Lean Manufacturing Workshop Series


LEAN SIG
Process Improvement and Quality in Lean Manufacturing
John Bicheno, CFPIM
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Lean Manufacturing Workshop Series

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John Bicheno, CFPIM, is South African. He graduated with an engineering degree from the University of the Witwatersrand in Johannesburg. Thereafter, he spent 12 years in industry and local government in South Africa in the areas of project and design engineering, management services, operations research, and operations management.

Bicheno joined the Department of Industrial Engineering (School of Mechanical Engineering) at the University of the Witwatersrand in 1981 and became associate professor and head in 1984. During this time he had close associations with a number of leading Just-in-Time companies in South Africa including Toyota, Nissan, Afrox, and GEC. In 1987 he became a senior lecturer in operations management at the University of Buckingham, became a reader in 1990, and was dean in 1992. He has lectured to master's participants at Warwick University, Cranfield University, London Business School, Cardiff Business School, and Fachhochschule Wedel.

Bicheno's books have sold more than 50,000 copies. These include *Implementing JIT, Cause and Effect Lean, The Lean Toolbox, The Quality 75, and Operations Management* (with Brian Elliott). He has produced three videos and several lean-related games. He has also codeveloped several computer programs in JIT, MRP, and quality.

Bicheno consults and trains in the areas of lean, productivity improvement and measurement, and quality in Britain, Germany, Denmark, and South Africa. He runs regular CPIM and lean training programs in Britain and Denmark and lean programs for the Manufacturing Institute Trafford Par, Manchester, England. In 1996 and 1997 he was part of a research team led by the Department of Manufacturing Engineering at the University of Cambridge investigating the implementation of performance measurement in manufacturing. In 1997 he joined the Lean Enterprise Research Centre, Cardiff Business School and in 1999 initiated and became director of a new MSc program in lean operations at Cardiff Business School. In 2001, he helped found the Association for Manufacturing Excellence (UK). He conducted the first AME-UK event and serves on the board.

Acknowledgments

Special thanks to the Lean Enterprise Research Centre, Cardiff Business School for its contribution to the lean manufacturing body of knowledge.

Workshop Objectives

- **To illustrate the symbiotic relationship between lean and quality**
- **To appreciate the application of some quality techniques in a lean context.**
- **To appreciate how lean and six sigma can work together.**

Workshop Topics

- Views from the Gurus
- The Lean View and Kaizen
- Problem Solving and PDCA
- Types of Defect
- Sporadic Problems: The Seven Tools and Five Whys
- Chronic Problems and Six Sigma
- Improvement Types
- Improvement Events (Blitz)
- Holding the Gains and Sustainability

Views from The Gurus

- **Crosby**
- **Juran**
- **Deming**
- **Kano**

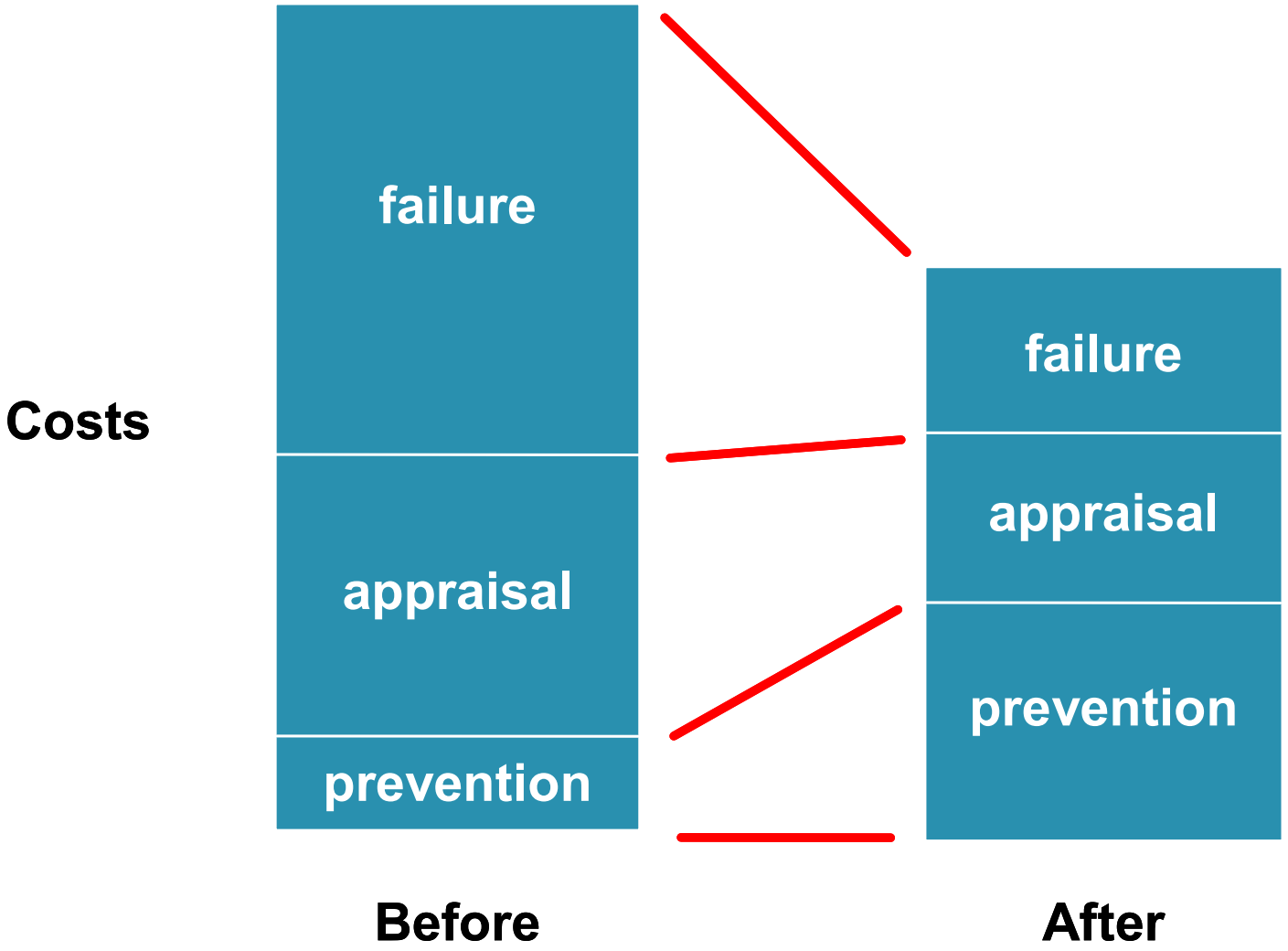
Crosby

- Quality is free
  - It is not a gift
  - It is the basis of future profit
- The four absolutes
  - Quality means conformance to requirements, not elegance
  - The system of quality is prevention
  - The performance standard is zero defects
  - The measurement of quality is the price (or cost) of nonconformance

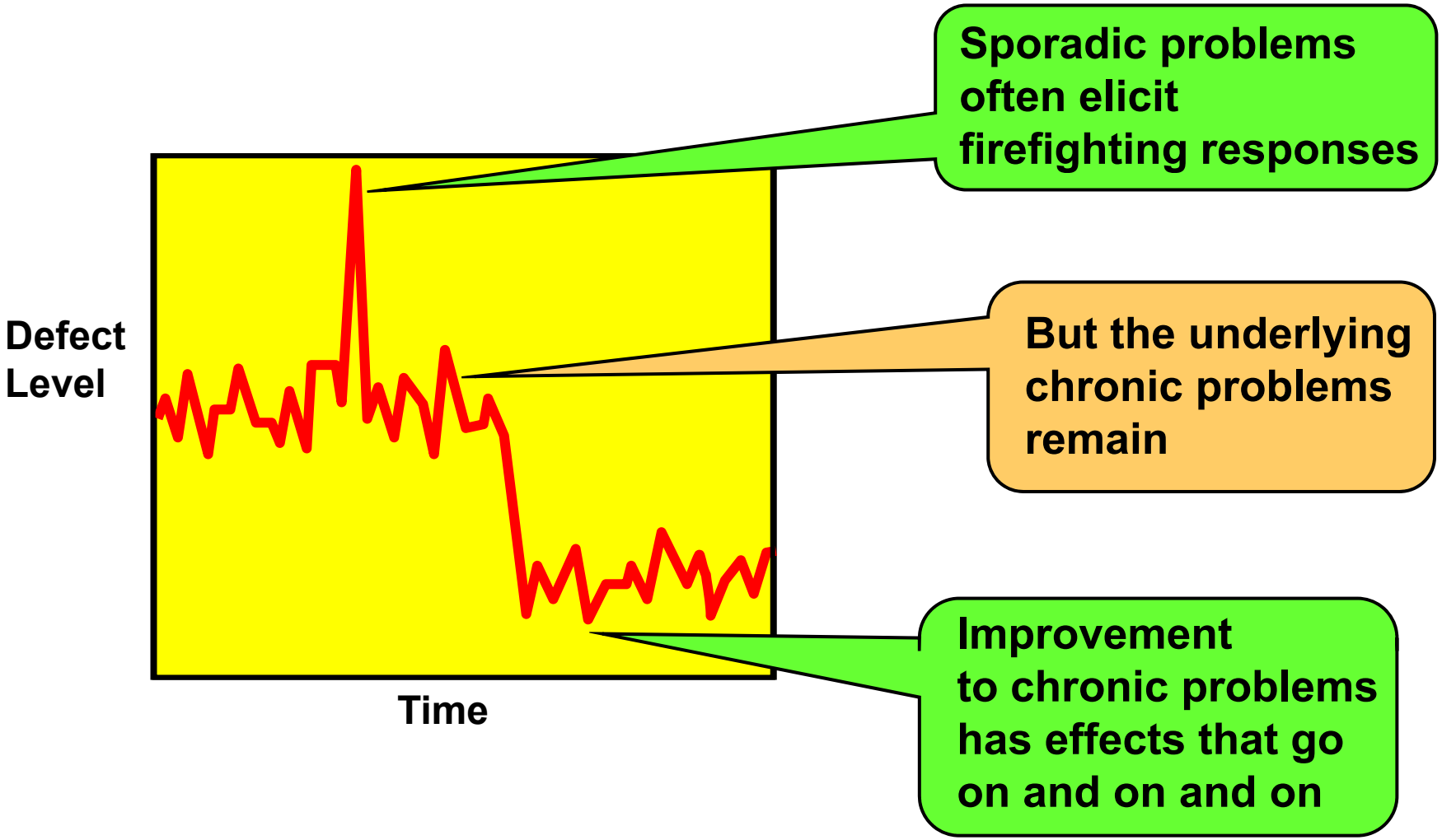
Cost of Quality

- **Appraisal costs**
  - To assure outgoing and incoming quality
  - Appraisal activities detect nonconforming items
  - Include acceptance sampling, inspection, and final testing
- **Prevention costs**
  - Prevent rework, scrap, and other failures
  - Activities include process control, preventive maintenance, most ISO 9000 activities, and training
- **Failure costs**
  - Internal failure: scrap, rework, rectification, retest, and lost opportunity costs
  - External failure: warranty, returns, customer dissatisfaction, customer defection

Quality Costs



Chronic and Sporadic (Juran)

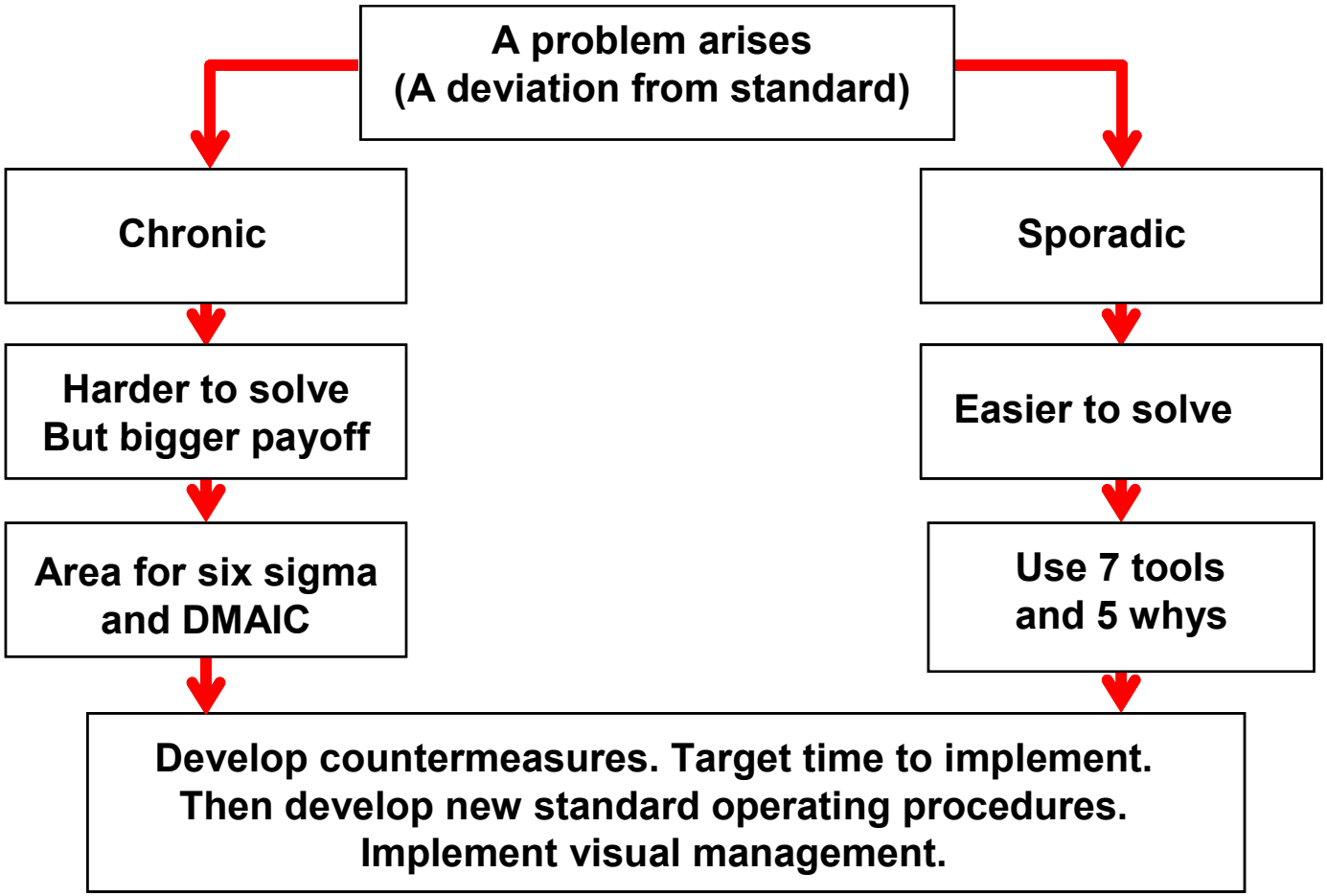


Chronic and Sporadic Problems

- **A *sporadic* problem is an annoying problem occurring from time to time. Such problems tend to get attention. Firefighting results.**
- **A *chronic* problem recurs regularly and tends to become part of daily life. Procedures are developed to get around them. But chronic problems are a major source of waste and make work frustrating and less enjoyable.**
- **Attacking both types should be seen as both reducing the magnitude and the variation of the problem.**

– Juran, *Quality Control Handbook*; and Nakajima,TPM Development Program

Tackling Problems



– Developed from an original by Suzaki,
The New Manufacturing Challenge, Free Press, 1987

The Deming Philosophy

- **Deming had two big themes—waste and variation.**
- **Waste reduction is strongly associated with lean. Variation reduction is strongly associated with six sigma.**
- **But management is responsible for about 85 percent of quality problems.**

Deming on Waste and Variation

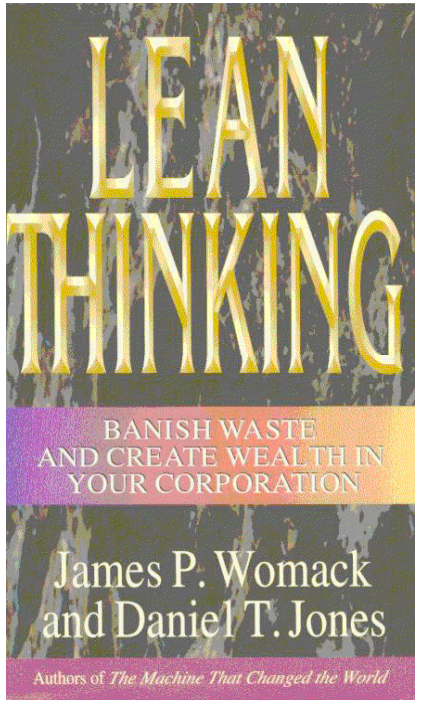
- **Waste can be tackled by the Deming (or Shewart) cycle.**
- **Natural variation is inherent in all processes. It is the task of management to understand and control the causes of undue variation.**

Five Lean Principles

Begin with the Customer!

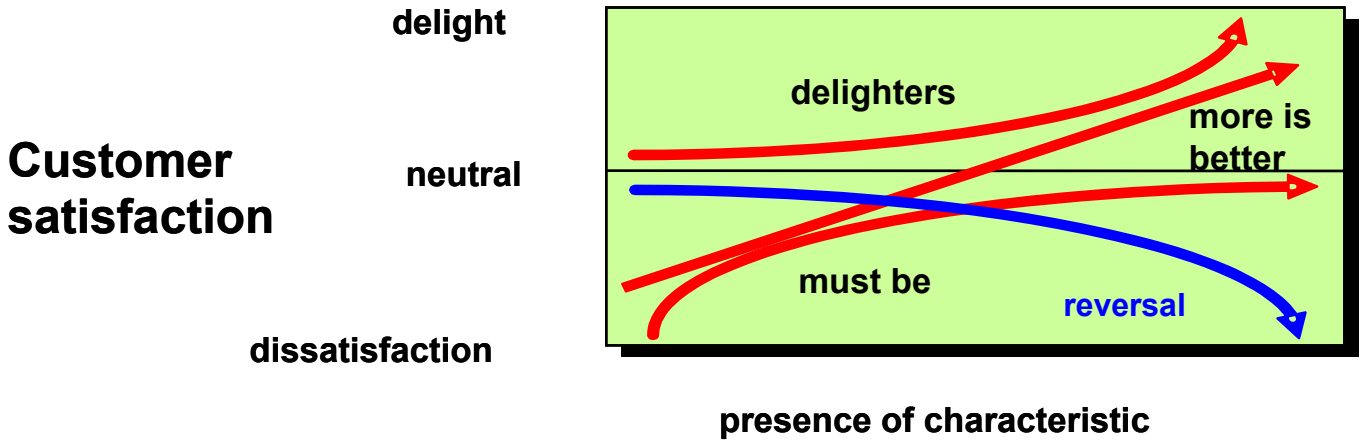
- Specify what creates *value* from the customer's perspective
- Identify all steps across the whole *value stream*
- Make those acti… *flow*
- Only make what is …*led* by the customer Just-in-T…me
- Strive for *perfection* by continually removing successive layers of waste

Perfection is ongoing! But first understand the first four principles.



The Kano Model

- Must be (Basics) : characteristics or features taken for granted. (hotel: clean sheets and hot water)
- More is better (Performance): we are disappointed if a need is poorly met but have increasing satisfaction the better it is met. (hotel: response time for room service)
- Delighter: features that surprise and delight in a positive way (hotel: wine and flowers upon arrival)
- Reversal: features that annoy: TV in a smart restaurant



Delighters

The possibility of creating

Magic Moments

and

Wow!

Delighters

The possibility of creating

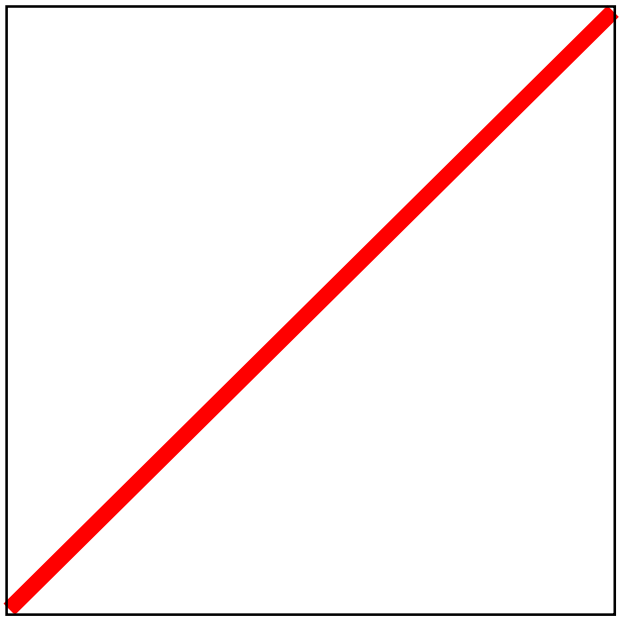
Magic Moments

and

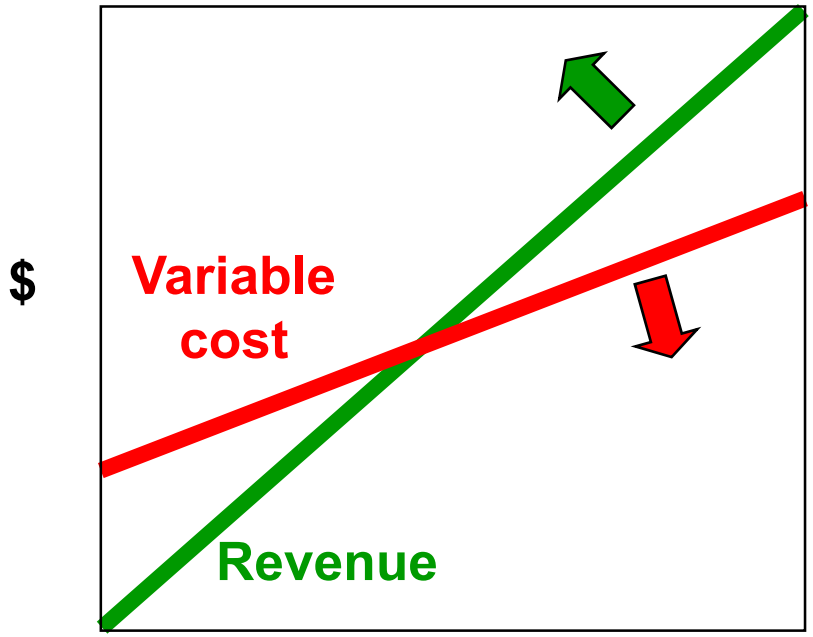
Wow!

