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Management and Industrial Strategy

אסטרטגיה ניהולית ותעשייתית

פרופ' רון קנת

ד"ר יוסי רענן

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Dr. Yossi Raanan - yossir@kpa.co.il

Part III

מטרת הקורס

- הבנת חשיבות אסטרטגיה ניהולית ותעשייתית בסביבה עתירת טכנולוגיה להשגת:
  - כושר תחרות
  - התאמה לסביבה משתנה
  - יציאה ממשבר
  - כניסה לשווקים חדשים

מבנה הקורס

תנאי קדם: אין

שיטת הלימוד:

- הרצאות פרונטליות
- ביצוע פרויקט במסגרת צוות

הרכב הציון:

- עבודת גמר – 60% (40% עבודה, 20% מצגת)
- מבחן סיום – 40% (נדרש ציון עובר לשקלול)

נושאי הקורס - 1

מבואות:

התפתחות תפיסות ניהוליות ומיצוב הטכנולוגיה בתעשייה תוך ניתוח משמעויות המהפכה התעשייתית ומהפכת המידע (סולם האיכות).

מבוא לאסטרטגיות הניהוליות העיקריות המיושמות בתעשייה: ניהול איכות, שש סיגמה, מערכות ייצור גמישות, מערכות תוכנה תעשייתיות ומיכון ארגוני.

אסטרטגיה עסקית ושיווקית:

מודלים לניתוח אסטרטגי כגון: BCG, מקינזי, ארטור ד. ליטל, בוז אלן, אופציות ריאליות.

אסטרטגית שרות:

מערך השירות ותפקידו במחזור חיי המוצר. התמיכה הטכנולוגית הנדרשת במערך השירות. הצגת האסטרטגיות הניהוליות העיקריות בשירותים: שירות מבוזר / מרוכז, מוקדי שרות.

אסטרטגית משאבי אנוש:

מודלים למיפוי ארגוני, סקרי עמדות עובדים, מודלים למיפוי משאבי אנוש, הערכת עובדים ממוקדת תהליך.

נושאי הקורס - 2

אסטרטגית התפעול והאיכות:
ניהול זמין ושיטות ייצור ארגוניות יפניות. שש סיגמה.
מערכות ייצור גמישות, ייצור ברשתות ועקרונות הניהול הרב - מוצרי בתעשיות עתירות מיכון.

אסטרטגית מו"פ וניהול סיכונים:
CMMI, ניהול סיכונים, פרויקט MUSING.

אסטרטגית מערכות מידע ותקשורת:
אסטרטגית IT. תקשורת לסוגיה והשפעותיה על ההיערכות התעשייתית והשירותית.

ניהול השינוי:
מתודולוגית BEST ו EKD

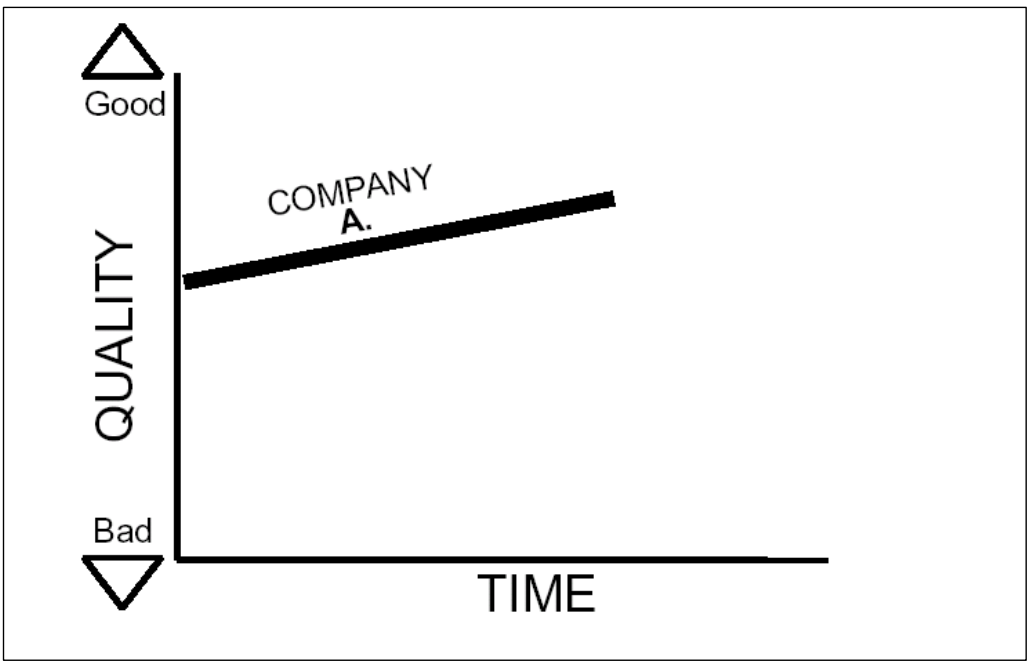
5

תפעול ואיכות

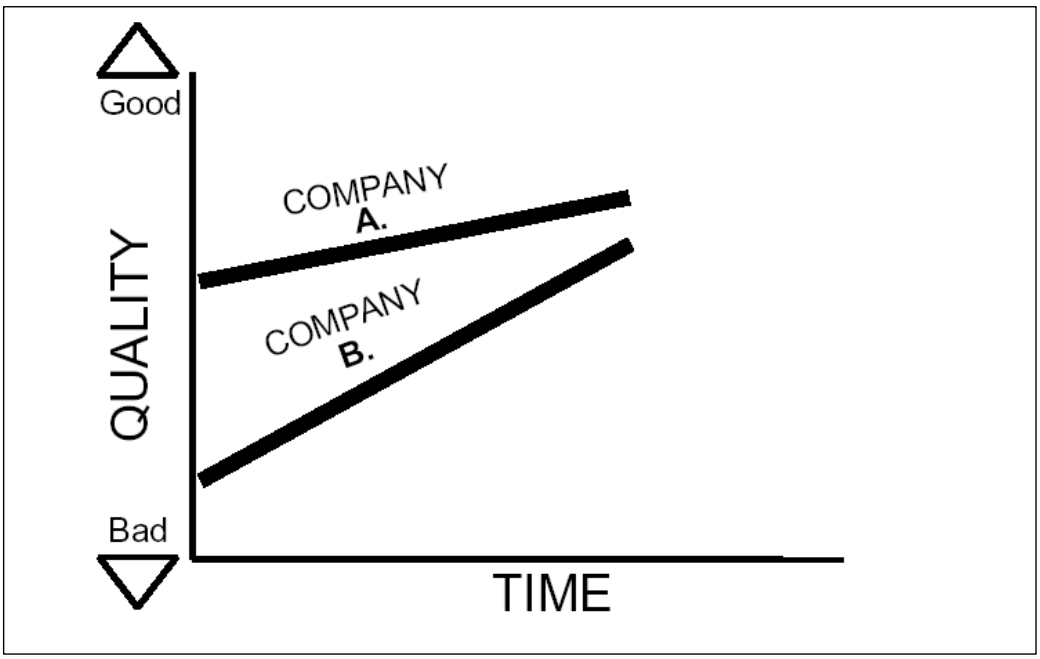
What is Quality?

	Effectiveness	Efficiency
	Features	*Free from Deficiency*
Needs	Right thing	Done right
Customer	Satisfaction	Dissatis-faction
Effect	Income	Costs
Higher quality costs	More	Less

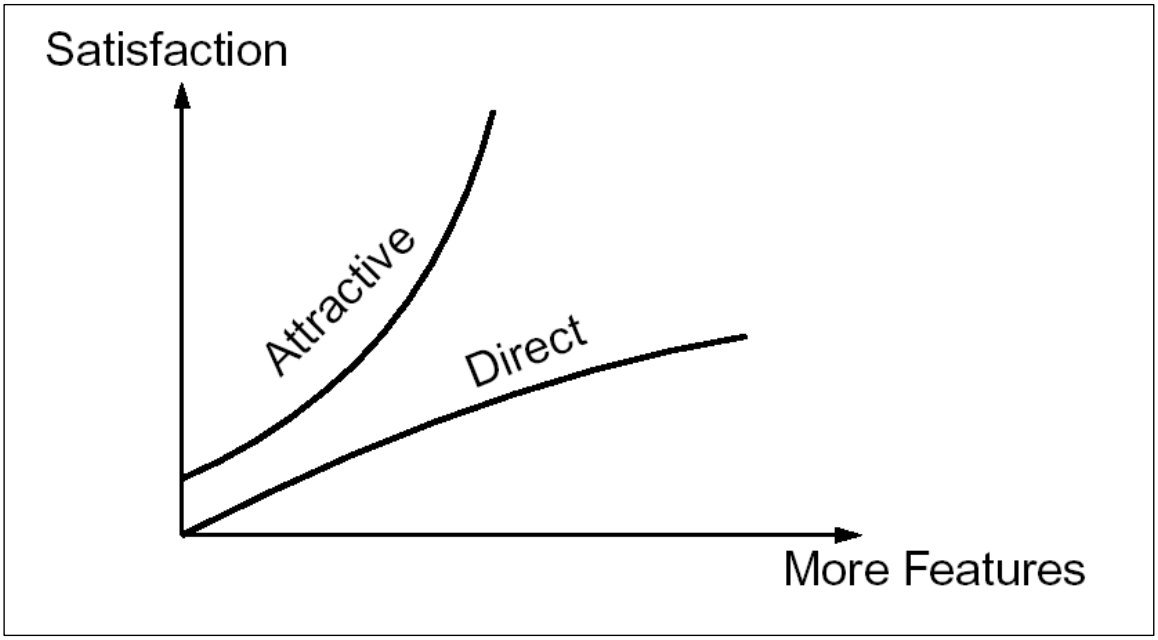
Improvement



Competitive improvement



Customer Satisfaction



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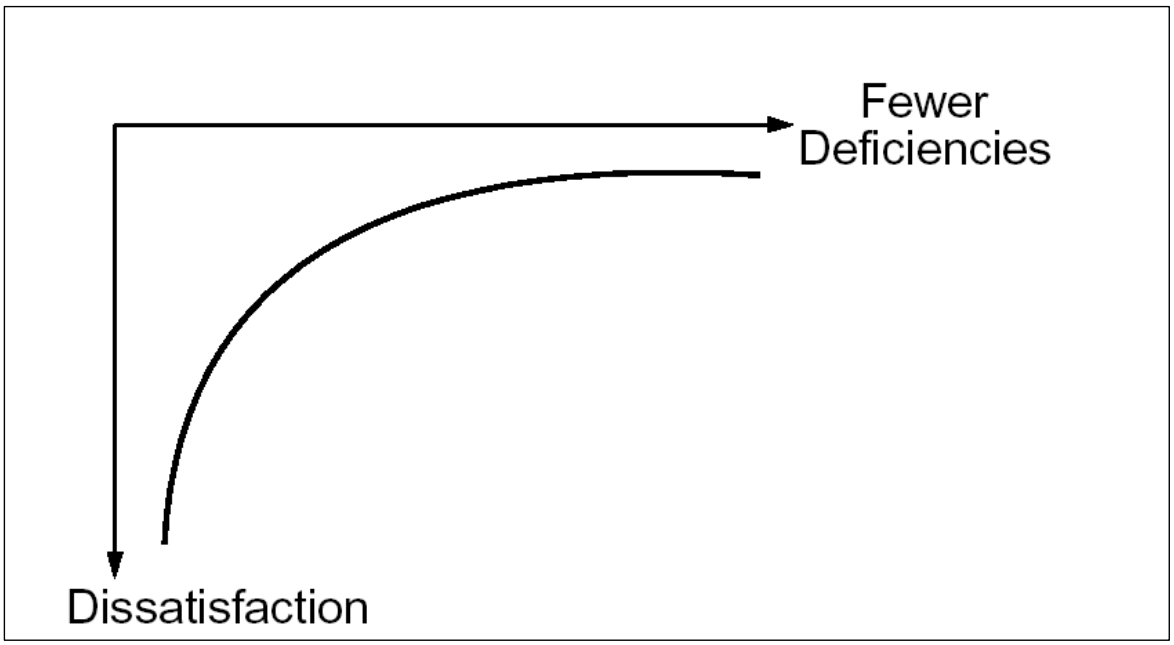
Customer Dissatisfaction



