# 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 <u>fixing products</u> so they are perfect to <u>fixing processes</u> so that they produce nothing but perfection, or close to it." - Jack Welch*

# What Six Sigma is

Goal

Metric

Benchmark

Philosophy

6 Sigma

Value

Vision
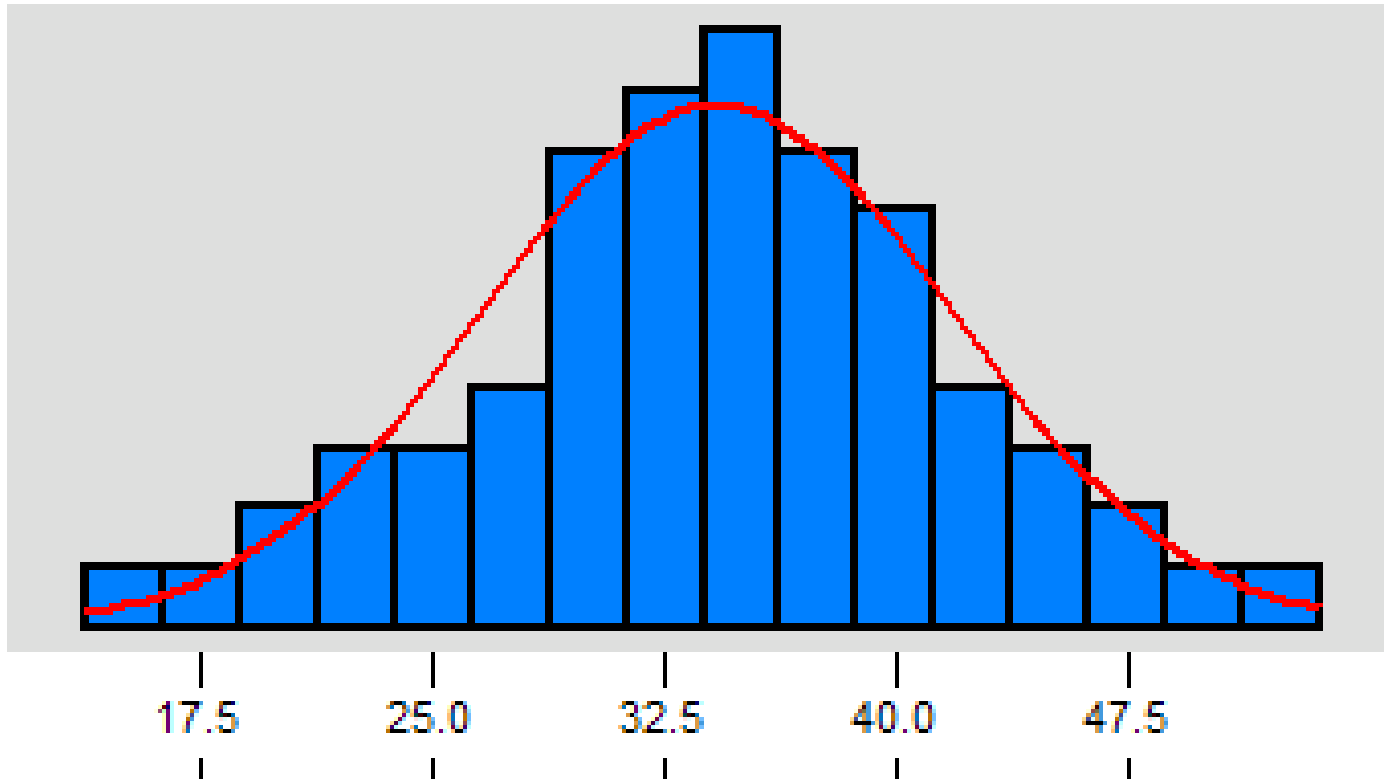
Symbol

Method

Tool
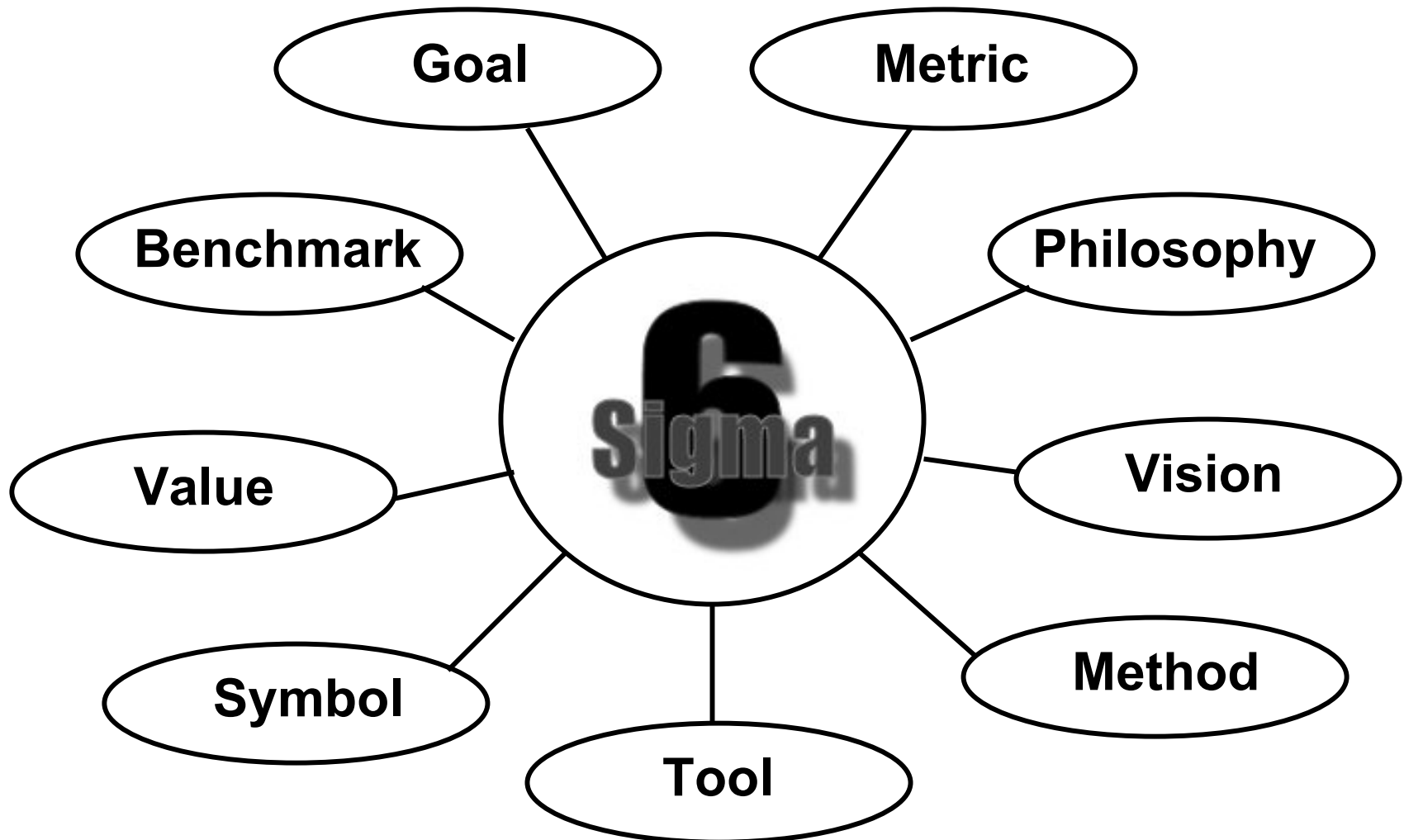
# The Concept of Variation

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

# The Concept of Variation



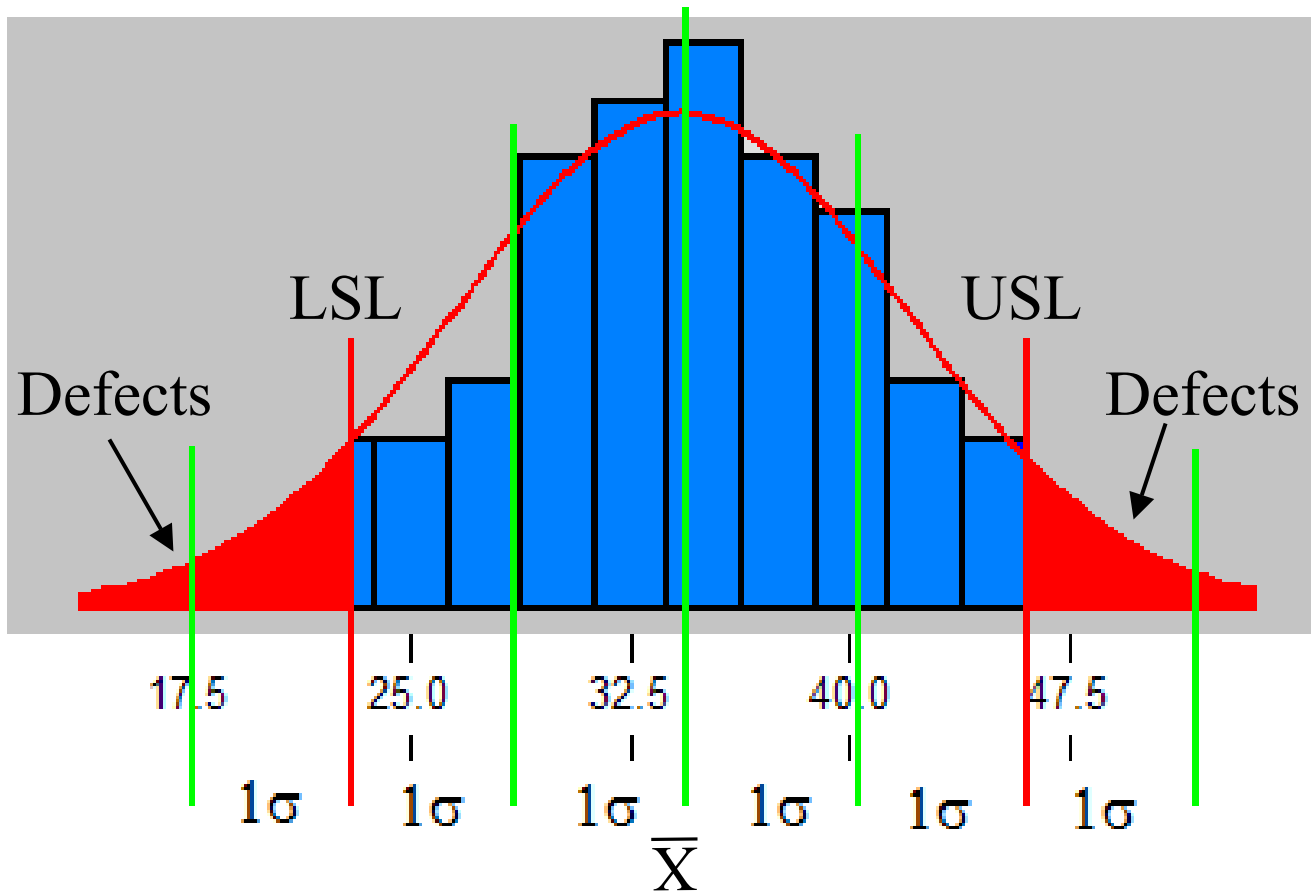**Every repeatable process exhibits variation**

# Measuring Variation



17.5   25.0   32.5   40.0   47.5