Quality, Value, Cost, and Waste

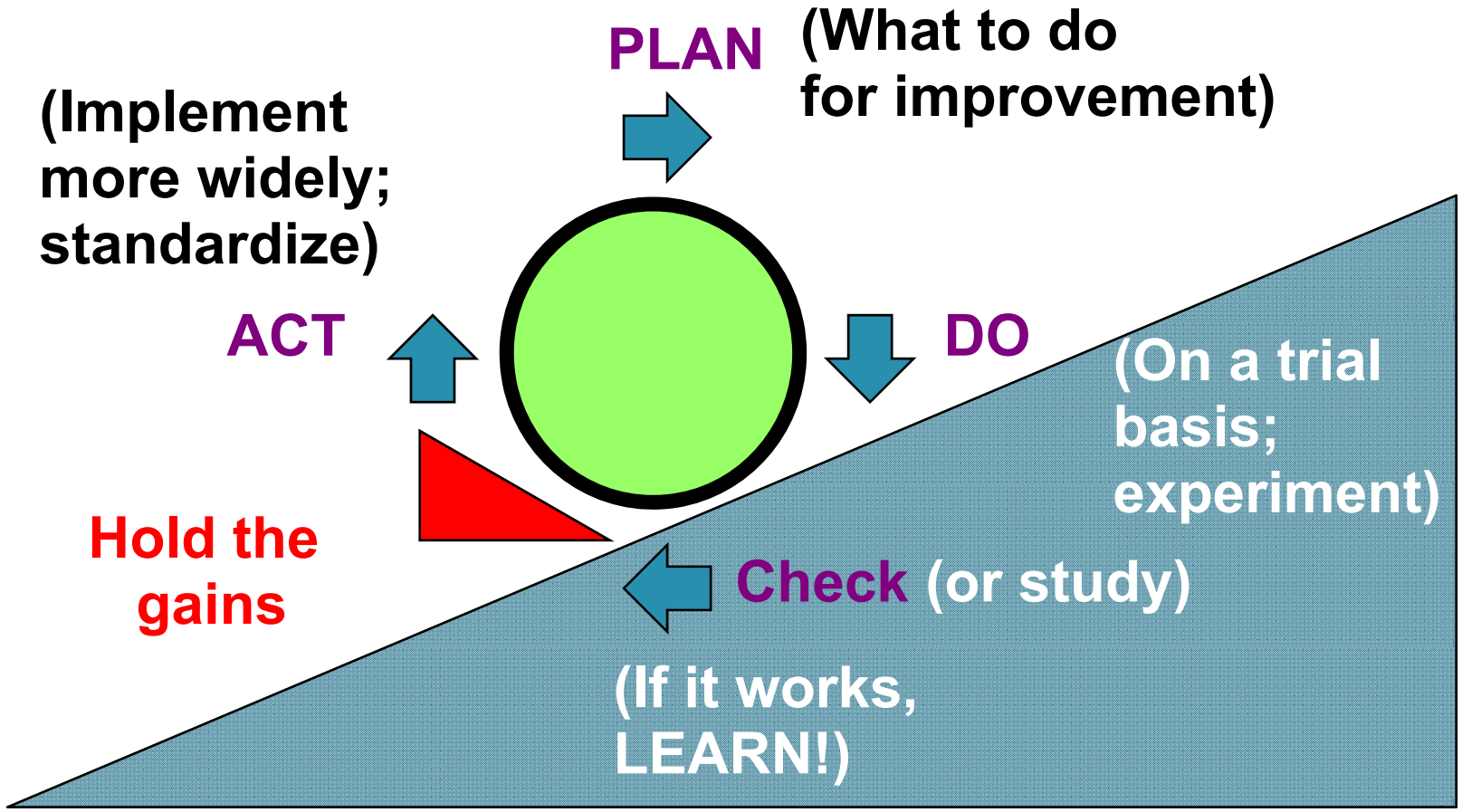
Quality as value/cost



Two paths to Improvement

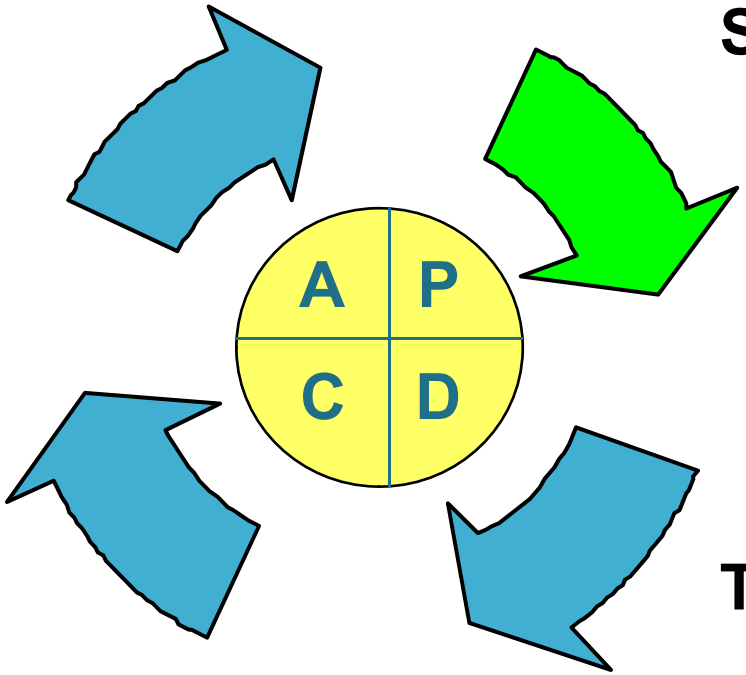


Perfection: The Deming Cycle



Plan

Note the Japanese way of taking much longer over this step.



Determine customer needs
Identify the concern

Set objectives

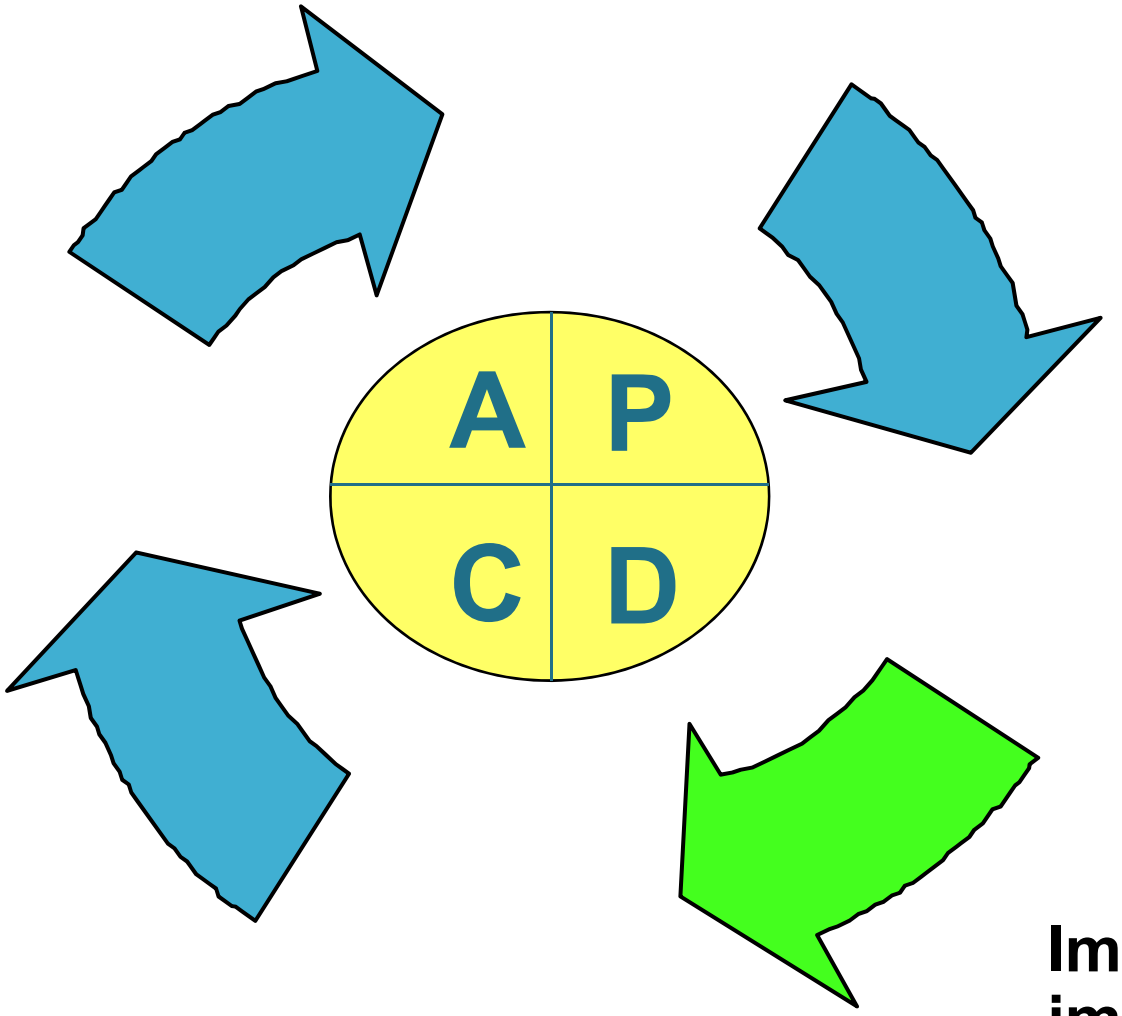
Set out the working plan

Collect data and study

Seek root causes

Train as necessary

Do



Implement the improvement

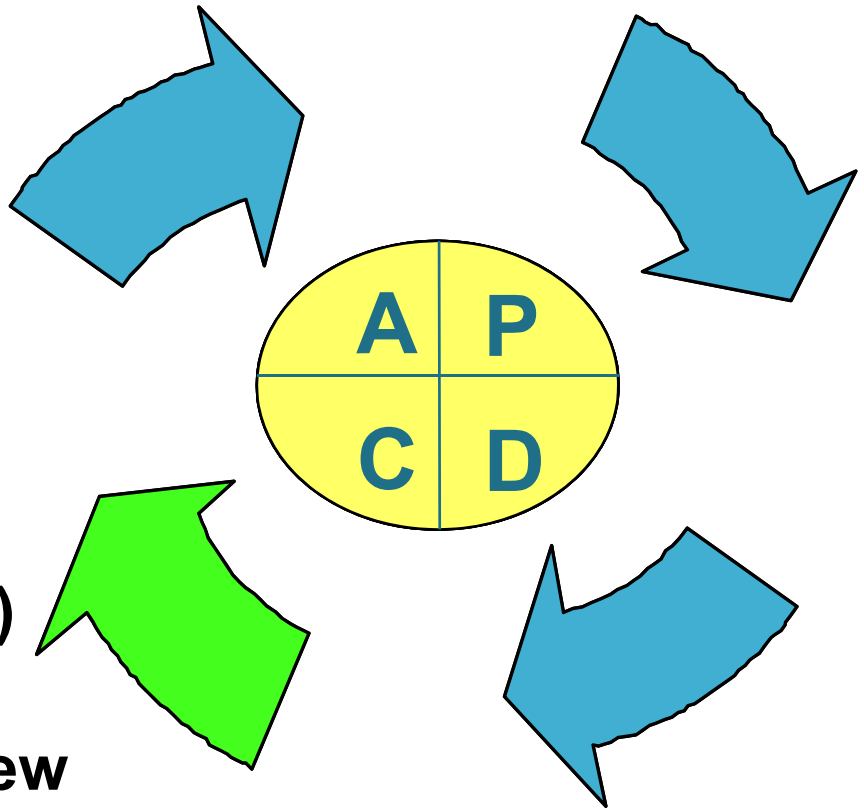
Check (and Learn)

Were the objectives met?

Review root causes

Confirm the results
“B vs. C” analysis
(alpha and beta risks?)

After-action review



Is the problem completely solved?

Act (and Standardize)

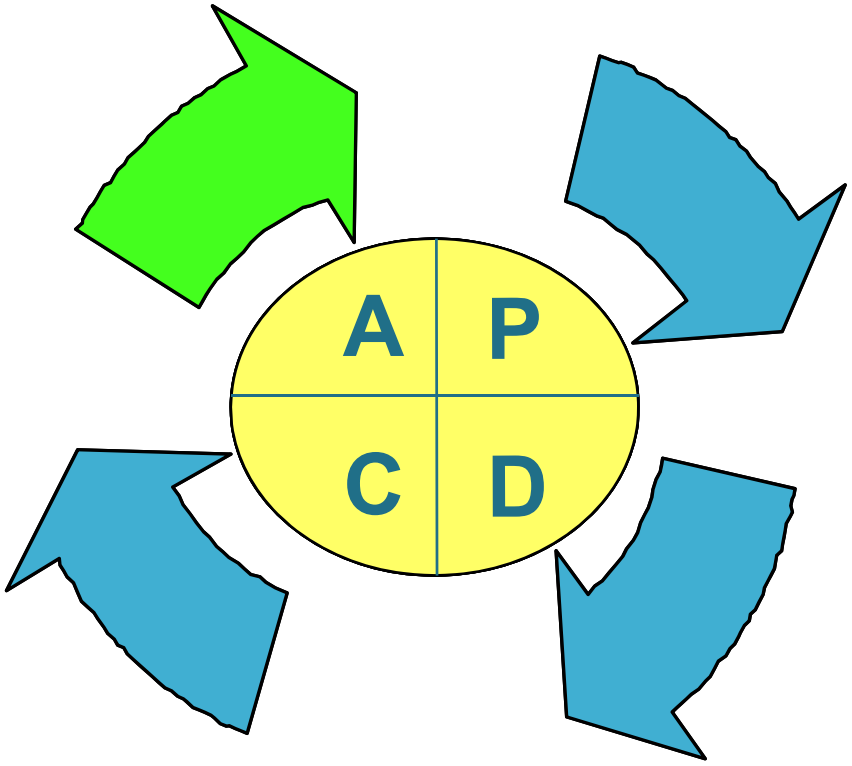
Identify further improvements

Adopt new standards

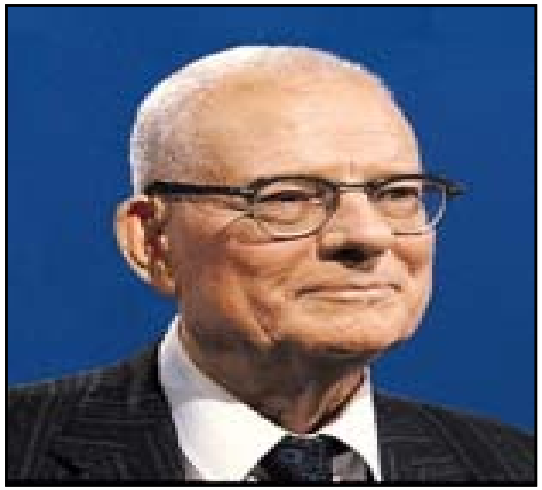
Communicate the requirements

Prevent recurrence

Celebrate and congratulate



“In God We Trust …
—all others must bring data.”



W. Edwards Deming

PDCA, DMAIC, and Tools

Plan	Define	What is the problem?	**Identify Opportunities** **Scope the Project**	**Benchmarking, QFD, Disruptive Tech, Hoshin, FMEA, Serv Gaps, Pareto, Importance Performance, Cost of Quality, Market Survey Tree Diagram, Critical Path Anal, Mapping, NGT**
	Measure	How are we doing?	**Analyze the Process** **Define Outcomes**	**7 tools, DPMO, Data Presentation, Process Chain, 5 Whys, MoT, Kano 6 Honest Men, Supplier Partners Capability Analysis, CoQ** **Maps, Blueprints, SERVQUAL**
	Analyze	What is wrong?	**Identify Root Causes**	**5 Whys, FMEA, 7 tools, DOE, QFD, Matrix Analysis, Shainin Gap Analysis, Benchmarking,**
Do	Improve	Fix it	**Prioritize** **Refine** **Implement**	**QFD, Matrix Analysis, Policy Deployment** **QFD, Affinity, Contingency, FMEA** **Force Field, Kaizen, Blitz Critical Path, Single Point Lessons**
Check Act	Control	Hold the gains. Celebrate.	**Measure Outcomes** **Acknowledge**	**Control Charts and SPC, 5 S Standardization, DPMO, Cusum Cost of Quality, ISO 9001:2000, Sustainability, Capability, Supplier Partnership**

Improvement ... a Toyota View

- **All systems display entropy—they run down unless active effort is put in.**
- **Therefore improvement effort is necessary just to maintain current performance.**

Problem Solving in Lean

The Problem Is

"When I was asked to attend a general manager's meeting the first time, I was happy to attend because I thought I could say that there were no problems in my department. And I said so when it was my turn to report. Then this general manager from Toyota looked straight into my eyes and said, "Steve, when you say that you do not have a problem, that is the problem."

– Kiyoshi Suzaki, *The New Shop Floor Management,* Free Press, p153

Mess Management

- **Resolving (clinical)**
  - **Relies on past experience; qualitative opinions**
  - **"Most problems are so messy as to render alternative approaches inappropriate."**
- **Solving (research)**
  - **Based on scientific approach, tools, and techniques**
  - **Often resort to resolving for those parts that cannot be quantified**
- **Dissolving (design)**
  - **Change the nature of the problem to remove it**
  - **Process and people development; systems view**

— Russell Ackoff,
"The Art and Science of Mess Management"

Go to Gemba

- The actual place (gemba)
- The actual work center
- The actual thing (gembutsu)
- The actual facts (gemjitsu)
- The actual people

Don’t problem solve in the office! (You can’t see the state of 5 S, visible management, etc.)

