Executive Education: Mini MBA Program

Lean Six Sigma Quality Management

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Lean Management

What is “Lean”?

Popular Books

- The Machine That Changed the World : The Story of Lean Production *by James P. Womack, Daniel T. Jones, Daniel Roos*
- The Toyota Way *by Jeffrey Liker*
- LEAN THINKING : Banish Waste and Create Wealth in Your Corporation *by James P. Womack, Daniel T. Jones*
- Lean Solutions: How Companies and Customers Can Create Value and Wealth Together *by James P. Womack, Daniel T. Jones*

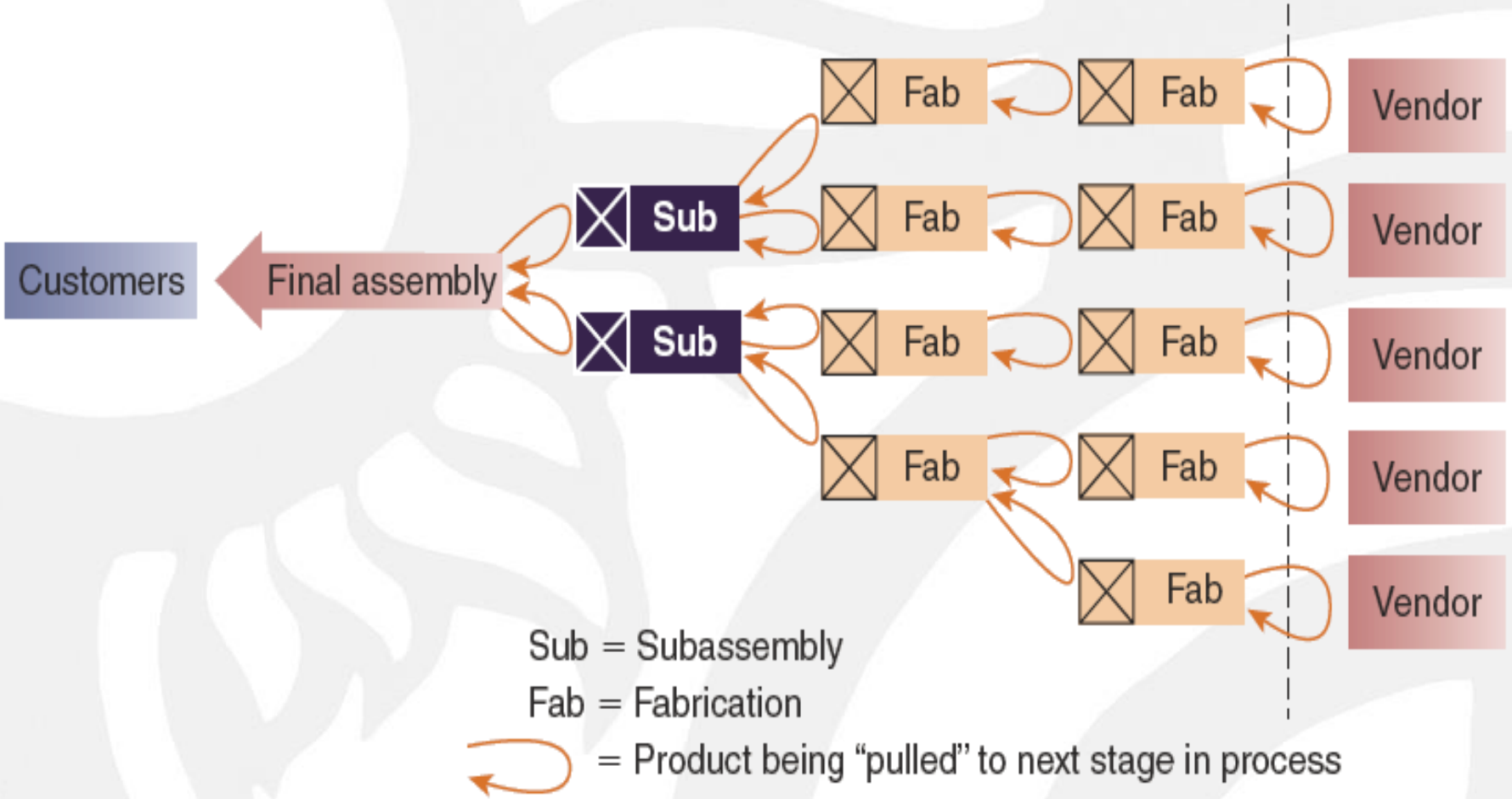
Lean Six Sigma

- The combination of Lean and Six Sigma
- Six Sigma is typically problem focused on variance reduction
- Lean is typically process focused on removal of waste & throughput increase
- These two can be viewed as a complimentary to each other

The Seven Deadly Wastes (Muda's)

1. *Overproduction: producing more than is required by the market.*
2. *Waiting time: workers who are idle because they have completed their work or who watch machines but cannot prevent problems.*
3. *Transportation: moving materials between workstations without adding value.*
4. *Over-processing: downtime because machines need maintenance or repair.*
5. *Inventory: the costs associated with loss, obsolescence, carrying excess inventory and damage to inventories.*
6. *Motion: movement that is not related to adding value to the product.*
7. *Waste from defects: the costs of scrap and rework and, external failure costs.*

Fundamentals of Lean Production – Pull System



Elimination of Waste in Toyota (Fujio Cho)

- Just-in-time production
- Jidoka – quality at the source/on the spot
- Heijunka – Uniform plant loading/ production smoothing
- Kaizen – continuous improvement
- Kanban – signals, index card
- Poka-yoke – fail-safing, fool-proof
- Andon – signboard, also pull-cord
- Minimal setup times

Toyota Production System

The 5S

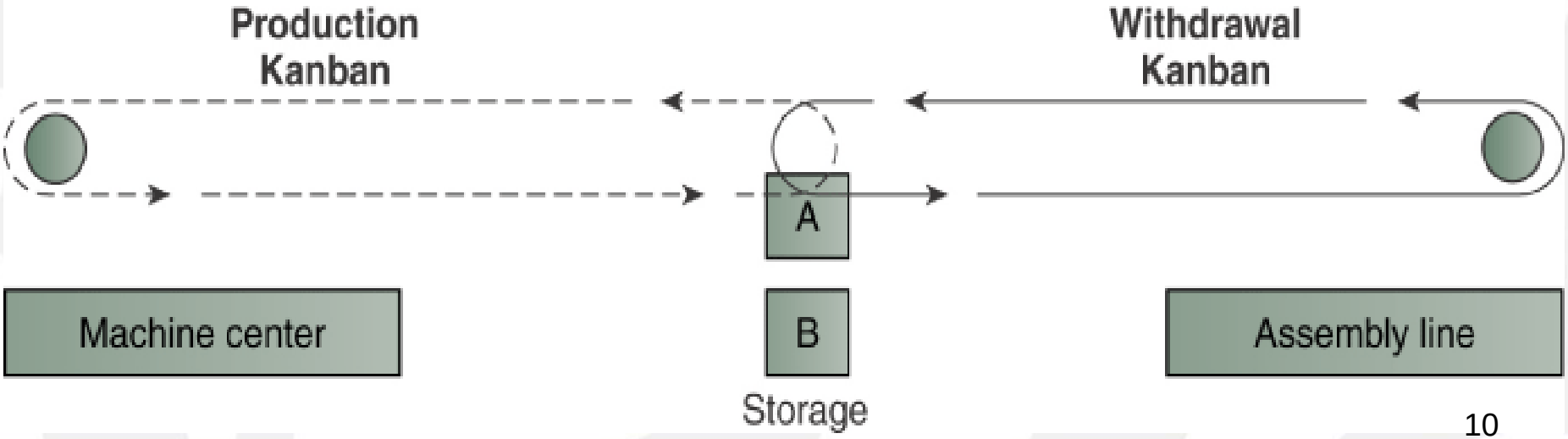
- Seiri (Sort) – Sort needed items from unneeded items
- Seiton (Simplify) – “A place for everything and everything in it’s place”
- Seiso (Shine) – Ensure everything stays clean everyday
- Seiketsu (Standardize) – Develop systems to maintain and monitor the first 3 S’s
- Shitsuke (Sustain) – Use team oriented continuous improvement to sustain the first 3 S’s

Lean/Kaizen/Just-in-Time (JIT)

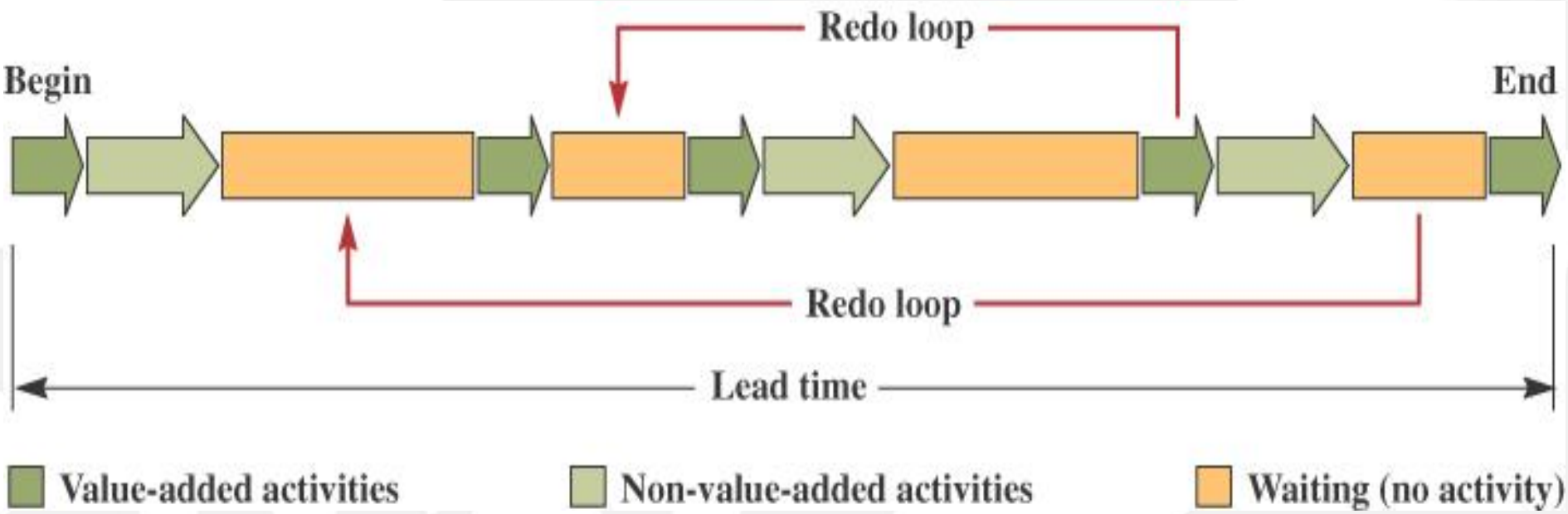
What it is	What it does
• Management philosophy • "Pull" system through the plant	• Attacks waste (time, inventory, scrap) • Exposes problems and bottlenecks • Achieves streamlined production
What it requires	**What it assumes**
• Employee participation • Industrial engineering/basics Continuing improvement Total quality control • Small lot sizes	• Stable environment (production linearity)