$1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$

$\overline{X}$
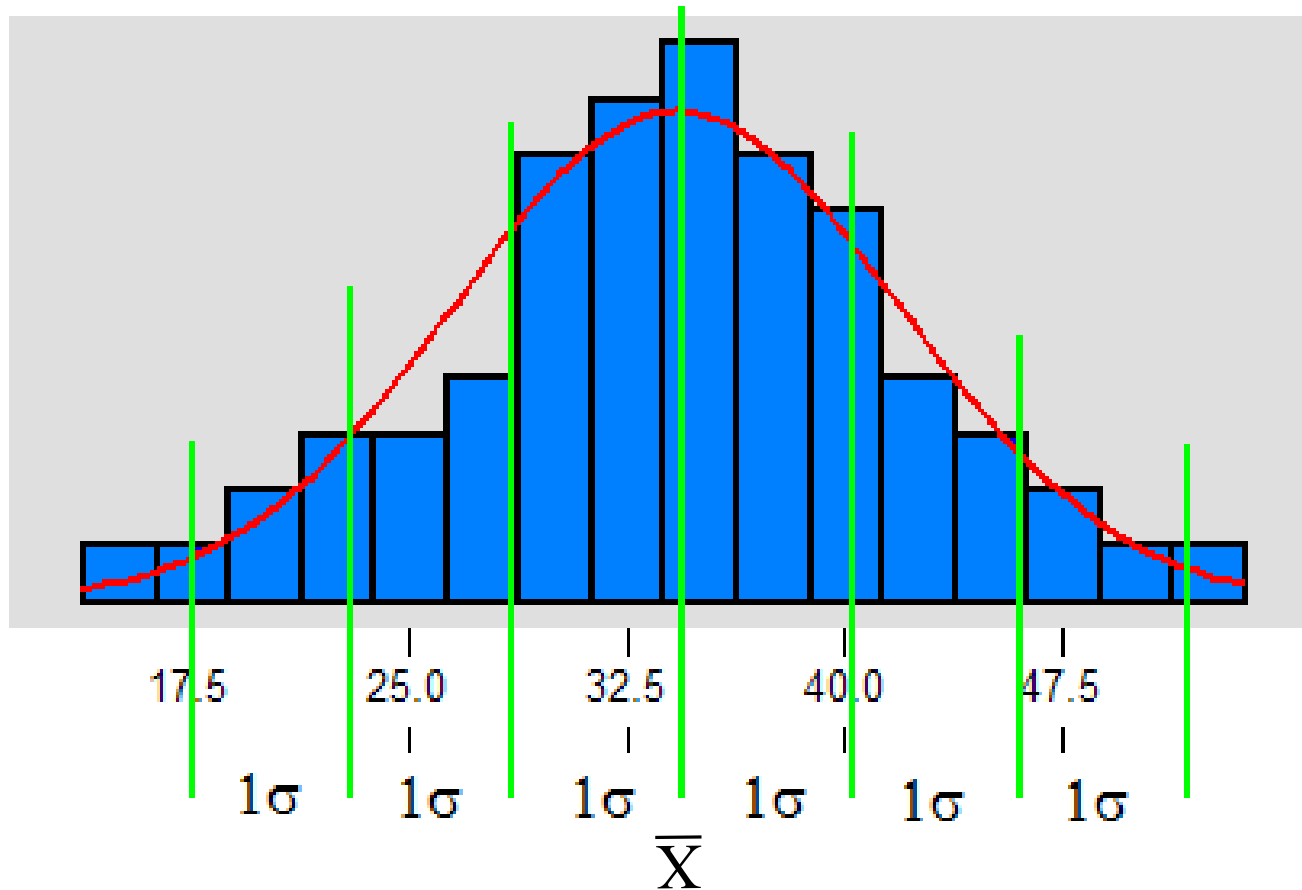
**We measure variation using standard deviation ($\sigma$)**

# Performance and defects



LSL

USL

Defects

Defects

17.5   25.0   32.5   40.0   47.5

$1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$

$\overline{X}$

**Reducing Variability Is The Essence of Six Sigma**

# Performance and Yield

| $\sigma$ | Defects per Million opportunities | Yield |
|:---:|:---:|:---:|
| 2 | 308,537 | 69.20% |
| 3 | 66,807 | 93.32% |
| 4 | 6,210 | 99.38% |
| 5 | 233 | 99.98% |
| 6 | 3.4 | 99.99% |