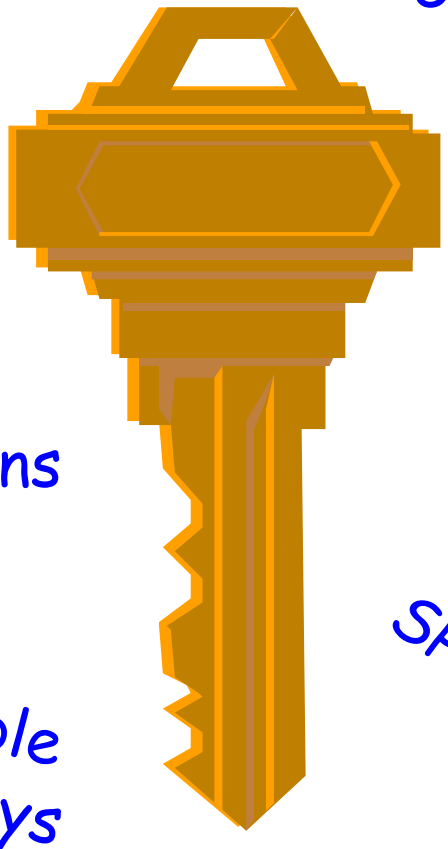
Problem Analysis:
Task Analysis and Data

- **Go to gemba. Walk the area.**
- **Draw a map.**
- **Speak with data.**
- **Collect the 6 honest men.**

The 6 Honest Serving Men

- **What**
- **Why**
- **When**
- **Who**
- **Where**
- **How**

Problem Identification Is the Key to Improvement



Schedule attainment "heijunka" board

5 S

OEE displays

Mapping

Standard operations

Line stop

Andon

Visible displays

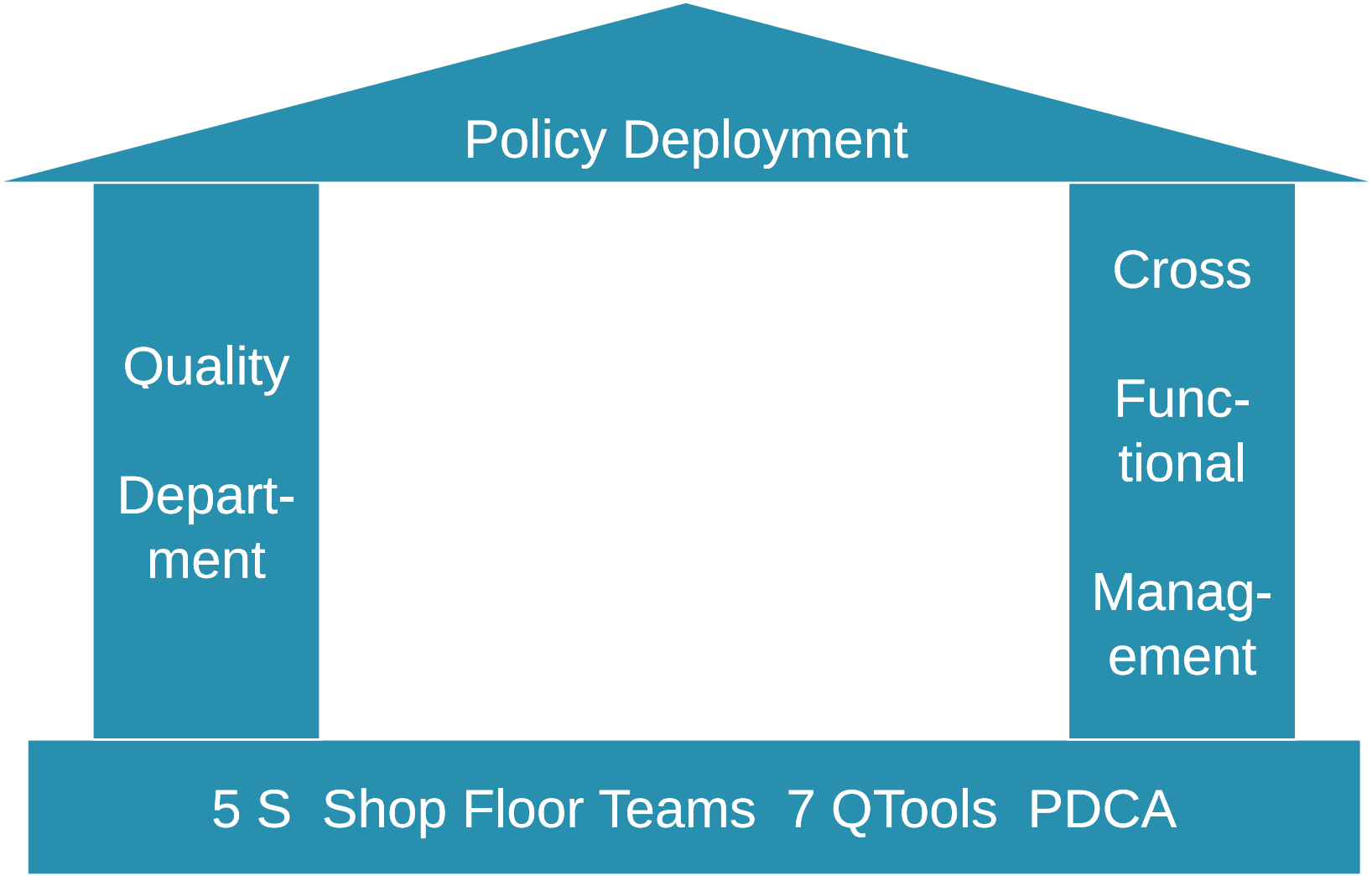
SPC charts

Inventory withdrawal

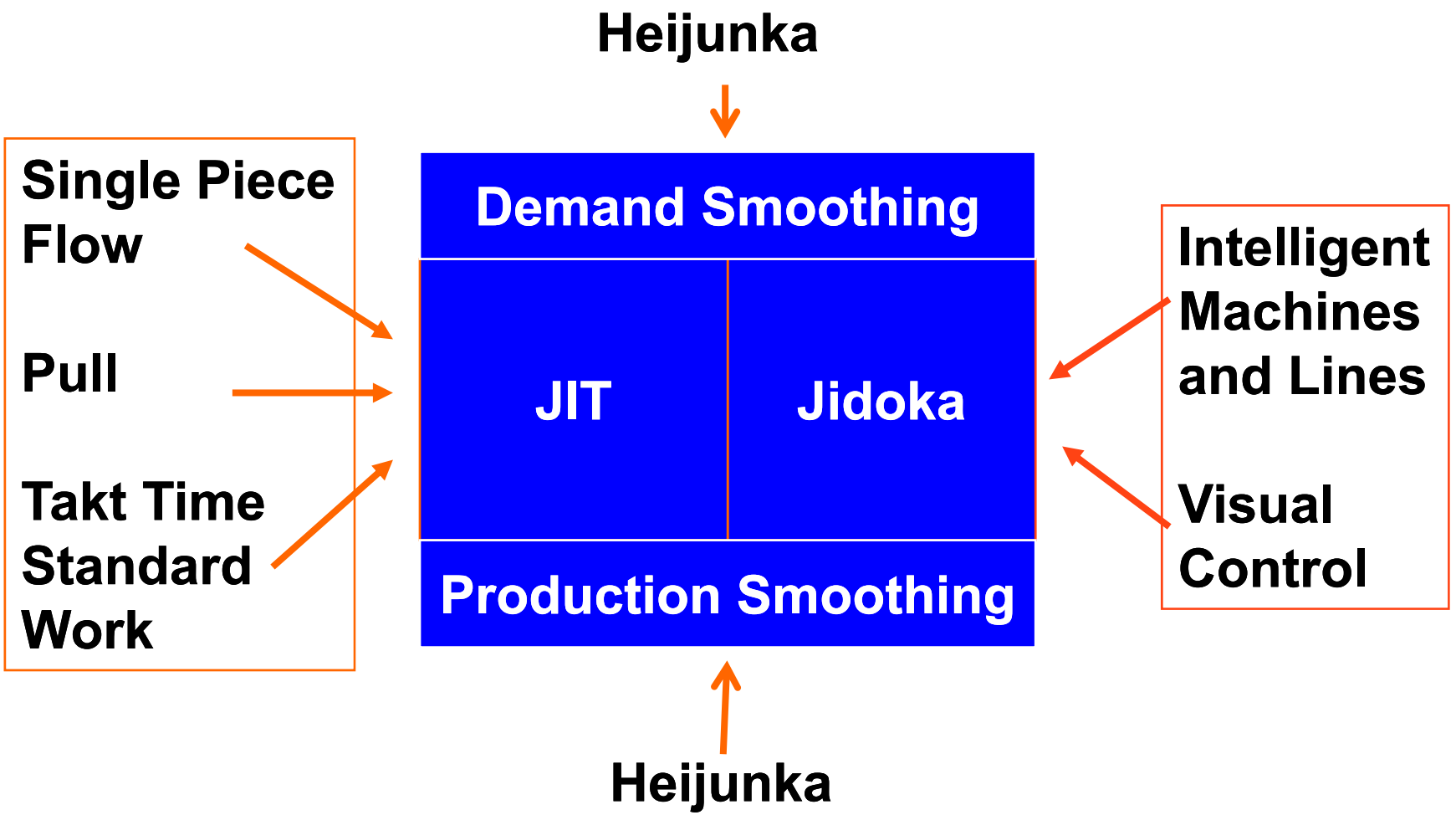
Defining the Problem

- A problem as a deviation from standard. (Is there a standard?)
- Has the problem been clearly stated? (including the effects)
- Is there an earlier problem (the source of the problem)?
- Is it measurable?
- A problem statement should not contain an indication of the solution (e.g., no maintenance).

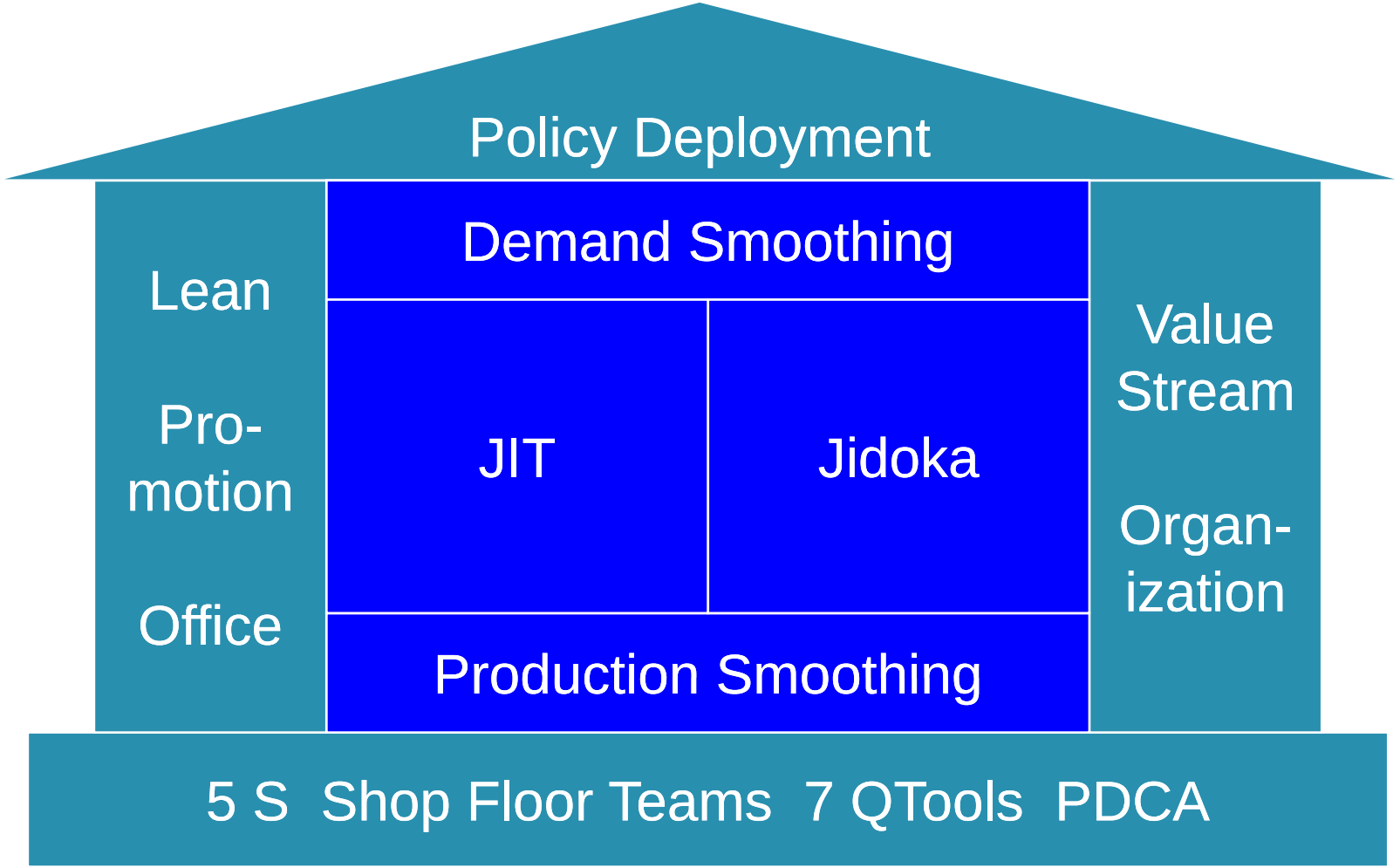
Total Quality



Toyota Production System



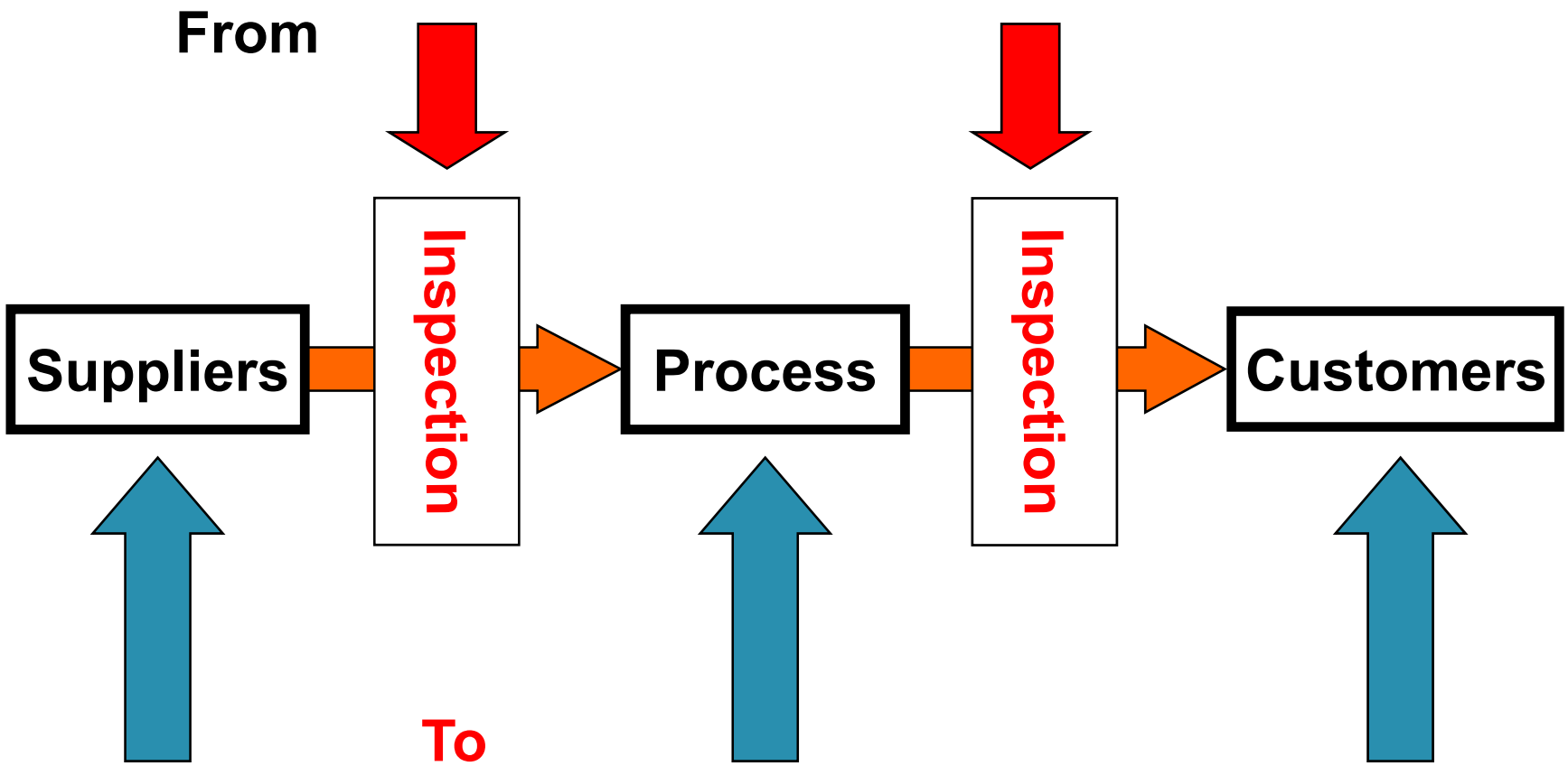
TPS + TQC



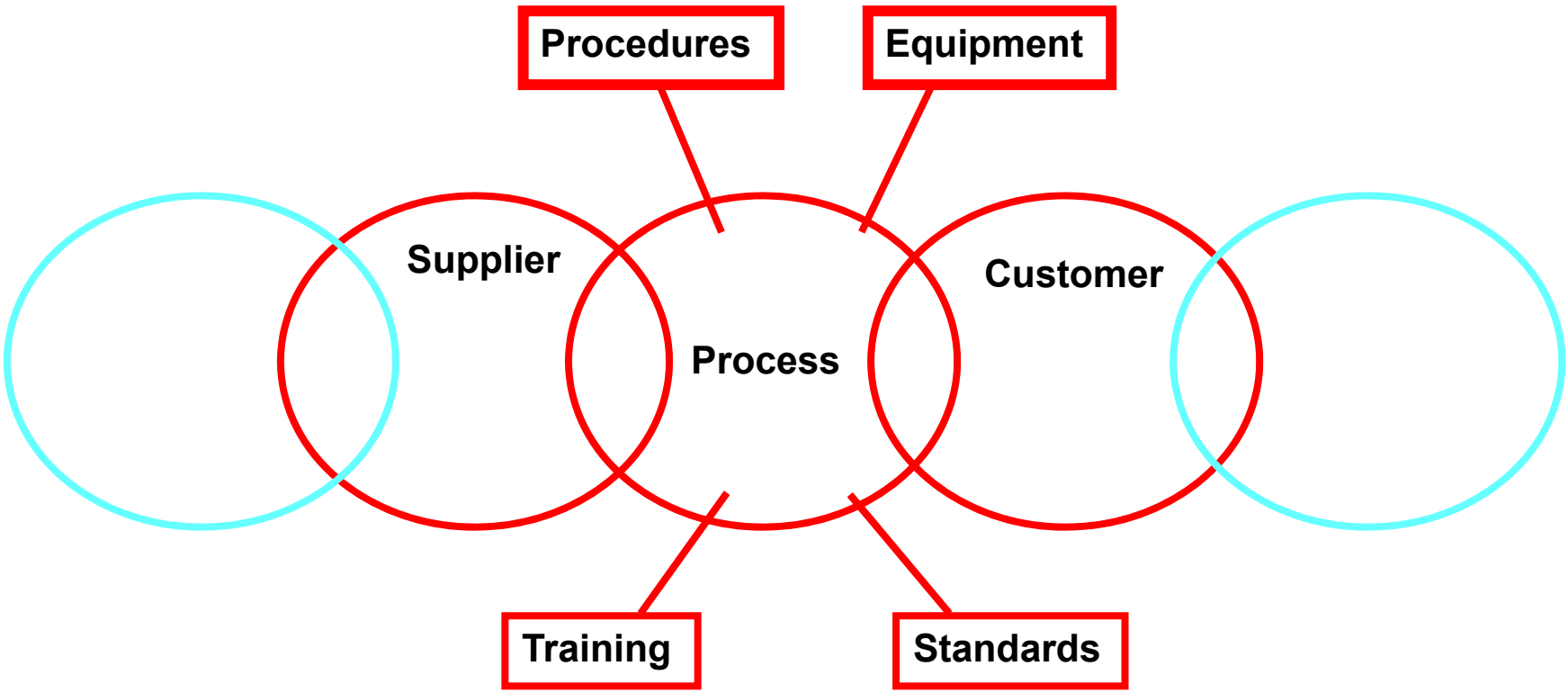
Jidoka

- **A composite term meaning**
  - **built in quality (Standard and Davis)**
  - **autonomation (Shingo)**
  - **automation with a human touch (Toyota) (N.B., not to automate work, but to make work and decisions easier)**
  - **in-station process control (ISPC) (Ford)**
- **Stems from Toyota's original involvement with looms in 1902**
- **Combines**
  - **poka-yoke**
  - **quality at source**
  - **andon**

