Lean Six Sigma Overview

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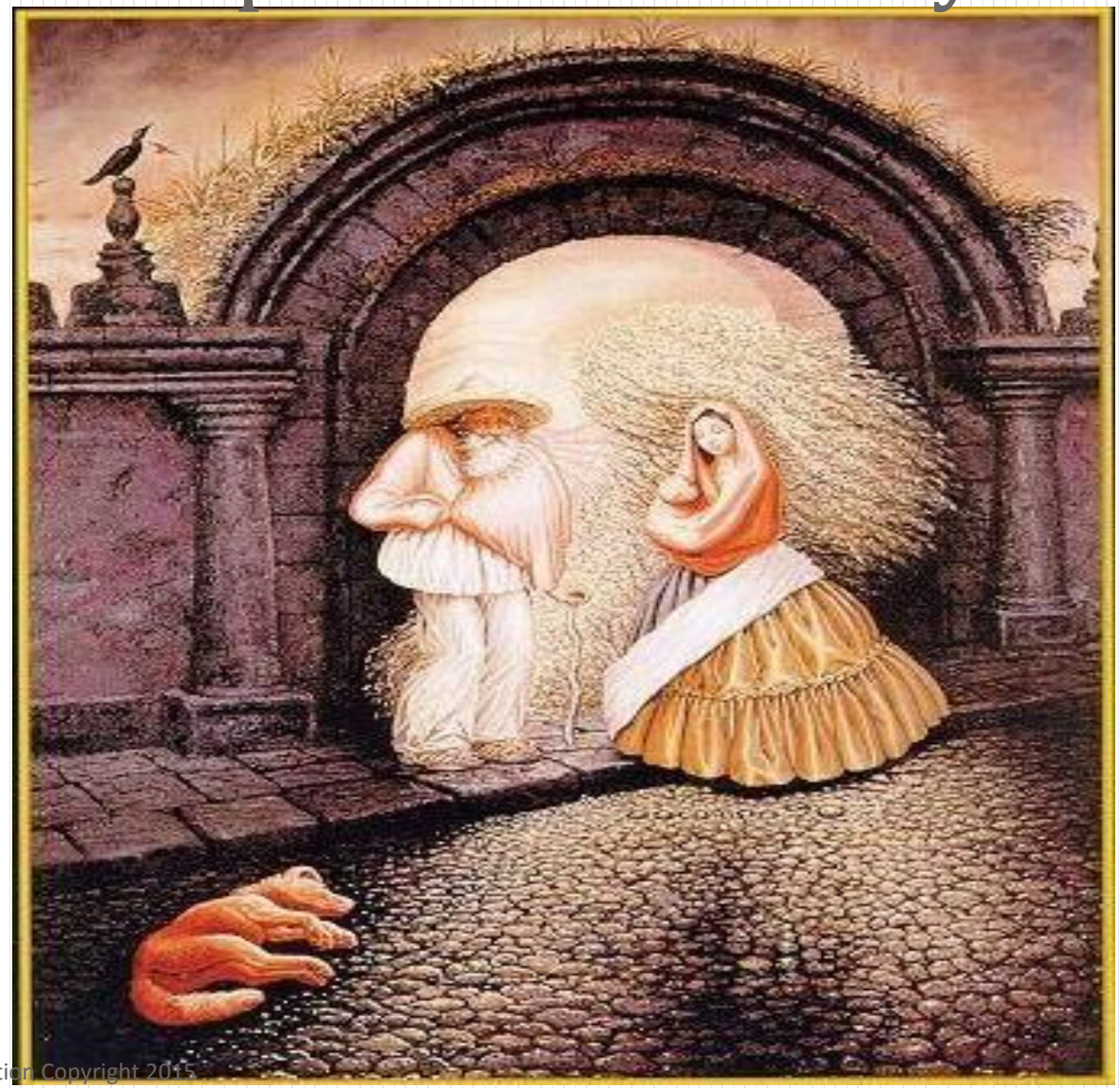
Learning Objectives

Upon successful completion of this module, the student should be able to:

- Understand the need for process improvement
- Understand Lean Basics
- Understand Six Sigma Basics
- Understand Theory of Constraints (TOC) Basics

Seeing Workplaces Differently

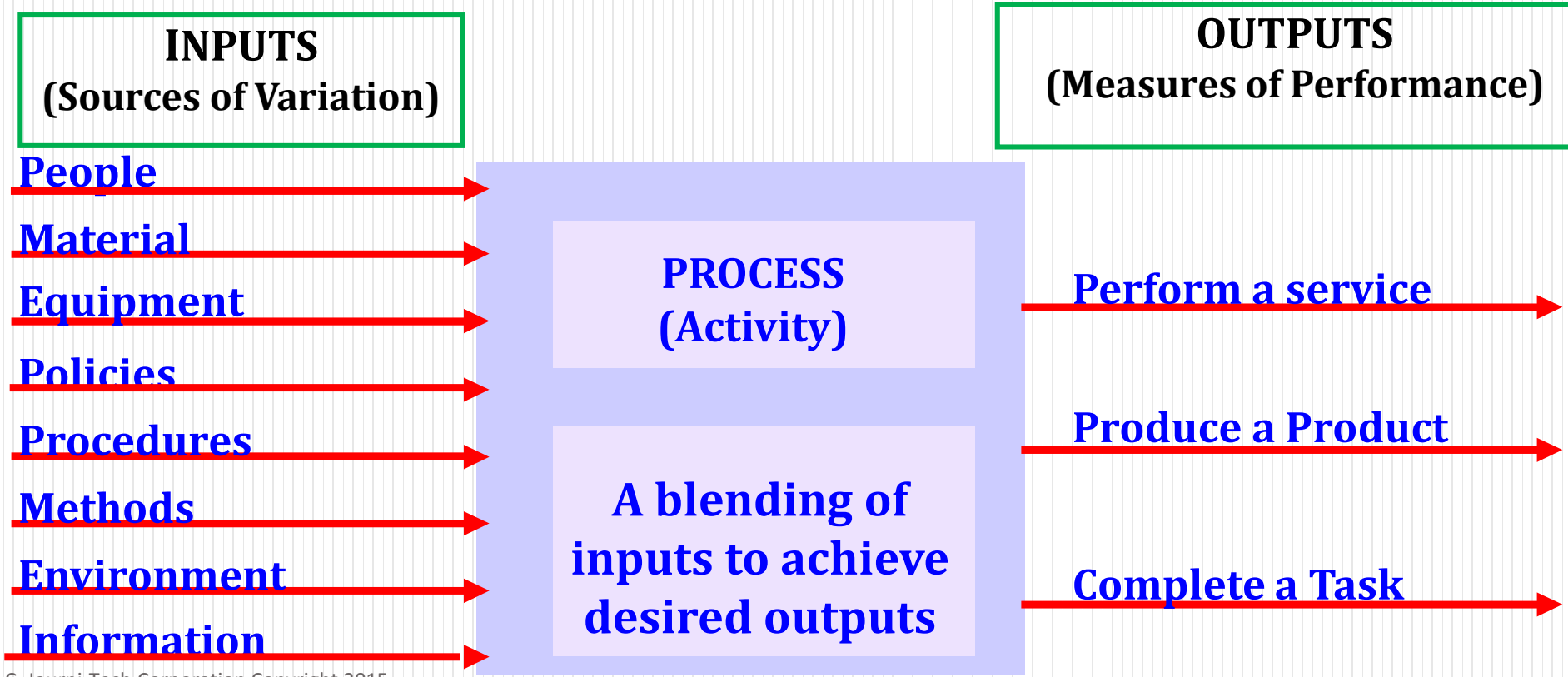
How many faces?



