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Faculty Development Program for IIHMR Group of Institutions

Lean Six Sigma in Health Care

Date: March 27, 2021

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IIHMR Intellectual Capacity Building and Faculty Development

Lean Six Sigma in Healthcare

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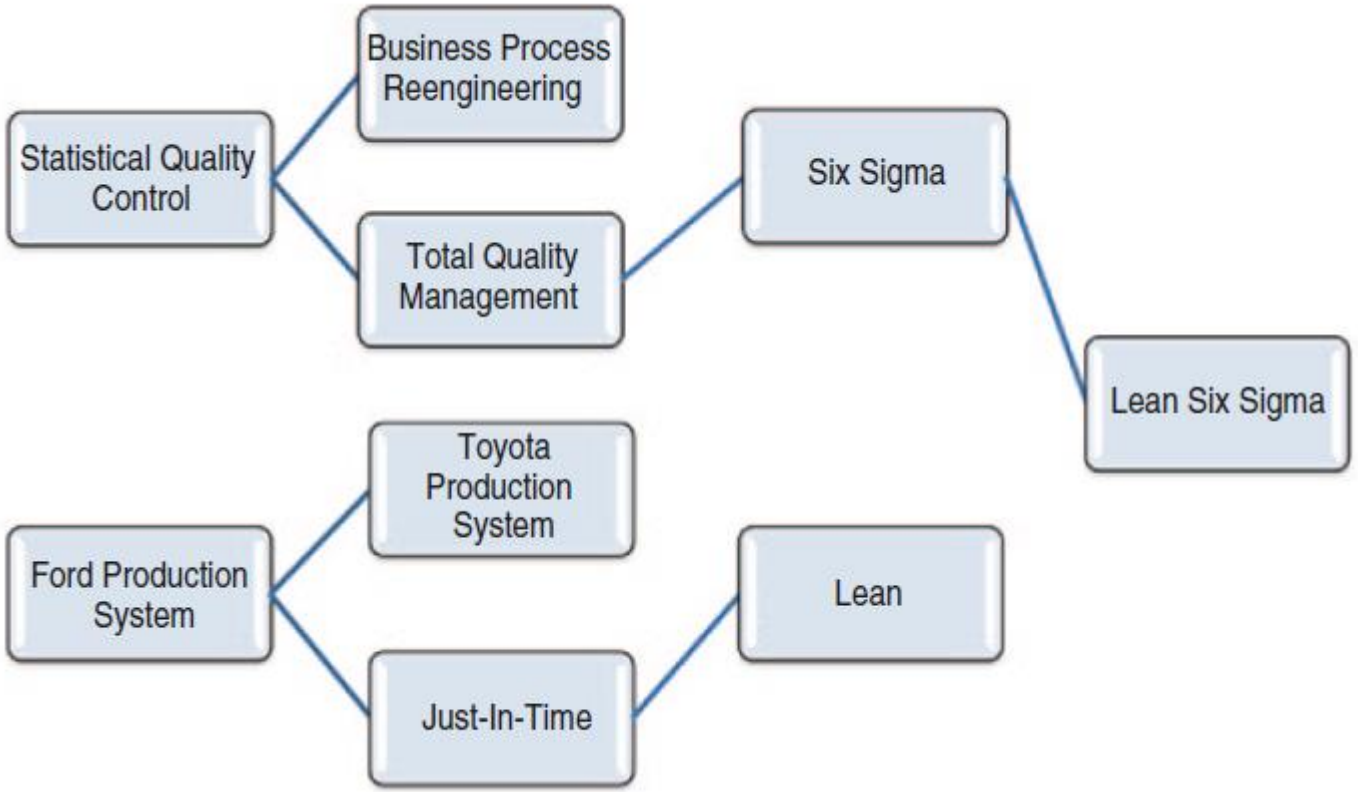
March 27, 2021, 10:00 AM – 11:30 AM

What is Lean Six Sigma?

- A problem solving and process improvement approach that combines two powerful methodologies that focus on reducing **waste** and **variation.**

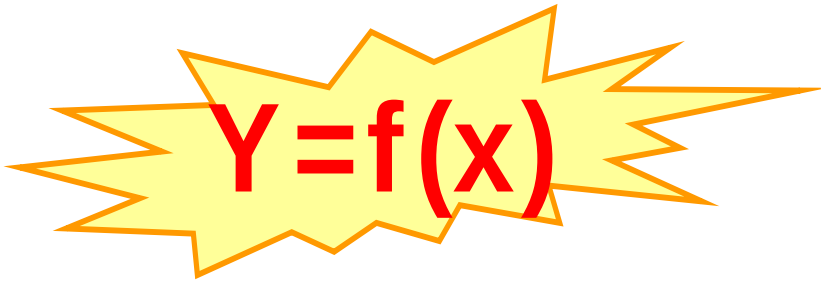
- **Lean Manufacturing (TPS) Principles = Waste reduction**
- **Six Sigma Methodology = Variation reduction**

Evolution of Lean and Six Sigma



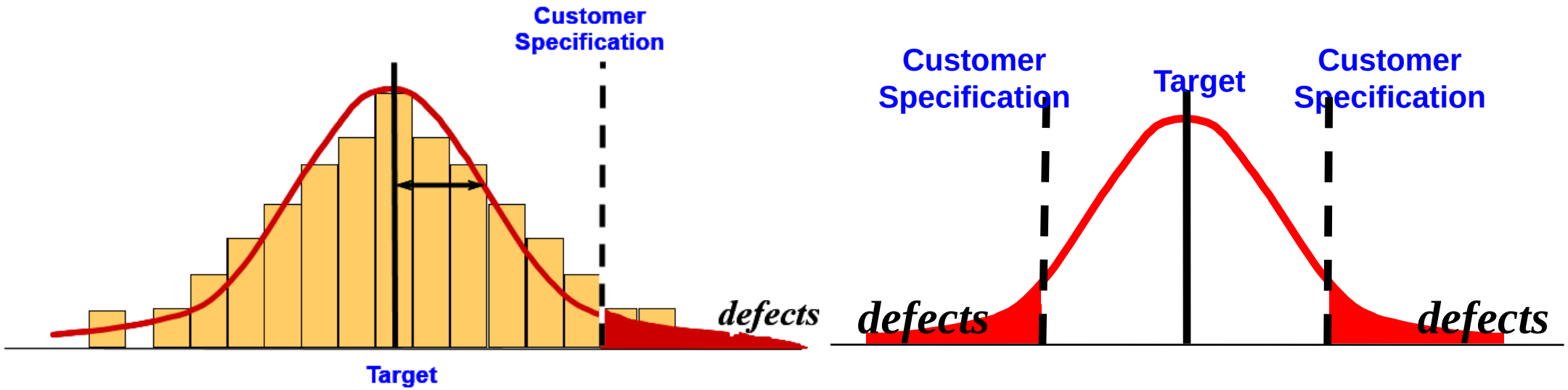
Where Did 6σ Come From?

- Started at Motorola Corporation in the mid-1980's - Bill Smith
- Popularized by former General Electric CEO Jack Welch's.
- Six Sigma brought back statistical measurement to quality.
- Reduce variation Sigma (σ)
- Sigma (σ) is a statistical concept that represents how much variation there is in a process relative to customer specifications.
- Y=f(X)
- Making decisions based on data



Six Sigma (σ) Concept

Every Human Activity Has Variability...



Reducing Variability is the Key to Understanding Six Sigma

What is Six Sigma (6σ)?

Sigma Level	DPMO	Yield
2	308,537	69.15%
3	66,807	93.32%
4	6,210	99.38%
5	233	99.98%
6	**3.4**	**99.99966%**

By reducing the variability, we improve the process

What is Lean?

- Original ideas - Sakichi Toyoda, 1950s
- Elimination of waste Mura (斑) – JIT, Muri (無理) - Standardize work, Muda (無駄) – TIMWOOD.
- **Core ideas**
  - **Determine and create value**
  - **"pull" instead of "push" systems** (American supermarkets)
  - **One piece flow**
  - **Eliminate the non-value adds caused by waste**
  - **JIT, 5 S, Kanban, poka-yoke.**

The origin of LSS Healthcare..

- Virginia Mason Medical Center in Seattle, Washington (2001) - Engaged production engineers from Toyota and the Boeing Aircraft Company) to teach them how to apply the Toyota Production System to the production of healthcare services.
- E.g. in hospitals - Throughput Improvement, TAT Improvement, 5S, Leaning the healthcare process, Loss Reduction, Reducing wait time, Prevent falls and injuries, Reduce medication errors, TAT for lab results, Improving flow, Reducing discharge time etc..
- Pharmaceutical manufacturing..

LSS Methodology

Lean Six Sigma DMAIC Most Common Tools

Define	Measure	Analyze	Improve	Control
• Project Charter • Stakeholder Analysis • SIPOC • Process Map (high level) • Project Plan	• Process Map • CTS • Data collection plan • Quality Function Deployment (QFD) • Pareto Chart • Cost of Poor Quality	• Cause & Effect Diagram • Why-Why Diagram • Histogram and Graphical Analysis • Correlation & Regression Analysis • Basic Statistics • Sampling • VSM • Failure Mode and Effects Analysis • Gap Analysis • Hypothesis Tests • Waste Elimination • 5S, Kaizen	• Recommendations • Improvement Plan • Action Plan • Cost/benefit Analysis • Cost of Poor Quality • Future State Map • Hypothesis Testing • Dashboards	• Hypothesis Testing • Basic Statistics • Graphical Analysis • Sampling • Standard Work • FMEA • Statistical Process Control (SPC) charts • DPMO • Dashboards

Minitab Software ..

Project charter template

Project Name: Name of the Lean Six Sigma Project
Project Overview: Background of the project.
Problem Statement: Business problem, describe what, when, impact, consequences.
Customer/Stakeholders: (Internal/External) Key groups impacted by the project.
What is important to these customers – CTS: Critical to satisfaction, the key business drivers.
Goal of the Project: Describe the improvement goal of the project.
Scope Statement: The scope of the project, what is in the scope and what is out of scope.
Financial and Other Benefit (s): Estimated benefits to business, tangible and intangible.
Potential Risks: Risks that could impact the success of the project and the probability of occurrence.
Milestones: DMAIC Phase and Estimated Completion Dates
Project Resources: Champion, Black Belt Mentor, Process Owner, Team Members.

Hospital and Emergency Department Throughput Improvement - Project charter

Project Overview: This project is focused on improving patient throughput in the ED.

Problem Statement: The Emergency Department is experiencing delays in moving the patient through the ED in a timely manner. There are excessive delays and a high percentage of patients left without being seen.

Customer/Stakeholders: ED Patients, Medical Associates (Doctors, Nurses, Technicians, Transportation), Administration, EMS, Inpatient areas, diagnostic departments.

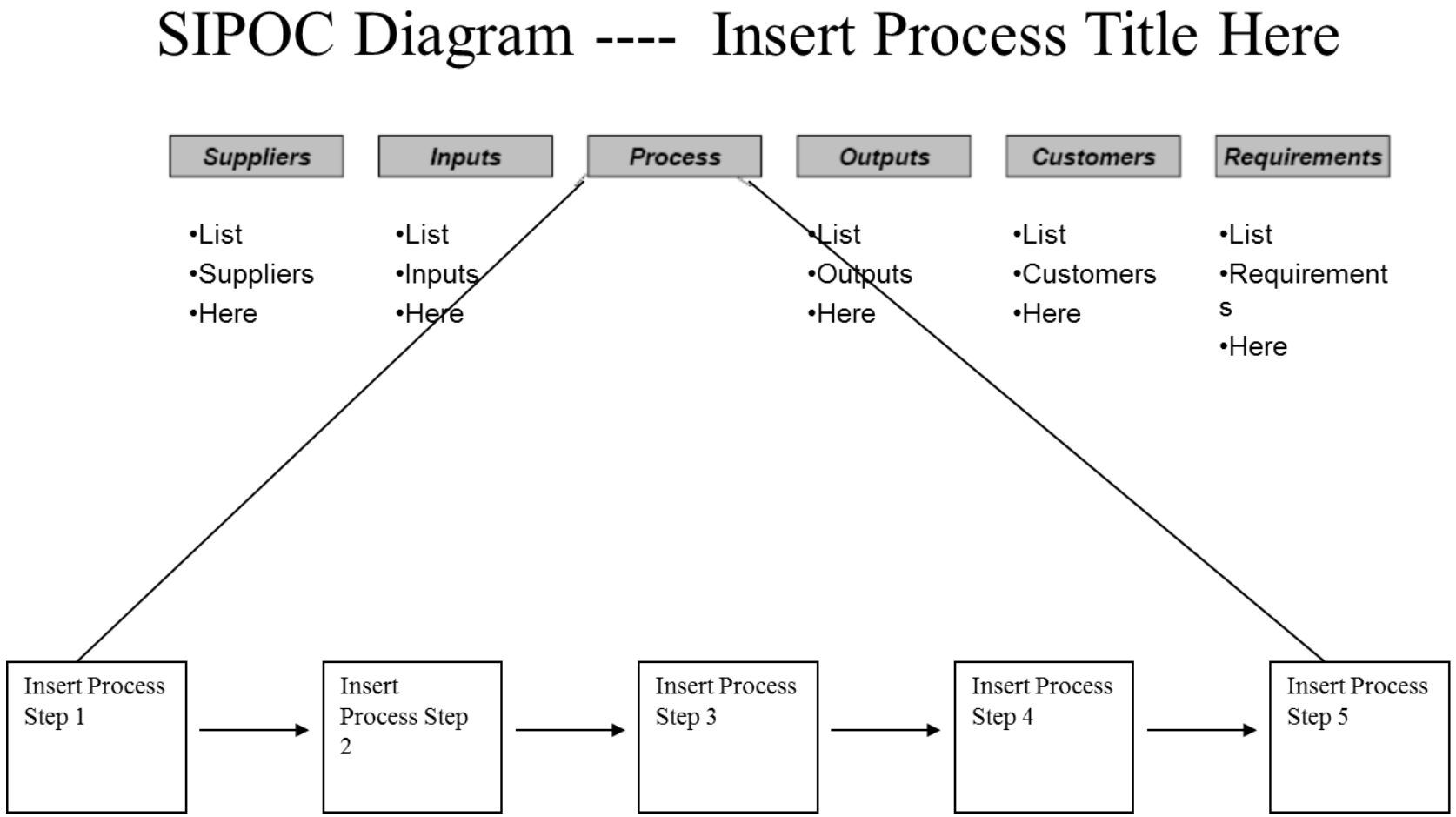
What is important to these customers – CTS (Critical to Satisfaction): Patient Satisfaction, Quality of Care, Throughput Time, Waiting time.

