Lean six sigma

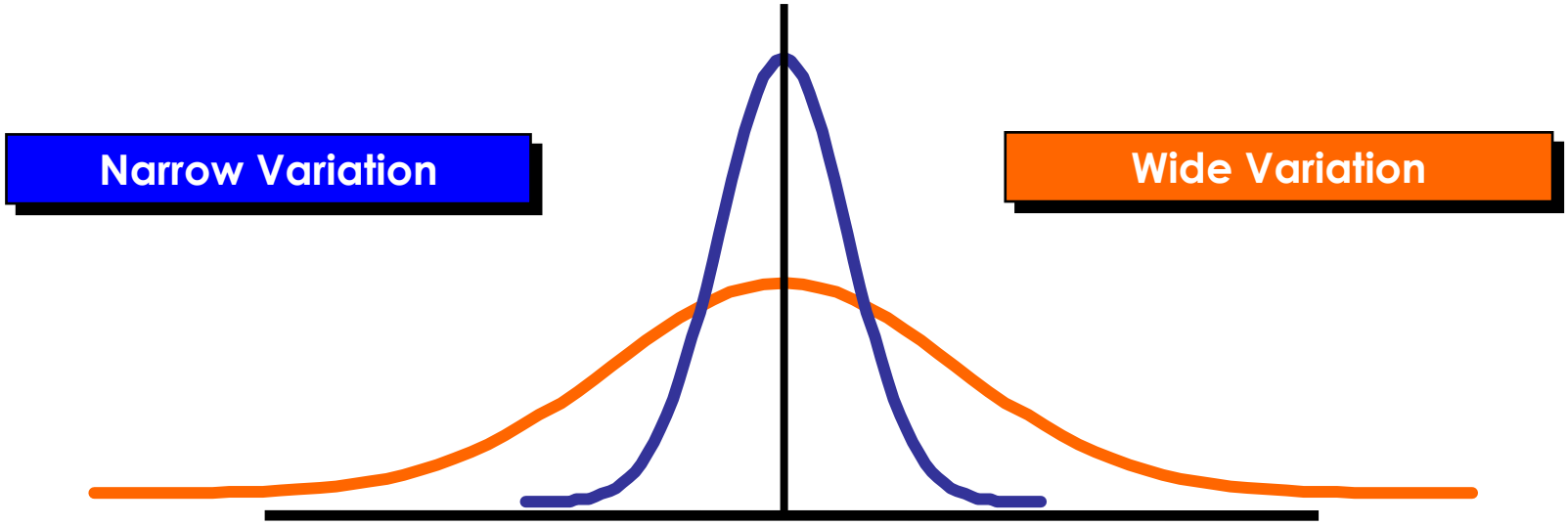
Eng: Musa Kambal Yousif – Mechanical engineer (Bsc honor)

Certified lean six sigma black belt / Certified lean six sigma green belt

International Association of Six Sigma Association (IASSC) - USA

σ sigma is a letter of the Greek alphabet.

- Mathematicians use this symbol to signify Standard Deviation, an important measure of variation.
- Variation designates the distribution or spread about the average of any process.



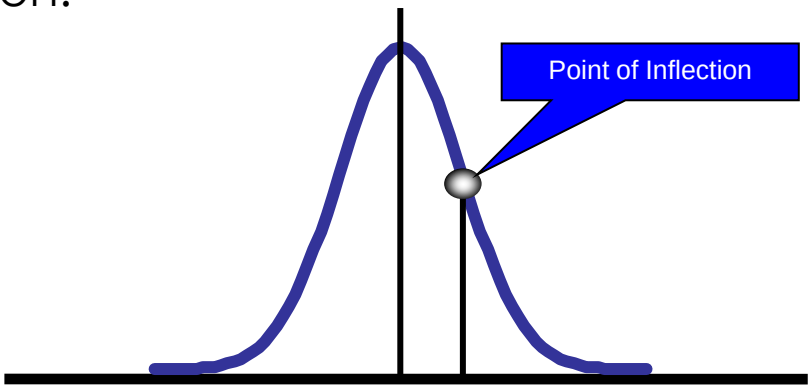
The *variation in a process* refers to how tightly all the various outcomes are clustered around the average. No process will produce the EXACT same output each time.

Sigma is a measure of deviation. The mathematical calculation for the Standard Deviation of a population is:

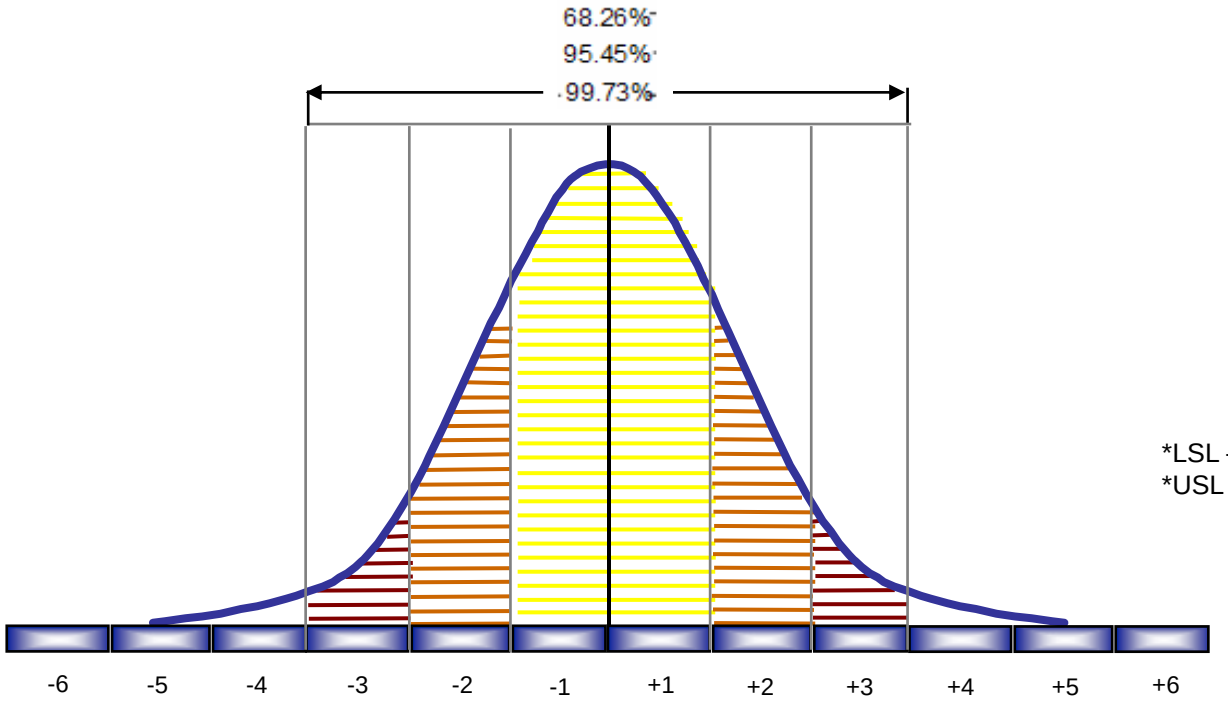
$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \mu)^2}{N}}$$

By definition, the Standard Deviation is the distance between the Mean and the point of inflection on the normal curve.

- Sigma can be used interchangeably with the statistical term Standard Deviation.
- Standard Deviation is the average distance of data points away from the Mean in a distribution.



The probability of creating a defect can be estimated and *translated* into a "Sigma" level.

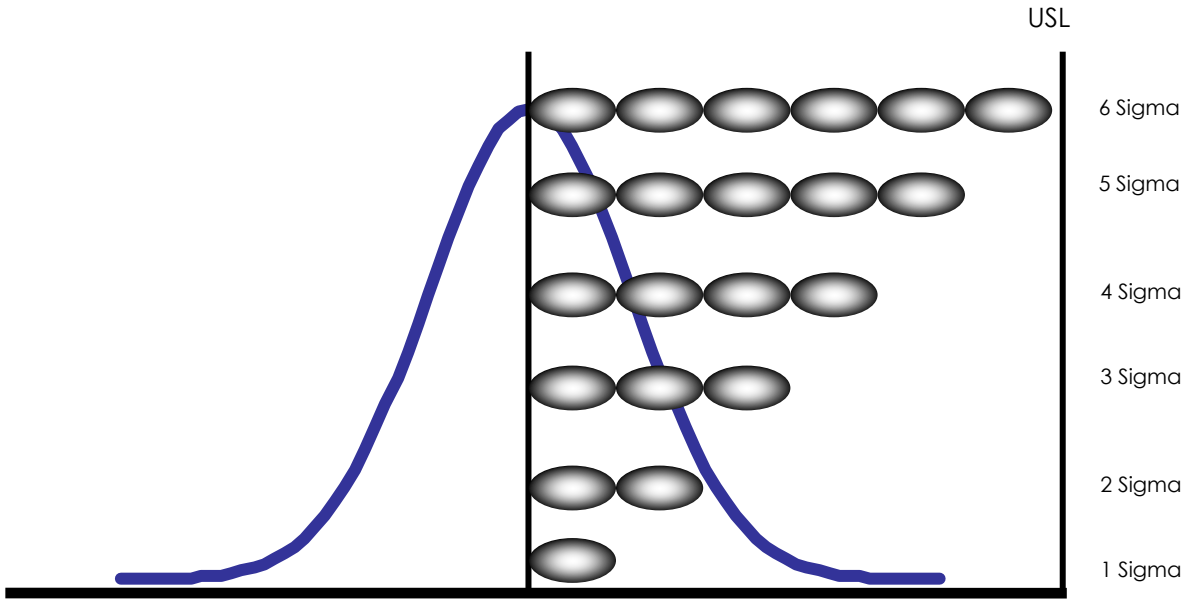


*LSL – Lower Spec Limit
*USL – Upper Spec Limit

The higher the sigma level, the better the performance. Six Sigma refers to a process having 6 Standard Deviations between the average of the process center and the closest specification limit or service level.

"Sigma Level" is:

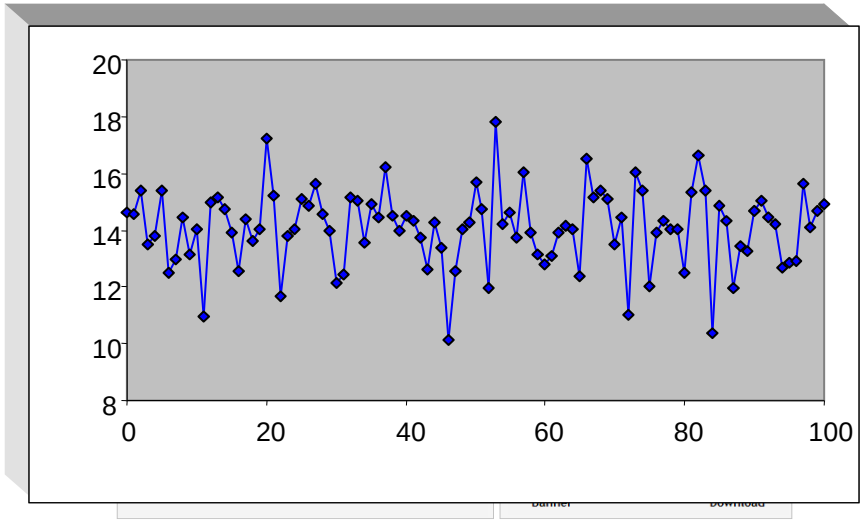
- **A statistic used to describe the performance of a process relative to the specification limits**
- **The number of Standard Deviations from the Mean to the closest specification limit of the process**



The likelihood of a defect decreases as the number of Standard Deviations that can be fit between the Mean and the nearest spec limit increases.