Flow of Two Kanbans

- Kanban Pull System
  - A manual, self-regulating system for controlling the flow of material. Workers produce only when the Kanban ahead of them is empty, thereby creating a “pull” system



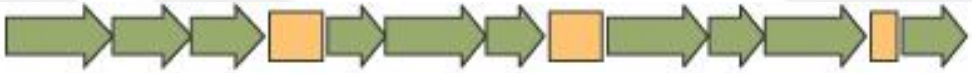
Value-Stream Mapping



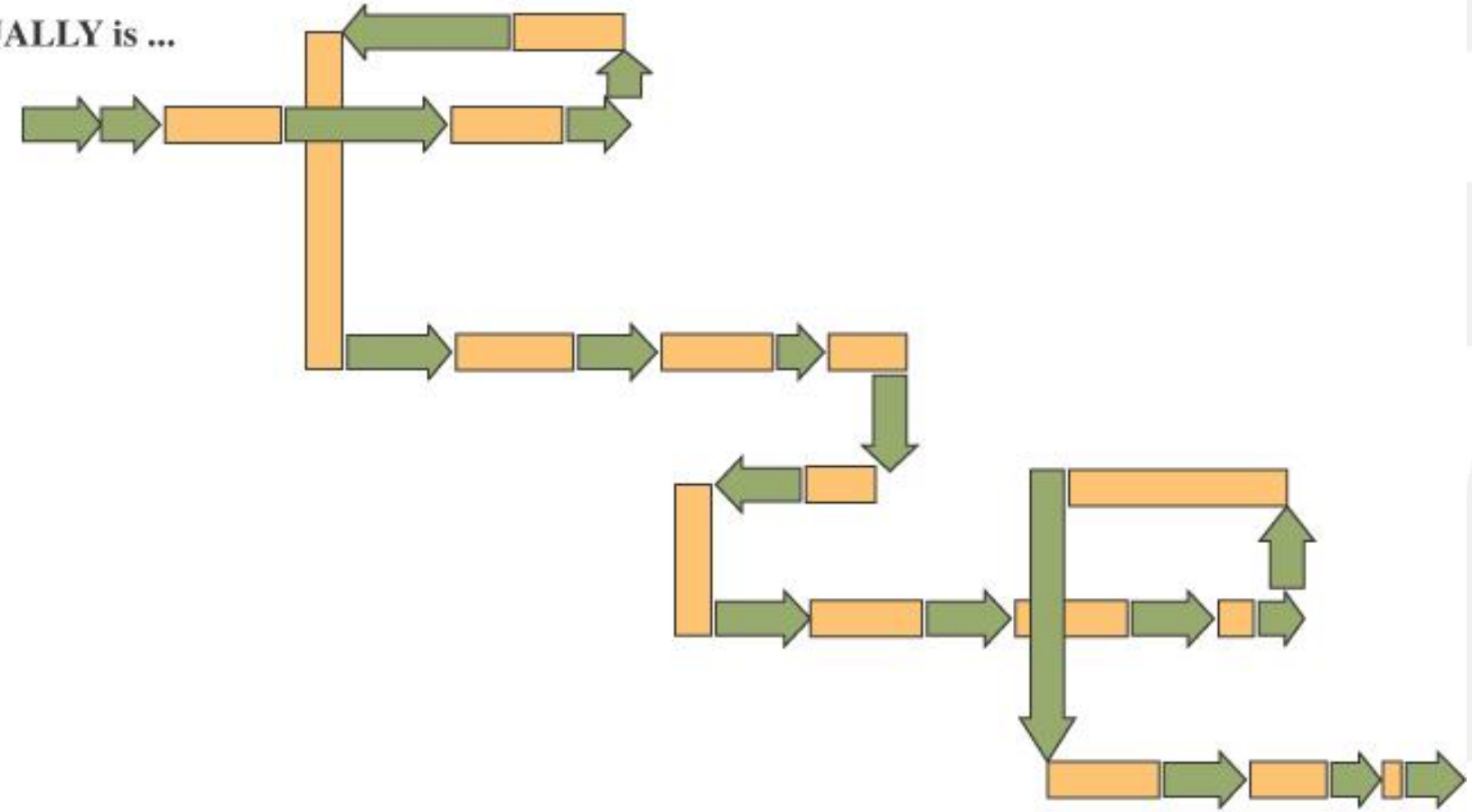
Value-Stream Principles

1. Keep stream moving at maximum velocity
2. Eliminate waste that stops, slows down, or diverts value stream
3. Concentrate on removing waste, rather than speeding up value-added operations
4. Look for waste in factory, office, procedural and technical operations

What we THINK it is ...

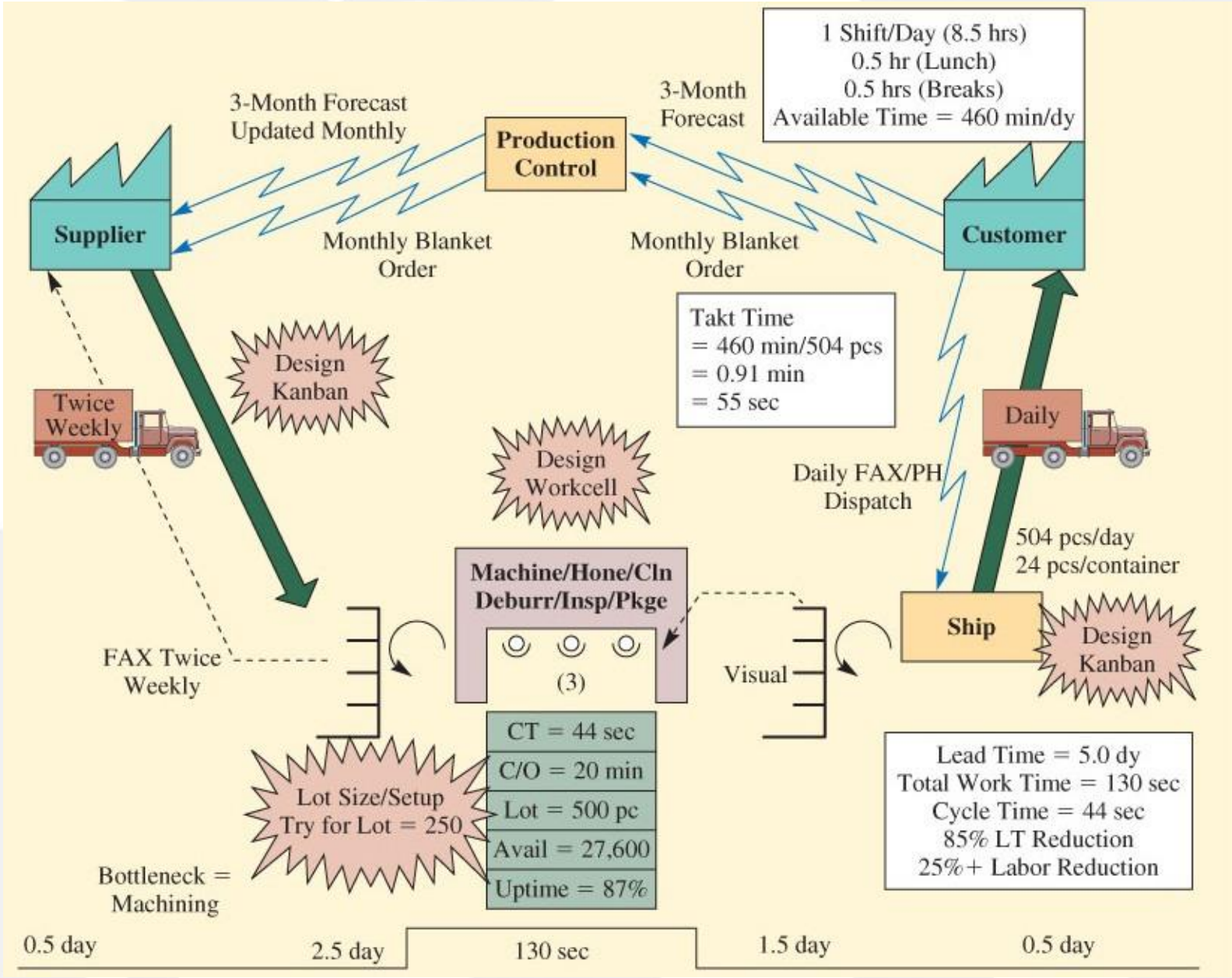


What it ACTUALLY is ...



What is ACHIEVEABLE ...

VSM showing potential areas for improvement



Lean in Service Industry

- Lean in Services
  - –Synchronization and balance of information and workflow
  - –Total visibility of all components and processes
  - –Continuous improvement of the process
  - –Holistic approach to the elimination of waste
  - –Flexibility in the use of resources
  - –Respect for people

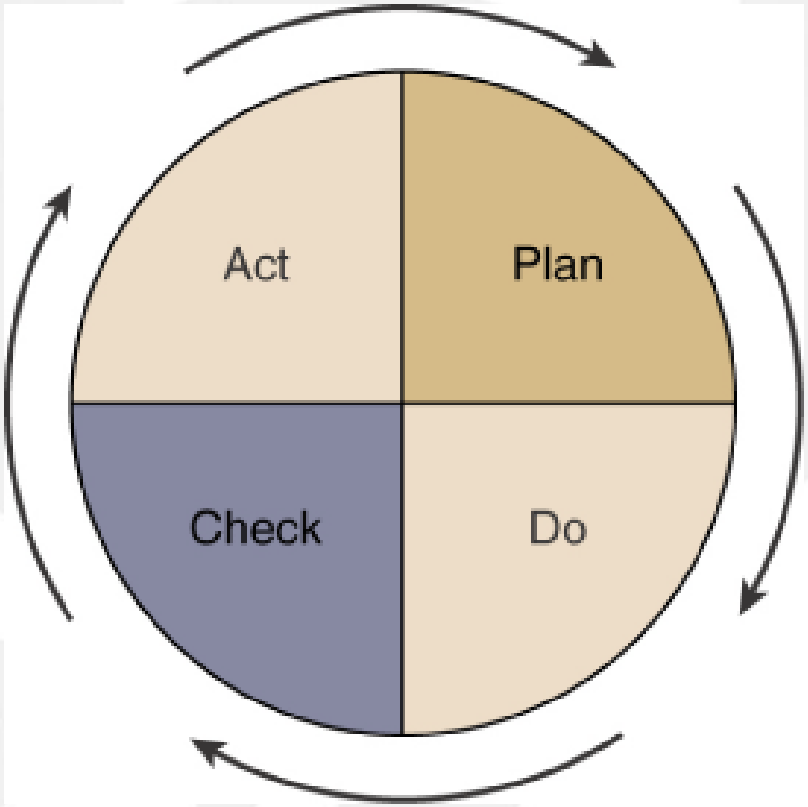
Quality Management

Statistical Quality Control

The Quality Gurus

- W. Edwards Deming
- Joseph M. Juran
- Philip Crosby
- Genichi Taguchi
- Kaoru Ishikawa

Plan-Do-Check-Act (PDCA) Cycle



Source: "The PDCA Cycle" from *Deming Management at Work* by Mary Walton, copyright © 1990 by Mary Walton. Used by permission of G. P. Putnam's Sons, a division of Penguin Putnam, Inc.