Goal of the Project: Improve ED throughput time to 3 average hours for discharged patients and 5 average hours for admitted patients.

Scope Statement: The scope includes the ED processes starting from patient entrance, to triage, treat, transport, test/diagnose, disposition and discharge/admit.

Projected Financial Benefit (s): Improved revenue; increased volume (reduction of Left Without Being Seen (LWBS)), increased volume through increased performance; reduced costs through improved efficiency (time per patient).

SIPOC Diagram (An important Lean Six Sigma Tool)

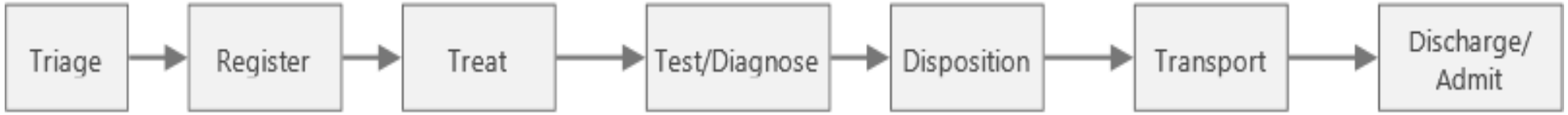


SIPOC Emergency Services

Suppliers	Inputs	Process	Outputs	Customers
• Patient • EMS • Physicians • Staff	• Request for ED care • Referrals • Patient Info	Triage	• Acuity Level • Triage Decision	• Medical staff • Patient
• Patient • Medical Staff	• Patient information	Register	• Registration	• Medical staff • Patient
• Medical Staff • Patient	• Patient information	Treat	• Orders	• Medical staff • Patient
• Medical Staff • Patient • Ancillary staff	• Orders	Test/ Diagnose	• Results • Diagnosis	• Medical staff • Patient • Ancillary staff
• Medical Staff • Patient	• Results • Diagnosis	Disposition	• Disposition • Instructions	• Medical staff • Patient
• Medical Staff • Patient • Ancillary staff	• Transport Device • Order	Transport	• Completed transport order	• Medical staff • Patient
• Medical Staff • Patient • Ancillary staff	• Disposition • Orders • Instructions • Prescriptions	Discharge or Admit	• Instructions	• Patient • Family

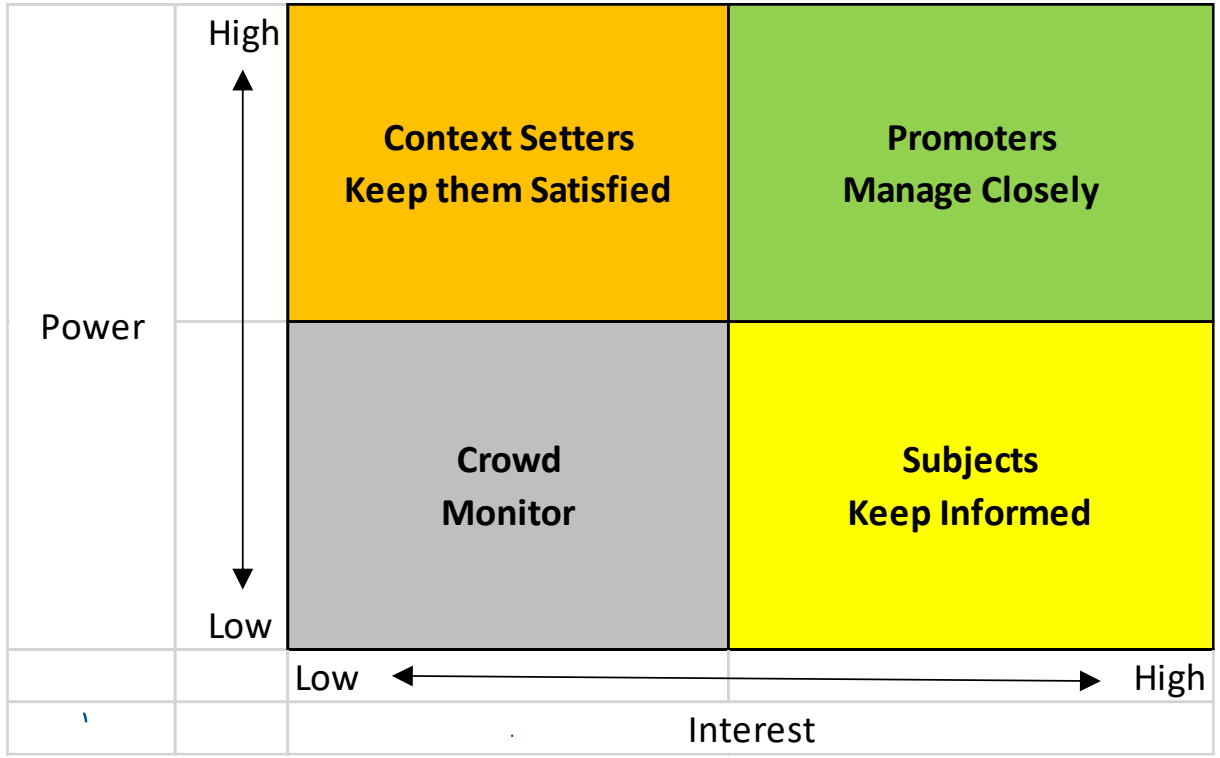
High-Level Process Map (SIPOC Process Map)

- The process steps can be simply turned 90° from SIPOC - displayed horizontally instead of vertically.
- Identify the inefficiencies and non-value added activities, and then create the future state process during the improve phase.



Stakeholder Analysis

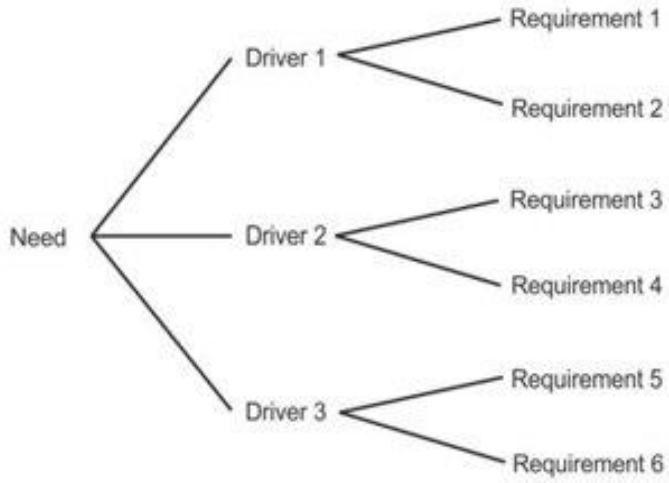
- power/interest matrix

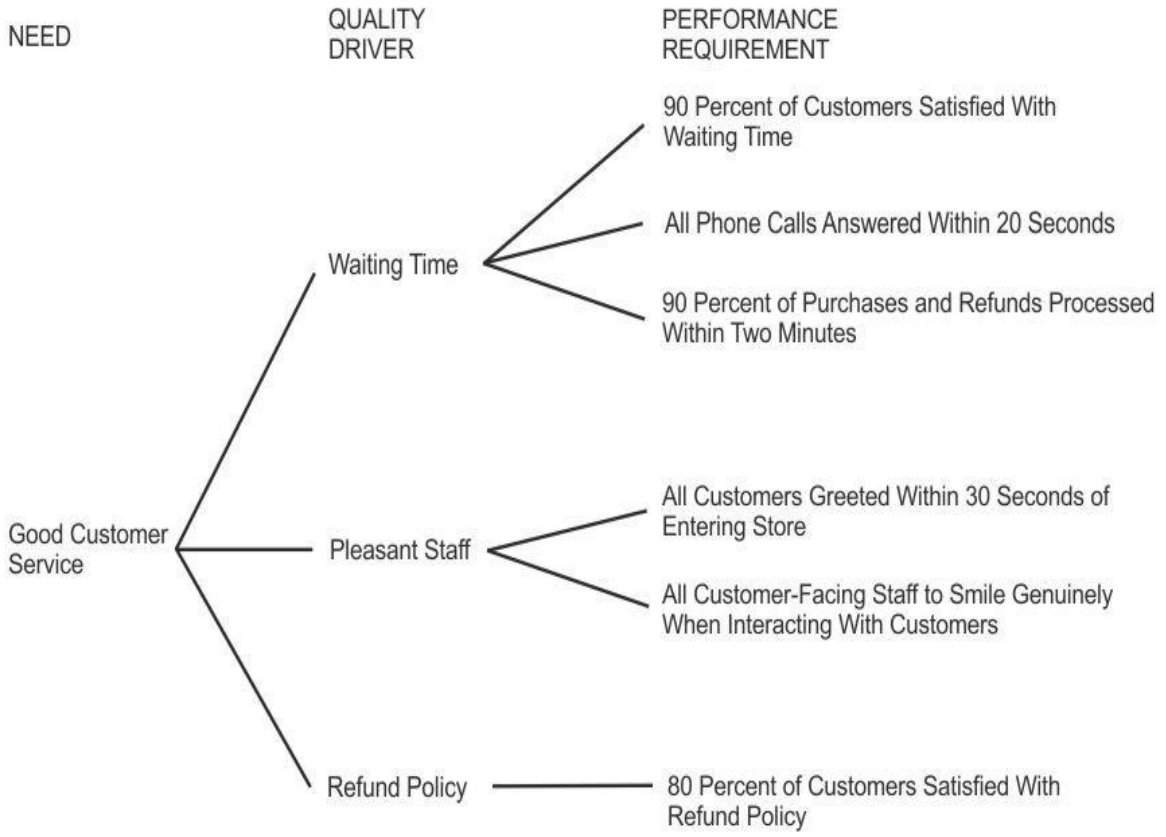


Perform Stakeholder Analysis

Stakeholders	Who They Are?	Potential Impacts/Concerns
EMS	Emergency Medical Services who transport patients to the ED from outside the hospital	Quality of Care Low waiting time Patient Satisfaction
Registration	Register the patient	Correct registration Accurate billing
Regulatory Agencies	Regulatory Agencies who define regulatory criteria.	Quality of Care Revenue Integrity
Administration	Administration of the Hospital	Efficient processes Patient Satisfaction Patient throughput

Critical to Quality Tree (CTQ Tree)