***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
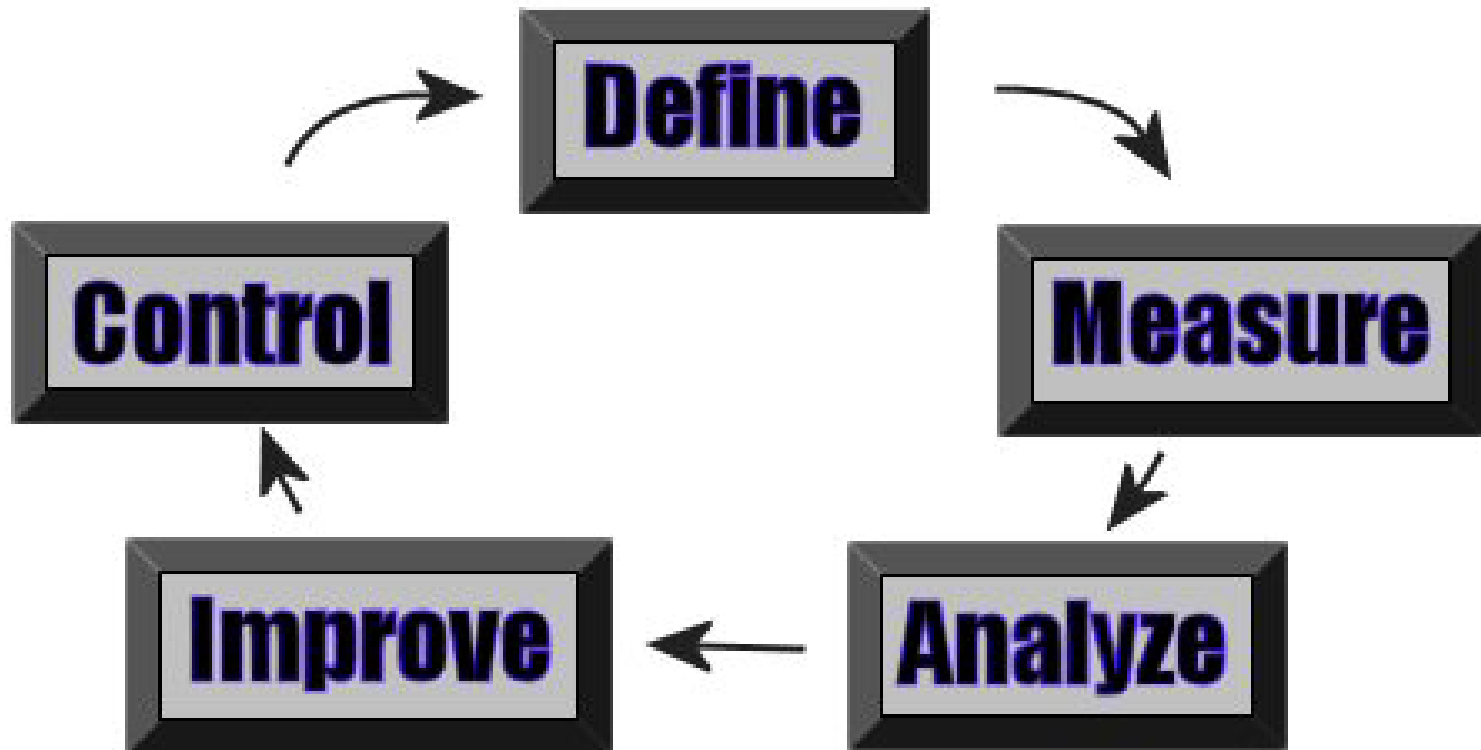
# Methodologies

- Two distinctly different methodologies

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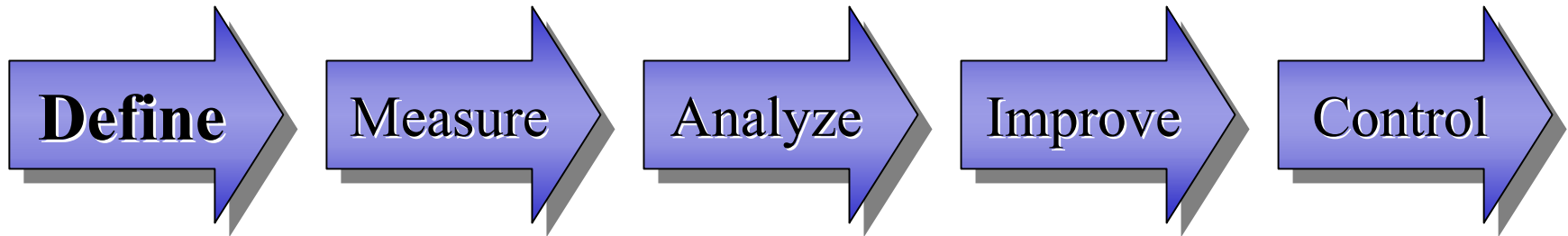  – Control
  When a process needs to be improved

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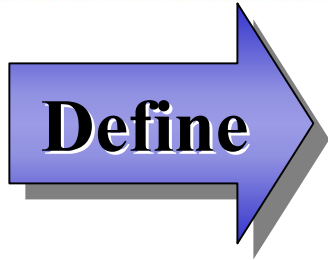
# The Improvement Methodology

# Define

| Define | Measure | Analyze | Improve | Control |

## Deliverables

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

# Identify Customer Wants

**Define**

- 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?

**Define**
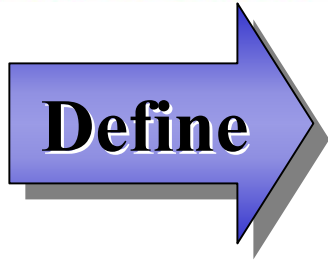
# Project Charter

- Project scope

- Business case

- Cost benefit

- Roles & responsibilities

- Milestones

- Deliverables

# High-level Process Map

**Define**
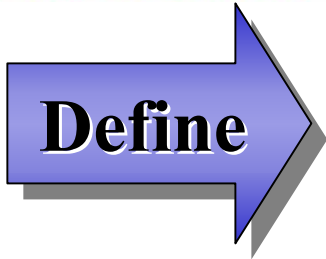
**PROCESS**

**SIPOC / COPIS**

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

### OUTPUTS
1) Part Usage
2) Inventory
3) Credit/Debit to P&L
4) Part
5)

**Part Required for a Service Call** → Create Part Request → Action Part Request → Receive Part into WIP → Use / Consume Part → Fulfill & Ship Part to Vendor / NPC → **Part Removed from WIP**
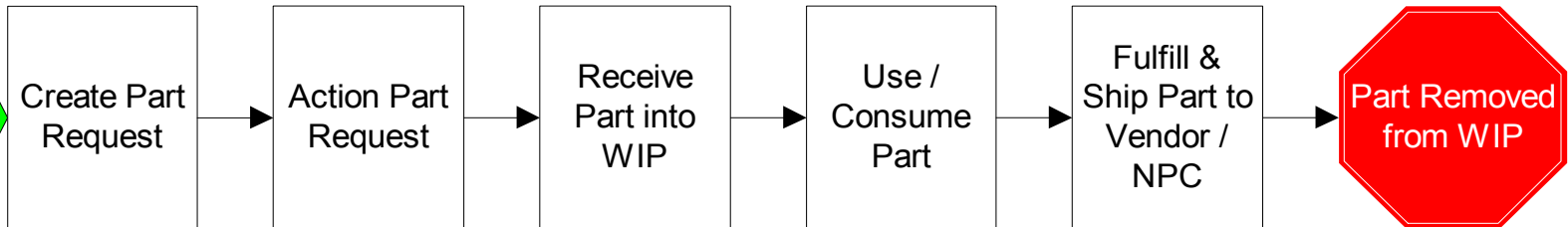
### SUPPLIERS
1) Technicians
2) Buyers
3) NPC
4) Refurb
5) Vendors
6) NSC

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

# Measure

| Define | Measure | Analyze | Improve | Control |
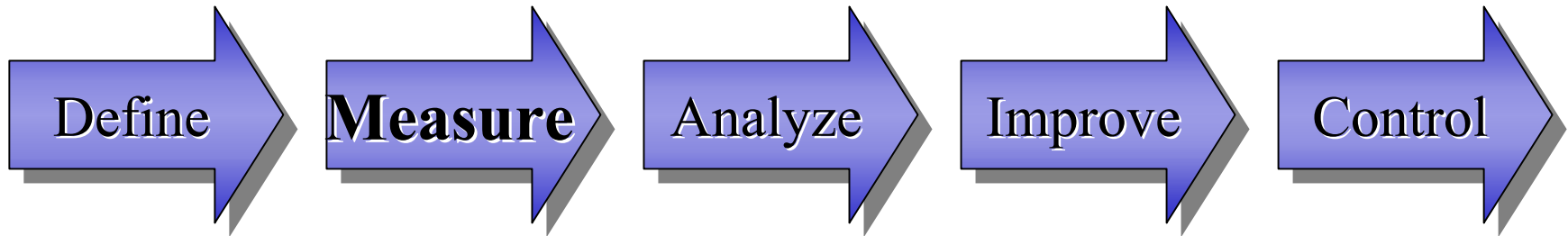
## <u>**Deliverables**</u>