Shifting the Quality Emphasis



Process Elements: PETS



Seeing the Whole

LEAN SIG

Customer survey process

Marketing process

Design process

Engineering process

Manufacturing process

Supplier and supply chain process

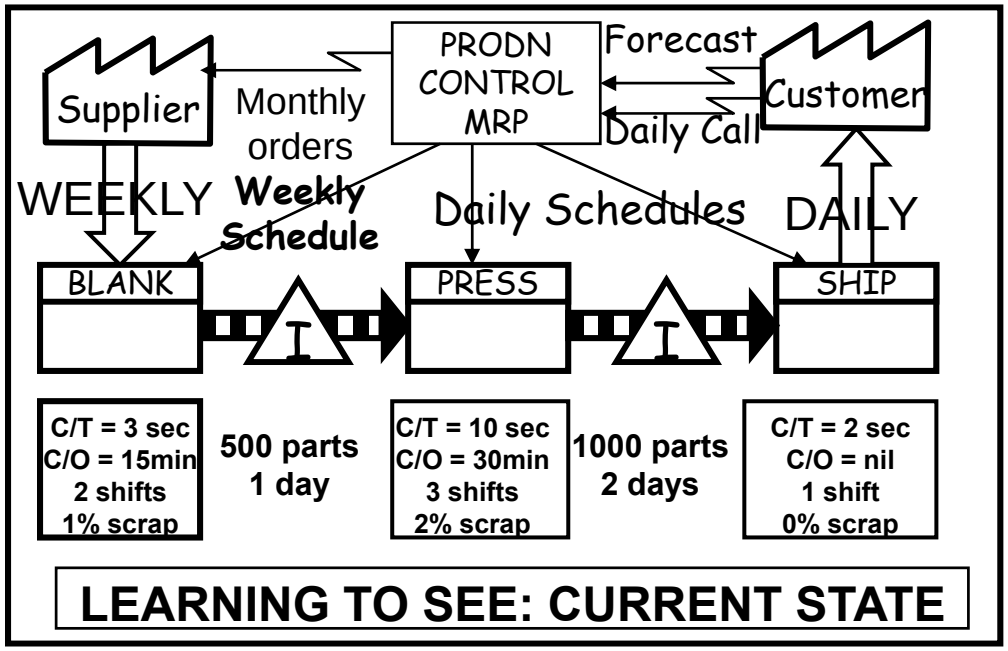
Warehousing/inventory process

Distribution and demand process

Sales and delivery process

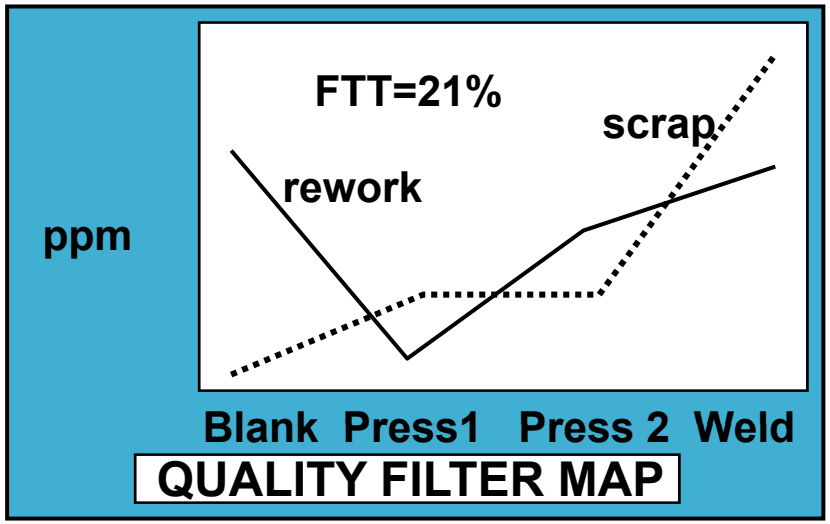
Mapping Links

Value Stream Map

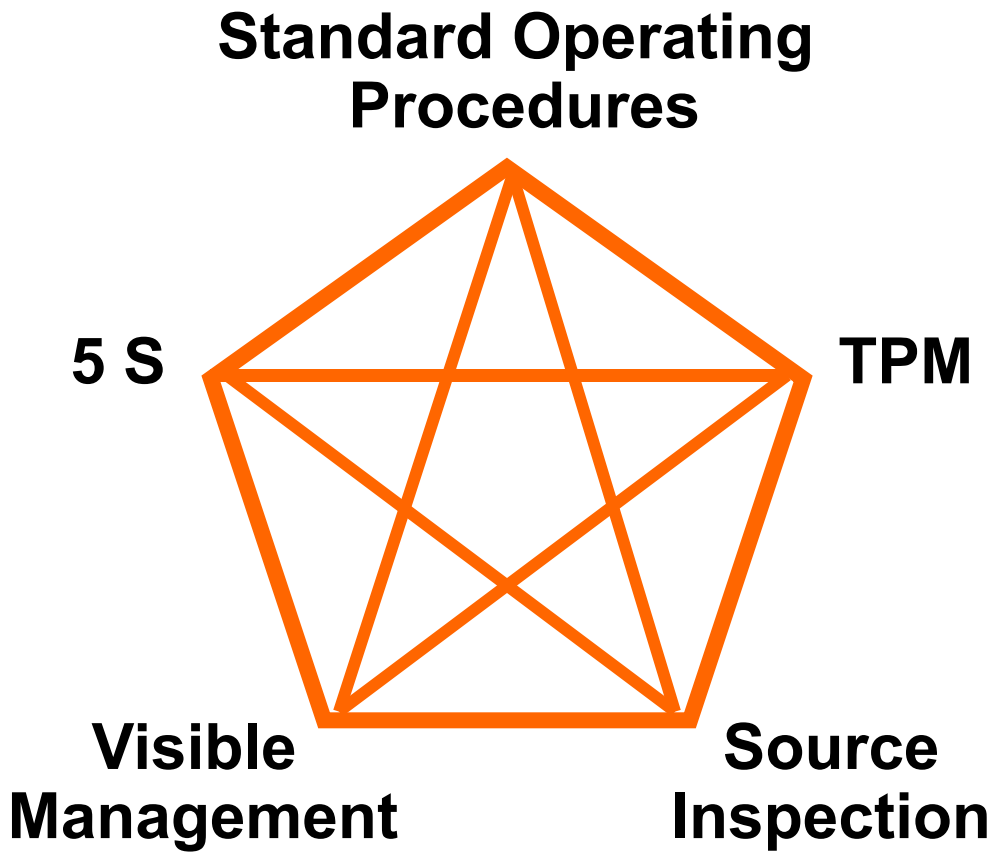


and

Quality Filter Map



Lean Quality's "Big 5"



Mutual Support Leading to
Stability
Consistency
Low Variability

Three Sources of Defects

- **Variation**
  - **Address by statistics, six sigma, SPC, DOE**
- **Complexity**
  - **Address by simplification, visibility, design, especially DFM, GT, modularity, and platforms**
- **Mistakes**
  - **Waiting to happen: address via SOPs, 5 S**
  - **Actually happened: address via successive inspection, self-inspection, but best source inspection (poka-yoke)**

– Standard, Davis, et al. *A Proven Strategy for Lean Manufacturing.* Hanser Gardner Publications, 1999.

Lean Tools for Process Improvement

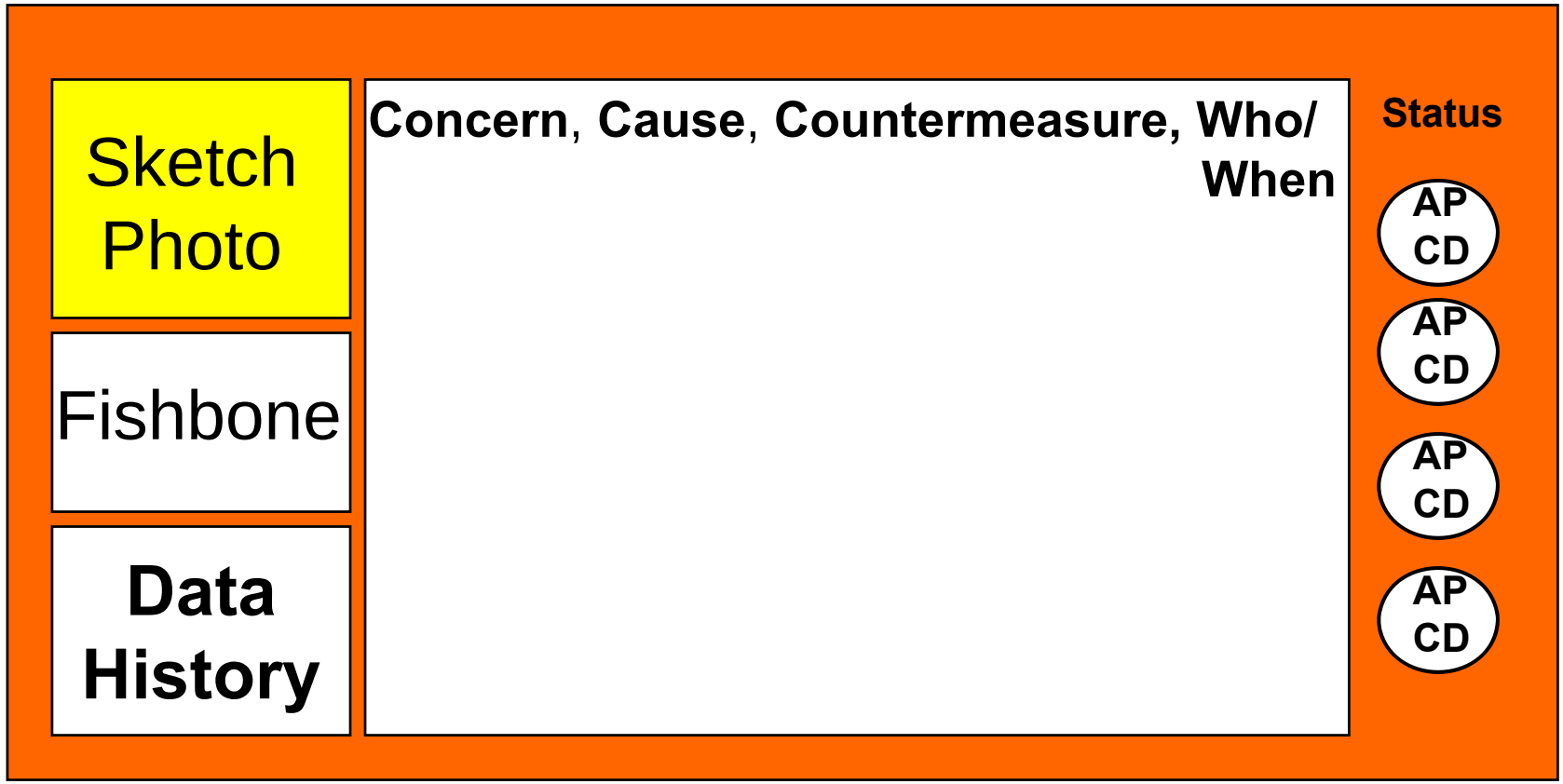
- Kaizen
- 5 S
- Standard operating procedures/standard work
- Visual management
- 5 whys and root cause analysis
- 7 wastes
- Quality at source
- Poka-yoke/mistake proofing
- 7 tools
- Kaizen blitz (kaikaku)
- Approaches to continual improvement

Kaizen

- **“I fixed the machine six times today.”**
- **“Experience is the ability to recognize a problem when it occurs over and over again.”**

!!

Recording the Problem Sequence: Kaizen Storyboard



Foundations of Lean and Quality

- **5 S**
- **Standards and standard operating procedures (SOPs)**
- **Visual management**

5 S Housekeeping

- **Sort, clean out**
- **Simplify, configure**
- **Sweep, clean, and check, (includes visual sweeping)**
- **Standardize, conform**
- **Self-discipline, custom, and practice training and routine.**

The basis of Japanese (and, now increasingly, Western) quality

5 S Is More than Housekeeping

- Basis of safety
- Directly cuts waste, particularly waste of motion
- Reduces variation
- Basis for improvement—building on reduced variation
- Helps recognize further waste
- Changes the mindset

5 S Housekeeping—Can Do

C ► Cleanup ► Sort

A ► Arranging ► Simplify

N ► Neatness ► Sweep

D ► Discipline ► Standardize

O ► Ongoing Improvement ► Self-discipline

5 S Housekeeping—Can Do (continued)

C ► Cleanup ► Sort

A ► Arranging ► Simplify

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C ► Cleanup ► Sort

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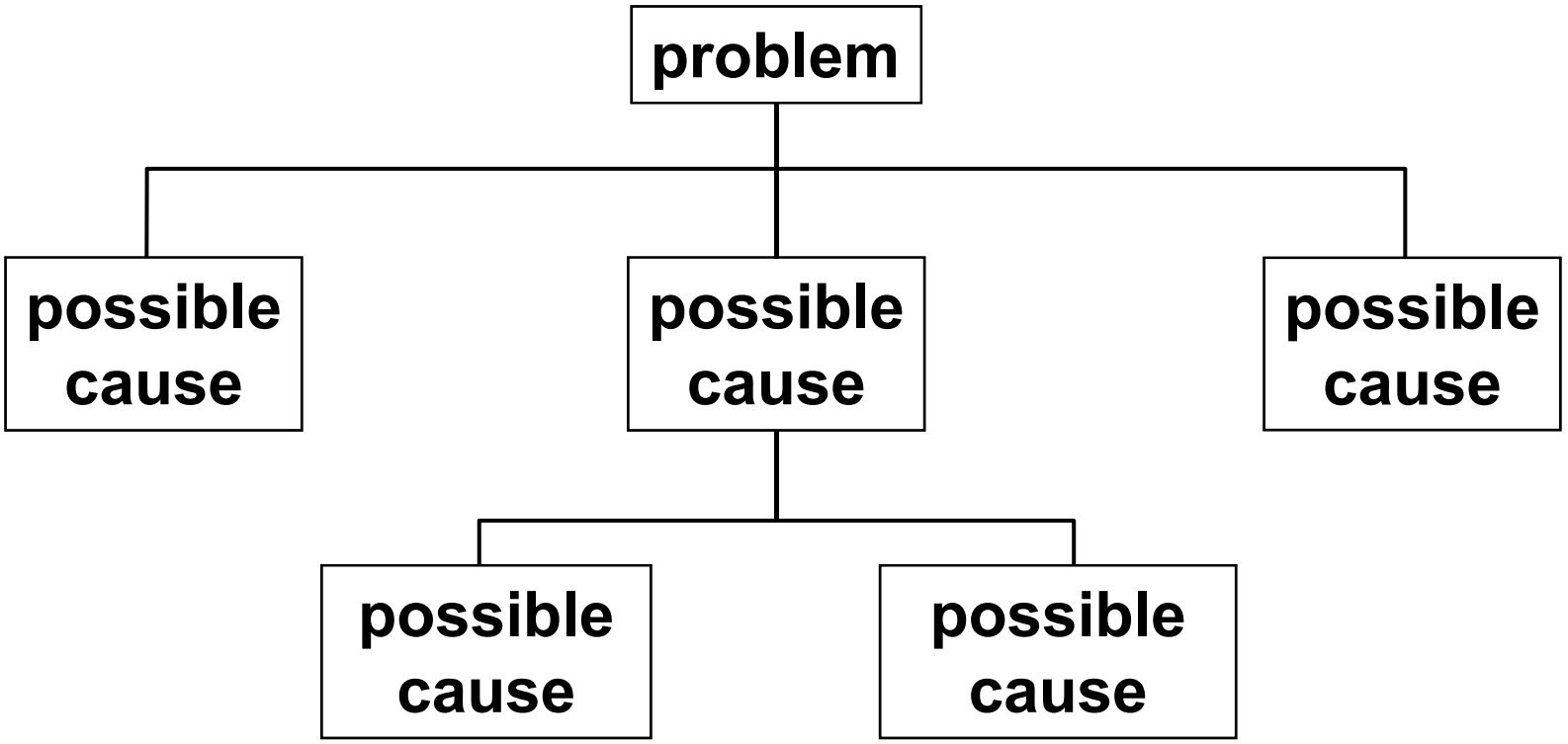
Root Causes:
Fault Trees and Five Whys



Root Causes ...

“For want of a nail, the shoe is lost;

For want of a shoe, the horse is lost;

For want of a horse, the rider is lost;

For want of a rider, the message is lost;

For want of a message, the battle is lost;

For want of a battle, the war is lost;

For want of a war, the country is lost.”

– Herbert: *Jacula Prudentum*

The Seven Wastes and Quality

- **Overproduction: delays in detection, more rework**
- **Waiting: delays in detection, money tied up, freshness**
- **Transporting: damage and delay**
- **Inappropriate processing: failsafing not added, machines not capable**
- **Unnecessary inventory: delay, smaller batches more frequently can improve customer service**
- **Unnecessary motion: handling damage, stress at work, tiredness, quality of work life**
- **Defects: rework and scrap.**

Standards

"To standardize a method is to choose out of many methods the best one and use it. What is the best way to do a thing? It is the sum of all the good ways we have discovered up to the present. It, therefore, becomes the standard.

Today's standardization is the necessary foundation on which tomorrow's improvement will be based. If you think of standardization as the best we know today but which is to be improved tomorrow—you get somewhere. But if you think of standards as confining, then progress stops."

– Henry Ford, *Today and Tomorrow*, 1926

Standards—Another Quotation

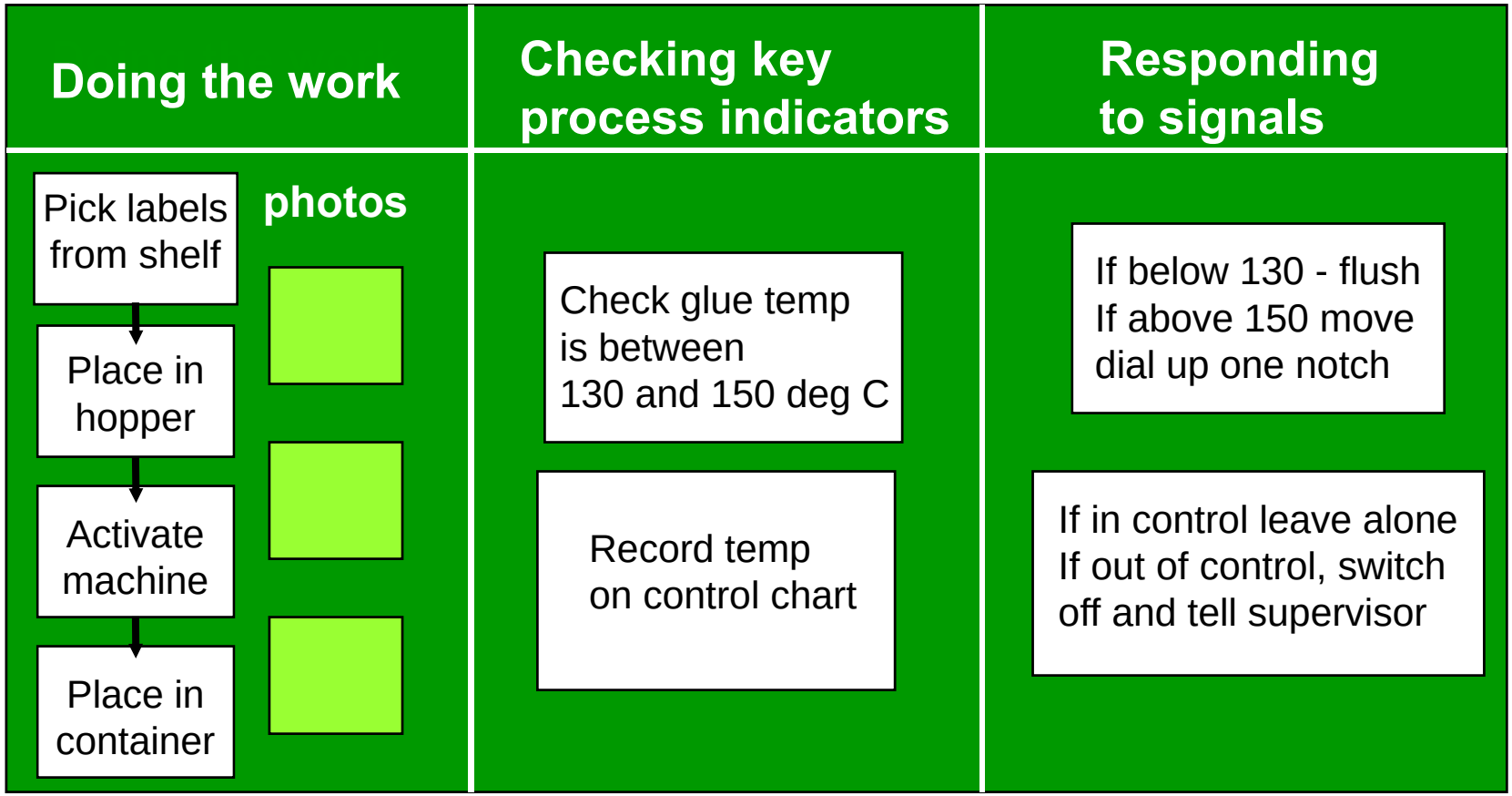
"In a Western company, the standard operation is the property of management or the engineering department. In a Japanese company, it is the property of the people doing the job. They prepare it, work to it, and are responsible for improving it. Contrary to Taylor's teaching, the Japanese combine thinking and doing and thus achieve a high level of involvement and commitment."

– Peter Wickens, 1995

Standards: Characteristics

- Detail main and important steps, especially for safety and quality
- Use verb plus noun—and picture for critical steps
- Develop with operators (from all shifts) and let them write the SOP in their own words
- Confirm or test
- Keep at the point of use
- Compare actual to standard to uncover waste or problems; a problem is a deviation from standard
- If there are no changes to SOPs, there has been no improvement

Standardized Process Chart



The Vision of Vision

- **Every item in the workplace must be needed and have a designated location when not in use.**
- **The environment is immaculate, safe, and self-cleaning.**
- **Standards are easy to identify.**
- **Abnormal conditions are easier to detect.**
- **Performance and progress are easily noticed.**
- **Zero defects are a reality!**

ΑΠΑΓΟΡΕΥΕΤΑΙ ΤΟ ΚΑΠΝΙΣΜΑ

- GREEK

PU?ENJE ZABRANJENO

- CROATIAN

VIETATO FUMARE

- ITALIAN

Universal and Standardized !