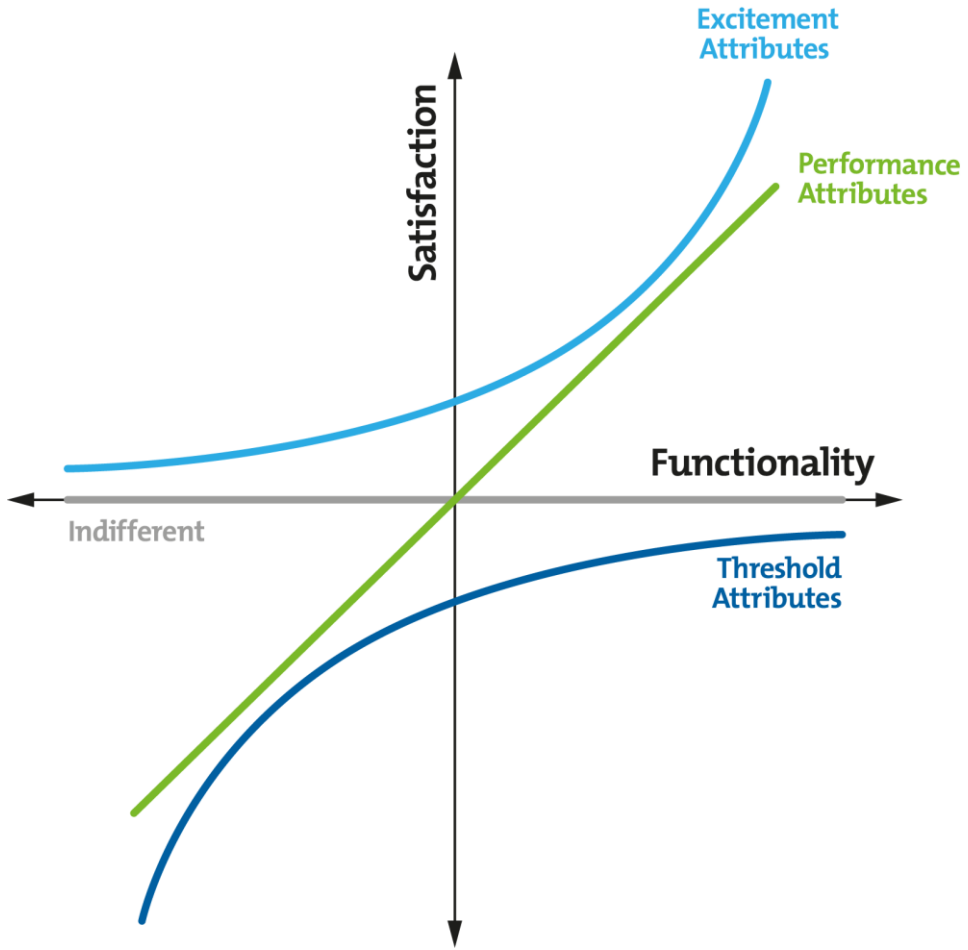


CTS - Hospital and Emergency Department

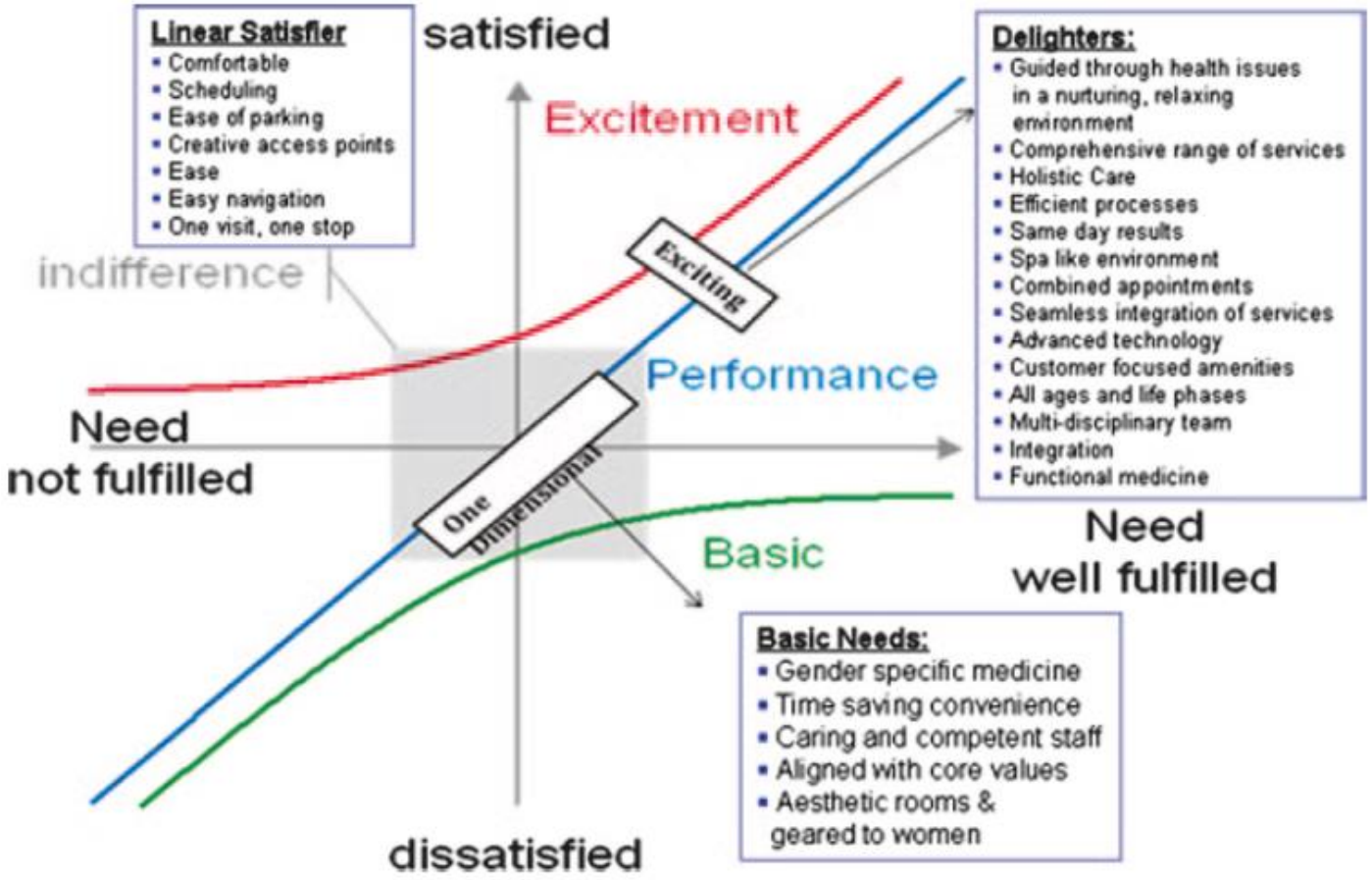
CTS	PERFORMANCE REQUIREMENT (Metric)
Patient throughput time	LOS
Patient Satisfaction	percent of patients leaving without treatment
Quality of Care	quality of care measures
Patient waiting times	waiting to be seen by the EDP, waiting to be tri- aged, waiting for tests or test results, waiting for transportation, and waiting to be a admitted or discharged.
Lab time; Diagnostic time;	Lab time; Diagnostic time;
Admit time; Register time	register time; admit time

Identify Quality Drivers - **Kano Analysis**

- Dr Noriaki Kano - (1984) - Tokyo University of Science



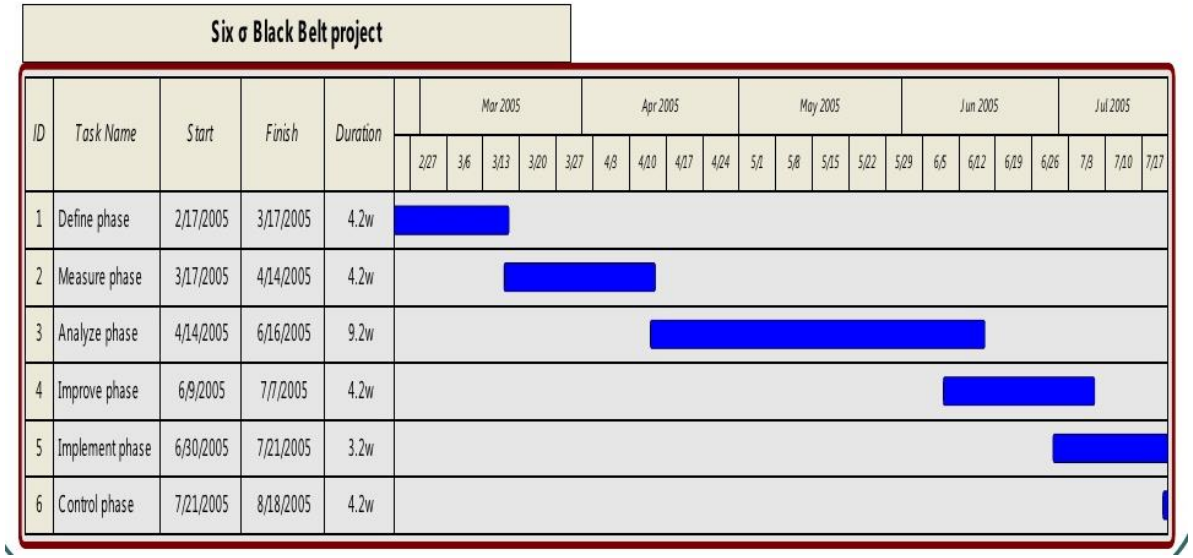
Comprehensive Women's Centers patients - Kano analysis



Select Team and Launch the Project

Role / Responsibility	Team Leader	Black Belt	Champion	Process Owner	Team members
Facilitate meetings	X				
Manage project	X				
Mentor team members	X	X			
Transfer knowledge of Six Sigma tools		X			
Remove roadblocks			X		
Monitor project progress			X		
Approve project			X		
Implement improvements				X	
Subject matter expertise				X	
Apply Six Sigma tools					X
Statistical Analysis					X
Data collection					X

Project time line (Gantt Chart)



Measure Phase - Main activities mapped to the tools or deliverables

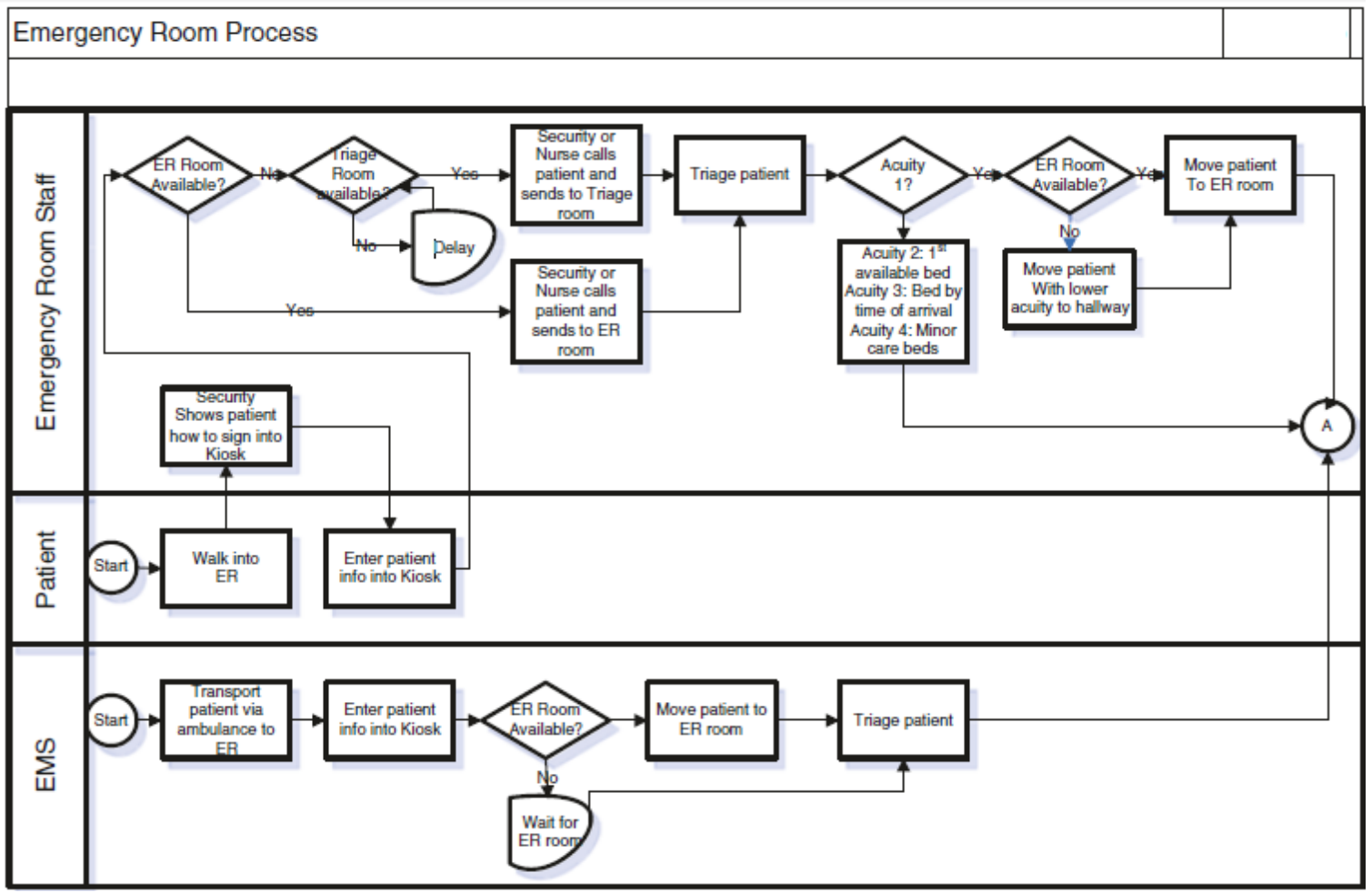
Measure Activities	Tools/Deliverables
Define the current process	• Process Map • Operational definitions • Metrics • Baseline • Data Collection Plan
Define the detailed Voice of Customer (VOC)	• Surveys, Interviews, focus groups • Quality Function Deployment
Define the Voice of Process (VOP) and current performance	• Pareto charts • Benchmarking, check sheets, histograms • Statistics
Define the Cost of Poor Quality (COPQ)	• Cost of Poor Quality

AS-IS Process Map (Define the Current Process)

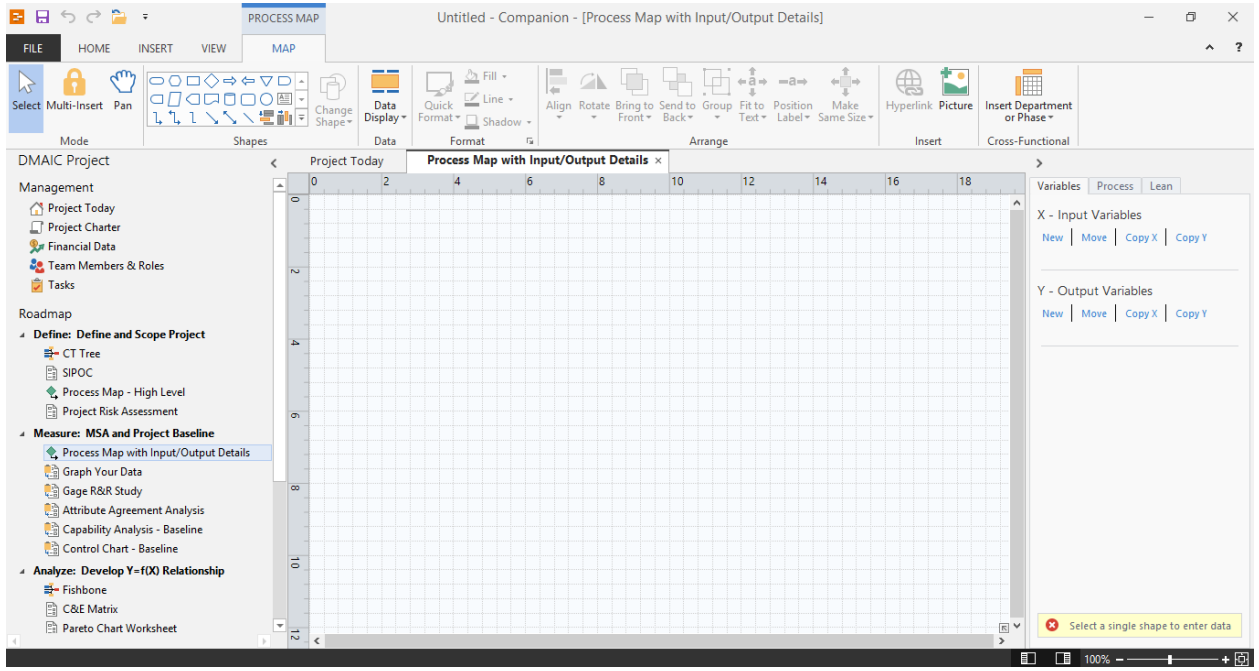
- Process Map symbols (Few)