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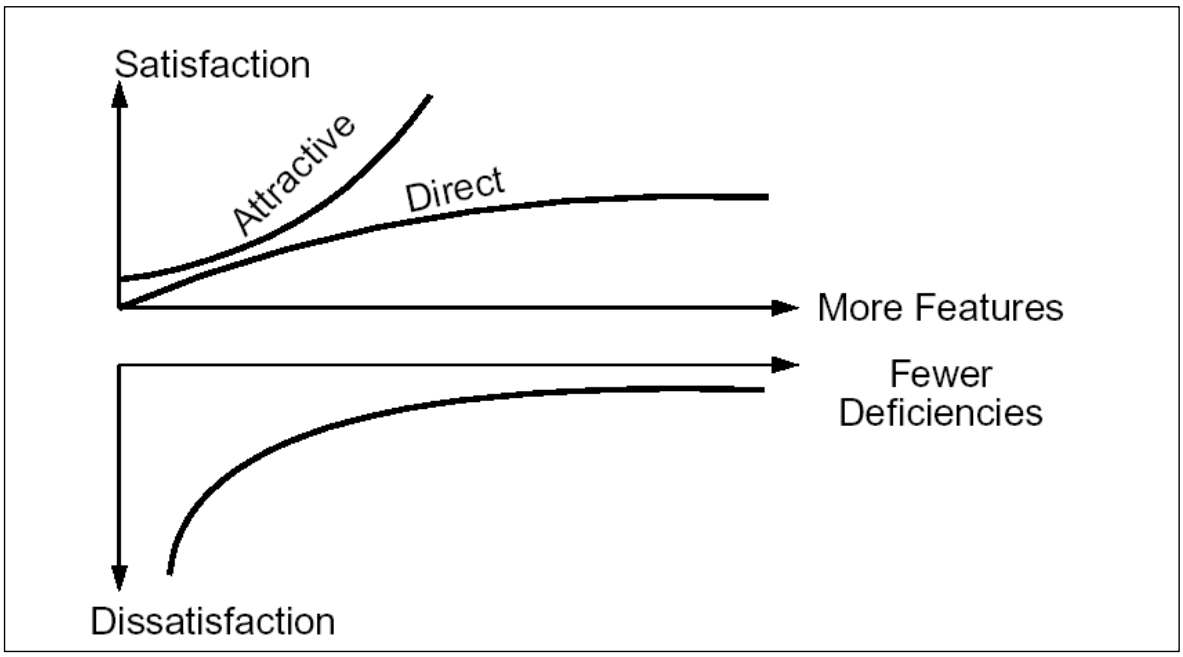
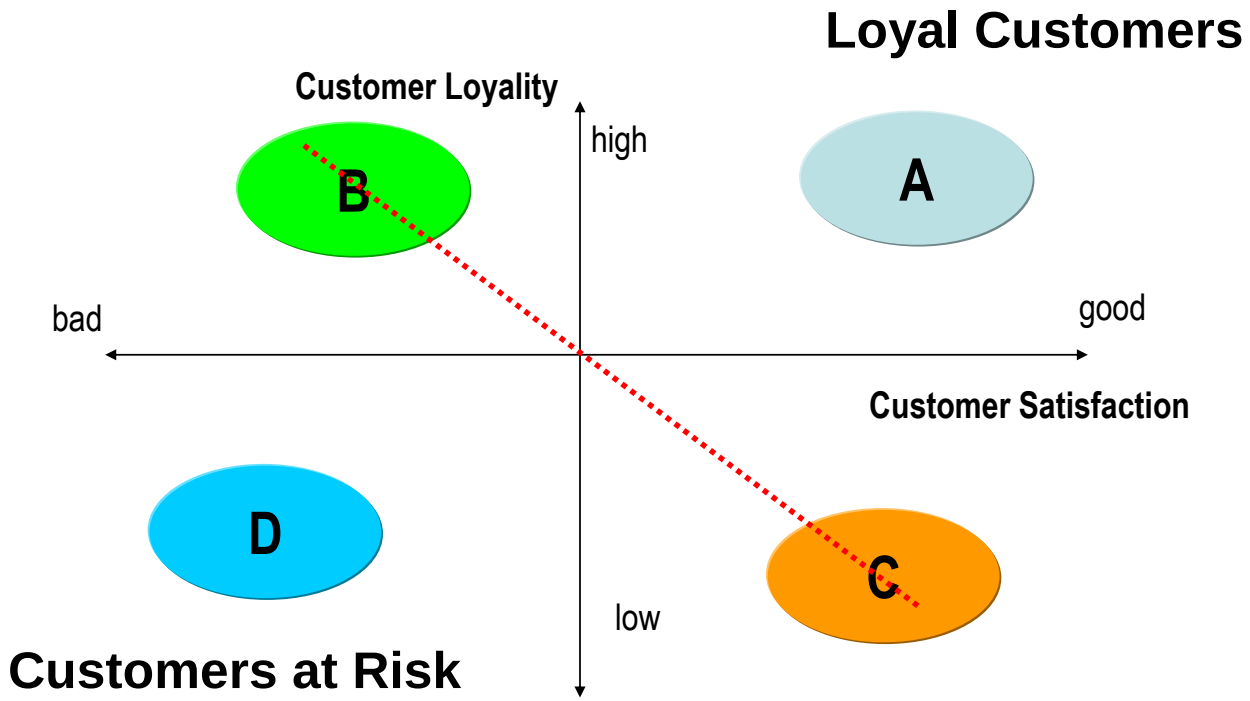
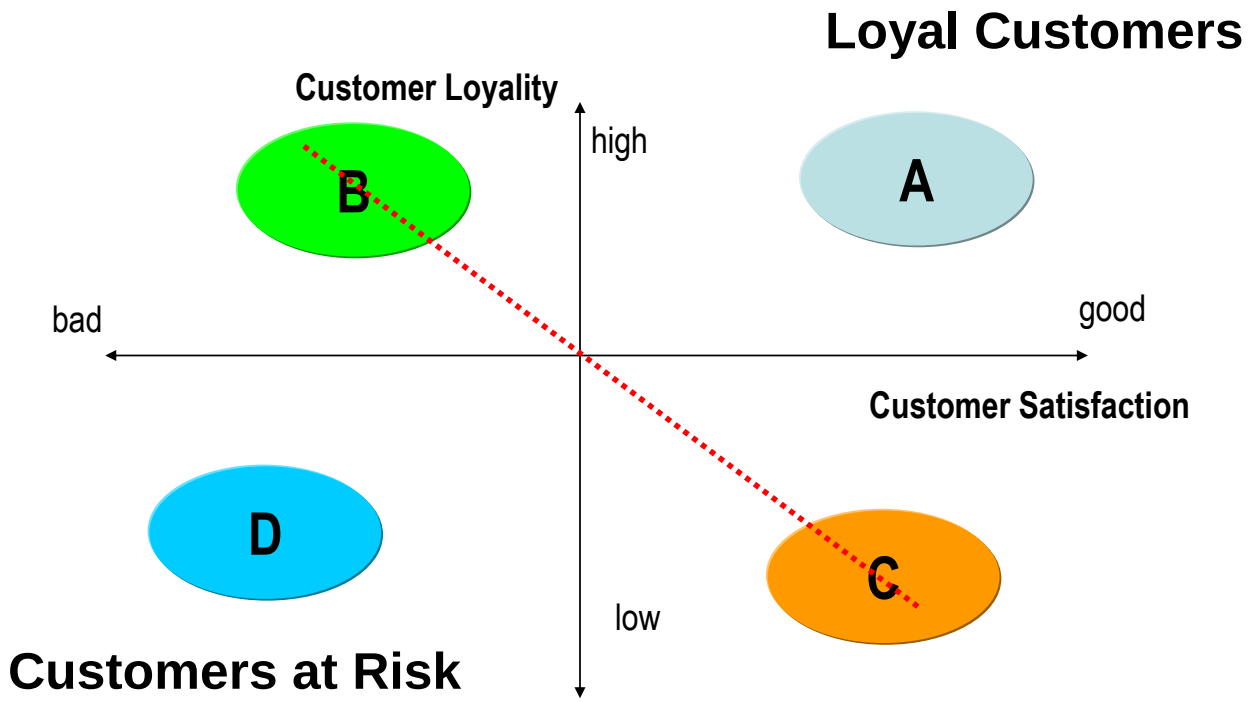
Customer Satisfaction and Customer Dissatisfaction



