Six Sigma

Concepts in Quality Management:
Sessions 1 and 2

Lecture Objectives

- Overview of Quality Management
- Total Quality Management defined
- Quality Specifications and Costs
- TQM Tools; External Benchmarking
- ISO 9000
- Service Quality Measurement
- Six Sigma Quality

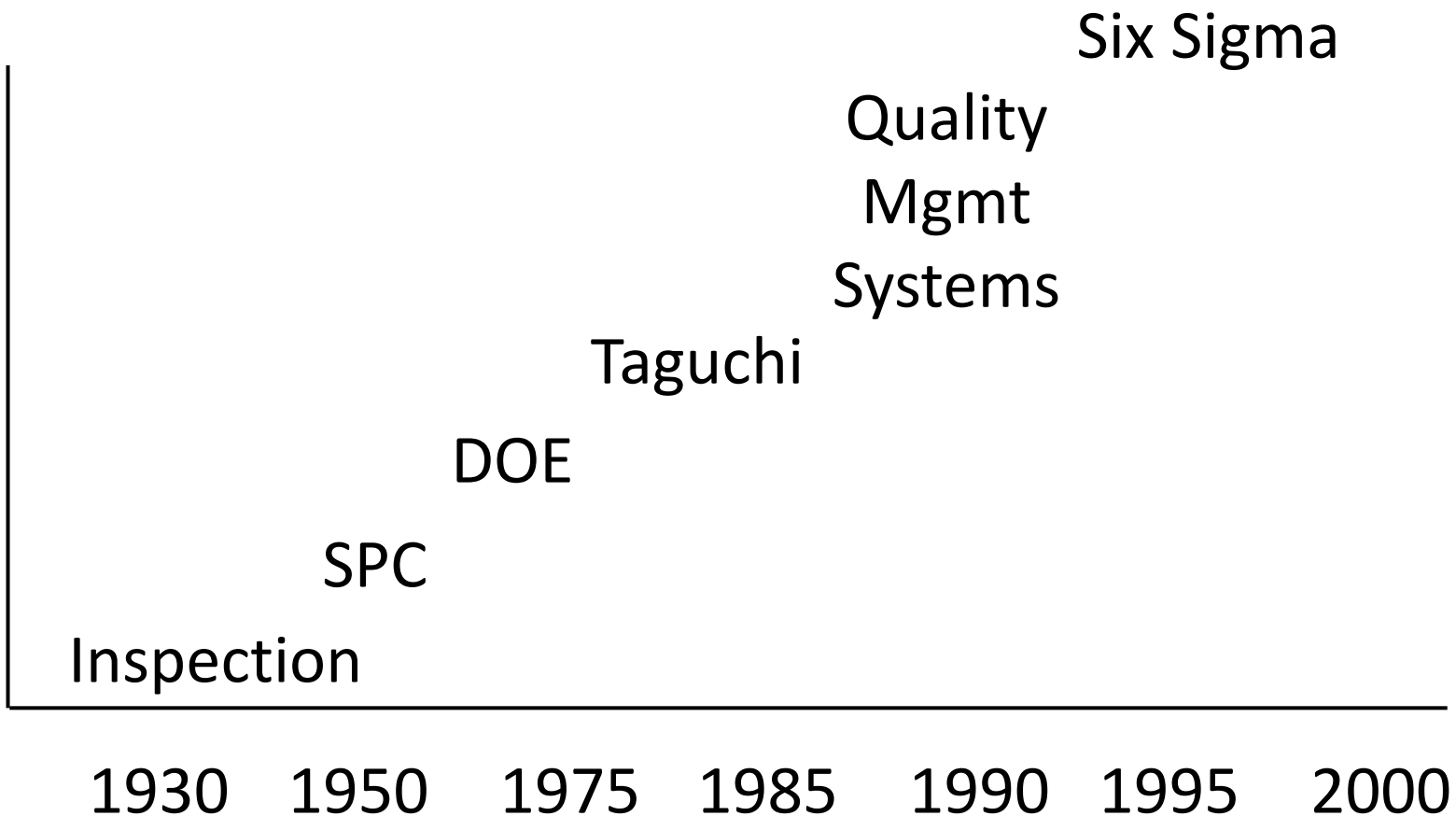
Defining Quality

Perfection
Providing a good, usable product
Eliminating waste
Consistency
Fast delivery
Fitness for use
Doing it right the first time
Delighting or pleasing customers
Total customer service and satisfaction

What is Six Sigma?

- Six Sigma is a business improvement approach
- Seeks to find and eliminate causes of defects and errors in manufacturing and service processes
- Focuses on outputs that are critical to customers and a clear financial return for the organization
- Aims at producing no more than 3.4 ppm defects
- Pioneered by Motorola in the mid-1980s
- Popularized by the success of General Electric

Evolution of Quality Management



Quality Management and the Evolution of Six Sigma

- Skilled craftsmanship during Middle Ages
- Industrial Revolution: rise of inspection and separate quality departments
- Early 20th Century: Statistical methods at Bell System
- Quality control during World War II
- Post-war Japan: evolution of quality management

Quality Management and the Evolution of Six Sigma

- Quality awareness in U.S. manufacturing industry during 1980s: from “Little Q” – QC – to “Big Q” – Total Quality Management
- Malcom Baldrige National Quality Award (1987)
- Disappointments and criticism

Quality Management and the Evolution of Six Sigma

- Emergence of quality management in service industries, government, health care, and education
- Birth of Six Sigma
- Current and future challenge: keep progress in quality management alive

Quality Management has matured…

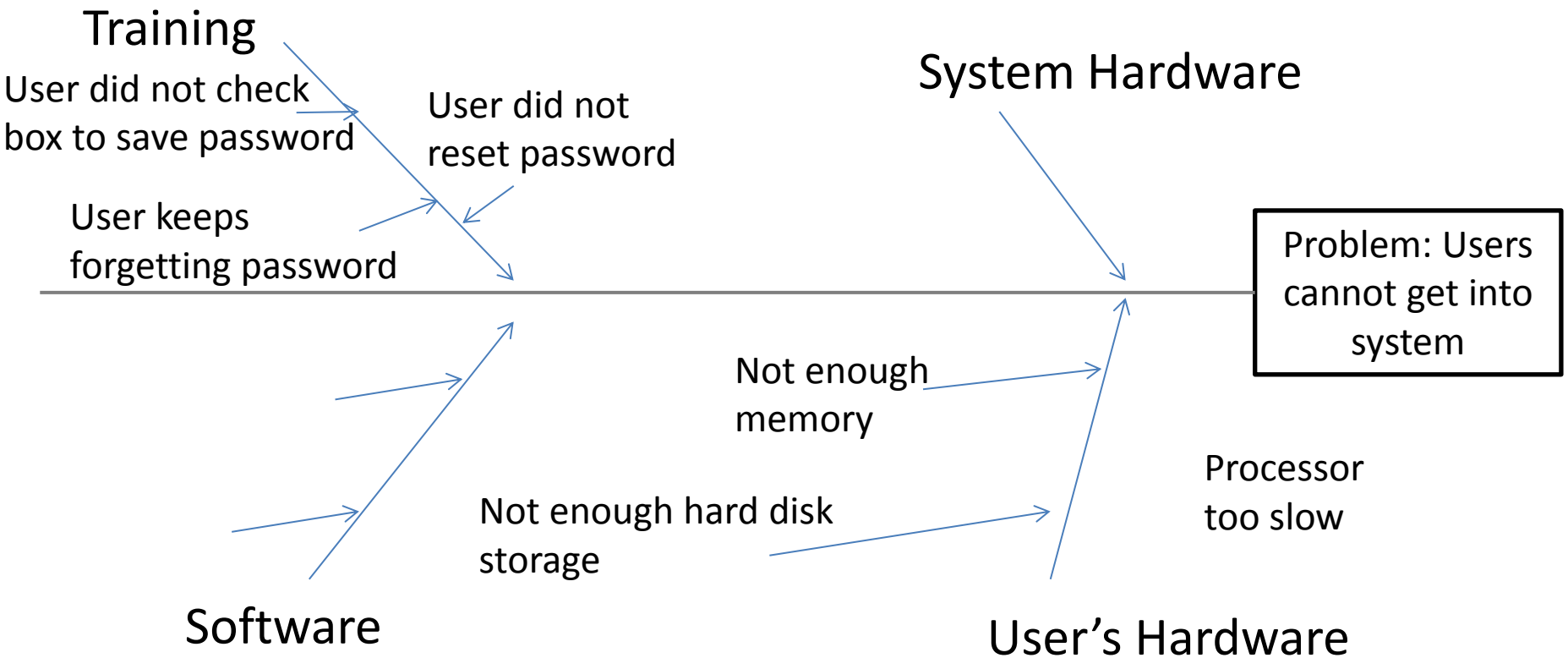
- Quality Planning
- Quality Assurance
- Quality Control

TQM vs. Six Sigma

- TQM
  - Based on worker empowerment and teams
  - Department or workplace focus
  - Simple improvement tools
  - Little financial accountability
- Six Sigma
  - Owned by business leader champions
  - Cross functional projects
  - Rigorous and advanced statistical tools
  - Requires verifiable return on investment

A Typical TQM tool

- Illustrates relationships between causes and quality problems
- Subdivides causes into their underlying components
- An effective tool to generate ideas systematically about causes for problems and to present them in a structured form

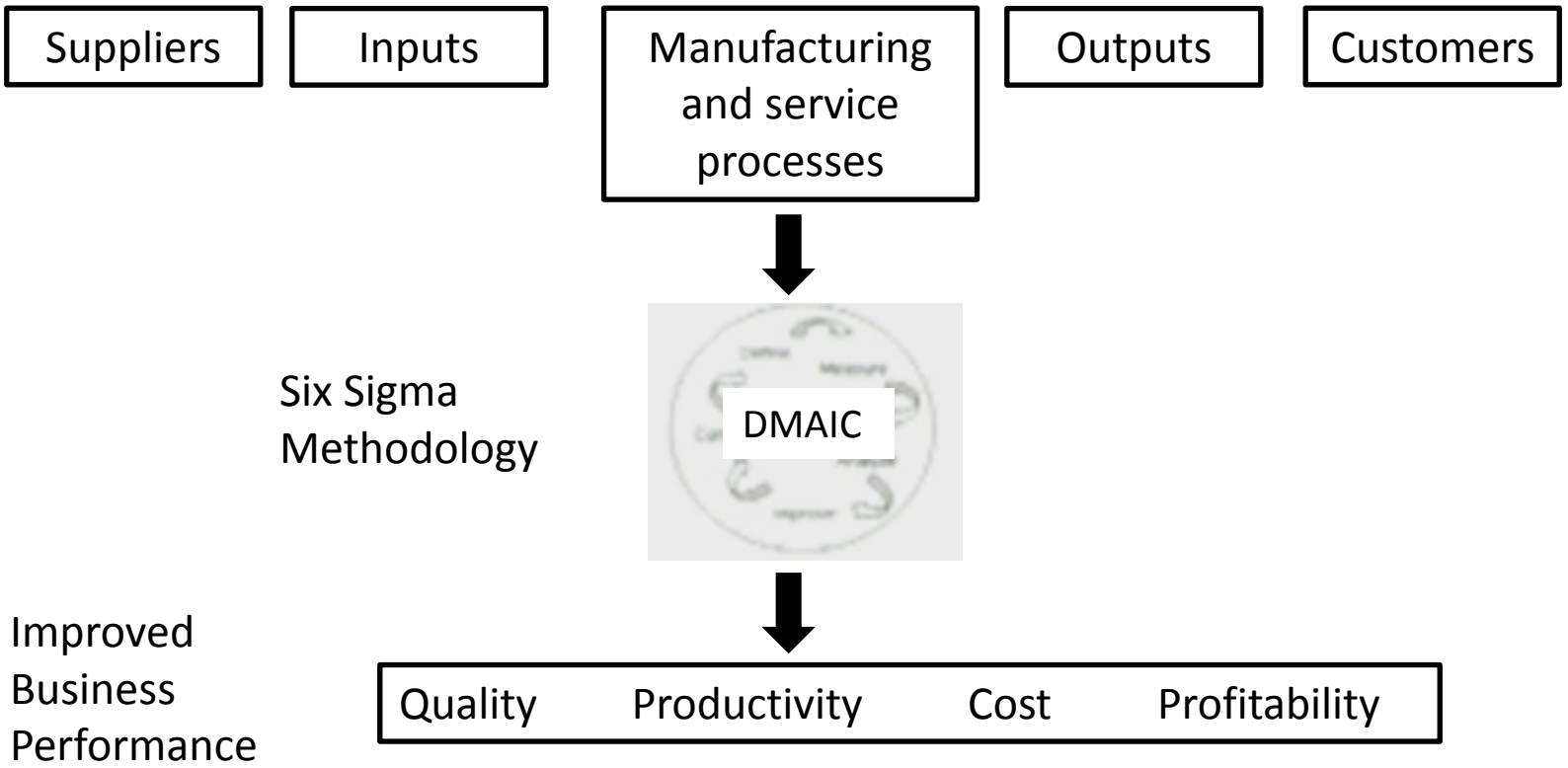


Six Sigma Methodology

- DMAIC
  - Define
  - Measure
  - Analyze
  - Improve
  - Control

- Incorporates a wide variety of statistical and process improvement tools
- Generally the goal is to reach 3.4 ppm defect level

Six Sigma Improvement Model



Six Sigma works for Everyone

- Customers – higher satisfaction at lower cost
- Plant managers –reduce waste, improve product consistency, solve equipment problems, create capacity
- Human resource managers – reduce cycle time for hiring processes
- Sales managers – improve forecast reliability, pricing strategies, pricing variation
- Anyone – better understand customer needs and tailor service offerings to meet them

Quality Gurus

- Edward Deming
  - Plan – Do – Check – Act
  - Fourteen Points for Transformation Management
- J. M. Juran
  - Managerial Practices, Training, Cost of Quality
- Armand Feigenbaum
  - Total Quality Control
- Kaoru Ishikawa
  - Quality Circles, 7 Tools
- Philip Crosby
  - Zero defects and Quality is free
- Genichi Taguchi
  - Quality loss function
  - Robust design by DOE