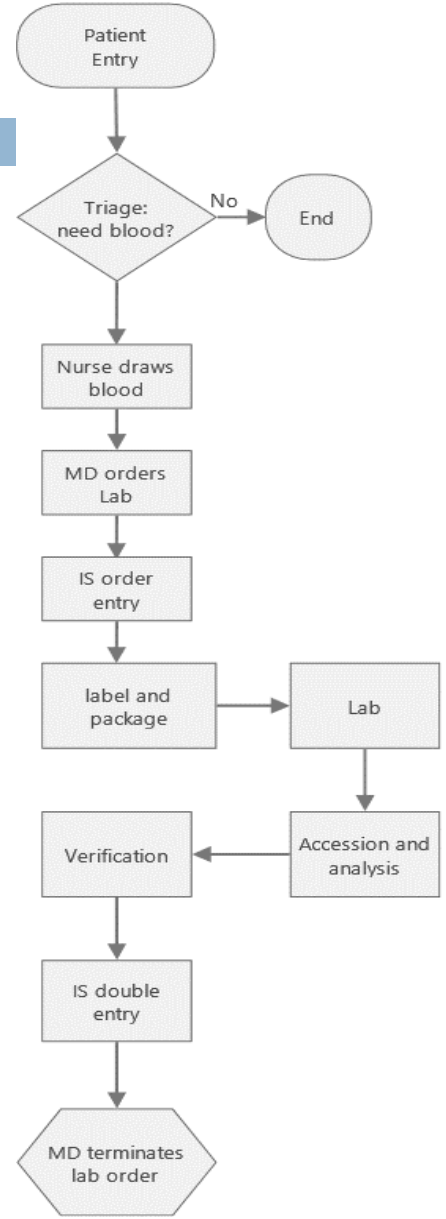
	Start/ Finish		Process (Task/ Activity)
	Decision box		Process connector
	Flow		Delay
	Document		Storage

Process Map Cross-functional or Swim Lane



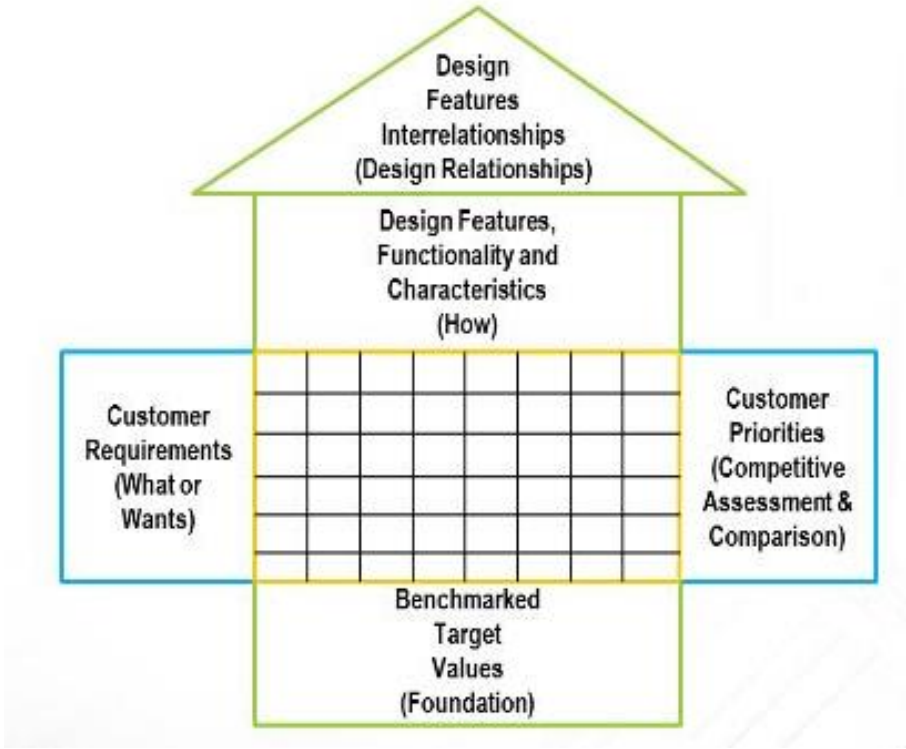
- flow chart of Emergency Room Specimen Processing

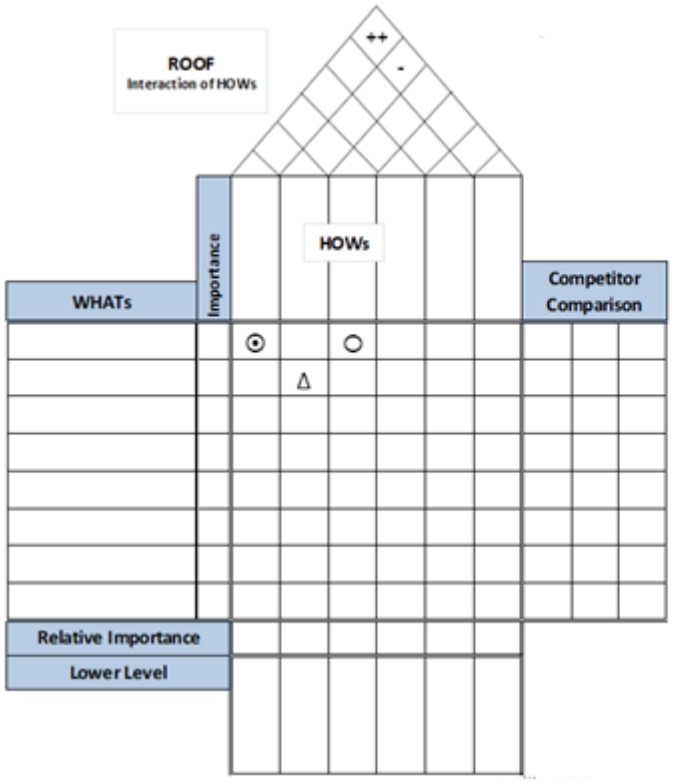




QFD matrix - voice of the customer information

- Yoji Akao – Japan, method to transform qualitative user demands into quantitative parameters (first used in1966)
- customer needs - summarized in a QFD matrix also called as “house of quality”.





Roof Ranking System	
+ +	Strong Positive
+	Positive
	None
-	Negative
- -	Strong Negative

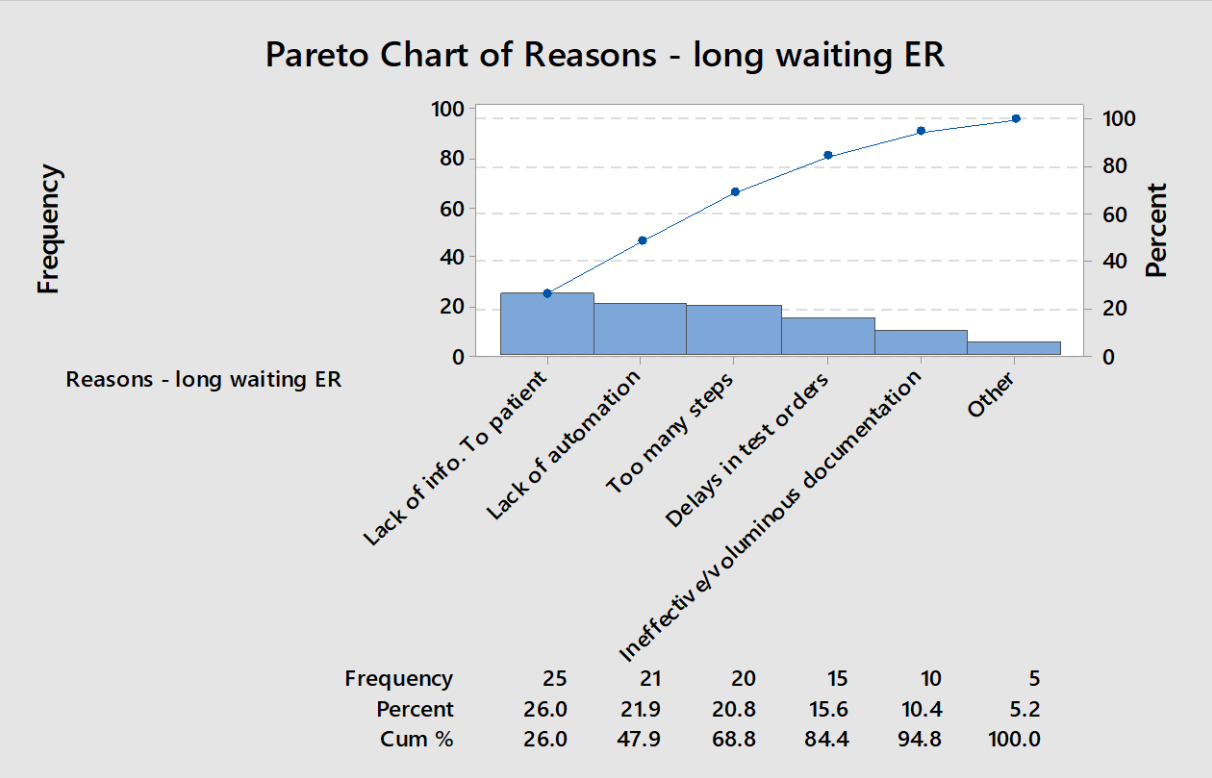
Body Ranking System		
⊙	Strong	9
○	Moderate	3
Δ	Weak	1
	None	0

Voice of the Process (VOP) and Current Performance

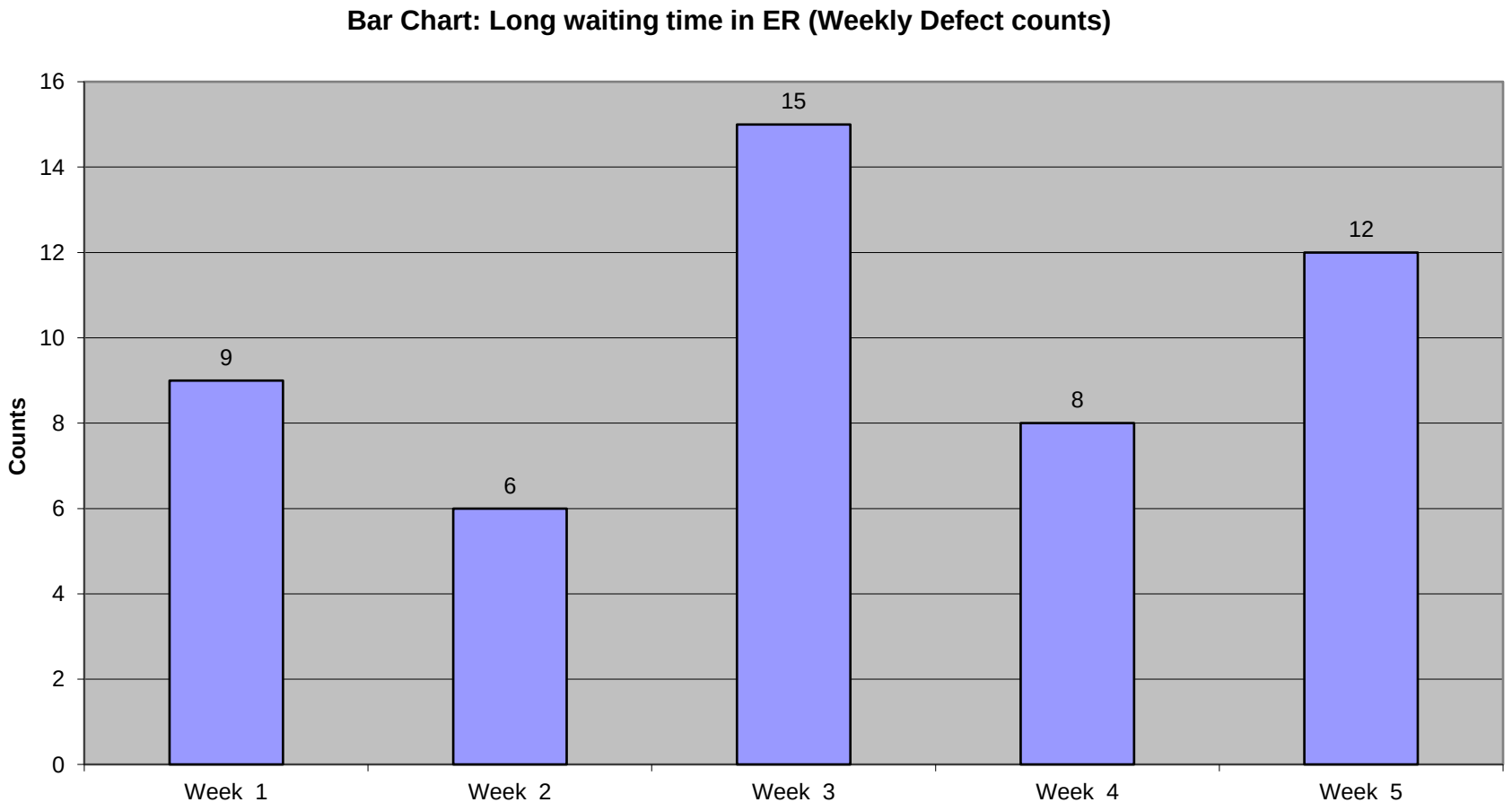
The most common statistical measures of a process are mean, maximum and minimum, and standard deviation etc., which is known as "voice of the process" (VoP).