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

**Measure** → 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



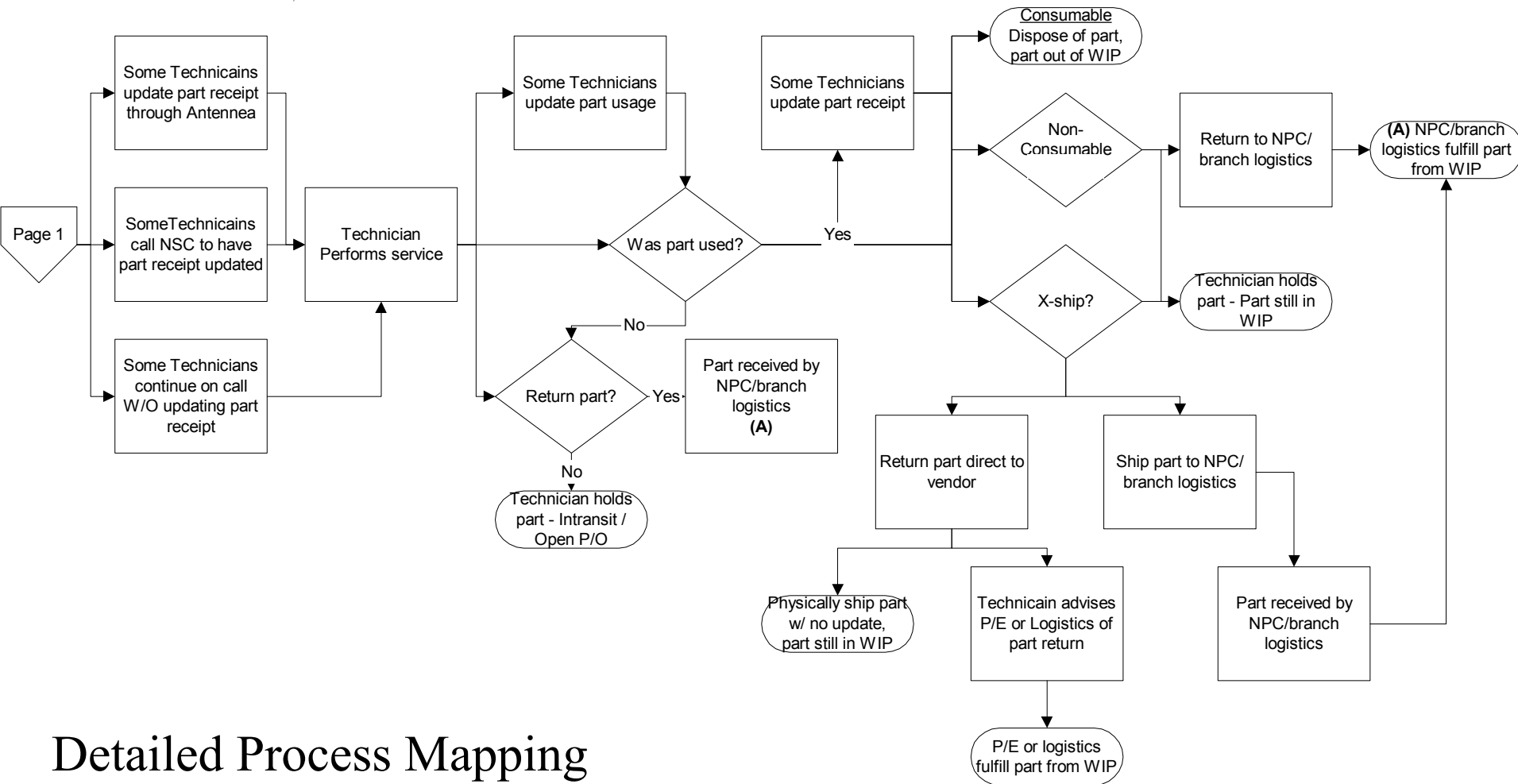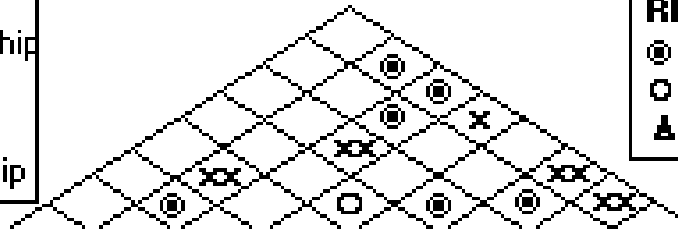Some Technicains update part receipt through Antennea

SomeTechnicains call NSC to have part receipt updated

Some Technicians continue on call W/O updating part receipt

Page 1

Technician Performs service

Some Technicians update part usage

Was part used?

Return part?

Technician holds part - Intransit / Open P/O

Part received by NPC/branch logistics (A)

Some Technicians update part receipt

Consumable Dispose of part, part out of WIP

Non-Consumable

X-ship?

Return to NPC/branch logistics

Technician holds part - Part still in WIP

(A) NPC/branch logistics fulfill part from WIP

Return part direct to vendor

Ship part to NPC/ branch logistics

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

Technicain advises P/E or Logistics of part return

Part received by NPC/branch logistics

P/E or logistics fulfill part from WIP

## Detailed Process Mapping

KETCH CONSULTING INC

**Measure** → # Identify CTQ Characteristic

Quality
Functional
Deployment
(QFD)

**INTERACTIONS:**
- ✕✕ Strong negative relationship
- ✕ Mild negative relationship
- ⊛ Mild positive relationship
- ○ Strong positive relationship

**RELATIONSHIPS:**
- ⊛ Strong relationship
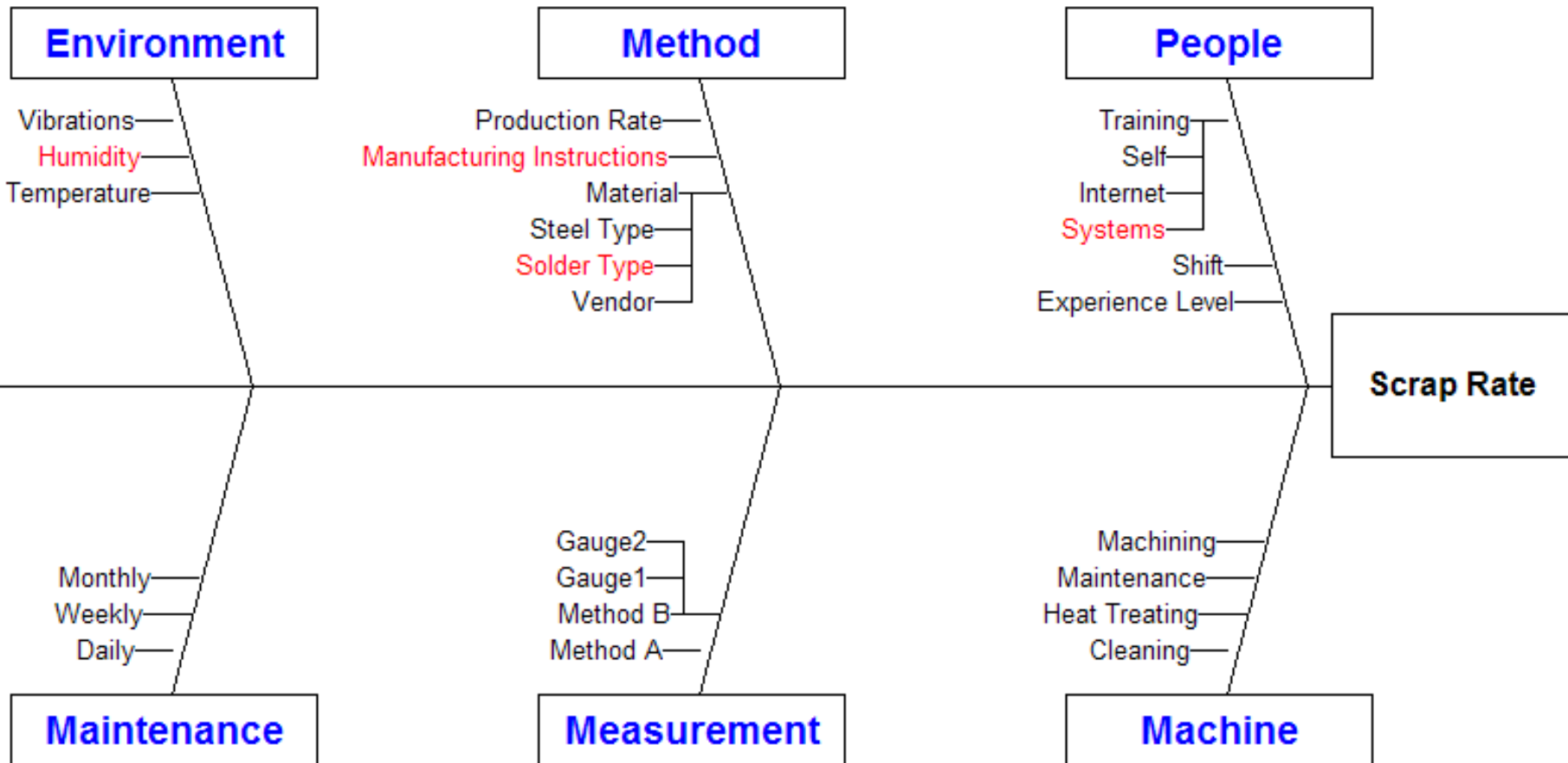- ○ Moderate relationship
- ▲ Weak relationship