Each of these metrics serves a different purpose and may be used at different levels in the organization to express the performance of a process in meeting the organization's (or customer's) requirements. We will discuss each in detail as we go through the course.

- **Defects**
- **Defects per unit (DPU)**
- **Parts per million (PPM)**
- **Defects per million opportunities (DPMO)**
- **Rolled Throughput yield (RTY)**
- **First Time Yield (FTY)**
- **Sigma (s)**



These are certain metrics that we use in Six Sigma. You will learn more about these through the course of your study.

Yield	PPMO	COPQ	Sigma	
99.9997%	3.4	<10%	6	**World Class Benchmarks**
99.976%	233	10-15%	5	**10% GAP**
99.4%	6,210	15-20%	4	**Industry Average**
93%	66,807	20-30%	3	**10% GAP**
65%	308,537	30-40%	2	**Non Competitive**
50%	500,000	>40%	1	

Source: Journal for Quality and Participation, Strategy and Planning Analysis

What does 20 - 40% of Sales represent to your Organization?

DMAIC provides the method for applying the Six Sigma philosophy in order to improve processes.

- Define - the business opportunity
- Measure - the process current state
- Analyze - determine Root Cause or Y= *f* (x)
- Improve - eliminate waste and variation
- Control - evidence of sustained results

Six Sigma contains a broad set of tools, interwoven in a business problem-solving methodology. Six Sigma tools are used to scope and choose projects, design new products and processes, improve current processes, decrease downtime and improve customer response time.

- ***Six Sigma has not created new tools, it has simply organized a variety of existing tools to create flow.***

Customer Value Responsiveness, Cost, Quality, Delivery	**=**	**EBIT,**	**Management (Enabler)**	**, Product Design**	**, Process Yield**	**, Process Speed**	**, System Uptime ,**	**Functional Support**

5+ Sigma

3 - 5 Sigma

3 Sigma

1 - 2 Sigma

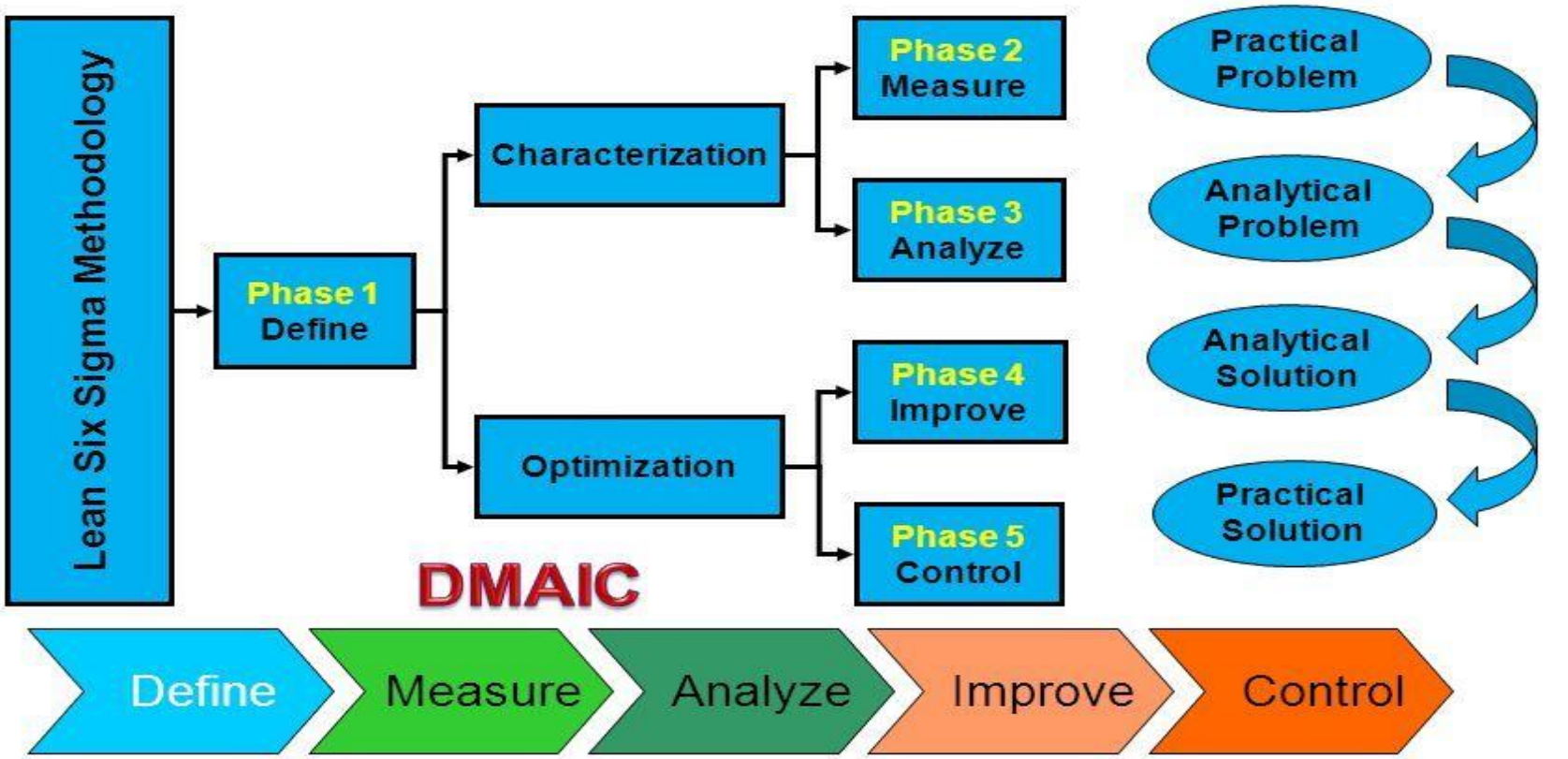
Sweet Fruit
Design for Six Sigma

Bulk of Fruit
Process Characterization and Optimization

Low Hanging Fruit
Basic Tools of Problem Solving

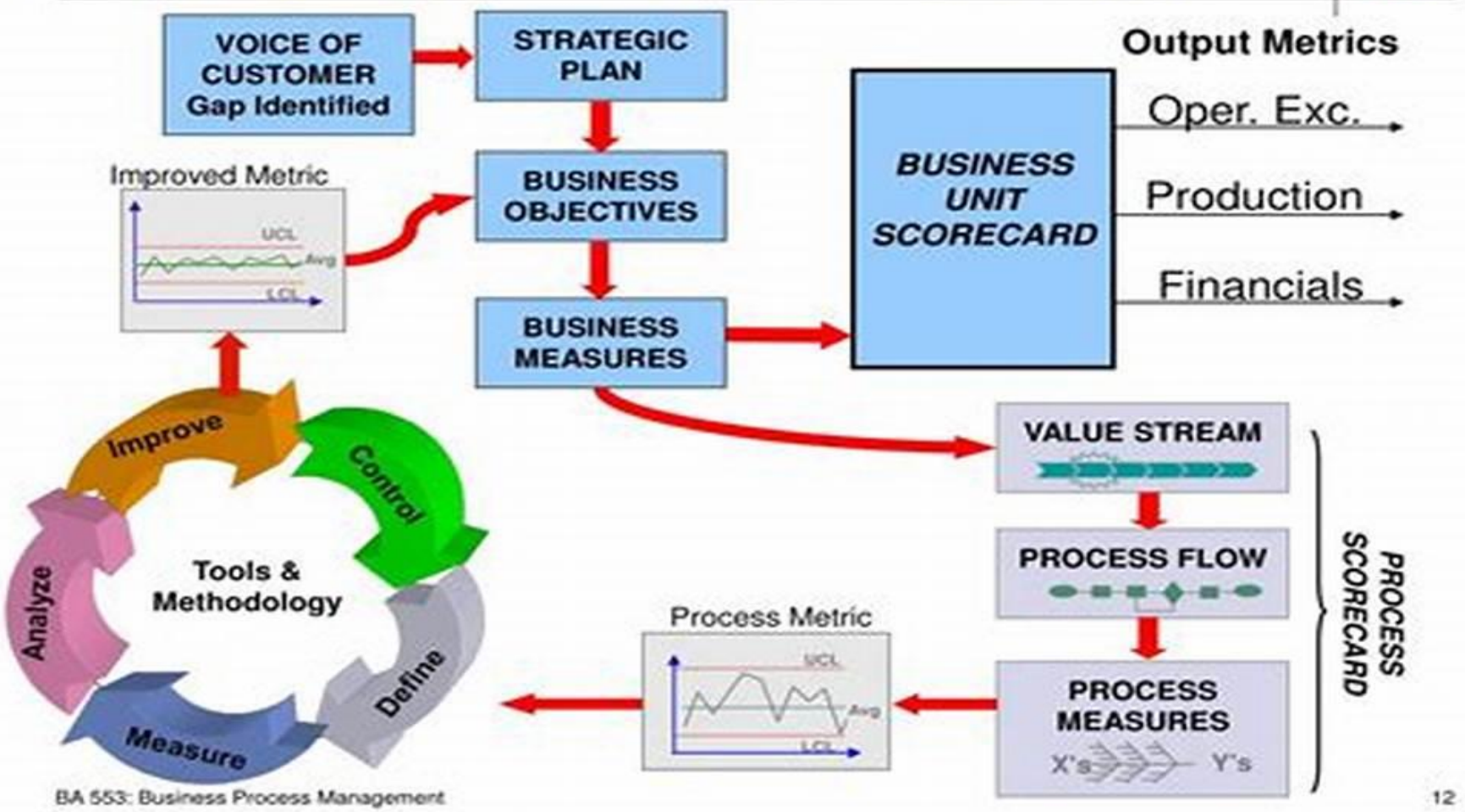
Ground Fruit
Simplify and Standardize

Lean Six Sigma Methodology



"Safety is a Measure of Success"