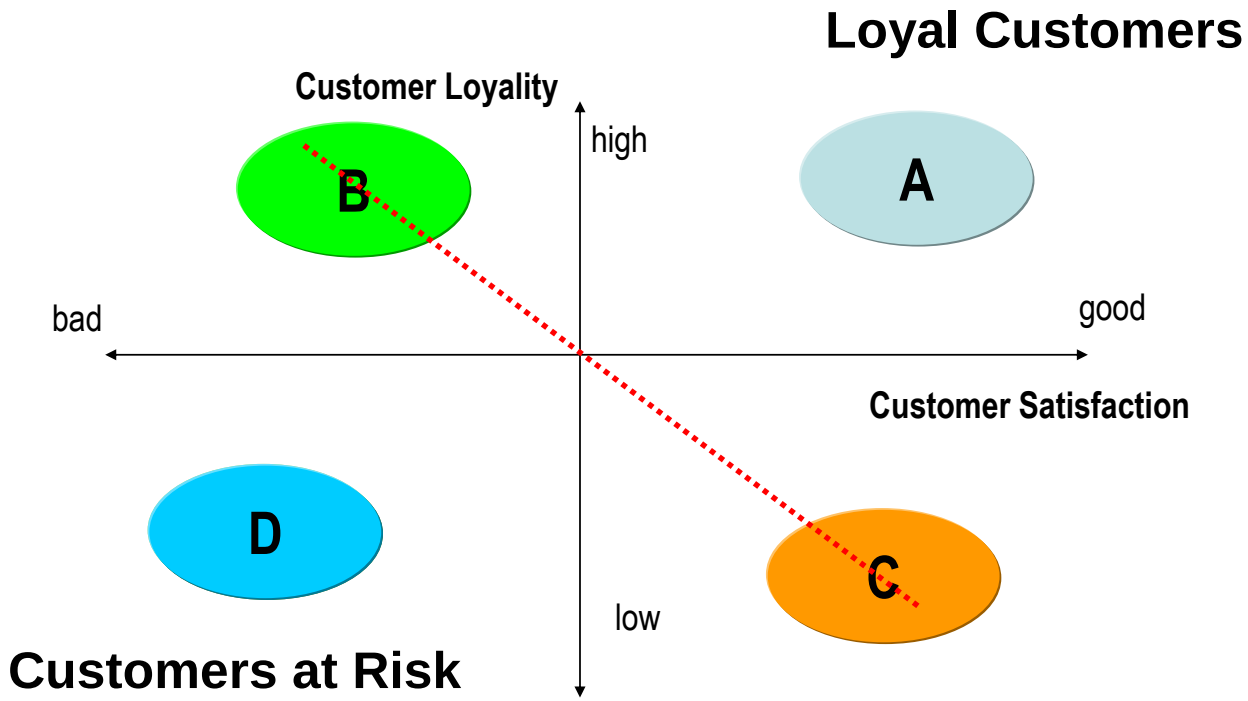
Today



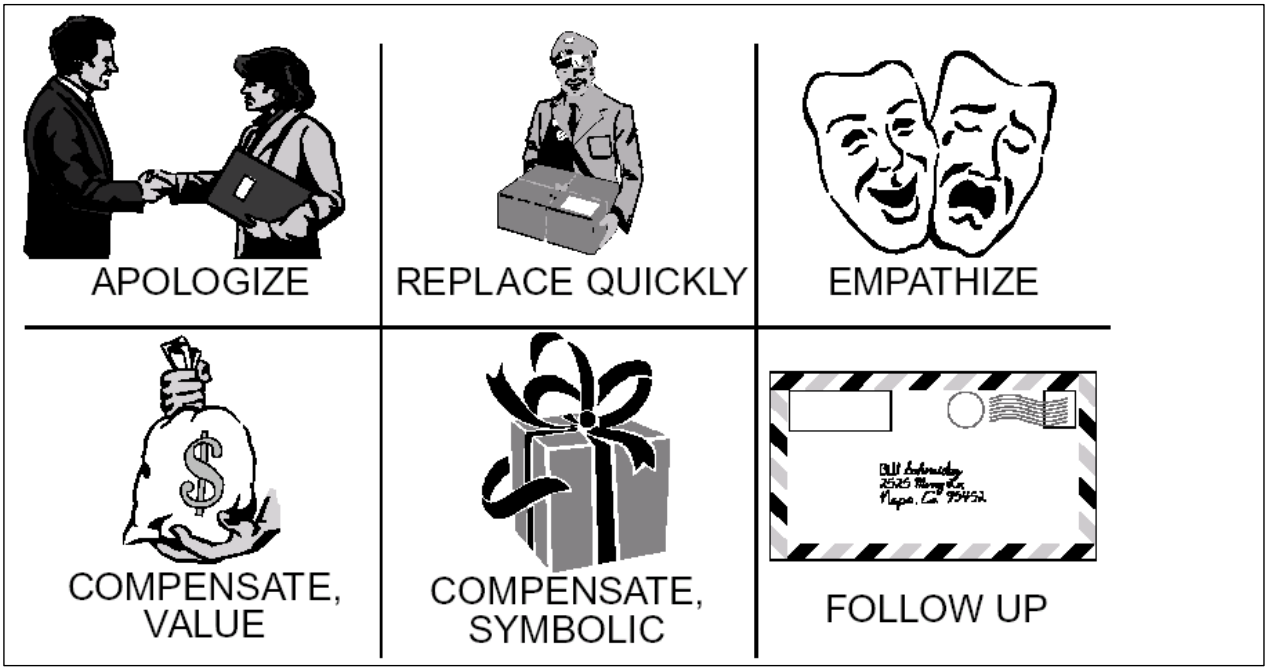
Tomorrow without action



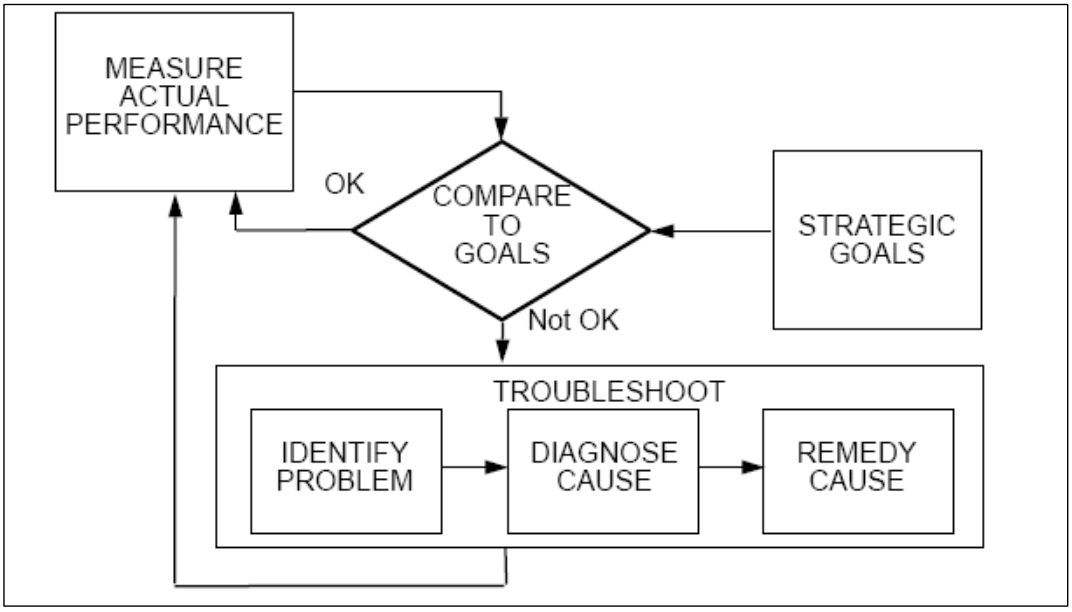
Tomorrow with action



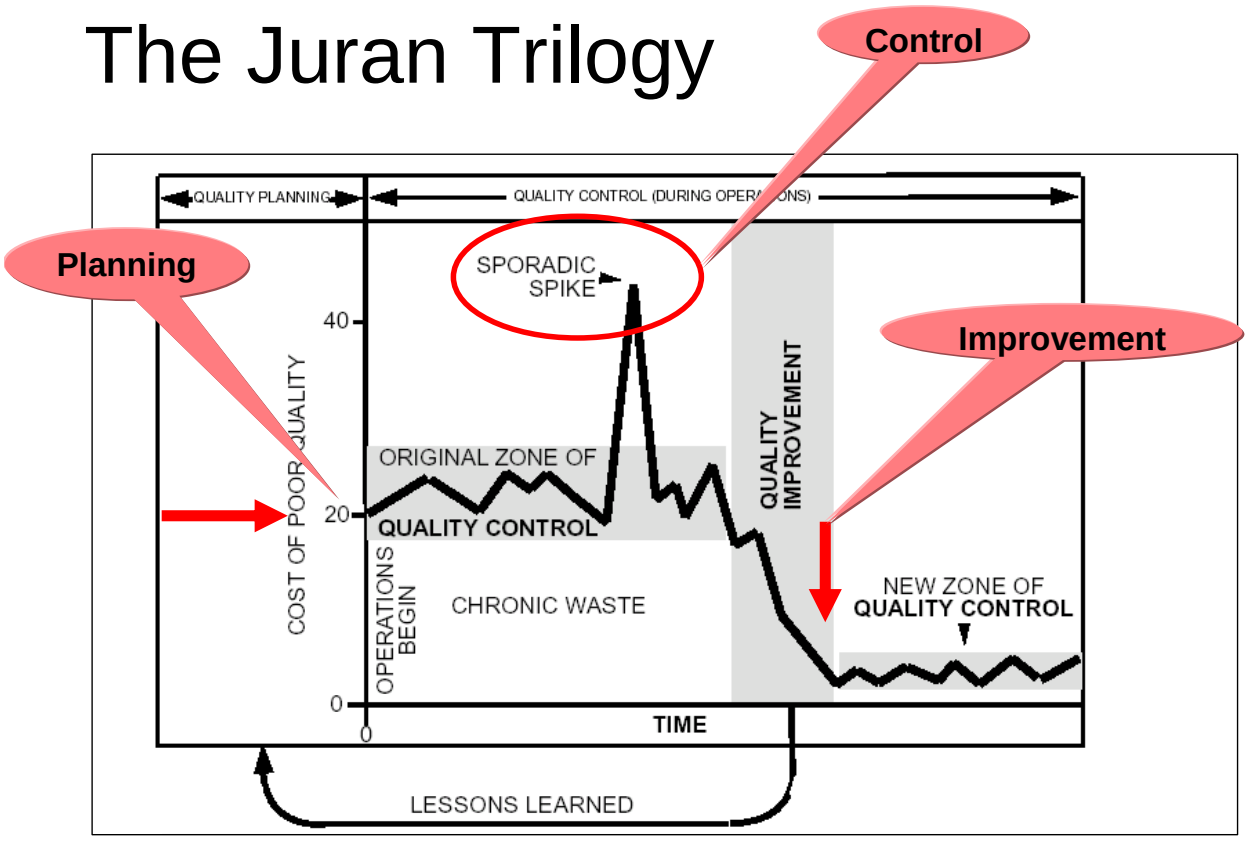
Recovery Strategies



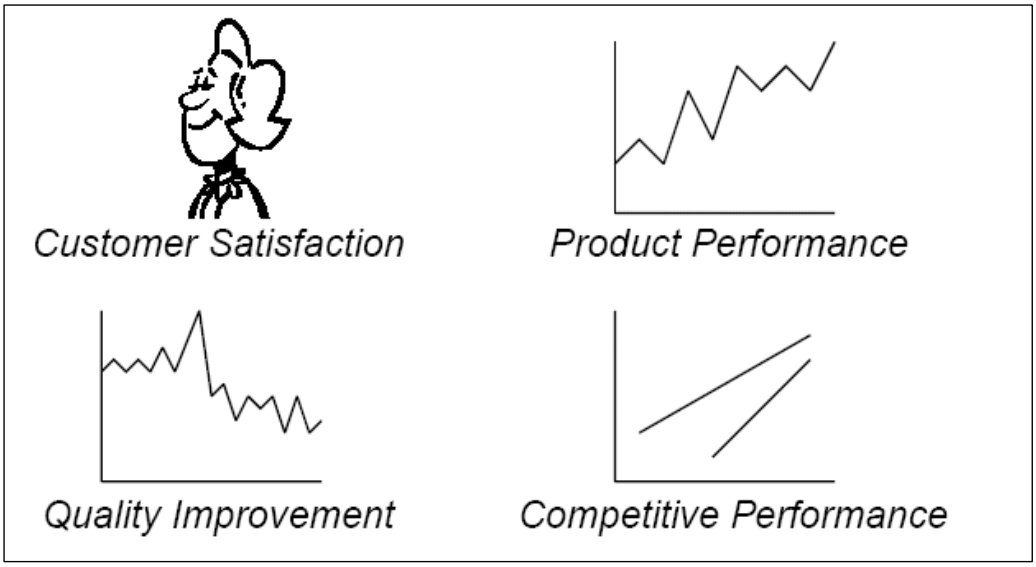
Control mechanisms



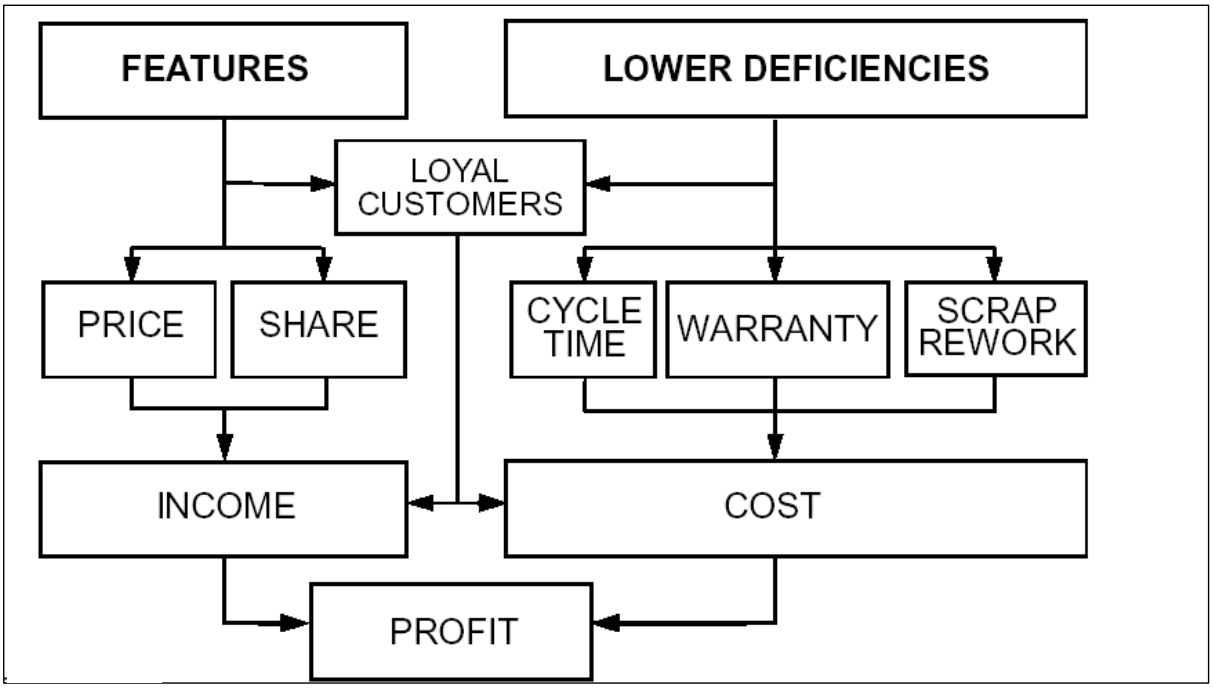
The Juran Trilogy



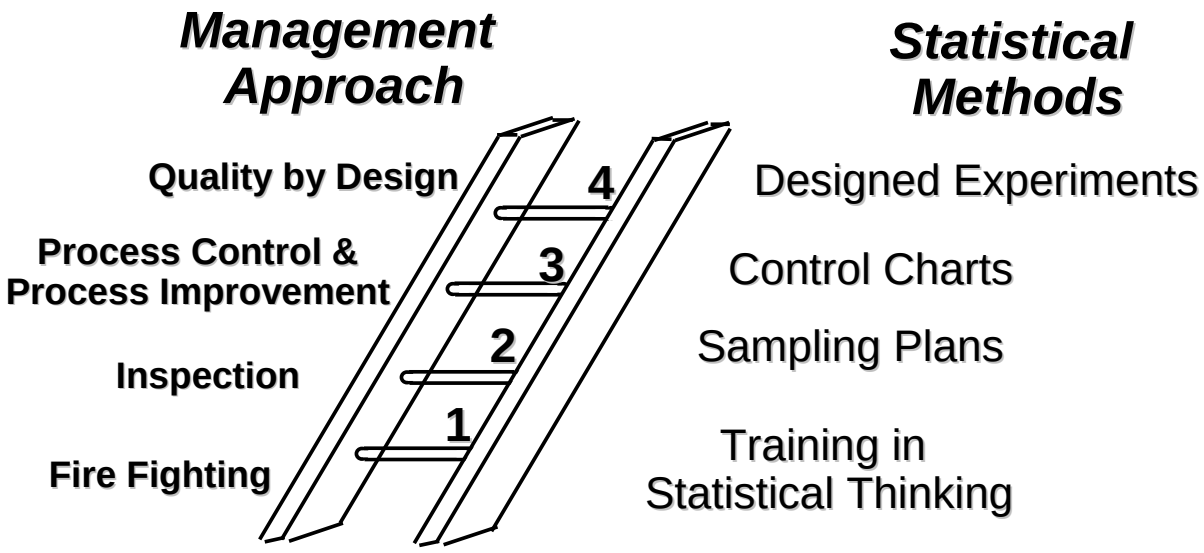
Strategic goals



ROI, Quality and Market Share



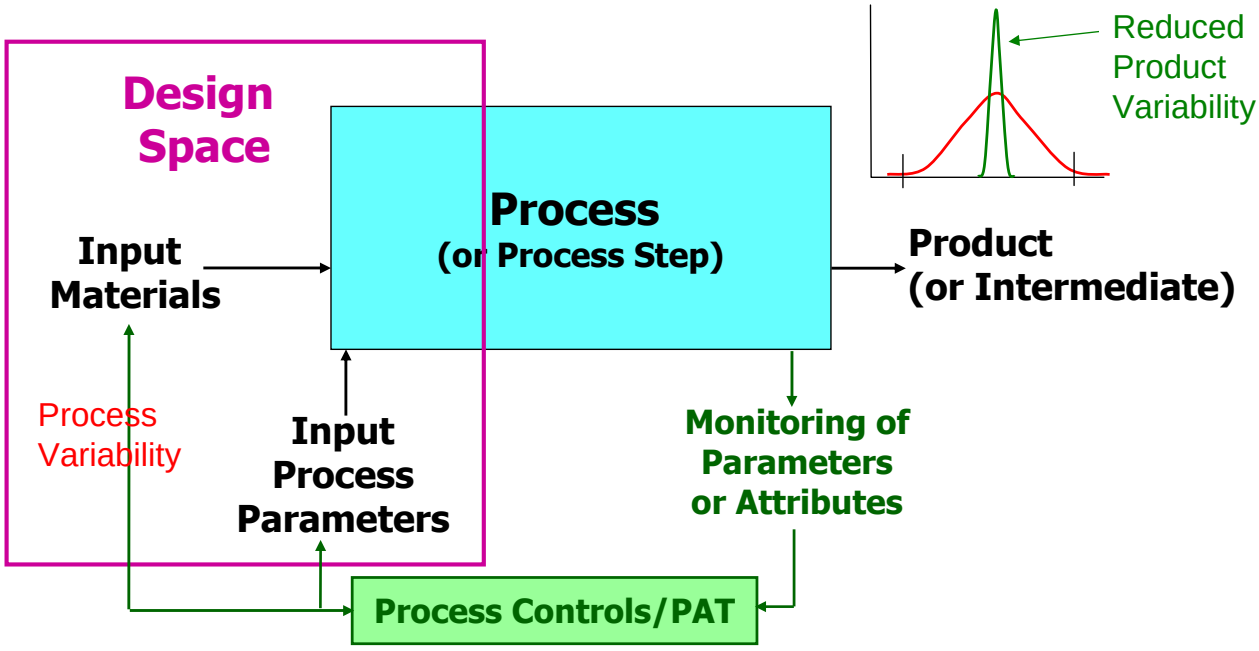
The Quality Ladder*



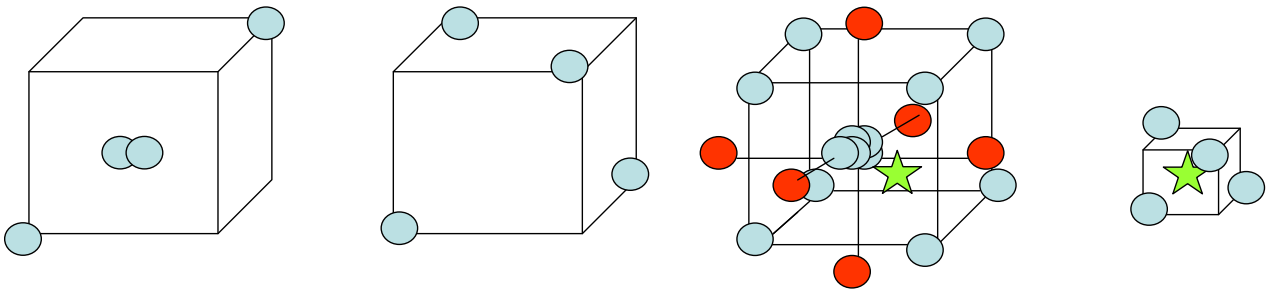
How do you handle the inconvenience of customer complaints ?

*MODERN INDUSTRIAL STATISTICS by Kenett and Zacks, Duxbury, 1998

What is QbD?



The Design of Experiments Strategy



Scoping
Initial assessment

Screening
Fractional designs

Optimizing
Response surfaces

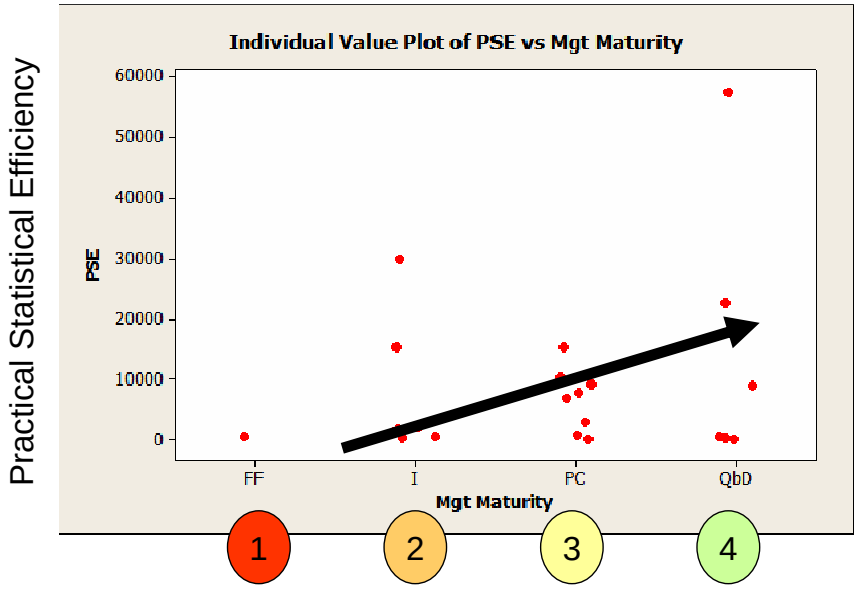
Robustness
Robust designs

Process knowledge

Process Confidence

*The Statistical Efficiency Conjecture**:

higher maturity ==> higher efficiency



*Kenett, R., De Frenne, A., Tort-Martorell, X and McCollin, C., "The Statistical Efficiency Conjecture", *Applying Statistical Methods in Business and Industry – the state of the art*, Coleman S., Greenfield, T., Stewardson, D. and Montgomery, D. (editors), Wiley, 2008.

5

An exercise in inspection

"federal fuses are the results of years of scientific study combined with the experience of years"

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An exercise in inspection

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An exercise in inspection

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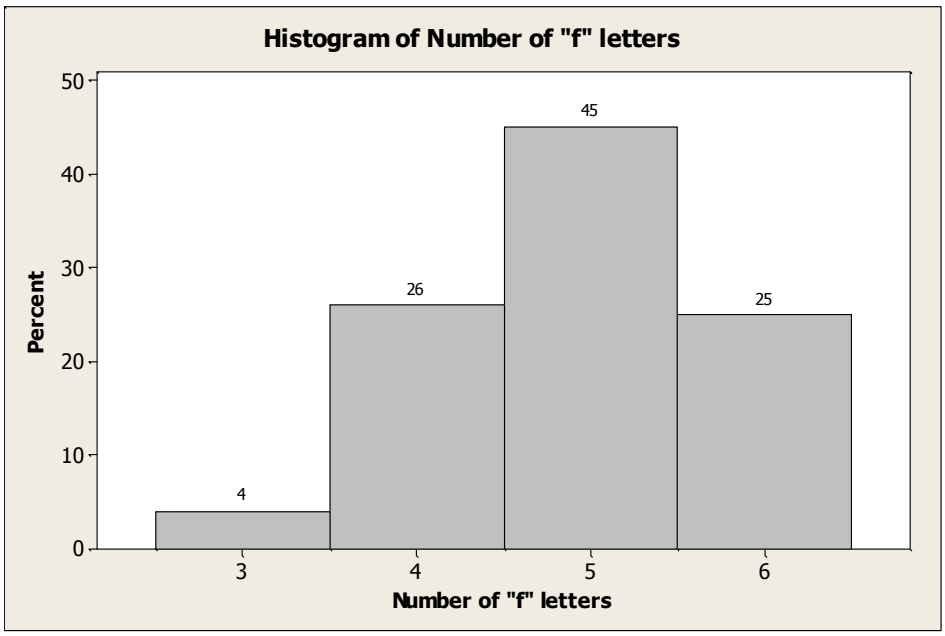
An exercise in inspection



Six Sigma Basics

"Show me the data"

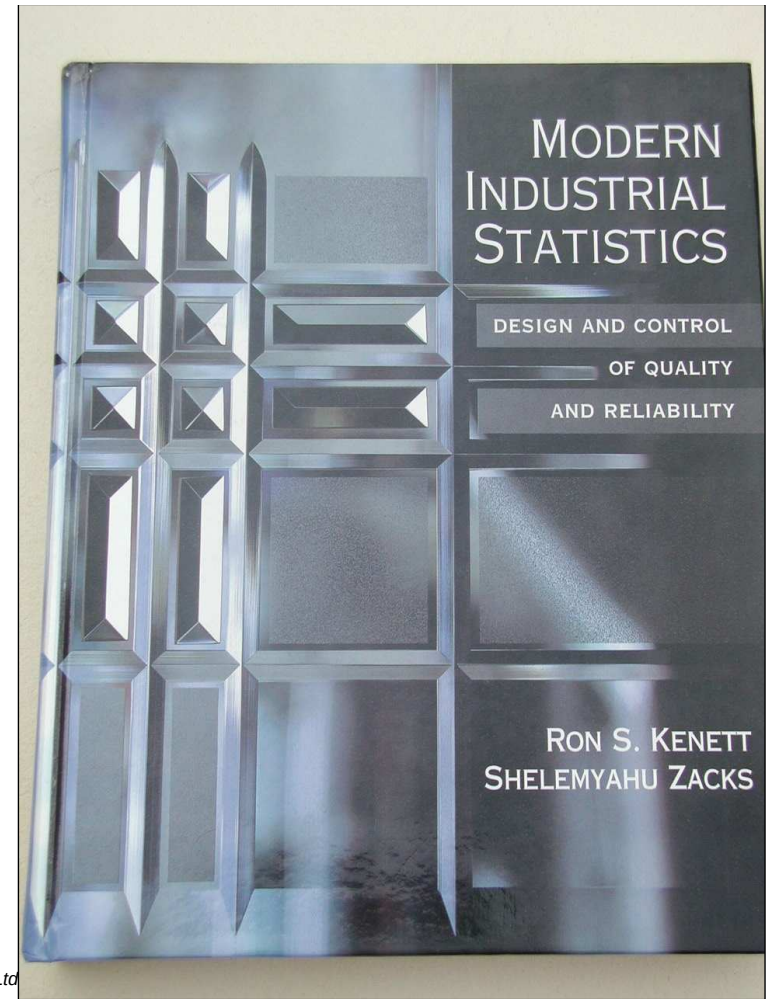
Scientific:

- Structured approach.
- Assuming quantitative data.