Visual Management

There are two aspects

- **Process**
  - **Visible SOPs kept at gemba**
  - **Easy to see controls (maximum and minimum inventory, kanban status, heijunka boards, inventory footprints)**
  - **Problem indicators (lights, andon)**
  - **SPC and precontrol boards**
  - **Clear indicators on machines**
  - **Single-point lessons**
- **Information**
  - **Skills matrix board**
  - **Company performance**
  - **Kaizen storyboards**

– G .D. Galsworth, *Visual Workplace Visual Order Associate Handbook.*

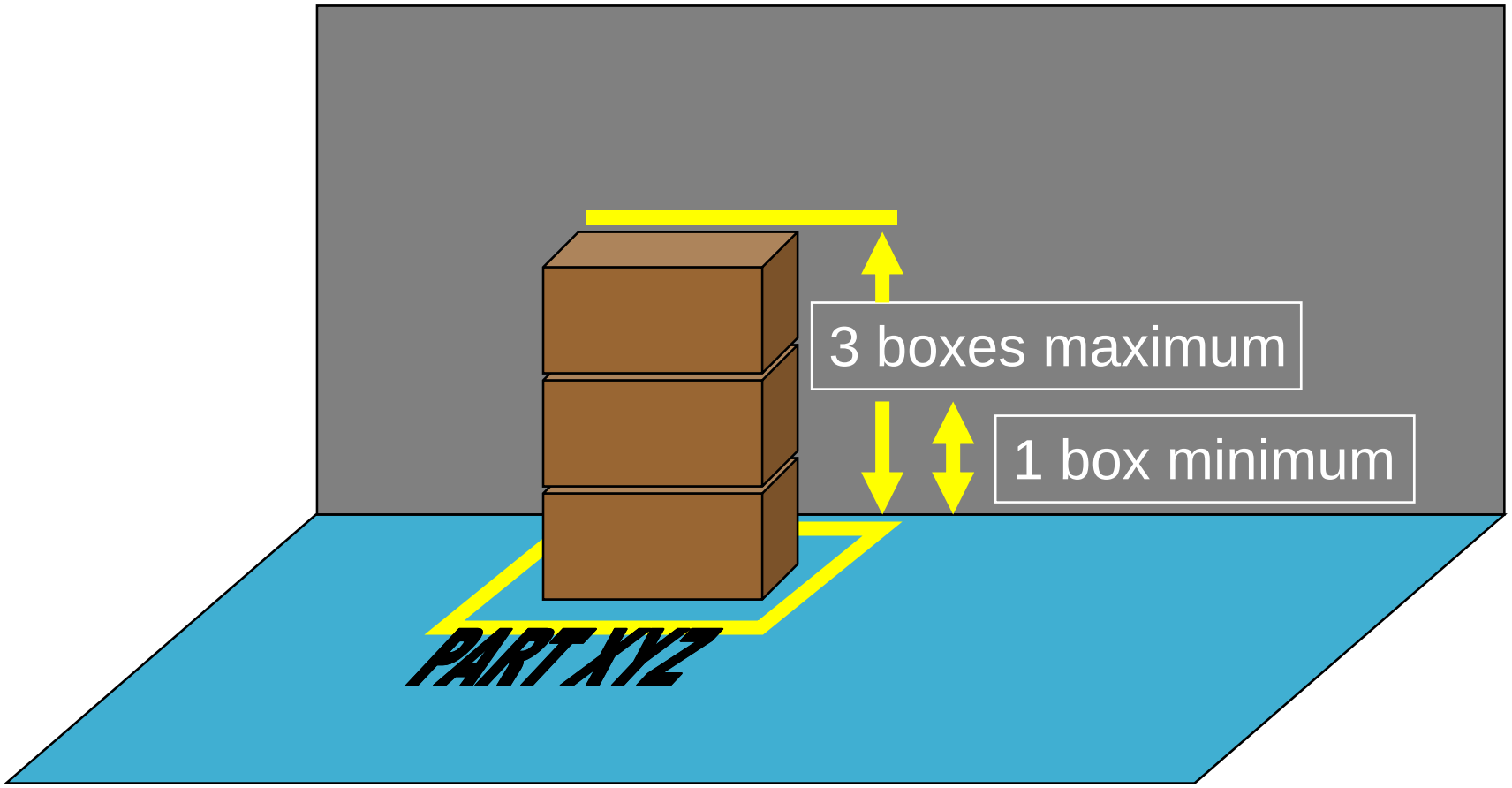
Visual Management

- **These two aspects each have two functions:**
  - **To manage the process—to hold the gains**
  - **To improve the process—the foundation for improvement**

The Visual Factory and 5 S

- **5 S is NOT the visual factory**
- **The visual factory is a far wider concept and includes**
  - 5 S
  - Kanban
  - Visible schedules
  - SOPs
  - Heijunka
  - Inventory footprinting
  - OEE graphs
  - Storyboards
  - Single-point lessons
  - Information sharing
  - Graphs on SPC
  - Red tags for TPM
  - Red tags for 5 S
  - Changeover time graphs

Visual Management



Quality at Source: Types of Inspection

- **Judgment**
  - Compares the part to a standard
  - Uses blueprints
- **Information**
  - Focuses on feedback from a downstream operator
  - Or worse, from an end of line inspector
  - The less WIP the better
  - The less delay to point of inspection, the better
- **Point of Use**
  - Focuses on prevention
  - Relies on operator judgment or SOPs
  - May incorporate poka-yoke or SPC

How Many Fs ?

Finished files of financial information are the result of four years of scientific study combined with the experience of research from fifty professionals from the University of Frankfurt. These files will be frozen effective the first day of February.

Operators and Self Inspection: Conditions

- **Operators must know, and managers ensure, that inspection is not a means for evaluation. Errors and mistakes are inevitable.**
- **Juran says operators must be given**
  - **Knowledge about what they are supposed to do**
  - **Knowledge about what they are actually doing**
  - **A process that is capable of meeting specifications**
- **Oakland says managers should not ask whether operators are doing the job correctly but whether the operator and process system is capable of doing the job correctly.**

Self-Inspection

- Big advantage: immediacy
- Requirement: authority, knowledge, time
  - Maximum of 2 or 3 checks per operator
- Problem: objectivity and lapses
- Successive inspection and where necessary specialized inspection
  - Not done by supervisors
  - Only a slight loss of immediacy
- But data must be accumulated

Poka-yoke

- For six sigma perfection, standards and SPC may not be enough
- You can have high process capability but still fail due to mistakes

Hence,

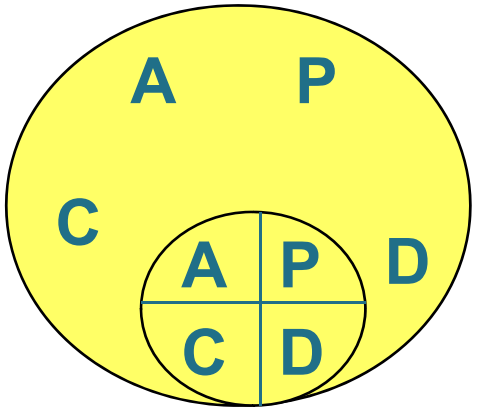
- 100% automatic inspection together with warning or stop

Poka-Yoke Methods and Examples

	Control	Warning
Contact	Parking height bars Armrests on seats	Staff mirrors Shop entrance bell
Fixed Value	French fry scoop Predosed medication	Trays with indentations
Motion Step	Airline lavatory doors	Spellcheckers Beepers on ATMs

– Richard Chase and Douglas Stewart, *Mistake Proofing Based on Shigeo Shingo*

Poka-Yoke Cycles



- **Little poka-yoke**
  - Immediate detection and stop or warning
  - Short-term prevention
- **Big poka-yoke**
  - Getting after the root cause of the problem
  - Long-term prevention and problem solving
  - Accumulate the evidence

Poka-Yoke References

- **Shigeo Shingo, *Zero Quality Control: Source Inspection and the Poka-yoke System*, Productivity, 1983**
- **Nikkan Kogyo (ed), *Poka-Yoke*, Productivity, 1989**
- **Web site by John Grout**
  http://campbell.berry.edu/faculty/jgrout/
- **C. Martin Hinckley, *Make No Mistake!*, Productivity, 2001**

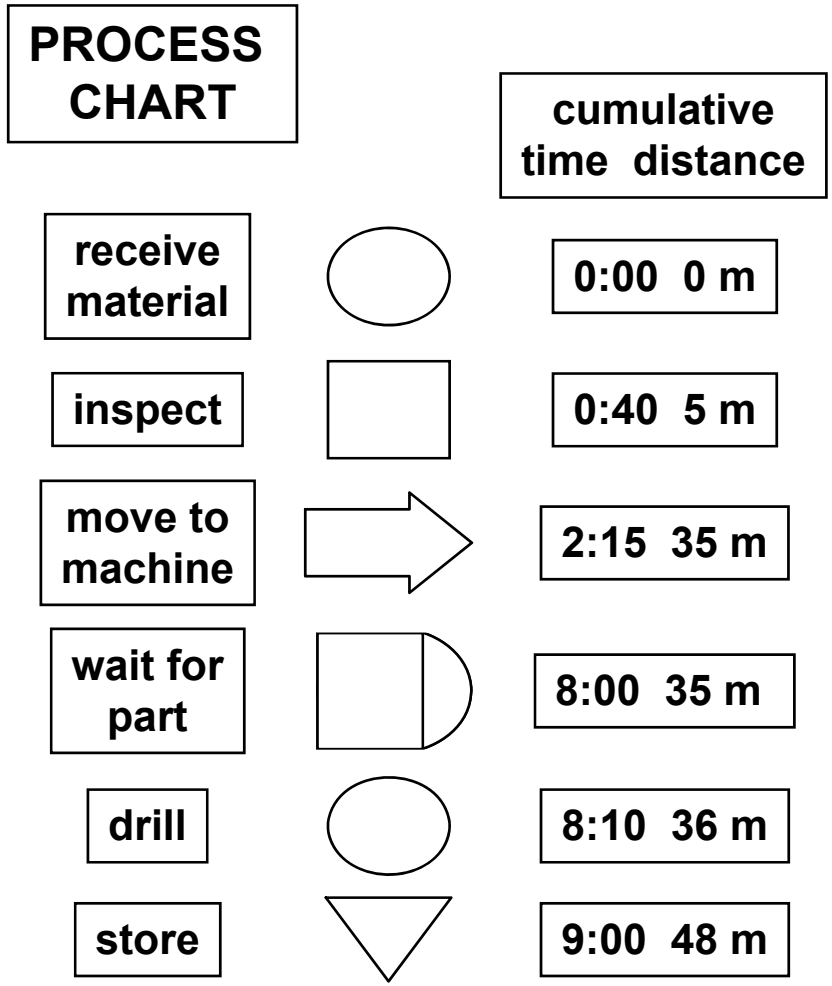
Seven Tools of Quality

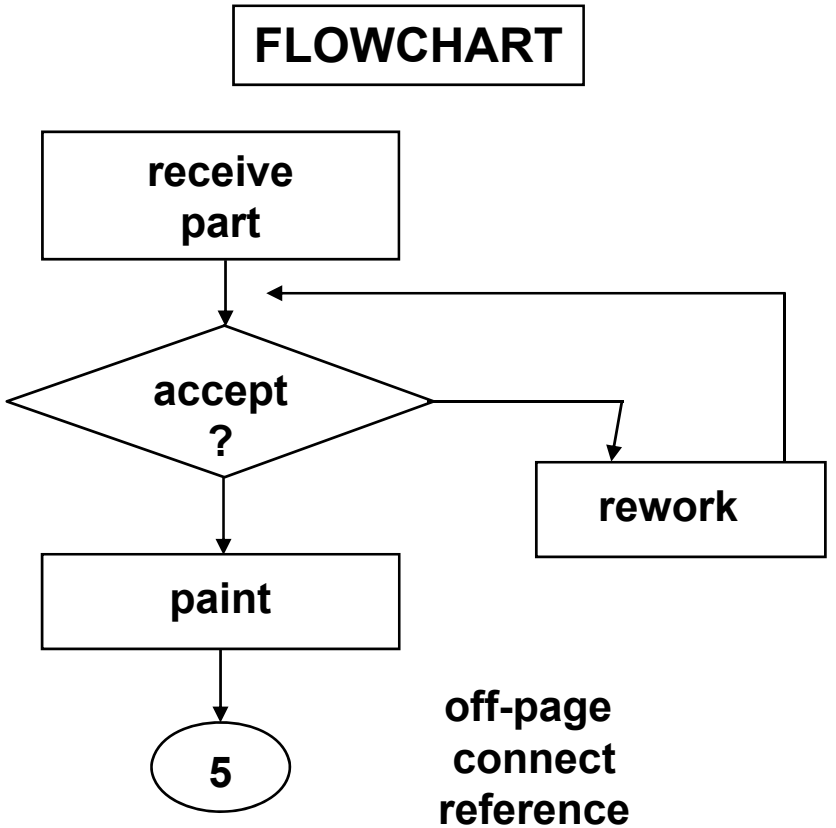
- Flowcharts/maps
- Pareto
- Fishbone
- Run diagram
- Tally/histogram/measles
- Correlation
- SPC (Check sheets SOPs)

The seven tools are a set !

Flowcharts and Maps

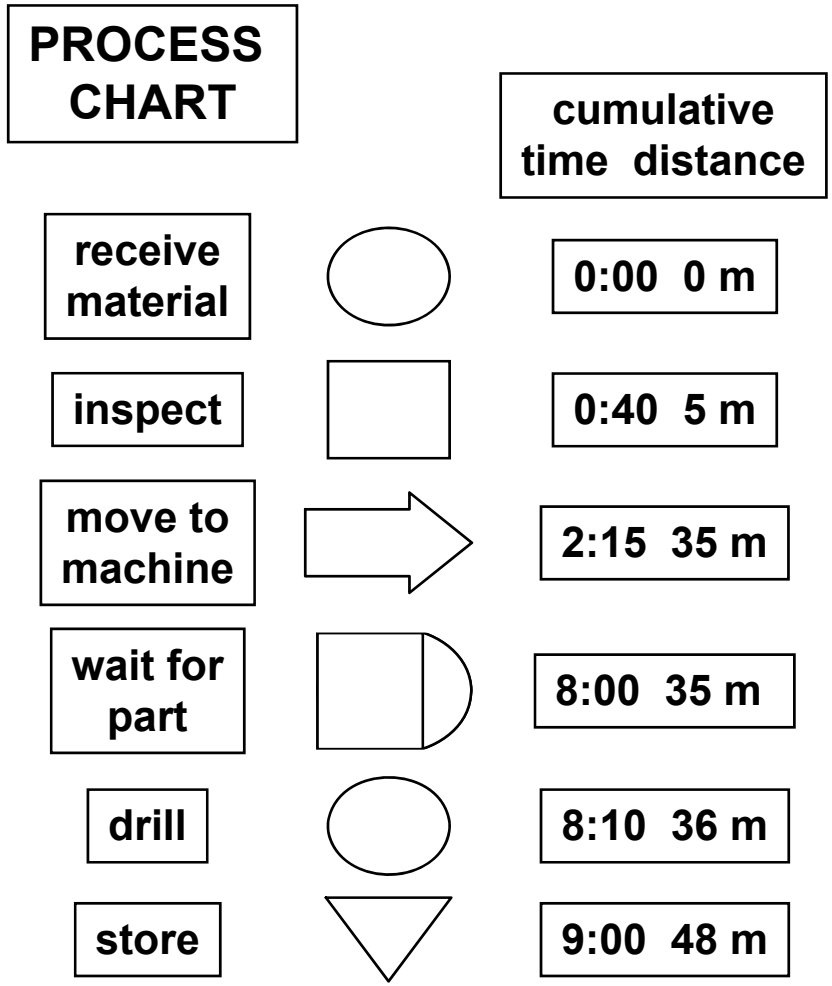
Activity maps, spaghetti, logic

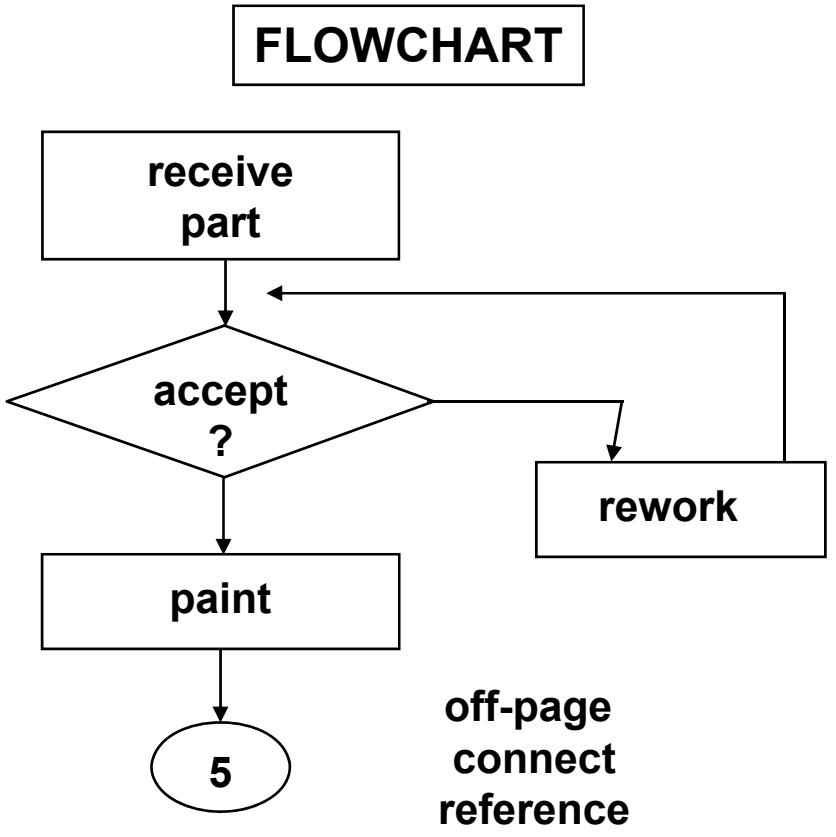




Flowcharts and Maps (continued)

Activity maps, spaghetti, logic





Pareto

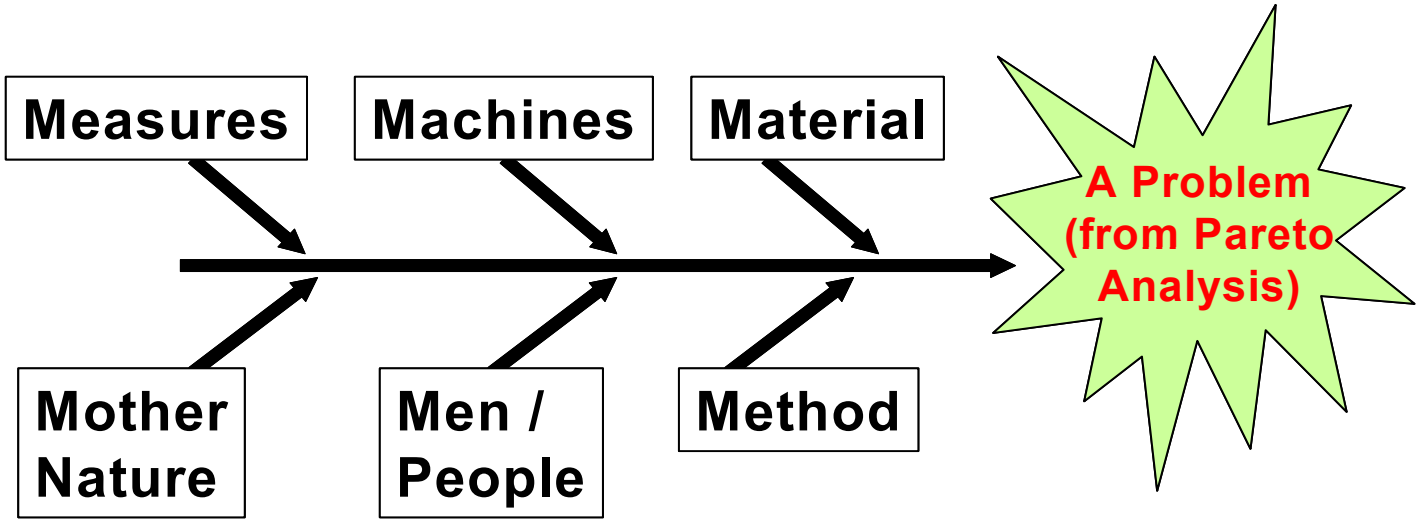
- 80/20, ABC, the vital few and trivial many
- the single most powerful management concept of all time
- Examples:
  - 1% of Web sites get 32% of Web traffic
  - 5% of cars cause 85% of emission pollution
  - Inventory, problems, innovation, customers, products

Pareto (continued)

- 80/20, ABC, the vital few and trivial many
- the single most powerful management concept of all time
- Examples:
  - 1 percent of Web sites get 32 percent of Web traffic
  - 5 percent of cars cause 85 percent of emission pollution
  - Inventory, problems, innovation, customers, products

Fishbone

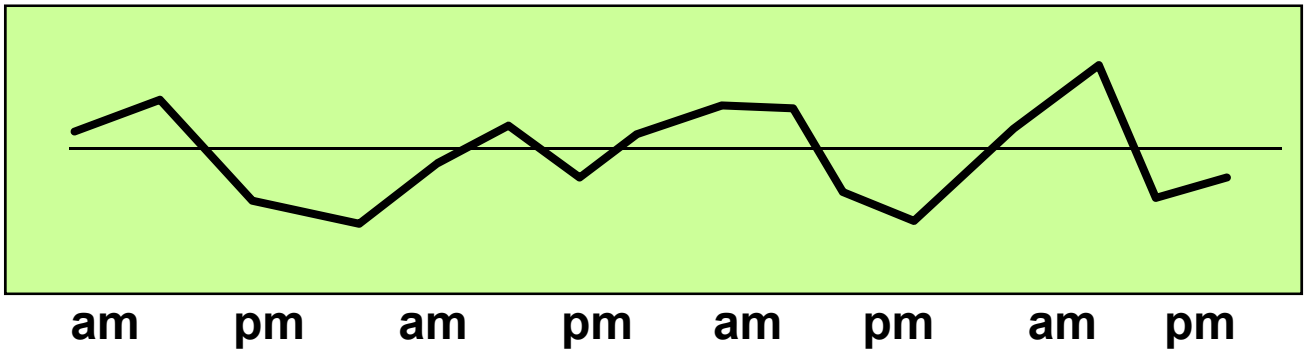
- **Brainstorming**
- **Root cause**
- **CEDAC**



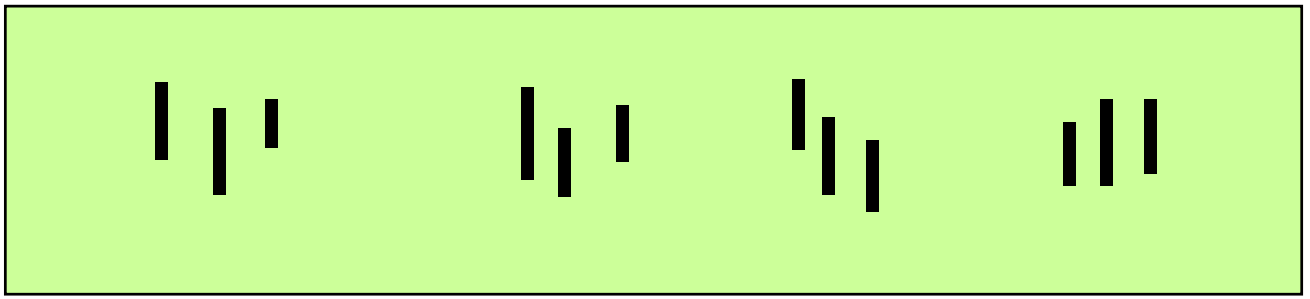
Run Diagram

defect rate

problems are more common in the a.m.