| Customer Reqmts. / Product Design Reqmts | Priority | Bleed air ducting to interface pt. A | Low APU weight | Low turbine wheel weight | High equivalent shaft horsepower | Controlled turbine inlet temperature | Turbine assy. tri-hub containment | Strong internal containment ring | Lightweight containment ring | Competitive Evaluation 1 — 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cust. envelope/interface | 3 | ⊛ | | | | | | ⊛ | | ✕ ○ |
| Max. Weight 160 lbs. | 4 | ○ | ⊛ | ○ | | | ○ | | ⊛ | ○ ✕ |
| Bleed air 75 lbs/min | 4 | ○ | | | ⊛ | ⊛ | | | | ○ ✕ |
| Turbine containment | 5 | | | ○ | | ○ | ⊛ | ⊛ | | ○✕ |
| Elect pwr. 40 KVA | 3 | | | | ⊛ | | | | | ✕ ○ |
| Reliable | 5 | | | ○ | | ⊛ | ○ | | | ✕○ |
| Support oil-cooled gen. | 5 | | ○ | | | | | | | ○ ✕ |
| • • • | | | | | | | | | | |
| **Technical Evaluation** 5···1 | | ✕—○ | ○—✕ | ✕—○ | ✕—○ | ○—✕ | ○—✕ | ✕—○ | ✕—○ | |
| **Target Value** | | Targ. Loc. | 158lb | <6 lb | 350hp | 1850° | 2.5 lb @ Pwr | 3 lb @ Pwr | <6 lb | |
| **Technical Difficulty** | | 1 | 4 | 3 | 5 | 3 | 4 | 2 | 4 | |
| **Importance Rating** | | 39 | 35 | 42 | 35 | 60 | 52 | 40 | 20 | |

**EVALUATIONS:**
- ✕ We
- ○ XYZ Co.

**Measure** → # Identify CTQ Characteristic



| Environment | Method | People |
|---|---|---|
| Vibrations | Production Rate | Training |
| Humidity | Manufacturing Instructions | Self |
| Temperature | Material | Internet |
| | Steel Type | Systems |
| | Solder Type | Shift |
| | Vendor | Experience Level |

**Scrap Rate**

| Maintenance | Measurement | Machine |
|---|---|---|
| Monthly | Gauge2 | Machining |
| Weekly | Gauge1 | Maintenance |
| Daily | Method B | Heat Treating |
| | Method A | Cleaning |

Cause & Effect Analysis, or Fishbone, or Ishikawa diagram

# KETCH CONSULTING INC
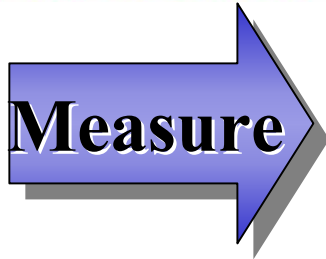
## Measure → Identify CTQ Characteristic

| System | Design Verification Process | **Potential** | FMEA Number | Project III |
| --- | --- | --- | --- | --- |
| Subsystem | | **Failure Mode and Effects Analysis** | Prepared By | Houston Mayer |
| Component | | **(Design FMEA)** | FMEA Date | 22/10/1999 |
| Design Lead | Houston Mayer | Key Date | Revision Date | 21/08/2000 |
| Core Team | See Project III R1 Report | | Page | 1 of 6 |

| Item / Function | Potential Failure Mode(s) | Potential Effect(s) of Failure | Sev | Potential Cause(s)/ Mechanism(s) of Failure | Prob | Current Design Controls | Det | RPN | Recommended Action(s) | Responsibility & Target Completion Date | Actions Taken | New Sev | New Occ | New Det | New RPN |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Customer sends in a quote request for product. | System, Software, Integration and Shipping requirements overlooked by | Customer needs not fully met by delivered system. | 7 | Human error | 1 | Design configuration tool. | 3 | 21 | Use configuration tool when available. | Closed 10/21/99 | | | | | |
| Requirement entered and verified by Inside Sales in config. tool. | Data entry error | System compatability requirements not evaluated by config. tool. | 3 | Human error | 1 | Order verified by a configuration tool. | 3 | 9 | Continue order verification by configuration tool. | Closed 10/21/99 | | | | | |
| Sales identifies need for CII or SHC | Specific packing, labeling and shipping requirements may not be | On time delivery and integraty of the product may be compramised | 7 | Requirements Overlooked. | 3 | Customer Inspection Instruction/ Special Handling Codes Process | 3 | 63 | Publish comprehensive procedure for the 1st Article Process. | Jun-00 | Customer shipping requirements reviewed by quality assurance in | | | | |

## FMEA-Failure Modes & Effects Analysis
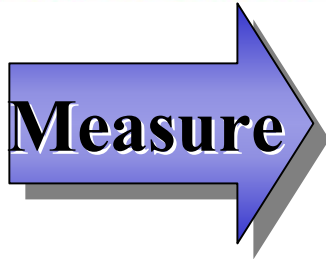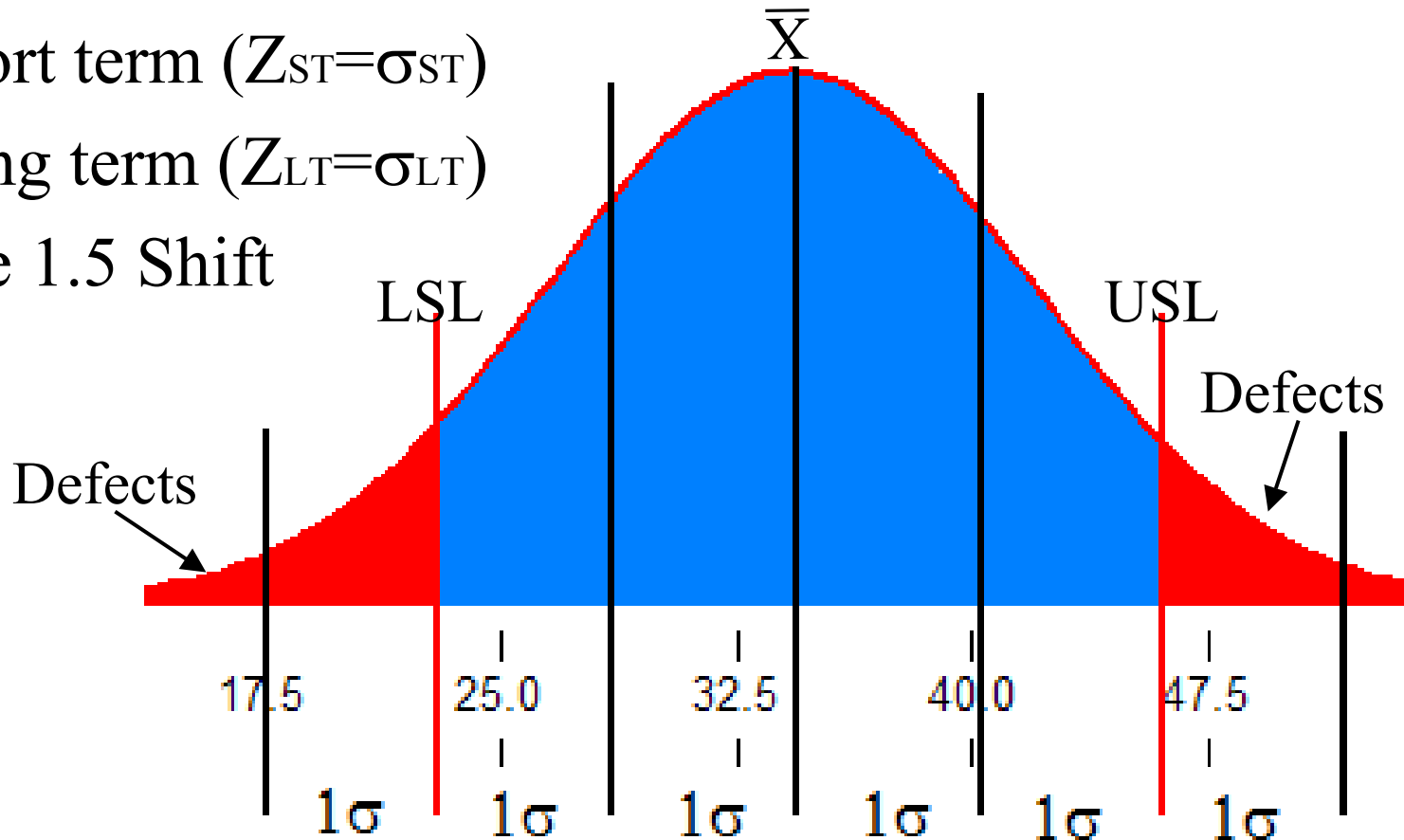
**Measure**