The best way to discover the VOP is to plot it on a control chart

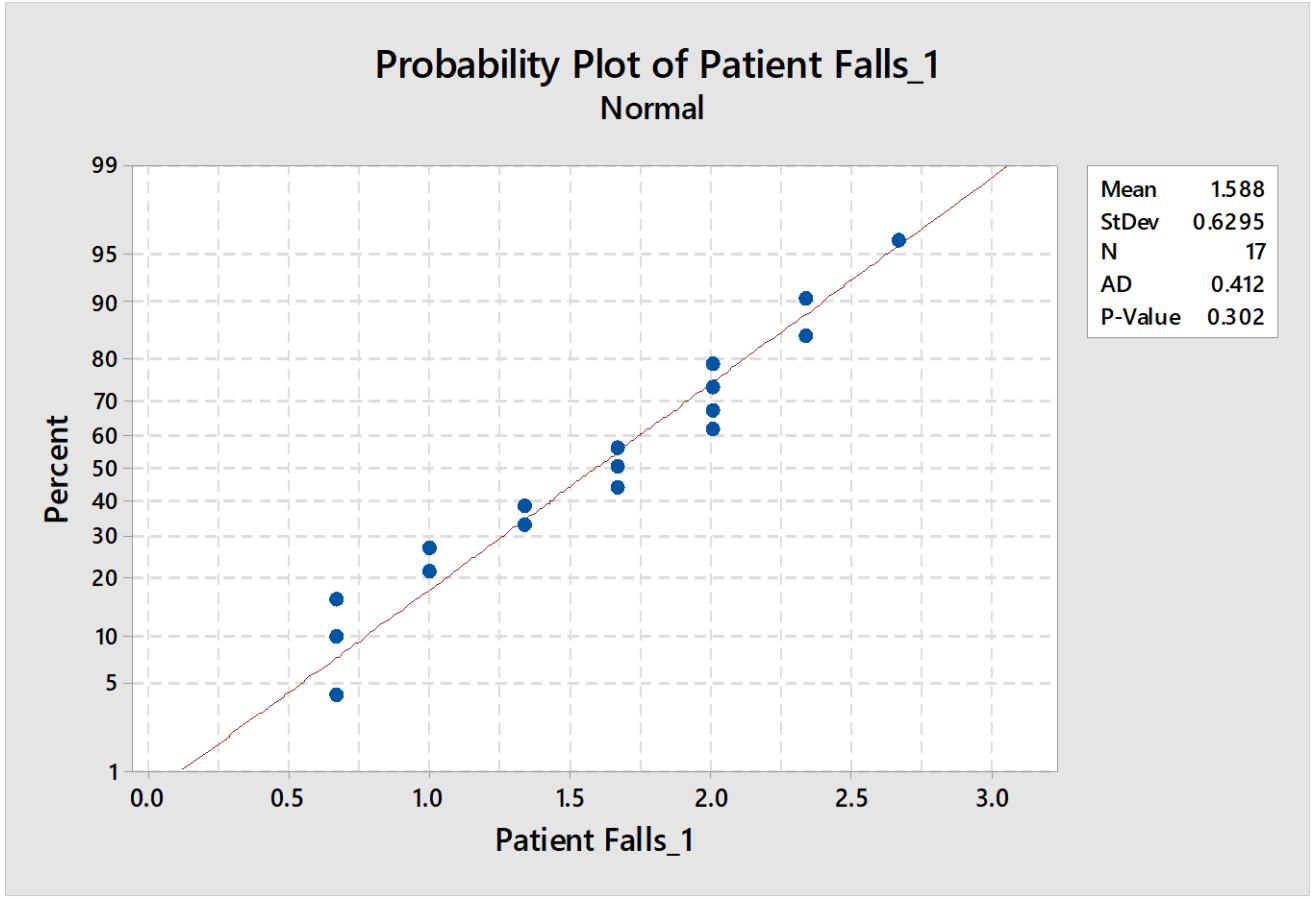
Pareto Chart - A Pareto chart helps to identify critical areas causing the majority of the problems



Bar chart

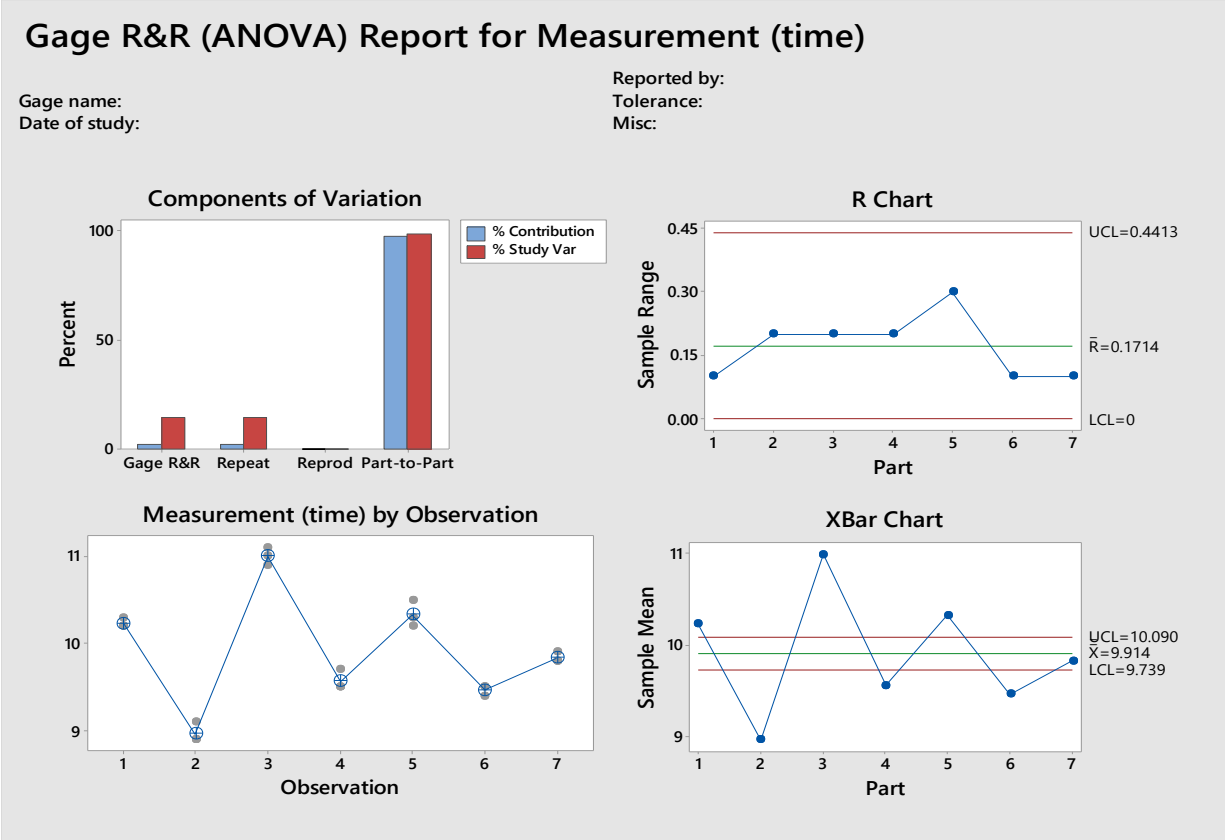

Bar Chart: Long waiting time in ER (Weekly Defect counts)
Counts
16
14
12
10
8
6
4
2
0
9
6
15
8
12
Week 1
Week 2
Week 3
Week 4
Week 5

Normality test using Minitab



If the P value is greater than .05, we can assume that the data is normal

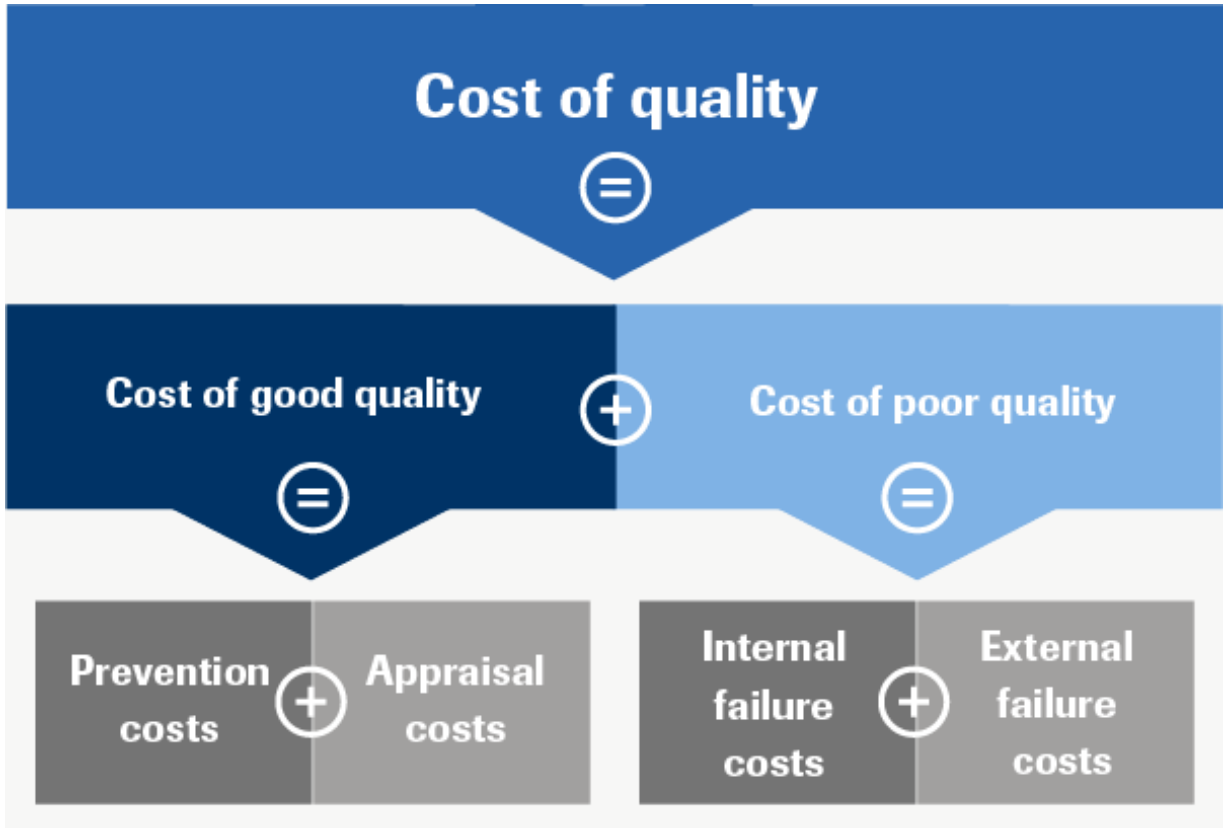
Gage Repeatability & Reproducibility (R&R) study



variation is less than 10%

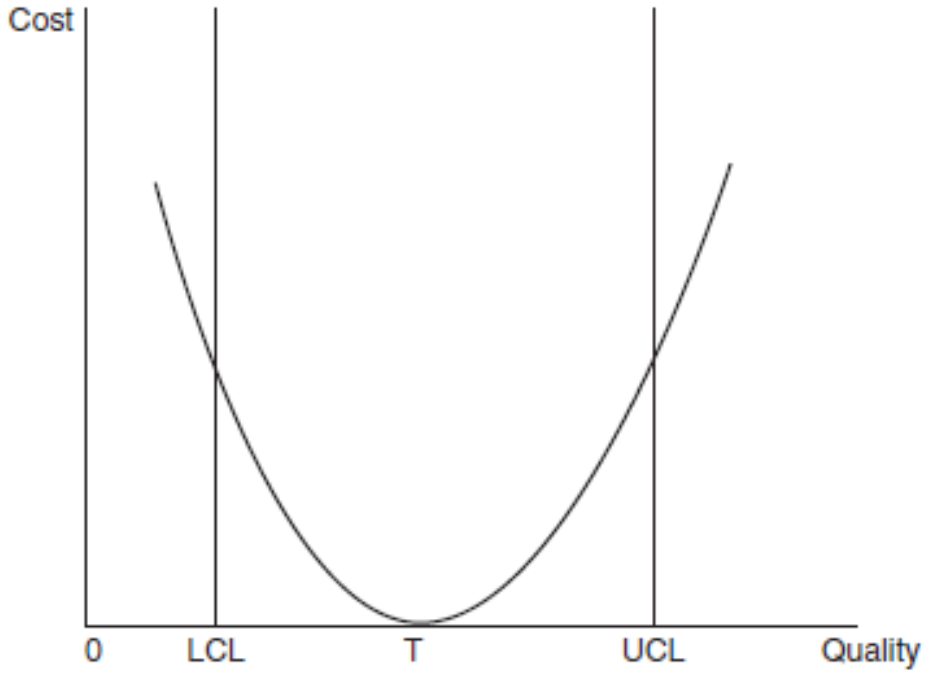
Define the Cost of Poor Quality (COPQ)

- Phil Crosby - 'Quality is Free'
- COPQ - defects, errors, and wastes



Cost of Quality According to Taguchi

- Loss function is quadratic..