Consequences of Poor Quality

- Product fails!
- Does not meet requirements
- Goes over competitive pricing
- Delivery goes beyond deadline
- Loss of business:

  Poor designs or defective products or services can result in loss of business
- Liability:

  Damage or injuries resulting from faulty design
- Productivity loss:

  Productivity and quality are closely related
- Cost:

  Poor quality increases production and marketing costs

TQM says “Responsibility for Quality must be shared throughout”

- Top management
- Design; technology
- Procurement. Contract mgmt
- Production/operations/inspectors
- Quality assurance
- Packaging and shipping; delivery
- Marketing and sales
- Customer service/after sales

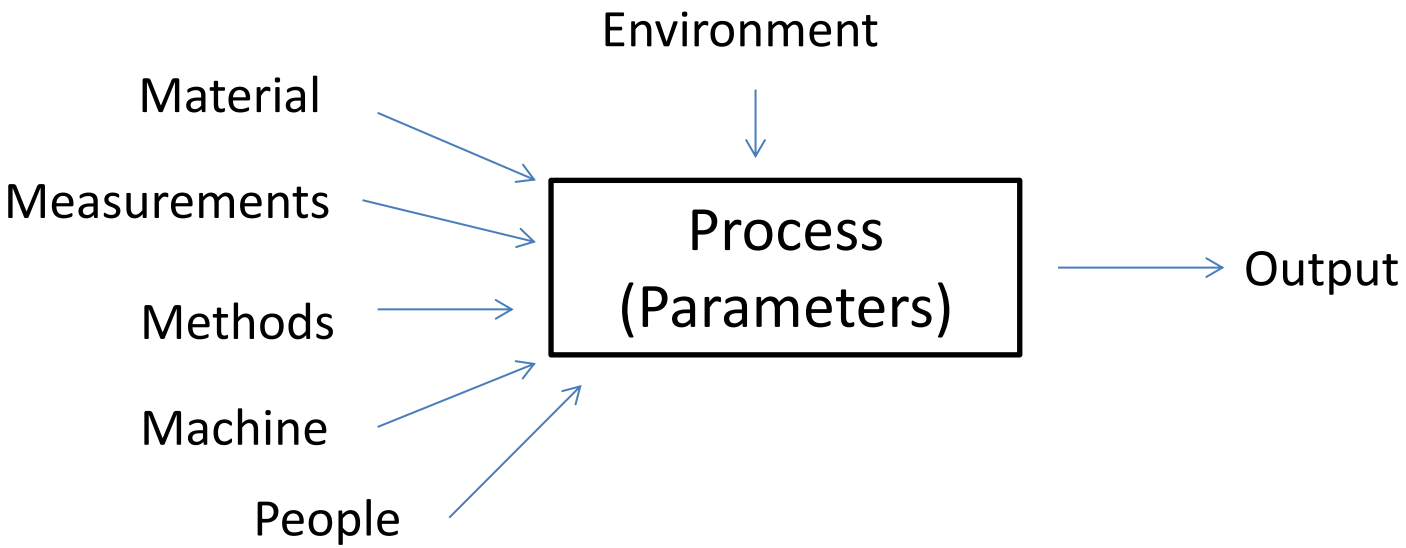
Customer Acceptance Criteria: Now it is the *total experience*

Criteria	Product Automobile	Service Auto Repair
1. Performance	Everything works, fit & finish Ride, handing, grade of materials used	All work done, at agreed price Friendliness, courtesy. Competency, quickness
2. Aesthetics	Interior design, soft touch	Clean work/waiting area
3. Special features, Convenience High tech	Gauge/control placement Cellular phone, CD player	Location, call when ready Computer diagnostics
4. Safety	Antilock brakes, airbags	Separate waiting area

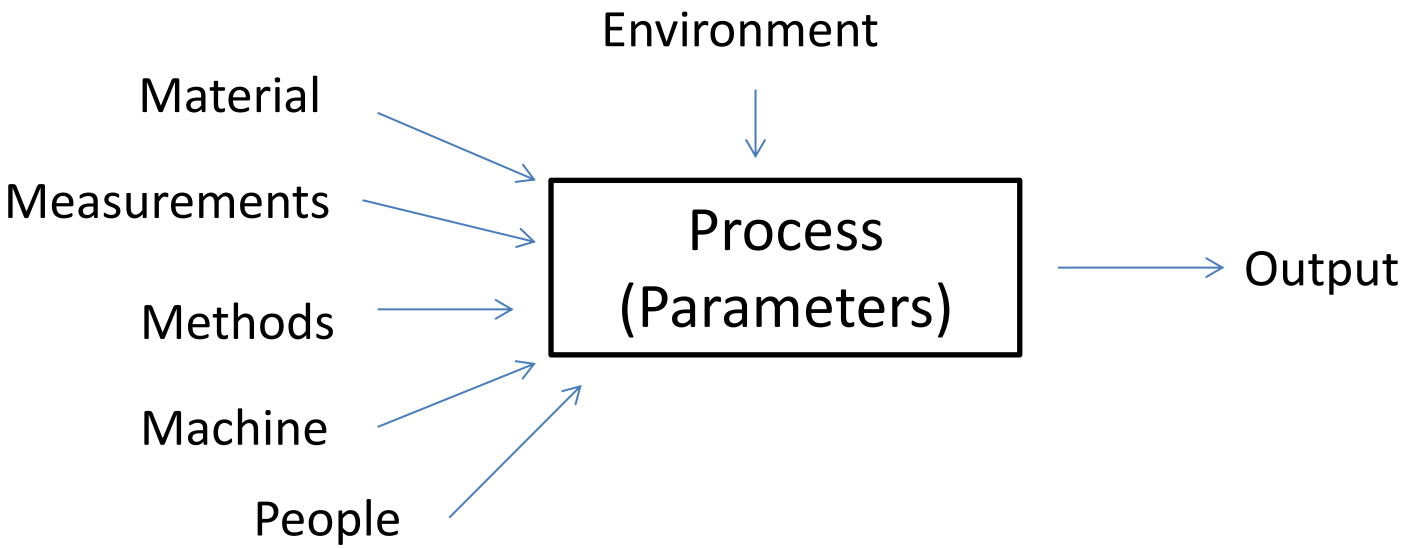
Customer Acceptance Criteria: Now it is the *total experience*

Criteria	Product Automobile	Service Auto Repair
5. Reliability	Infrequency of breakdowns	Work done correctly, ready when promised
6. Durability	Useful life in miles, resistance To rust & corrosion	Work holds up over time
7. Perceived quality	Top-rated car	Award-winning service department
8. Service after sale	Handling of complaints and/or requests for information	Handing of complaints

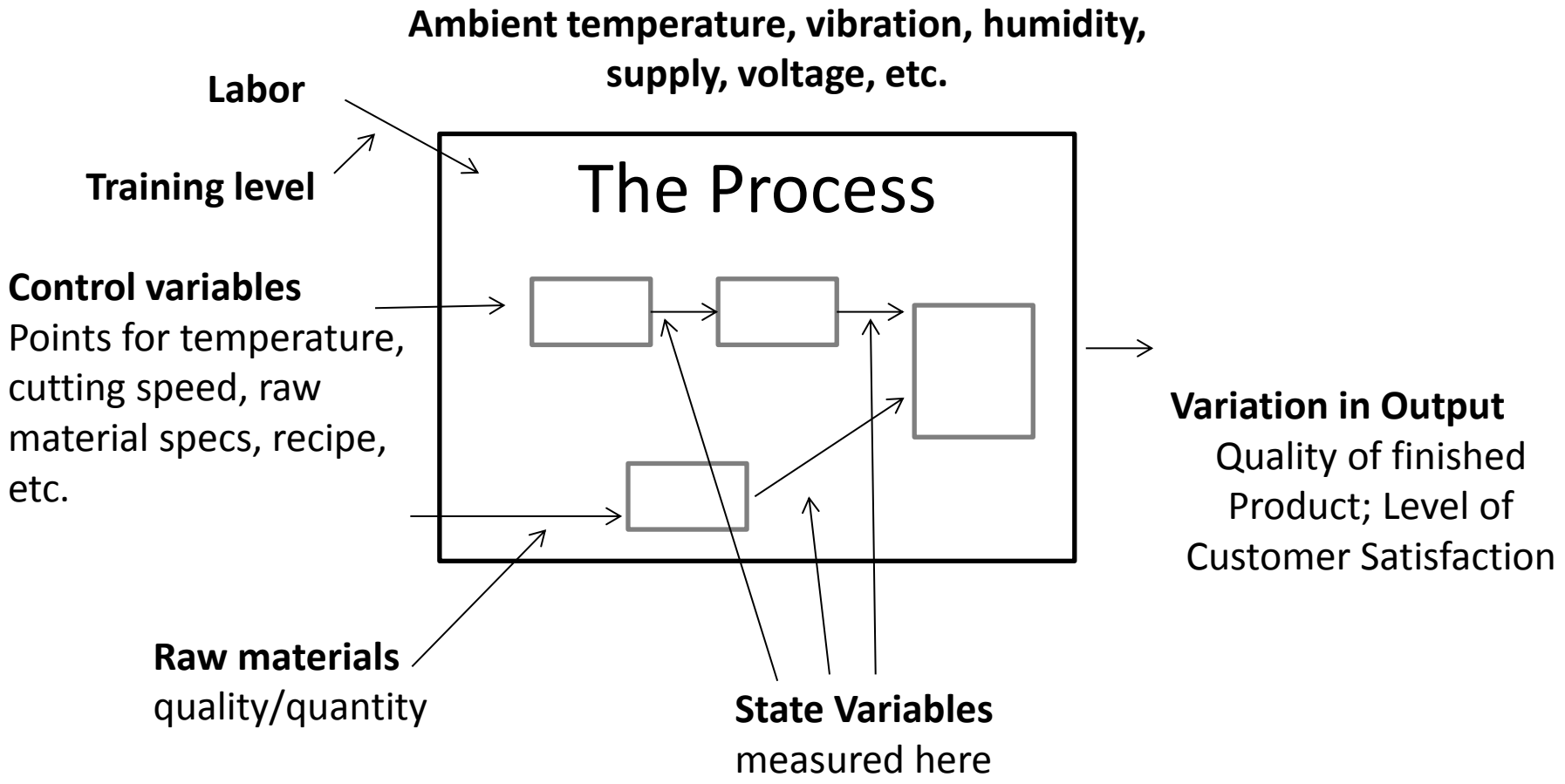
Moving QC toward QA: Causes and the Effect



Moving QC toward QA: Causes and the Effect



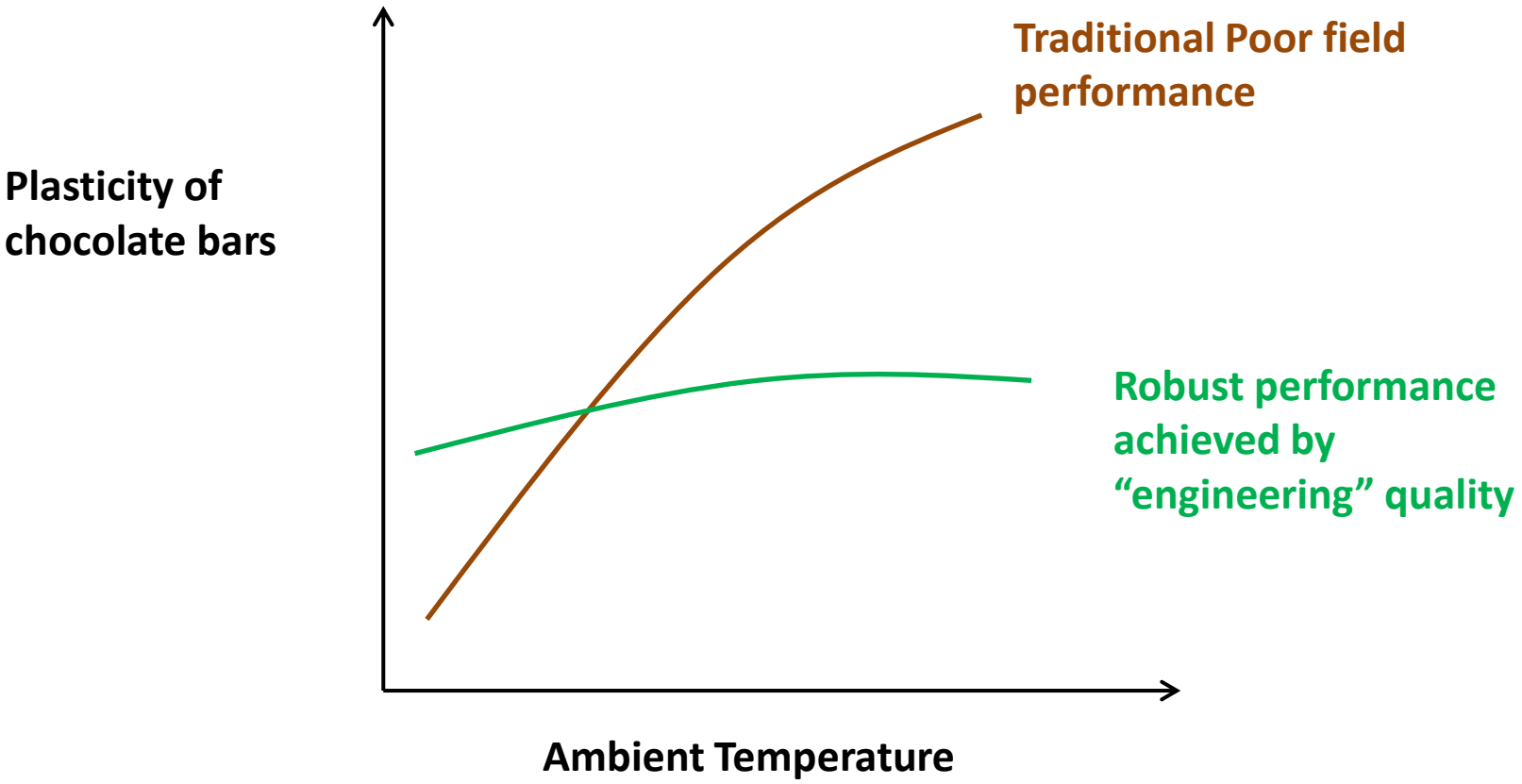
Why is quality so difficult to deliver?



