Knowledge Institute of Technology, Salem.

Department of Mechanical Engineering

TOTAL QUALITY MANAGEMENT

UNIT – I

What is Quality ?

- *Quality* is the degree to which a commodity meets the requirements of the customer .
- Quality is in its essence a way of management of the organization.
- A distinctive attribute or characteristic possessed by someone or something.

What is Quality ?

- Quality is conformance to customer requirements
- *Quality* is about meeting the minimum standard required to satisfy customer needs.
- Quality is fitness for use
- Quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated and implied needs of customer.

Quality In an information technology product or service

- *quality* is sometimes defined as "meeting the requirements of the customer."
- The term *quality* assurance describes any systematic process for ensuring *quality* during the successive steps in developing a product or service.

Quality in management

- A **quality management system** (QMS) is a collection of business processes focused on achieving **quality** policy and **quality** objectives to meet customer requirements

Quality In manufacturing

- a measure of excellence or a state of being free from defects, deficiencies and significant variations.

Quality in education

- **Quality in education** is a dynamic concept. It evolves with time and is subject to social, economic and environmental conditions.
- However, international human rights law provides a general legal framework that guarantees **quality education**.

Quality in Software

- *Software quality* is a field of study and practice that describes the desirable attributes of software products.

In business

- *quality* has a pragmatic interpretation as the non-inferiority or superiority of something.

Need for quality

- ***Competition*** – Today's market demand high quality products at low cost. Having `high quality' reputation is not enough! Internal cost of maintaining the reputation should be less.
- ***Changing customer*** – The new customer is not only commanding priority based on volume but is more demanding about the "quality system."

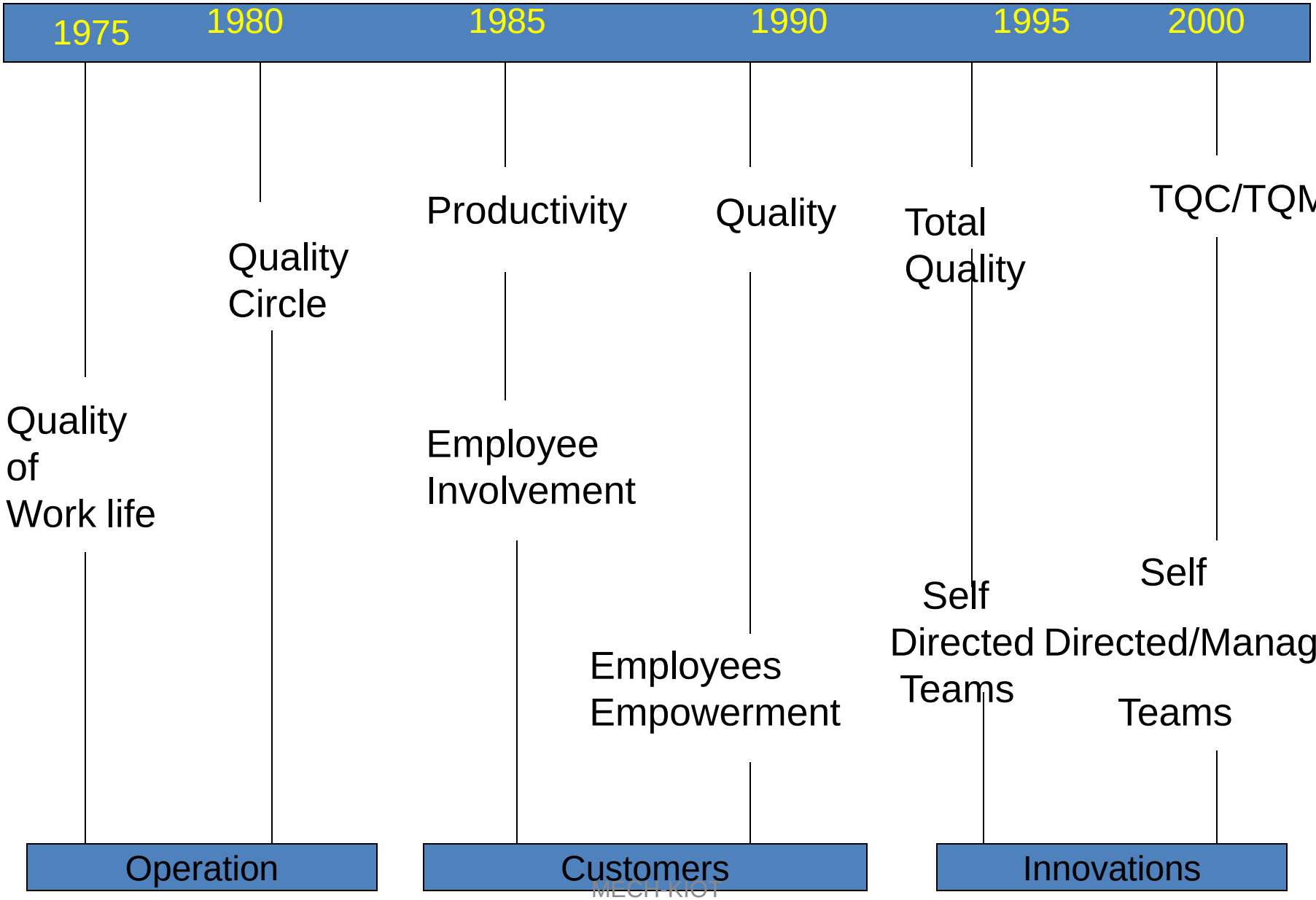
Need for quality

- ***Changing product mix*** – The shift from low volume, high price to high volume, low price have resulted in a need to reduce the internal cost of poor quality.
- ***Product complexity*** – As systems have become more complex, the reliability requirements for suppliers of components have become more stringent.