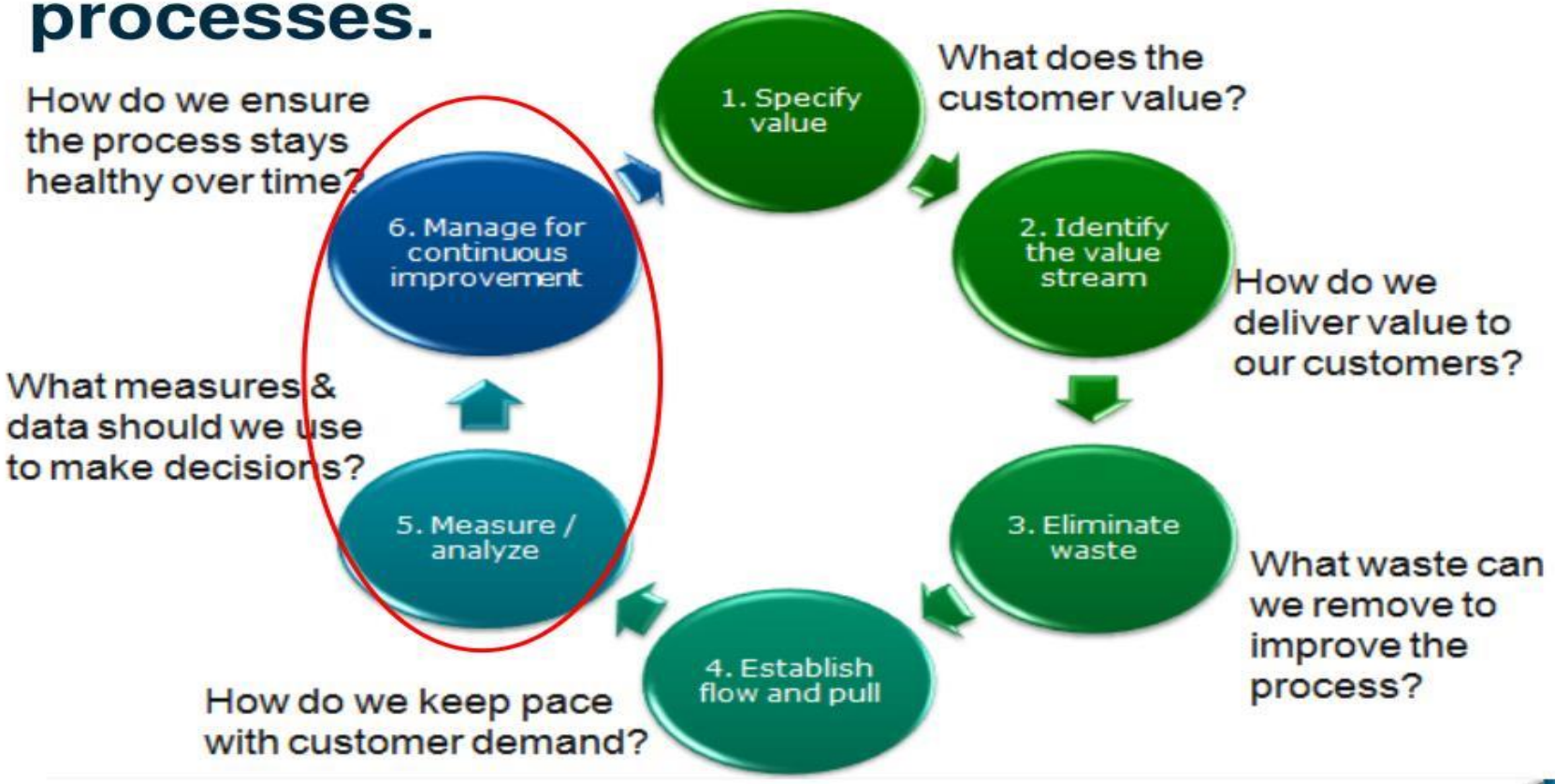
Lean Sigma Process Improvement Cycle



BA 553: Business Process Management

12

Lean Sigma has six steps to optimize processes.



GUIDON PERFORMANCE SOLUTIONS


Lean
Eliminate
Waste
Six Sigma
Reduce
Variation
Continual Improvement

Levels Of Six Sigma

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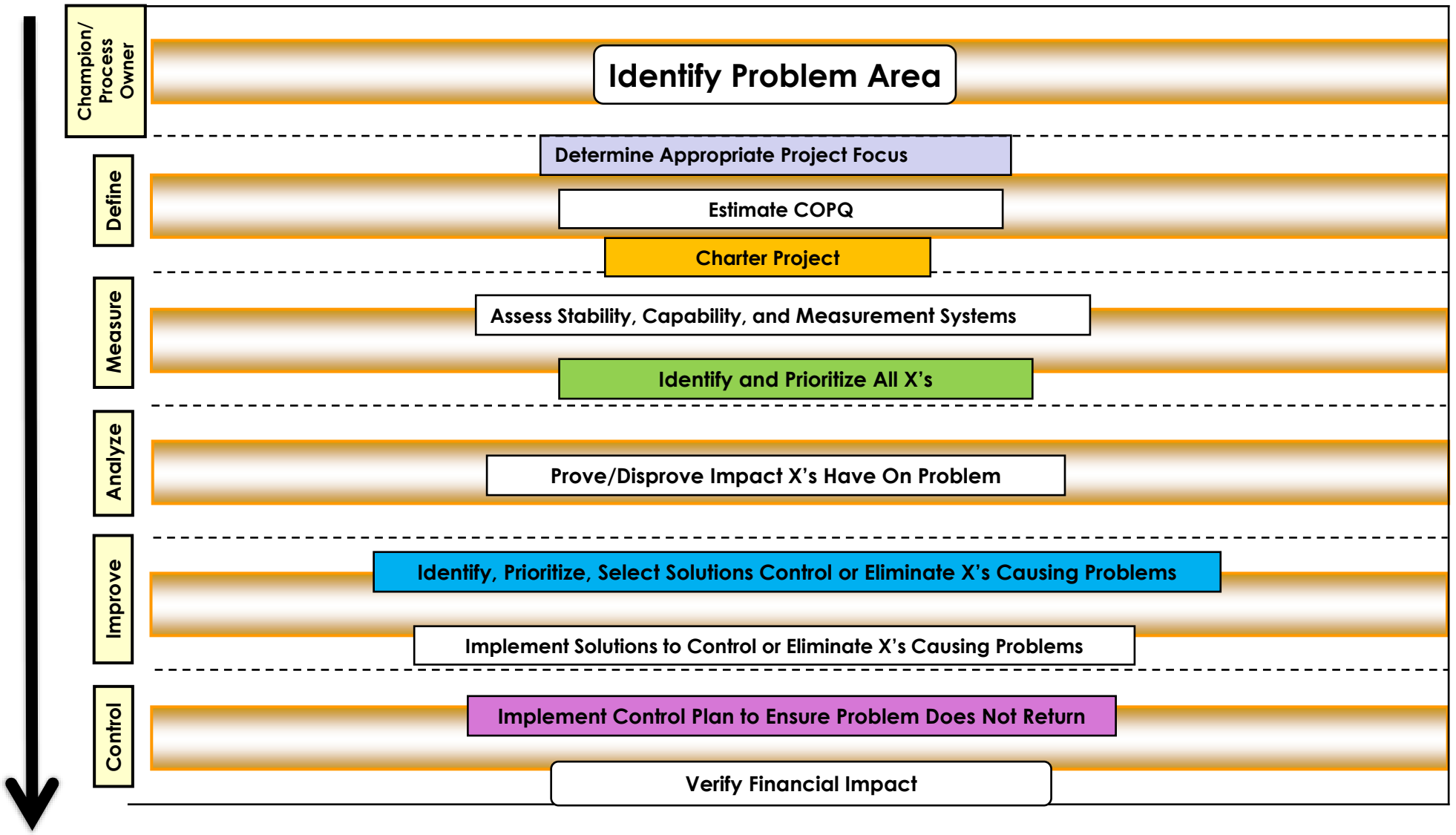
Lean Six Sigma combines the strengths of the two systems:

- **Lean**
  - Guiding principles based operating system
  - Relentless elimination of all waste
  - Creation of process flow and demand pull
  - Resource optimization
  - Simple and visual

- **Six Sigma**
  - Focus on voice of the customer
  - Data and fact based decision making
  - Variation reduction to near perfection levels
  - Analytical and statistical rigor

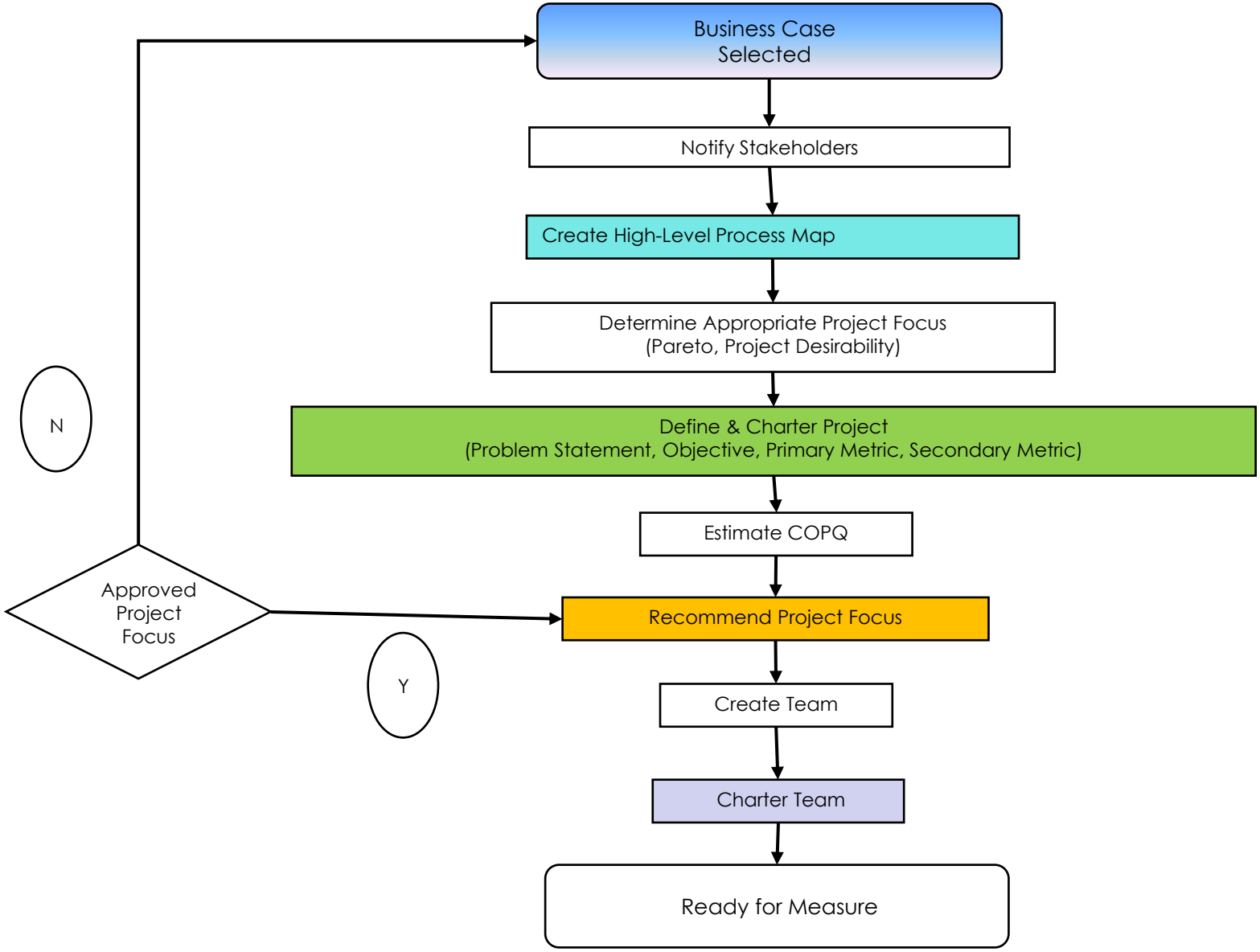
Strength: Efficiency ***Strength: Effectiveness***

An Extremely Powerful Combination!