Where?

What is a Process?

- **Processes:** A group of related tasks executed in a structured manner with common **inputs** and **outputs** that can be performed repeatedly to support an organizational goal.

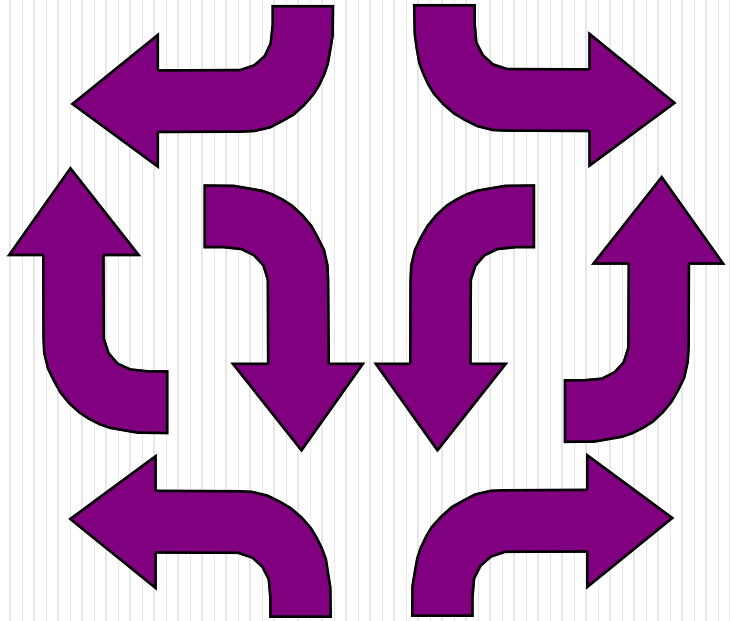


Process Improvements Using LSS

- Means making things better
- Setting aside the customary practice of blaming people for problems or failures
- It is a way of looking at how we can do our work better
- Understanding the root cause of the difficulty

What Drives Poor Performance?

- Waste – any non-value added step in a process defined by the Customer
- Variation - anything that causes process outputs to not perform at their nominal value