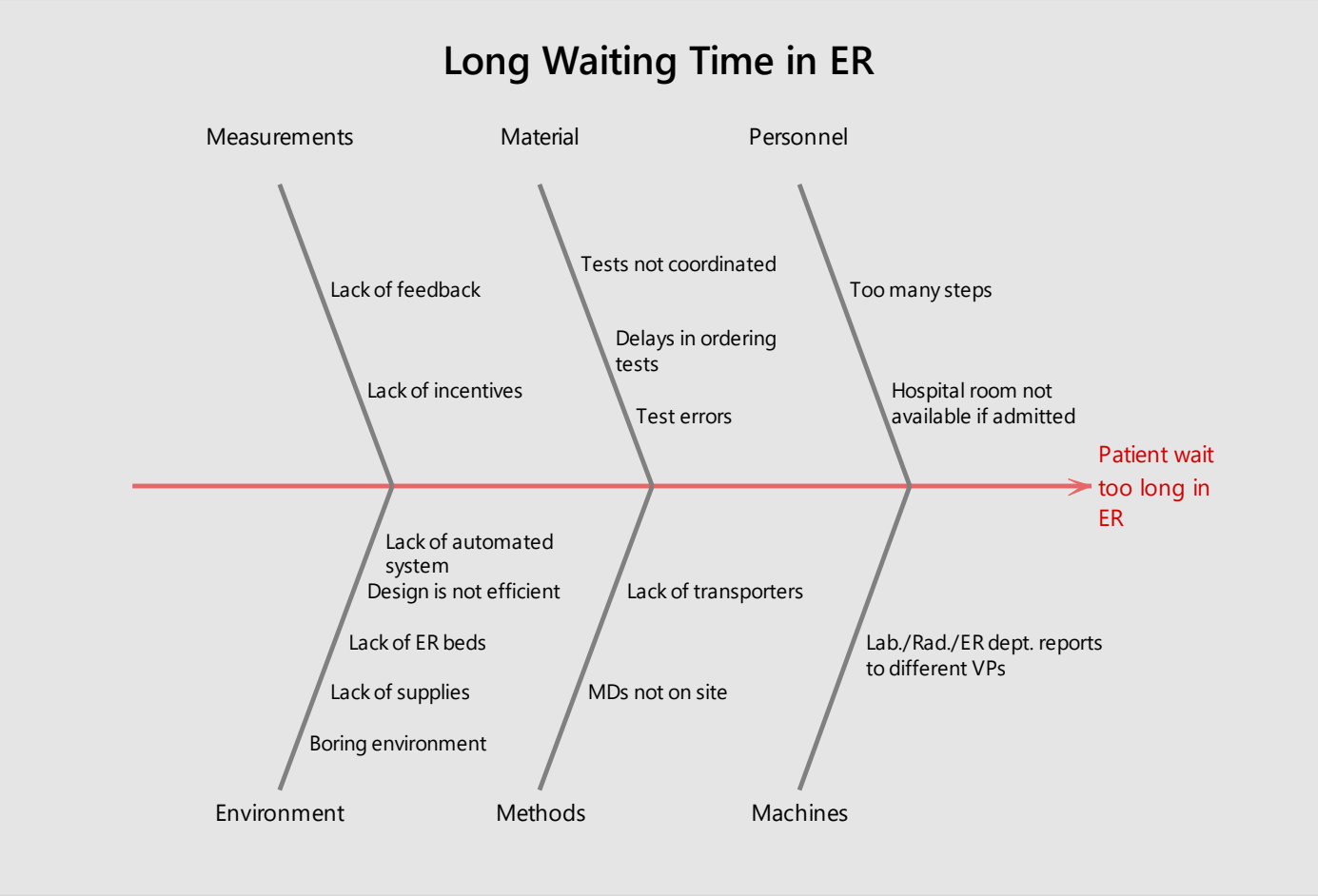


Analyze Phase

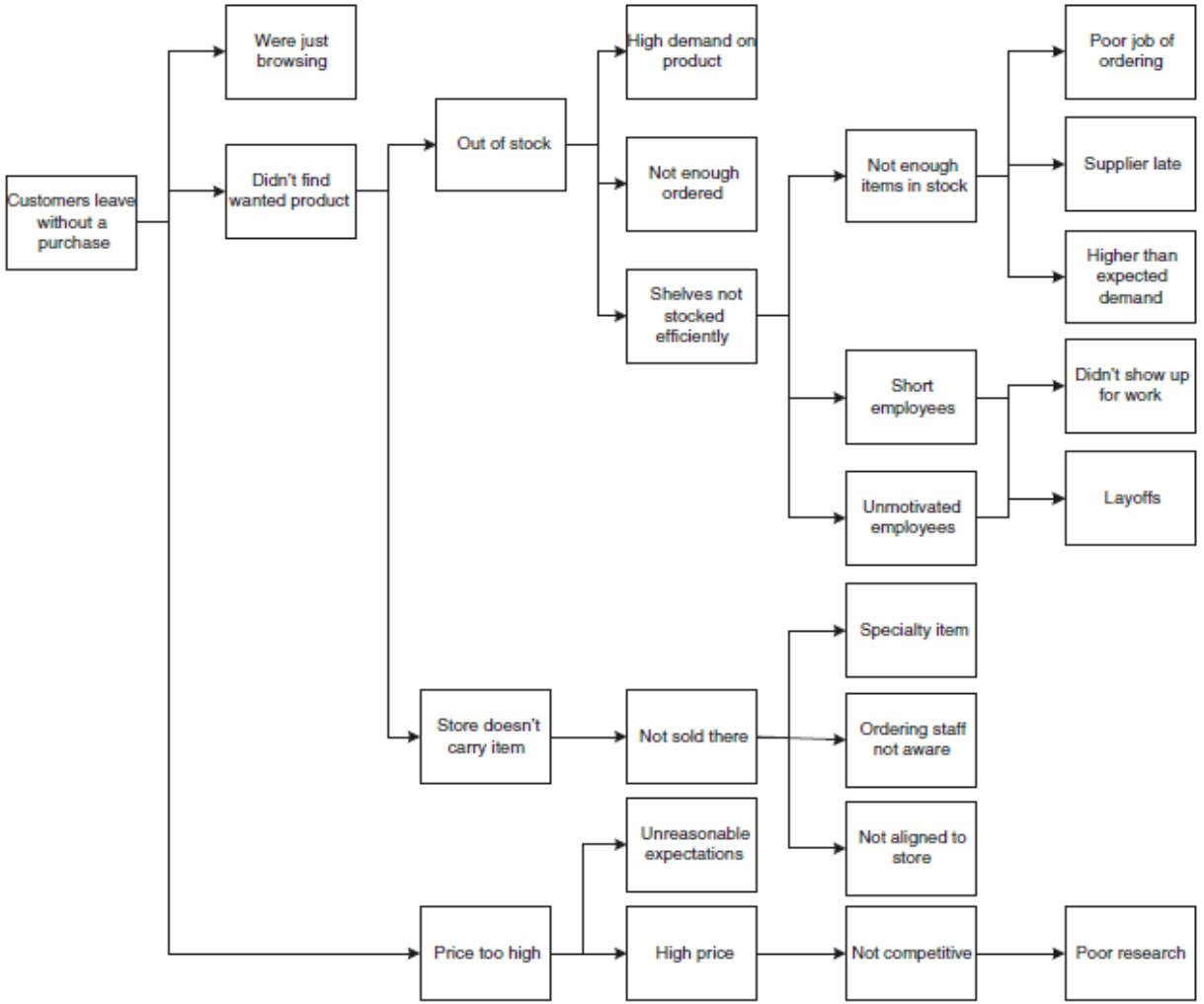
Analyze Activities	Deliverables
Develop cause and effect relationships	Cause and Effect Diagrams Why-Why Diagram
Validate root causes	Histograms, Graphical Analysis, waste elimination, Value Stream Map, 5S, JIT, Standard Time, Kaizen, FMEA, Correlation analysis, regression analysis, Basic Statistics, Confidence Intervals, Hypothesis testing, ANOVA etc.
Process Capability	DPMO

Cause and Effect Relationships

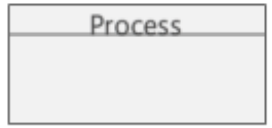
Cause and Effect Diagram



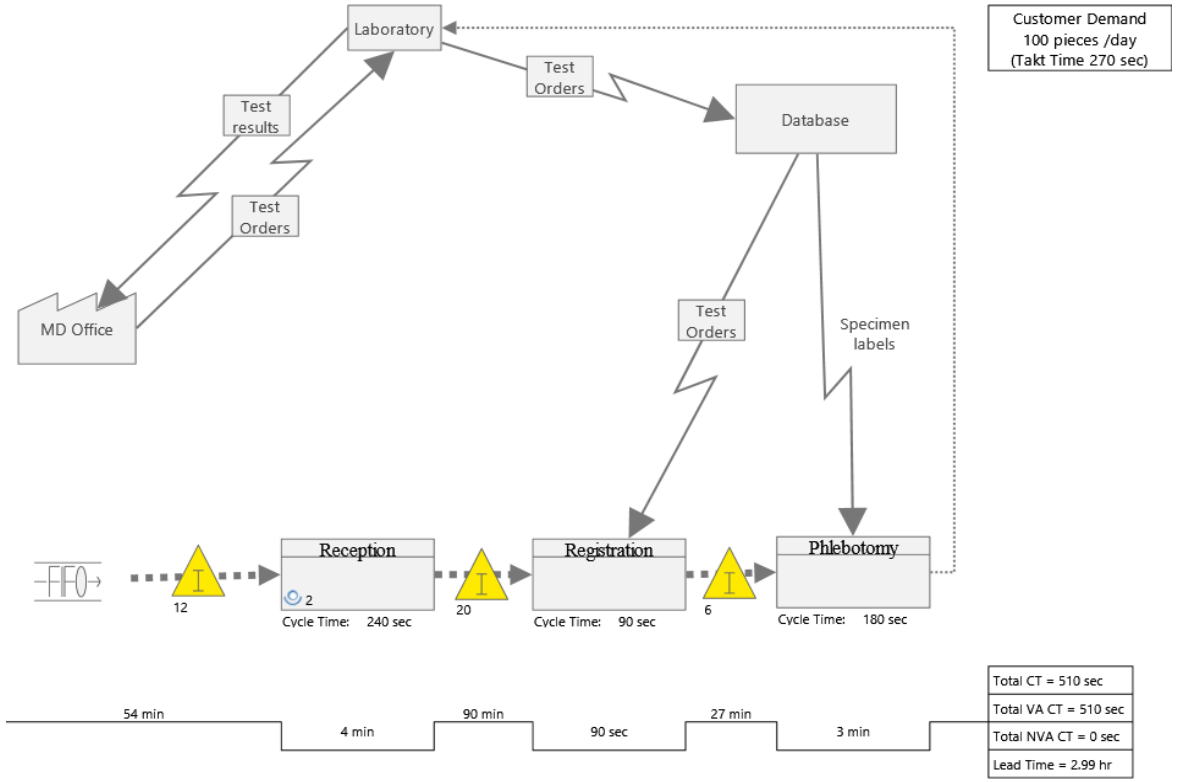
Why–Why Diagram

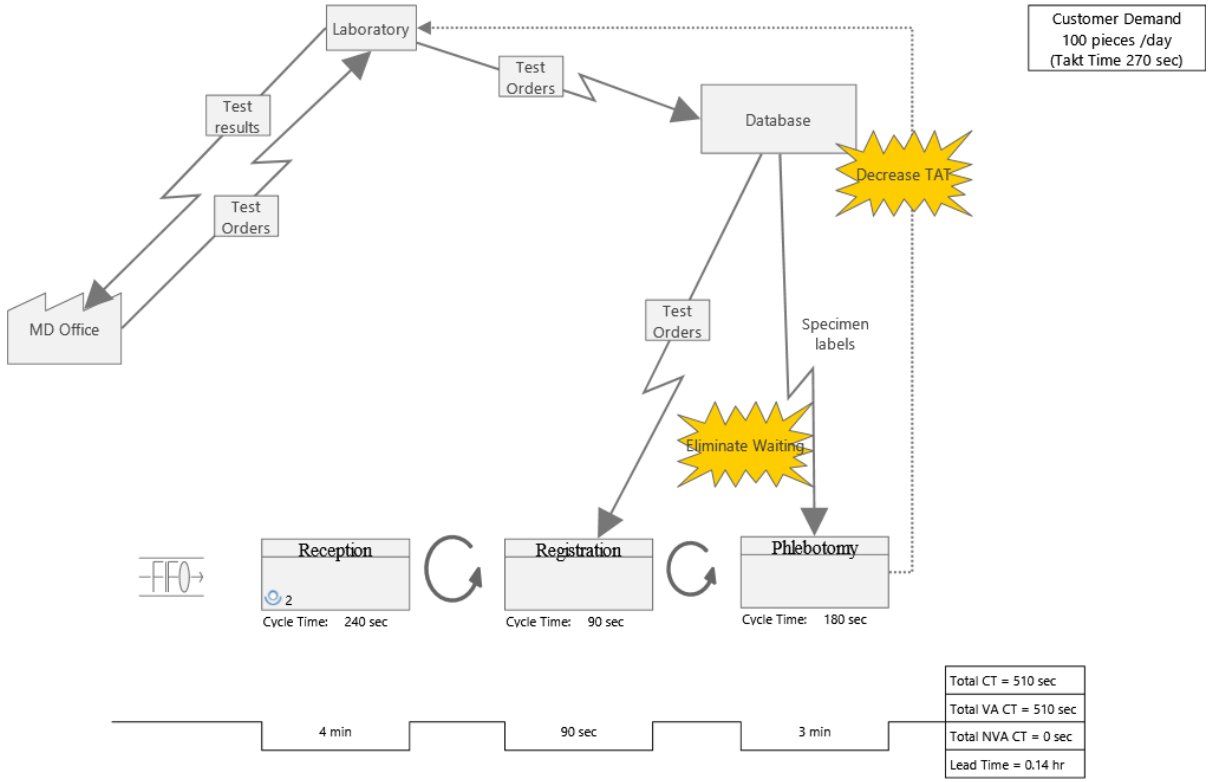


Value Stream Map – Basic Shapes

	Process		Push Arrow
	Manual information flow		Electronic information flow
	Kaizen event (improvement)		Pull
	First-In-First-Out system		Outside sources e.g. Suppliers