Traditional Quality Management

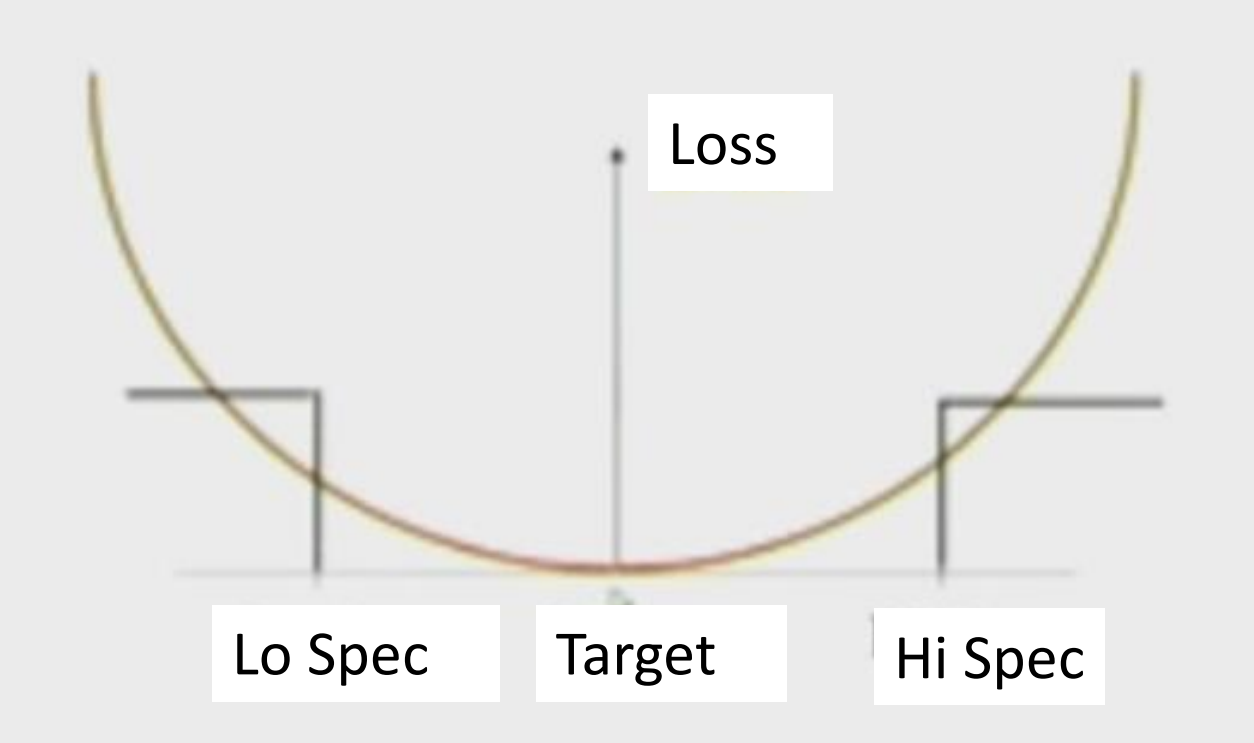
- Focus on short term profits, stock price
- No clear strategic position in target sectors (poor competitive positioning)
- Clamping down on costs while tolerating high levels of waste
- Take-it-or-leave-it attitude to customers
- Buying at lowest price
- Managers are troubleshooters

Response to new Chocolate Bars: A supermarket chain wanted to launch EU chocolates in Kuala Lumpur



The Taguchi Loss Function

Customer incurs a loss when quality is off target



Taguchi's Quality Philosophy

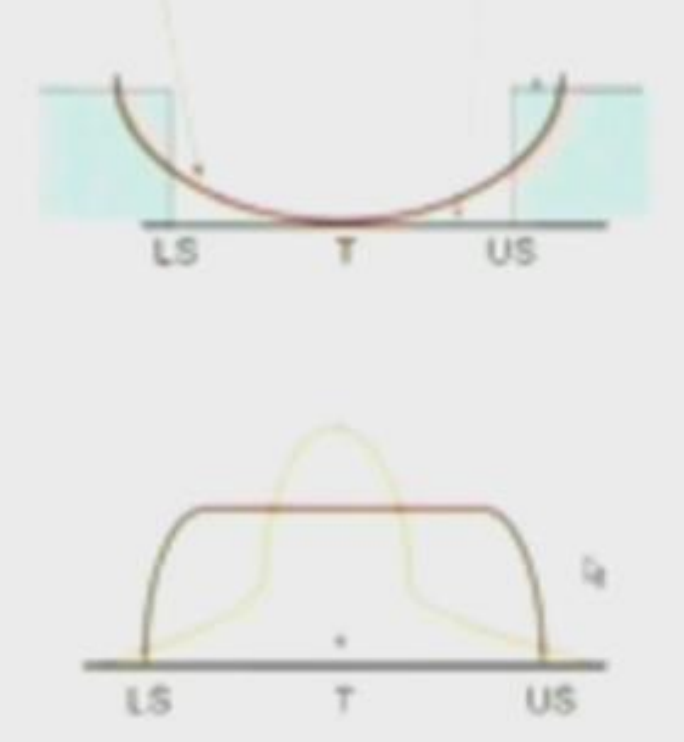
Taguchi's view

Conventional view

$$\text{Loss} = k(P - T)^2$$

Loss ≠ 0 if within specs and 1 if outside

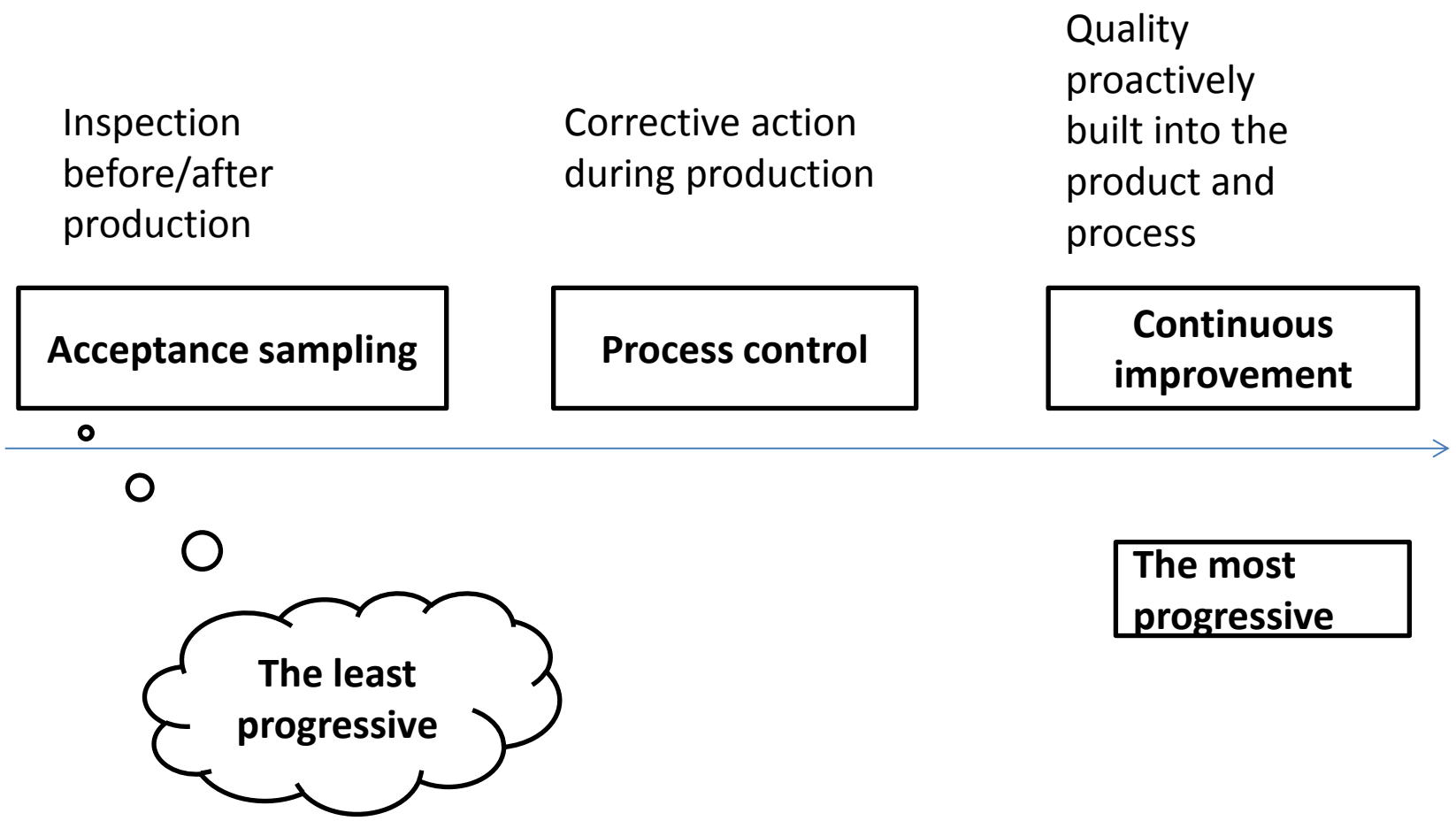
"On Target Production" is more important than producing within Specs
Sony TV, Ford Cars



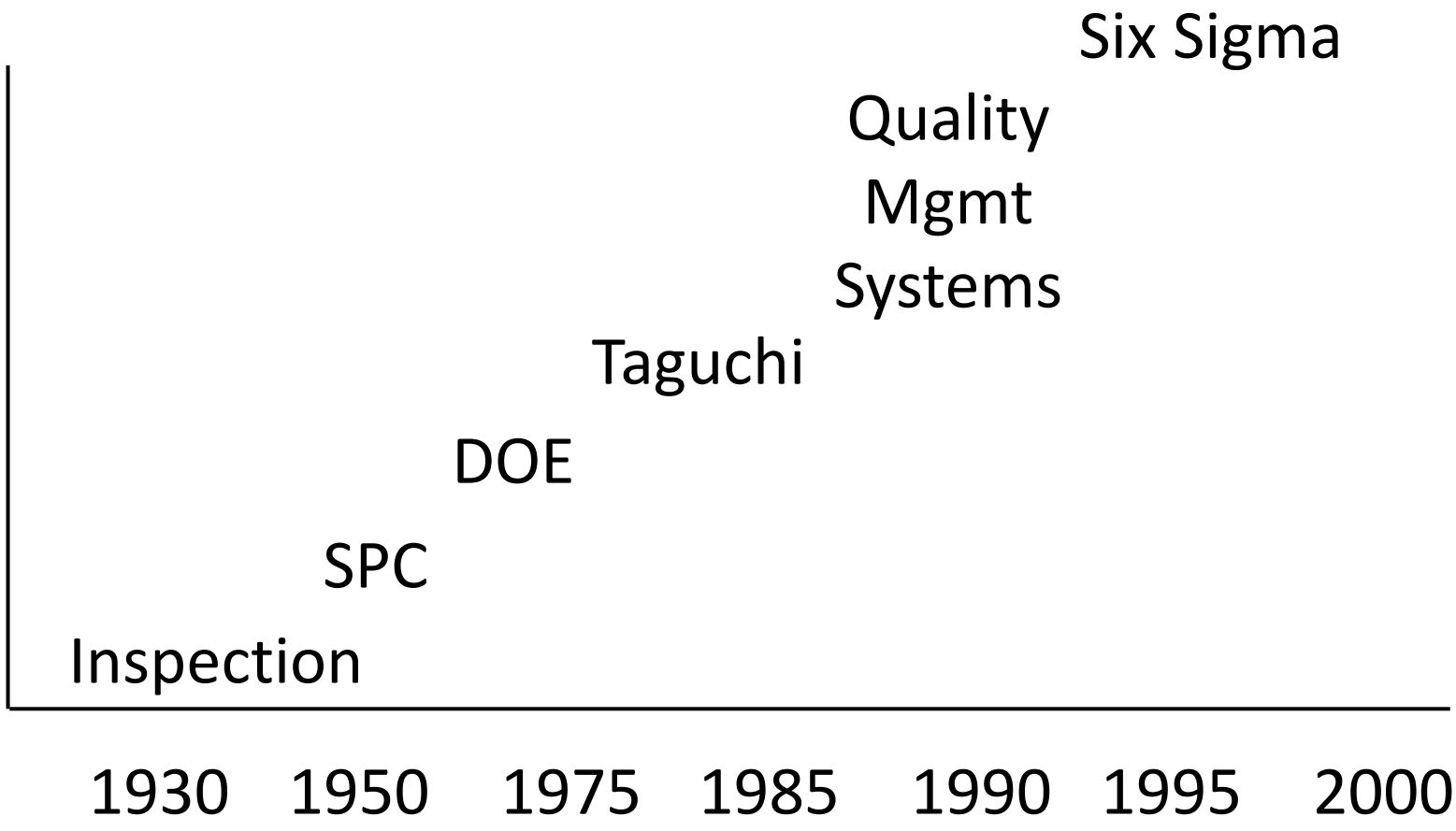
Current Situation Worldwide

- More competitors than ever
- Fiercely competitive strategies in play
- Fluid and unpredictable financial systems
- Customers' expectations increasing
- Employees' expectations increasing
- Investors expect more
- Rapid changes in technology

Phases of Quality Assurance



Recall the Evolution of QA Methods… Moving from QC to QA to QE



How to tell ‘TQM’

- Top Management’s direct involvement
- Strong customer orientation
- Problems solved by systematic methods
- Everyone participates
- Continuous improvement is the theme

TQM encourages problem solving at all levels

- A different management policy
- Appropriate organizational structure to put this into effect
- Use of the simple and advanced statistical tools
- Training at all levels
- The power to delegate to those who can make the necessary changes