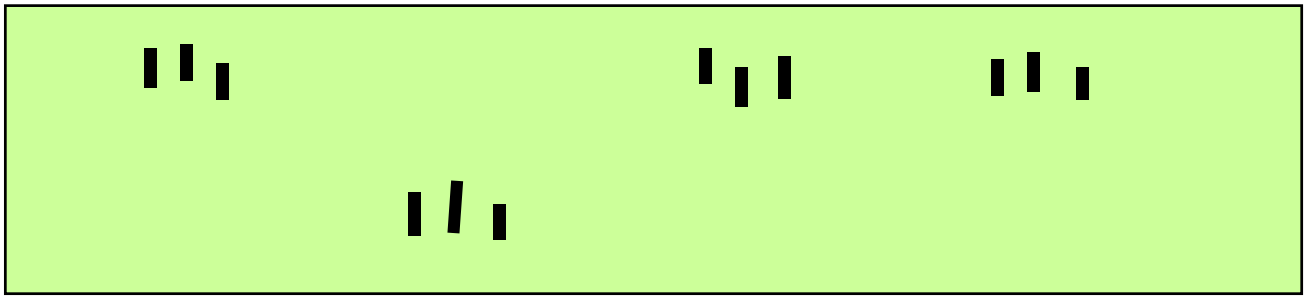


dimension variation occurs within units; not over time



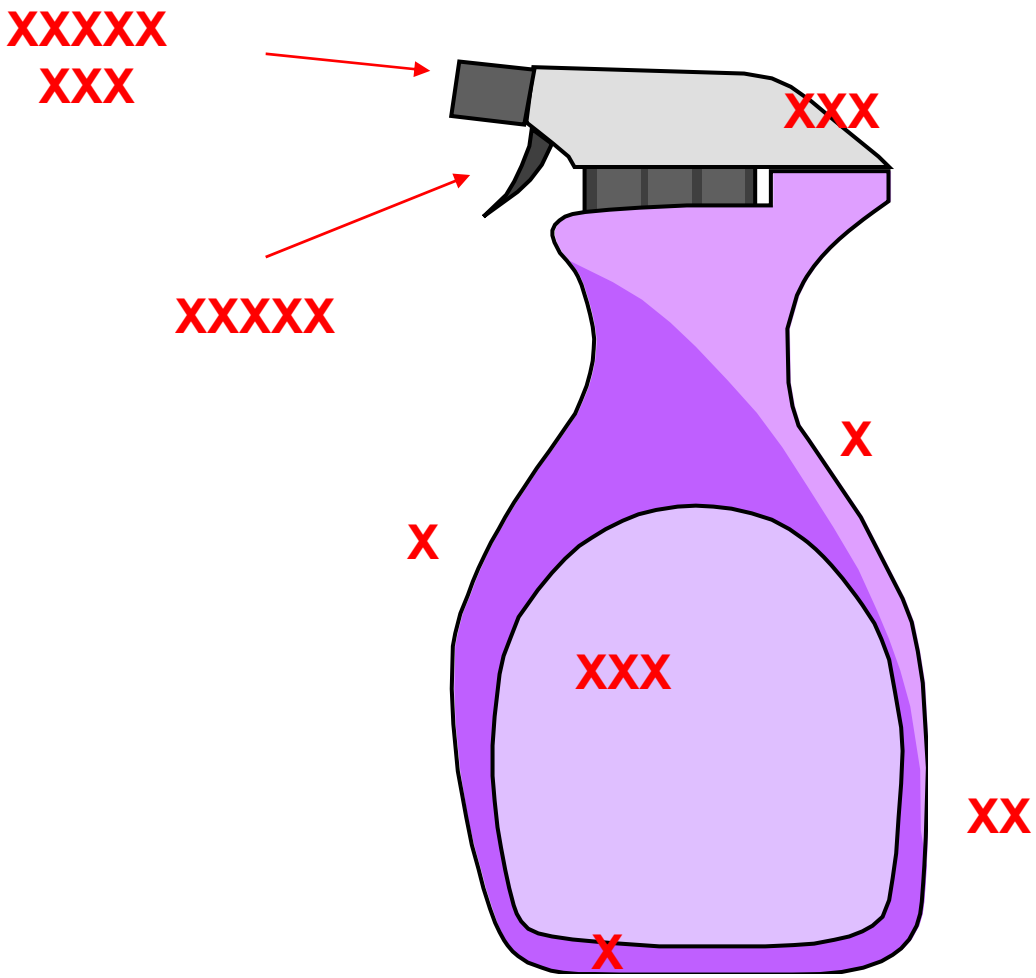
samples taken from batches over time

dimension variation is batch dependent; not within units



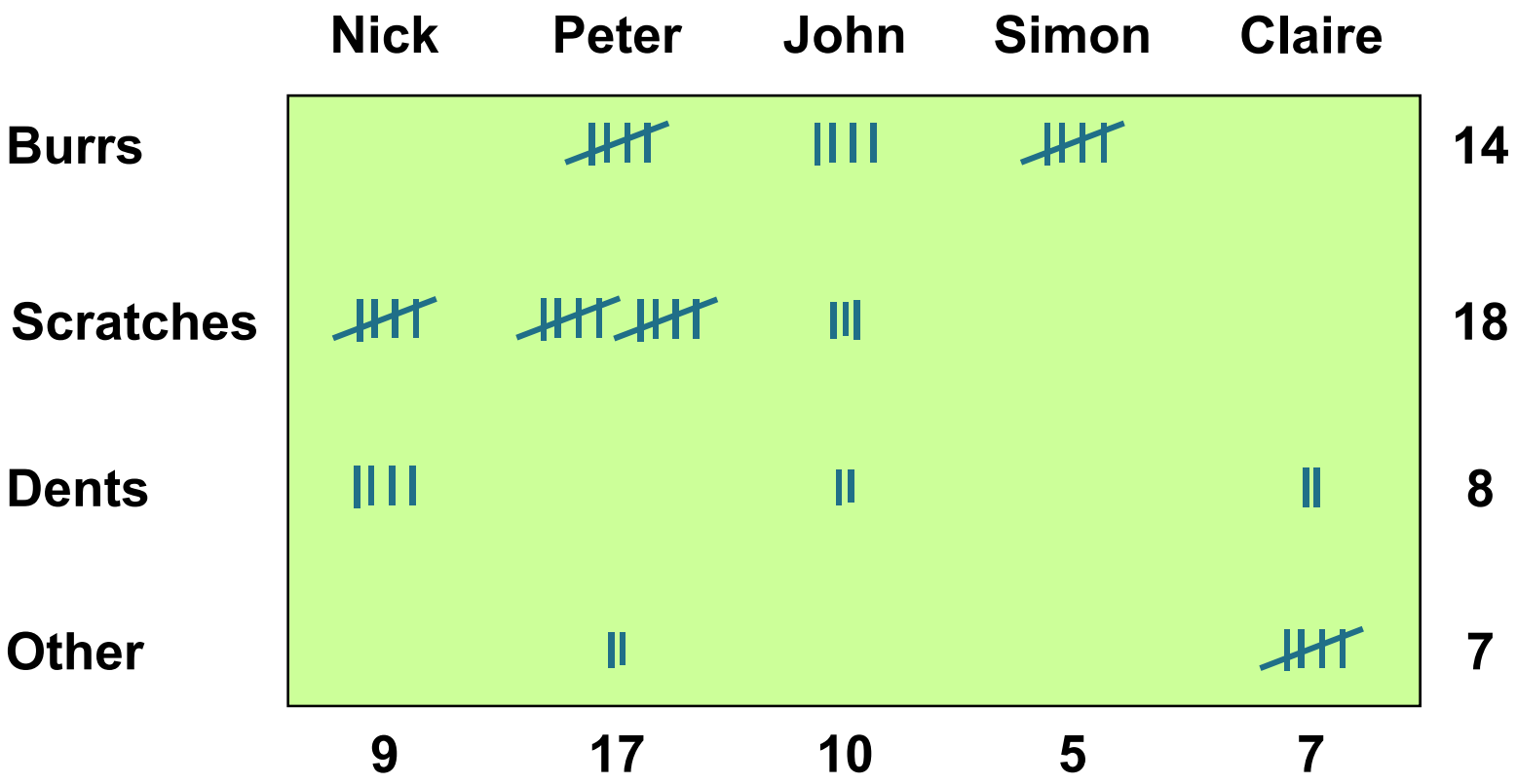
samples taken from batches over time

Measles Chart



MEASLES CHART Example: defects in spray bottle manufactured over one week

Tally Chart

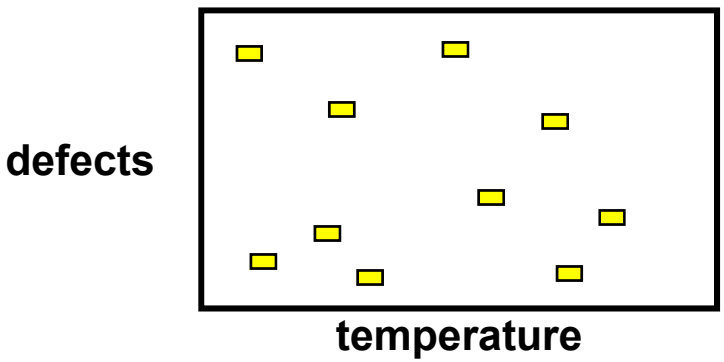


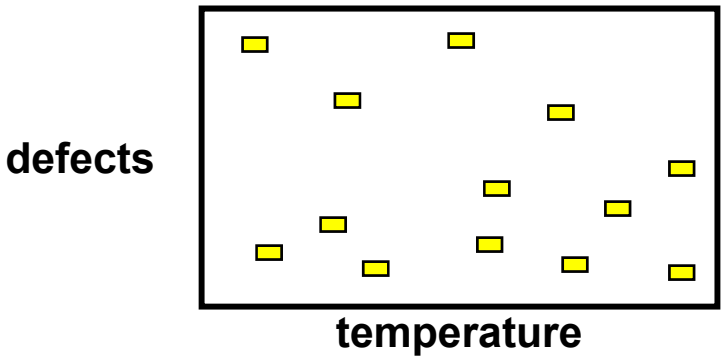
Other axes could be time: time vs. person, time vs. defect

Correlation

LEAN SIG

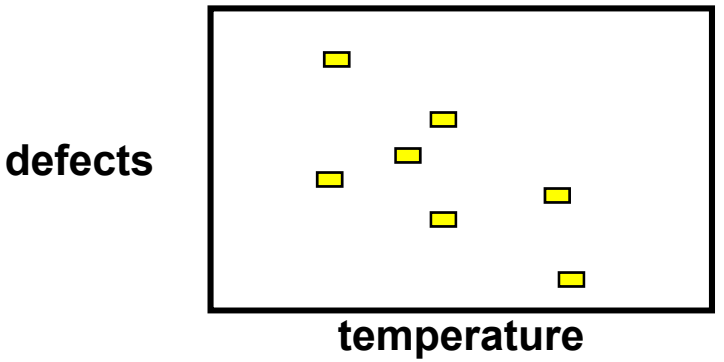
No Correlation

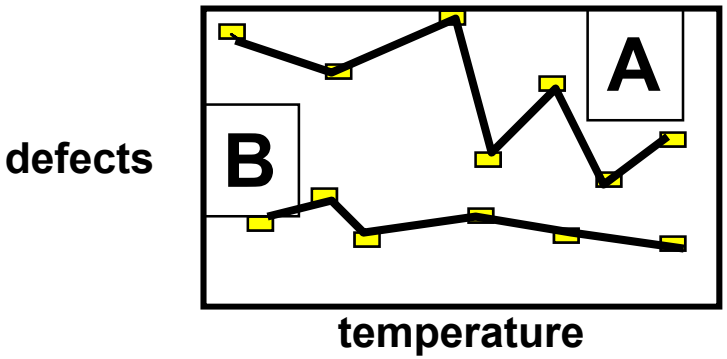




no apparent relationship

Clear Correlation



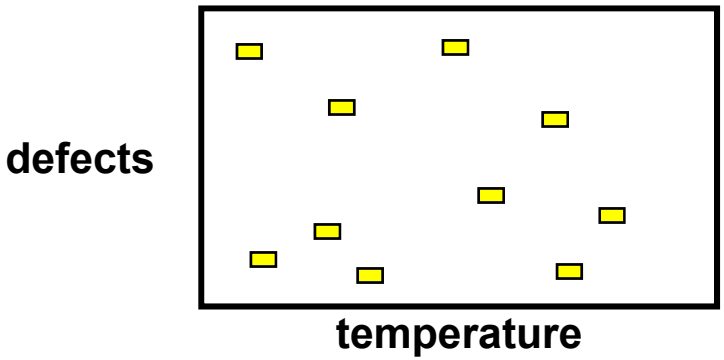


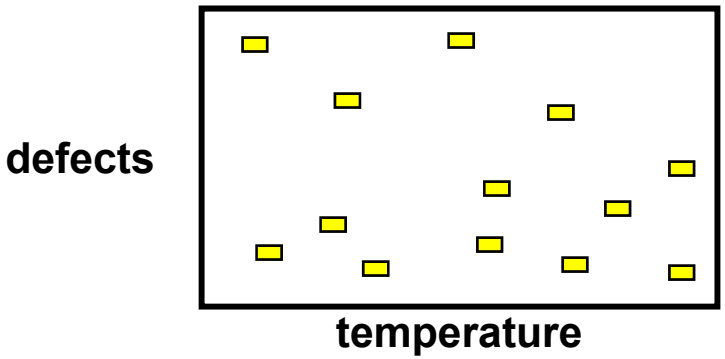
but stratified, there appears to be a negative relationship for Machine A

Correlation (continued)

LEAN SIG

No Correlation





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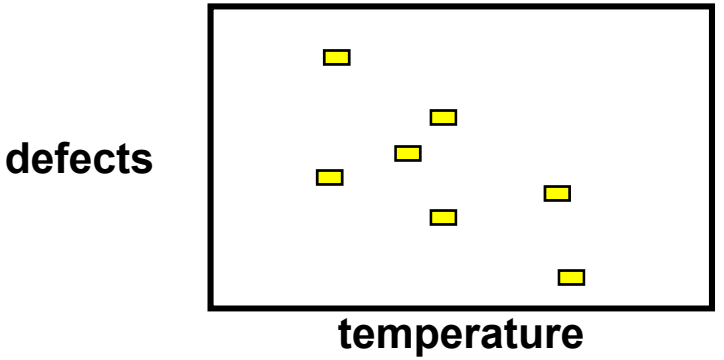
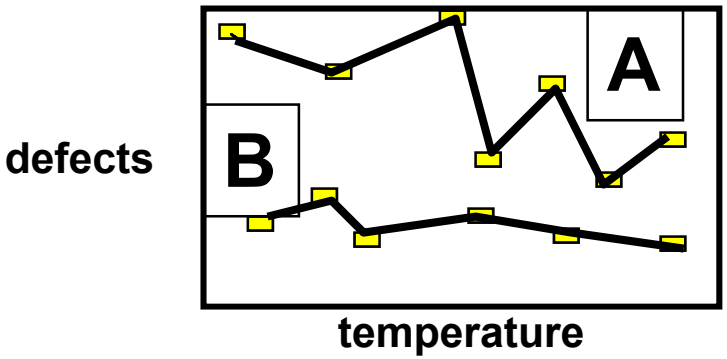
Clear Correlation

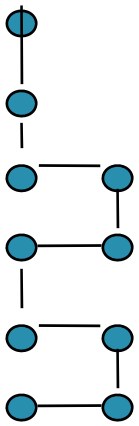




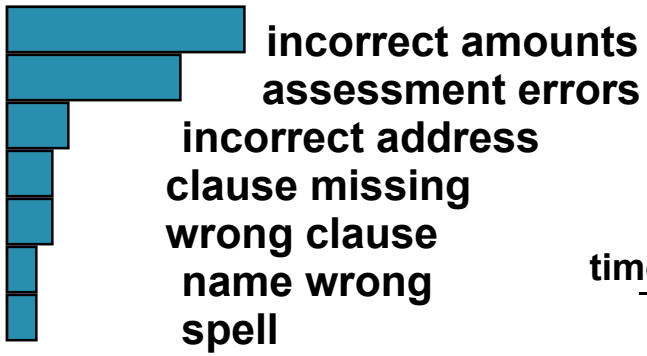
but stratified, there appears to be a negative relationship for Machine A

Seven Tools:
Insurance Example

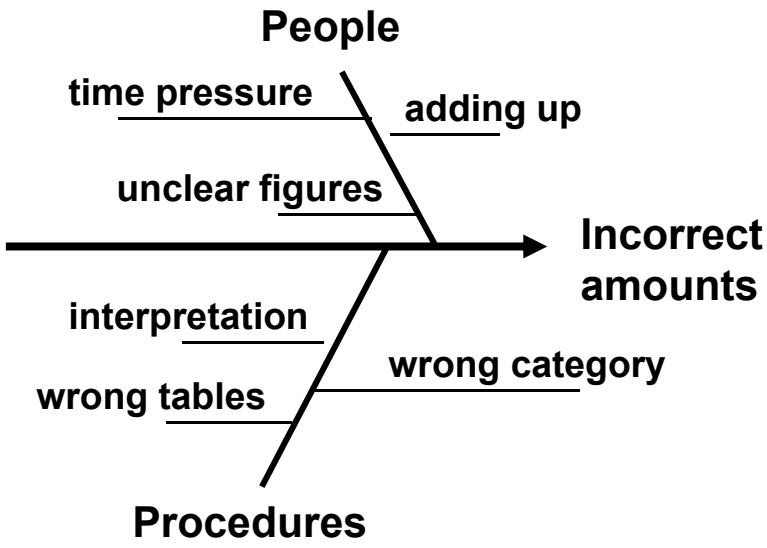
Flowchart



Pareto on rework



Fishbone



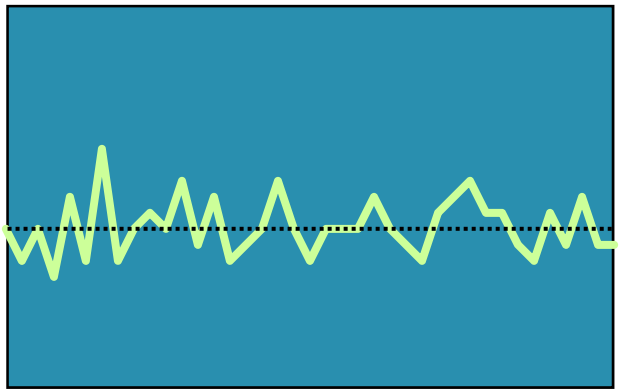
Identified :

- large number of back and forth visits
- large amount of rework
- throughput time 60 hrs,
- value adding time 12 mins

Seven Tools: Insurance Example (continued)

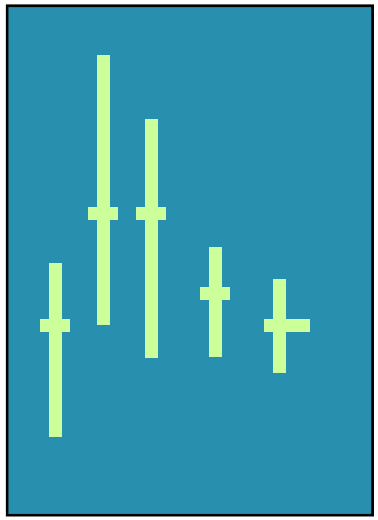
LEAN SIG

Run Diagram



peaks on Tuesdays
overcapacity on 3 days per week, but average OK

Correlation



note variation patterns

Solutions

cross train staff
automate some procedures
flexible hours
move inspection point earlier

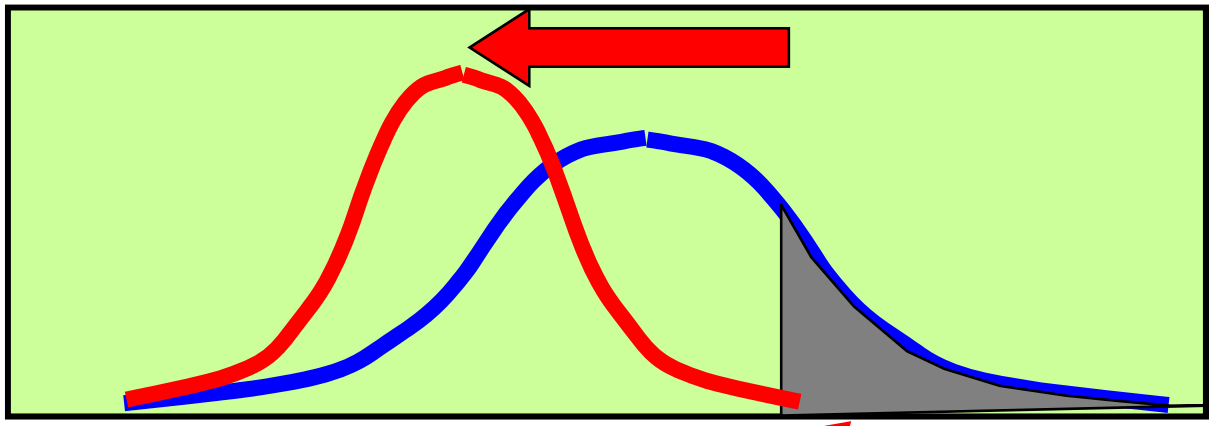
Outcomes

60% drop in errors
average process time down to 2 days

Chronic Problems and Six Sigma

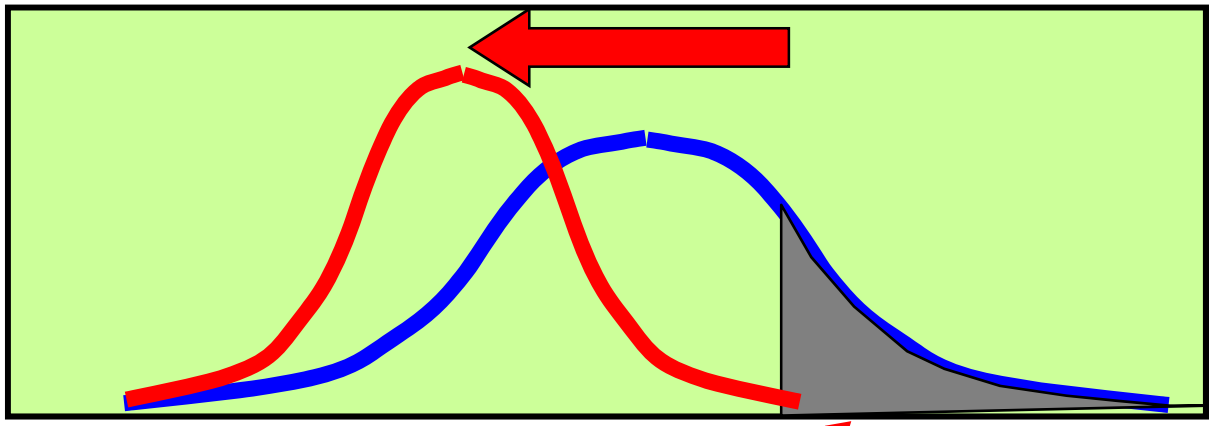
Six Sigma

An objective of six sigma is to reduce variation and to move outputs permanently inside critical customer requirements



Six Sigma (continued)

An objective of six sigma is to reduce variation and to move outputs permanently inside critical customer requirements



Origins

- **Both six sigma and lean trace roots back to Deming**
  - **Six sigma on variation and PDCA**
  - **Lean on waste**
- **Strong Juran influence**
  - **Project-by-project improvement**
  - **The customer**
  - **Improvement tools**

Why Six Sigma and Lean?