Champion/ Process Owner
Identify Problem Area
Define
Determine Appropriate Project Focus
Estimate COPQ
Charter Project
Measure
Assess Stability, Capability, and Measurement Systems
Identify and Prioritize All X's
Analyze
Prove/Disprove Impact X's Have On Problem
Improve
Identify, Prioritize, Select Solutions Control or Eliminate X's Causing Problems
Implement Solutions to Control or Eliminate X's Causing Problems
Control
Implement Control Plan to Ensure Problem Does Not Return
Verify Financial Impact

Define Phase

Define Phase Deployment



Define Questions

Step One: Project Selection, Project Definition And Stakeholder Identification

Project Charter

- What is the problem statement? Objective?
- Is the business case developed?
- What is the primary metric?
- What are the secondary metrics?
- Why did you choose these?
- What are the benefits?
- Have the benefits been quantified? It not, when will this be done?
  Date:_____
- Who is the customer (internal/external)?
- Has the COPQ been identified?
- Has the controller's office been involved in these calculations?
- Who are the members on your team?
- Does anyone require additional training to be fully effective on the team?

Voice of the Customer (VOC) and SIPOC defined

- Voice of the customer identified?
- Key issues with stakeholders identified?
- VOC requirements identified?
- Business Case data gathered, verified and displayed?

Step Two: Process Exploration

Processes Defined and High Level Process Map

- Are the critical processes defined and decision points identified?
- Are all the key attributes of the process defined?
- Do you have a high level process map?
- Who was involved in its development?

General Questions

- Are there any issues/barriers that prevent you from completing this phase?
- Do you have adequate resources to complete the project?
- Have you completed your initial Define report out presentation?

Quality function deployment for customer requirements

VOC Prioritized Comments	*VOC Prioritization Rating*	*Process Requirements*	CCR #1	CCR #2	CCR #3	CCR #4	CCR #5	CCR #6	Totals "What Importance"					
										1	2	3	4	5
VOC 1	0		0	0	0	0	0	0	0					
VOC 2	0		0	0	0	0	0	0	0					
VOC 3	0		0	0	0	0	0	0	0					
VOC 4	0		0	0	0	0	0	0	0					
VOC 5	0		0	0	0	0	0	0	0					
VOC 6	0		0	0	0	0	0	0	0					
VOC 7	0		0	0	0	0	0	0	0					
VOC 8	0		0	0	0	0	0	0	0					
VOC 9	0		0	0	0	0	0	0	0					
VOC 10	0		0	0	0	0	0	0	0					
VOC 11	0		0	0	0	0	0	0	0					
VOC 12	0		0	0	0	0	0	0	0					
VOC 13	0		0	0	0	0	0	0	0					
VOC 14	0		0	0	0	0	0	0	0					
VOC 15	0		0	0	0	0	0	0	0					
Totals "How Importance"			**0**	**0**	**0**	**0**	**0**	**0**						

COPQ - Iceberg

Inspection

Warranty

Recode

Rework

Rejects

Visible Costs

Engineering change orders

Lost sales

Time value of money

Late delivery

Expediting costs

More Set-ups

Excess inventory

Working Capital allocations

Long cycle times

Excessive Material Orders/Planning

Hidden Costs

Lost Customer Loyalty

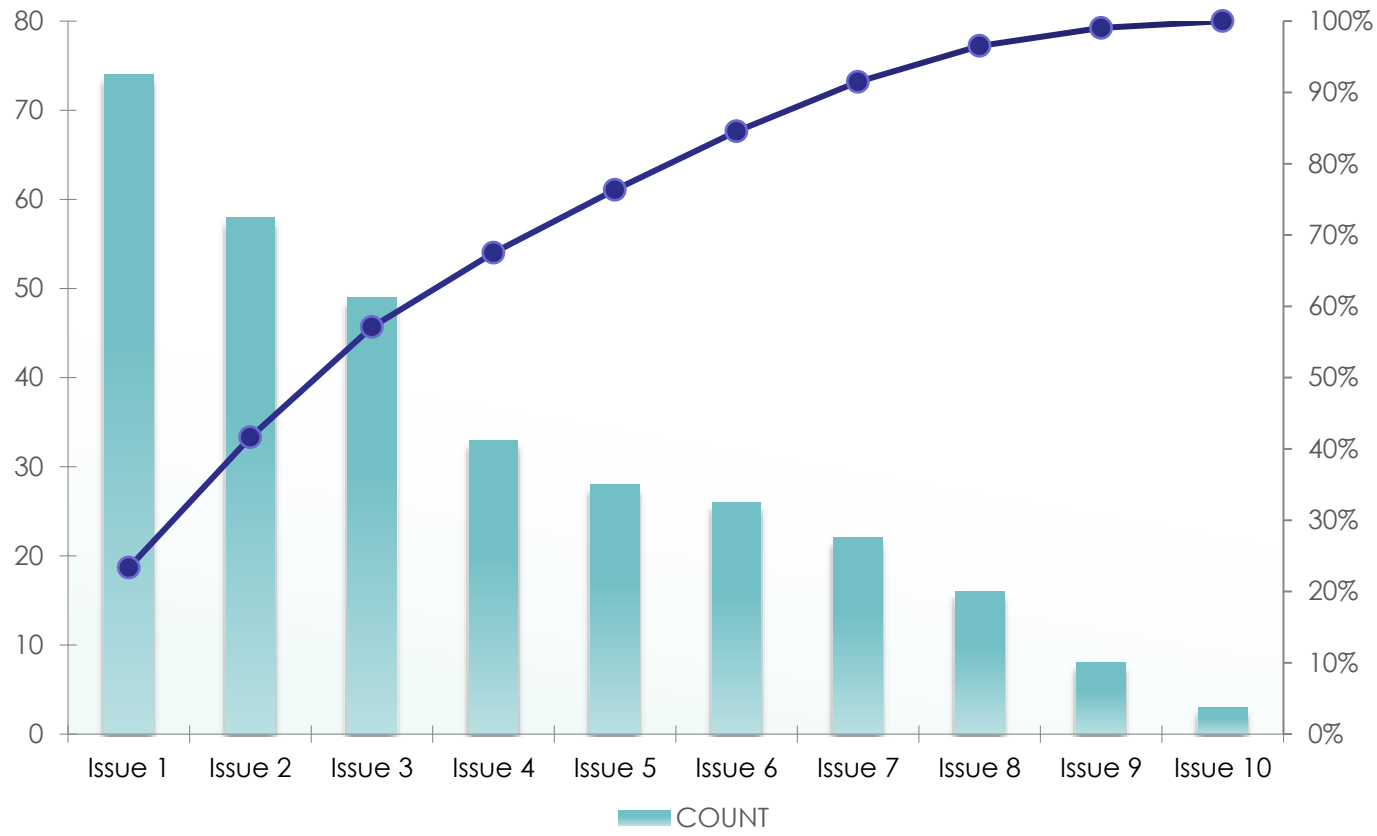
Parteto analysis tool for prioritization

PARETO CHART TEMPLATE

The Pareto principle states that, for many events, roughly 80% of the effects come from 20% of the causes.

SORT DATA DESCENDING / HIGH-TO-LOW

CAUSE	EFFECT	CUMULATIVE PERCENTAGE
CATEGORY / DESCRIPTION	COUNT	
Issue 1	74	23%
Issue 2	58	42%
Issue 3	49	57%
Issue 4	33	68%
Issue 5	28	76%
Issue 6	26	85%
Issue 7	22	91%
Issue 8	16	97%
Issue 9	8	99%
Issue 10	3	100%



Muda is classified into seven components:

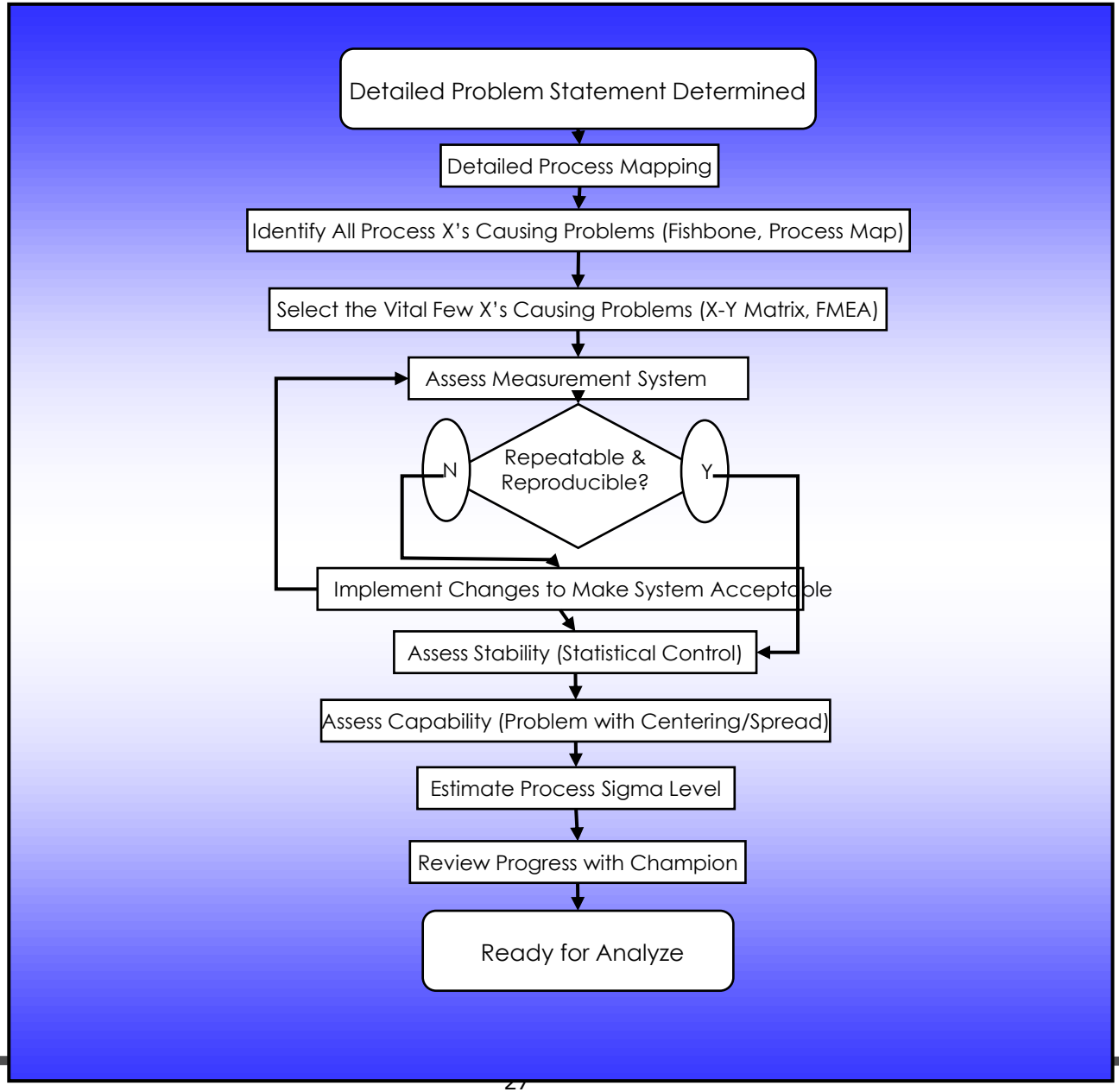
- Overproduction
- Correction (defects)
- Inventory
- Motion
- Overprocessing
- Conveyance
- Waiting

Sometimes additional forms of muda are added:

- Under use of talent
- Lack of safety

Being Lean means eliminating waste.