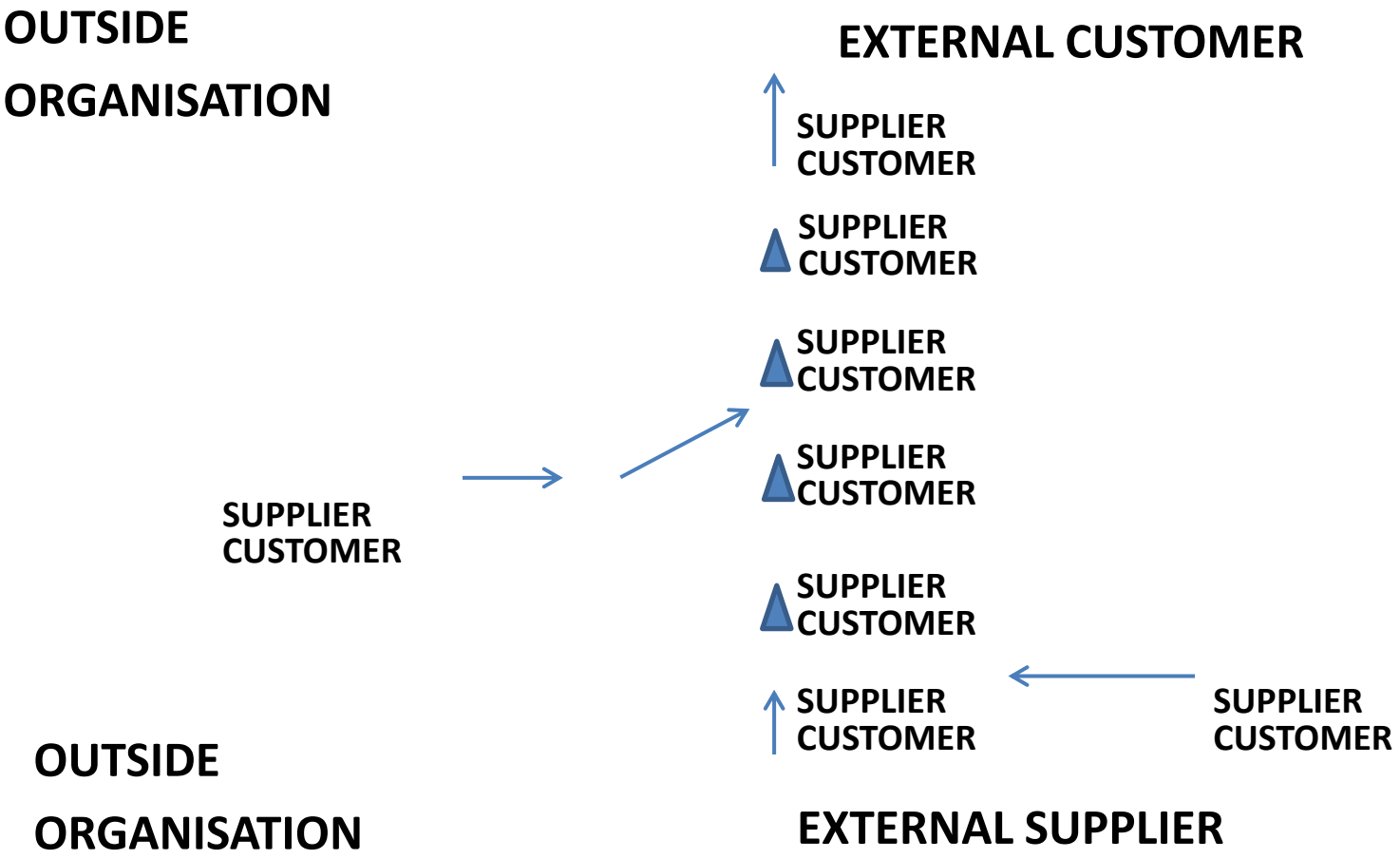
TQM is not a collection of tools and techniques. It is a *culture*.

TQM is an attitude of mind based on pride in job, teamwork, and management commitment extending to all employees at all levels and in all departments

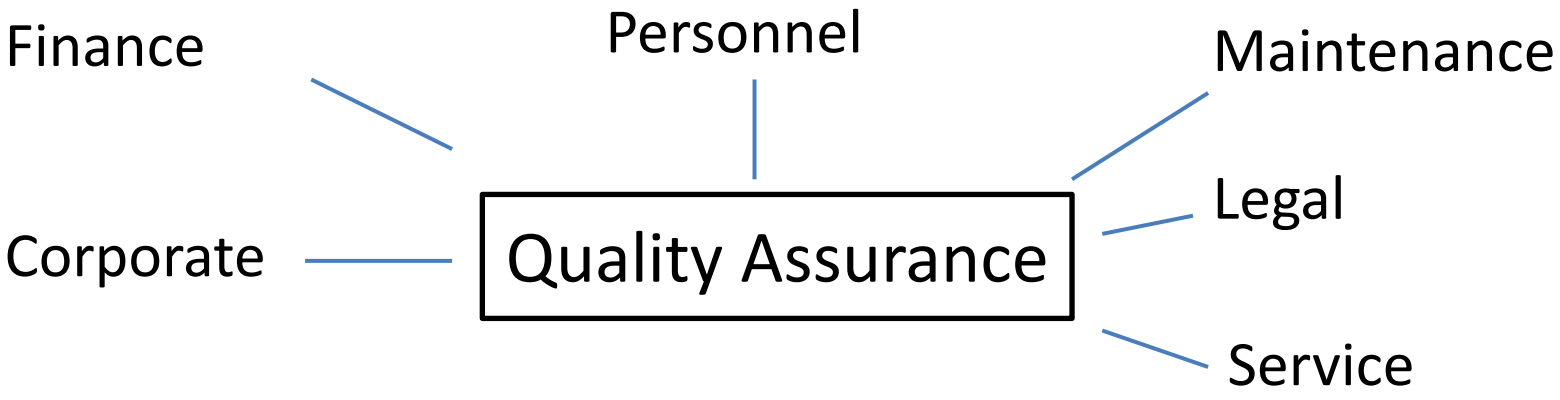
A TQM view: Quality Chains

- Throughout and beyond the organization a series of quality chains exist
- Quality chains exist within the organization also
- Chains may be broken by
  - One person, or
  - One equipment, not meeting the requirements of the customer—internal or external

The Quality Chain



The Quality Processes: QC, QA and QE



Quality Engineering

Product Design
Process Design
Procurement

Quality Control

Manufacturing
Packaging
Distribution
Field Service

Quality Awards recognize good performance

Malcom Baldrige National Quality Award

- Help improve quality in U.S. companies
- Recognize achievements of excellent firms and provide examples to others
- Establish criteria for evaluating quality efforts
- Provide guidance for other American companies

Malcom Baldrige National Quality Award

1.0 Leadership (125 points)

2.0 Strategic Planning (85 points)

3.0 Customer and Market Focus (85 points)

4.0 Information and Analysis (85 points)

5.0 Human Resource Focus (85 points)

6.0 Process Management (85 points)

7.0 Business Results (450 points)

MB Audit Criteria for Performance Excellence

- Leadership
- Strategic Planning
- Customer and Market Focus
- Measurement, Analysis, and Knowledge Management
- Human Resource Focus
- Process Management
- Business Results

Benefits of Baldrige Competition

- Financial success
- Winners share their knowledge
- The process motivates employees
- The process provides a well-designed quality system
- The process requires obtaining data
- The process provides feedback

The Deming Prize

- Instituted 1951 by Union of Japanese Scientists and Engineers (JUSE)
- Several categories including prizes for individuals, factories, small companies, and Deming application prize
- American company winners include Florida Power & Light and AT&T Power Systems Division

The Deming Prize

- Honoring W. Edwards Deming
- Japan’s highly coveted award
- Main focus on statistical quality control

European Quality Award

Prizes intended to identify role models

- Leadership
- Customer focus
- Corporate social responsibility
- People development and involvement
- Results orientation

Other Quality Awards

- Canadian Awards for Business Excellence
- Australian Business Excellence Award
- Rajiv Gandhi Quality Award—patterned after Baldrige (TQM)

Contemporary Quality Philosophies and Management Strategies

- Total Quality Management (TQM)
- Quality Standards and Registration
  - ISO 9000 & QS 9000
- Just-in-time, Lean Manufacturing, Poka-Yoke, etc.
- Six Sigma- Black Belt Program

TQM was the first major QM initiative

- Top management's direct involvement
- Strong customer orientation
- Systematic problem solving
- Companywide participation
- Continuous improvement is the theme

But!

- Quantification of incentives is missing in TQM
- Six Sigma is the extended QA paradigm

ISO 9000: 2000

- A big help in housekeeping in most organizations
- A Quality system standard adopted by International Organization for Standardization in 1987; revides in 1994 and 2000
- Technical specifications and criteria to be used as rules, guidelines, or definitions of characteristics to ensure that materials, products, processes, and services are fit for their purpose

Rationale for ISO 9000

- ISO 9000 defines quality system standards, based on the premise that certain generic characteristics of management practices can be standardized, and carefully managed quality system provides confidence that the out-puts will meet customer expectations and requirements.

Objectives of ISO Standards

- Achieve, maintain, and continuously improve product quality
- Improve quality of operations to continually meet customers' and stakeholders needs
- Provide confidence to internal management and other employees that quality requirements are being fulfilled

Objectives of ISO Standards

- Provide confidence to customers and other stakeholders that quality requirements are being achieved
- Provide confidence that quality system requirements are fulfilled

ISO 9000: 2000 Quality Management Principles

1. Customer Focus
2. Leadership
3. Involvement of People
4. Process Approach
5. System Approach to Management
6. Continual Improvement
7. Factual Approach to Decision Making
8. Mutually Beneficial Supplier Relationships

Quality Certification, e.g. ISO 9000 improves b2b trades

ISO 9000

- Set of international standards on quality management and quality assurance, critical to international business
- Helps put your house in order

ISO 14000

- A set of international standards for assessing a company's environmental performance

ISO 9000 Quality Management Principles

- A systems approach to management
- Continual improvement
- Factual approach to decision making
- Mutually beneficial supplier relationships
- Customer focus
- Leadership
- People involvement
- Process approach

The ISO 9000 QM System

- Series of standards agreed upon by the International Organization for Standardization (ISO)
- Adopted in 1987; now called ISO 9000: 2000
- More than 100 countries have adopted
- A prerequisite for global competition?
- ISO 9000 directs you to “document what you do and then do as you documented”

Three parties in ISO Certification

1. First party: A firm (the supplier) audits itself against ISO 9000 standards

2. Second party: A customer audits its supplier

3. Third party: A "qualified" national or international standards or certifying agency serves as auditor ← the basis for getting ISO 9000

Objectives of ISO Standards

- Provide confidence to customers and other stakeholders that quality requirements are being achieved
- Provide confidence that quality system requirements are fulfilled

ISO 14000

- ISO 14000 – A set of international standards for assessing a company's environmental performance
- Standards in three major areas
  - Management systems
  - Operations
  - Environmental systems

ISO 14000

- Management systems
  - Systems development and integration of environmental responsibilities into business planning
- Operations
  - Consumption of natural resources and energy
- Environmental systems
  - Measuring, assessing and managing omissions, effluents, and other waste

Getting Started to improve Quality

- The most effective approach is to launch DMAIC projects
- Recognize customers: discover their needs and expectations
- Set performance standards that meet customer requirements
- Control processes and improve their capability
- Establish quality management systems
- Set quality policy, motivate through leadership and equip people to achieve
- Empower everyone to act for quality improvement

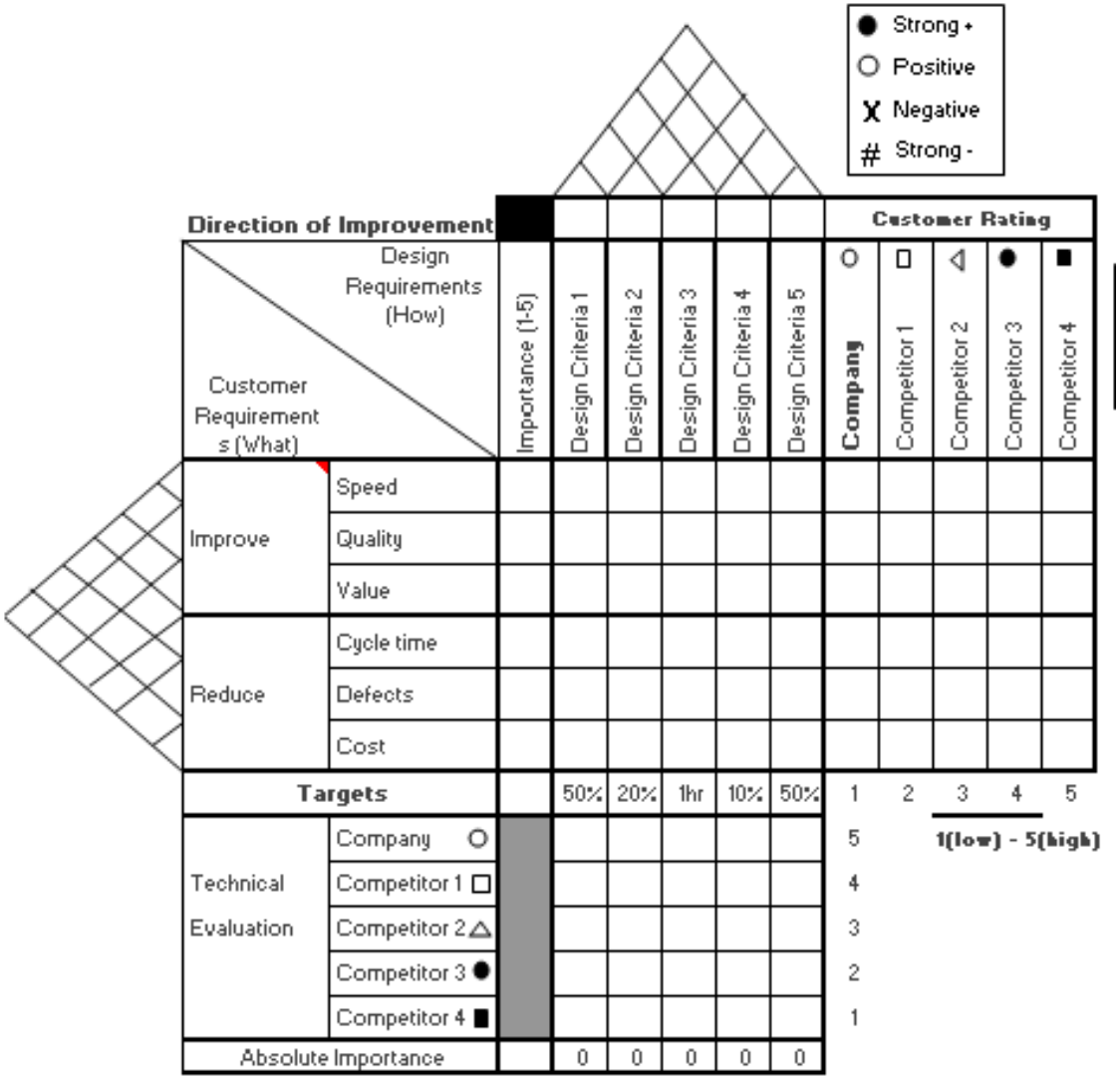
Doing “QFD” (Quality Function Deployment) can be a good start