- **Six sigma has strength in variation reduction and problem solving**
- **Lean has strength in waste reduction and seeing the whole**
- **These are synergistic**
- **Both are necessary**
- **Don’t separate the lean and six sigma functions**

Comparing 99% with 6σ

- 3000 misdeliveries per 300k letters
- 1 misdelivery
- 4100 crashes per 500k computer starts
- Less than 2 crashes
- 1.68 hours of dead time per week of TV broadcasts
- 1.8 seconds of dead airtime

Recent History of Six Sigma

- Developed by Alan Larson and others at Motorola during 1980s, strongly supported by CEO Bob Galvin
- 1987 Motorola's head of communication, George Fisher, unified several Q programs into six sigma (Fisher later took it to Kodak)
- Several articles in *Quality Progress* early 1990s
- Black belt certification developed by Motorola, IBM, TI, and Kodak
- Adopted by Jack Welch, CEO of GE, in 1995
- AlliedSignal and Cisco adopt in 1998
- Japanese (Sony, Toshiba) adopt in 1998/1999
- Delphi and big three U.S. automakers adopt in 2000

Six Sigma: The Basis

- Everything is a process
- Every process has variatio
- Every process can be sured
- Every process can mproved and variation reduce
- The long te rget is 3.4 defects per million o tunities (note not “ppm”) in custo utput

Based on Statistical Thinking

Six Sigma: The Basis (continued)

- Everything is a process
- Every process has variatio
- Every process can be sured
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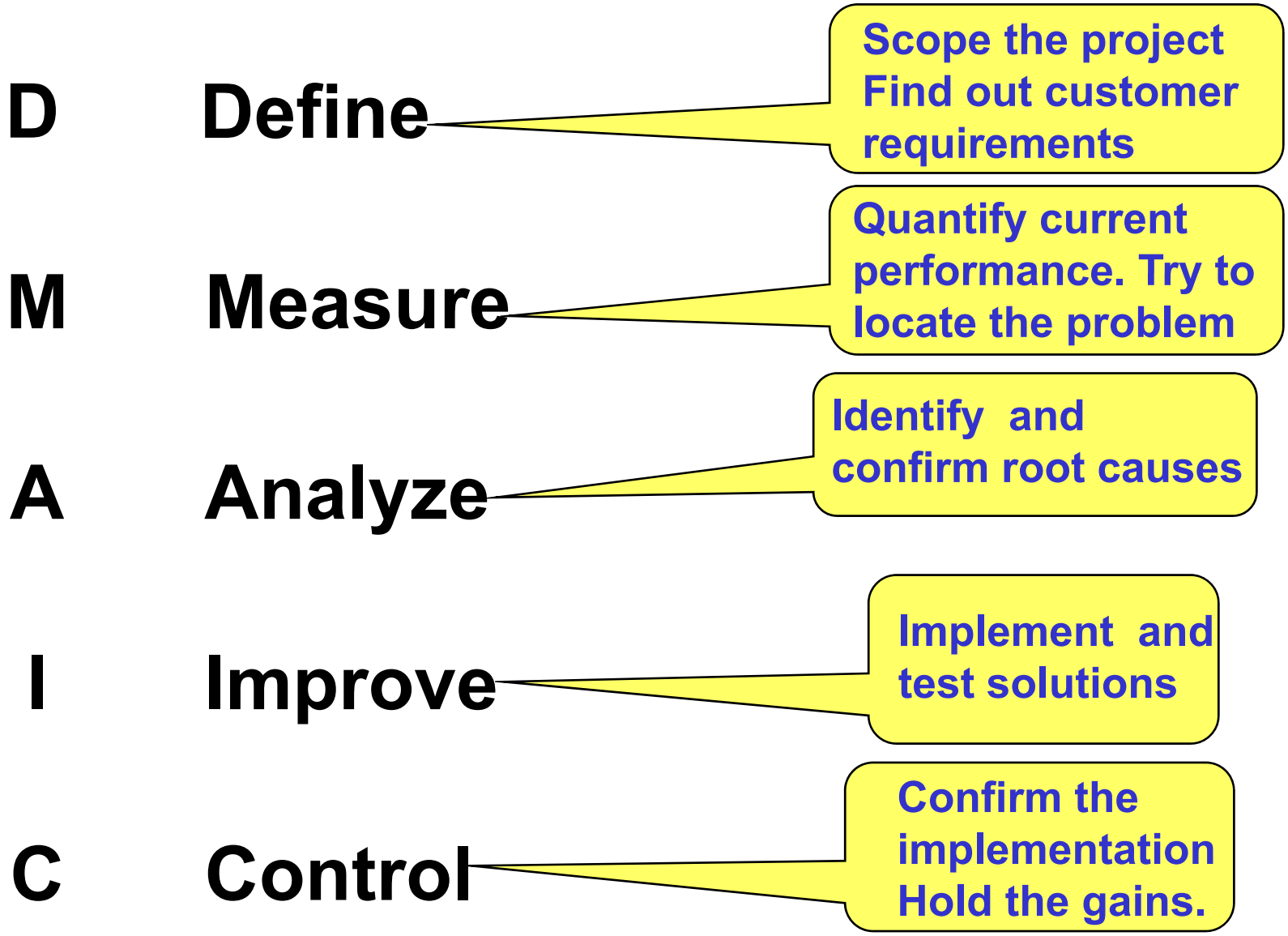
Based on Statistical Thinking

Six Sigma Stages



PDCA, DMAIC, and Tools

Plan	Define	What is the problem?	**Identify Opportunities Scope the Project**	**Benchmarking, QFD, Disruptive Tech, Hoshin, FMEA, CTQ Pareto, Importance Performance, Cost of Quality, Market Survey Tree Diagram, Critical Path Anal, Mapping, NGT, SIPOC**
	Measure	How are we doing?	**Analyze the Process** **Define Outcomes**	**7 tools, DPMO, Data Presentation, Process Chain, 5 Whys, 6 Honest Men, Gage R&R, Cost of Quality, Capability Analysis, Kano** **Maps, Blueprints,**
	Analyze	What is wrong?	**Identify Root Causes**	**5 Whys, FMEA, 7 tools, DOE, QFD, Matrix Analysis, Shainin, Gap Analysis, Benchmarking, Hypothesis Tests**
Do	Improve	Fix it	**Prioritize** **Refine** **Implement**	**QFD, Matrix Analysis, Policy Deployment** **QFD, Affinity, Contingency, FMEA** **Force Field, Kaizen, Blitz Critical Path, Single Point Lessons**
Check Act	Control	Hold the gains. Celebrate.	**Measure outcomes** **Acknowledge**	**Control Charts and SPC, 5 S Standardization & SOPS, Cusum Cost of Quality, ISO 9001:2000, Sustainability, Capability, Supplier Partnership**

Lean and Six Sigma

D	Define	Kano Model Understand value (Check 5 S)
M	Measure	Value-stream map Current state map Takt time, Amplification
A	Analyze	VA and NVA Constraints to FLOW
I	Improve	Future State Kaizen and Blitz Many Lean tools
C	Control	5 S, SOPS, Poka-yoke Sustainability

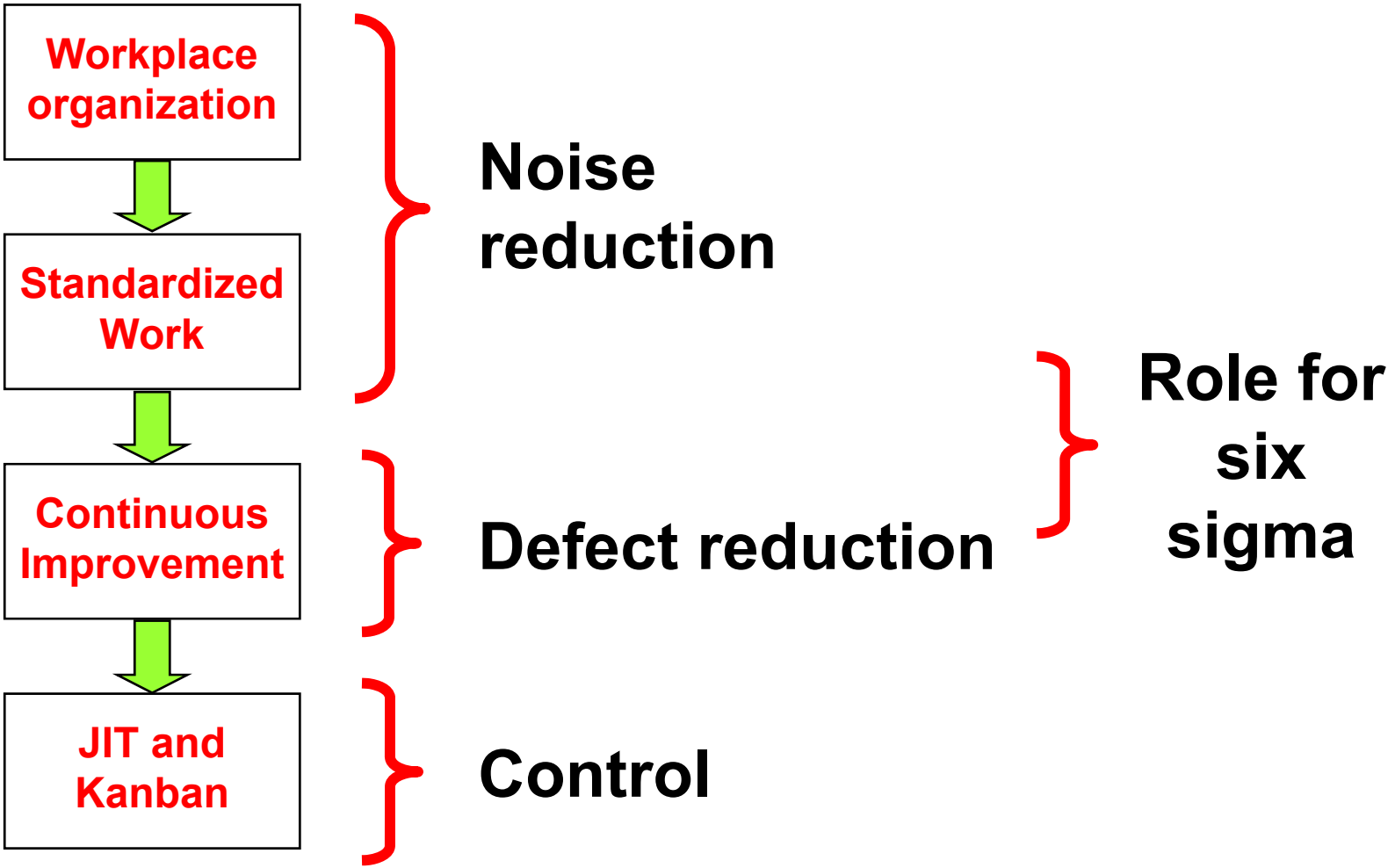
Using Six Sigma with Lean

- **Do not study and measure waste when you can remove much of it straight away**
  - **Do not spend time measuring, for example, excess transport or changeover**
- **Build on a firm foundation. Check that 5 S and SOPs are in place and working before doing a six sigma or other study**
  - **Do not waste time measuring when there is an inherently poor variable foundation through poor or lax 5 S or standard operations.**
- **If so, do these lean things first**

Using Six Sigma with Lean (continued)

- **Use lean mapping and policy deployment first to get after the big picture, and identify priorities before using DMAIC on a project-by-project basis.**
- **If you don't do this, you may target valuable six sigma expertise on inappropriate problems.**

Lean and Six Sigma: A Motorola View



– Adapted from John Lupienski, Motorola, AME Conference 2001

Reducing Variation by Surfacing

- **An alternative or supplement to reducing and controlling variation is to surface it by, for example**
  - **Jidoka**
  - **Heijunka**
  - **Meeting the schedule**
- **In each case, stop and investigate immediately. Use the five whys.**
- **Address variation immediately, not as a special study later on.**

Six Sigma and Lean

Analagous to a surgeon working in a third world country. The surgeon can make acclaimed improvements one at a time. But the public health engineer works behind the scenes on larger projects that ultimately have much greater impact.

– Kaufman Consulting Group White Paper, "Integrating Lean and Six Sigma," 2000

Typical Six Sigma Organization

- **Steering committee/quality council (see Juran)**
- **Six sigma champion (sitewide)**
- **Project leader (master black belt)**
- **Coach (black belt or master black belt)**
- **Team leader (black belt)**
- **Team member (green belt)**

Typical Black Belt Program

- **Core Skills**
  - Problem solving
  - Quality tools
  - Basic statistics
- **Interpersonal Skills**
  - Change management
  - Effective presentations
  - Consulting skills
  - Teamwork skills
  - Business skills
  - Project management
  - Coaching
- **Technical Skills**
  - Nonparametric statistics
  - Measurement systems
  - DOE
  - Robust design and tolerancing
  - Reliability analysis
  - Survey design and analysis
  - Multivariate analysis
  - Advanced regression
  - Response surface analysis
  - Time series forecasting
  - Benchmarking

Gage Repeatability and Reproducibility (Gage R&R)

- Also known as measurement system analysis
- How well (consistent) operators are in using test equipment and whether the measurement system is effective
- Often involves several operators using the same equipment and blind testing a set of numbered parts in random order. Each part is measured three times at random intervals.
- A gage error of 10 percent is usually considered acceptable
- Also use of SOPs for test equipment

Six Sigma and Lean References

- Anand Sharma and Patricia Moody, *The Perfect Engine*, Free Press, 2001 - chapters on Lean Sigma Leadership
- Michael George, *Lean Six Sigma*, McGraw Hill, 2002
- John Bicheno, *The Quality 75: Towards Six Sigma Performance in Service and Manufacturing*, PICSIE, 2002
- Mikel Harry and Richard Schroeder, *Six Sigma: The Breakthrough Strategy,* ASQ Press, 2000
- Motorola Web site at www.motorola.com
- *Quality Progress* magazine
- Forrest Breyfogle, James Cupello, Becki Meadows, *Managing Six Sigma*, Wiley Interscience, 2001

Statistical Process Control

- **Measure the process not the product**
- **Common causes and special causes; don't tinker!**
- **The last tool, not the first**
- **Cpk and capability**
- **Chart interpretation**

Variation

- **Common cause variation**
  - **The variation a process would exhibit if behaving at its best or stable**
  - **It occurs in every process**
- **Special cause variation**
  - **Results from the occurrence of sources or people external to the usual operation of the process**
  - **An unusual event**

Variation (continued)

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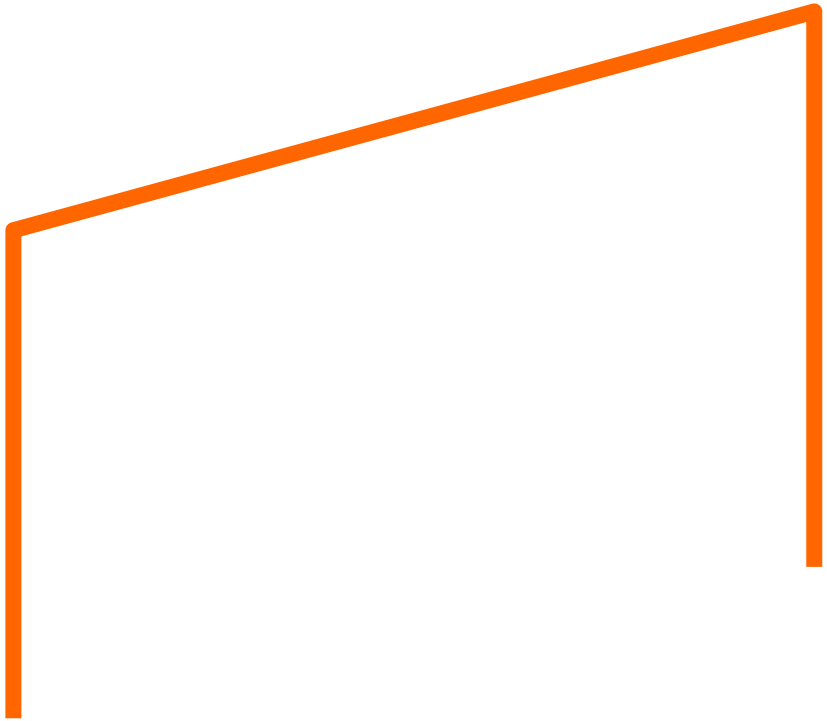
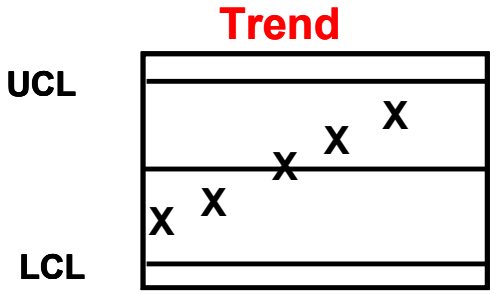
SPC and Limits



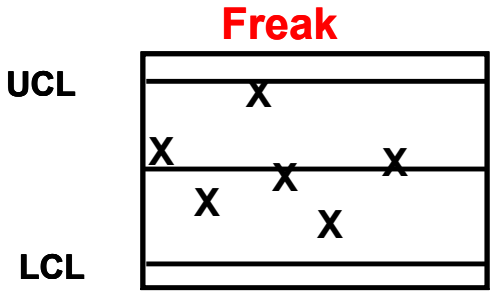
In Control

- In control means that variation is occurring between the control limits.
- Common cause variation is at work.
- If you are in control, don't tinker.
- In control means the process is stable.
- But, in control does not necessarily mean things are good—you can have a stable high level of complaints.