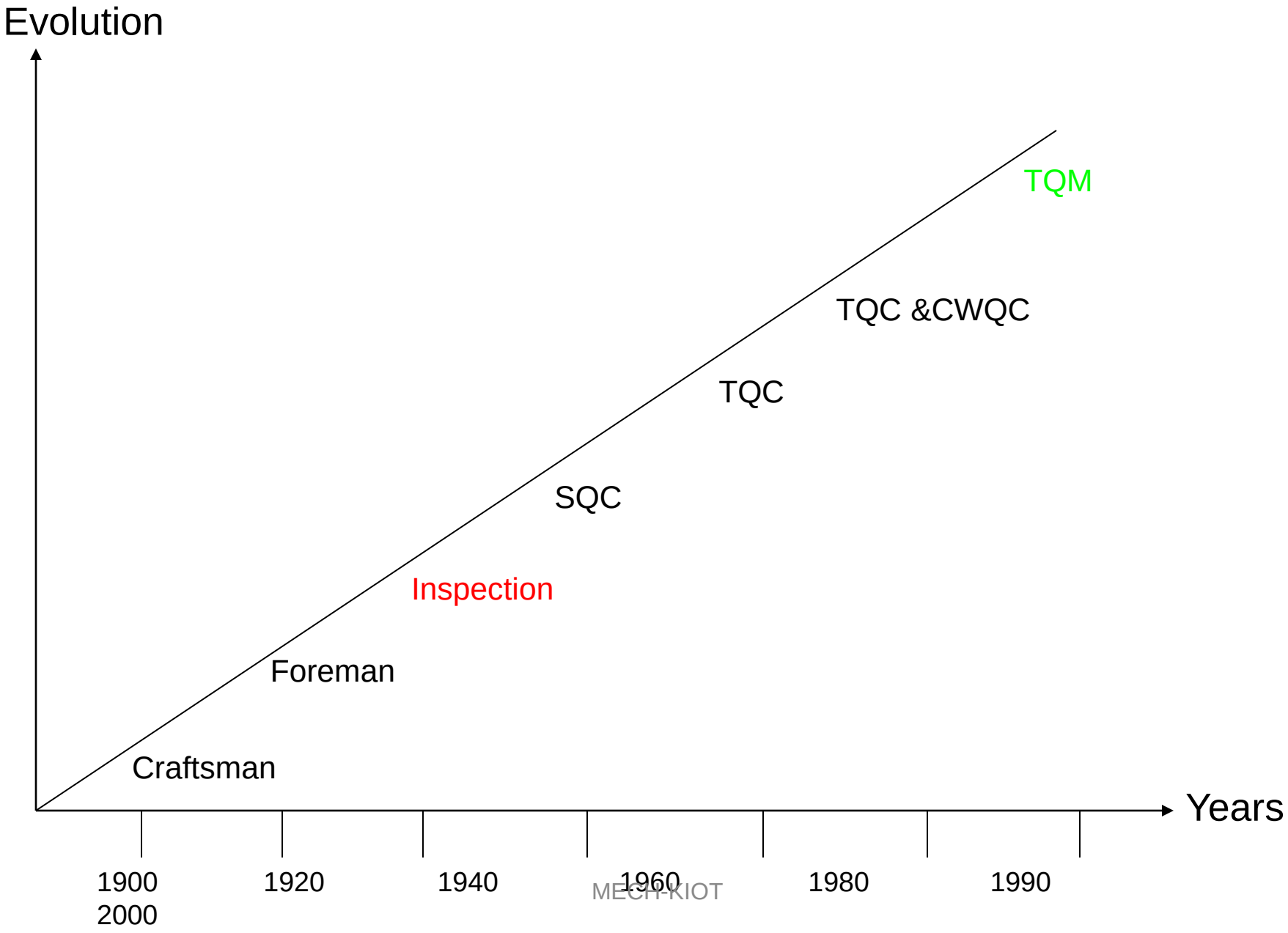
Need for quality

- ***Higher levels of customer satisfaction*** – Higher customers expectations are getting spawned by increasing competition.
- **The quality of your work defines you**- Whoever you are, whatever you do, I can find the same products and services cheaper somewhere else.But your quality is your signature.

Evolution of quality –Means & Focus



Evolution of quality Era



Evolution of Quality Management

Inspection	Salvage, sorting, grading, blending, corrective actions, identify sources of non-conformance
Quality Control	Develop quality manual, process performance data, self-inspection, product testing, basic quality planning, use of basic statistics, paperwork control.
Quality Assurance	Quality systems development, advanced quality planning, comprehensive quality manuals, use of quality costs, involvement of non-production operations, failure mode and effects analysis, SPC.
TQM	Policy deployment, involve supplier & customers, involve all operations, process management, performance measurement, teamwork, employee involvement.

Time Until 1960s	Events
Prior to the 20th century	Quality is an art Demands overcome potential production An era of workmanship
F.Taylor 1900s	The scientific approach to management resulting in rationalization of work and its break down leads to greater need for standardization, inspection and supervision
Shewart 1930s	Statistical beginnings and study of quality control. In parallel, studies by R A Fisher on experimental design; the beginning of control charts at western Electric in USA

Late 1930s	Quality standards and approaches are introduced in France and Japan. Beginning of SQC, reliability and maintenance engineering
1942	Seminal work by Deming at the ministry of war in USA on quality control and sampling Working group setup by Juran and Dodge on SQC in US army Concepts of acceptance sampling devised
1944	Daodge and Deming carried out seminal research on acceptance sampling
1945	Founding of the Japan standard association
1946	Founding of the ASQC
1950	Visit of Deming in Japan at the invitation of K Ishikawa

1951	Quality assurance increasingly accepted
1954	TQC in Japan ; Book published 1956
1957	Founding of European organization for the control of quality
After 1960s	
1961	The Martin Co in USA introduces the zero defects approach while developing and producing Pershing Missiles. Quality motivation is starting in the US and integrated programmes begun
1962	Quality circles are started in Japan

Define Quality

- Predictable degree of uniformity and dependability at low cost and suited to the market –Deming.
- Fitness for use-Juran.
- Conformance to requirements – Crosby.
- Minimum loss imparted by a product to society from the time the product is shipped – Taguchi.

Define Quality

- A way of managing tile organization – Feigenbaum
- Correcting and preventing loss, not living with loss - Hosffin .
- The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs – ISO

QUANITIFICATION OF QUALITY

Q= P / E

P = Performance

E = Expectations

Q = Quality

DIMENSION OF QUALITY

- Quality has 2 dimensions.

These dimensions are

1. Product Quality.
2. Service Quality

DIMENSION OF QUALITY
Product Quality

1. Performance:

   primary product characteristics, e.g. picture brightness in TV.

2. Features:

   secondary characteristics, added features, e.g. remote control, picture-in-picture.

3. Usability:

   ease of use with minimum training.

Product Quality (cont.)

4. Conformance:

   meeting specifications, industry standards,. (E.g. ISI specs.,emission norms).

5. Durability

   how long product lasts before replacement

6. Serviceability

   ease of getting repairs, speed of repairs, courtesy and competence of repair person

Product Quality (cont.)

7. Aesthetics:

   how a product looks, feels, sounds, smells, or tastes

8. Safety :

   assurance that customer will not suffer injury or harm from a product; an especially important consideration for automobiles

9. Perceptions:

   subjective perceptions based on brand name, advertising, and the like

Product Quality (cont.)

10. Efficiency:

    ratio of output to input. E.g. mileage, braking distance, processing time.

11. Reputation:

    subjective assessment based of past performance, brand image, industry ranking.

Dimensions of Quality: Service Quality

- Time and Timeliness
  - How long must a customer wait for service, and is it completed on time?
  - Is an overnight package delivered overnight?
- Completeness:
  - Is everything customer asked for provided?
  - Is a mail order from a catalogue company complete when delivered?

Dimensions of Quality: Service (cont.)

- Accessibility and convenience
  - How easy is it to obtain service?
  - Does a service representative answer you calls quickly?
- Accuracy
  - Is the service performed right every time?
  - Is your bank or credit card statement correct every month?
- Responsiveness
  - How well does the company react to unusual situations?
  - How well is a telephone operator able to respond to a customer’s questions?

DIMENSION OF QUALITY	
product quality	**Service quality**
Performance	Time
Features	Timeliness
Usability	Completeness
Conformance	Consistency
Reliability	Accessibility/Convenience
Durability	Accuracy
Maintainability/Serviceability	Responsiveness
Efficiency	Courtesy
Aesthetics	Competency/Expertise
Reputation	
Safety	

INTRODUCTION TO TQM

What is TQM?

TQM is the integration of all functions and processes within an organization in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction.

" No doubt , humans are always deficient"

(Al-Quran)

Total Quality Management Introduction

- **Total** – Made up of the whole(or) Complete.
- **Quality** – Degree of Excellence a product or service provides to the customer in present and future.
- **Management** – Act , art, or manner of handling , controlling, directing, etc.

TQM is the art of managing the whole to achieve excellence.

- "TQM is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society."

CHARACTERISTICS OF TQM

1. TQM is a customer oriented.
2. TQM required a long term commitment for continuous improvement of all processes.
3. TQM is teamwork.
4. TQM requires the leadership of top management and continuous involvement.
5. TQM is a strategy for continuous improving performance at all levels and in all areas of responsibility.

TQM BASIC CONCEPTS

- **Management Involvement –** Participate in quality program, develop quality council, direct participation
- **2. Focus on customer –** who is the customer – internal and external, voice of the customer, do it right first time and every time.
- **3. Involvement and utilisation of entire work force –** All levels of management

TQM BASIC CONCEPTS(cont.)

4. **Continuous improvement –** Quality never stops, placing orders, bill errors, delivery,

   minimise wastage and scrap etc.