Defining the Dimensions of Quality

- Quality in Goods
  - –Performance
  - –Features
  - –Reliability
  - –Durability
  - –Conformance
  - –Serviceability
  - –Aesthetics
  - –Perceived quality
- Quality in Services
  - –Reliability
  - –Tangibles
  - –Responsiveness
  - –Assurance
  - –Empathy

The Cost of Quality (Juran's Model)

Cost Category	
Cost of prevention	**Costs associated with the development of programs to prevent defectives from occurring in the first place**
Cost of detection/ appraisal	**Costs associated with the test and inspection of subassemblies and products after they have been made.**
Cost of failure	**Costs associated with the failure of a defective product.** ***Internal failure costs*—producing defective products that are identified before shipment.** ***External failure costs*—producing defective products that are delivered to the customer.**

Six Sigma

- Goals of Six Sigma
  - To reduce process variation to the point where only 3.4 defects per million are produced by a process that involves a high volume of manufactured units or service transactions on a continuous basis.
  - Provide a framework and methodologies to analyze and evaluate business processes and reduce waste.
- Successful Implementation
  - Training and selection of the workforce
  - Impressive cost savings of program

Six-Sigma Roles & Responsibilities

Executive

- Own vision, direction, integration, results
- Lead change

Project Member

- Part-time
- Project-specific

Champion

- Project owner
- Implement solutions
- Black Belt managers

All employees

- Understand vision
- Apply concepts

Green Belts

- Part-time
- Help Black Belts

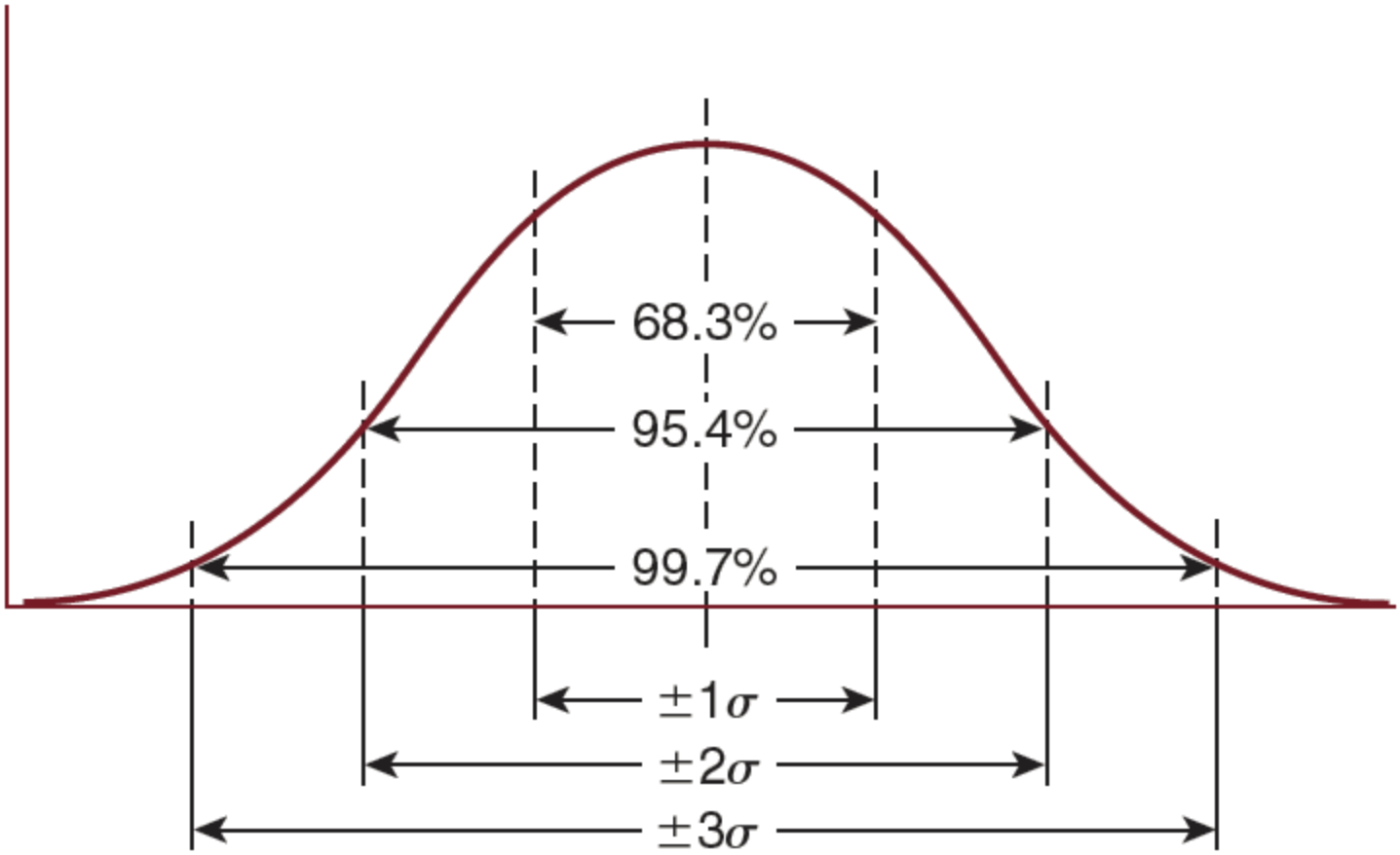
Master Black Belt

- Full time
- Train and coach Black and Green Belts
- Statistical problem solving experts

Black Belts

- Devote 50%-100% of time to Black Belt activities
- Facilitate and practice problem solving
- Train and coach Green Belts and project teams