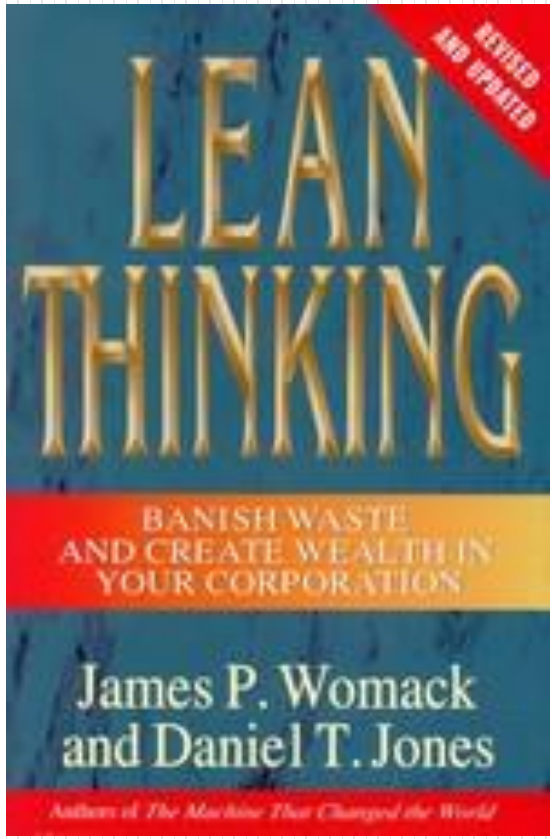


Change Management

INSANITY=

Doing what you've always done and expecting different results

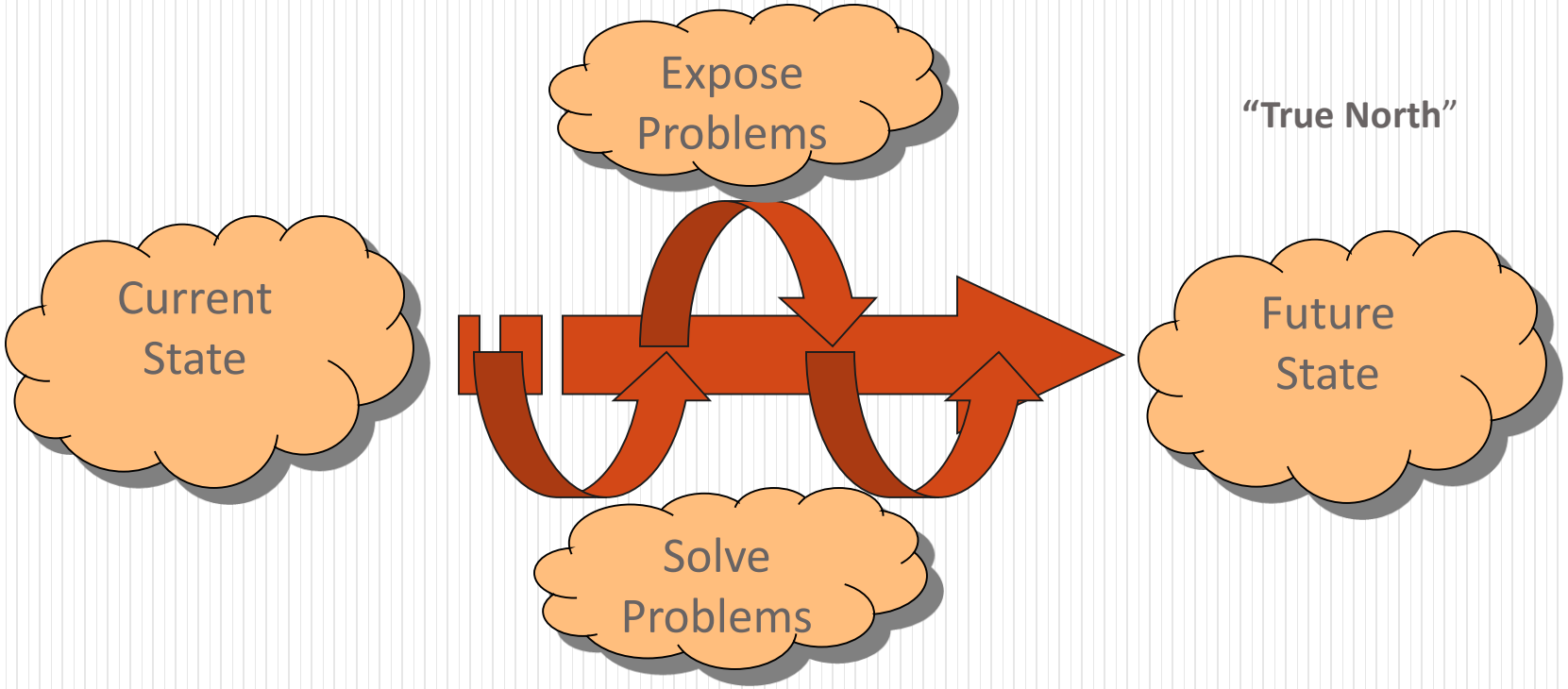
Lean Principles



- Specify *Value* from the Customer's Perspective
- Map & Analyze the *Value Streams*
- Make the Value Streams *Flow*
- Enable the Customer to *Pull*
- Value from the Value Streams
- Seek Perfection

Lean Thinking, Womack and Jones, 2nd Edition, 2003

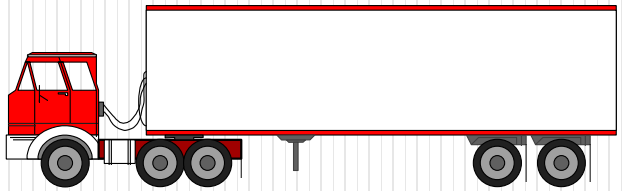
Lean Thinking Philosophy



Compete against perfection by identifying all activities that are waste and eliminating them. This is an absolute rather than a relative standard.

TIM WOOD (Waste)