Value Stream Mapping - Measure & Improve Phase of DMAIC





Future state map

Toyota Standard Work Combination Chart

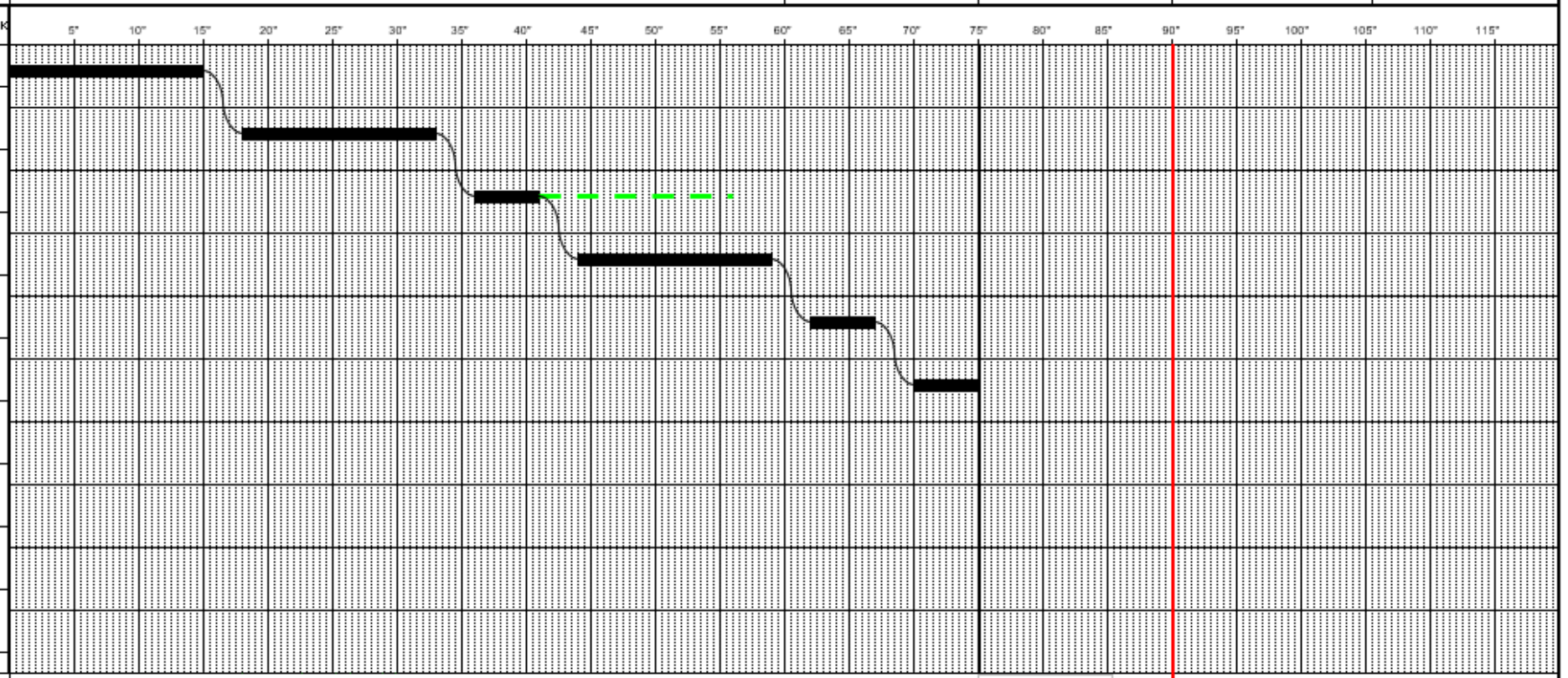
Standardized Work 2: Standardized Work Combination Table

Standardized Work Combination Table	From:	Date:	Required Units per Shift:	Hand / Walk / Auto
	To:	Area:	Takt Time:	

Work Elements	Time (sec.) Hand	Auto	Walk	Seconds 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Totals		Waiting		5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 Seconds

PART NO		STANDARDIZED WORK COMBINATION TABLE SHEET	TAKEN BY		TYPE	
PROCESS			DATE TAKEN		PCS / DAY	
			SEC. / LINE		LINE TAKT TIME	

NO	WORK NAME	MAN	AUTO	WALK
1	Take Order	15.0		
2	Prep lemons	15.0		3.0
3	Juice lemons	5.0	15.0	3.0
4	Mix Ingredients	15.0		3.0
5	Add lemon juice	5.0		3.0
6	Serve Customer	5.0		3.0
TOTAL		60.0	Wait 0.0	15.0



= Manual = Automatic
= Walking = Waiting

SWCT

STANDARD TIME

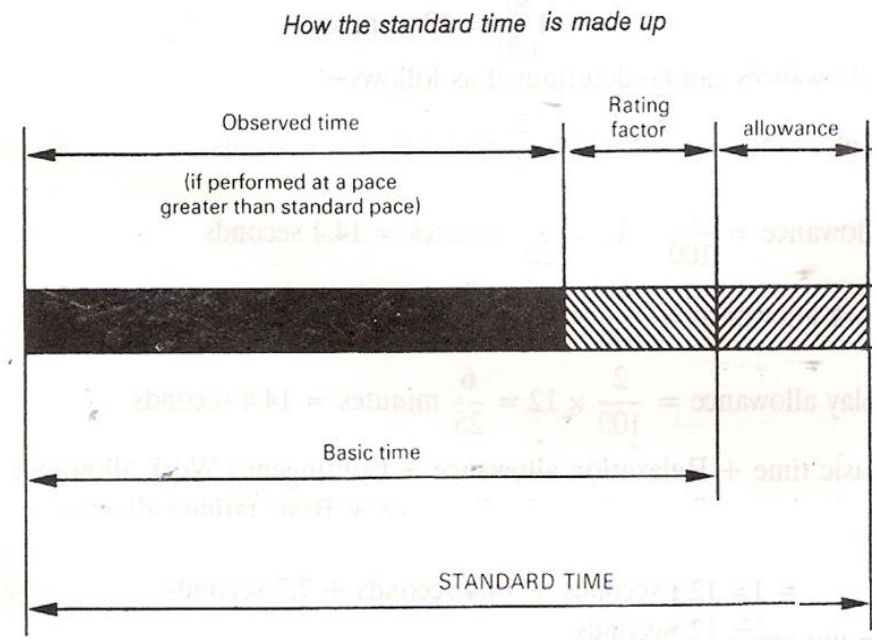


TABLE 1. Typical Allowance Percentages for Varying Health Care Delivery Working Conditions.

Allowance Level	Percent
1. Basic-low (personal, fatigue, standing)	11
2. Basic-moderate (basic-low and mental strain)	12
3. Basic-high (basic-moderate and slightly uncomfortable heat/cold or humidity	14
4. Medium-low (basic high and awkward position)	16
5. Medium-moderate (medium-low and lifting requirements up to 20 lbs.)	19
6. Medium-high (medium-moderate and loud noise)	21
7. Extensive-low (medium-high and tedious nature of work)	23
8. Extensive-medium (extensive-low and with complex mental strain)	26
9. Extensive-high (extensive-medium and lifting requirement up to 30 lbs.)	28

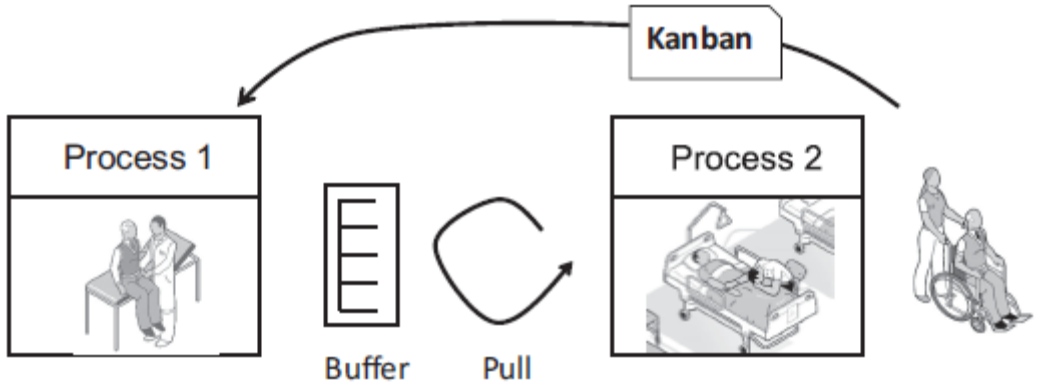
Source: Adapted from B. W. Niebel, 1988.

TABLE 3. Observed and Normal Time Calculations for Nursing Unit Activities.

(1)	(2)	(3)						(4)	(5)
Nursing Unit Activities	Performance Rating	Sample Observed Times in Minutes						Observed Time	Normal Time (NT)
	(PR)	1	2	3	4	5	6	(OT)	OT * PR
1. Patient assessment	1.08	12	11	12	9	13	12	11.50	12.42
2. Care planning	0.95	9	7	6	8	7	9	7.67	7.28
3. Treatments	1.12	8	8	7	9	10	11	8.83	9.89
4. Medication	1.05	4	3	4	5	6	4	4.33	4.55
5. Collecting blood/lab specimens	1.10	8	7	6	9	10	7	7.83	8.62
6. Passing/collecting trays, snacks, feeding patients	1.20	18	21	18	19	21	20	19.50	23.40
7. Shift report	0.97	5	6	5	7	8	6	6.17	5.98
8. Charting/documentation	0.98	8	5	6	8	9	10	7.67	7.51
9. Responding to patients' call lights	1.15	4	3	3	5	6	5	4.33	4.98
10. Staff scheduling phone calls	0.95	5	4	4	5	6	7	5.17	4.91
11. Phone calls to/from other departments	0.96	6	5	5	4	6	7	5.50	5.28
12. Transporting patients, specimens etc.	1.05	9	11	12	11	9	10	10.33	10.85
13. Patient acuity classification	1.11	5	6	5	6	7	4	5.50	6.11
14. Attending educational in-services	1.00	75	75	75	75	75	75	75.00	75.00
15. Order transcription and processing	0.94	5	6	4	6	7	6	5.67	5.33
16. Ordering/stocking supplies and lines	0.98	6	4	5	6	7	4	5.33	5.23
17. Equipment maintenance and cleaning	0.95	9	11	8	9	11	10	9.67	9.18
18. General cleaning/room work (garbage, making beds etc.)	1.15	12	9	12	10	9	11	10.50	12.08
19. Assisting with the admission process	1.06	11	9	10	9	8	9	9.33	9.89
20. Breaks/personal time (not including lunch)	1.00	15	15	15	15	15	15	15.00	15.00
								234.83	243.49
								Job—OT	Job—NT

$$ST = NT \times AF = 243.49 \times 1.26 = 306.80 \text{ minutes or } 5.1 \text{ hours}$$

Pull the care process with kanban

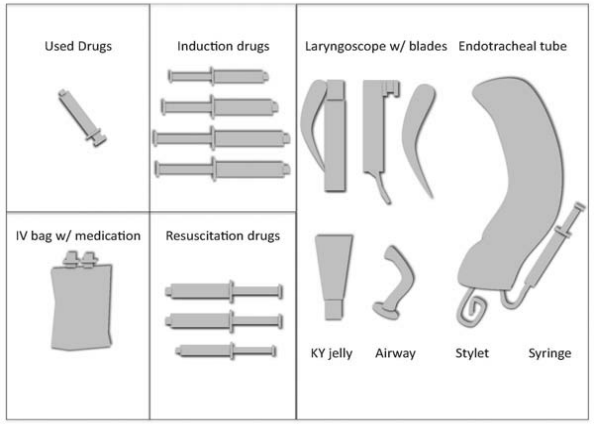


The patient is "pulled" by the next downstream process, but only when it is ready to serve the patient. When Process 2 discharges a patient, a kanban card is sent to Process 1.

Courtesy of Toyota, supply systems throughout the world are now run as efficiently as American supermarkets.

5S for Healthcare

- Workplace organization method - list of five Japanese words: seiri, seiton, seisō, seiketsu, and shitsuke
- "Sort", "Set In order", "Shine", "Standardize" and "Sustain“



Healthcare Failure Mode and Effect Analysis (FMEA)

Failure mode and effect analysis form

Process Step	Potential Failure Mode	Potential Effects of Failure	SEVERITY	Potential Causes of Failure	OCCURRENCE	Current Process Controls	DETECTION	RPN	Recommended Action

RPN = Severity x Occurrence x Detection

Criticality = Severity x Occurrence

Sigma to DPMO conversion (assuming 1.5 sigma shift)

Sigma Level	DPMO
6 σ	3.4 DPMO
5 σ	233 DPMO
4 σ	6,210 DPMO
3 σ	66,810 DPMO
2 σ	308,770 DPMO
1 σ	691,462 DPMO

DPMO = (Defects × 1, 000, 000) / (Units × Opportunities)