Properties of a Normal Distribution

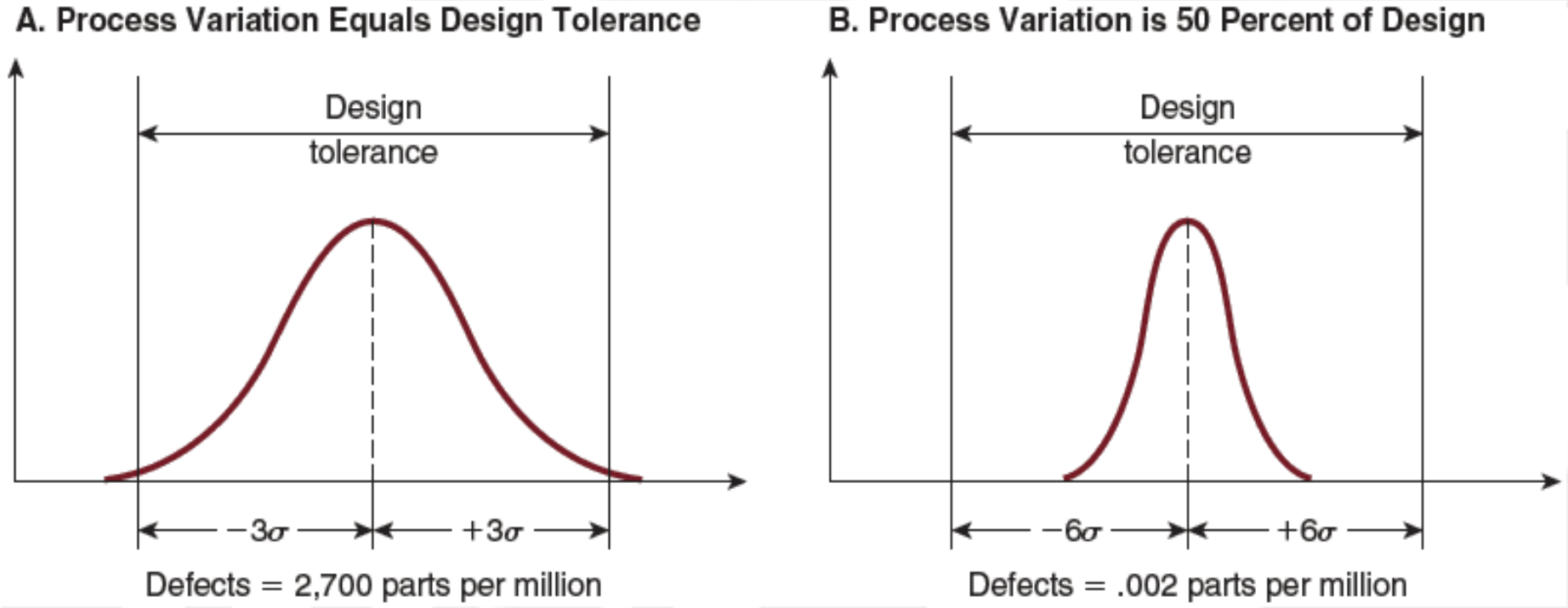


Quality Performance Levels for Various Processes

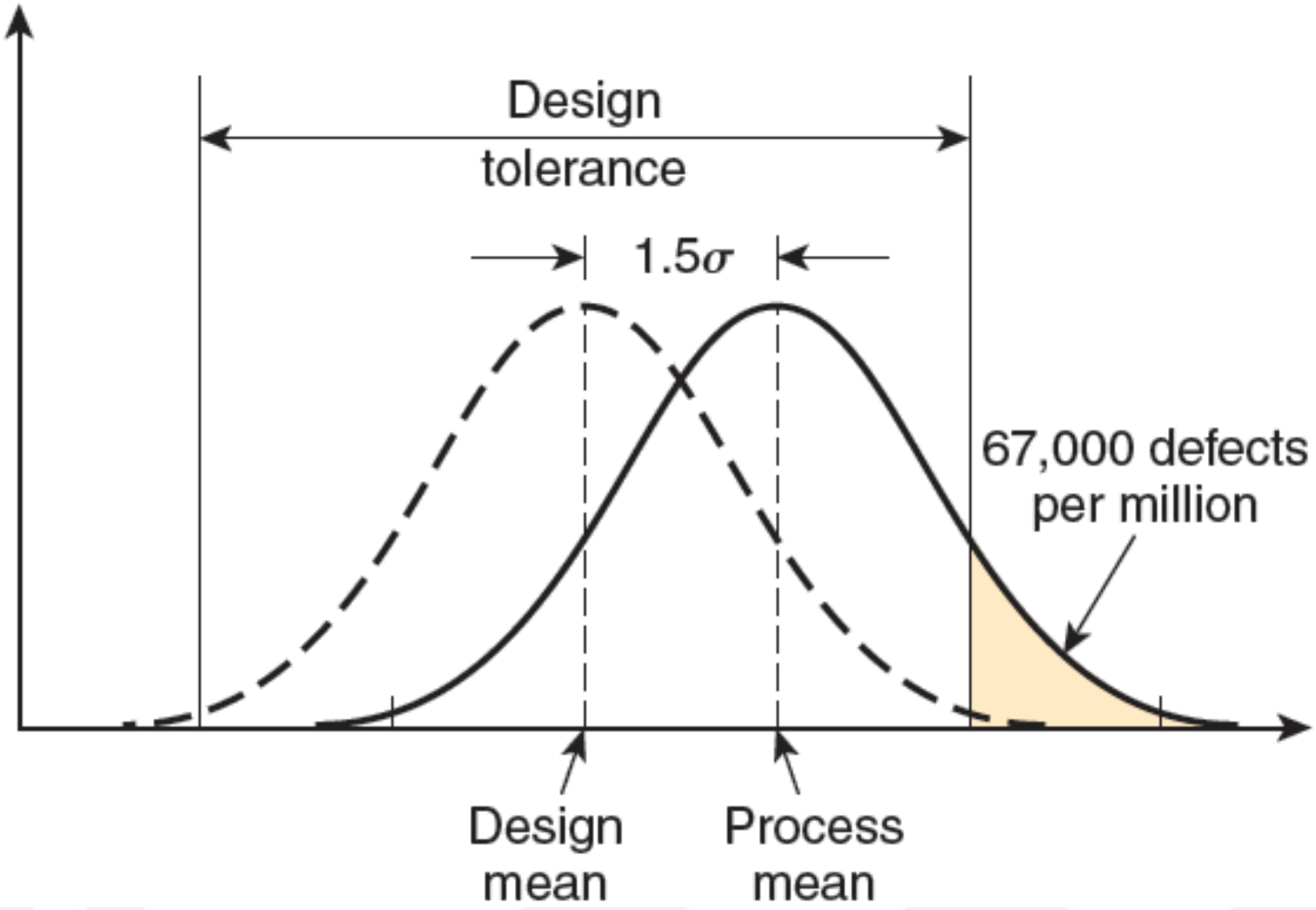
Process Description	Quality Performance Level
IRS phone-in tax advice	2.2σ
Restaurant bills, doctors' prescription writing, payroll processing	2.9σ
Average company	3.0σ
Airline baggage handling	3.2σ
Best-in-class companies	5.7σ
U.S. Navy aircraft accidents	5.7σ
Watch off by 2 seconds in 31 years	6.0σ
Airline industry fatality rate	6.2σ

Source: Dave Harold, "Designing for Six Sigma Capability," *Control Engineering,* January, 1999.

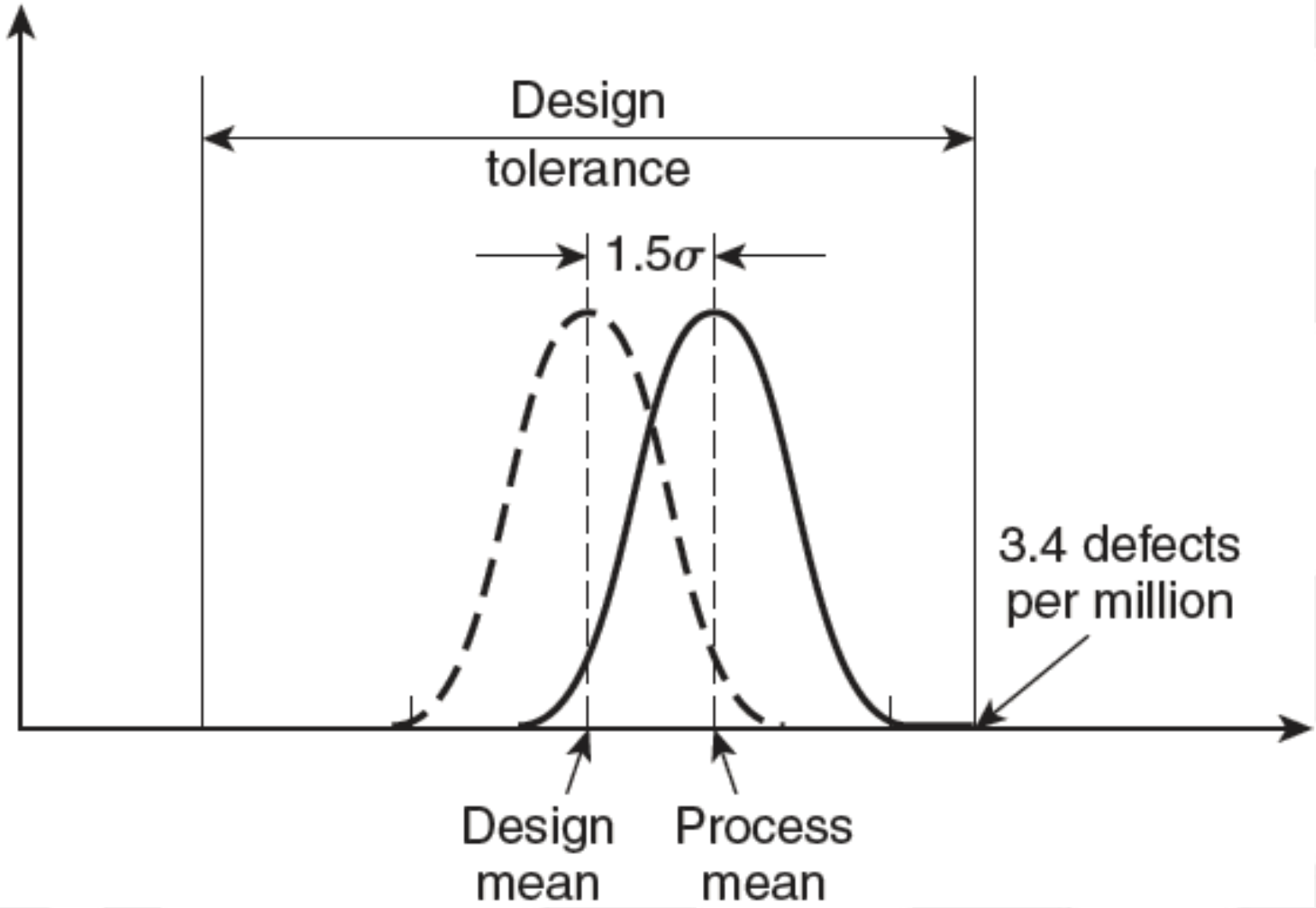
Six Sigma


A. Process Variation Equals Design Tolerance
Design
tolerance
−3σ
+3σ
Defects = 2,700 parts per million
B. Process Variation is 50 Percent of Design
Design
tolerance
−6σ
+6σ
Defects = .002 parts per million

Impact of 1.5σ Shift on 3σ Process



Impact of 1.5σ Shift on 6σ Process

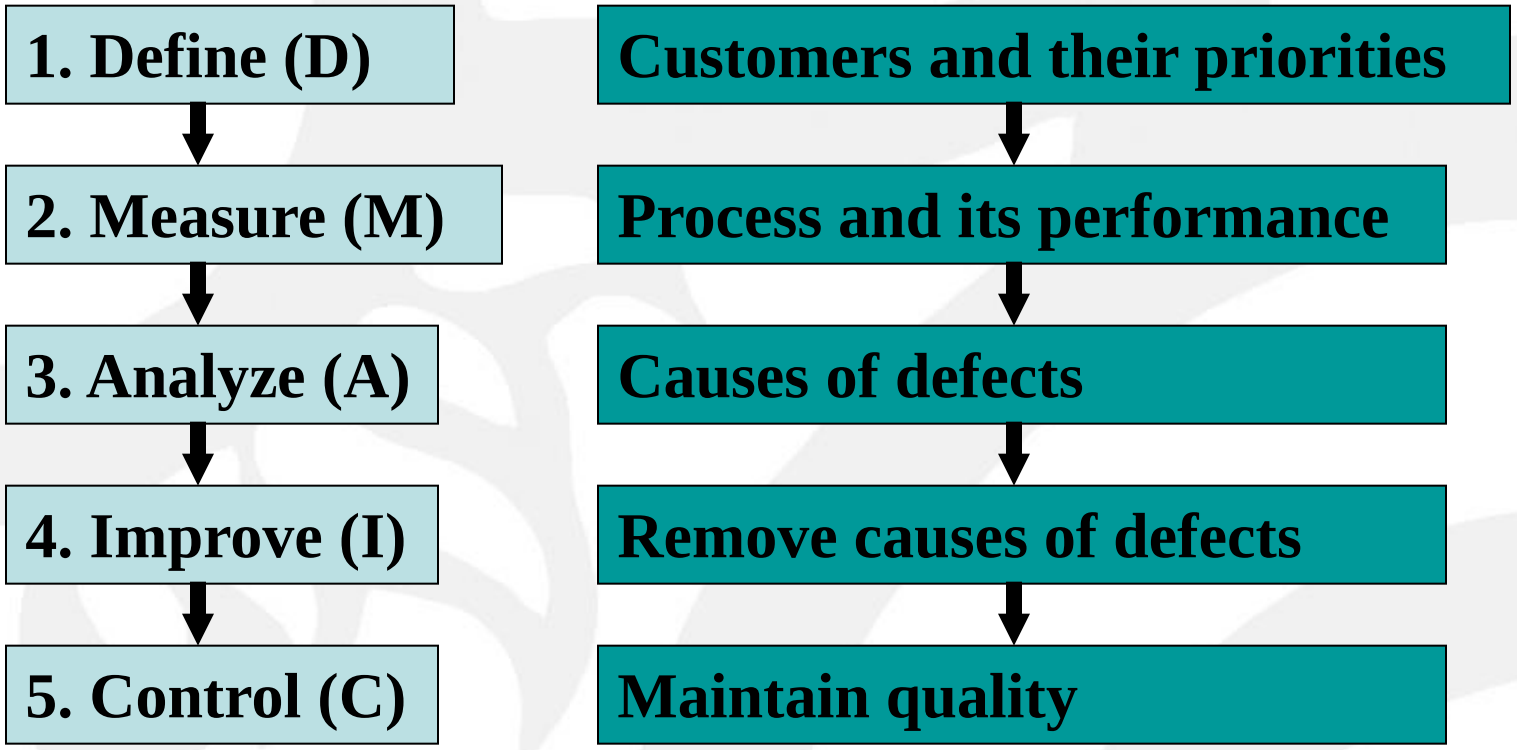


Defect Rates for Different Levels of Sigma (σ)

Assuming a 1.5 Shift in Actual Mean from Design Mean

Sigma Level of Quality	Defects per Million
1.5σ	500,000
2.0σ	308,300
2.5σ	158,650
3.0σ	67,000
3.5σ	22,700
4.0σ	6,220
4.5σ	1,350
5.0σ	233
5.5σ	32
6.0σ	3.4

Six Sigma Quality: DMAIC Cycle (GE model)



Example to illustrate the process…

- We are the maker of cereal. *Consumer Reports* has just published an article that shows that we frequently have less than 15 ounces of cereal in a box that claim to have 16 ounces.
- What should we do?