"Show me the money"

Practical:

- Emphasis on financial result.
- Start with the voice of the customer.



MODERN INDUSTRIAL STATISTICS, Kenett and Zacks, Duxbury, 1998
2nd edition, 2003
Chinese edition, 2004

MOTOROLA

"At Motorola we use statistical methods daily throughout all of our disciplines to synthesize an abundance of data to derive concrete actions…. How has the use of statistical methods within Motorola Six Sigma initiative, across disciplines, contributed to our growth? Over the past decade we have reduced in-process defects by over 300 fold, which has resulted in a cumulative manufacturing cost savings of over 11 billion dollars"*.

Robert W. Galvin
Chairman of the Executive Committee
Motorola, Inc.

***From the forward to MODERN INDUSTRIAL STATISTICS by Kenett and Zacks, Duxbury, 1998**

General Electric

- In 1995 mandated each GE employee to work towards achieving 6 sigma
- The average process at GE was 3 sigma in 1995
- In 1997 the average reached 3.5 sigma
- GE's goal is to reach 6 sigma by 2001
- Investments in 6 sigma training and projects reached 45MUS$ in 1998, profits increased by 1.2BUS$

"the most important initiative GE has ever undertaken".

Jack Welch
Chief Executive Officer
General Electric

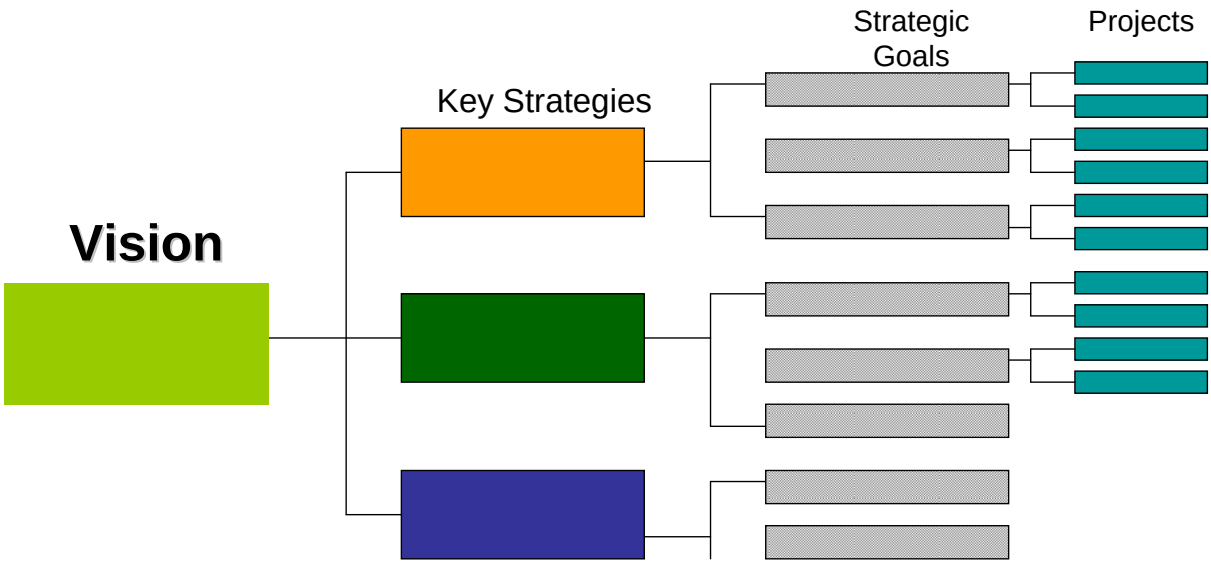
Alcoa
Ford
Lear Corporation
American Express
ABB
Dow
DuPont
Nokia
3M
Verbatim

Caterpillar Inc
Texas Instruments
American Express
LG
Air Products
Xerox
Avery
JP Morgan-Chase
Invensys
Seagate
Cummins
Navistar
GKN
Nokia

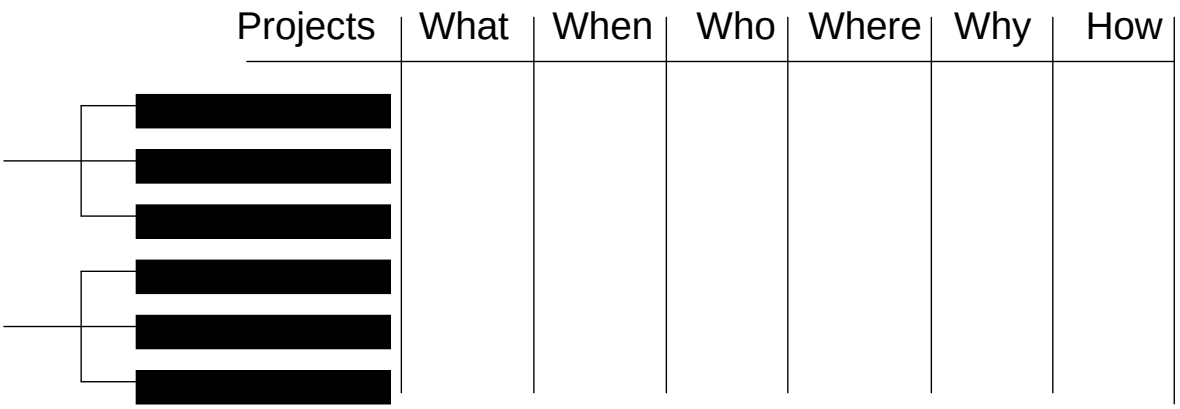
A.B. Dick Company, Abbott Labs, Adolph Coors, Advanced Micro Devices, Aerospace Corp, Airborne, Alcoa, Allen Bradley, Allied Signal, Ampex, Apple Computers, Applied Magnetics, ASQC, Atmel, Baxter Pharmaseal, Beatrice Foods, Bell Helicopter, Boeing, Bombardier, Borden, Bristol Meyers - Squibb, Bryn Mawr Hospital, Campbell Soup, Cellular 1, Chevron, Citicorp, City of Austin, TX, City of Dallas, TX, Clorox, Cooper Ind, Dannon, Defense Mapping Agency, Delnosa (Delco Electronics in Mexico), Digital Equipment Corp, DTM Corp, Eastman Kodak, Electronic Systems Center, Empak, Florida Dept. of Corrections, Ford Motor Company, GEC Marconi, General Dynamics, General Electric, Hazeltine Corp, Hewlett packard, Holly Sugar, Honeywell, Intel, Junior Achievement, Kaiser Aluminum, Kraft General Foods, Larson & Darby, Inc, Laser Magnetic Storage, Lear Astronics, Lenox China, Littton Data Systems, Lockhed Martin, Loral, Los Alamos National labs, Martin Marietta, McDonnell Douglas, Merix, Microsoft, Morton Int'l, Motorola, NASA, Nat'l Institute of Corrections, Nat'l Institute of Standards, Nat'l Semiconductor, Natural Gas Pipeline Company of America, Northrop Corp, PACE, Parkview Hospital, Pentagon, Pharmacia, PRC, Inc, Qualified Specialists, Ramtron Corp, Rockwell Int'l, Rohm & Haas, Seagate, Society of Plastics Egineers, Solar Optical, Sony, Star Quality, Storgae Tek, Symbios Logic, Synthes, Technicomp, Tessco, Texaco, Texas Commerce Bank, Texas Dept. of Transportation, Texas Instruments, Titleist, Trane, TRW, Ultratech Stepper, United States Air Force, United States Army, United technologies, UPS, USAA, Verbatim, Walbro Automotive, Walker parking, Woodward Governor, Xerox

5

Deploying the vision



Deploying the vision



Choosing Six Sigma Projects

Eastman Chemical Company

Be the Best International Chemical Company...

Choosing Six Sigma Projects

5

Strategic Objectives

1. **Achieve higher customer satisfaction**
2. **Create shareholder value**
3. **Be a trusted member of the community**
4. **Join alliances to gain competitive advantage**

Choosing Six Sigma Projects

5

Achieve higher customer satisfaction

- **Improve reliability of supply by 50%**
- Improve responsiveness to product changes to 70% of the time
- Demonstrate concern for the customer by doubling customer follow-ups
- Improve feedstock on-time delivery by 80%
- Improve billing accuracy 95%

Topics drawn from Pareto analysis of customer survey responses indicating first choices for improvements.

Choosing Six Sigma Projects

Improve reliability of supply by 50%

1. Improve tanker supply
2. Decrease equipment downtime
3. Revise scheduling process

Topics drawn from Pareto analysis of reasons for unreliable supply from customer complaints and investigations.

Choosing Six Sigma Projects

Achieve higher customer satisfaction

SSM Health Care — Leading the Way

Founded more than 130 years ago by Mother Mary Odilia Berger and sponsored today by the Franciscan Sisters of Mary

SSM Health Care is a private, not-for-profit health care system based in St. Louis, Mo, that provides primary, secondary, and tertiary health care services.

The system owns, manages, and is affiliated with 21 acute care hospitals and three nursing homes in four states: Illinois, Missouri, Oklahoma, and Wisconsin.

SSM HEALTH · CARE "Through our exceptional health care services, we reveal the healing presence of God."
5

Mission

Through our exceptional health care services, we reveal the healing presence of God.

Values

Compassion
We reach out with openness, kindness, and concern.

Respect
We honor the wonder of the human spirit.

Excellence
We expect the best of ourselves and one another.

Stewardship
We use our resources responsibly.

Community
We cultivate relationships that inspire us to serve.

SSM Health Care — Main Achievements

• In 1999, SSMHC started a clinical collaborative program with 4 teams to improve patient outcomes. By 2002, 85 teams have been involved in six clinical collaboratives.
• Physicians connected to an automated information system have increased steadily from 3,200 in 1999 to 7,288 in 2002.
• For four consecutive years, SSMHC has maintained an investment "AA Credit Rating"—a rating attained by fewer than 1 percent of U.S. hospitals.
• SSMHC's share of the St. Louis market increased over each of the past three years to 18 percent, while three of its five competitors lost market share.

5

SSM Health Care — Improvement Projects

• Safely Reducing Cesarean Sections
• Improving Outcomes and Reducing Costs in Adult intensive Care
• Improving Outcomes and Reducing Costs for Adult Cardiac Surgery
• Reducing Medication Errors
• Reducing Wait Times and Delays
• Idealized Design of Clinical Office Practices
• Care at the End of Life
• Improving Secondary Prevention of Ischemic Heart Disease
• Using Patient Information to Improve Care and Ensure Success
• Improving Treatment and Decreasing Readmissions for Patients with Congestive Heart Failure
• Achieving Exceptional Safety in Health Care

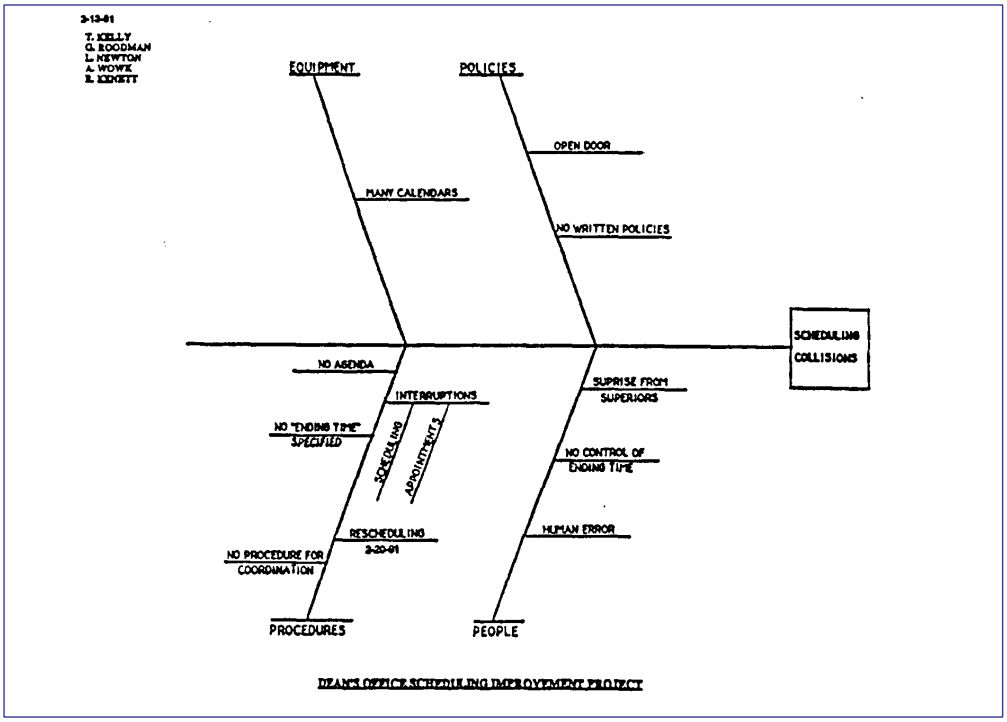
Quality Management also applies to a School of Management

The experience of the

State University of New York - Binghamton

Project team leader: Tom Kelly - Dean
Team member: Garry Roodman - Associate Dean
Team member: Angie Wounk - Secretary
Team member: Liz Newton - Secretary
Facilitator: Ron Kenett - Professor