Measure Phase


Detailed Problem Statement Determined
Detailed Process Mapping
Identify All Process X's Causing Problems (Fishbone, Process Map)
Select the Vital Few X's Causing Problems (X-Y Matrix, FMEA)
Assess Measurement System
N
Repeatable & Reproducible?
Y
Implement Changes to Make System Acceptable
Assess Stability (Statistical Control)
Assess Capability (Problem with Centering/Spread)
Estimate Process Sigma Level
Review Progress with Champion
Ready for Analyze

Measure Questions

Identify critical X's and potential failure modes

- Is the "as is" Process Map created?
- Are the decision points identified?
- Where are the data collection points?
- Is there an analysis of the measurement system?
- Where did you get the data?

Identify critical X's and potential failure modes

- Is there a completed X-Y Matrix?
- Who participated in these activities?
- Is there a completed FMEA?
- Has the Problem Statement changed?
- Have you identified more COPQ?

Stability Assessment

- is the "Voice of the Process" stable?
- If not, have the special causes been acknowledged?
- Can the good signals be incorporated into the process?
- Can the bad signals be removed from the process?
- How stable can you make the process?

Capability Assessment

- What is the short-term and long-term Capability of the process?
- What is the problem, one of centering, spread or some combination?

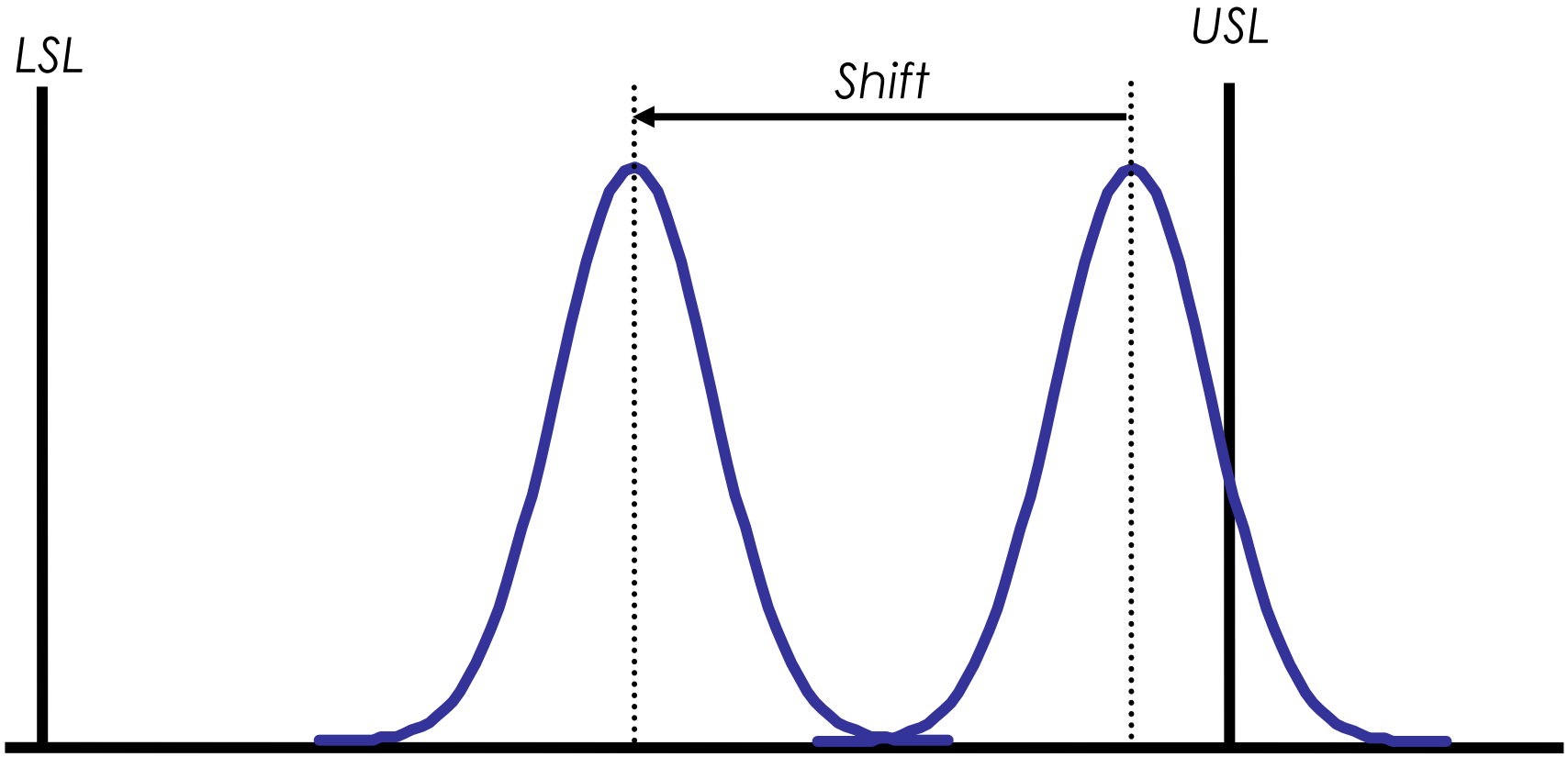
General Questions

- Are there any issues or barriers that prevent you from completing this phase?
- Do you have adequate resources to complete the project?

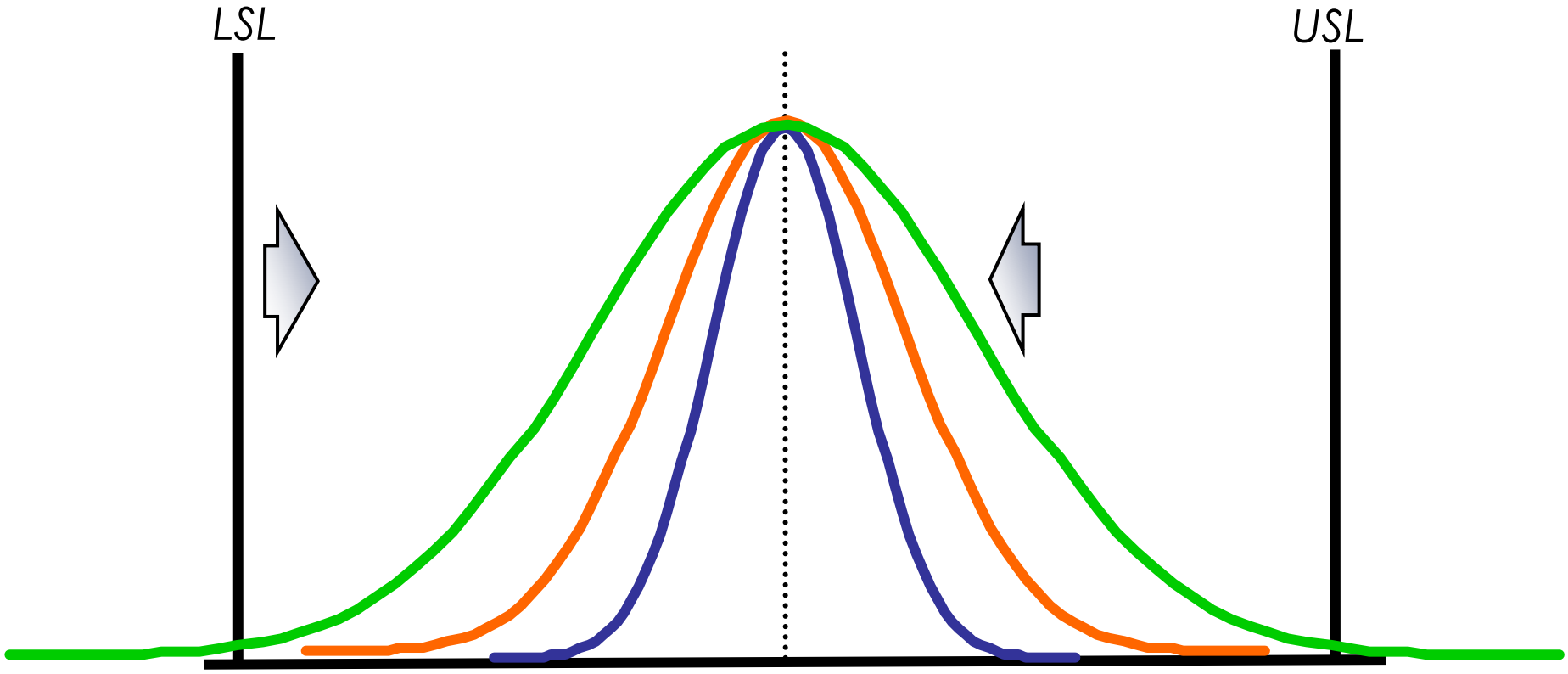
SIPOC DIAGRAM TEMPLATE

S	SUPPLIERS	I	INPUT	P	PROCESS	O	OUTPUT	C	CUSTOMER
	who is providing input to a process		resource provided by supplier for incorporation to process		steps taken to convert input to output		resource resulting from process		receiver of newly created output
SUPPLIERS		INPUT		PROCESS		OUTPUT		CUSTOMER	
				1					
				2					
				3					
				4					
				5					
				6					
				7					
				8					