Step 1 - Define

- What is the critical-to-quality characteristic?
- The CTQ (critical-to-quality) characteristic in this case is the weight of the cereal in the box.

2 - Measure

- How would we measure to evaluate the extent of the problem?
- What are acceptable limits on this measure?

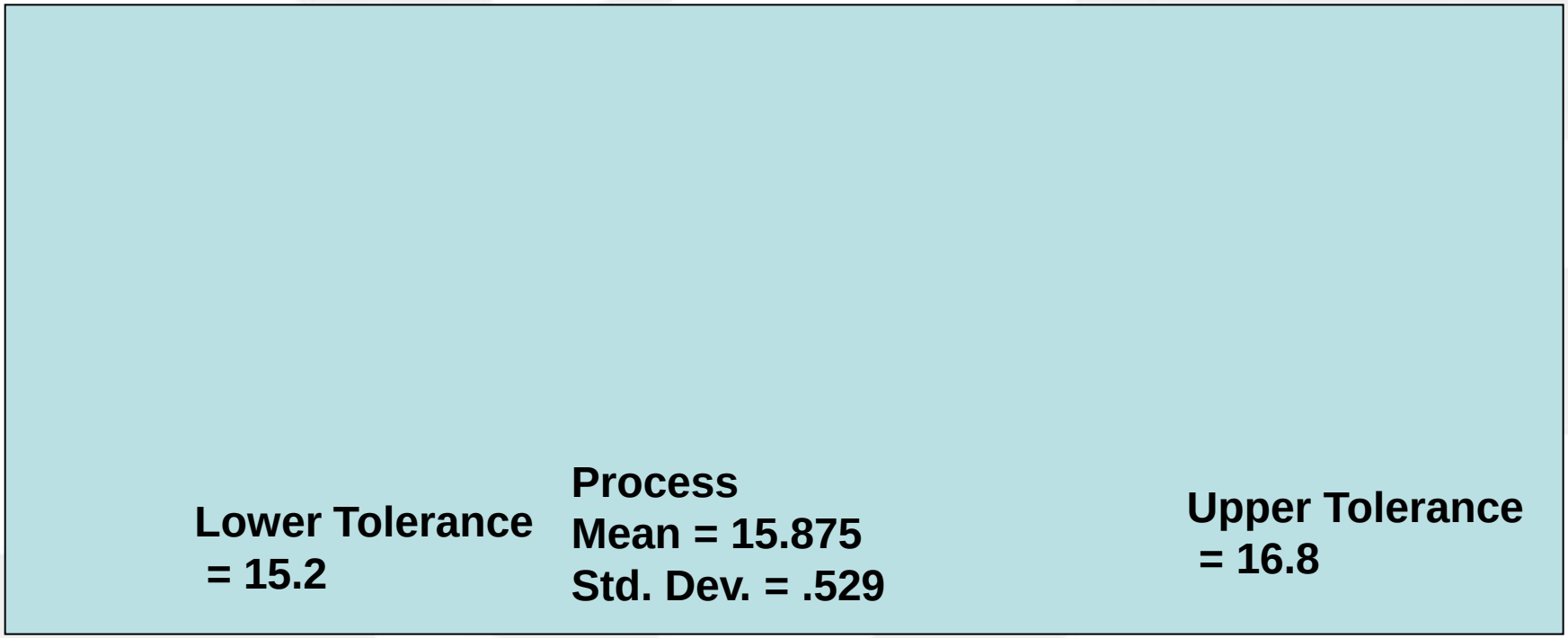
2 – Measure (continued)

- Let's assume that the government says that we must be within ± 5 percent of the weight advertised on the box.
- Upper Tolerance Limit = 16 + .05(16) = 16.8 ounces
- Lower Tolerance Limit = 16 – .05(16) = 15.2 ounces

2. Measure (continued)

- We go out and buy 1,000 boxes of cereal and find that they weight an average of 15.875 ounces with a standard deviation of .529 ounces.
- What percentage of boxes are outside the tolerance limits?

Step 3 - Analyze



What percentage of boxes are defective (i.e. less than 15.2 oz)?

Z = (x – Mean)/Std. Dev. = (15.2 – 15.875)/.529 = -1.276

NORMSDIST(Z) = NORMSDIST(-1.276) = .100978

Approximately, 10 percent of the boxes have less than 15.2 Ounces of cereal in them!

Step 4 – Improve: How can we improve the capability of our cereal box filling process?

Show Excel nornsdist 6-sigma

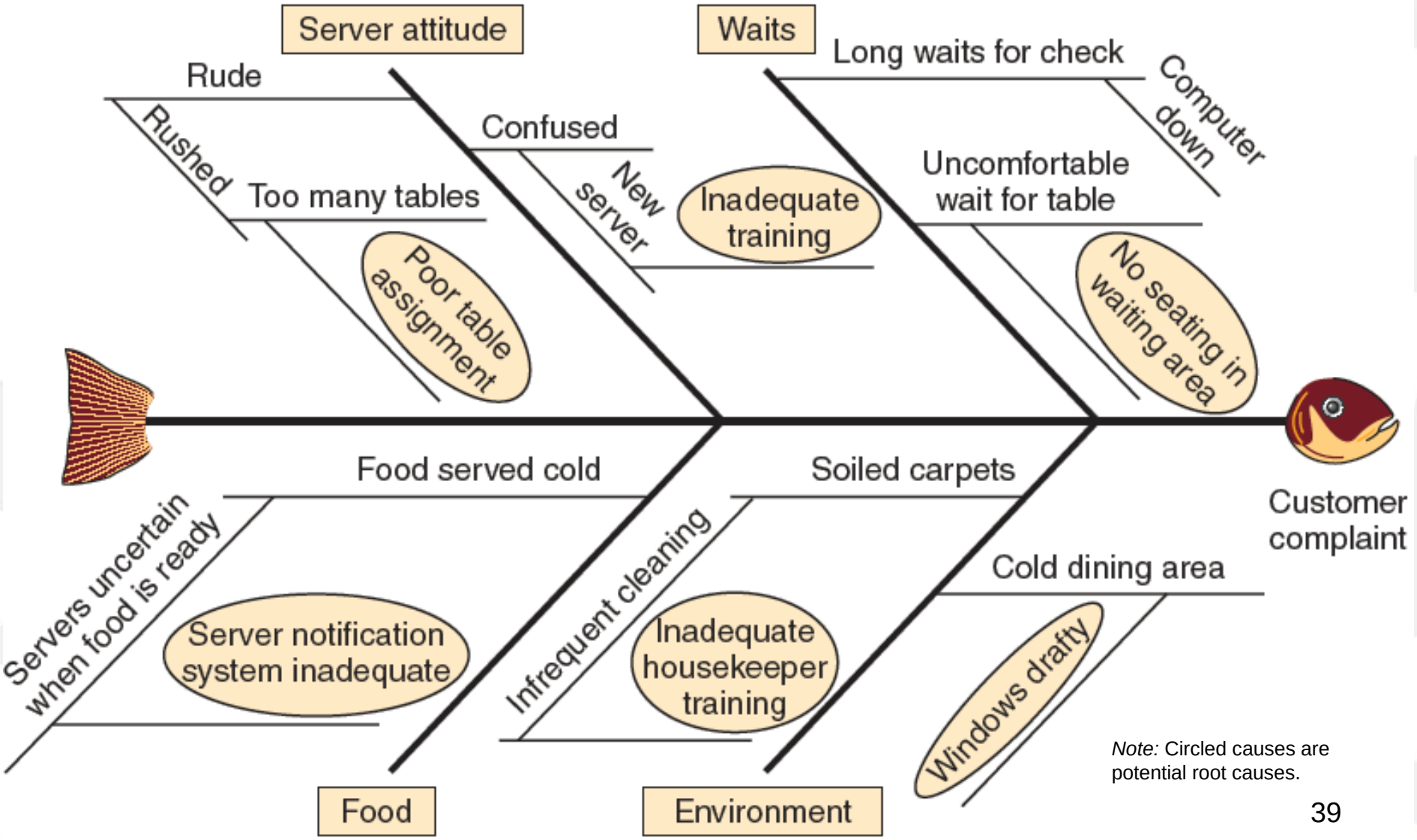
Step 5 – Control

- Statistical Process Control (SPC)
  - Use data from the actual process
  - Estimate distributions
  - Look at capability - is good quality possible
  - Statistically monitor the process over time

The Basic Quality Control Tools

- Seven Basic Quality Control (QC) Tools
  - Process flowcharts (or diagrams)
  - Checksheets
  - Bar charts and histograms
  - Pareto charts
  - Scatterplots (or diagrams)
  - Run (or trend) charts
  - Cause-and-effect (or fishbone) charts

Cause-and-Effect Diagram for Customer Complaints in a Restaurant



Note: Circled causes are potential root causes.