Fishbone diagram



Force Field Analysis - before

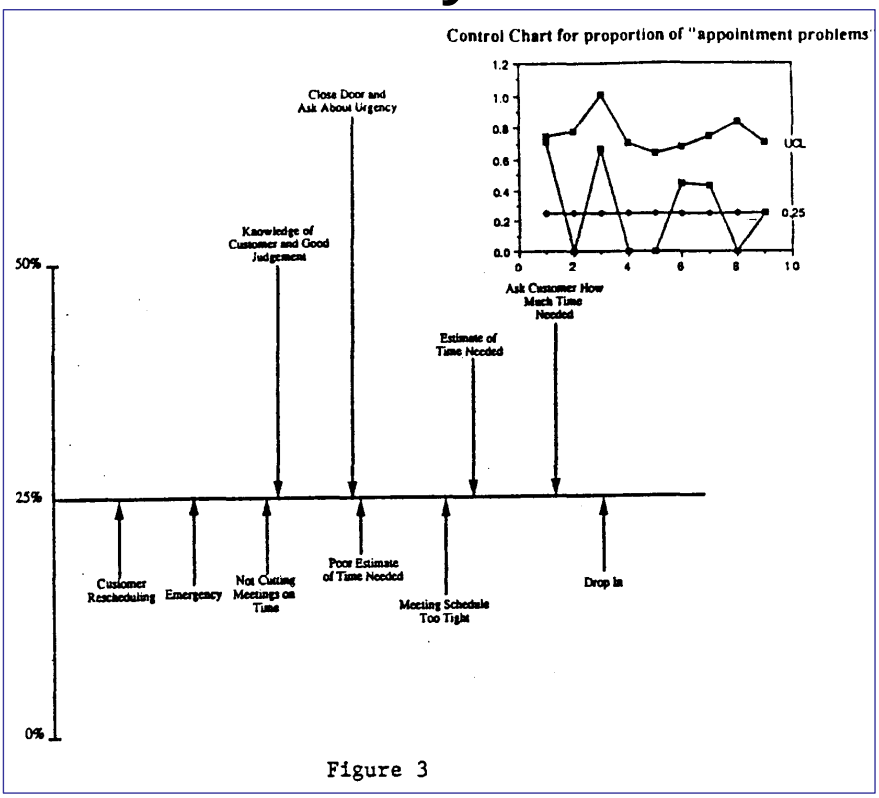


Figure 3

Force Field Analysis - after

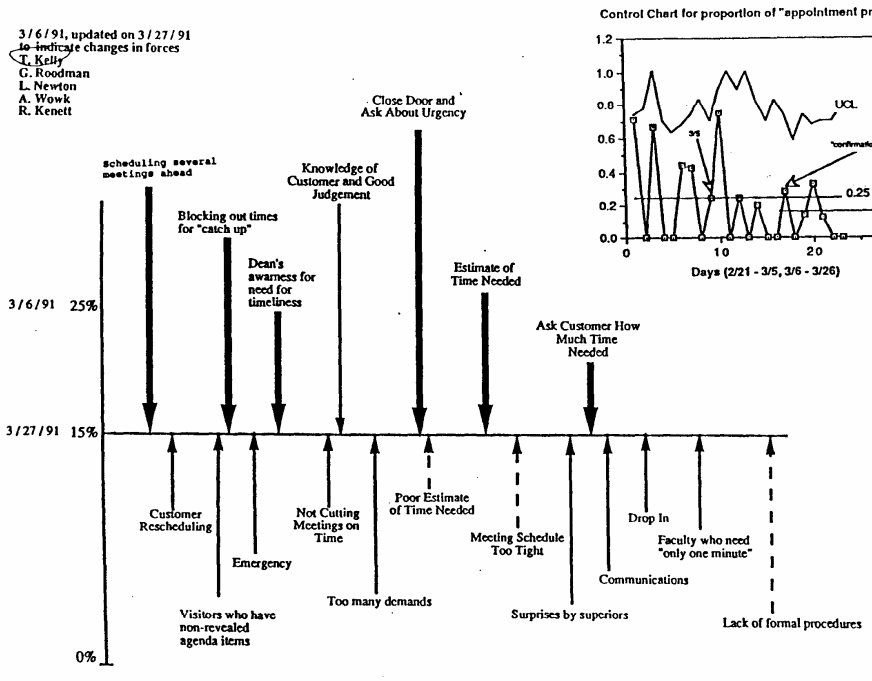


Figure 4

Control Chart for ongoing control

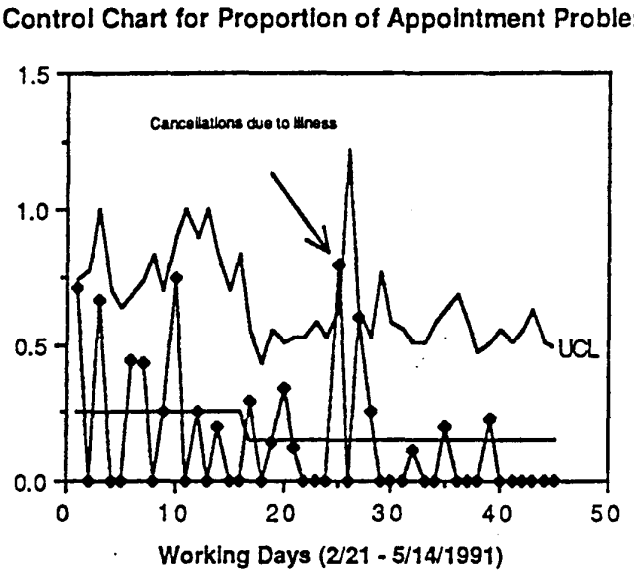


Figure 5

Six Sigma Projects

Define	Select a project
Measure	Map out the current situation
Analyze	Characterize the current situation
Improve	Optimize the process
Control	Hold the gains

DMAIC

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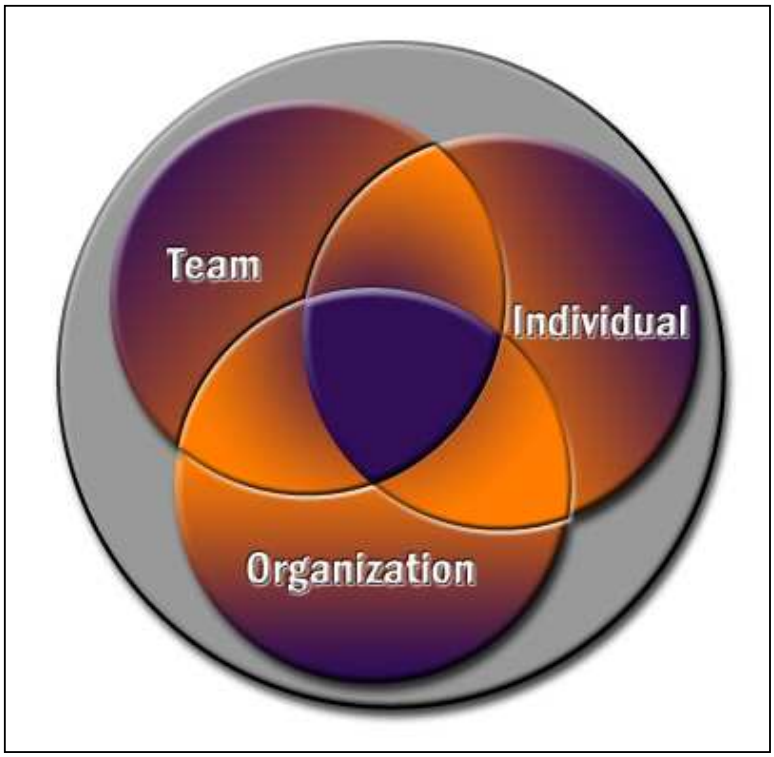
Three Levels of Competence



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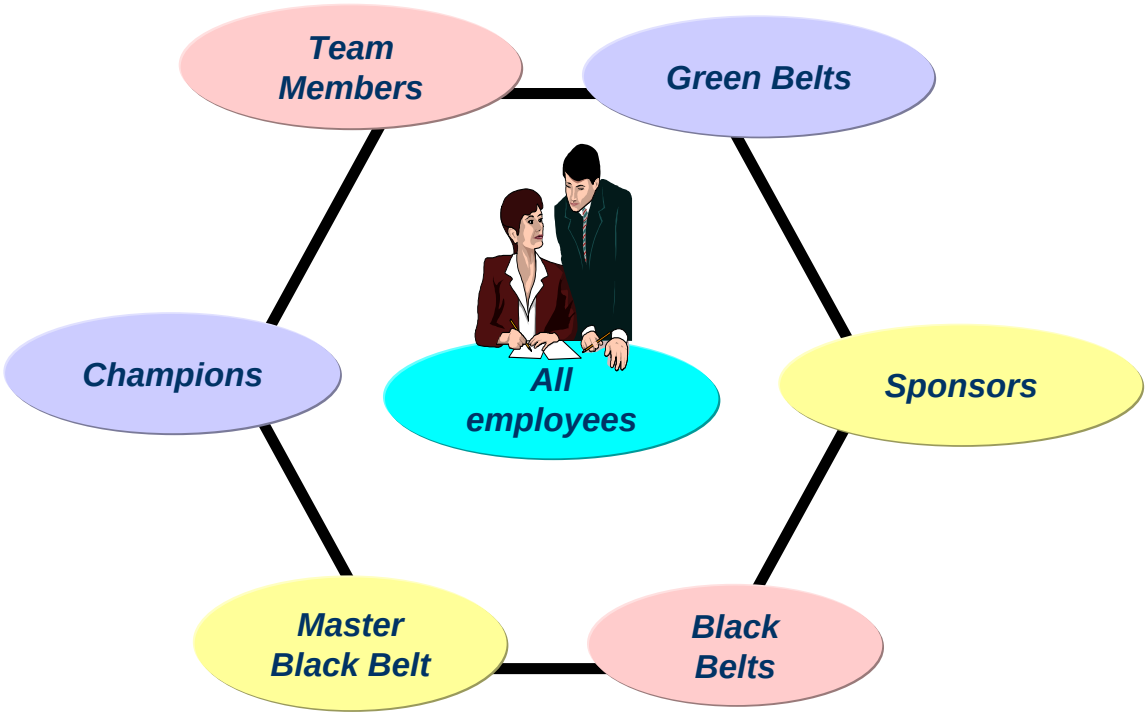
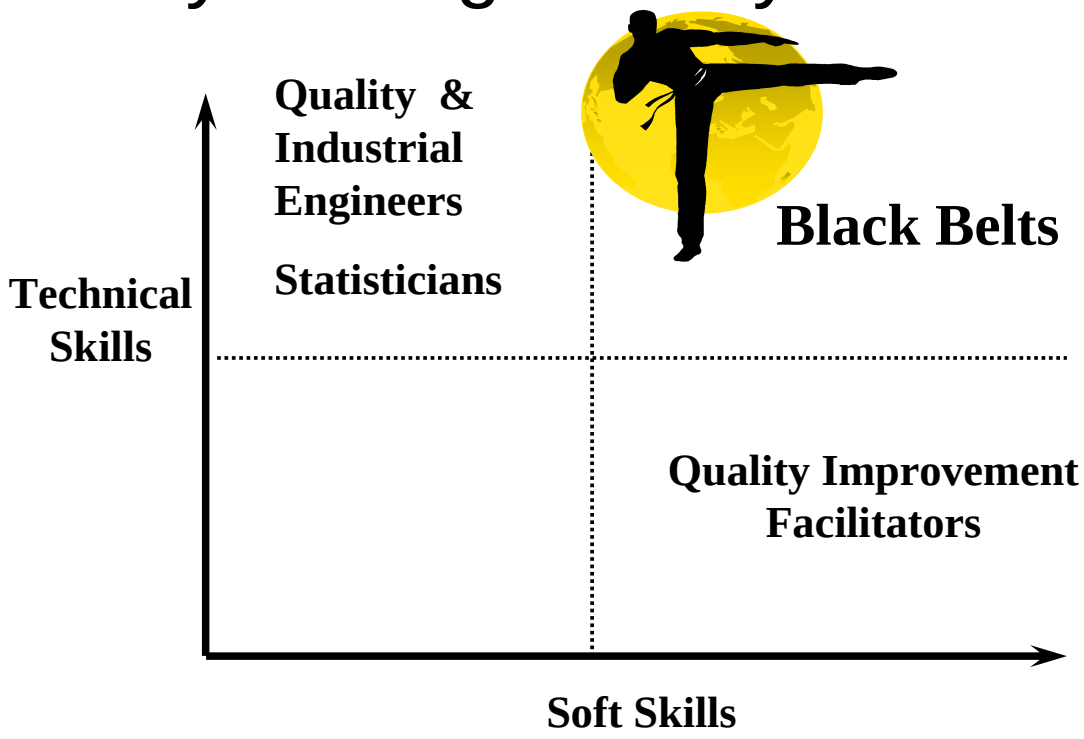
Key Six Sigma Players



Key Six Sigma Players

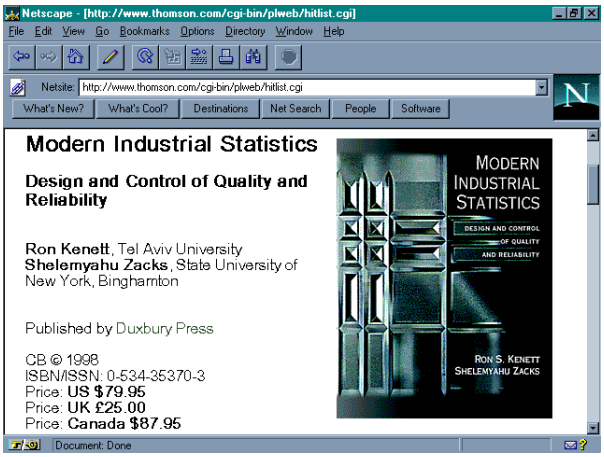


Black Belt training program

- 6 sigma principles
- Quality Improvement
- Quality by Design
- Quality Control
- Teamwork
- Effective presentations
- QFD/VOC
- Statistical thinking
- Process mapping
- Barriers to breakthroughs
- JMP, MINITAB…..
- Gage R&R
- SPC
- SPC Strategy
- Risk Management
- FMEA
- Statistical Inference
- Design Of Experiments
- DOE Strategy
- Bootstrapping
- Robust Designs
- System Thinking

Black Belt certification process

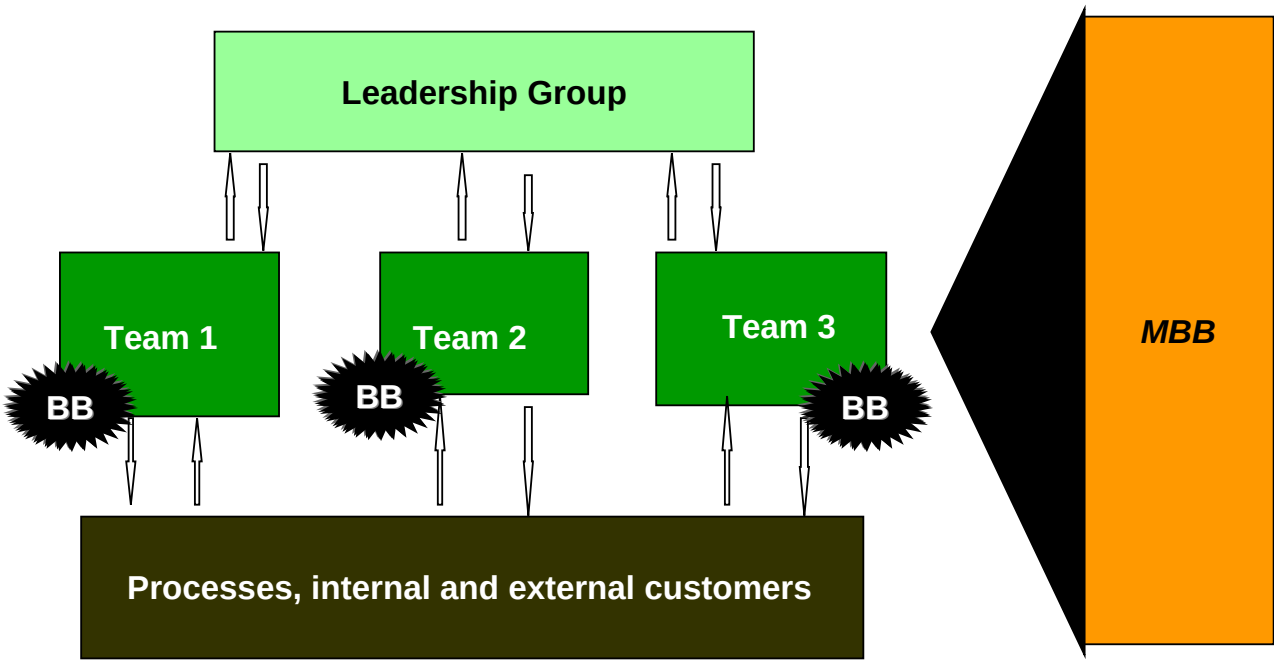
MODERN INDUSTRIAL STATISTICS: Design and Control of Quality and Reliability, Kenett and Zacks, Duxbury Press, 1998