5. **Treating suppliers as partners** – no business exists without suppliers.

6. **Performance** measures – creating accountability in all levels

Definition *TQM*

- TQM is composed of three paradigms:
- **Total**: Organization wide
- Quality: With its usual Definitions, with all its complexities (External Definition)
- Management: The system of managing with steps like Plan, Organise, Control, Lead, Staff, etc.

Definition *TQM(cont.)*

- TQM is the management approach of an organization, centered on quality, based on me participation of all its members and aiming at long-term success through customer satisfaction. and benefits to all members of me organization and to society.- **ISO**

Definition *TQM(cont.)*

- TQM is an integrated organizational approach in delighting customers (both internal and external) by meeting their expectations on a continuous basis through every one involved with the organization working on continuous improvement in all products, services, and processes along with proper problem solving methodology - **INDIAN STATISTICAL INSTITUTE (ISI)**

Definition *TQM(cont.)*

- TQM is people - focused management system that aims at continual increase in customer satisfaction at continually lower cost. TQM is a total system approach and an integral part of high level strategy. It works horizontally across functions and departments, involving all employees, top to bottom, and exceeds backwards and forward to include the supply chain and the customer chain – TOTAL QUALITY FORUM OF USA

Definition *TQM(cont.)*

- Philips B Crosby

Quality is Conformance to requirements

- W.Edwards Deming

A predictable degree of uniformity and dependability at low cost and suited to market

Definition *TQM(cont.)*

- Bill Conway

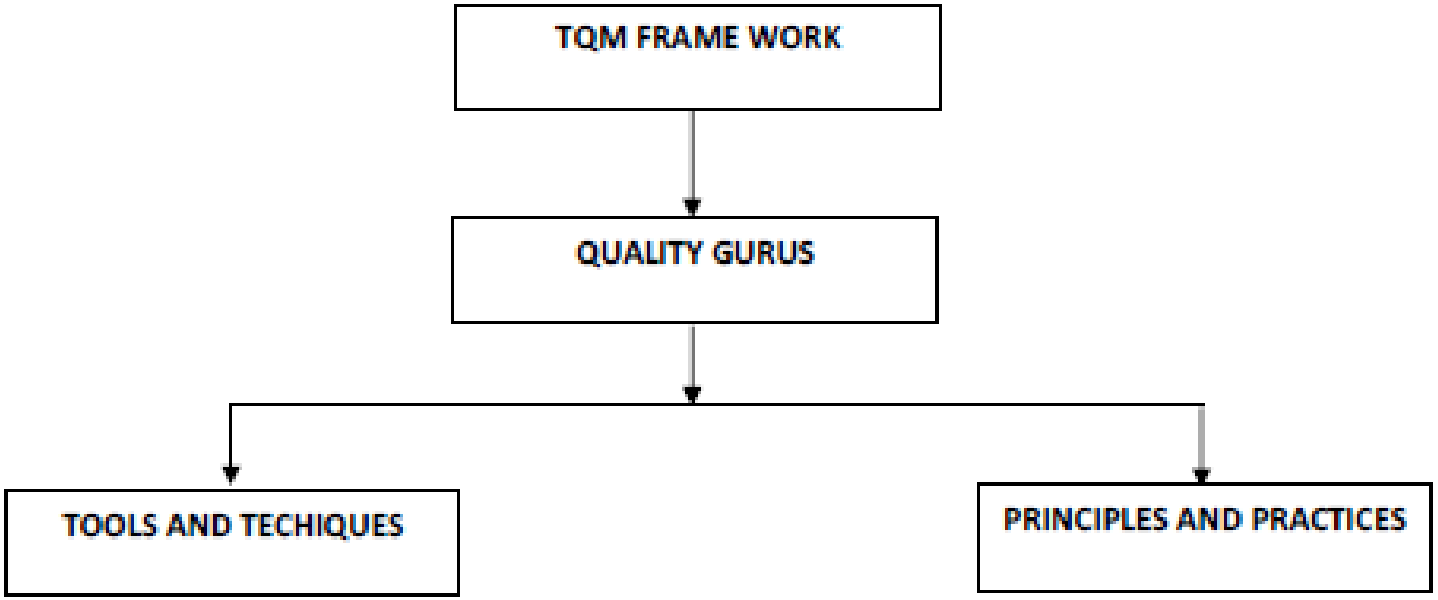
  Development,manufacture,administration And distribution of consistently low cost and products and services that customers need and want.

- Joseph Juran

  Total quality is defined as fitness for use or purpose

TQM Framework

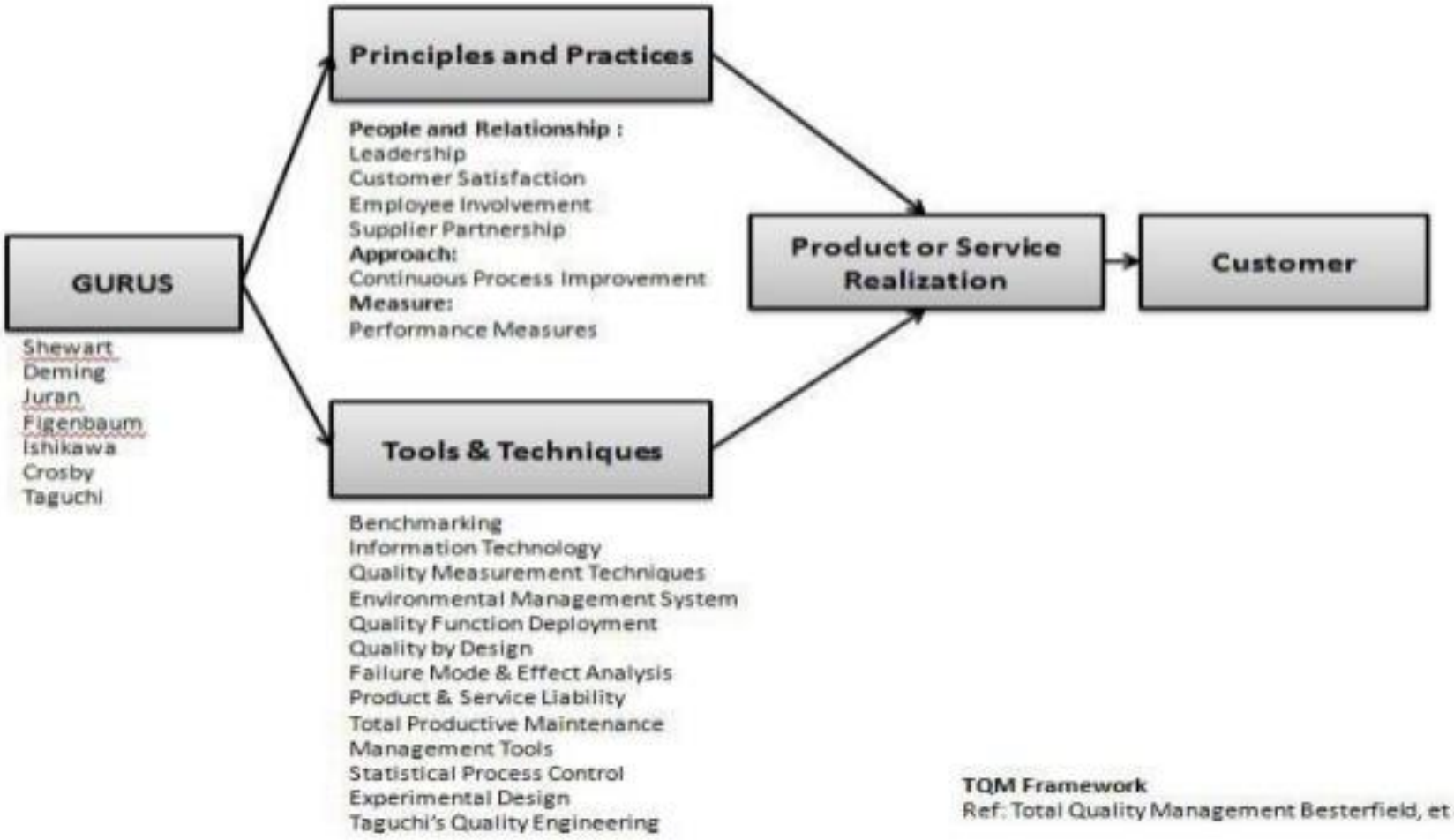
TQM Frame work:



1. Benchmarking
2. Six sigma
3. Seven Traditional Tools
4. New seven management tools
5. FMEA
6. Quality circle
7. Quality function deployment
8. Taguchi quality loss function
9. TPM

1. Leadership
2. Quality statements
3. Customer focus
4. Employee involvement
5. Performance appraisal
6. PDSA cycle
7. 5S
8. Kaizen
9. Supplier partnership.