Transportation



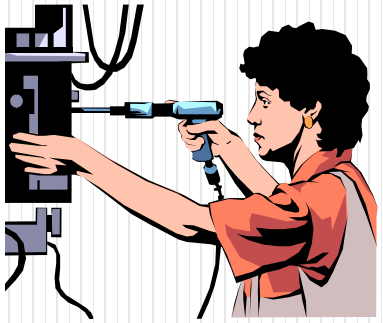
Inventory

Motion

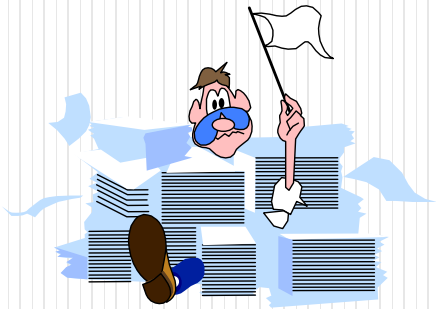
Seven *Wastes*

Waiting

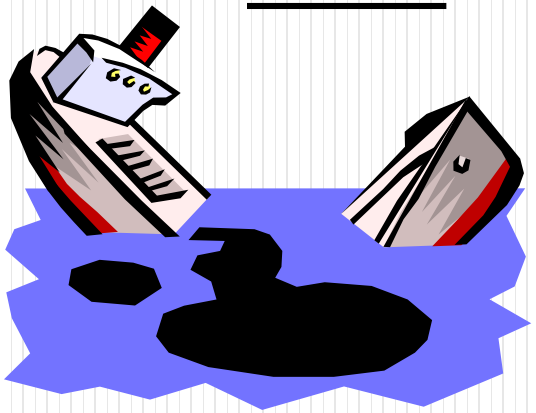
Over-processing



Overproduction

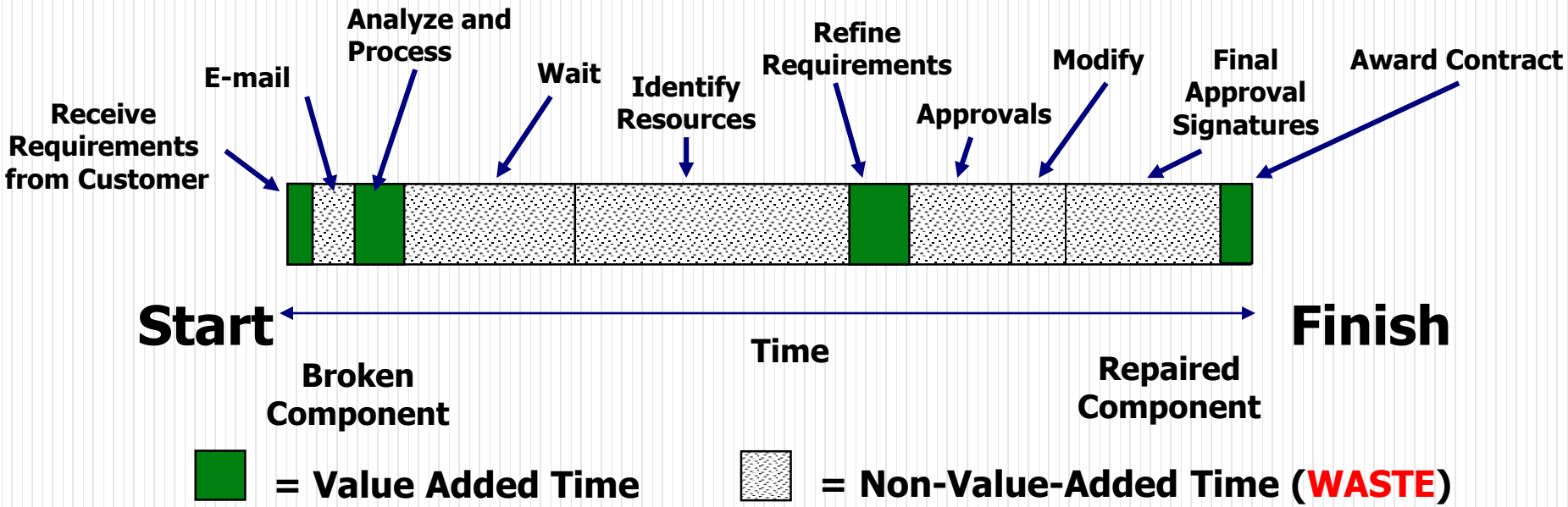


Defects



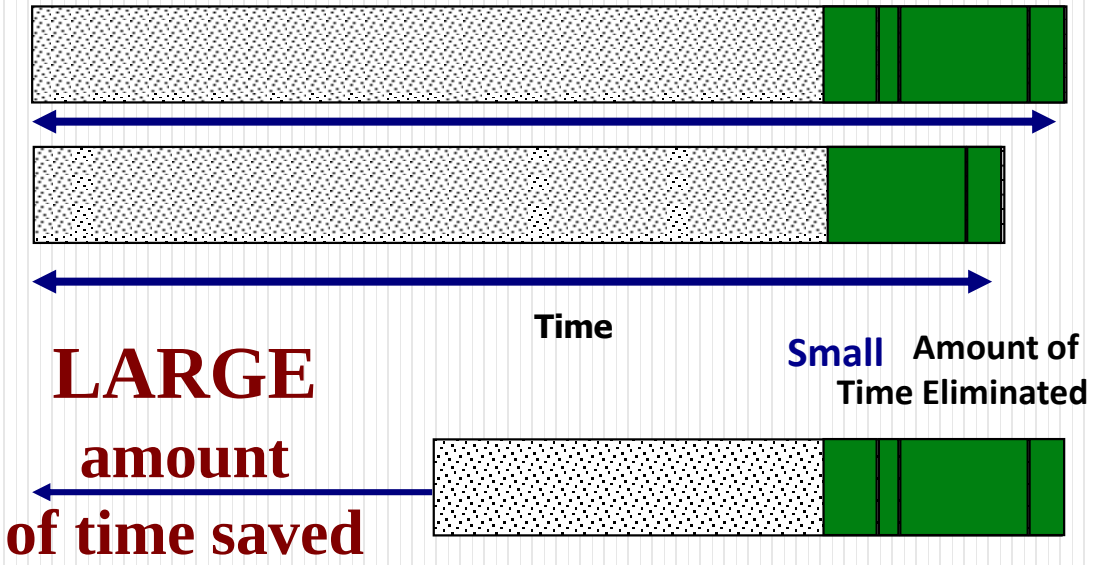
Value of Time

Within the 7 wastes, time is a significant factor



Value-Added time is only a very small percentage of the total time

The Value of Time



Traditional Focus

- Improve Value-Added work steps
- Better tools, machines, instructions
- Result: Small time savings

Lean Focus

- Make all of the Value Stream visible
- Reduce or eliminate Non-Value-Added portions of the process
- Result: Large time savings

Note: The focus is not on the value-added steps or the people performing them.
Instead, the focus is to remove barriers and better support the people doing the work!

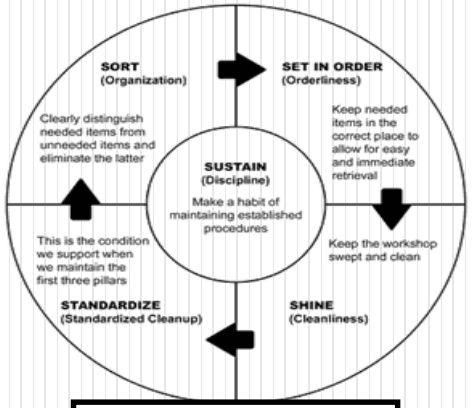
Workplace Organization (5S)