Checksheets

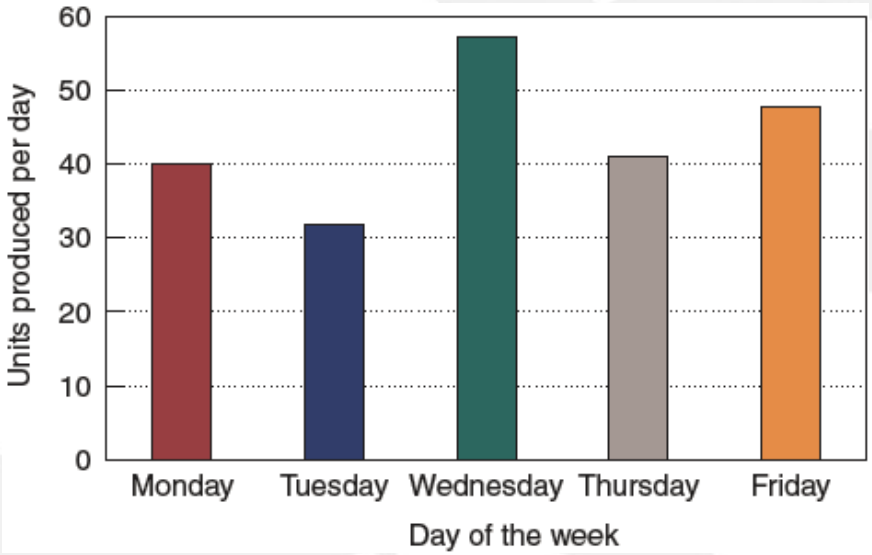
Type of Complaint	Frequency
Cord too short	𝍸 ||||
Dirt bags hard to change	𝍸
Too heavy	𝍸 𝍸
Breaks down a lot	𝍸 ||
Accessories don't always work	|||
Other	||||

Checksheet for Recording Complaints

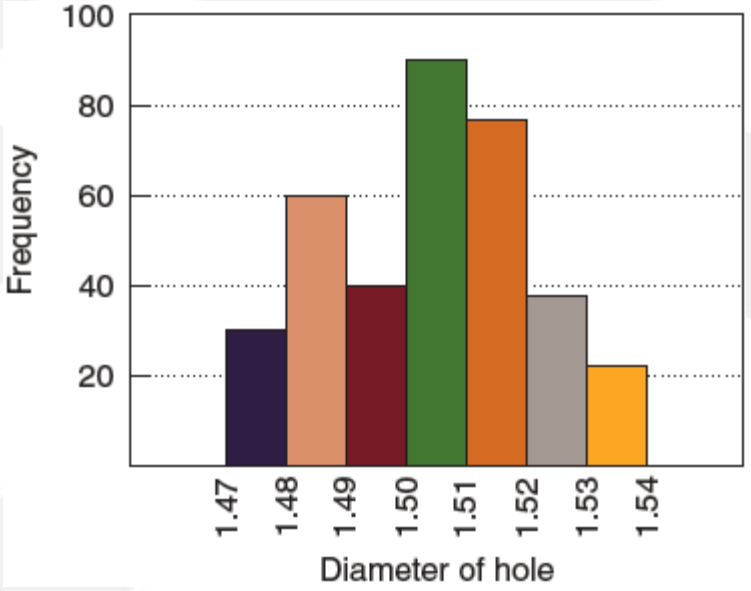
Customers in Party	Count
1	||||
2	𝍸 𝍸 𝍸 𝍸 |||
3	𝍸 𝍸 ||
4	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸|
5	𝍸 𝍸 𝍸
6	𝍸 ||
>6	||