TQM Framework



TQM Framework
Ref: Total Quality Management Besterfield, et al.

PRINCIPLES OF TQM

- Customer's requirements must be met the first time, every time.
- There must be agreed requirements, for both internal and external customers.
- Everybody must be involved, from all levels and across all functions.

PRINCIPLES OF TQM(cont.)

- Regular communication with staff at levels is must. Two way communication at all levels must be promoted.
- Identifying training needs and relating them with individual capabilities and requirements is must.

PRINCIPLES OF TQM(cont.)

- Top management's participation and commitment is must.
- A culture of continuous improvement must be established.
- Emphasis should be placed on purchasing and supplier management
- Every job must add value.
- Quality improvement must eliminate wastes and reduce total cost.

PRINCIPLES OF TQM(cont.)

- There must be a focus on the prevention of problems.
- A culture of promoting creativity must be established.
- Performance measure is a must at organization, department and individual levels. It helps to asses and meet objectives of quality.
- There should be focus on team work.

OBSTACLES (BARRIERS) IN IMPLEMENTING TQM

- Lack of Management Commitment
- Inability to change Organizational culture
- Improper planning
- Lack of continuous training and education
- Failure to continually improve
- Incompatible organizational structure and isolated individuals and departments

OBSTACLES (BARRIERS) IN IMPLEMENTING TQM(cont.)

- Ineffective measurement techniques and lack of access to data and results
- Paying inadequate attention to internal and external customers
- Inadequate use of empowerment and teamwork

BENEFITS OF TQM

- Improved quality
- Employee participation
- Team work
- Working relationships
- Customer satisfaction

BENEFITS OF TQM(cont.)

- Employee satisfaction
- Productivity
- Communication
- Profitability
- Market share

Guru's of TQM

- Walter.A.Shewhart - TQC &PDSA
- W.Edwards Deming - 14 Points & PDCA
- Joseph.M.Juran - Juran's Trilogy
- A.Feiganbaum - Customer

Requirement, Employee Involvement, TQC.

W. Edward Deming

Biographical:

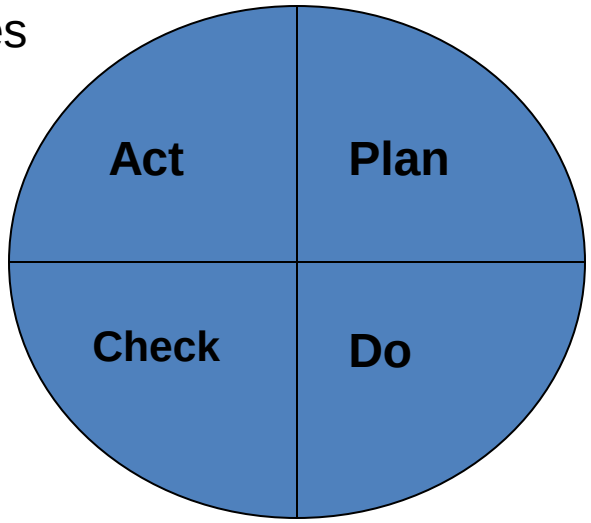
- Pioneered the use of statistics and sampling methods
- Became interested in the work of statistician Walter Shewhart and believed the principles could be applied to non-manufacturing environments
- In the early 1950's he lectured Japanese business on quality concepts leading directly to the emergence of Japan as a quality leader

CONTRIBUTIONS OF W. Edward Deming

- Encouraged the adoption of a systematic approach to problem solving known as the Deming or PDCA (Plan Do Check Act) cycle

- Immediate remedies
- future actions

- Objectives
- Methods



- Against objectives

- Train
- Execute

Deming's 14 Points for Management

1. Create constancy of purpose for the improvement of the product and service.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on the basis of price tag alone. Instead, minimize total cost by working with a single supplier.

Deming's 14 Points for Management(cont.)

5. Improve constantly and forever every process for planning, production, and service.
6. Institute training and retraining.
7. Adopt and institute leadership.
8. Drive out fear.
9. Breakdown barriers between staff areas.
10. Eliminate slogans, exhortations, and targets for the workforce.

Deming's 14 Points for Management(cont.)

11. Eliminate numerical quotas for the workforce and numerical goals for management.
12. Remove barriers that rob people of workmanship.
13. Institute a vigorous program of education and self-improvement for everyone.
14. Put everybody in the company to work to accomplish the transformation.

Joseph Juran

Biographical:

- Like Deming, was invited to Japan in the early 1950's by the Union of Japanese Scientists and Engineers (JUSE)
- Strong advocate of the need for quality planning and the setting of clear and measurable goals
- Has been very critical of some of the quality initiatives of the 1990's as lacking substance

THE JURAN TRILOGY

- Juran views quality as fitness for use.
- Juran Trilogy is designed to reduce the cost of quality over time.

1. QUALITY PLANNING

2. QUALITY CONTROL

3. QUALITY IMPROVEMENT

1. QUALITY PLANNING

- Determine internal & external customers.
- Their needs are discovered.
- Develop product / service features.
- Develop the processes able to produce the product / service features.
- Transfer plans to operations.

2. QUALITY CONTROL

- Control is used by operating forces to help meet the product, process and service requirements.
- It consists of the following steps
- 1. Determine items to be controlled.
- 2. Set goals for the controls.
- 3. Measure actual performance.
- 4. Compare actual performance to goals.
- 5. Act on the difference.

3. QUALITY IMPROVEMENT

- Aims to attain levels of performance that are higher than current levels.

It consists of the following steps

- Establishment of quality council.
- Identify the improvement projects.
- Establish the project teams with a project leader.
- Provide the team with the resources.

Juran's 10 Steps to Quality Improvement

1. Build awareness of the need and opportunity for improvement.
2. Set goals for improvement.
3. Organize to reach the goals (establish a quality council, identify problems, select projects, appoint teams, designate facilitators).
4. Provide training.
5. Carry out projects to solve problems.
6. Report progress.

Juran's 10 Steps to Quality Improvement(cont.)

7. Give recognition.
8. Communicate results.
9. Keep score.
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company.

CONTRIBUTIONS OF CROSBY

- **The Four absolutes of quality are**
- 1. Quality is defined as conformance to requirements.
- 2. The system for causing Quality is prevention.
- 3. The performance standard must be zero defects.
- 4. The measurement of Quality is the Price of Nonconformance

Crosby's 14 Steps to Quality Improvement

1. Make it clear that management is committed to quality.
2. Form quality improvement teams with representatives from each department.
3. Determine where current and potential quality problems lie.
4. Evaluate the cost of quality and explain its use as a management tool.
5. Raise the quality awareness and personal concern of all employees.