# Collect Data

- Create a data collection plan

- Perform a MSA

  – Measurement Systems Analysis

    • Gage R & R

    • Attribute R & R
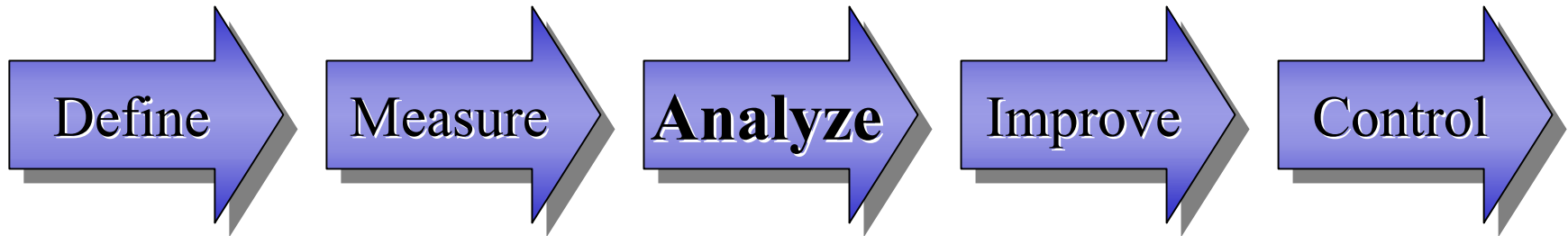
    • Test re-test study

- Collect data
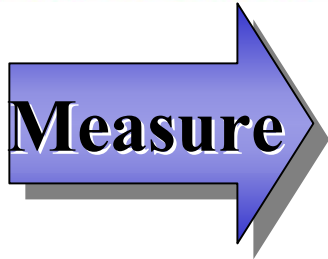
# Calculating Sigma

**Measure**

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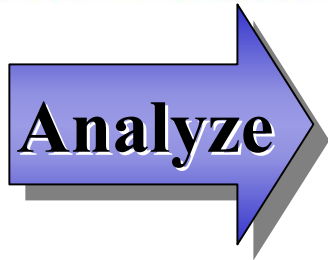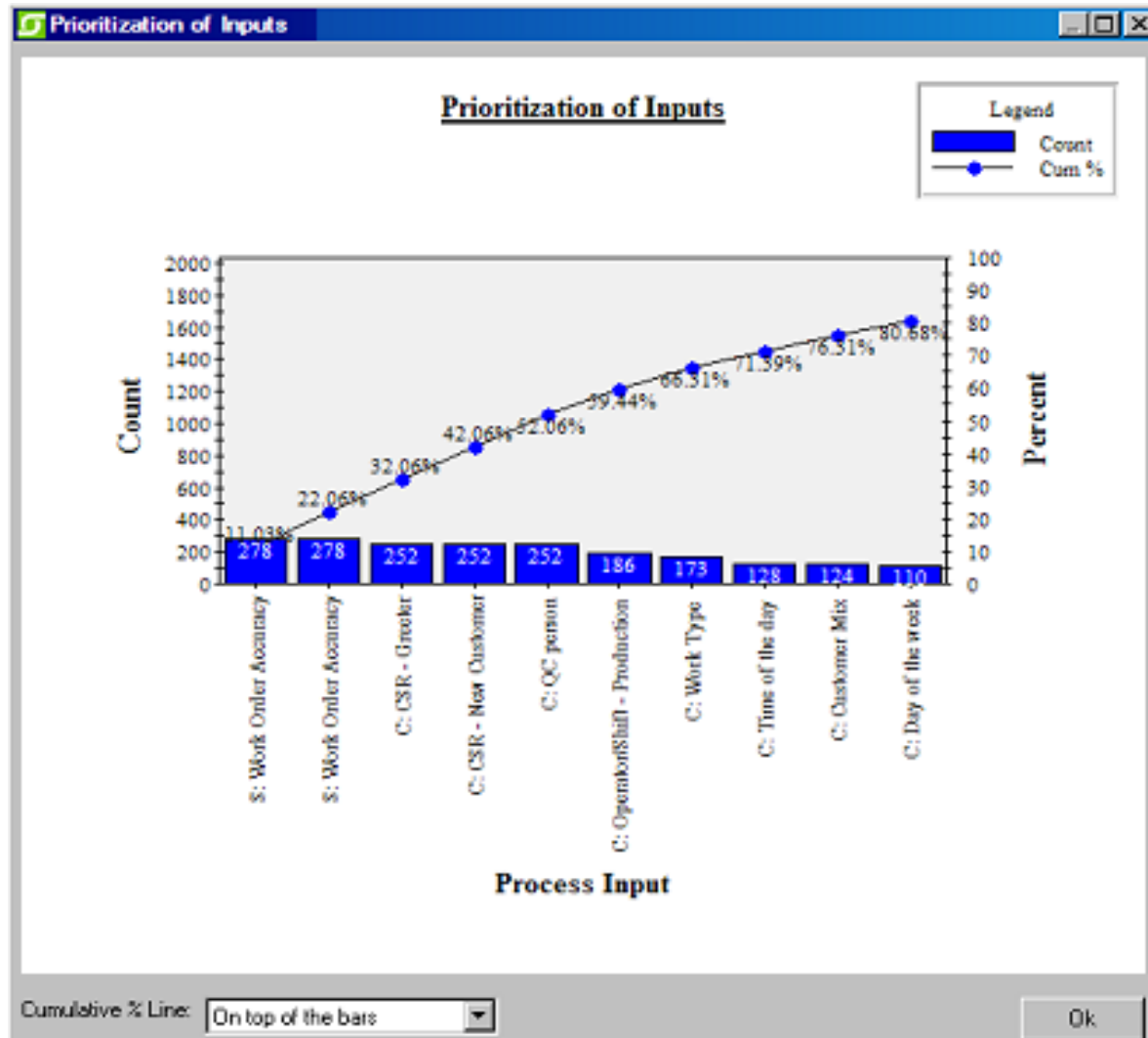  - The 1.5 Shift

$\overline{X}$

LSL

USL

Defects

Defects

17.5      25.0      32.5      40.0      47.5

$1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$   $1\sigma$

# Analyze

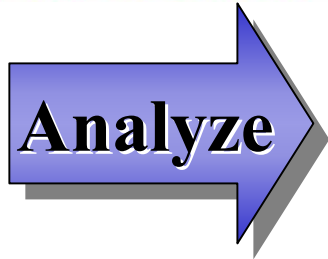| Define | Measure | **Analyze** | Improve | Control |