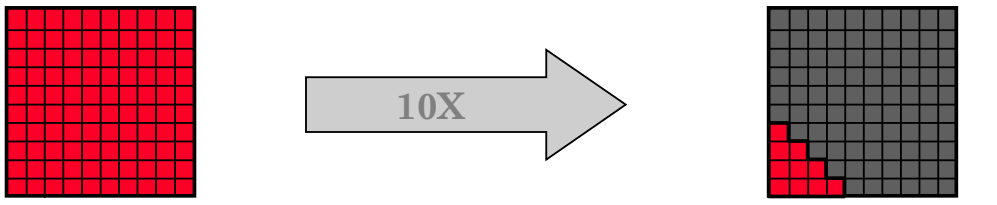
Participants must show:
- **Active participation in training**
- **Project completion**
- **Demonstrated skills, soft and hard**
- **Problem handling skills using simulators**

Management's role:
- **Management sponsorship**
- **Management reviews**
- **Monthly status report**
- **Project final report**

The organizational structure supporting Six Sigma implementation

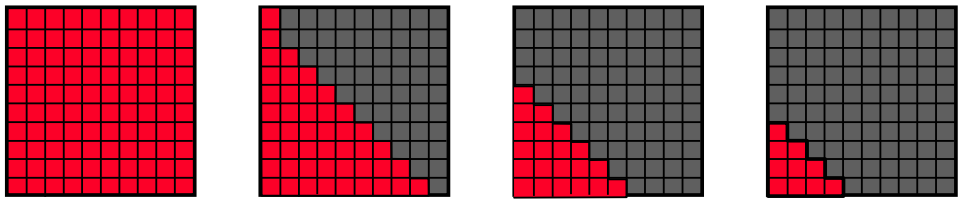


10X Improvement



End of Year 3
10 Errors in Process

Constant improvement each of the next 3 years, requires 54% improvement per year



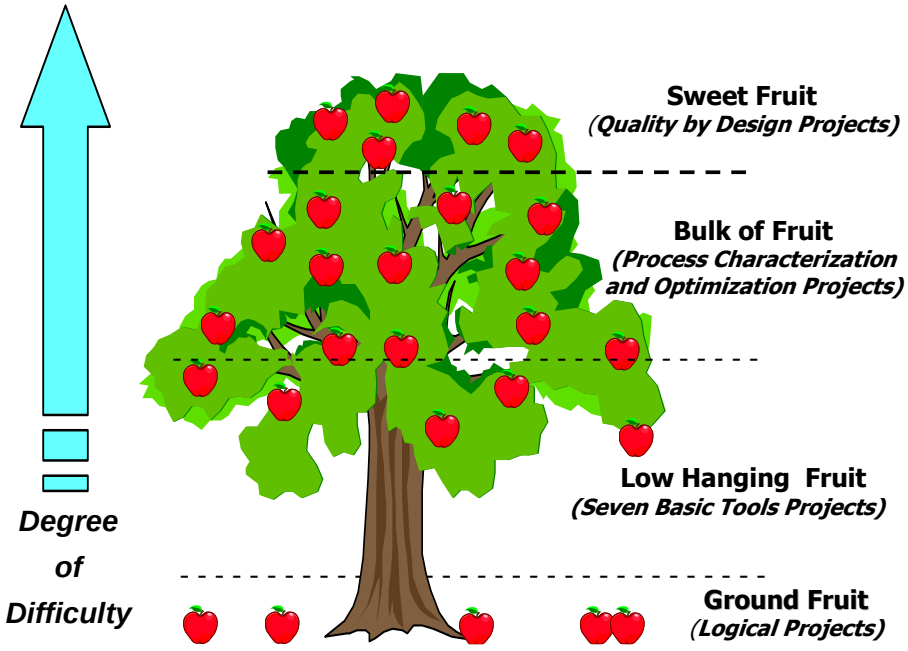
Start of Year 1
100 Errors
in Process

End of Year 1
46 Errors
in Process

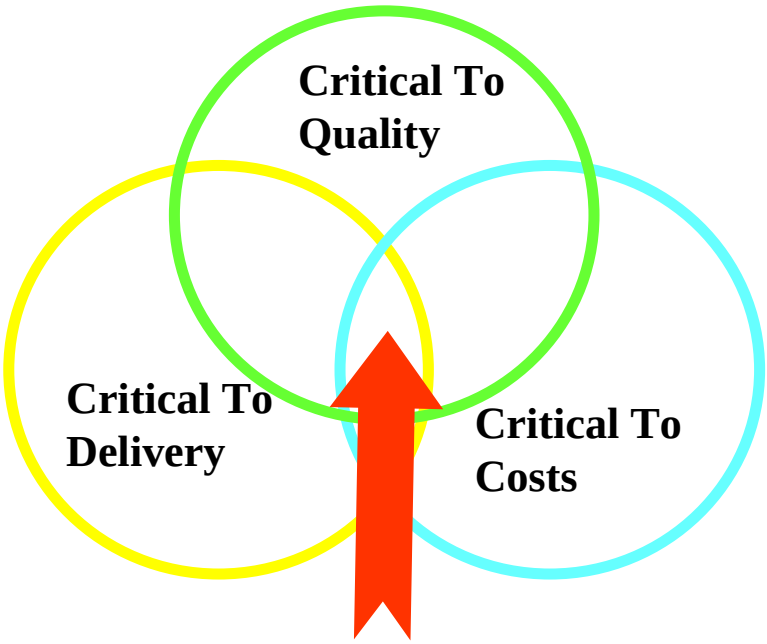
End of Year 2
21 Errors
in Process

End of Year 3
10 Errors
in Process

Choosing Improvement Projects



Choosing Six Sigma Projects



Maximum Leverage

Six Sigma Projects

Six Sigma Project Review Form

Black Belt Candidate:	Date:	1		3		4	5
Project Name:	Reviewer:						
Six Sigma Black Belt Methodology Phases		Completed	Incomplete	Not started	N/A	Action Items/Comments	
A. MEASUREMENT							
A1	Problem identification. Key product/process selected, based on business impact (DPU, Yield, COPQ, etc)	3	2	1			
A2	Project Customer, Mission, goals, metrics, client, measures of success established.	3	2	1			
A3	Team members identified.	3	2	1			
A4	Cashable return for Kodak identified (Return on investment)	3	2	1			
A5	Potential barriers identified and listed.	3	2	1			
Items above (A1-A5) should be complete by Week 1 review							
A6	Team formed and fully functional	3	2	1			
A7	Project Baseline elements completed including scope, scale, analysis of defects, cycle time, and costs	3	2	1			
A8	VOC collected, refined, and documented.	3	2	1			
A9	Internal and external gaps identified through benchmarking	3	2	1			
A10	Detailed process map documented (inputs, outputs, product/ process parameters, parameters classified, measurement points).	3	2	1			
A11	Performance (key) parameters measured using basic Quality tools, basic statistics, and Six Sigma measures	3	2	1			
A12	Project Management plan established including milestone dates and critical path	3	2	1			
Items above (A1-A12) should be complete by Week 3 review							
B. ANALYSIS							
B1	Process/product data analyzed using control charts and other tools to determine stability, capability, variability and process limits	3	2	1			
B2	Failure Modes and Effects Analysis performed using identified steps from product/process map.	3	2	1	N/A		
B3	Function Anaylsis Based Process Verification performed.	3	2	1	N/A		
B4	Systems Thinking tools applied (Reality Trees, Causal Loop Diagrams, etc.).	3	2	1	N/A		
B5	Key parameters prioritized based on capability analysis, defect pareto, cost analysis, FMEA, FAB-PV, Value Analysis, etc.	3	2	1			
B6	Measurement System Analysis performed on key measurement processes (key parameters)	3	2	1			
B7	"Measurement" phase elements updated (contract, baseline, metrics, flow maps, etc.).	3	2	1			
B8	Project Management plan updated with proposed improvement strategy including milestone dates and critical path	3	2	1			
Items above (A and B) should be complete by Week 4 review							
C. IMPROVEMENT							
C1	Key parameters selected for improvement. Response variables documented.	3	2	1			
C2	Diagnostic studies completed (modeling, nested designs)	3	2	1			
C3	Causal factor identification completed. Generate potential solutions.	3	2	1			
C4	Factor levels established, design selected and factors loaded, DOE plan established	3	2	1	N/A		
C5	Experiment(s) conducted and data collected.	3	2	1	N/A		
C6	DOE analysis.	3	2	1	N/A		
C7	Select and test solution(s). Decision and risk analysis assessed.	3	2	1			
C8	Implement solution(s).	3	2	1			
C9	"Measurement" phase elements updated (contract, baseline, metrics, flow maps, etc.).	3	2	1			

DEFINE

MEASURE

ANALYZE

IMPROVE

CONTROL

"Through our exceptional health care services, we reveal the healing presence of God."

SSM Health Care Management Medical Report

Radiology Retakes

SSM HealthCare St. Louis
Clinical Performance Improvement Center
Medical Management Report DRAFT

	July-03		YTD 2003		Year 2002	Year 2001
Hospital A	Actual	Budget	Actual	Budget	Actual	Actual
Medicare (traditional and managed)						
ALOS - traditional - acute ***	5.2	5.0	5.1	5.0	5.3	5.8
ALOS - managed care - acute***	5.2	5.1	4.9	5.1	5.1	5.1
Care 1*	5.2		4.9		5.9	5.9
Care 2*	6.3		6.4		6.1	5.5
Care 3*	4.9		4.7		4.8	4.8
Total Medicare Patient Days (acute and SNF) *	2,705		12,467		38,218	34,804
Catastrophic Acute Trad Medicare Cases, excluding Behavioral Health, as % of all cases*	9.5%		10.0%		10%	11%
Total All Patient Days (acute and SNF)***	15,223	16,521	62,224	63,843	92,259	93,859
Top DRGs (ICD9s) */**						
DRG 79 & 89 Respiratory Infection/Pneumonia		Goal		Goal		
Traditional Medicare ALOS (acute)	5.1	5.2	5.6	5.2	6.0	6.4
Total ALOS (acute)	5.2	5.2	5.1	5.2	5.6	5.7
Antibiotic time, arrival to administer-median in min (Core Measure)	144	<160	144	<160		
31 days readm rate for related condition - Quarterly	6.6%	2.0%	6.6%	2.0%	5.4%	6.0%
DRGs 106, 107,109 & other DRGs with CABG, not Valve Sx						
Traditional Medicare ALOS (acute)	9.8	8.0	10.5	8.0	8.4	9.4
Total ALOS (acute)	9.1	8.0	9.2	8.0	8.4	8.2
Patient Satisfaction	90%	95%	83%	95%	89%	92%
In-hospital mortality (not risk adjusted)	0.0%	3.0%	0.0%	3.0%	2.1%	4.0%
APR-DRG 174 & 175 Cardiac Stent						
Traditional Medicare ALOS (acute)	2.1	3.0	3.2	3.0	3.5	3.5
Total ALOS (acute)	3.3	3.0	2.8	3.0	3.1	3.1
Inhospital Mortality	0.00%	1.50%	1.49%	1.50%	1.5%	2.0%
% patients with EF<40% on ACE Inhibitor (Core Measure)	97%	95%	97%	95%	96%	
DRG 209 Hip/Knee Surgery						
Traditional Medicare ALOS (acute)	5.2	5.0	4.2	5.0	4.7	4.6
Total ALOS (acute)	4.1	4.5	3.9	4.5	4.3	4.3
Complication rate: Total Knee Replacement - Quarterly	7%	3%	7%	3%	8%	
Complication rate: Total Hip Replacement - Quarterly	3%	4%	3%	4%	9%	
Patient Satisfaction	90%	95%	89%	95%	89%	87%
ICD9 Code 410 Acute Myocardial Infarction						
Traditional Medicare ALOS (acute) DRG 121,122, 123	7.5	6.0	5.7	6.0	5.9	7.8
Total ALOS (acute) DRG 121, 122, 123	6.6	6.0	5.2	6.0	5.7	7.0
% charged for Beta Blocker	73%	85%	76%	85%	77%	69%
% of pts with Beta Blocker prescribed at discharge (Core Measure)	100%	95%	94%	95%	95%	
DRG 127 Heart Failure						
Traditional Medicare ALOS (acute)	3.4	4.0	5.6	4.0	5.3	5.6
Total ALOS (acute)	2.1	4.0	5.2	4.0	4.9	5.2
% charged for ACE Inhibitor or ARB	68%	75%	70%	75%	72%	75%
% patients with EF<40% on ACE Inhibitor (Core Measure)	97%	95%	97%	95%	96%	
31 days readm rate for related condition - Quarterly	9.6%	8.0%	9.6%	8.0%	11.2%	9.8%
Achieving Exceptional Patient Safety (AES) Collaborative**						
Near Miss (reports per month)	63		63		18	
% Compliance with Surgical Site Marking	100%	100%	100%	100%	100%	
% Compliance with Dangerous Abbreviation Policy	95%	100%	95%	100%	92%	
Quality (System Measures)***						
Patient Loyalty	82.4%	82.0%	81.6%	82.0%	43.9%	44.1%
31-Day Acute Readmission Rate	11.0%	10.0%	10.0%	10.0%		
Unscheduled Returns to ER	0.92%	1.5%	1.05%	1.5%	1.3%	1.9%
Unscheduled Returns to OR	0.38%	0.75%	0.74%	0.75%	1.1%	1.7%

Medicare patients' section looks at patients' ALOS and other utilization data.

Six groups of patients have been designated for performance improvement efforts based on volume of cases and opportunities for positive change when compared to selected benchmarks. Primary outcomes for these patients are tracked on monthly reports.

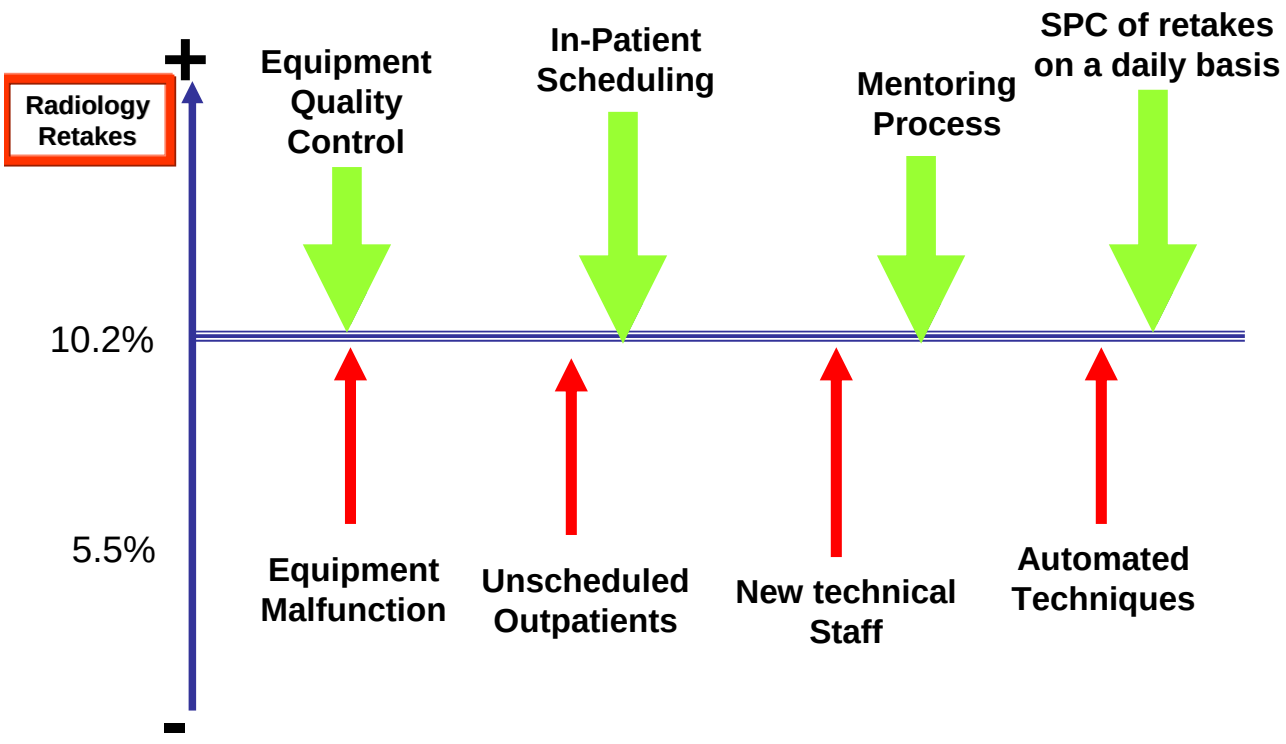
Patient Safety Indicators

SSMHC System-wide Indicators

* Two dollar data
** Submitted by hospitals
*** Hospital Operations Performance Indicator Report

5

"Through our exceptional health care services, we reveal the healing presence of God."