Crosby's 14 Steps to Quality Improvement(cont.)

6. Take actions to correct problems identified through previous steps.
7. Establish a committee for the zero-defects program.
8. Train supervisors to actively carry out their part of the quality improvement program.
9. Hold a "zero-defects day" to let all employees realize that there has been a change.

Crosby's 14 Steps to Quality Improvement(cont.)

10. Encourage individuals to establish improvement goals for themselves and their groups.
11. Encourage employees to communicate to management the obstacles they face in attaining their improvement goals.
12. Recognize and appreciate those who participate.

Crosby's 14 Steps to Quality Improvement(cont.)

13. Establish quality councils to communicate on a regular basis.
14. Do it all over again to emphasize that the quality improvement program never ends.

Comparison

	Deming	Juran	Crosby
Definition of quality	Continuous improvement	Fitness for use	Conformance to requirements
Emphasis	Tools/system	Measurement	Motivation (behaviour)
Types of tools	Statistical process control	Analytical, cost-of-quality	Minimal use
Use of goals and targets	Not used	Significant emphasis	Posted goals for workers

Quality statements

- **Vision statement – a short declaration of what the organization hopes to be tomorrow.**
- **Mission statement – a statement of purpose –who we are, who are our customers, what we do , and how we do it.**
- **Quality policy – is a guide for everyone in the organization ,how they should provide products and services to the customers.**

Strategic Planning

- Strategic business planning is similar to strategic quality planning.
- 7 steps to strategic planning
- Customer needs
- Customer positioning
- Predict the future
- Gap analysis
- Closing the gap
- Alignment
- Implementation.

Strategic Quality Goals and Objectives

- Goals must be focused
- Goals must be concrete
- Goals must be based on statistical evidence
- Goals must have plan or method with resources
- Goals must have a time-frame
- Goals must be challenging yet achievable

Goals of Customer Focus:

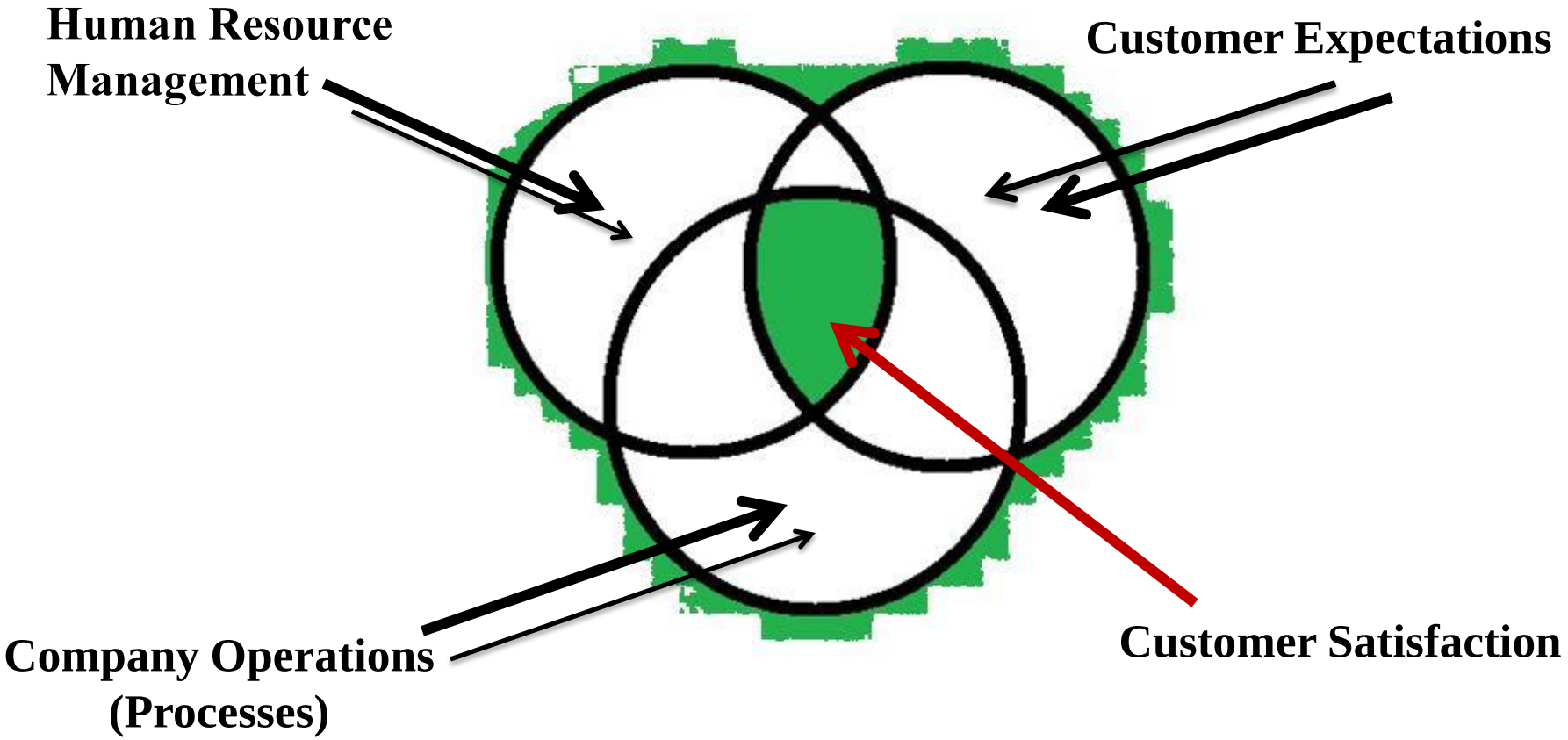
1. Creating Better Products or Services
2. Offering compelling customer experience
3. Building deeper customer relationships

End goal of customer focused strategies is the same:

Boosting retention and repurchase = more sales!!!