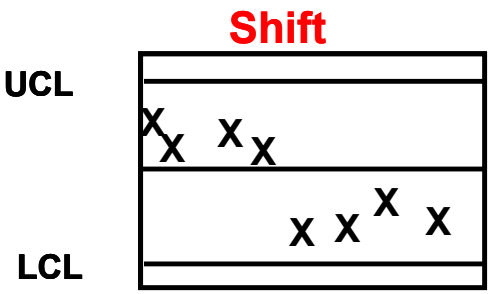
SPC: Tracing Problems



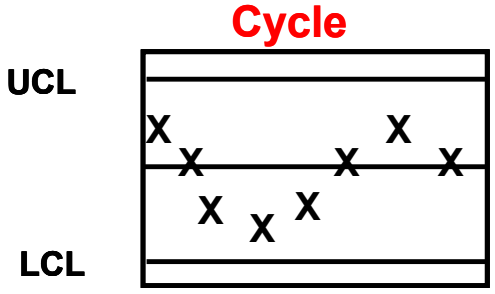
maintenance
wear
dirt
environment



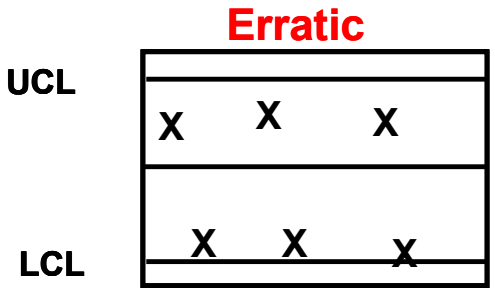
misread
data entry
other people
other material



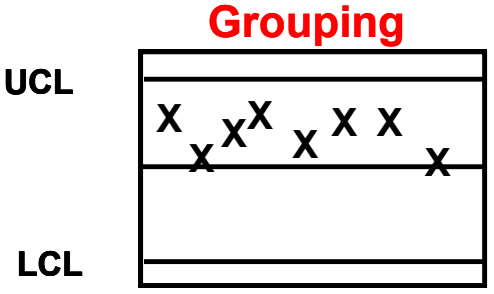
machine speed
other people
other material



work pattern
other people
environment



careless
overadjustment



other people
new method
another
distribution

— from John Bicheno, *The Quality 75*, PICSIE Books, Buckingham, 2002.

SPC Cautions

- **Delay in detection of problems**
- **Risk of error (type 1 and type 2)**
- **Frequency (risk and cost) and sample size (cost, time, confidence)**
- **Workers distanced from the quality of their product**
  - **Don't understand what they are doing**
- **The means (charts) become confused with the end (perfection)**
- **Discourage continual improvement (still under control)**
- **Autocorrelation on long runs**
  - **Previous parts affect present parts—e.g., tool wear**

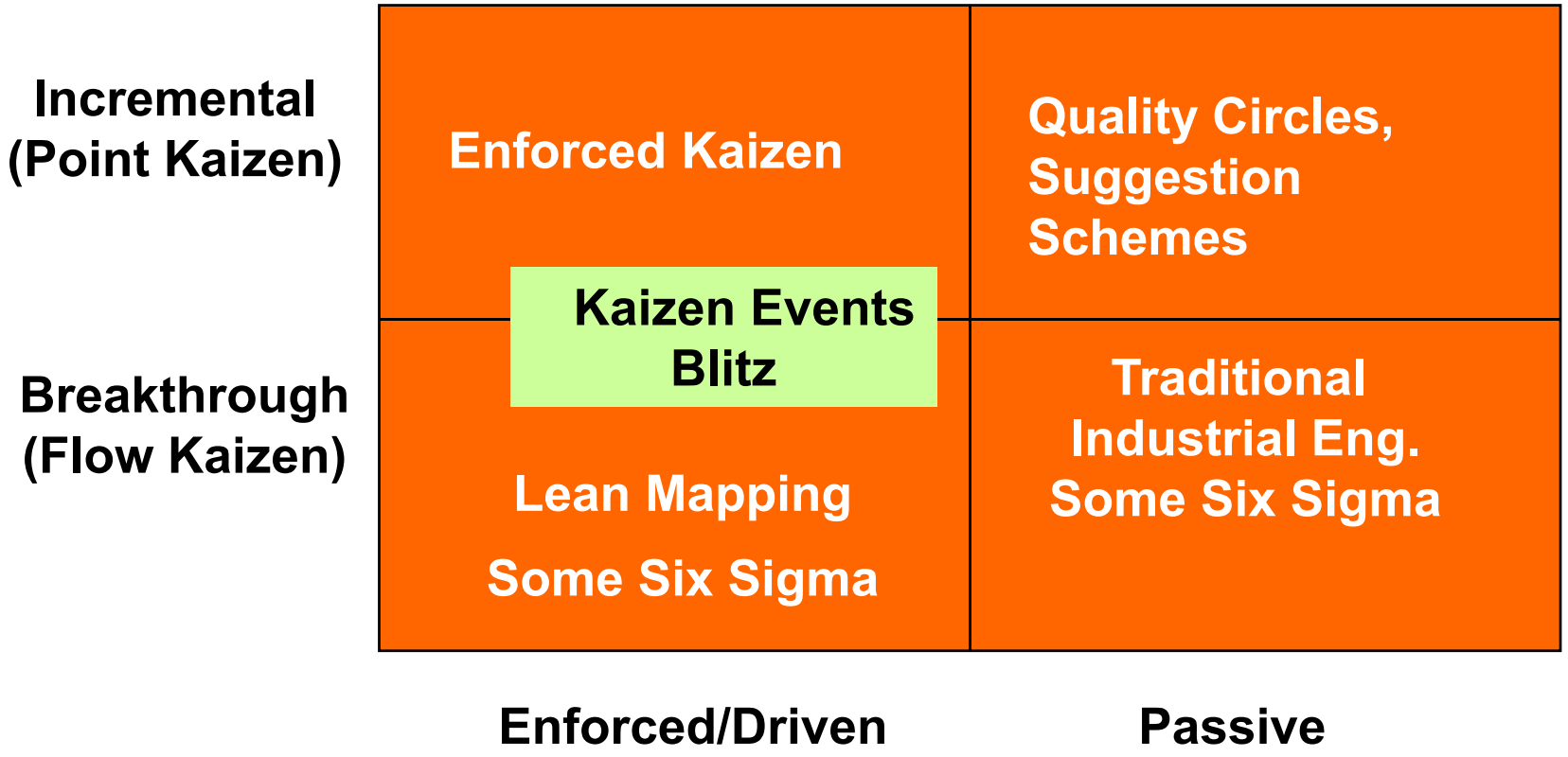
– Standard & Davis, *Running Today's Factory*,
– Nicholas, *Competitive Manufacturing Management*, pages 514-520
– Ronald Blank, *The SPC Troubleshooting Guide*, Quality Resources, 1998

Improvement Types

Point and Flow Kaizen

- **Point Kaizen**
  - Localized improvements
  - Often to sporadic problems
  - Done by operators
  - Often identified as low-hanging fruit as a result of value-stream mapping
- **Flow Kaizen**
  - Bigger picture improvements
  - Involving more of the value stream
  - Done by lean promotion office or six sigma black belts working with operators
  - Almost invariably arising out of value-stream mapping

Improvement Types



Passive Breakthrough

- **Classic large-scale industrial engineering projects or some six sigma projects**
  - **failure: noninvolvement or nonconsultation by IE or other experts**
  - **success: areas of urgency plus involvement**

Passive Incremental

- **Quality Circles**
  - **the cycle of failure**
  - **cycle of success: muda spectacles, 5 S, OEE, flexible manpower lines**
- **Suggestion Schemes**
  - **failure: delay, red tape**
  - **success: every idea is valuable**

Passive Incremental (continued)

- **Quality Circles**
  - **the cycle of failure**
  - **cycle of success: muda spectacles, 5 S, OEE, flexible manpower lines**
- **Suggestion Schemes**
  - **failure: delay, red tape**
  - **success: every idea is valuable**

Enforced Incremental

- **The classic is Toyota**
  - response analysis
  - line stop
  - inventory withdrawal exposing the rocks
  - waste checklists
  - every improvement opens another opportunity
  - cell rebalance according to takt—when done by operators
- **Organizing for enforced incremental**
  - individual, team, process, intercompany with full-time facilitator support
  - failure: no management follow-through
  - success; expectation

Enforced Incremental (continued)

- **The classic is Toyota**
  - response analysis
  - line stop
  - inventory withdrawal exposing the rocks
  - waste checklists
  - every improvement opens another opportunity
  - cell rebalance according to takt—when done by operators
- **Organizing for enforced incremental**
  - individual, team, process, intercompany with full-time facilitator support
  - failure: no management follow through
  - success; expectation

Enforced Breakthrough

- **Value-stream mapping**
- **(See the Lean Mapping Workshop, session 2, in this Lean Manufacturing Workshop Series.)**

Breakthrough Flow Kaizen

- **Kaizen Events or Blitz**
  - **5-day event typical**
  - **a self-fulfilling expectation; no barriers**
  - **30% to 50% improvement**
  - **you can do it again (and again)**
    - **change the emphasis**
    - **when the mix changes**
- **Failure: No management involvement, expectations; no standardization**
- **Success: Careful preparation, mixed teams, follow up; part of a wider lean program**

Kaizen Blitz

“Whether you believe you can, or whether you believe you can’t, you’re absolutely right.”

– Henry Ford

Characteristics

- **Immediate action**
  - **not ponderous analysis, reporting, etc.**
- **Improvement, not perfection**
- **Trial and error**
  - **just do it**
- **Team based**

Steps in a Breakthrough Event (1)

- **Identify the area**
  - **possibly with mapping**
- **Identify the focus of the event**
- **Establish the event pattern**
  - **5 days, 3 days, 1-2-2 days, etc.**
- **Gain management support and commitment**
  - **including involvement**

Steps in a Breakthrough Event (2)

- **Select the team**
  - **must include operators, supervisors, managers, outsiders**
- **Establish the takt time**
  - **available time / average demand**
- **Preparation**
  - **BOMs, costs, schedule, staffing, shifts**
  - **maintenance standby**

Steps in a Breakthrough Event (3)

- **Awareness and training**
  - **waste, flow, takt time, CQDT**
  - **clarifying objectives**
- **Establish block diagram**
- **Establish subteams**
  - **layout, inventory, process**
- **Mapping and data collection**
  - **measures**

Steps in a Breakthrough Event (continued)

- **Awareness and training**
  - **waste, flow, takt time, CQDT**
  - **clarifying objectives**
- **Establish block diagram**
- **Establish subteams**
  - **layout, inventory, process**
- **Mapping and data collection**
  - **measures**

Steps in a Breakthrough Event (4)

- **Initial analysis and brainstorming**
- **Initial changes and testing**
- **Further changes and measures**
- **Standardization**
- **Follow up**
  - **holding the gains**

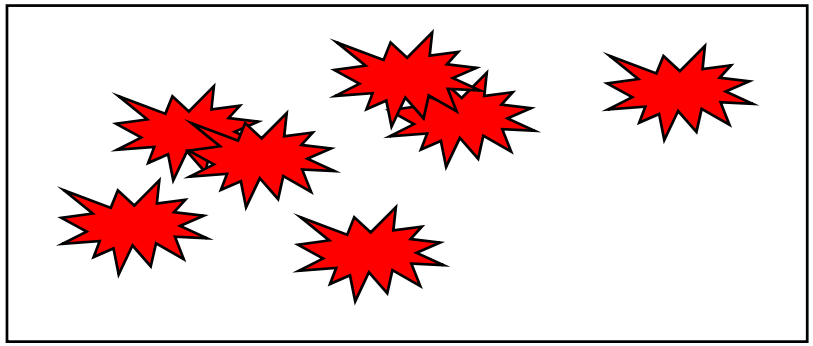
Performance Measurements

	Start	Day 1	Day 2	Day 3	Day 4	Day 5
Lead time						
Flow length						
Inventory						
Space						
Defect rate						

Blitz: Watch out for....

The paintball effect (You may get there eventually but how much wasted effort?)

– Standard and Davis



Improvement: Conclusions

- **Each approach can be effective**
- **They can be made to work together**
- **No one formula—so find the way that works!**

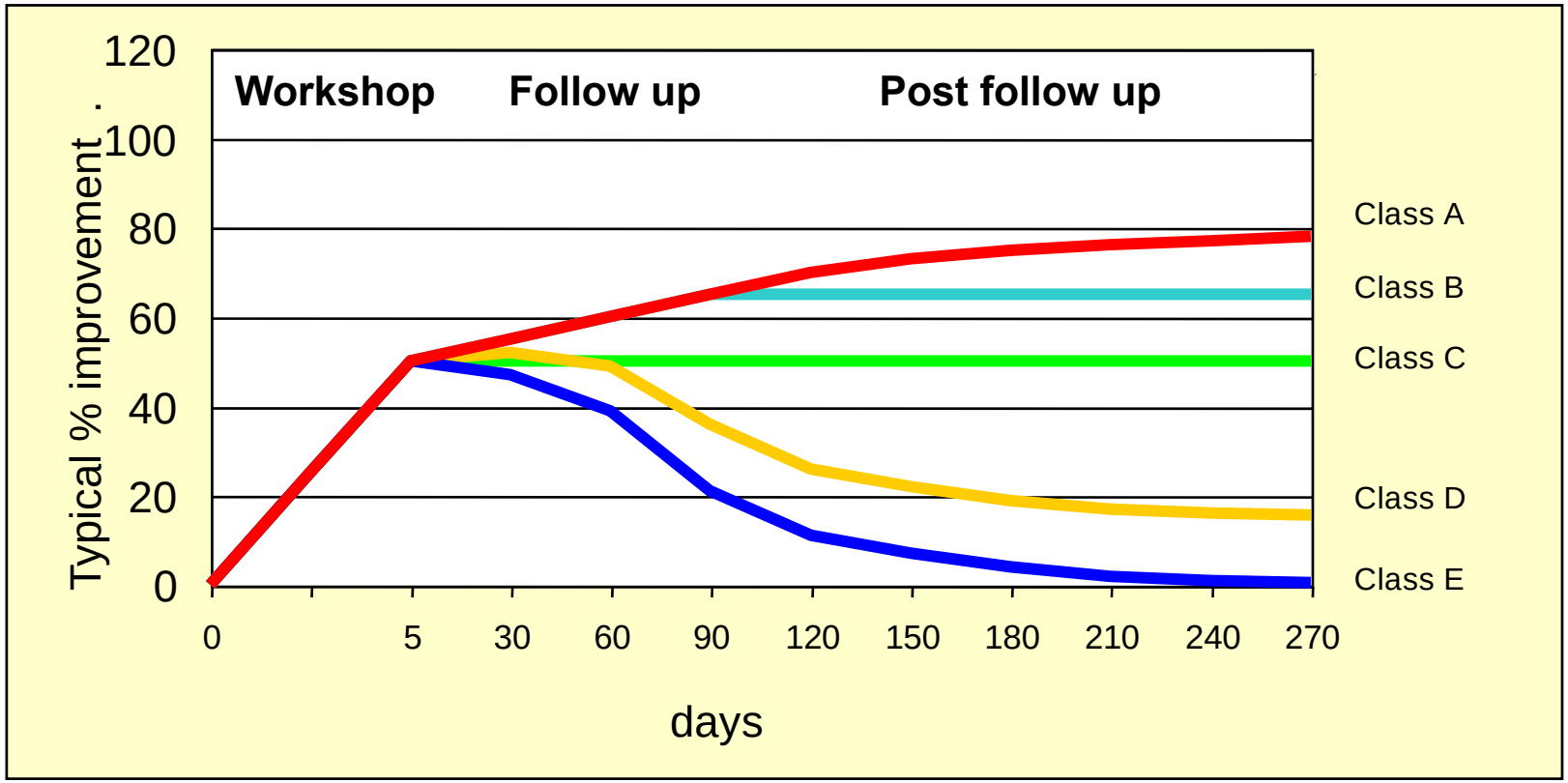
Blitz Events in the U.S. and U.K.

- **Widespread in automotive and aerospace with others following**
- **Focused over a short period**
- **Applying simple tools, (5 S, 7W, SOP, visual. man.) rigorously**
- **Getting people who perform the process to improve the process**
- **Sustainability has become a major issue**

Industry Forum Model for Blitz

- **Industry Forum (IF) is a group set up by the U.K. Society of Motor Manufacturers and Traders and various Automotive OEMs**
- **The IF has developed a model for blitz**
- **Comprises**
  - **1-day prediagnostic (objectives)**
  - **3-day diagnostic (analyze, map, identify)**
  - **5-day event itself**
  - **Three 1-day follow up events over 3 months**

Sustainability Model



– Developed by Nicola Bateman

Class A and B Enablers

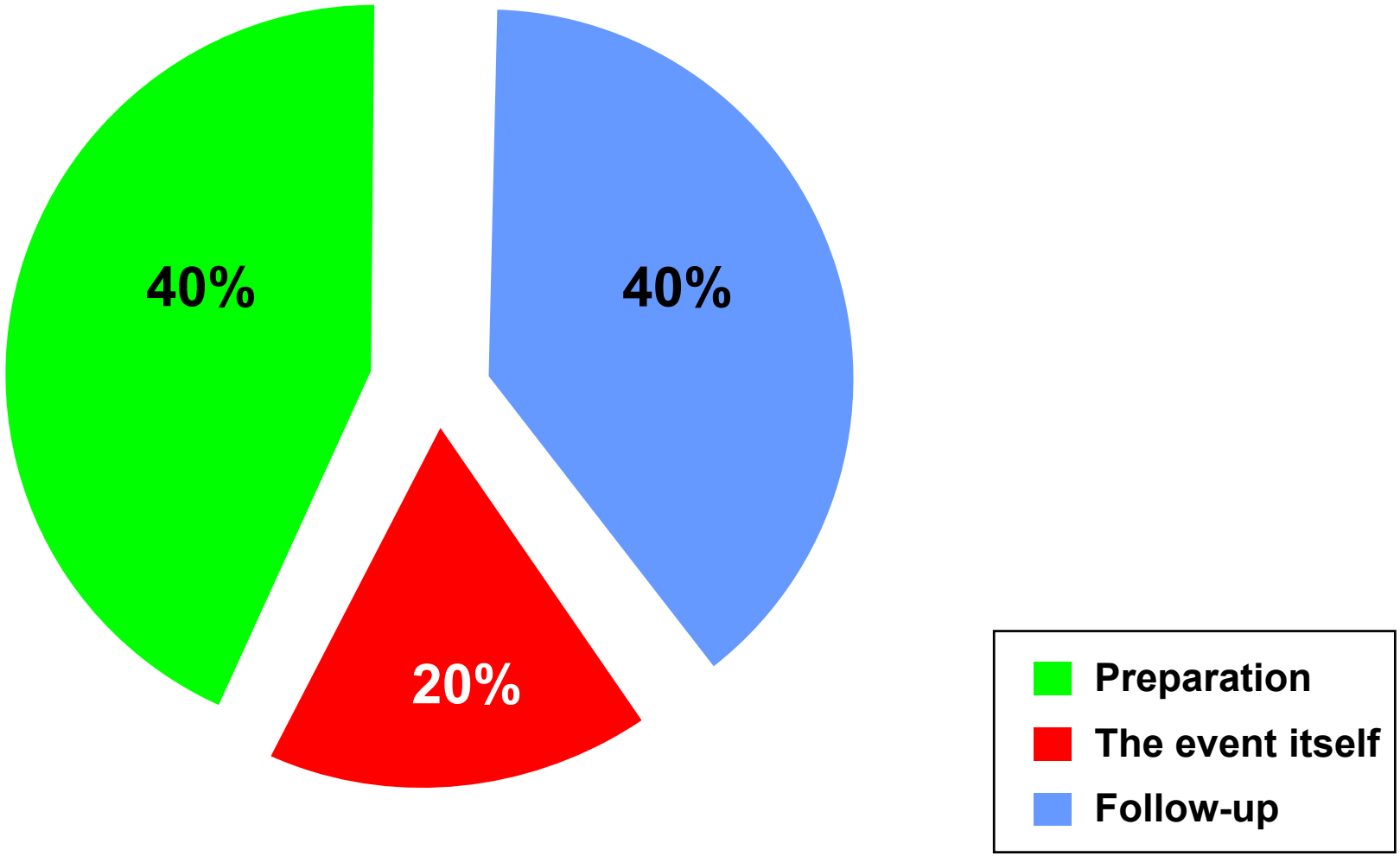
- **A formal way of documenting ideas from the shop floor**
- **Operators make decisions in a team about the way they work**
- **Time is dedicated to maintaining 5 S standard every day**
- **Measurements to monitor the improvements**
- **Cell leaders and immediate managers to stay focused on improvement activities**

– Research by Nicola Bateman

Class A Enablers

- **Method changes formally introduced**
  - **Formal hands-on training by those involved in the improvement**
- **Direction given on improvement**
  - **For example, mapping, target changeover time**
- **An improvement or kaizen coordinator**
- **Senior manager involvement**
- **Senior managers retain focus on improvement**
  - **Built into review and assessment agendas**

Time Spent on Successful Blitz Events



Workshop Topics Review

- Views from the Gurus
- The Lean View and Kaizen
- Problem Solving and PDCA
- Types of Defect
- Sporadic Problems: The Seven Tools and Five Whys
- Chronic Problems and Six Sigma
- Improvement Types
- Improvement Events (Blitz)
- Holding the Gains and Sustainability

Workshop Objectives Review

- To illustrate the symbiotic relationship between lean and quality
- To appreciate the application of some quality techniques in a lean context.
- To appreciate how lean and six sigma can work together.

Questions?

Take home some answers!

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Additional References

- **APICS (800) 444-APICS (2742) or (703) 354-8851**
- **APICS Online Bookstore. www.apics.org/Bookstore/default.htm**
- **APICS International Conference and Exposition**
- **Other Web Sites:**

  John Grout http://campbell.berry.edu/faculty/jgrout/
  Motorola http://www.motorola.com

The end.
Thank you!