- Captures the Customer’s voice
- QFD Facilities
  - Finding what customers want
  - Comparisons to competitors
  - Setting target values for operating requirements—the product or service you are going to produce

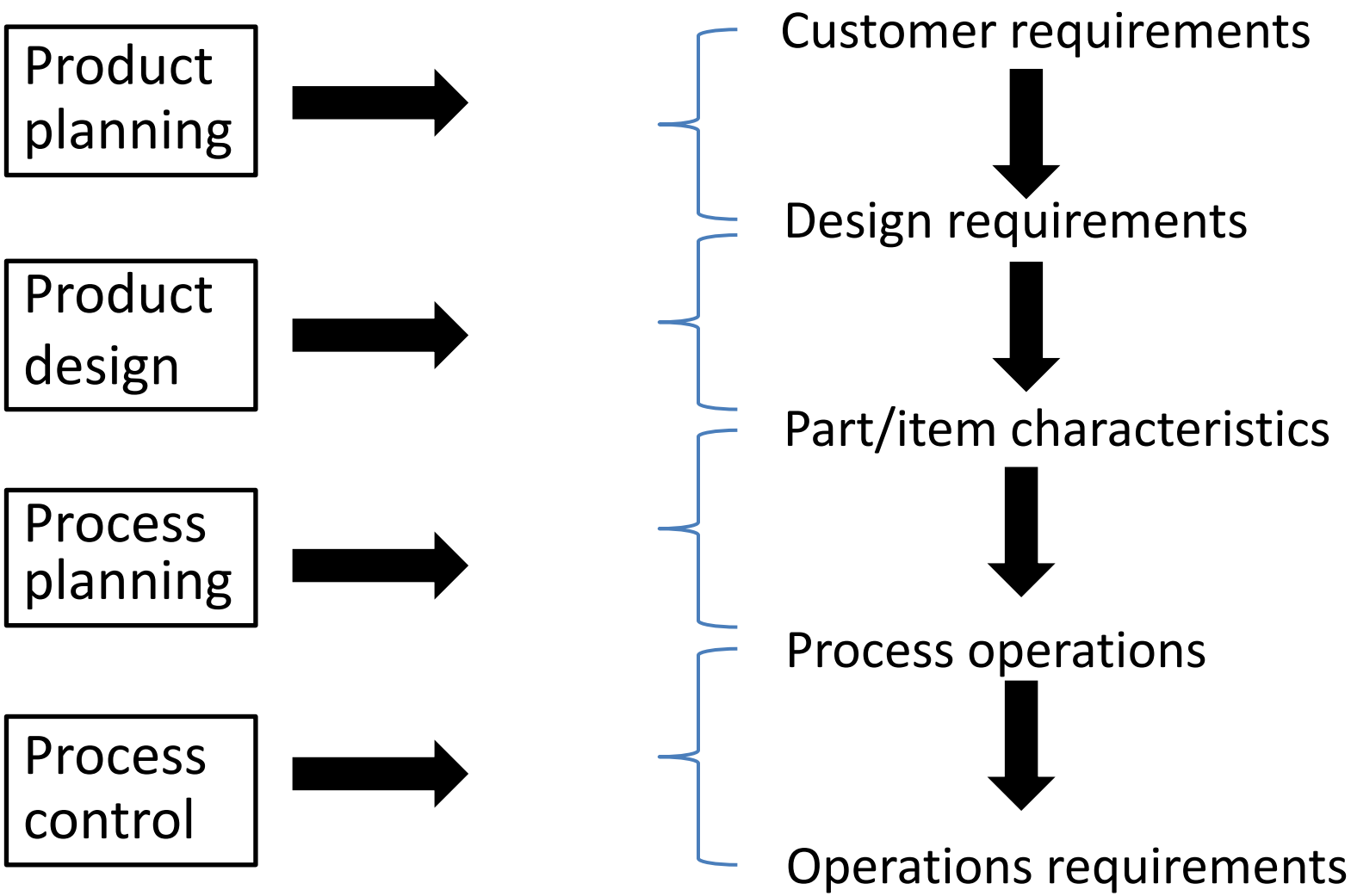
How you capture the customer's wants and preferences

- QFD Provides Structure for Integrating Product and Process Design
- Multiple Matrix Representation (House of Quality)
  - Walls: customer requirements (what's): competitive evaluation
  - Ceiling: operating requirements (how's)
  - Interior: correlation between what's and how's
  - Roof: correlation among how's
  - Basement: target values for how's
  - Foundation: competitive evaluation of how's

Example of “House of Quality”



QFD Phases


Product planning
Product design
Process planning
Process control
Customer requirements
Design requirements
Part/item characteristics
Process operations
Operations requirements

Cost of Mismanaging Quality is Enormous—it can set the stage for improvement

- 15-30% manufacturing sales revenue goes in
  - Failing to satisfy customer's needs and expectations
  - Not doing it right the first time – re-work and returns
- Up to 40% service effort goes in extra work to fix problems
- Mismanagement pushes away new customers
- Intangible losses are not quantifiable

Commitment to quality is easy to detect

- It shows on the shop floor, in hospital wards, in classrooms, in customer interaction…
- Things happen:
  - Material problems are corrected with suppliers
  - equipment faults are put right by improved maintenance programs or replacement
  - people are trained
  - partnerships are built
  - continuous improvement is observable
  - business grows

Some distinctions

- TQM is a *culture* not a program
- ISO 9000 is a set of guidelines to conduct all quality-related activities
- Six Sigma is heavy on techniques and results; it is a business process

Competitive Positioning

- Must decide first how you want to complete:
  - Low price or differentiation
  - Target market broad or niche marketing
  - Assess strength of buyers, suppliers, competition
- Determine how the value added will be distributed among suppliers, you, and your customers
- TQM starts with identifying needs and expectations of targeted potential customers

The TQM Approach to competitive positioning

1. Find out what the customer wants
2. Design a product or service that meets or exceeds customer wants
3. Design processes that facilitates doing the job right the first time
4. Keep track of the results
5. Extend these concepts to suppliers

Elements of TQM are several

- Continual improvement
- Competitive benchmarking
- Employee empowerment
- Team approach
- Decisions based on facts
- Knowledge of tools
- Supplier quality
- Champion
- Quality at the source
- Suppliers

Continuous Improvement

- Philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs.
- Kaizen: Japanese word for continuous improvement.

Targeting attainment of Quality at the Source

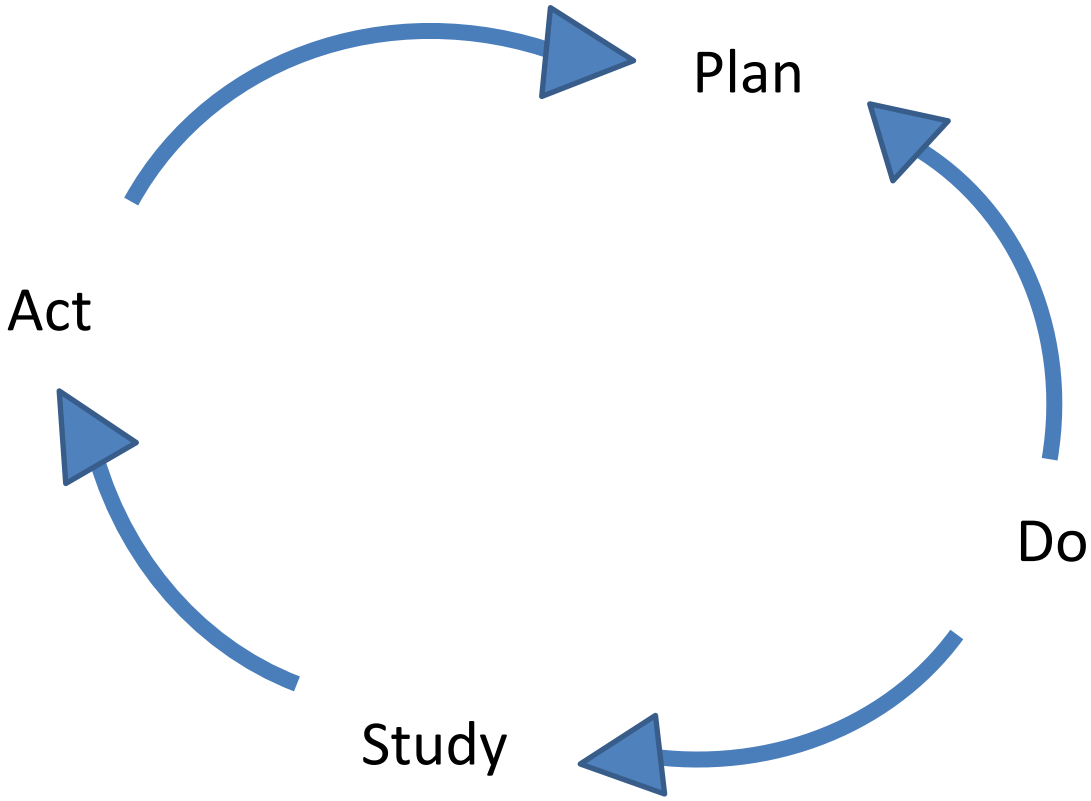
The philosophy of making each worker responsible for the quality of his or her work.

1. Steam Turbine Example
2. Parachute Factory

Classical Steps in Problem Solving

1. Define the problem and establish an improvement goal
2. Collect data
3. Analyze the problem
4. Generate potential solutions
5. Choose a solution
6. Implement the solution
7. Monitor the solution to see if it accomplishes the goal

The PDSA Cycle

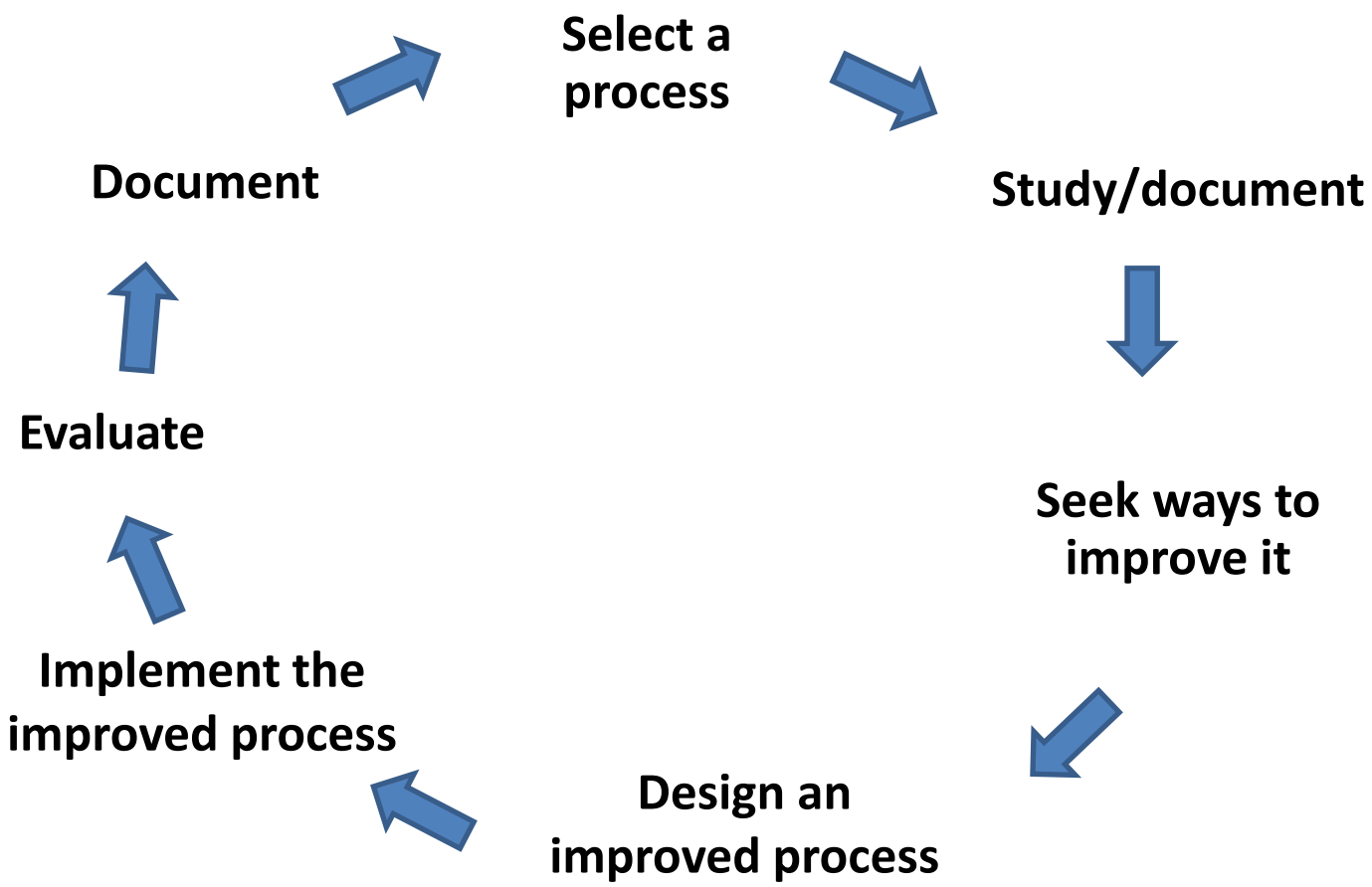


Like Deming's PDCA

Process Improvement

- Process Improvement: A systematic approach to improving a process
- Process mapping
- Analyze the process
- Redesign the process