Sort

Simplify

5S

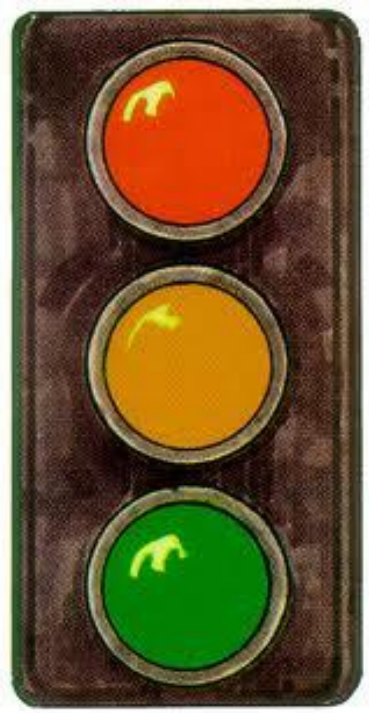
Sustain



Standardize

Shine

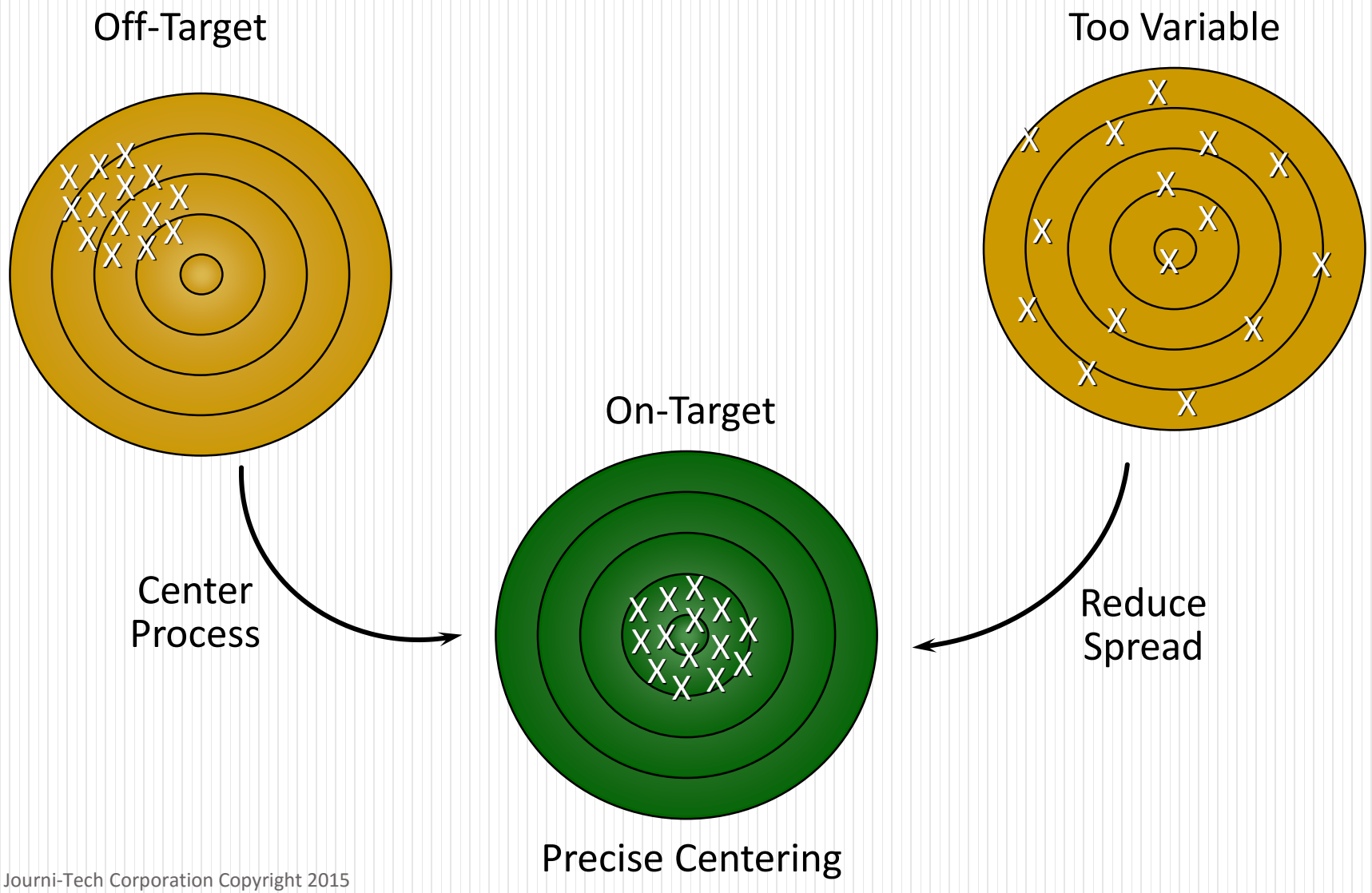
Lean Thinking: Color Codes



- Red = Waste that can be eliminated
- Yellow = Required by business or regulation as either an input or output, but not directly giving the customer/client direct value
- Green = Value-Added (Customer Viewpoint)
  - Customer willing to Pay for it
  - It changes Form/Fit/Function of product or service
  - Done Right the first time

"These are your 3 favorite colors moving forward in Lean Practices"

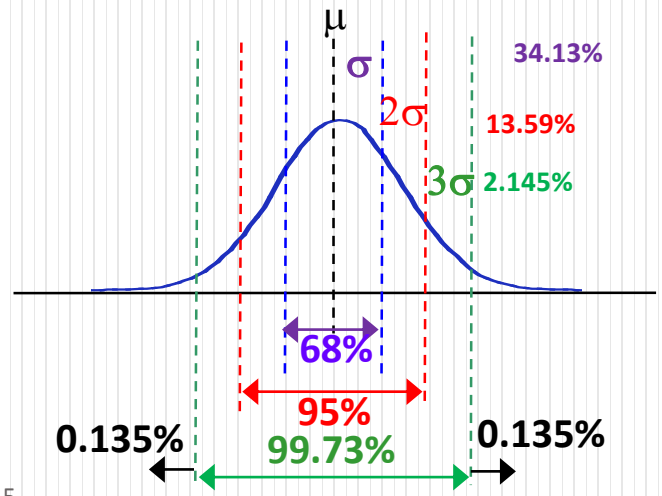
Six Sigma Focuses on Variation Elimination



Six Sigma Defined

- Sigma is the 18th letter in the Greek alphabet (σ)
  - Describes variability (spread or standard deviation) of data from mean
- Sigma Quality Level measures process performance with respect to customer requirements (specifications) → Higher Sigma = Higher Quality
- Six Sigma methodology provides the ability to "predict" process performance
- Six Sigma methodology provides a benchmark to determine if actions have produced results

Distributions can be linked to probability – making possible predictions of outcome or evaluation of the odds of an occurrence being "unusual"

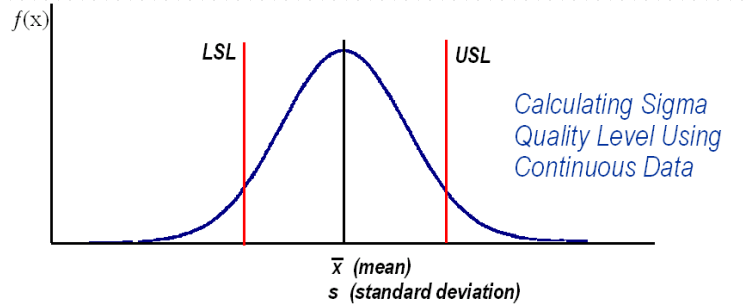


In a normal distribution, the number of standard deviations from the mean tells us the percent distribution of the data and thus the probability of occurrence

Sigma Quality Level Defined

There are two ways to calculate Six Sigma Quality Level (SQL):

- Mean, Standard deviation, and Specification limits



Sigma Quality Level (SQL) = The distance between average performance and specification limits divided by the standard deviation

$$\text{Sigma Quality Level (SQL)} = Min\left[\frac{USL - \bar{x}}{s} \text{ or } \frac{\bar{x} - LSL}{s}\right]$$

- Defects Per Opportunity

Yield	DPMO	Sigma
99.4%	6,210	4
99.5%	4,660	4.1
99.7%	3,460	4.2
99.9992%	8	5.8
99.9995%	5	5.9
99.99966%	3.4	6

Calculating Sigma Quality Level using Discrete Data

Mean – Standard Deviation – Spec Limits

- Mean – average of all entries under consideration obtained by adding all values and dividing by the number of entries
  - 1, 2, 3, 4, 5, 6, 7, 8, 9 = 45/9 = 5
- Standard Deviation – the average distance between an individual data point and the Mean
  - Population → $\sigma = \sqrt{\frac{\sum(X-\mu)^2}{N}}$
  - Sample (of population) → $S = \sqrt{\frac{\sum_{i=1}^{1}(xi-\bar{X})^2}{n-1}}$
- Specification Limits (Upper and Lower)
  - Is the limits of what is acceptable as defined by the customer

How to Calculate Sigma Quality Level Using Statistics

Data Set of the Sample of the Population: {1, 1, 2, 5, 6}

- Mean ($\bar{X}$)= 1+1+2+5+6= 15/5 = 3
- Standard Deviation of the Sample of the Population
  - $S = \sqrt{\frac{\sum_{i=1}^{1}(xi-\bar{X})^2}{n-1}} = \sqrt{\frac{22}{5-1}} = \sqrt{5.5} =$ 2.35
- Specification Limits
  - Upper Specification Limits (USL) = 5
  - Lower Specification Limits (LSL) = 2
- Sigma Level

$$\text{MIN}\left(\frac{USL-\bar{X}}{S} \; or \; \frac{\bar{X}-LSL}{S}\right)$$

$$\text{MIN}\left(\frac{5-3}{2.35} = 0.85 \text{ or } \frac{3-2}{2.35} = 0.43\right)$$

n (Sample Size)	X	$(X-\bar{X})$	$(X-\bar{X})^2$
n=5	1	1-3 = -2	$(-2)^2 = 4$
	1	1-3 = -2	$(-2)^2 = 4$
	2	2-3 = -1	$(-1)^2 = 1$
	5	5-3 = 2	$(2)^2 = 4$
	6	6-3 = 3	$(3)^2 = 9$
Total	15	0	22