Customer Satisfaction

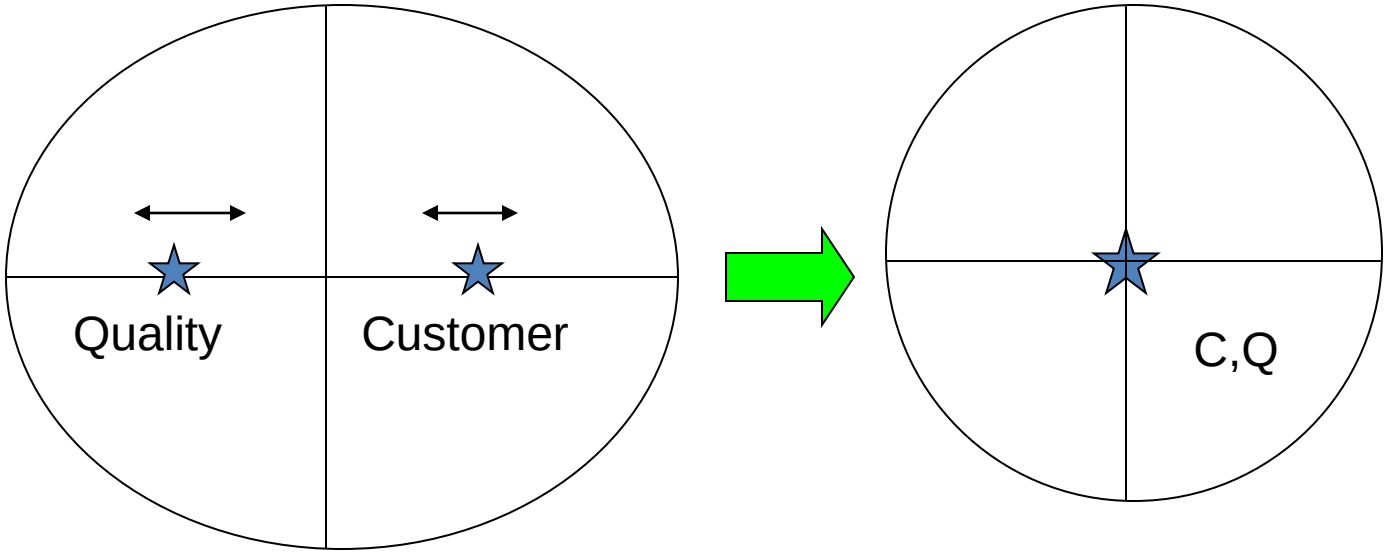
Three Part System



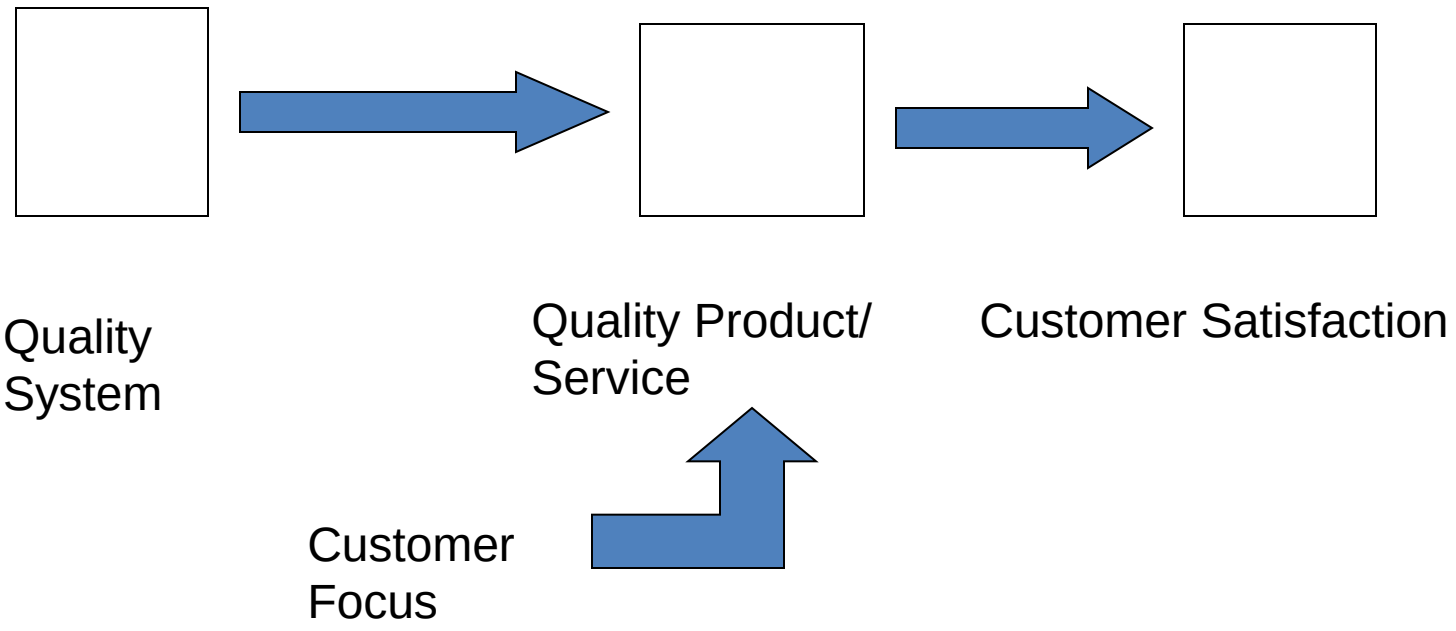
Customer satisfaction

- Customer is the Boss or'King'
- Customer dictates the market trends and direction
- Customer not only has needs to be supplied(basic performance functions)
- Also he 'wants what he wants!'(additional features satisfy him and influence his purchase decision)
- Hence the Suppliers and Manufacturers have to closely follow at the heel of the customer.