## **Deliverables**

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

# Identify Possible Causes

**Analyze**

- Identify sources of variation using:
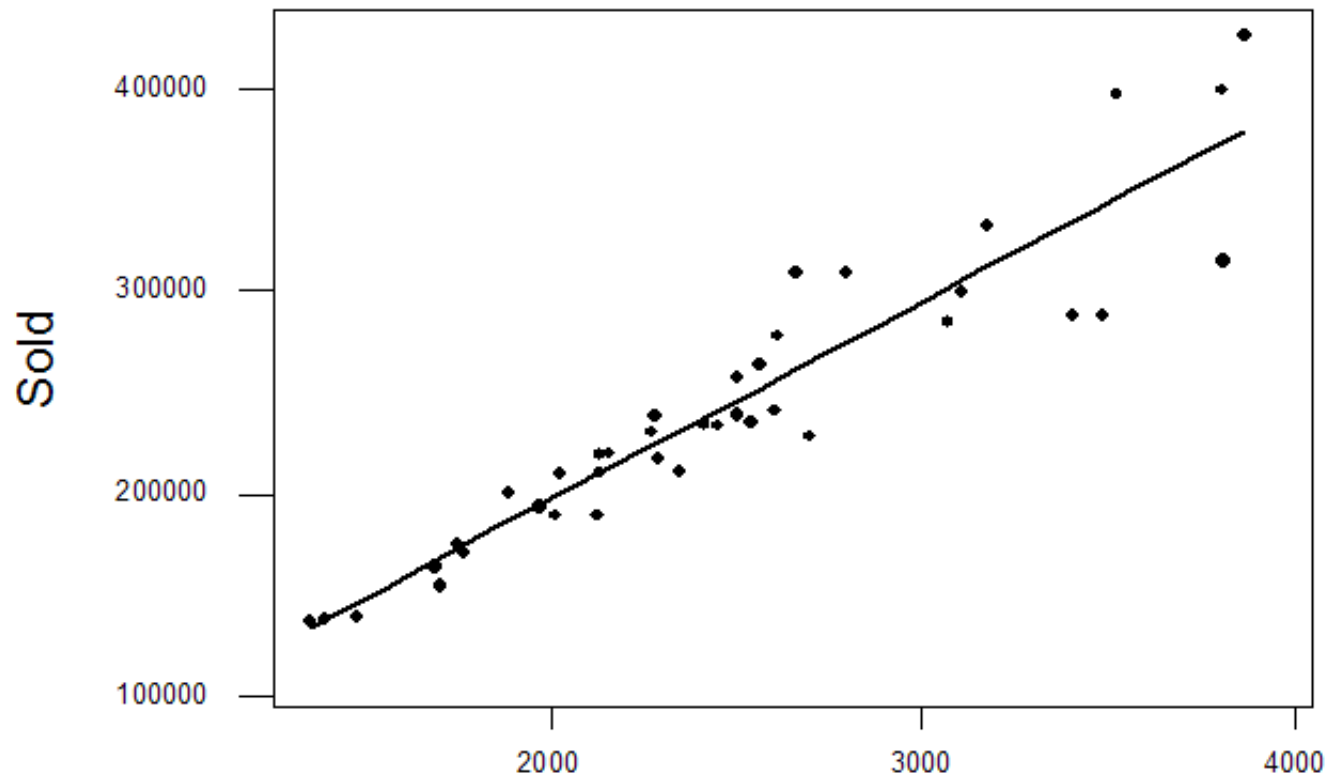  - Process map analysis
  - Graphical analysis
  - Brainstorming

# Narrow To Root Causes

**Analyze**

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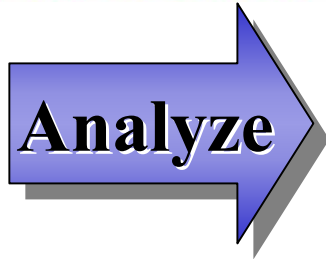  - Hypothesis testing
  - DOE-Design Of Experiment

### Regression Plot

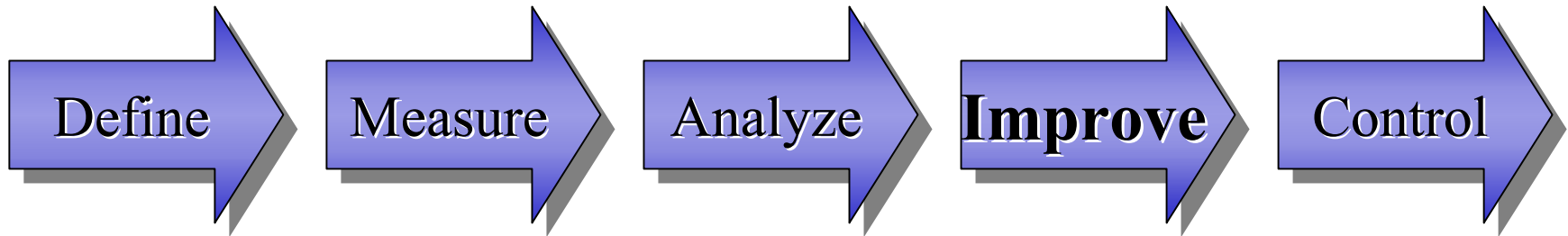Y = 1026.02 + 98.0500X

R-Sq = 87.9 %



P value = 0.000

**Analyze**

# 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

# Improve

| Define | Measure | Analyze | **Improve** | Control |

## Deliverables

1.  Generate and select solution
2.  Implement solution
3.  Confirm results

# Generate & Select Solution

**Improve**

- Solution generation through structured brainstorming

- Solution Selection based upon viability and trade-offs

| Pugh Matrix | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Solution Alternatives** | | | | | |
| *Concept Selection Legend*<br>Better     +<br>Same     S<br>Worse     - | | **Importance Rating** | **Benchmark Option** | **Alternative 1** | **Alternative 2** | **Alternative 3** | **Alternative 4** | **Alternative 5** |
| **Key Criteria** | | | | | | | | |
| Criteria 1 | | 4 | + | S | + | + | - | - |
| Criteria 2 | | 2 | S | - | S | + | + | + |
| Criteria 3 | | 3 | - | + | - | + | S | S |
| Criteria 4 | | 2 | + | S | + | + | - | + |
| Criteria 5 | | 5 | S | - | S | S | + | S |
| Criteria 6 | | 6 | - | - | - | - | - | - |
| Criteria 7 | | 10 | + | + | + | + | + | + |
| Criteria 8 | | 8 | S | S | S | S | S | S |
| **Sum of Positives** | | | 3 | 2 | 3 | 5 | 3 | 3 |
| **Sum of Negatives** | | | 2 | 3 | 2 | 1 | 3 | 2 |
| **Sum of Sames** | | | 3 | 3 | 3 | 2 | 2 | 3 |
| **Weighted Sum of Positives** | | | 16 | 13 | 16 | 21 | 17 | 14 |
| **Weighted Sum of Negatives** | | | 9 | 13 | 9 | 6 | 12 | 10 |
| **Totals** | | | 7 | 0 | 7 | 15 | 5 | 4 |

**Improve**

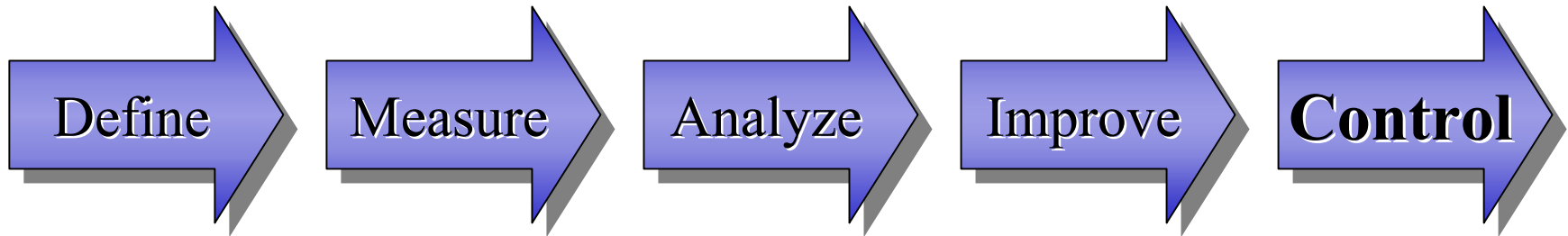# Implement Solution

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

**Improve**

# 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

| Define | Measure | Analyze | Improve | **Control** |
|--------|---------|---------|---------|-------------|

## **Deliverables**

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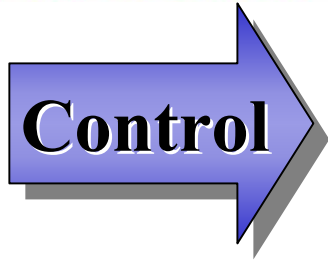
**Control**