NOTE: When computing Sigma level do both equations and pick the lowest number: Six Sigma Level in this example is 0.43

How to Calculate Sigma Quality Level Using DPO

Steps	Equation	Example
1. Determine number of defect opportunities per unit	O	2
2. Determine number of units processed	U	5
3. Determine total number of defects made	D	1
4. Calculate Defects per Opportunity	$DPU=\frac{D}{U\ X\ O}$	$DPU=\frac{1}{5*2}=0.1$
5. Calculate Yield	First Pass Yield = (1-DPO) X 100	(1 - 0.1)* 100 = 90
6. Look up the Sigma Quality Level using the Six Sigma Conversion Table (Round Down)	Process Sigma	2.7

Sigma Quality Level Conversion Table

Yield	DPMO	Sigma
6.6%	934,000	0
8.0%	920,000	0.1
10.0%	900,000	0.2
12.0%	880,000	0.3
14.0%	860,000	0.4
16.0%	840,000	0.5
19.0%	810,000	0.6
22.0%	780,000	0.7
25.0%	750,000	0.8
28.0%	720,000	0.9
31.0%	690,000	1
35.0%	650,000	1.1
39.0%	610,000	1.2
43.0%	570,000	1.3
46.0%	540,000	1.4
50.0%	500,000	1.5
54.0%	460,000	1.6
58.0%	420,000	1.7
61.8%	382,000	1.8
65.6%	344,000	1.9

Yield	DPMO	Sigma
69.2%	308,000	2
72.6%	274,000	2.1
75.8%	242,000	2.2
78.8%	212,000	2.3
81.6%	184,000	2.4
84.2%	158,000	2.5
86.5%	135,000	2.6
88.5%	115,000	2.7
90.3%	96,800	2.8
91.9%	80,800	2.9
93.3%	66,800	3
94.5%	54,800	3.1
95.5%	44,600	3.2
96.4%	35,900	3.3
97.1%	28,700	3.4
97.7%	22,700	3.5
98.2%	17,800	3.6
98.6%	13,900	3.7
98.9%	10,700	3.8
99.2%	8,190	3.9

Yield	DPMO	Sigma
99.4%	6,210	4
99.5%	4,660	4.1
99.7%	3,460	4.2
99.75%	2,550	4.3
99.81%	1,860	4.4
99.87%	1,350	4.5
99.90%	960	4.6
99.93%	680	4.7
99.95%	480	4.8
99.97%	330	4.9
99.977%	230	5
99.985%	150	5.1
99.990%	100	5.2
99.993%	70	5.3
99.996%	40	5.4
99.997%	30	5.5
99.9980%	20	5.6
99.9990%	10	5.7
99.9992%	8	5.8
99.9995%	5	5.9
99.99966%	3.4	6

The Goal of Six Sigma is Six Sigma

σ	DPMO*	Yield
6	**3.4**	**99.9997%**
5	233	99.977%
4	6,210	99.379%
3	66,807	93.32%
2	308,537	69.2%
1	690,000	31%

** Defects Per Million Opportunities*

Descriptive Example

- 1 Mistake in all books of a small library
- 1 Mistake in an encyclopedia set
- 1 Mistake on every 30 pages of a book
- 1.5 Mistake on each page of a book
- 1 Mistake in each paragraph of a book
- 1 Mistake in each sentence of a book

Not every process needs to be at a Six Sigma Quality Level.

DPMO is very valuable in analyzing high traffic volume processes.

DPMO is a ”fair and balanced” performance comparison of processes

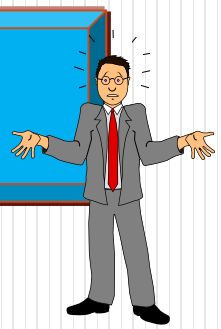
Example from Six Sigma Academy

What Is Good Enough?

99% Good (3.8 Sigma)	99.99966% Good (6 Sigma)
20,000 Lost articles of mail per hour	**7** Lost articles of mail per hour
200,000 Wrong drug prescriptions per year	**68** Wrong drug prescriptions per year
5,000 incorrect surgical operations per week	**1.7** Incorrect surgical operations per week
2 Unsafe airliner landings at major airports per day	**1** Unsafe airliner landing at major airports every **4** years (1,461 days)
7 Hours without electricity each month (**720** hours)	**1** Hour without electricity every 34 years (**297,840** hours)
1.5 Minutes of unsafe drinking water each day	**1.5** Minutes of unsafe water once every **8.5** years (3,105 days)

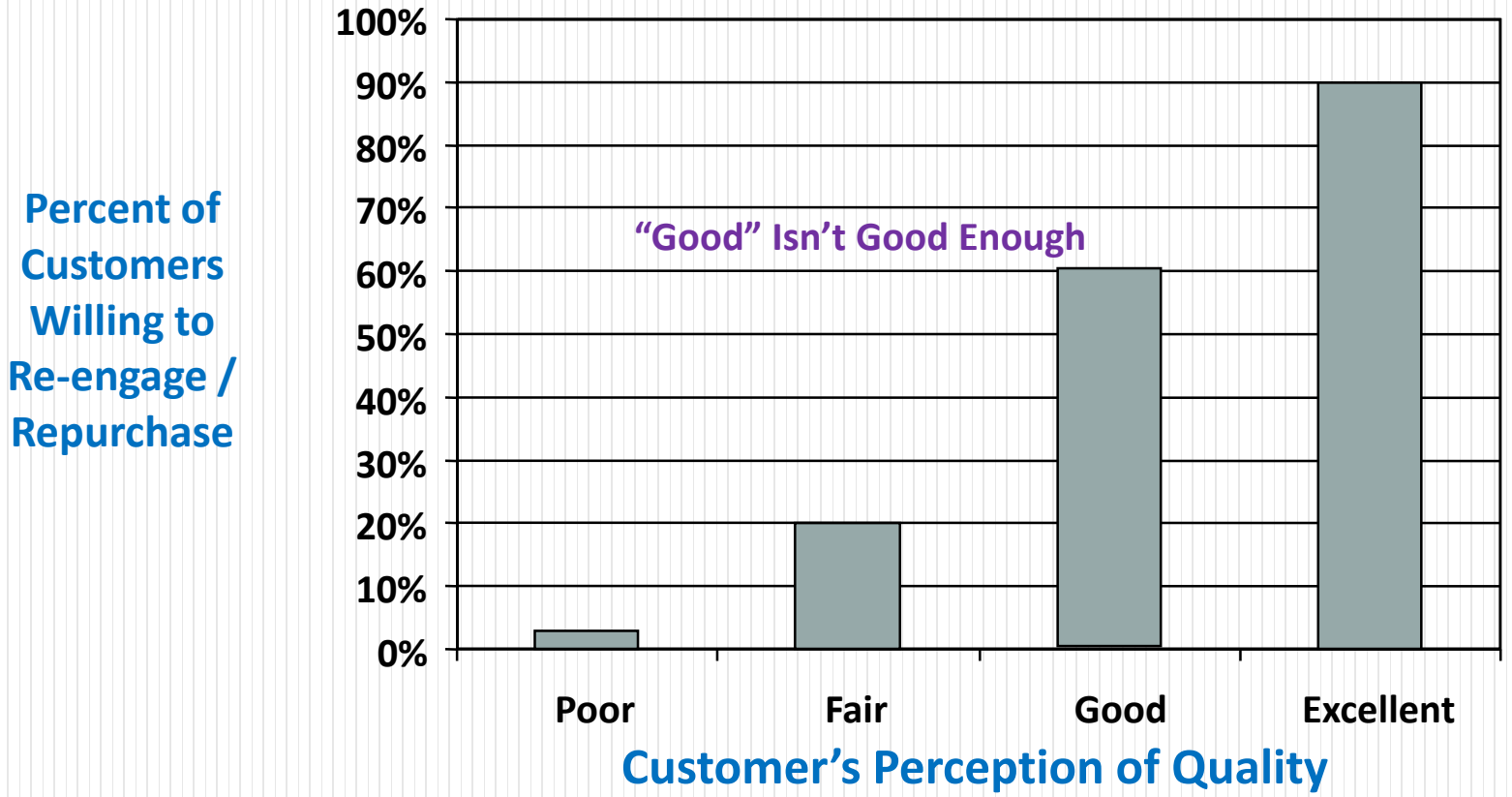
Forget about measuring yourself against competitors or peers…