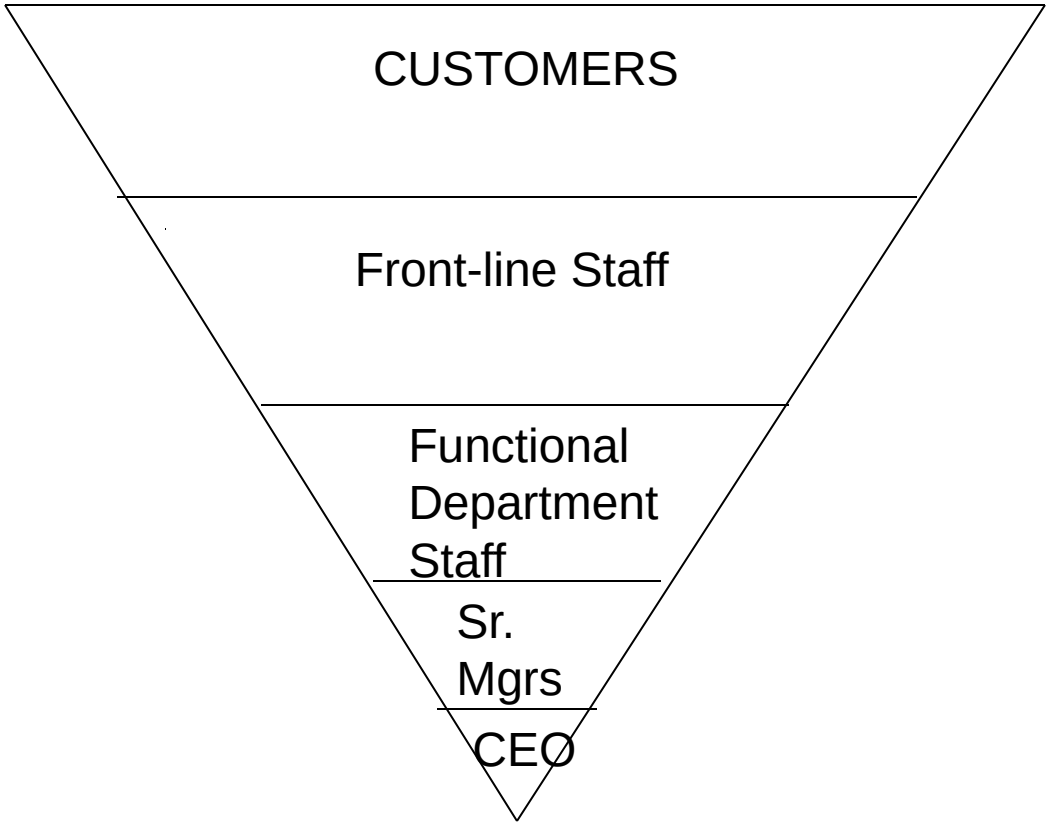
Norman’s Customer satisfaction model



Customer Satisfaction



Customer Satisfaction Organisational Diagram



Teboul Model of Customer Satisfaction

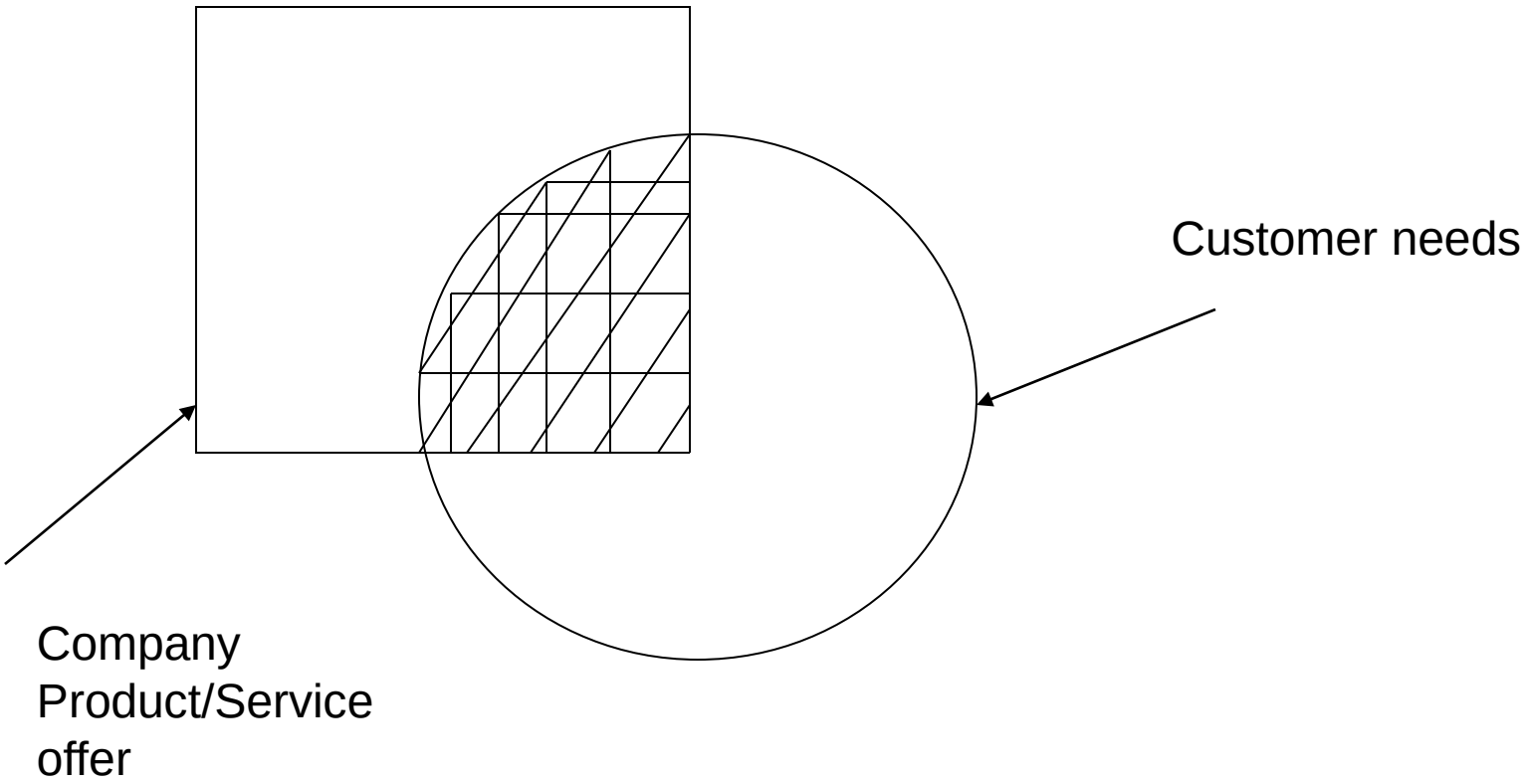


Figure 1. Kano Model

What is customer satisfaction?

- Is it due to Product quality?
- Is it due to pricing?
- Is it due to good customer service ?
- Is it due to company reputation?
- Is it something more?

Customer types

- **External and Internal** customers
- **External – current, prospective and lost customers**
- **Internal** – Every person in a process is a customer of the previous operation.(applies to design,manufacturing,sales,supplies etc.) [Each worker should see that the quality meets expectations of the next person in the supplier-to-customer chain]
- **TQM** is commitment to **customer-focus** - internal and external customers.

Quality Costs

COST OF QUALITY IS THE COST OF NON QUALITY

1: 10:100 Rule

“A stitch in time saves nine”

Types of Quality Costs

The cost of quality is generally classified into four categories

1. Cost of Prevention
2. Cost of Appraisal
3. Cost of Internal Failure
4. Cost of External Failure

Cost of Quality

- Quality affects all aspects of the organization
- Quality has dramatic cost implications of:
  - Quality control costs
    - Prevention costs
    - Appraisal costs
  - Quality failure costs
    - Internal failure costs
    - External failure costs

Cost of Quality – 4 Categories

Prevention costs.	Costs of preparing and implementing a quality plan.
Appraisal costs.	Costs of testing, evaluating, and inspecting quality.
Internal failure costs.	Costs of scrap, rework, and material losses.
External failure costs.	Costs of failure at customer site, including returns, repairs, and recalls.

Early detection/prevention is less costly

UNIT-III

TQM TOOLS & TECHNIQUES I

SEVEN QUALITY CONTROL TOOLS

(or)

OLD SEVEN TOOLS

Dr.Kaoru Ishikawa, Professor at Tokyo University & Father of Q C in Japan.

- **CAUSE ANALYSIS TOOLS are Cause and Effect diagram, Pareto analysis & Scatter diagram**.
- **EVALUATION AND DECISION MAKING TOOLS** are decision matrix and multivoting

- **DATA COLLECTION AND ANALYSIS TOOLS** are check sheet, control charts, DOE, scatter diagram, stratification, histogram, survey.
- IDEA CREATION TOOLS are Brainstorming, Benchmarking, Affinity diagram, Normal group technique.
- PROJECT PLANNING AND IMPLEMENTATIONTOOLS are Gantt chart and PDCA Cycle.

Cause-and-effect diagram (also called Ishikawa or fishbone chart)

DESCRIPTION

- The fishbone diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories.

WHEN TO USE

- When identifying possible causes for a problem.
- Especially when a team's thinking tends to fall into ruts

PROCEDURE

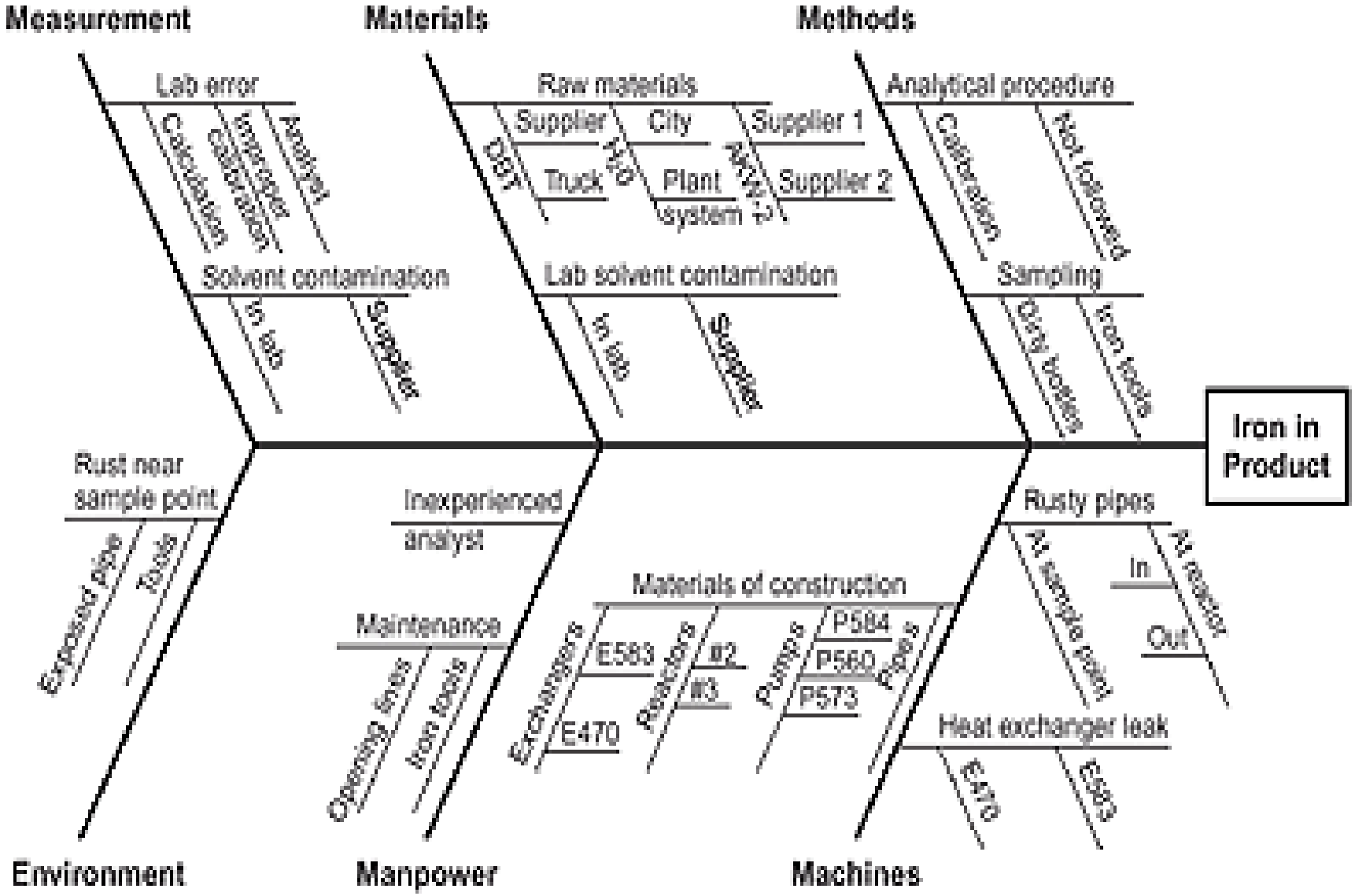
- **MATERISLS REQUIRED:** Flipchart (or) White Board, Marking Pens.