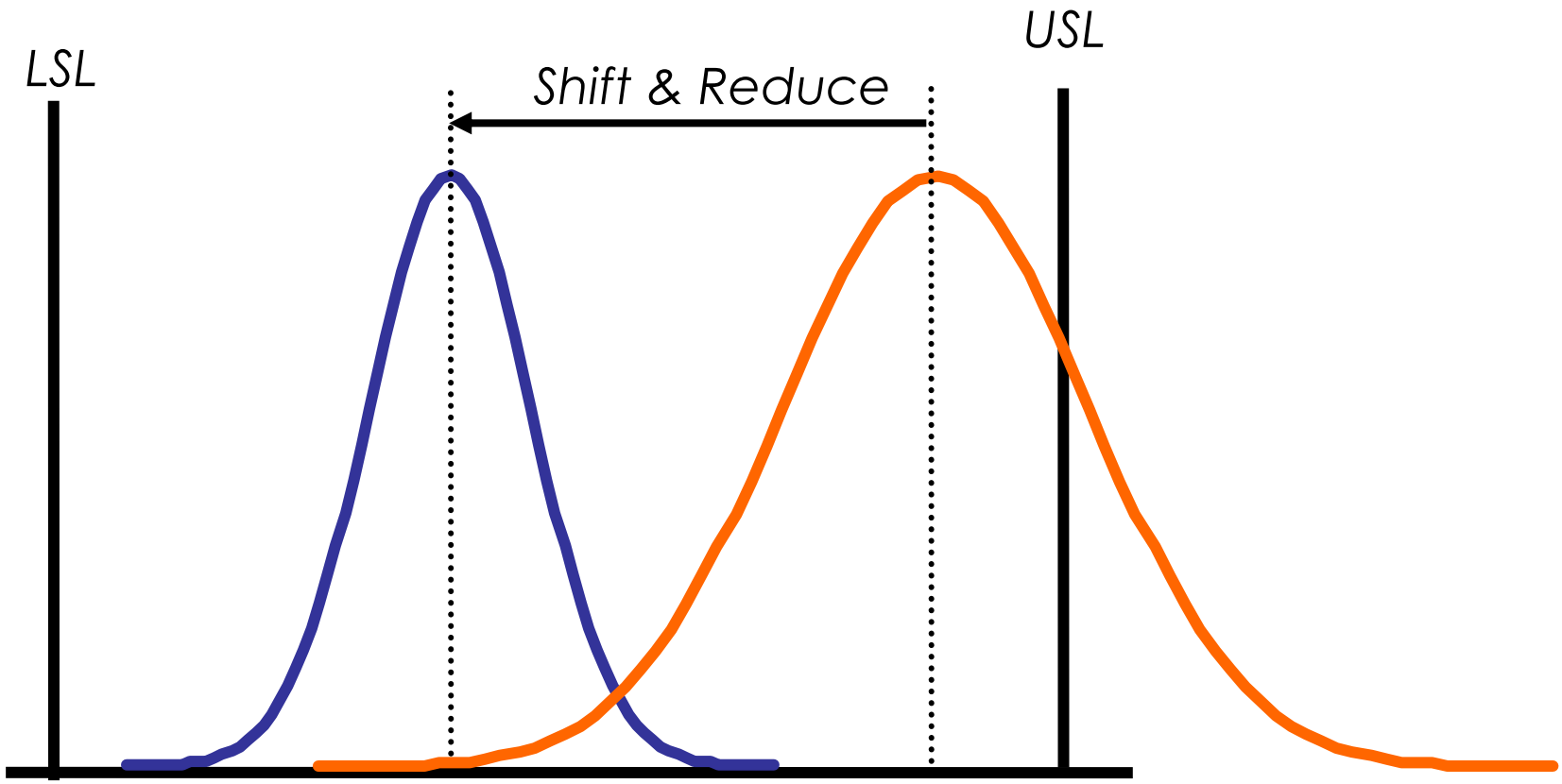
This involves finding the variables that will shift the process over to the target. This is usually the easiest option.



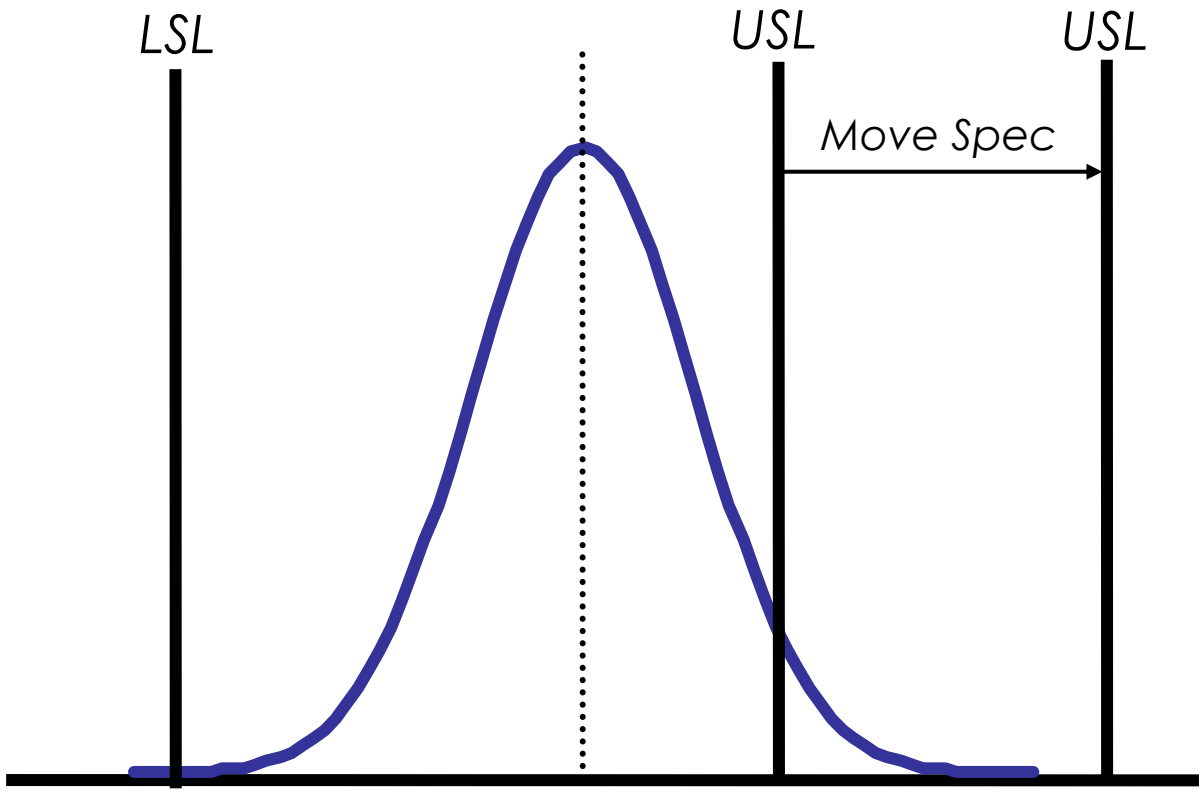
This is typically not so easy to accomplish and occurs often in Six Sigma projects.

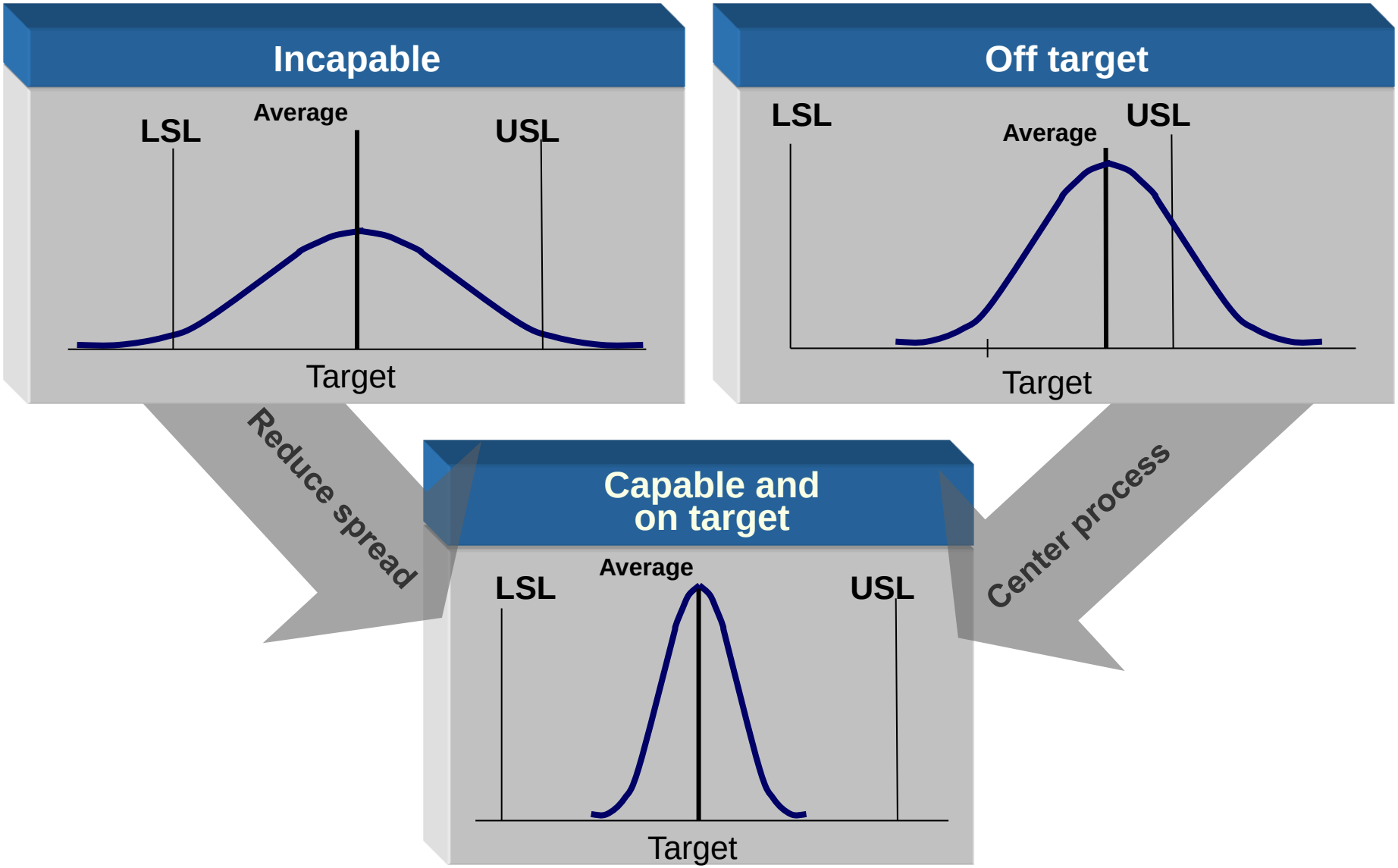


This occurs often in Six Sigma projects.