Measure yourself against **PERFECTION**



Errors cost time and money, and are a function of Initial Incorrect Service + Resolution to Make It Right

What Is Good Enough?

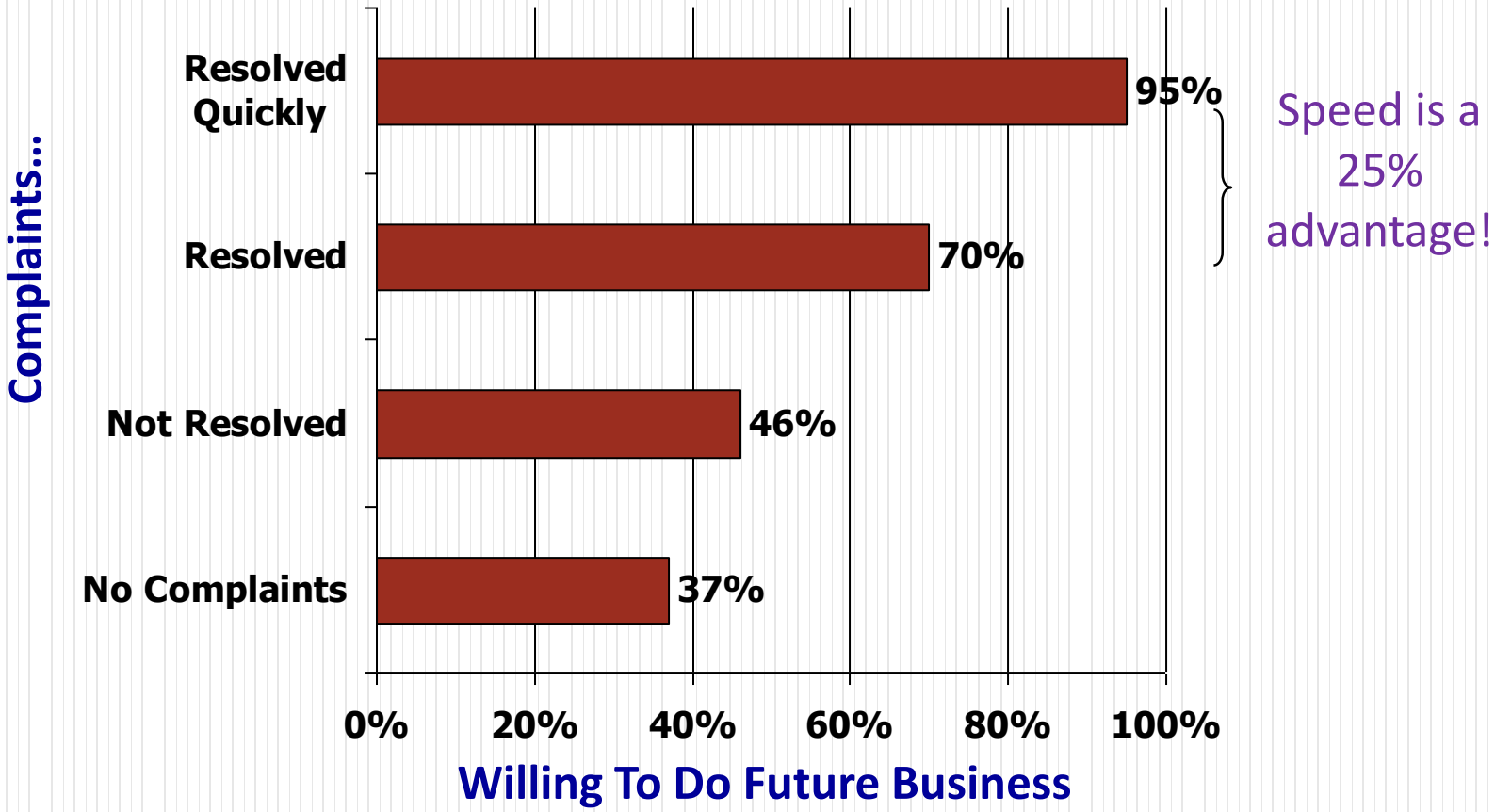


Source: Raymond E. Kordupleski and West Vogel, "The Right Choice – What Does It Mean?" AT&T 1988.

Customer Interactions That Effect the Bottom Line

A Complaining Customer ….

…is your best friend



Source: Knock Your Socks Off Service Recovery, Zemke, Bell and Bush

Examples of Variability That Effects the Bottom Line

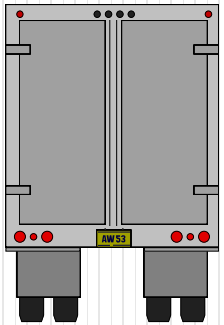
- Information availability
- Equipment and tools availability
- Poor priority management (hot jobs)
- Low process yields
- Material condition not as expected
- Unique/custom products
- Vacations, illness, shift changes
- Many, many more...

Theory of Constraints

Theory of Constraint (TOC) is…

Minimizing or eliminating "bottlenecks"

Constraints and Barriers



"The slowest vehicle in a convoy sets the pace"

A constraint is anything in an organization that slows down the processes and limits the organization from moving forward or achieving its goal

When the constraint (critical path) is not progressing, the process is not progressing!