The Improvement Cycle



Six Sigma provides a much more powerful framework for quality improvement -- DMAIC

Process Improvement and Tools

Process improvement – a systematic approach to improving a process

- Process mapping
- Analyze the process
- Redesign the process

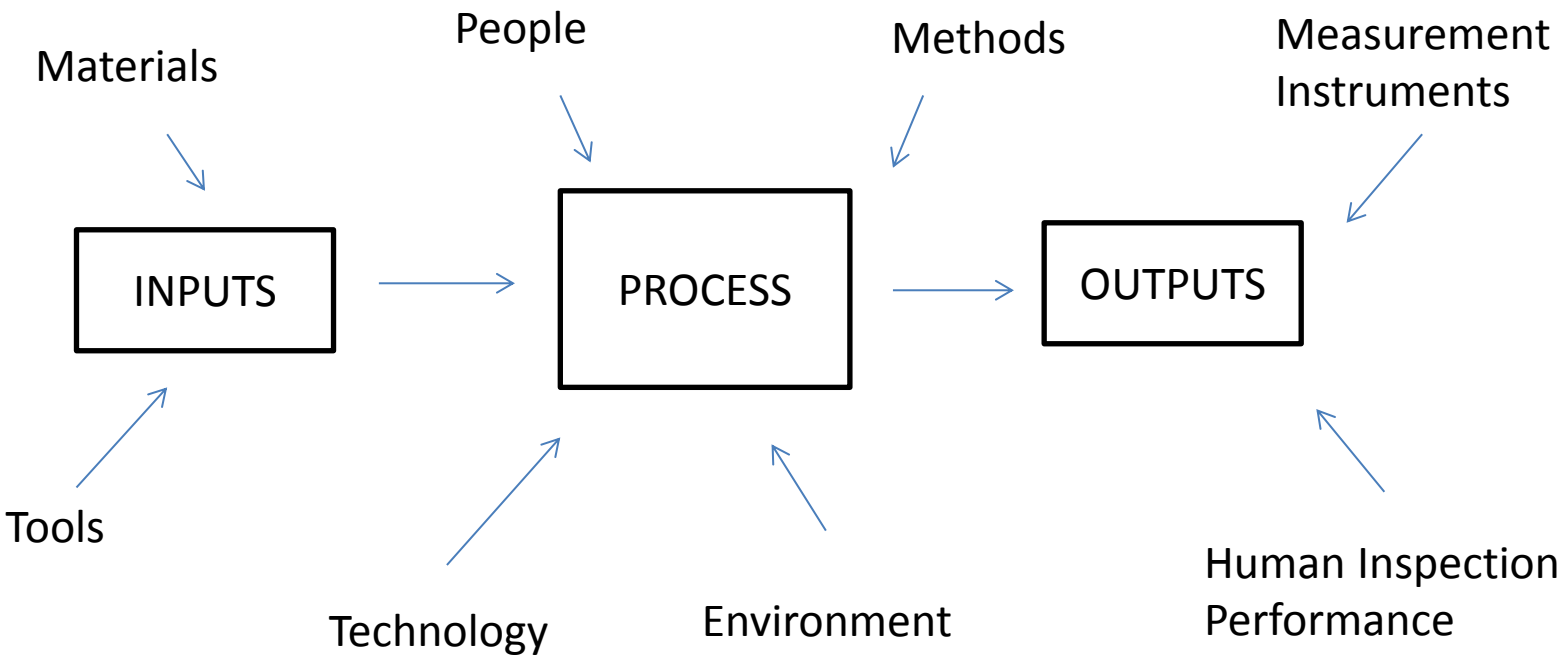
Tools

- There are a number of tools that can be used for problem solving and process improvement
- Tools aid in data collection and interpretation, and provide the basis for decision making

Basic TQM Tools

- Flowcharts
- Check sheets
- Histograms
- Pareto charts
- Scatter diagrams
- Control charts
- Cause-and-effect diagrams
- Run charts

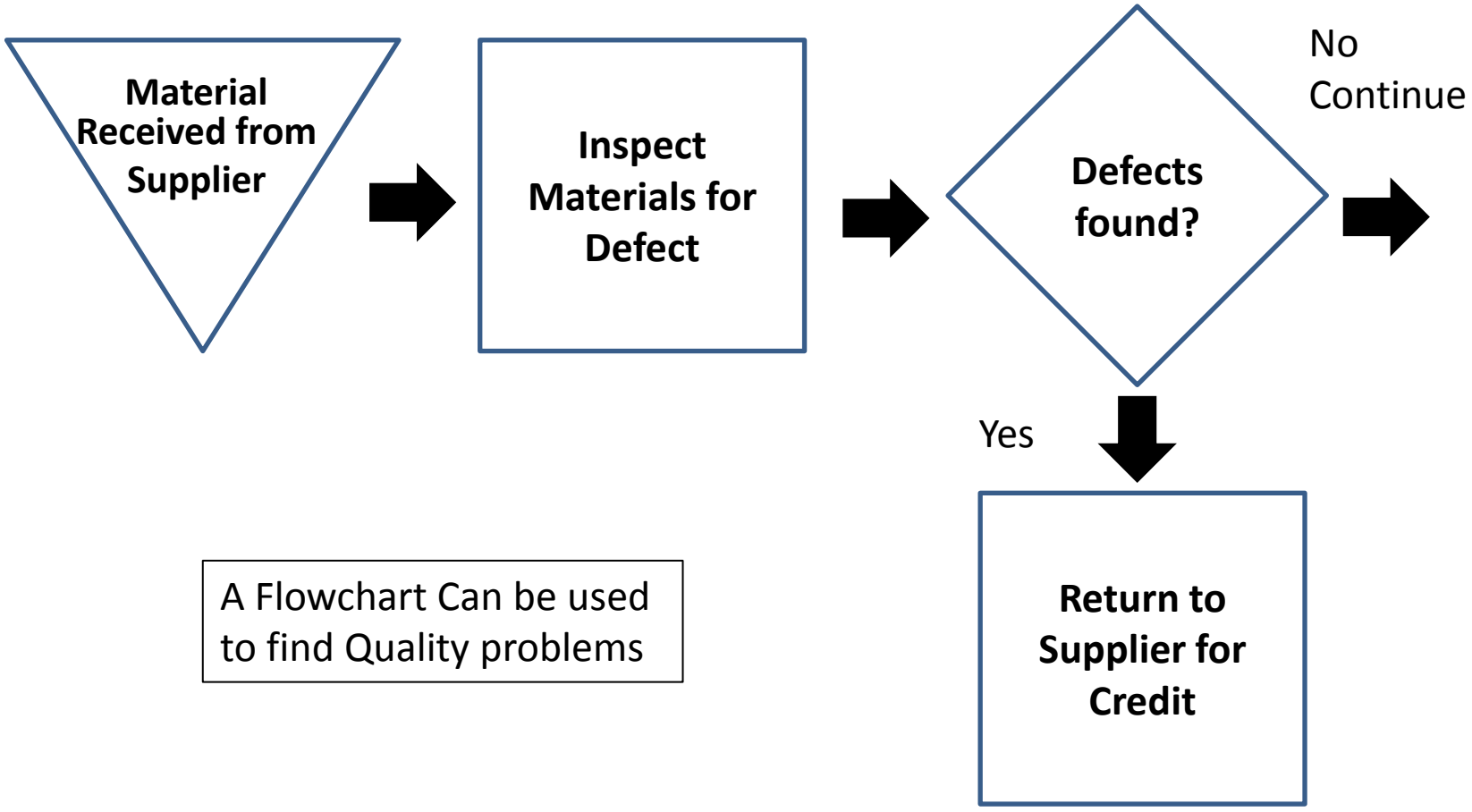
Sources of Variation in Production Processes



Variation

- Many sources of uncontrollable variation exist (common causes)
- Special assigned causes of variation can be recognized and controlled
- Failure to understand these differences can increase variation in a system

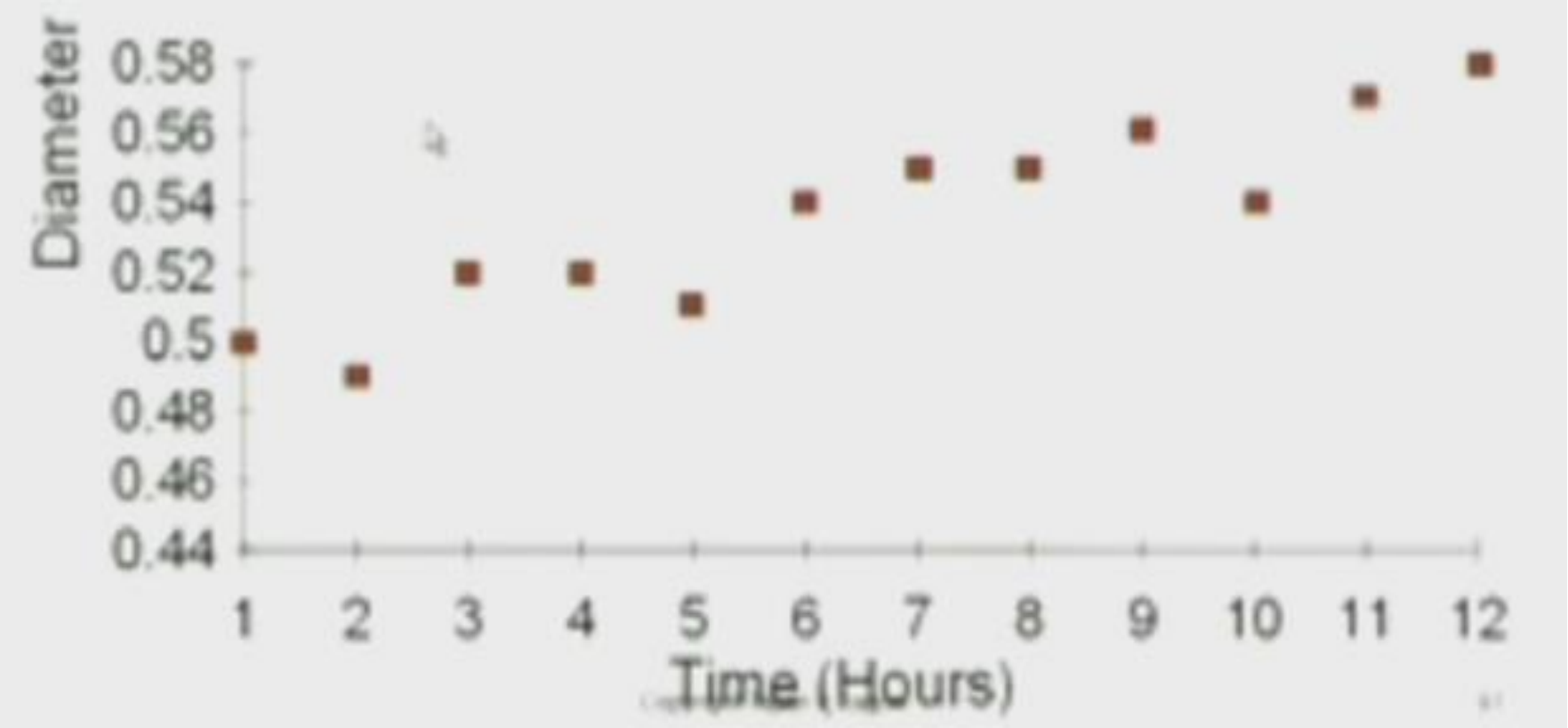
7 Tools for TQM and Continuous Improvement
Tool # 1 Flow Chart – Map the Process first!