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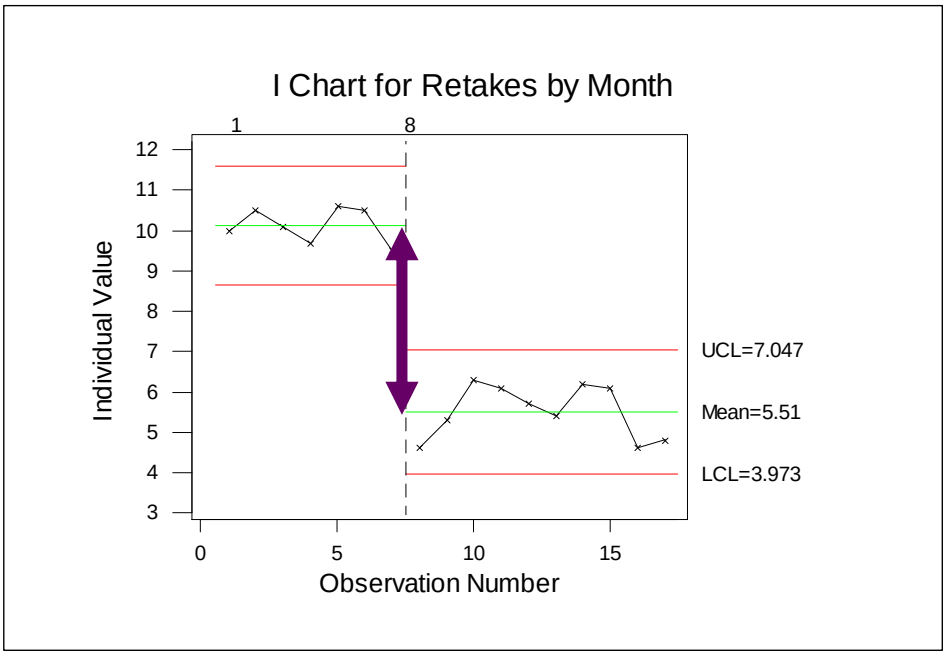
"Through our exceptional health care services, we reveal the healing presence of God."

Radiology Retakes

10.2%

5.5%



Sample projects

	Black Belt	Project Sponsor	Sub Unit	Project Name
1.	Boaz Parpar	Avi Bental	TC	Cost reduction in LABORATORY TEST
2.	Shimon Azani	Andre Sillam	SM	Cost reduction in CHLORINE production
3.	Meir Adler	Yitzhak Feier	IC	Reaching 6-Sigma target in AMMONIUM BROMIDE
4.	Victor Malka	Ofer Lifshitz	IC	6-Sigma target in HBr manufacturing
5.	Gregory Shapiro	Alon Tavor	FR/RD	Improving flowability of TBBA

Sample Black Belt Projects

Example 1

Repacking is currently estimated at 1.5M$
Reduce these costs by at least 500K$

Example 2

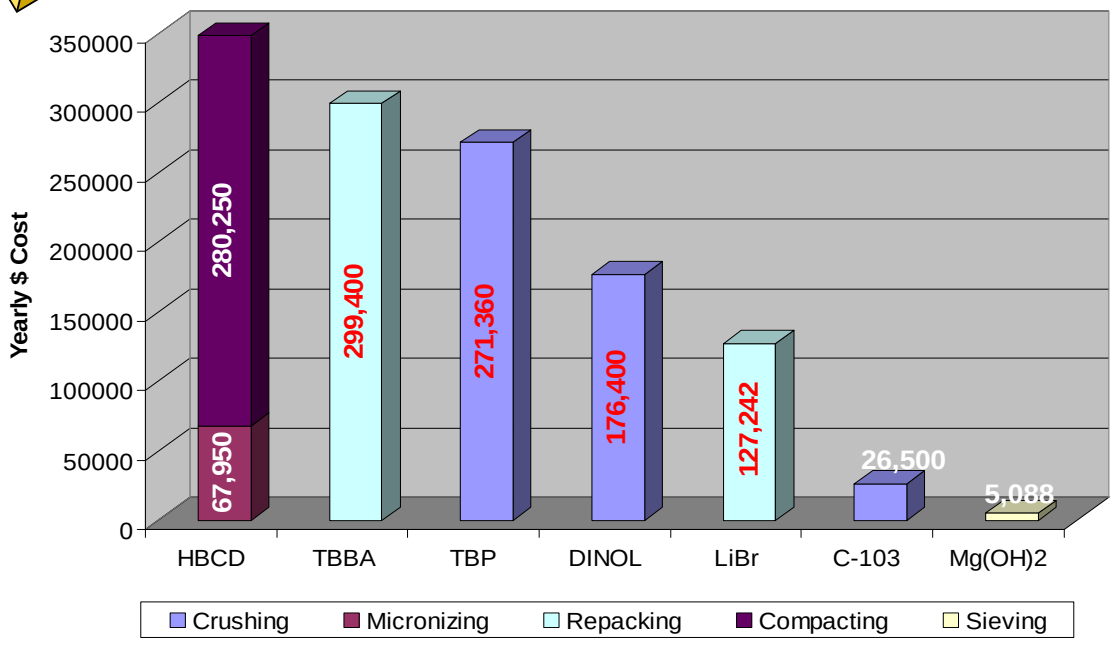
Plastic Injection moulding customers complain of residues blocking the mould injection orifices
Increase MTTF from 800 to 3000 injections

Example 3

Bromine raw material is delivered at 1-2.6 sigma levels using best in class specifications
Improve production capability to 6 sigma levels

Example 1

he Repacking Project



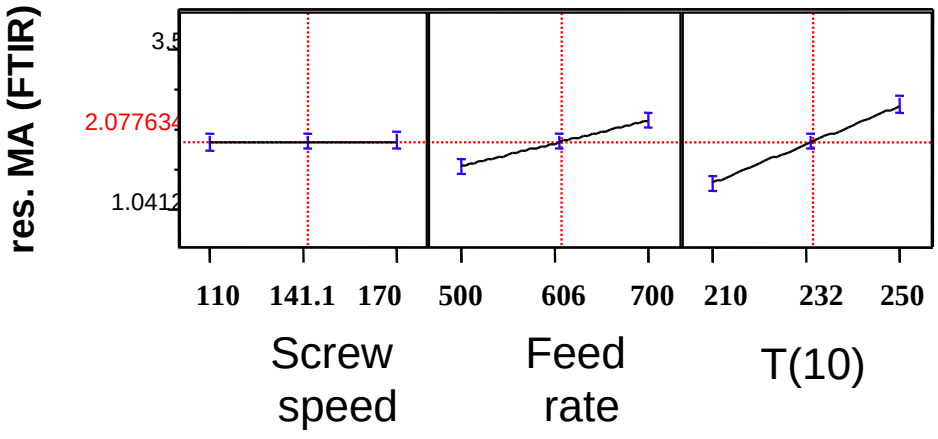
Example 2

ne Residues Project

	Parameter	Units	Level 1	Level 2
1	Screw Speed	RPM	110	170
2	Feed Rate	kg/hr	500	700
3	Temp (10)	C	210	250

N		Screw Speed	Feed Rate	T(10)
1	-	110	500	210
2	a	170	500	210
3	b	110	700	210
4	ab	170	700	210
5	c	110	500	250
6	ac	170	500	250
7	bc	110	700	250
8	abc	170	700	250

Example 2

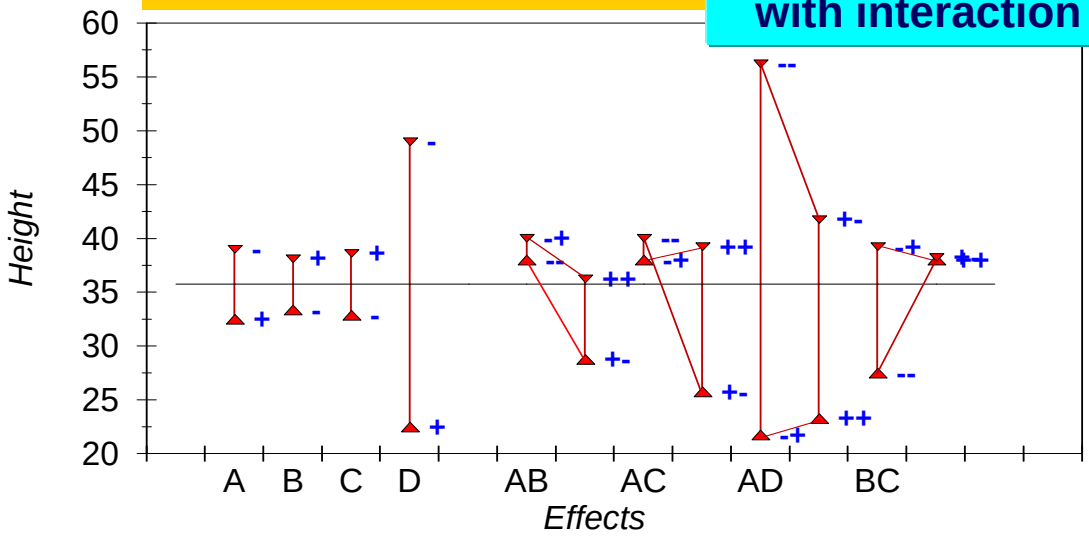


Example 2

"Going Beyond Main-Effect Plots" (with B. Vogel), *Quality Progress*, pp. 71-73, February 1991.

Response Variable:	Height of the moulded part (Measured in mm.)		
Factors		-	Levels +
A - Injection Speed (in./sec)		1.0	3.0
B - Injection Pressure (psi)		825	925
C - Injection Time (sec)		2.0	3.5
D - Pressure Hold Time (sec)		5.5	7.5
Design	Full factorial - 2^4		
	Replications per run - 20.		

Combining main effects with interaction plots

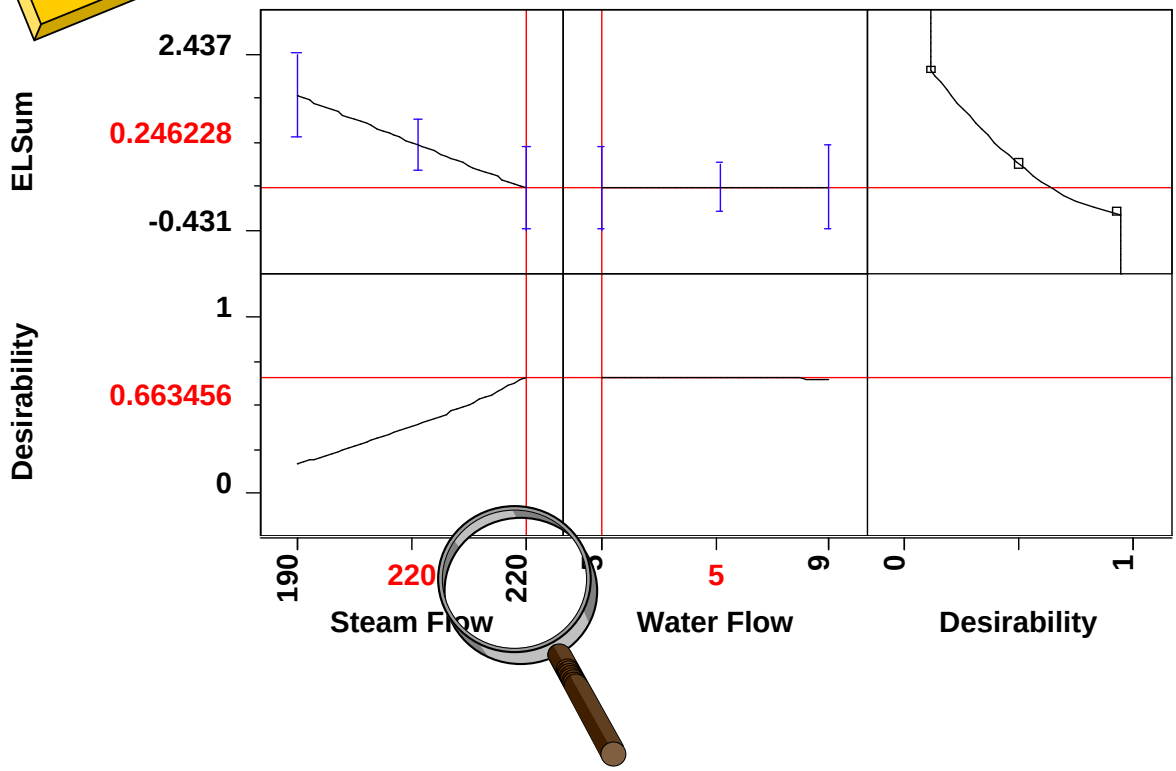


The Bromine Project

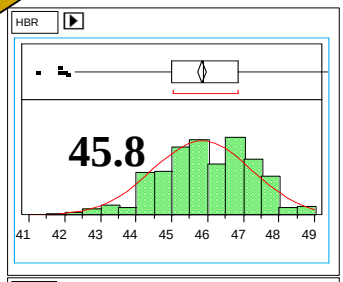
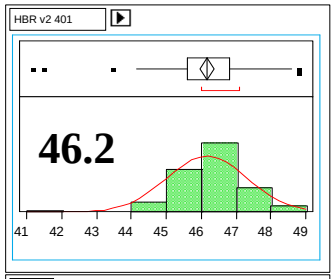
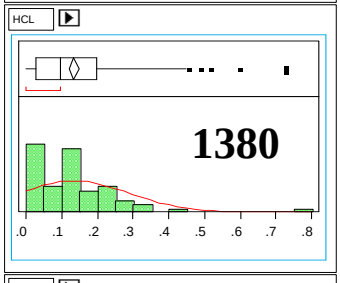
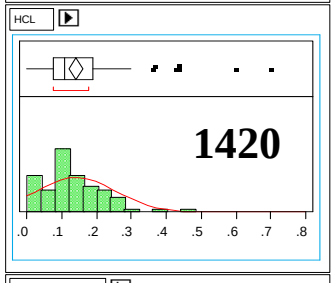
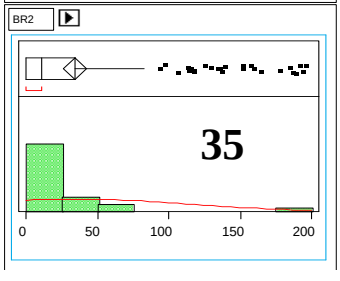
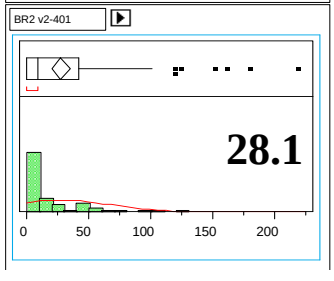
Example 3

Steam Flow	Water Flow	Chlorine	Moisture	Expected Loss Sum
190	6	63	9	1.1925
200	5	54	20	1.2544
210	6	72	14	1.6578
210	8	63	10	1.2136
220	8	10	12	0.1878
210	9	41	13	0.6547
2[illegible]	6	5	7	0.0614
[illegible]	7	8	8	0.0889
[illegible]	9	38	9	0.4911
[illegible]0	9	2	9	0.0911
190	5	73	18	1.8403
200	7	43	8	0.5847
190	7	57	9	0.9925
190	8	80	19	2.1789
190	9	57	12	1.0625
210	7	42	7	0.5444
220	5	4	8	0.0756
200	6	68	20	1.7289
200	8	60	26	1.7511
210	5	35	10	0.4514