Why Care About Constraints?

IF 25 PEOPLE WORKED

TO IMPROVE 100 DIFFERENT PROCESSES,

THE 1 PERSON WORKING ON THE CONSTRAINT

PROCESS WOULD SAVE THE ORGANIZATION

THOUSANDS MORE THAN ALL THE OTHER 24 PEOPLE

COMBINED!

WHERE ARE YOUR

RESOURCES FOCUSED?

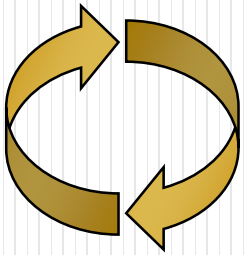
Steps to Constraint Management (From The Goal by Eli Goldratt)

1. Define the GOAL. Then…
2. Identify – What's the constraint?
3. Exploit – Utilize all resources to balance workloads
4. Subordinate – Focus non-constraints towards supporting the constraint
5. Elevate – Apply Lean
6. Repeat Step 1 – The constraint has probably moved

World Class Operating Excellence Demands Integration of Lean and Six Sigma

Lean Customer Value, Flow, Pull, and Waste Reduction (Speed)	Theory Of Constraints Customer Value, Flow, and Constraint Management (Speed and Throughput)	Six Sigma Customer Value, Quality, and Cost
Goal – Reduce waste and increase process speed	**Goal** – Reduce constraints and increase throughput	**Goal** – Improve performance on Customer CTXs
Focus – Bias for action / Implementing Toyota tools	**Focus** – Bias for action / Implementing Constraint Management	**Focus** – Use C-DMAIC-V with TQM tools to eliminate variation
Method – Kaizen events, Process / Value Stream Mapping	**Method** – Kaizen events, Process / Value Stream Mapping	**Method** – C-DMAIC-V Projects / Value Stream Mapping

Lean and TOC Speed Enables Six Sigma Quality (Faster Cycles of Delivery / Experimentation / Learning)



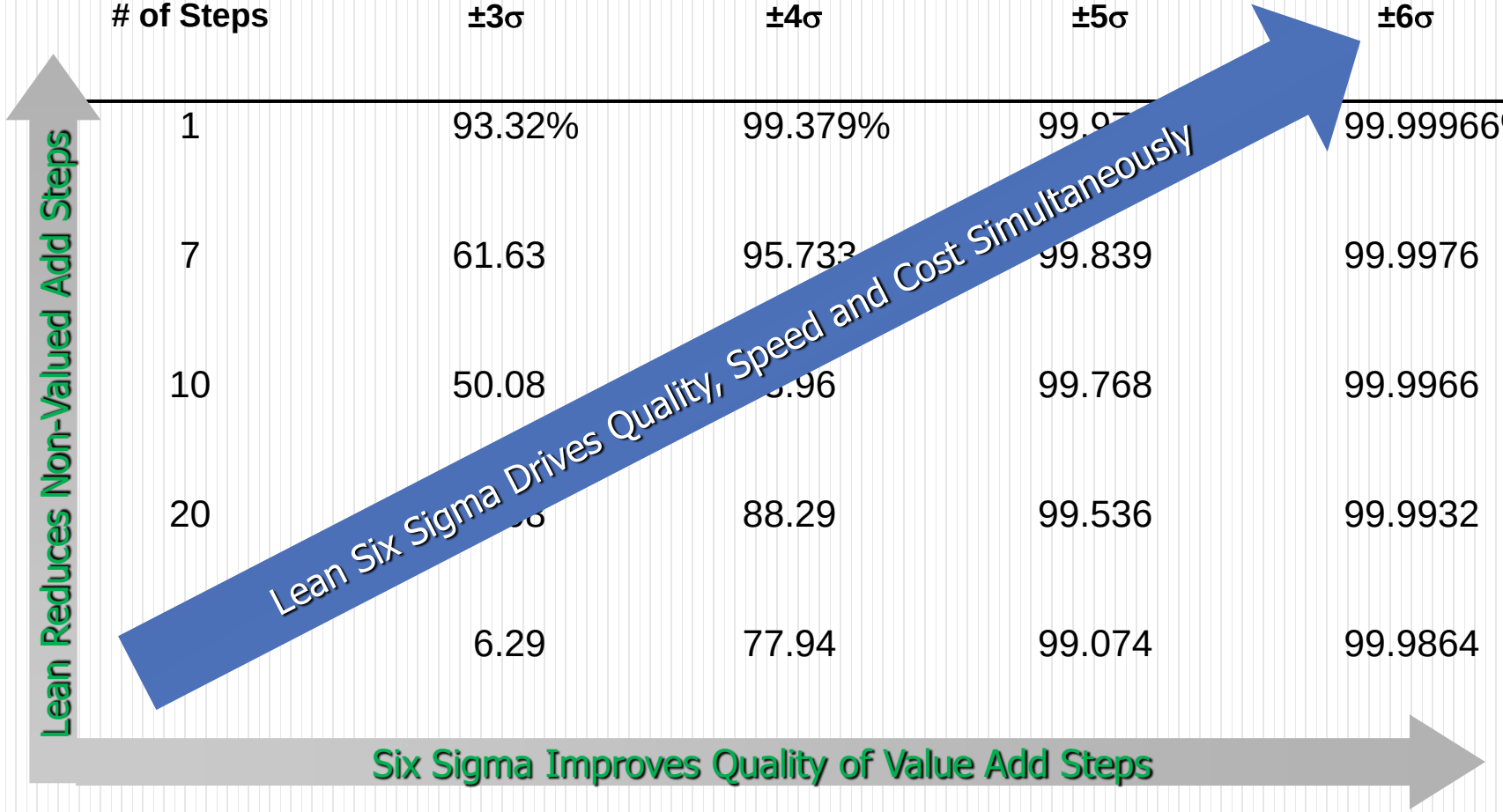
Six Sigma Quality Enables Lean and TOC Speed (Fewer Defects Mean Less Time Spent on Rework)

Six Sigma Improves Quality
Lean Eliminates or Mitigates Waste in the Process, and TOC Eliminates or Mitigates Constraints

Overall Yield vs. Sigma

(Distribution Shifted ±1.5σ)

# of Steps	±3σ	±4σ	±5σ	±6σ
1	93.32%	99.379%	99.9	99.99966%
7	61.63	95.733	99.839	99.9976
10	50.08	.96	99.768	99.9966
20		88.29	99.536	99.9932
	6.29	77.94	99.074	99.9864



Source: *Six Sigma Research Institute*, Motorola University, Motorola, Inc.

Summary

In this module you have learned about:

- The need for process improvement
- Lean Basics
- Six Sigma Basics
- Theory of Constraints (TOC)