A Flowchart Can be used to find Quality problems

Tools #2: Run Chart – quick analysis data

Can be used to identify when the equipment or processes are not behaving according to specifications



Tool #4: Checksheet

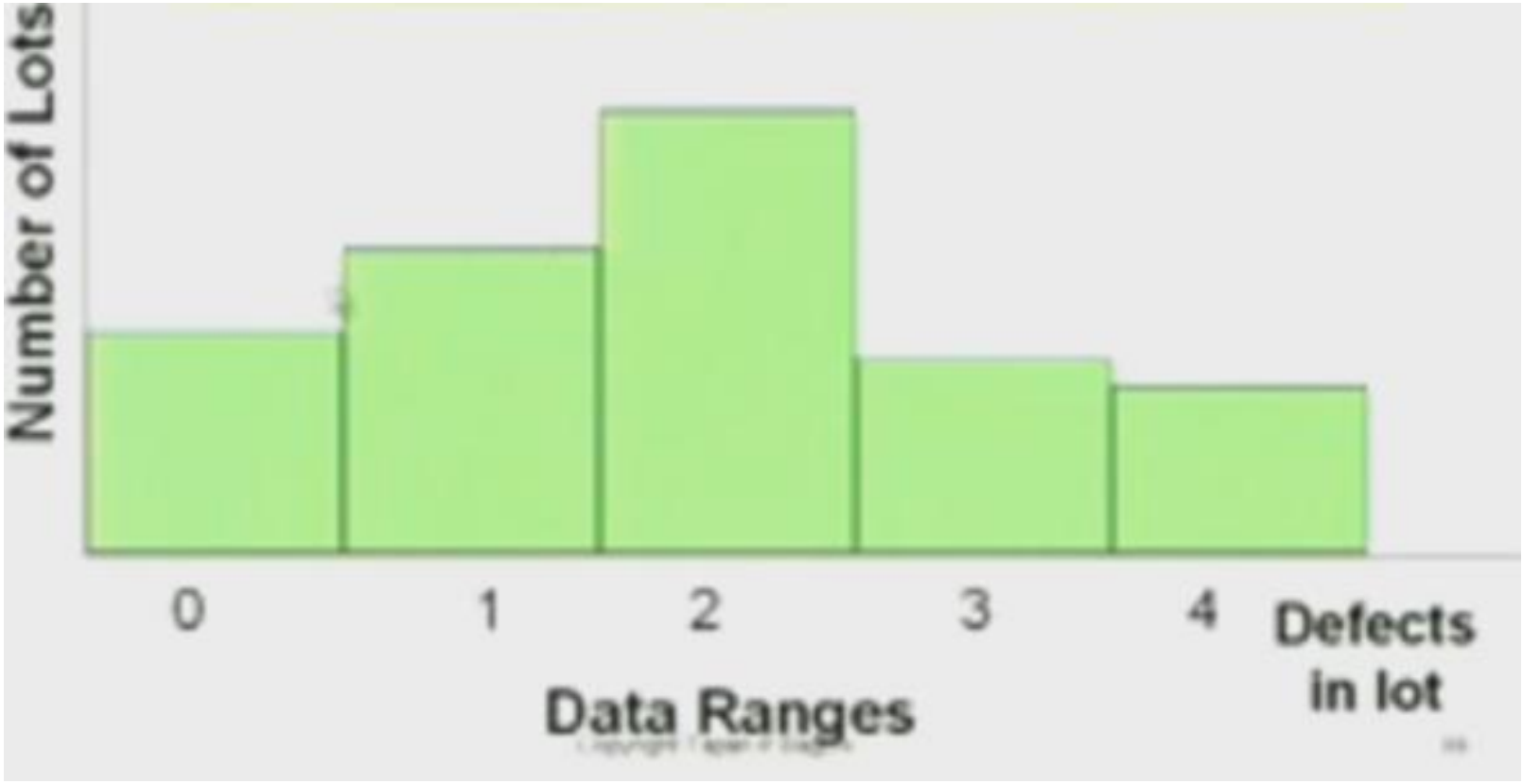
Can be used to keep track of defects or used to make sure people collect data in a correct manner

Monday

Billing Errors	
Wrong Account	
Wrong Amount	
A/R Errors	
Wrong Account	
Wrong Amount	

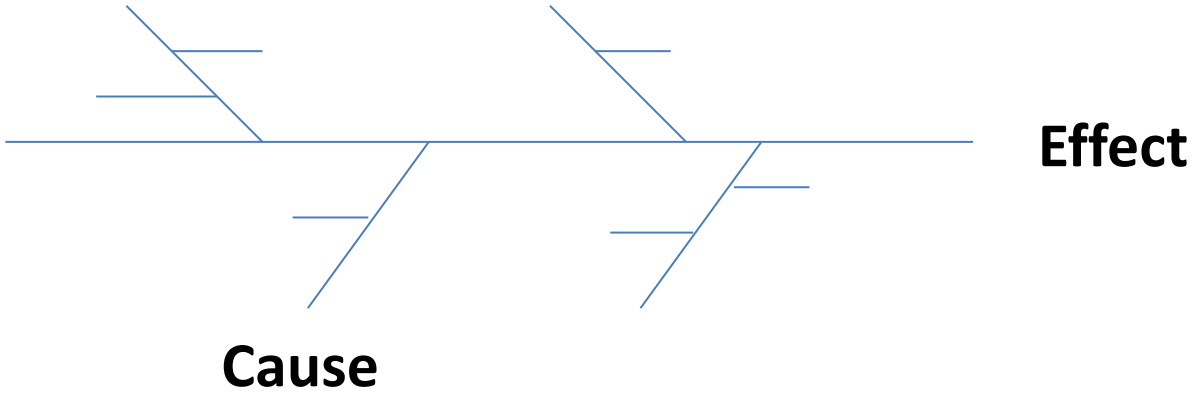
Tool#5: Histogram

Identifies the frequency of quality defect occurrence and displays quality performance



Cause and Defect Diagram

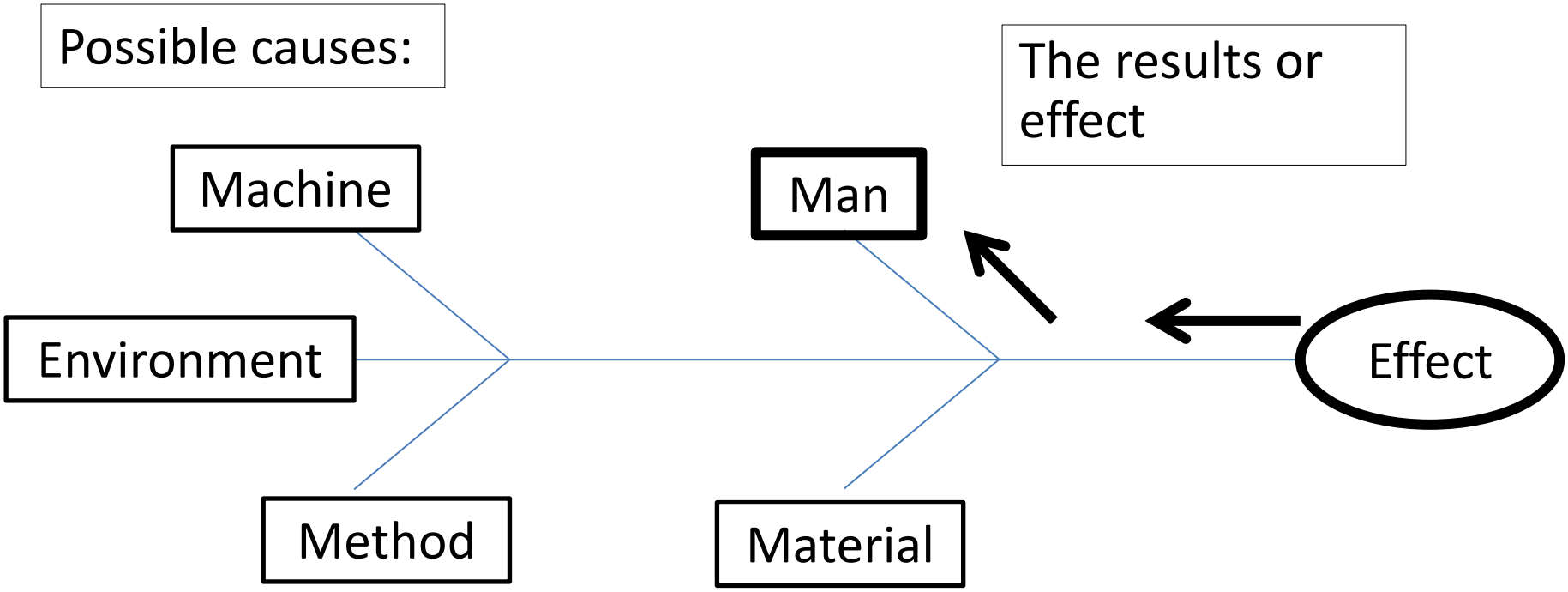
- Enables a team to focus on the content of a problem, not on the history of the problem or differing personal interests of team members
- Creates a snapshot of collective knowledge and consensus of a team; builds support for solutions
- Focuses the team on causes, not symptoms



Root Cause Analysis

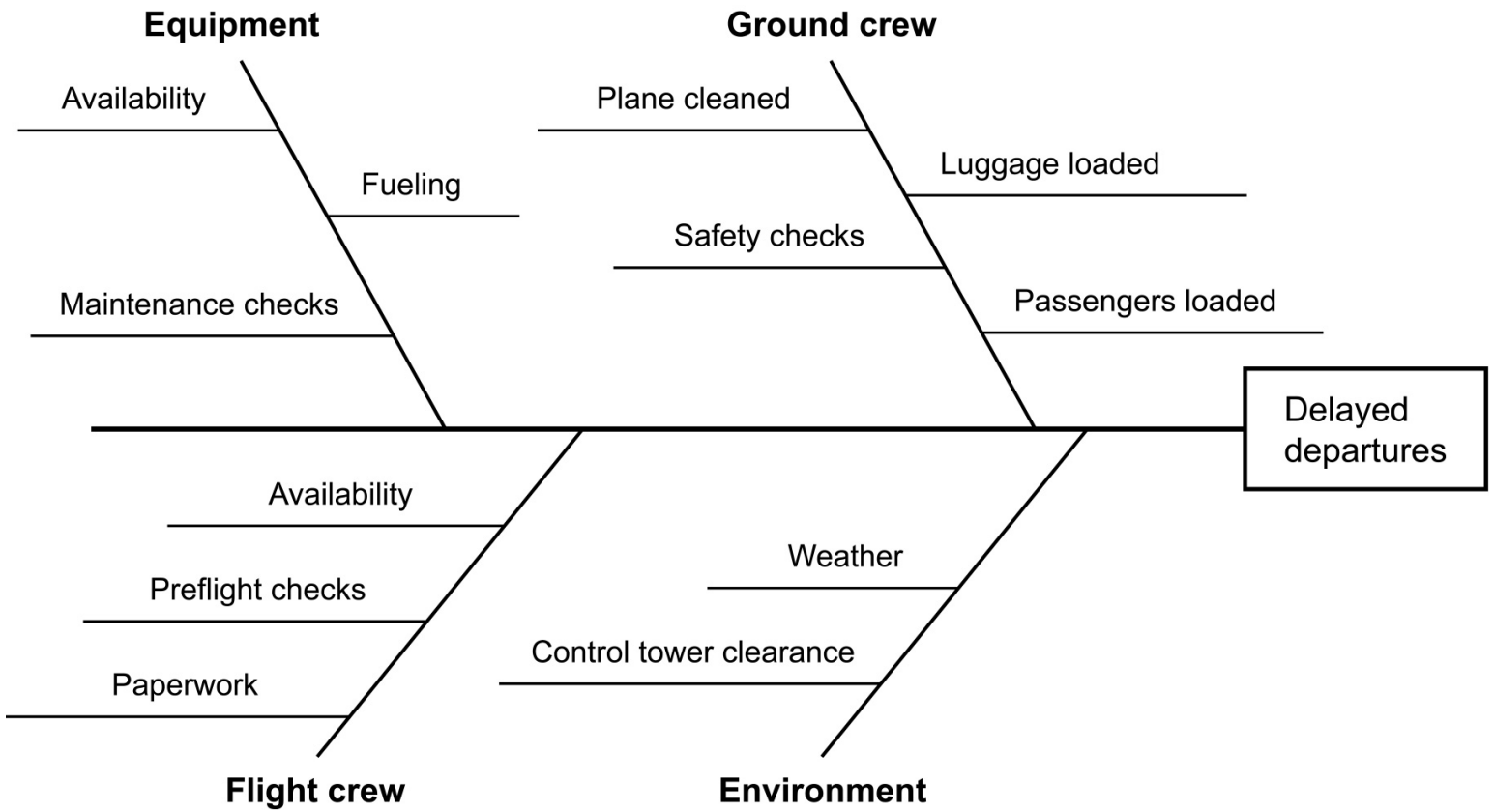
- Root causes – “that condition (or interrelated set of conditions) having allowed or caused a defect to occur, which once corrected properly, permanently prevents recurrence of the defect in the same, or subsequent, product or service generated by the process.”
- “5 Why” technique

Tool#6: Cause & Effect or Fishbone Diagram



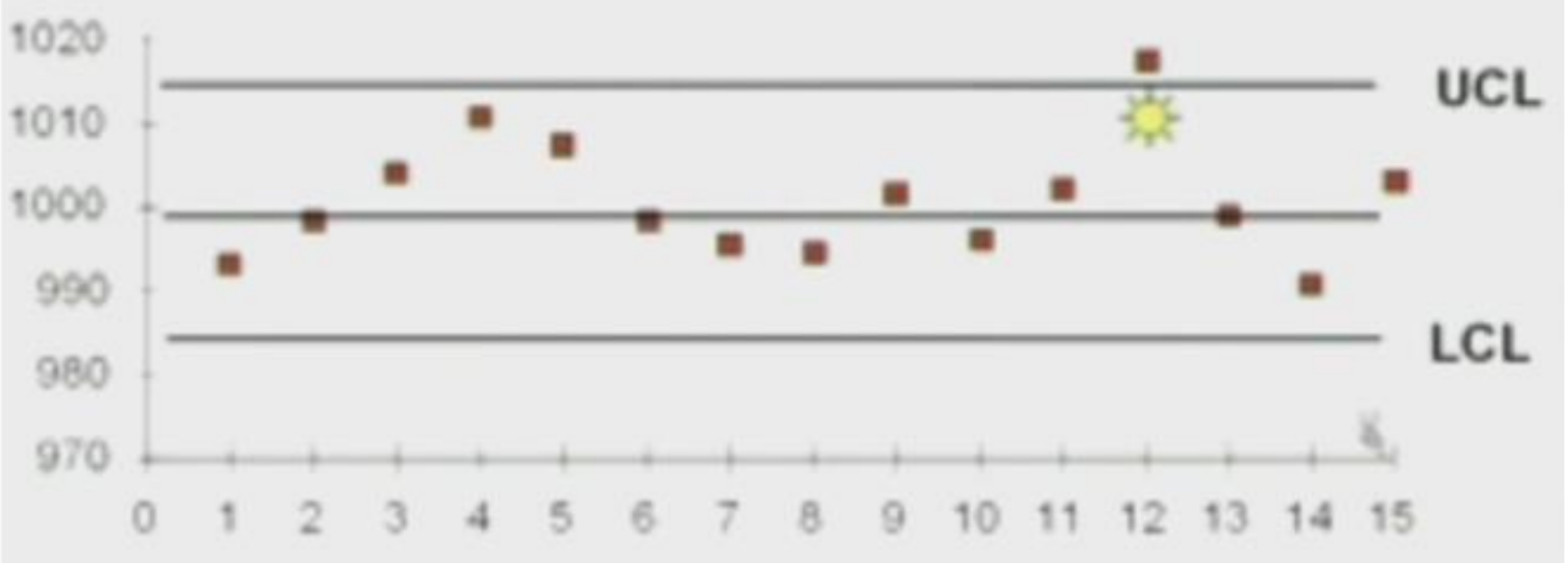
Systematically tracks backwards to find a possible cause of a quality problem (or effect)

A very powerful tool for Root Cause Analysis
The Ishikawa Cause-Effect or Fishbone Diagram



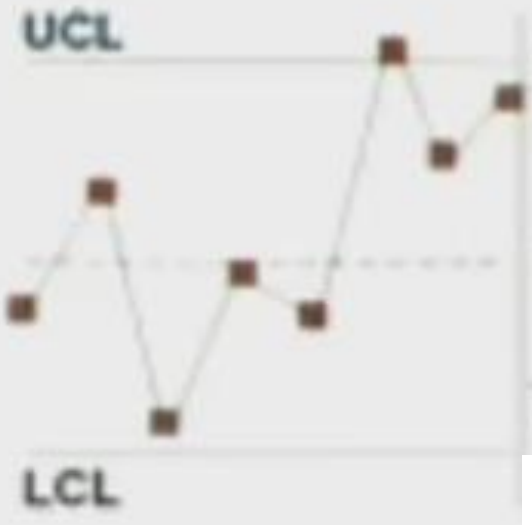
Tool #7: Control Charts (SPC) – on-line control

Can be used to monitor ongoing production process quality and quality conformance to stated standards of quality

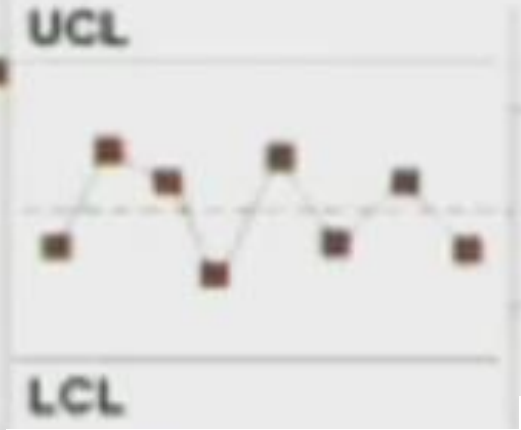


The chart gives the signal, but <u>you</u> must complete the control loop!