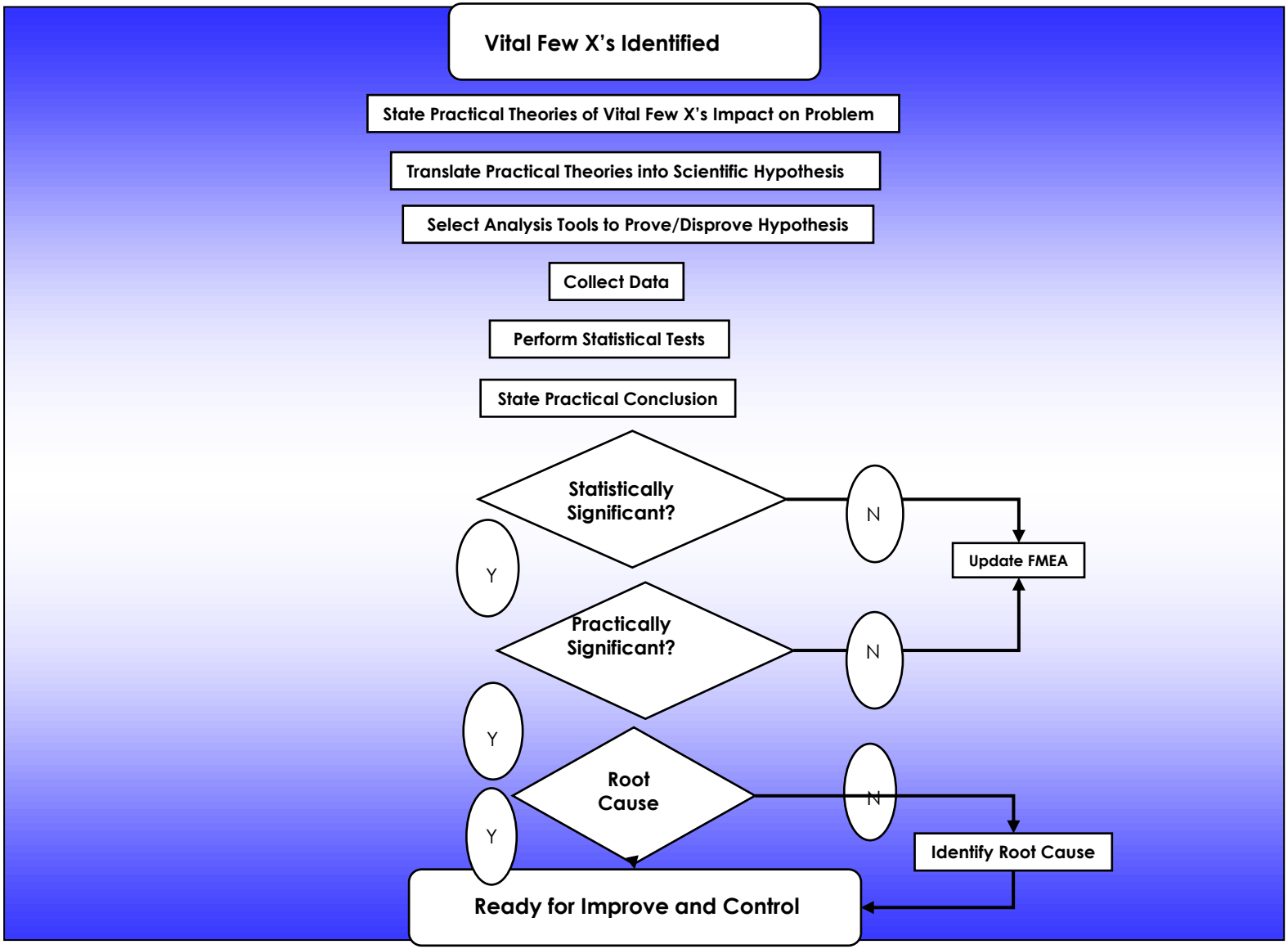


Obviously this implies making them wider, not narrower. Customers usually do not go for this option but if they do…it's the easiest!




Incapable
LSL
Average
USL
Target
Off target
LSL
Average
USL
Target
Reduce spread
Capable and on target
LSL
Average
USL
Target
Center process

Analyze Phase


Vital Few X's Identified
State Practical Theories of Vital Few X's Impact on Problem
Translate Practical Theories into Scientific Hypothesis
Select Analysis Tools to Prove/Disprove Hypothesis
Collect Data
Perform Statistical Tests
State Practical Conclusion
Statistically Significant?
N
Update FMEA
Y
Practically Significant?
N
Y
Root Cause
N
Identify Root Cause
Y
Ready for Improve and Control

Analyze Questions

Define Performance Objectives Graphical Analysis

- Is existing data laid out graphically?
- Are there newly identified secondary metrics?
- Is the response discrete or continuous?
- Is it a Mean or a variance problem or both?

Document Potential X's Root Cause Exploration

- Are there a reduced number of potential X's?
- Who participated in these activities?
- Are the number of likely X's reduced to a practical number for analysis?
- What is the statement of Statistical Problem?
- Does the process owner buy into these Root Causes?

Analyze Sources of Variability Statistical Tests

- Are there completed Hypothesis Tests?
- Is there an updated FMEA?

General Questions

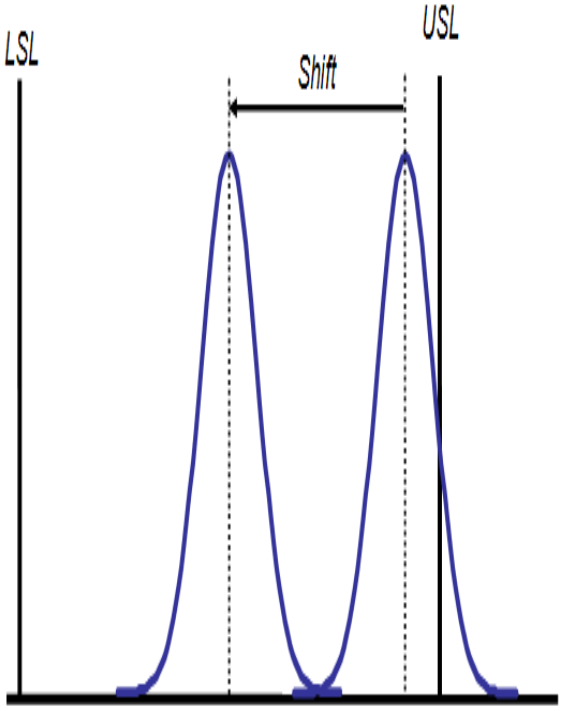
- Are there any issues or barriers that prevent you from completing this phase?
- Do you have adequate resources to complete the project?

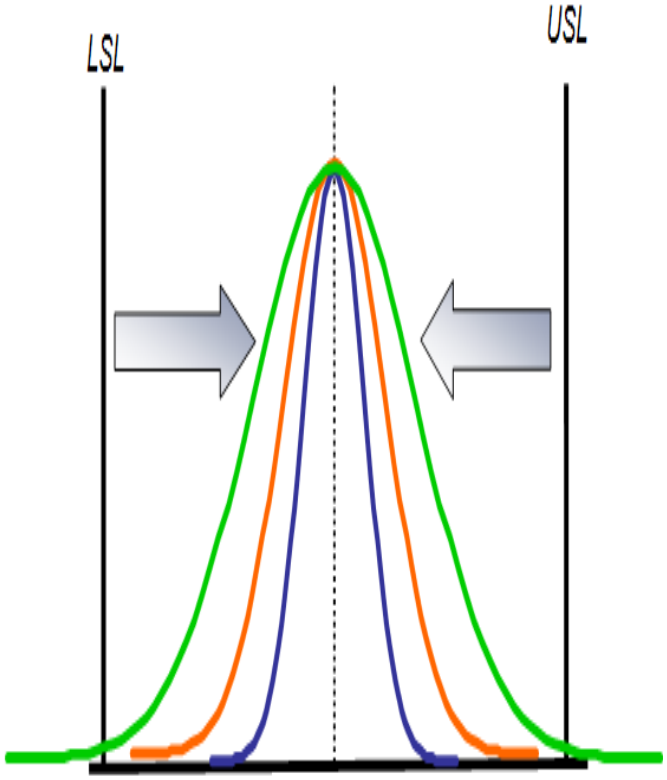
WHAT	WHO	WHEN	WHY	WHY NOT	HOW
Qualitative screening of vital from controllable trivial X's					
Qualitative screening for other factors					
Quantitative screening of vital from controllable trivial X's					
Ensure compliance to problem solving strategy					
Quantify risk of meeting needs of customer, business and people					
Predict risk of sustainability					
Chart a plan to accomplish desired state of culture					
Assess shift in process location					
Minimize risk of process failure					
Modeling Continuous or Non Continuous Output					
Achieving breakthrough in Y with minimum efforts					
Validate Financial Benefits					