Checksheet for Group Sizes in a Restaurant

Bar Charts and Histograms

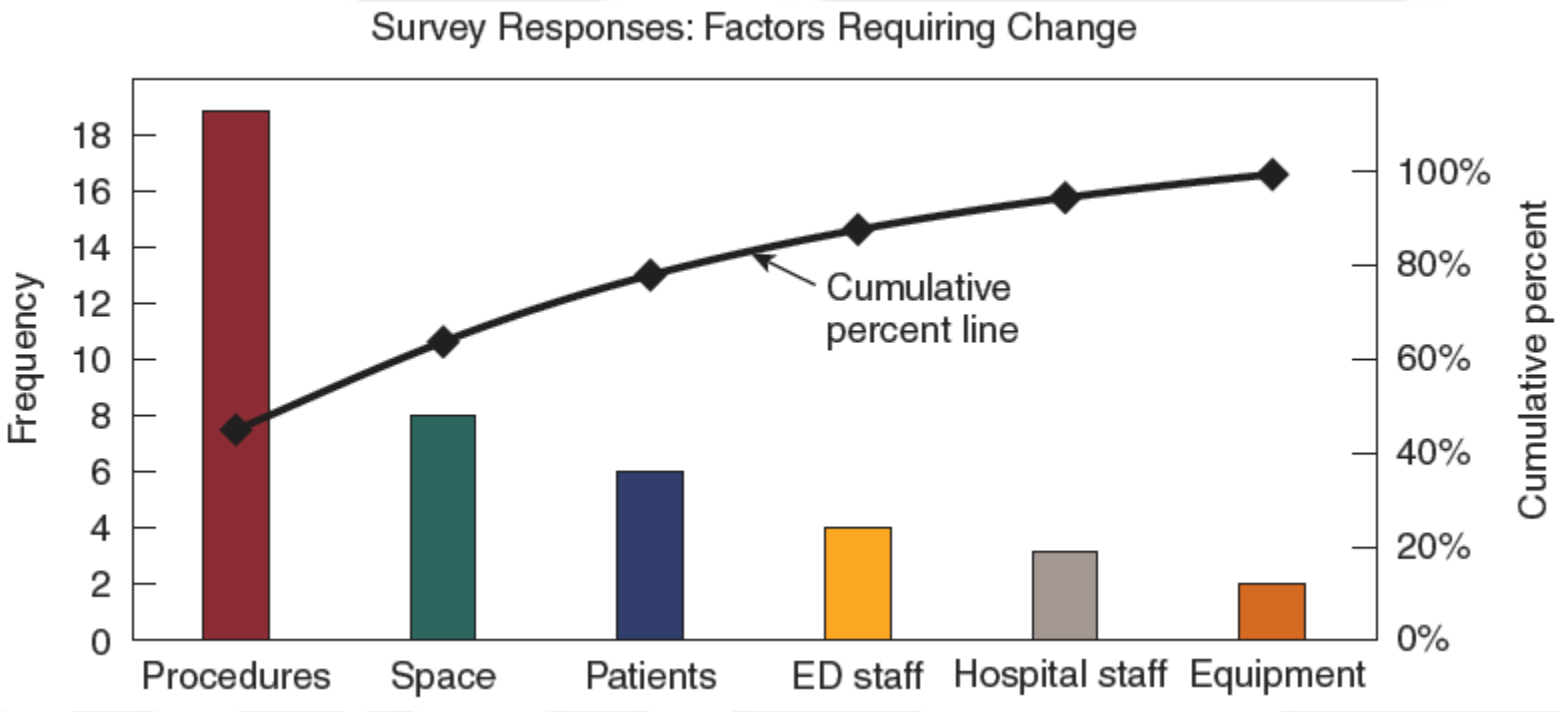


Bar Chart of Daily Units Produced

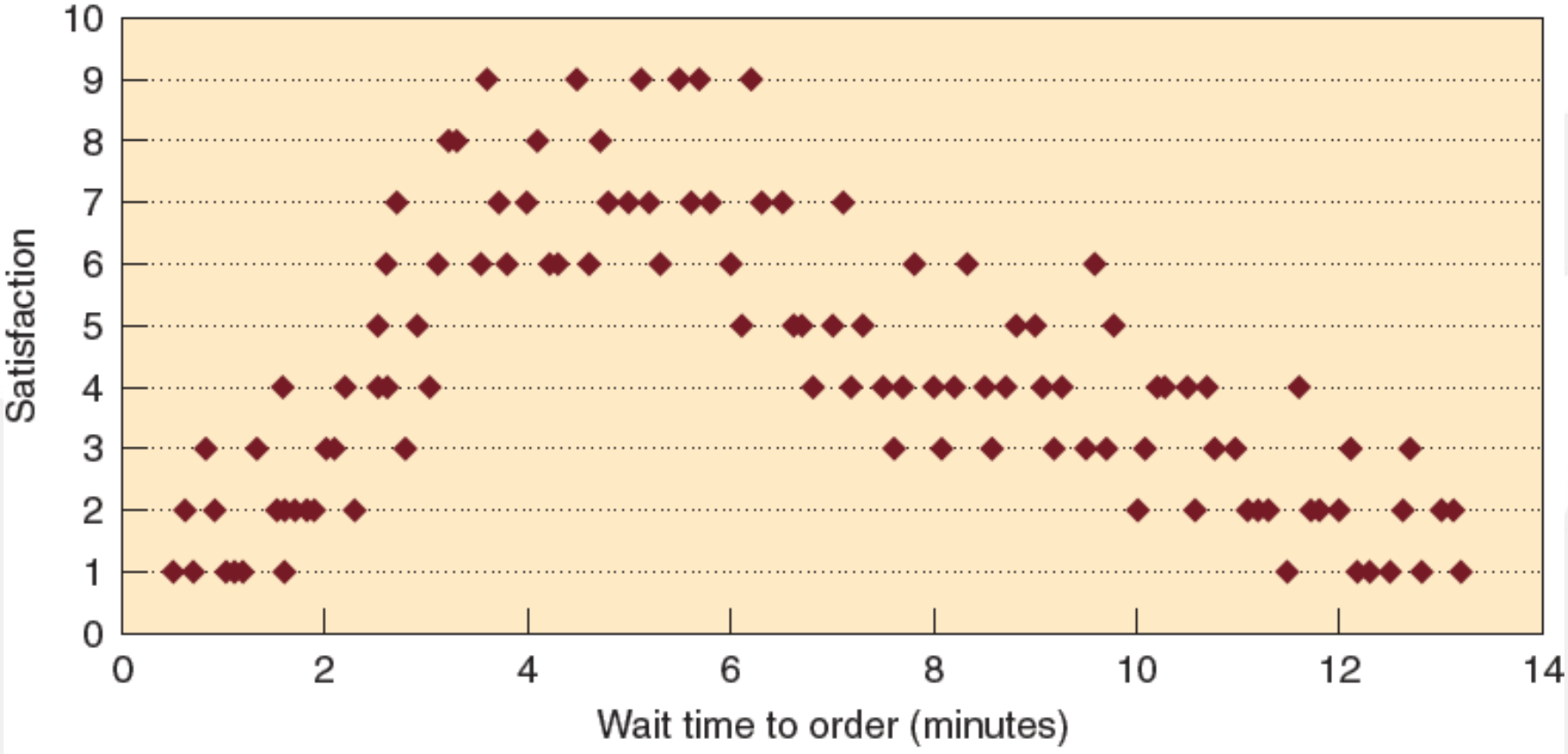


Histogram of Hole Diameters

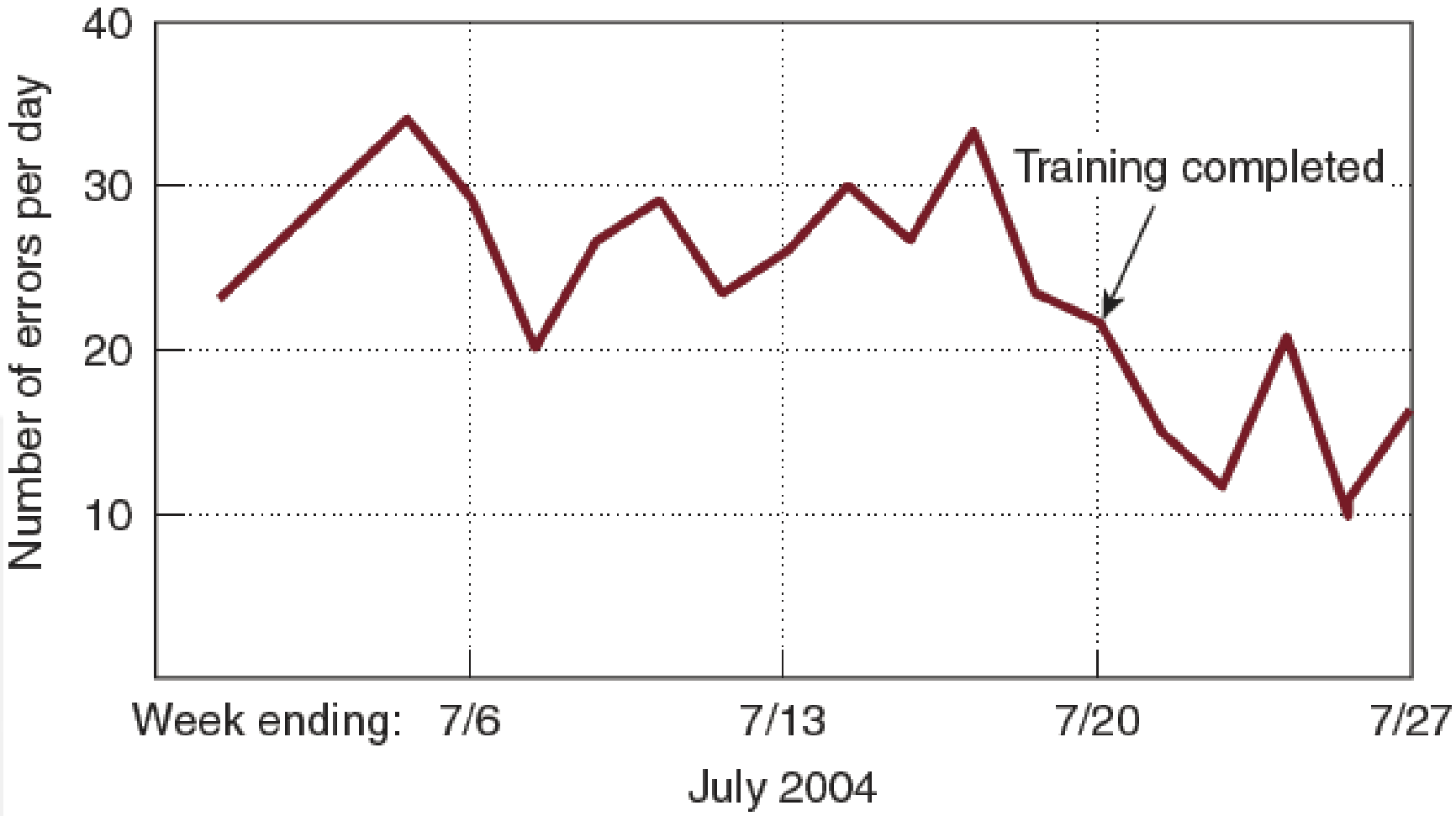
Pareto Chart of Factors in an Emergency Room



Scatter Plot of Customer Satisfaction and Waiting Time in an Upscale Restaurant



Run Chart of the Number of Daily Errors



The Shingo System: Fail-Safe Design

- Shingo's argument:
  - SQC methods do not prevent defects
  - Defects arise when people make errors
  - Defects can be prevented by providing workers with feedback on errors
- Poka-Yoke includes:
  - Checklists to make it failsafe
  - Special tooling that prevents workers from making errors

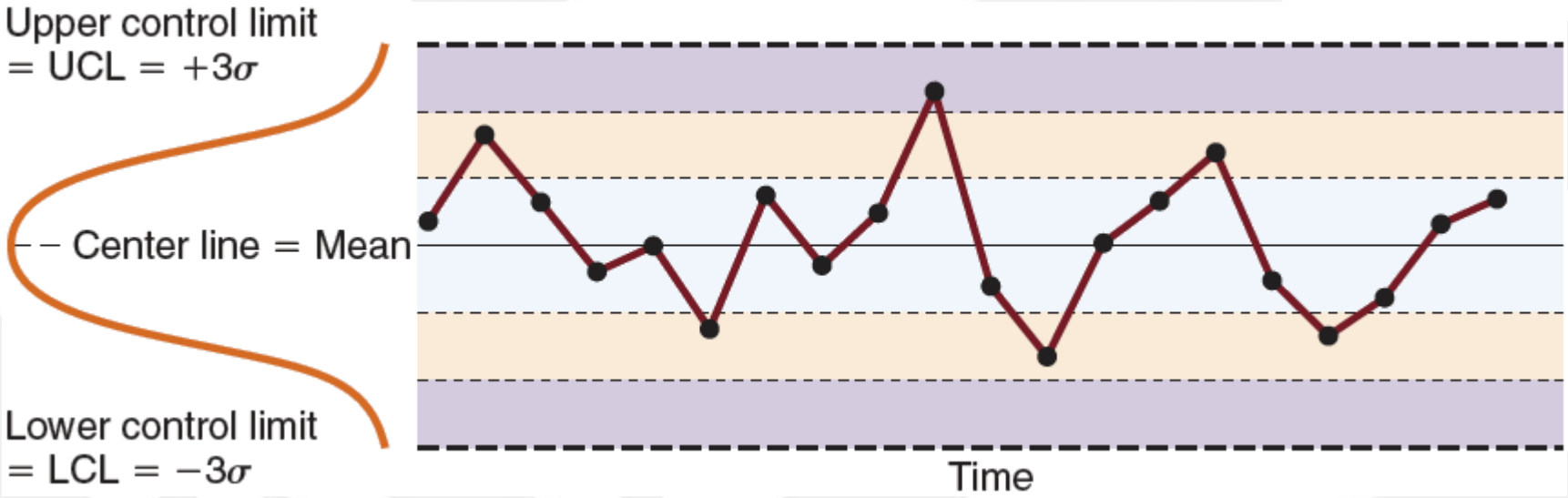
Sampling

- Designing a Sampling Plan for Attributes
  - –Costs to justify inspection
    - Costs of not inspecting must exceed costs of inspecting.
  - –Purposes of sampling plan
    - Find quality or ensure quality is what it is supposed to be.
  - –Acceptable quality level (AQL)
    - Maximum percentage of defects that a company is willing to accept.
- Operating Characteristic (OC) Curves
  - –Curves that illustrate graphically the probability of accepting lots that contain different percent defectives.

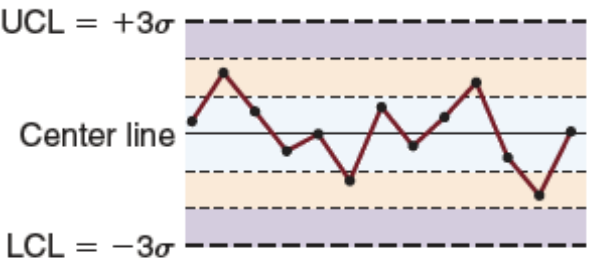
Types of Sampling Errors

		The population or process is actually:	
		Good or in control	Bad or out of control
The sample says that the population or process is:	Good or in control	no error	Type II error
	Bad or out of control	Type I error	no error

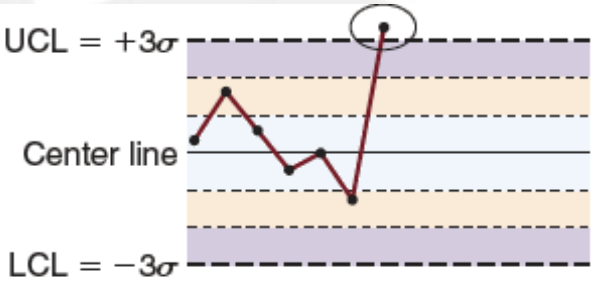
Statistical Process Control Chart



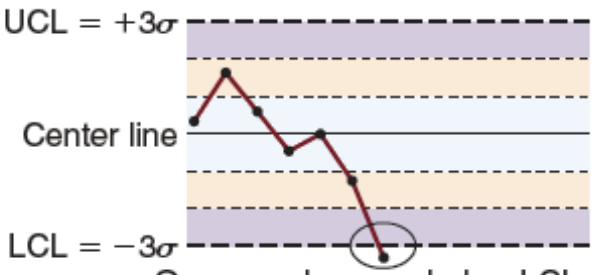
Control Chart Decision Rules



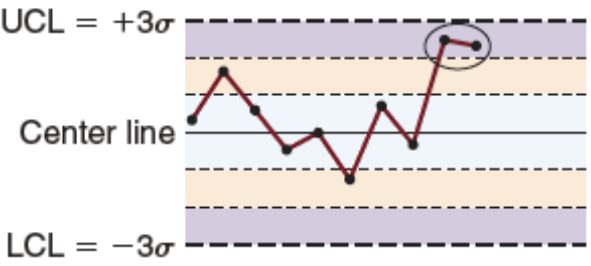
In control: random pattern.



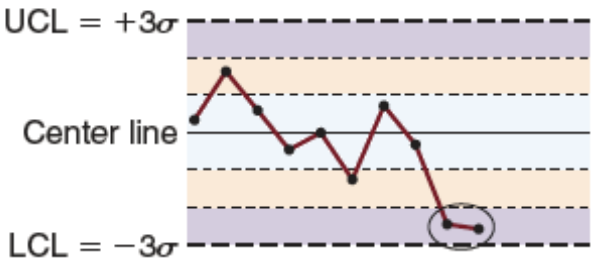
One sample mean above UCL; investigate for assignable cause.



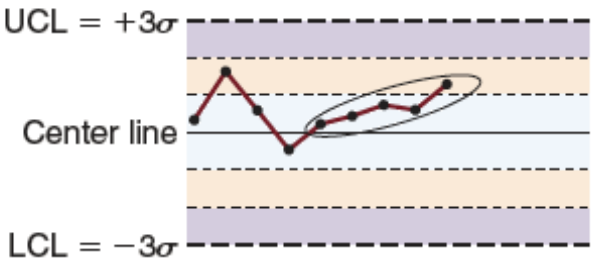
One sample mean below LCL; investigate for assignable cause.



Two consecutive sample means between +2 and +3σ; investigate for assignable cause.



Two consecutive sample means between −2 and −3σ; investigate for assignable cause.



Run of five sample means above center line; investigate for assignable cause.