# Standardize and Document

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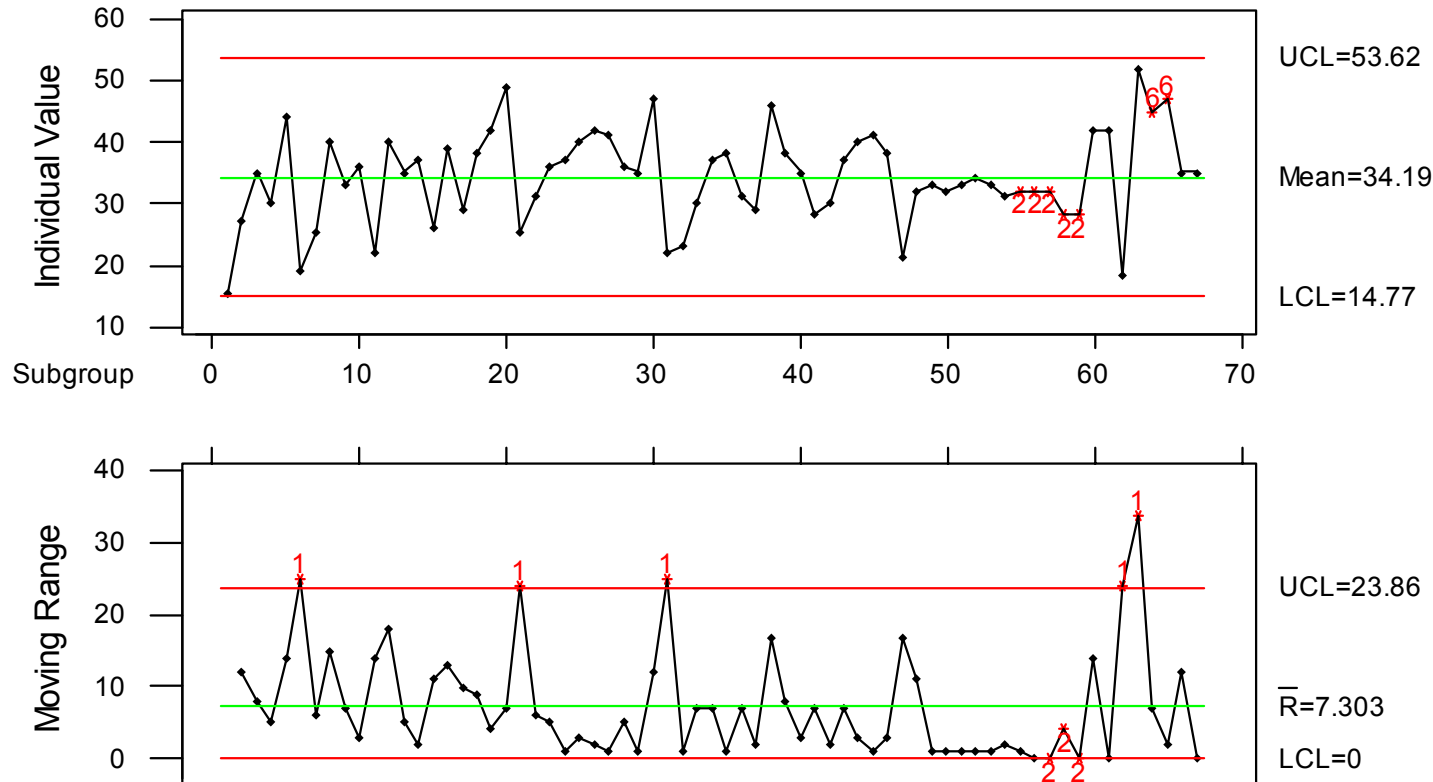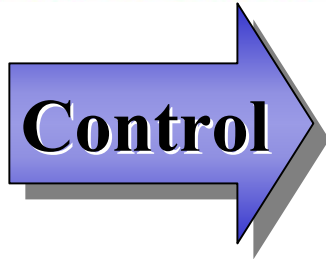    - Risk management plan

# Monitoring and Control

**Control**
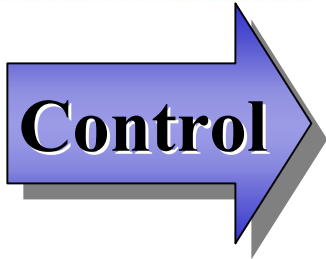
- Ensure project x's and y's remain in statistical control
  - SPC- Statistical Process Control



I and MR Chart for Days

**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 & Master Black Belts

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

# Black Belts & Green Belts

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

# 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
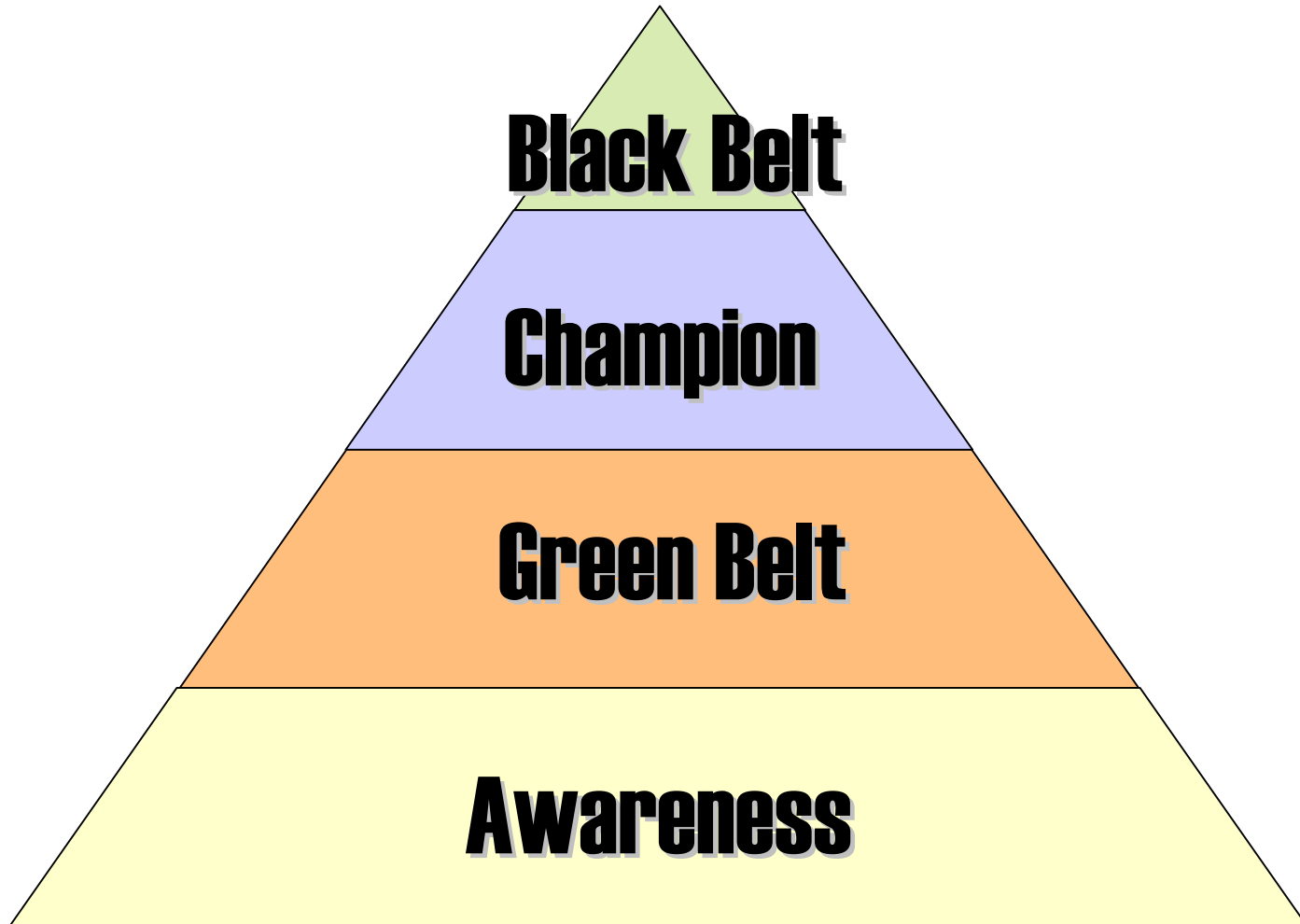
# Launching the Initiative

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

## Six Sigma Software