failures
  - -- Prevent Defects
  - -- Manage Risk
  - -- Control Schedule and Cost
  - -- Meet Scope

Conclusion: Complementary and Mutually Supporting Methodologies

# QMS – PMO Methodology Interface



# Types of Decision Making

**Unstructured** — **Structured**

**Uncertainty** — **Risk** — **Certainty**

- Unique
- Exceptional
- Unprogrammed
- Hueristics

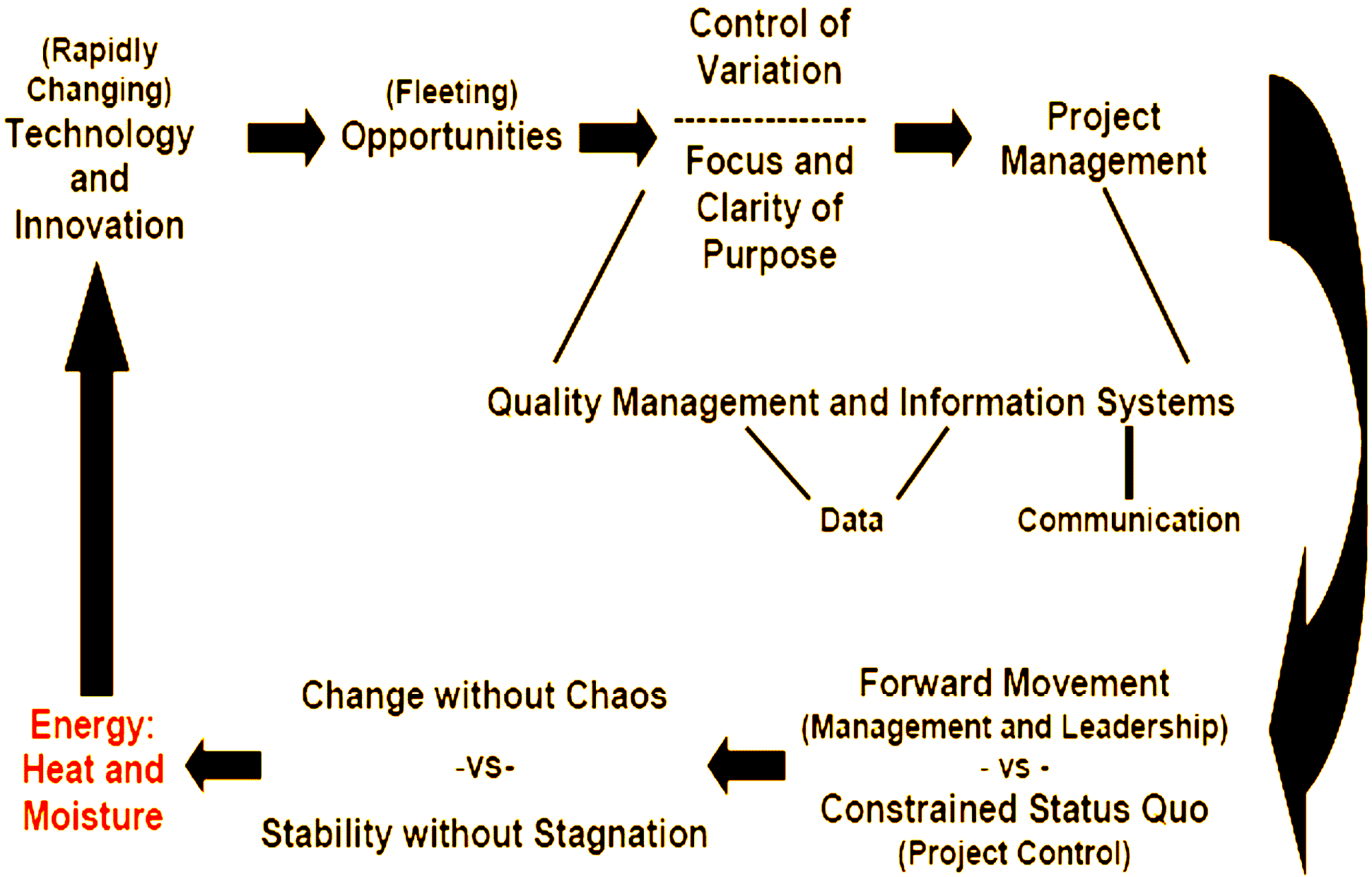
- Routine
- Repetitive
- Programmed
- Algorithms

**Strategies** — **Operations**

**Six Sigma**
**Project Management**
**+**
**Capability Maturity Model**

**Project Management and Leadership** — **Project Administration and Control**

# Lessons Learned



*Thank You*

If you need any clarification, pls let me know.

prasadchakra@yahoo.com
Prasad.chakrabarti@gmail.com