Dashboards/Scorecards

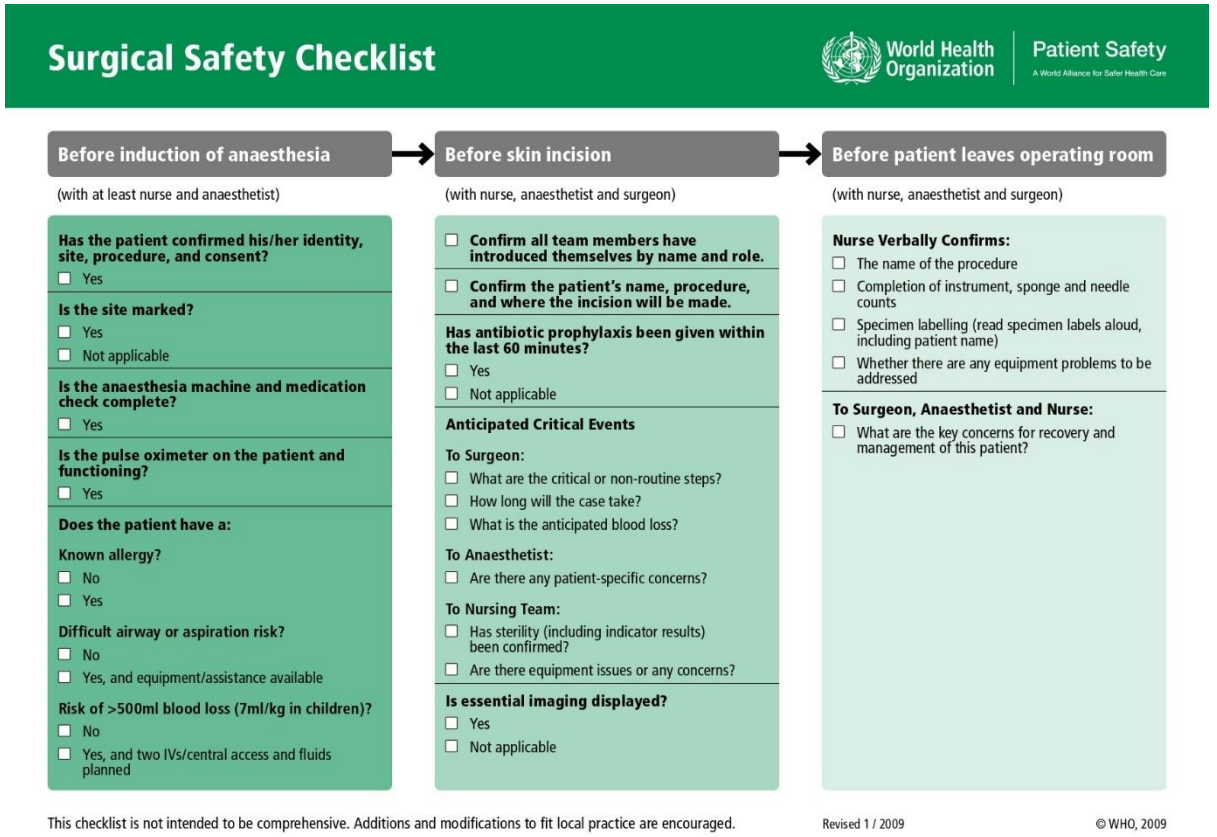
- Emergency services value chain metrics dashboard example

	Baseline		Target		Improved		% Improvement	
	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged
Total LOS:	8.7hrs	5.8 hours	5 (43%)	3 (48%)	5.6	3.9	36%	33%
% LWBS:	6.50%		3.50%		0.51%		92%	
Total Time to EDP:	93	109	35	35	26		75%	
Triage Time:	34	34	15	15	11		68%	
Wait time triage to EDP:	65	79	20	20	20		73%	
Time to ED Bed:	61	81	35	42	13		82%	
Bed to Physician	34	55	20	20	13		72%	
Treat/Diagnose to Disposition Time:	192	175	109	91	161		11%	

Improve & Control Phase

- ✓ Measure results and manage change
- ✓ Hypothesis tests
- ✓ Statistics, Mistake Proofing, FMEA
- ✓ Run Charts, Control Charts, Process Capability, DPMO
- ✓ Standard Work, Kaizen (PDCA)
- ✓ Dashboards, Scorecards

Mistake-Proofing Checklists



Surgical Safety Checklist

World Health Organization | Patient Safety
A World Alliance for Safer Health Care

Before induction of anaesthesia
(with at least nurse and anaesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
- ☐ Yes

Is the site marked?
- ☐ Yes
- ☐ Not applicable

Is the anaesthesia machine and medication check complete?
- ☐ Yes

Is the pulse oximeter on the patient and functioning?
- ☐ Yes

Does the patient have a:

Known allergy?
- ☐ No
- ☐ Yes

Difficult airway or aspiration risk?
- ☐ No
- ☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
- ☐ No
- ☐ Yes, and two IVs/central access and fluids planned

Before skin incision
(with nurse, anaesthetist and surgeon)

- ☐ **Confirm all team members have introduced themselves by name and role.**
- ☐ **Confirm the patient's name, procedure, and where the incision will be made.**

Has antibiotic prophylaxis been given within the last 60 minutes?
- ☐ Yes
- ☐ Not applicable

Anticipated Critical Events

To Surgeon:
- ☐ What are the critical or non-routine steps?
- ☐ How long will the case take?
- ☐ What is the anticipated blood loss?

To Anaesthetist:
- ☐ Are there any patient-specific concerns?

To Nursing Team:
- ☐ Has sterility (including indicator results) been confirmed?
- ☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
- ☐ Yes
- ☐ Not applicable

Before patient leaves operating room
(with nurse, anaesthetist and surgeon)

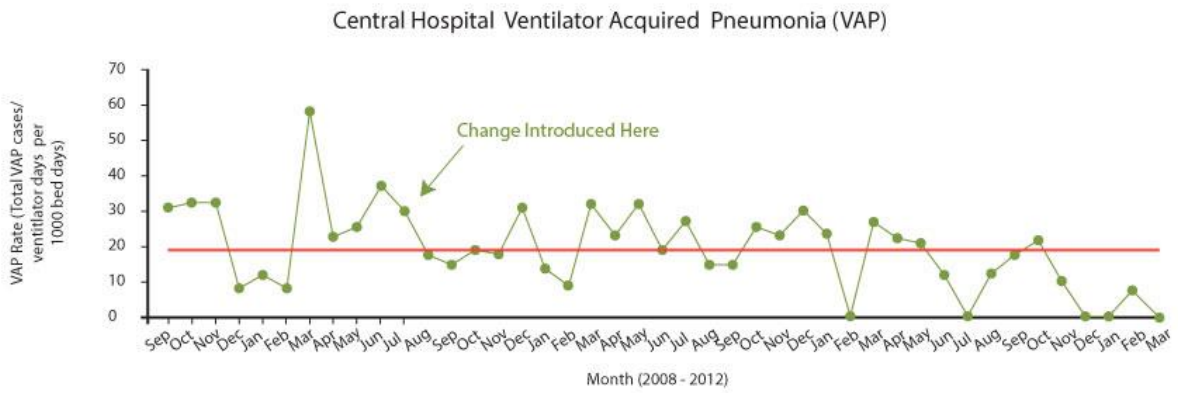
Nurse Verbally Confirms:
- ☐ The name of the procedure
- ☐ Completion of instrument, sponge and needle counts
- ☐ Specimen labelling (read specimen labels aloud, including patient name)
- ☐ Whether there are any equipment problems to be addressed

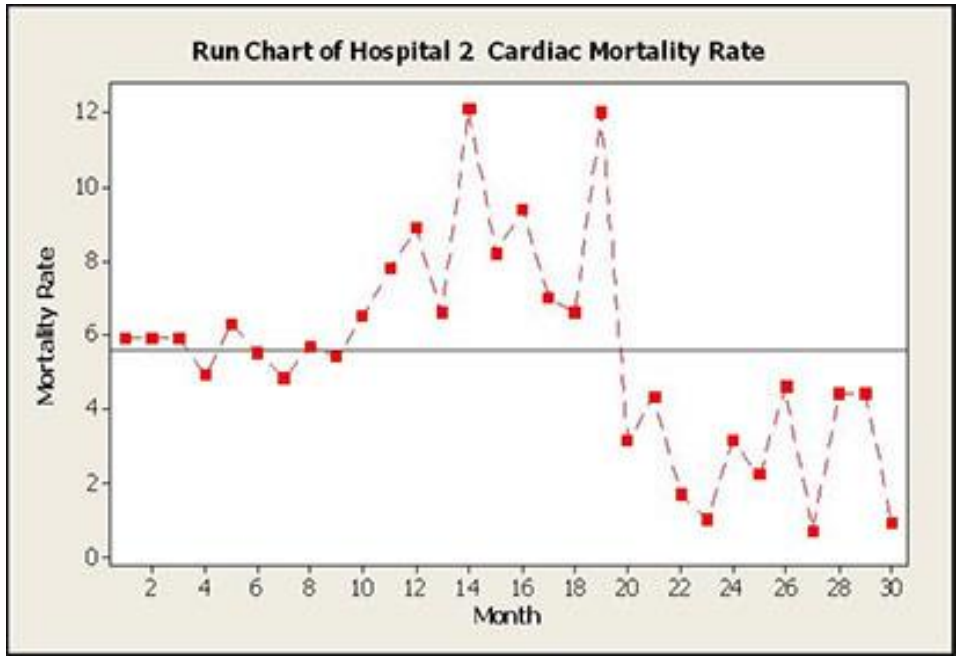
To Surgeon, Anaesthetist and Nurse:
- ☐ What are the key concerns for recovery and management of this patient?

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged.

Revised 1 / 2009

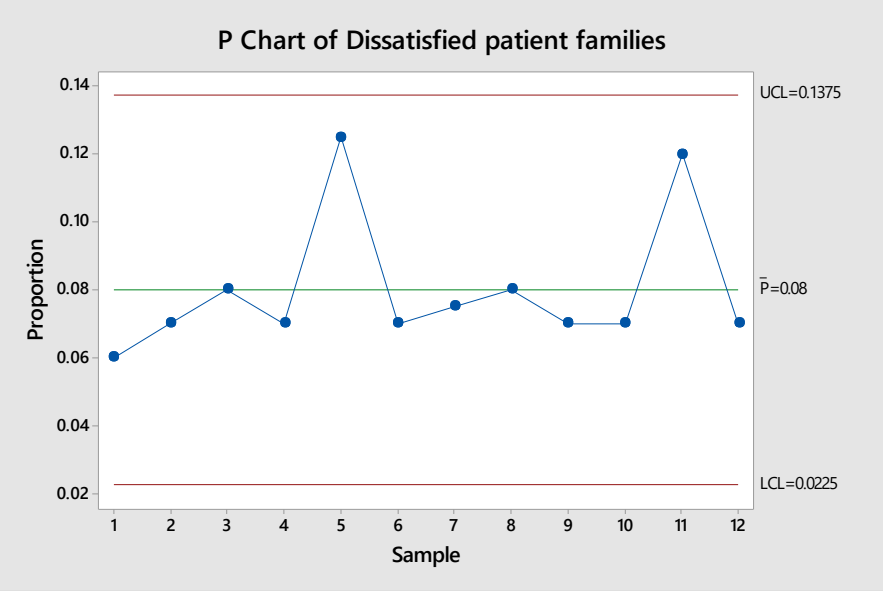
Run Charts

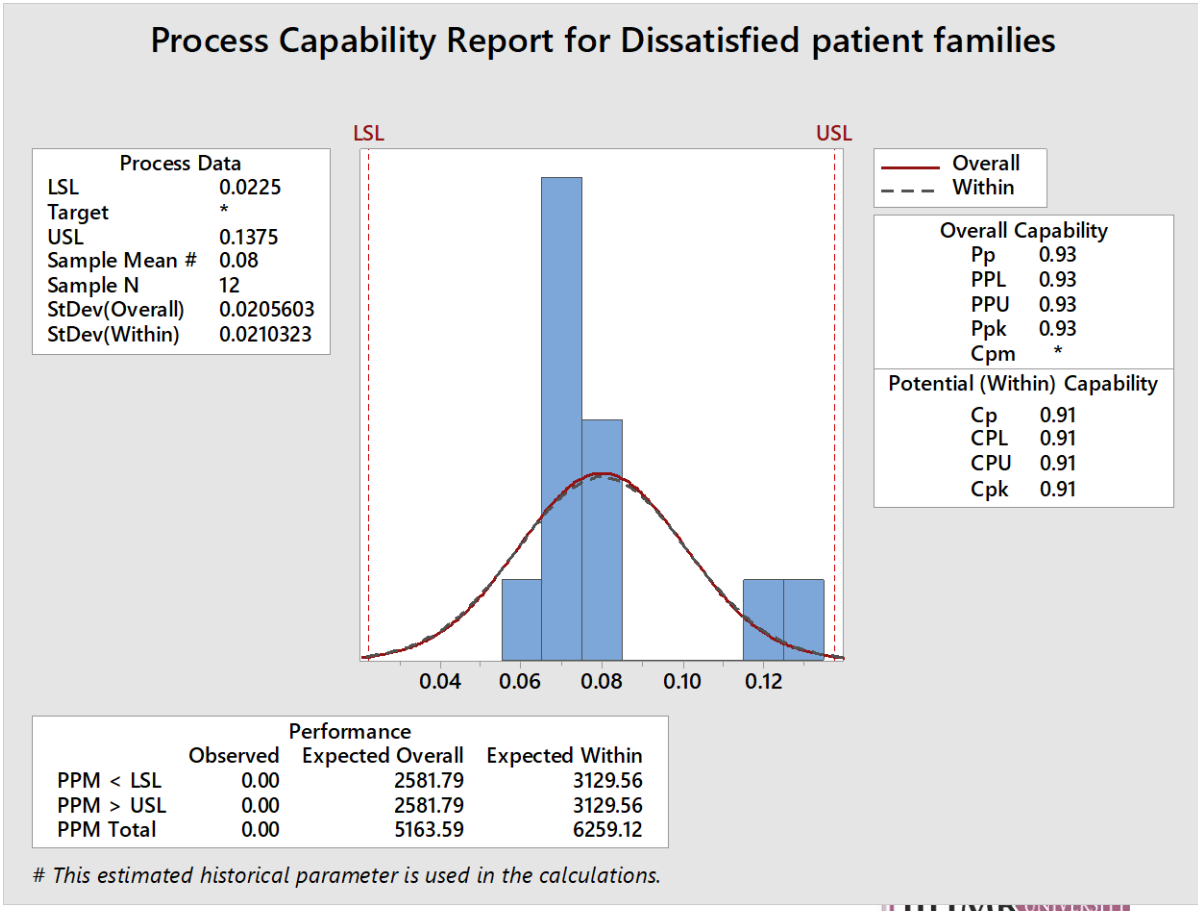

Central Hospital Ventilator Acquired Pneumonia (VAP)
VAP Rate (Total VAP cases/ ventitlator days per 1000 bed days)
Change Introduced Here
Month (2008 - 2012)


Run Chart of Hospital 2 Cardiac Mortality Rate
Mortality Rate
Month

Statistical Process Control (SPC) Charts

Most Common Attributes Charts	Most Common Variables Charts
P-charts (proportion non-conforming) C-charts (number of non-conformities)	X-bar and R-charts (average and range)





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THANK YOU...