Source: Bertrand L. Hansen, *Quality Control: Theory and Applications* © 1963, p. 65.
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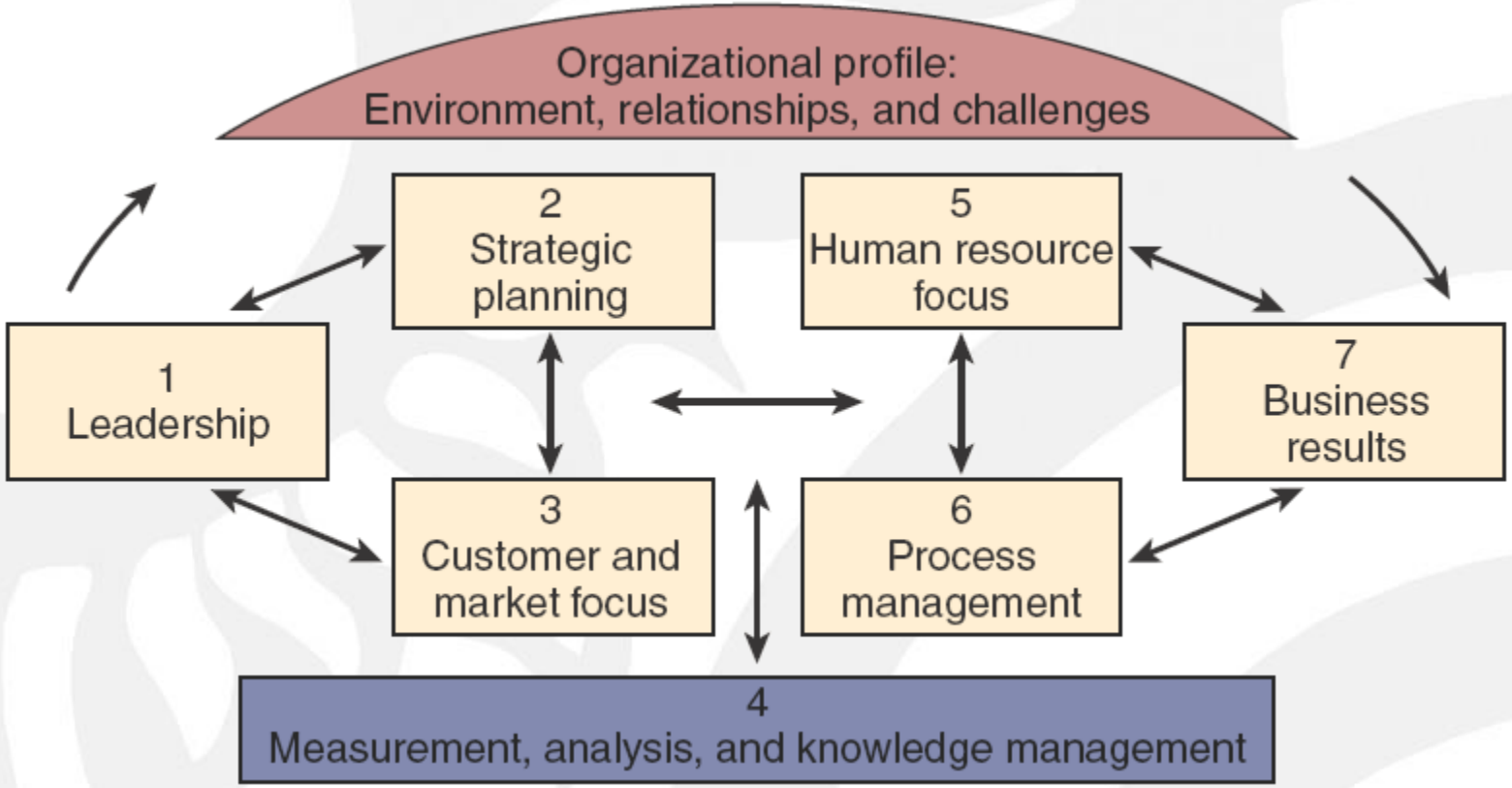
Recognizing and Rewarding Quality

- Promotion of High Quality Goods and Services
  - –Malcolm Baldrige National Quality Award (MBNQA) (United States)
  - –Deming Prize (Japan)
  - –European Quality Award (European Union)
  - –ISO9000 certification

The Integrated Framework of the Baldrige Award Criteria



Source: 2004 Criteria for Performance Excellence, U.S. Dept. of Commerce, Baldrige National Quality Program, National Institute of Standards and Technology, Gaithersburg, MD 20899. (www.quality.nist.gov)

Award Criteria—Item Listing

Categories/Items	Points Values
1.0 Leadership	120
2.0 Strategic planning	85
3.0 Customer and market focus	85
4.0 Measurement, analysis, and knowledge management	90
5.0 Human resource focus	85
6.0 Process management	85
7.0 Business results	450
Total Points	1,000

Source: 2004 Criteria for Performance Excellence, U.S. Dept. of Commerce, Baldrige National Quality Program, National Institute of Standards and Technology, Gaithersburg, MD 20899. (www.quality.nist.gov)

Baldrige Award Recipients

ISO 9000

- The International Organization for Standardization (ISO)
- ISO 9000 Certification
  - First party certification—A firm audits itself.
  - Second party certification—Customers audit their suppliers.
  - Third party assessment—Company is assessed by outside registrars from ASQ's Registration Accreditation Board (RAB).
- ISO 14000 – Environmental Management
- ISO 22000 – Food Safety

Assuring Customer Satisfaction

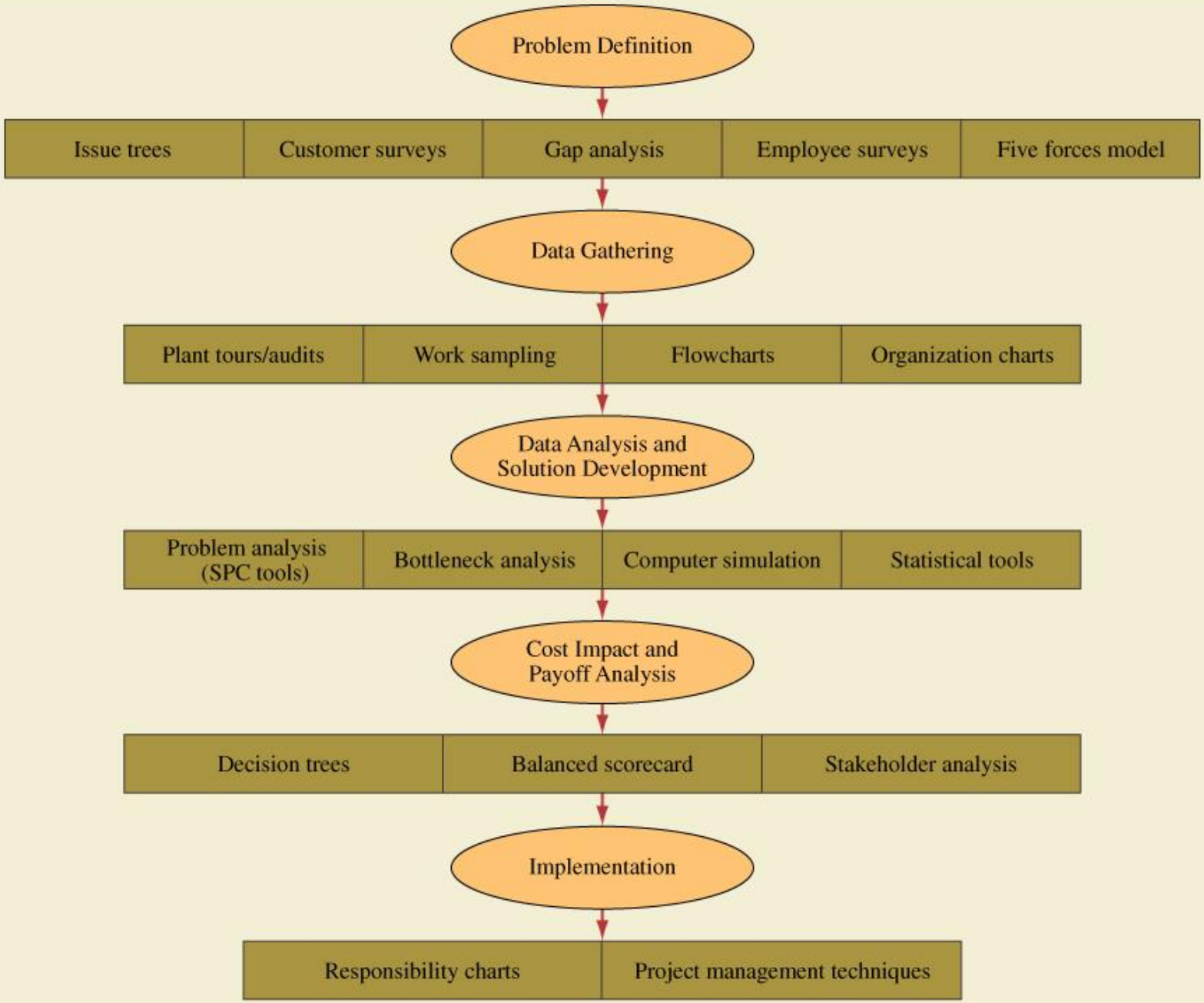
- Service Recovery
  - How quickly a firm rectifies a service mistake has a strong effect on establishing customer loyalty and creating customer satisfaction.
- Service Guarantees
  - Provide customer feedback on service operations
  - Effective guarantees
    - Unconditional
    - Easy to understand
    - Meaningful
    - Easy and painless to invoke
    - Easy and quick to collect on

Service Quality Measurement: ***SERVQUAL***

- A perceived service quality questionnaire survey methodology
- Examines “Dimensions of Service Quality” including: Reliability, Responsiveness, Assurance, Empathy, and Tangibles (e.g., appearance of physical facilities, equipment, etc.)
- Read more: http://en.wikipedia.org/wiki/SERVQUAL

Obstacles to Implementing TQM

- Lack of a company-wide definition of quality.
- Lack of a formalized strategic plan for change.
- Lack of a customer focus.
- Poor inter-organizational communication.
- Lack of real employee empowerment.
- Lack of employee trust in senior management.
- View of the quality program as a quick fix.
- Drive for short-term financial results.
- Politics and turf issues.


Problem Definition
Issue trees
Customer surveys
Gap analysis
Employee surveys
Five forces model
Data Gathering
Plant tours/audits
Work sampling
Flowcharts
Organization charts
Data Analysis and Solution Development
Problem analysis (SPC tools)
Bottleneck analysis
Computer simulation
Statistical tools
Cost Impact and Payoff Analysis
Decision trees
Balanced scorecard
Stakeholder analysis
Implementation
Responsibility charts
Project management techniques