Tracking Improvements with SPC



Process not centered and not stable



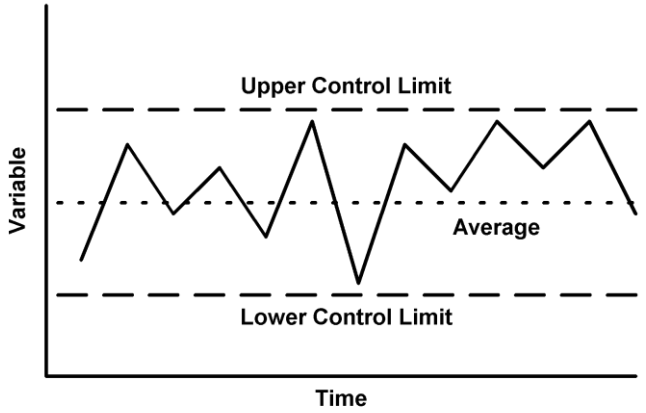
Process centered and stable

Additional improvements made to the process

Statistical Process Control – the tool is the control chart

Control Charts

- Control charts are used for process monitoring and variability reduction
- SPC is an on-line quality control tool.



Soft Methods for Generating Ideas to impact quality problems

- Brainstorming
- Quality Circles
- Interviewing
- Benchmarking
- 5W2H

Quality Circles

- Team approach – a team is formed to explore solutions
- The facilitator encourages idea generation
- Good people skills is critical
- Works well in Eastern cultures

Methods for Generating Solutions

Brainstorming: Technique for generating a free flow of ideas to solve a problem

Quality Circles:

- Groups of workers who voluntarily meet to discuss ways of improving products or process
- The circle comprises a number of workers who get together periodically to discuss ways of improving products and processes
- Quality circles are usually less structured and more informal than taskforces entrusted with a project

Benchmarking – a source of good ideas

- Involves identifying companies or other organizations that are best at something and studying how they do it, to learn how to improve your operation
- The other organizations need not be in the same line of business as yours
- Xerox used a mail-order company, L L Bean, to benchmark order filling. Others are …
    1. **American Express** is well-known for its ability to get customers to pay up quickly.
    2. **Disney World:** for its employees commitment.
    3. **Federal Express:** for its speed
    4. **McDonald's:** for its consistency.
    5. **Xerox:** for its benchmarking techniques.

Benchmarking Process

- Identify a critical process that needs improving
- Identify an organization that excels in this process
- Contact that organization
- Analyze the data
- Improve the critical process

Summary: 7 Basic quality improvement tools – where to use

- Run Chart – Tracking Trends

  Show changes in data over time | Measure one variable over time | Collect data sequentially

- Histogram – Process Centering, Spread and Shape

  Organize data | Evaluate process performance | Monitor process performance before and after a change

- Control Chart – Recognizing Sources of Variation

  Monitor the performance of a process over time | Recognize and control variation in a process | Methods to minimize variation and defects

Summary contd.
Quality improvement tools – where to use

- Pareto Chart – Focus on Key Problems

  Approach problems systematically| Discover the sources that may cause the majority of problems| Using different measurement scales break down problems in to smaller ones

- Flowchart – Picturing the Process

  See how an entire process works| Identify critical points in a process for data collection| Locate bottlenecks | Event, people and material flow

- Scatter Diagram – Relationships Between Variables

  Statistically test a theory about a possible cause and effect connection between two factors| Test and confirm a hypothesis using quantitative data| Data analysis

- Cause & Effect Diagram – Cure Causes, Not Symptoms

  Study a problem condition or improvement opportunity to find its 'root' causes | Blend creative thinking with data analysis in the problem-solving process

To control, you have to measure!

Discrimination

- Discrimination is the fineness of the scale divisions of an instrument.
- Finest division - .001”
- Discrimination - .001”

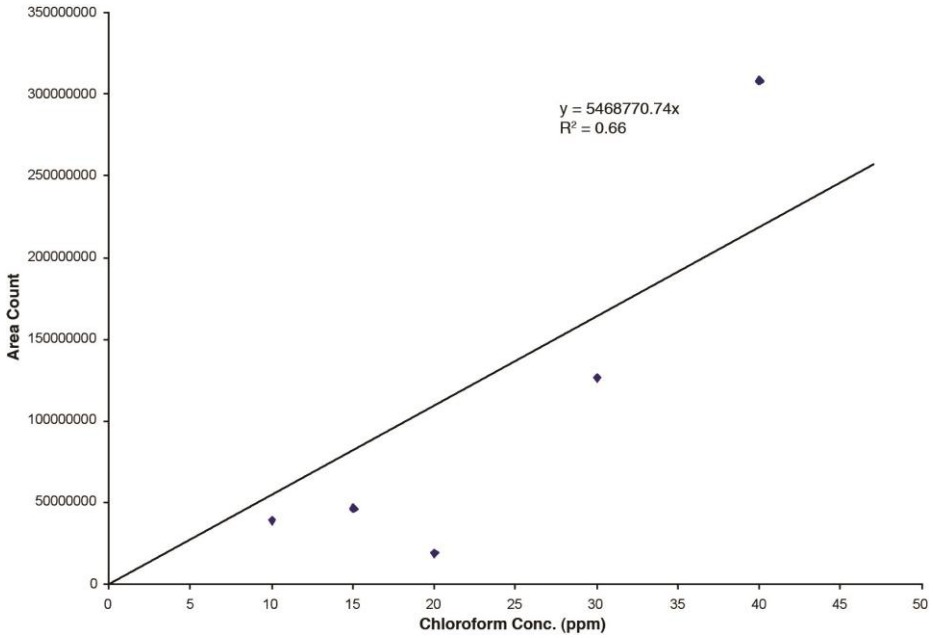
Discrimination is not the same as Accuracy or Repeatability, but is an indication of the smallest unit of measure on the scale

Calibration Plot

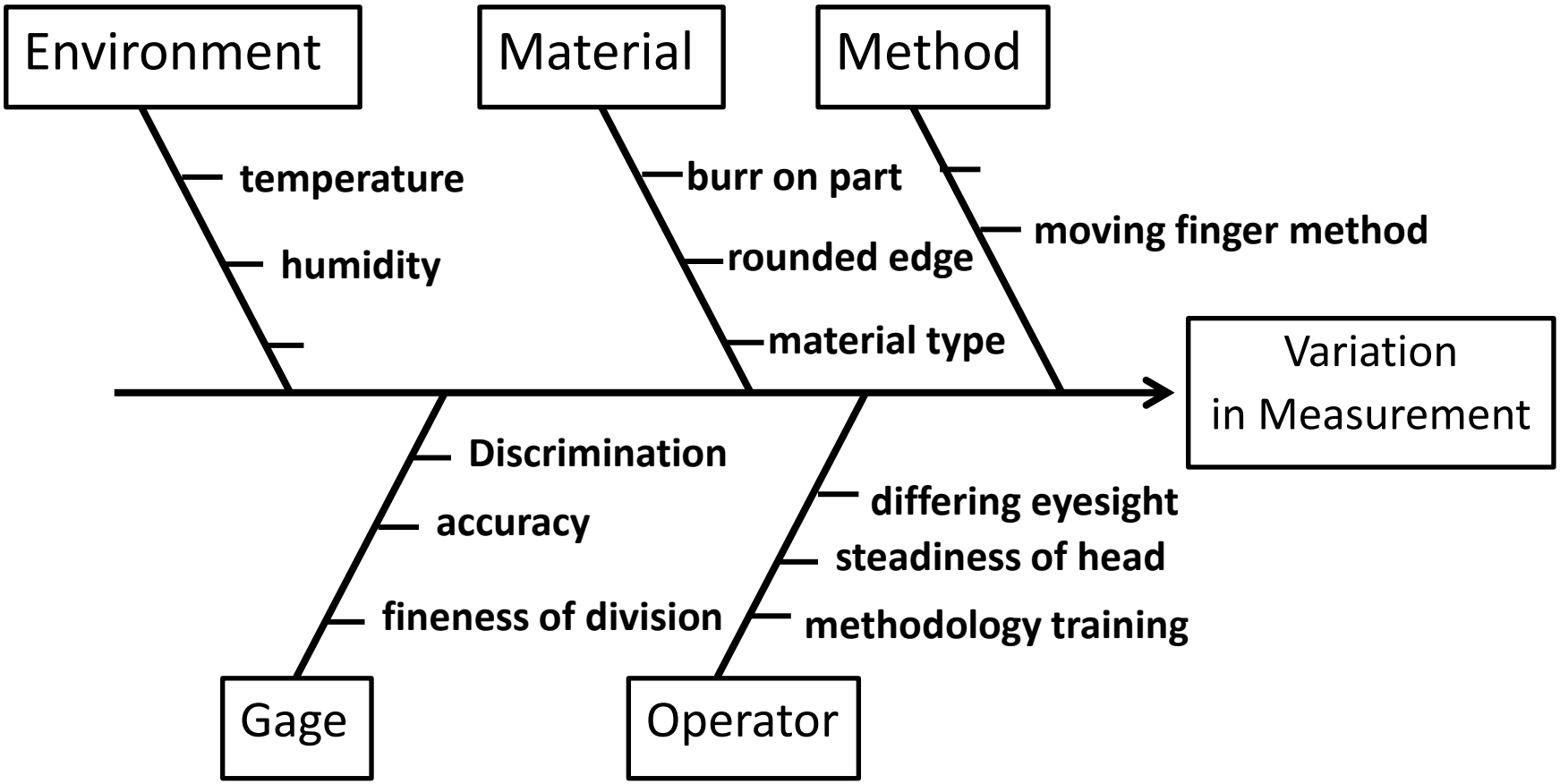
The line represents the perfect gage.

Deviations from the line represent the error of the gage at that master value.

Limits of maximum acceptable errors should be known.



Sources of Measurement Variation



Terminology

- Gage accuracy – bias expressed as % of Tolerance
- Gage repeatability (equipment error)
- Gage reproducibility (appraiser error)
- Gage R&R
- Precision to Tolerance (P/T) ratio
- Gage stability – readings Xbar/R stay within UCL/LCL
- Gage linearity

Assessing Measurement Data

- If we use an instrument or gage to measure several parts from a process and record the results, we must recognize that the resultant data represents the variation in the parts as well as the variation in the measurement process.

$$V_{\mathbf{data}} = V_{\mathbf{parts}} + V_{\mathbf{measurement}}$$

Interpretation?

Here **Operator B** has a **greater average** range than A. This means that his **repeatability is worse than A**. We should investigate by focussing on the method that B is using in comparison to A. **How can we get B to be as repeatable as A?**

Gage R&R Studies

Gage repeatability and reproducibility (R&R) studies involve breaking the total measurement variability or "gage variability" into two portions:

- **repeatability** is the basic inherent precision of the gage
- **reproducibility** is the variability due to different operators using the gage.

Measurement Variability

- Measurement variability can be broken down as

$$\sigma^2_{measurement\ error} = \sigma^2_{reproducibility} + \sigma^2_{repeatability}$$

- More than one operator (or different conditions) are needed to conduct the gage R&R study.

External Benchmarking as QM Strategy – it pays!

1. Identify those processes needing improvement
2. Identify a firm that is the world leader in performing the process
3. Contact the mangers of that company and make
    a) a personal visit of the facilities and
    b) to interview managers and workers
4. Analyze data

Another QM Strategy: 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 (Mistake proofing) includes:
  - Checklists
  - Special tooling that prevents workers from making errors

The Moment of Truth: “Service Quality”: 2/3rd of today’s economy is service-driven

- Tangibles
- Convenience
- Reliability
- Responsiveness
- Time
- Assurance
- Courtesy

Examples of Service Quality

Dimension	Examples from a Service Center
1. Tangibles	Were the facilities clean, personnel neat?
2. Convenience	Was the service center conveniently located? Too much confusion?
3. Reliability	Was the problem fixed?
4. Responsiveness	Were customer service personnel willing and able to answer questions?
5. Time	How long did the customer wait?
6. Assurance	Did the customer service personnel seem knowledgeable about the repair?
7. Courtesy	Were customer service personnel and the cashier friendly and courteous?