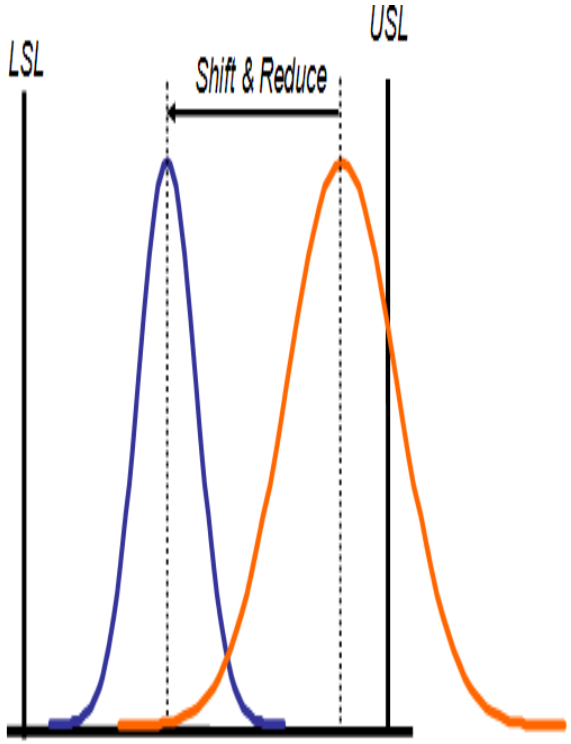
Mean Shift

Variation Reduction

Both

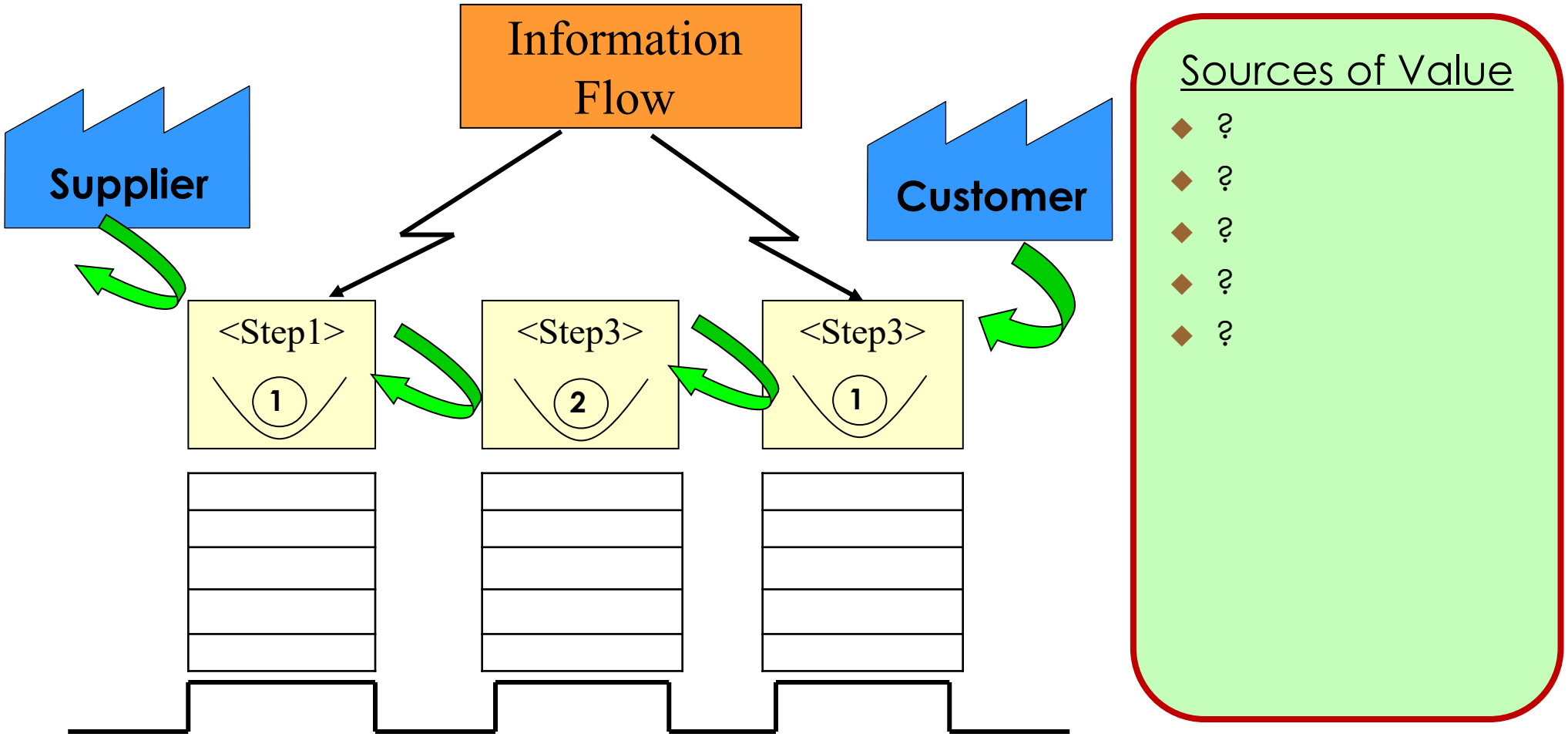






Improve Phase

Value Stream Map (VSM) Future State



Business Impact

	Annual Estimate	Replicated Estimate
Revenue Enhancement	• Type 1: ? • Type 2: ? • Type 3: ?	• Type 1: ? • Type 2: ? • Type 3: ?
Expenses Reduction	• Type 1: ? • Type 2: ? • Type 3: ?	• Type 1: ? • Type 2: ? • Type 3: ?
Loss Reduction	• Type 1: ? • Type 2: ? • Type 3: ?	• Type 1: ? • Type 2: ? • Type 3: ?
Cost Avoidance	• Type 1: ? • Type 2: ? • Type 3: ?	• Type 1: ? • Type 2: ? • Type 3: ?
Total Savings	• Type 1: ? • Type 2: ? • Type 3: ?	• Type 1: ? • Type 2: ? • Type 3: ?

Improve Summary

Root causes	Proof of causation	Practical solution	Operating tolerance

Solution Selection Criteria

How the solution was determined:

- What was the solution selection tool used?
- What project management tools were used?
- Cost/benefit analysis?
- Include any other tools or methods used

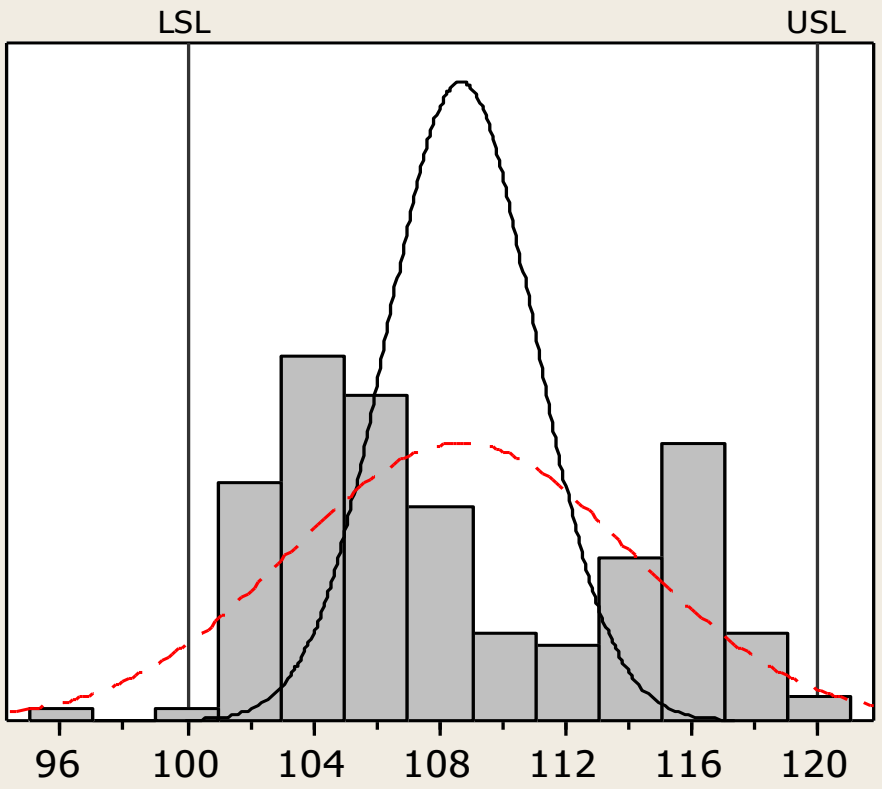
Pilot and Implementation Plan

1. ?
2. ?
3. ?
4. ?
5. ?

#					Timeline				
	Priority	Task (Action Item)	Assigned	Status	Start Date	Due Date	Resources Required	Cost	Notes
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Process Capability of Process Before

Process Data	
LSL	100.00000
Target	*
USL	120.00000
Sample Mean	108.65832
Sample N	150
StDev(Within)	2.35158
StDev(Overall)	5.41996



Within
Overall

Potential (Within) Capability	
Cp	1.42
CPL	1.23
CPU	1.61
Cpk	1.23
CCpk	1.42

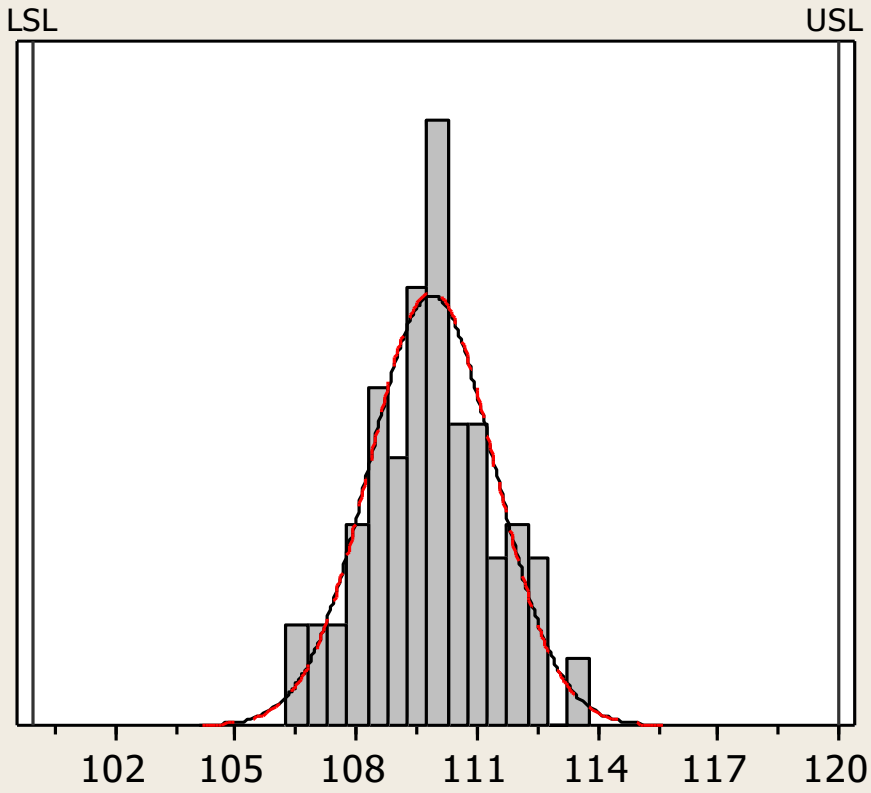
Overall Capability	
Pp	0.62
PPL	0.53
PPU	0.70
Ppk	0.53
Cpm	*

Observed Performance	
PPM < LSL	6666.67
PPM > USL	0.00
PPM Total	6666.67

Exp. Within Performance	
PPM < LSL	115.74
PPM > USL	0.71
PPM Total	116.45

Exp. Overall Performance	
PPM < LSL	55078.48
PPM > USL	18193.49
PPM Total	73271.97

Process Capability of Process After



Process Data	
LSL	100.00000
Target	*
USL	120.00000
Sample Mean	109.86078
Sample N	100
StDev(Within)	1.55861
StDev(Overall)	1.54407

Within
Overall

Potential (Within) Capability	
Cp	2.14
CPL	2.11
CPU	2.17
Cpk	2.11
CCpk	2.14

Overall Capability	
Pp	2.16
PPL	2.13
PPU	2.19
Ppk	2.13
Cpm	*

Observed Performance	
PPM < LSL	0.00
PPM > USL	0.00
PPM Total	0.00

Exp. Within Performance	
PPM < LSL	0.00
PPM > USL	0.00
PPM Total	0.00

Exp. Overall Performance	
PPM < LSL	0.00
PPM > USL	0.00
PPM Total	0.00

Control Phase

Project RACI Chart

Step	Action/Task	Responsible	Accountable	Consulted	Informed
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Continuous improvement project key roles and responsibilities

Project Selection	D-M-A-I-C	Implementation	3 Months Audit 6 Months Audit
Financial Representative	Financial Representative	Financial Representative	Financial Representative
Champion & Process Owner	Black Belt	Champion & Process Owner	Process Owner

Continuous Improvement projects achieved in other companies :

#	Project name	Project issue	Project type	Project out put
1	Nails factory - Sudan Mint Complex	Reaching target failure(M/C downtime)	Six sigma (variation reduction) pr.	Increased of daily production from 1.25/day tons up to 3 tons/day
2	GIAD AUTO AFTER SALES SERVICE COMPANY	Delay in service delivery	Lean (total flow management) pr.	Reduction of delivery time from 3 days to 45 minutes
3	Ammunition factory	Quality percentage not reached	Six sigma (variation reduction) pr.	Quality increased from 67% to 80%
4	GIAD STEEL FACTORY	Lower production rate	Six sigma (variation reduction) pr.	Increased of daily production from 4.5/day tons up to 9tons/day