Example 3

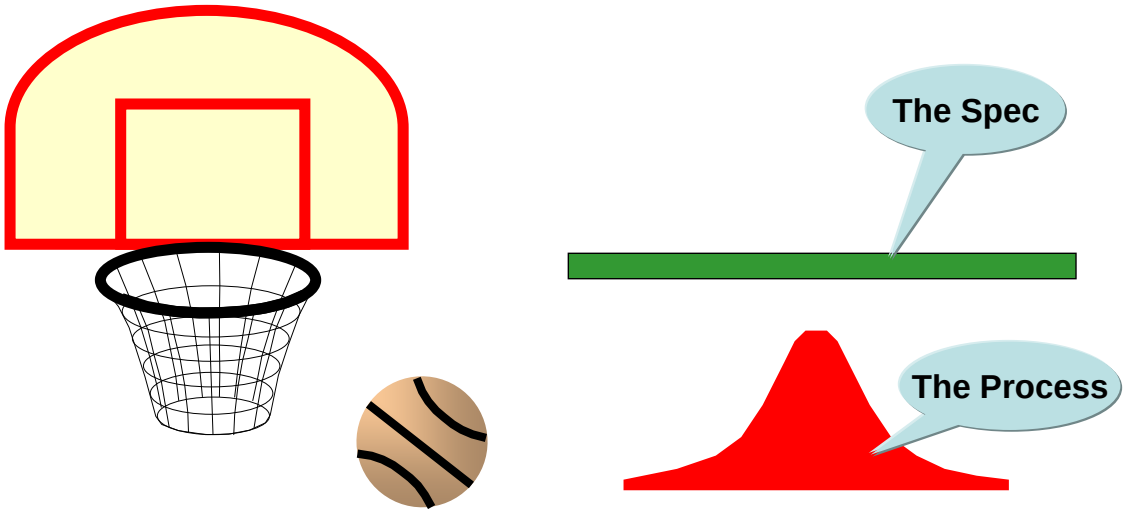


Example 3

Baseline	Improved	Variance Improvement
		$\frac{\sigma_b^2}{\sigma_i^2} = 1.45$
		$\frac{\sigma_b^2}{\sigma_i^2} = 1.8$
		$\frac{\sigma_b^2}{\sigma_i^2} = 3.0$

5

Measuring Capability

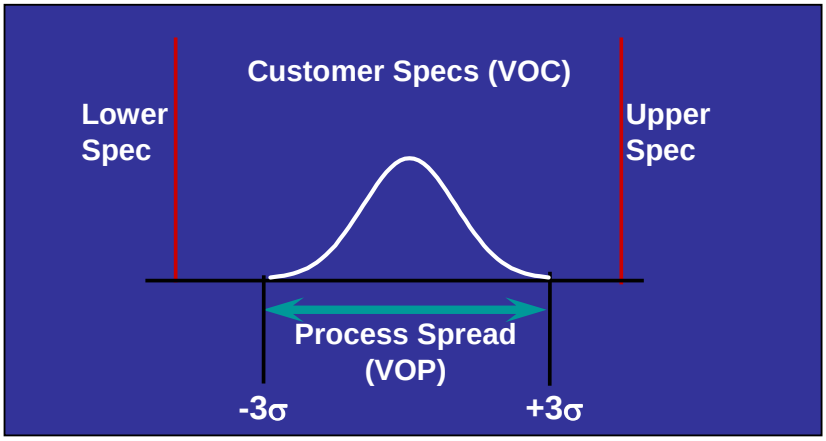


5

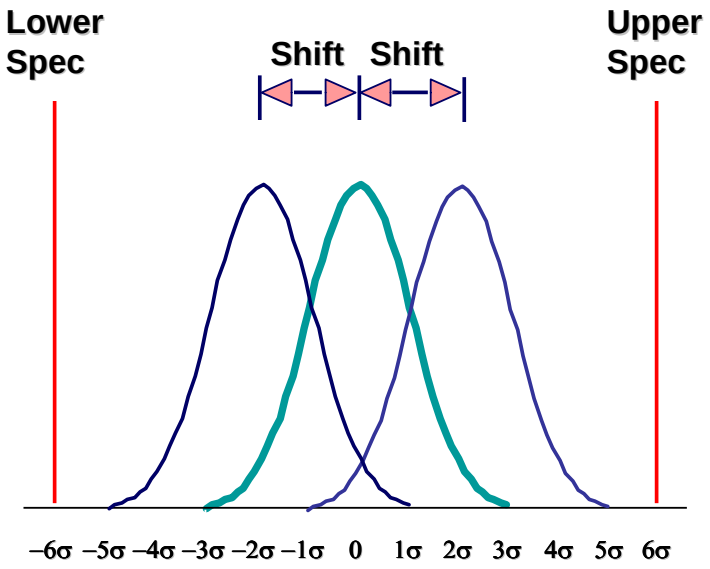
Measuring Capability

$$\frac{\text{Customer Specifications (VOC)}}{\text{Process Spread (VOP)}}$$

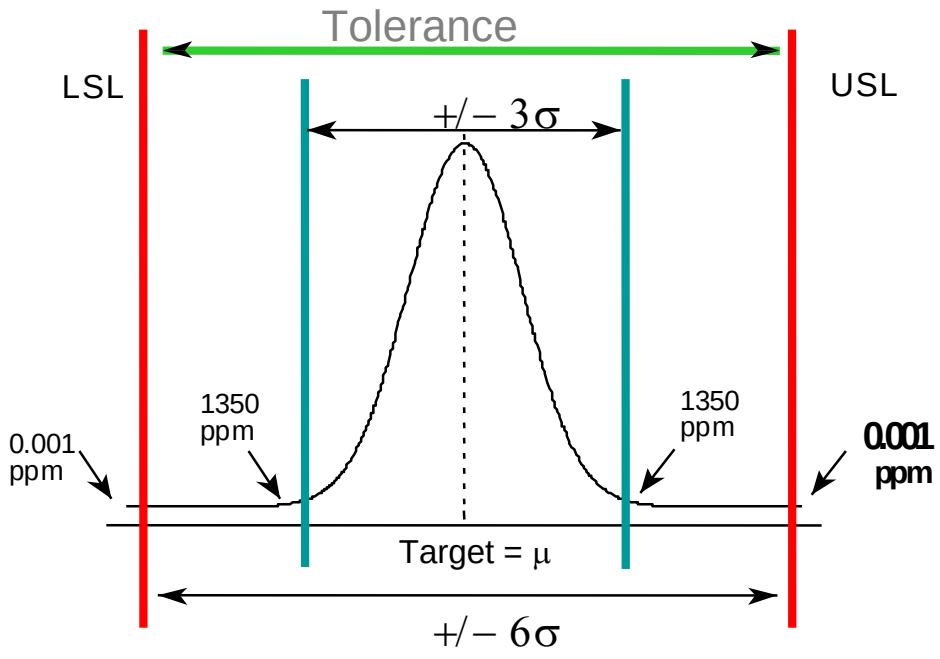
$$C_p = \frac{\text{Upper Spec} - \text{Lower Spec}}{6\sigma}$$



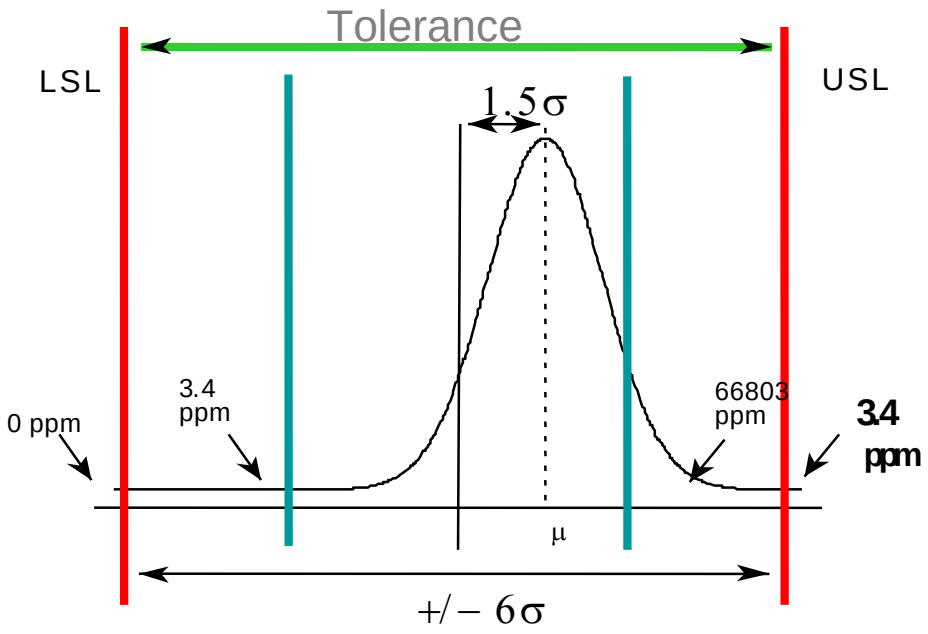
Measuring Capability



Measuring Capability



Measuring Capability



$$K = \left| \frac{\bar{X} - T}{\frac{USL - LSL}{2}} \right|$$

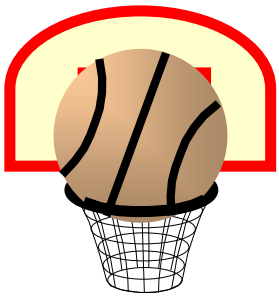
On-target index

Actual capability

Potential capability

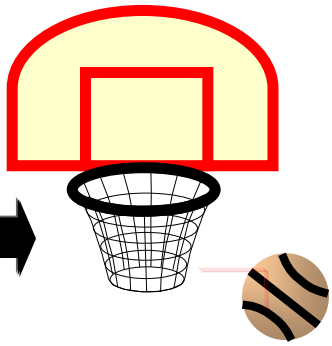
$$Cpk = Cp\ (1-K)$$

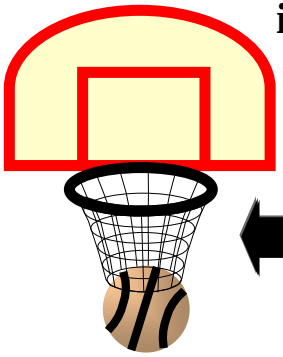
Actual and Potential Capability



There is no Potential Capability

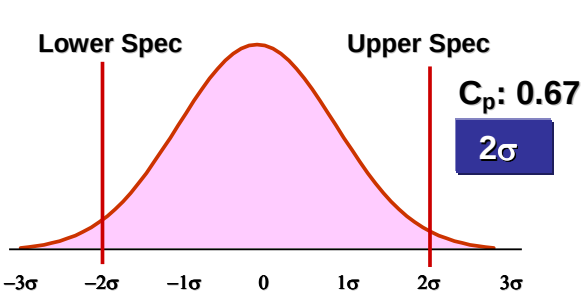
There is Potential Capability However there is no Actual Capability

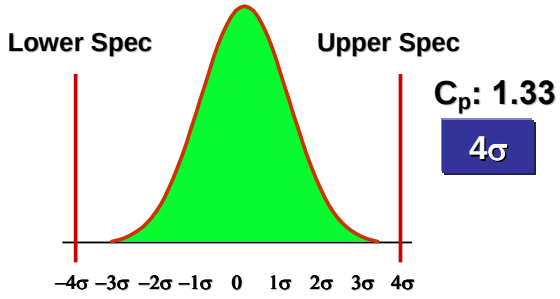


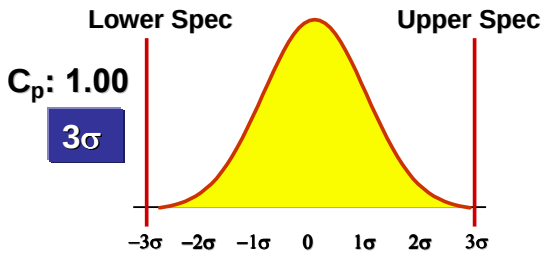


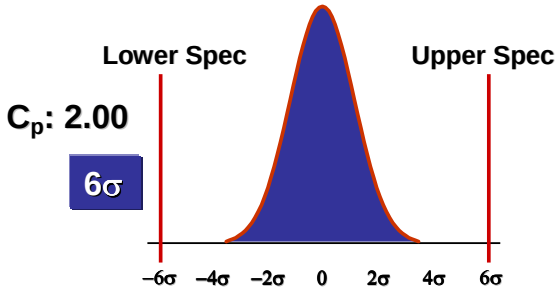
There is Actual Capability

Measuring Capability









C_p, C_{pk}, Defects, and Sigma

C_p	DPMO *	C_{pk}**	DPMO**	Sigma Level
0.67	50,000	0.17	308,770	2
1.00	2,700	0.50	66,811	3
1.33	63	0.83	6,210	4
2.00	0.002	1.50	3.4	6

* Assumes processed centered between specs
**Assumes a mean shift of 1.5 standard deviations

Converting Defect Levels to Sigma Level

175 defects are identified while producing 5000 controllers

DPU = 175 / 5000 = 0.035

There are 1367 defect opportunities per controller.

DPO = 0.035 / 1367= 0.0000256

DPMO = 25.6

Converting Defect Levels to Sigma Level

Sigma -- DPMOp Conversion Table

Sigma*	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5.30	72.3	69.5	66.7	64.1	61.5	59.1	56.7	54.4	52.2	50.1
5.40	48.1	46.1	44.3	42.5	40.7	39.1	37.5	35.9	34.5	33.0
5.50	31.7	30.4	29.1	27.9	26.7	25.6	24.5	23.5	22.5	21.6
5.60	20.7	19.8	18.9	18.1	17.4	16.6	15.9	15.2	14.6	13.9
5.70	13.3	12.8	12.2	11.7	11.2	10.7	10.2	9.77	9.34	8.93
5.80	8.54	8.16	7.80	7.46	7.12	6.81	6.50	6.2	5.93	5.67
5.90	5.41	5.17	4.94	4.71	4.50	4.29	4.10	3.91	3.73	3.56
6.00	3.40	3.24	3.09	2.95	2.81	2.68	2.56	2.44	2.32	2.22
6.10	2.11	2.01	1.92	1.83	1.74	1.66	1.58	1.51	1.43	1.37
6.20	1.30	1.24	1.18	1.12	1.07	1.02	0.97	0.92	0.88	0.83

MOTOROLA

*Shifted 1.5 sigma

An Example :

175 defects are identified while producing 5000 controllers

DPU = 175 / 5000 = 0.035

There are 1367 defect opportunities per controller.

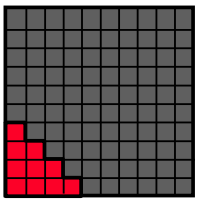
DPO = 0.035 / 1367= 0.0000256

DPMO = 25.6

"Sigma" level : 5.55

Benchmarking for Quality Costs

σ-level	Defect rate (ppm)	Costs of poor quality	Status of the company
6	3.4	< 10% of turnover	World class
5	233	10-15% of turnover	
4	6210	15-20% of turnover	Industry Average
3	66807	20-30% of turnover	
2	308537	30-40% of turnover	Noncompetitive



Reported Impact

Table 2: Six Sigma Cost And Savings By Company					
Year	Revenue ($B)	Invested ($B)	% Revenue Invested	Savings ($B)	% Revenue Savings
Motorola					
1986-2001	356.9(e)	ND	-	16 1	4.5
Allied Signal					
1998	15.1	ND	-	0.5 2	9.9
GE					
1996	79.2	0.2	0.3	0.2	0.2
1997	90.8	0.4	0.4	1	1.1
1998	100.5	0.5	0.4	1.3	1.2
1999	111.6	0.6	0.5	2	1.8
1996-1999	382.1	1.6	0.4	4.4 3	1.2
Honeywell					
1998	23.6	ND	-	0.5	2.2
1999	23.7	ND	-	0.6	2.5
2000	25.0	ND	-	0.7	2.6
1998-2000	72.3	ND	-	1.8 4	2.4
Ford					
2000-2002	43.9	ND	-	1 6	2.3

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