- Agree on a problem statement (effect). Write it at the center right of the flipchart or whiteboard. Draw a box around it and draw a horizontal arrow running to it.
- Brainstorm the major categories of causes of the problem. If this is difficult use generic headings:
  - Methods
  - Machines (equipment)
  - People (manpower)
  - Materials
  - Measurement
  - Environment

- Write the categories of causes as branches from the main arrow.
- Brainstorm all the possible causes of the problem. Ask: “Why does this happen?” As each idea is given, the facilitator writes it as a branch from the appropriate category. Causes can be written in several places if they relate to several categories.
- Again ask “why does this happen?” about each cause. Write sub-causes branching off the causes. Continue to ask “Why?” and generate deeper levels of causes. Layers of branches indicate causal relationships.
- When the group runs out of ideas, focus attention to places on the chart where ideas are few.

Example

- This fishbone diagram was drawn by a manufacturing team to try to understand the source of periodic iron contamination. The team used the six generic headings to prompt ideas. Layers of branches show thorough thinking about the causes of the problem.


Measurement
Materials
Methods
Lab error
Calculation
Improper calibration
Analyst
Solvent contamination
In lab
Supplier
Raw materials
Supplier
City
Supplier 1
DOT
Truck
Rail
Plant system
Supplier 2
Lab solvent contamination
In lab
Supplier
Analytical procedure
Calibration
Not followed
Sampling
Dirty bottles
Iron tools
Iron in Product
Rust near sample point
Exposed pipe
Tanks
Inexperienced analyst
Maintenance
Opening tanks
Iron tools
Materials of construction
Exchangers
E583
E470
Reactors
#2
#3
Pumps
P584
P560
P573
Pipes
Rusty pipes
At sample point
In
Out
At reactor
Heat exchanger leak
E470
E583
Environment
Manpower
Machines

- **For example, under the heading “Machines,” the idea “materials of construction” shows four kinds of equipment and then several specific machine numbers.**
- **Note that some ideas appear in two different places. “Calibration” shows up under “Methods” as a factor in the analytical procedure, and also under “Measurement” as a cause of lab error. “Iron tools” can be considered a “Methods” problem when taking samples or a “Manpower” problem with maintenance personnel**

CHECK SHEET (or) DEFECT CONCENTRATION DIAGRAM

DESCRIPTION

- **A check sheet is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes**

WHEN TO USE

- When data can be observed and collected repeatedly by the same person or at the same location.
- When collecting data on the frequency or patterns of events, problems, defects, defect location, defect causes, etc.
- When collecting data from a production process.

PROCEDURE

- Decide what event or problem will be observed. Develop operational definitions.
- Decide when data will be collected and for how long.
- Design the form. Set it up so that data can be recorded simply by making check marks or Xs or similar symbols and so that data do not have to be recopied for analysis.
- Label all spaces on the form.
- Test the check sheet for a short trial period to be sure it collects the appropriate data and is easy to use.
- Each time the targeted event or problem occurs, record data on the check sheet.

EXAMPLE

- **The figure below shows a check sheet used to collect data on telephone interruptions. The tick marks were added as data was collected over several weeks**.

Telephone Interruptions

Reason	Day					
	Mon	Tues	Wed	Thurs	Fri	Total
Wrong number	𝍸	II	I	𝍸	𝍸 II	20
Info request	II	II	II	II	II	10
Boss	𝍸	II	𝍸 II	I	IIII	19
Total	12	6	10	8	13	49

Histogram

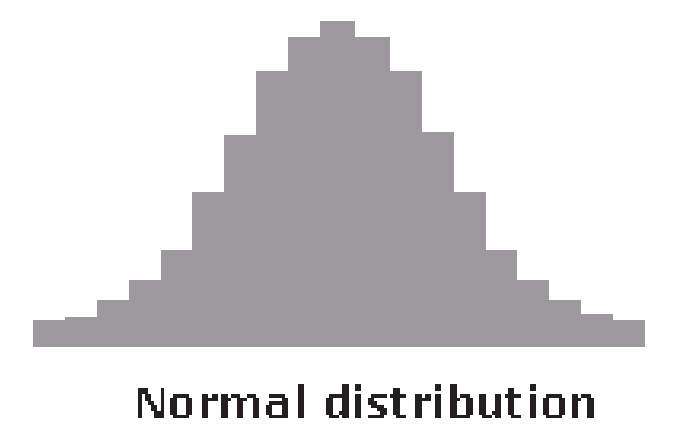
- ***Histogram:*** **The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs**

WHEN TO USE

- **The data are numerical values.**
- **To see the shape of the data's distribution, especially when determining whether the output of a process is distributed approximately normally.**
- **Analyzing whether a process can meet the customer's requirements.**
- **Analyzing what the output from a supplier's process looks like.**
- **Whether a process change has occurred from one time period to another.**
- **To determine whether the outputs of two or more processes are different.**
- **To communicate the distribution of data quickly and easily to others.**

Histogram Shapes and Meaning

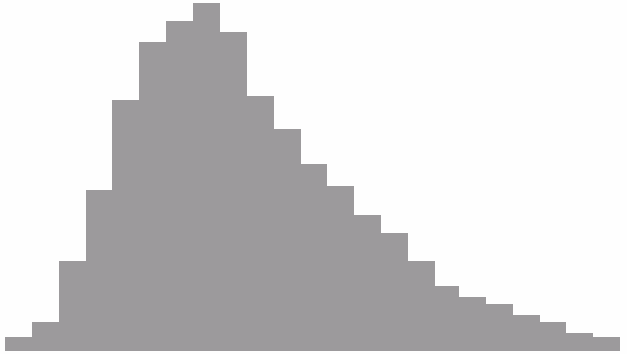
- **Normal.** A common pattern is the bell-shaped curve known as the “normal distribution.” In a normal distribution, points are as likely to occur on one side of the average as on the other.



Normal distribution

- **Skewed.** The skewed distribution is asymmetrical because a natural limit prevents outcomes on one side. The distribution's peak is off center toward the limit and a tail stretches away from it.

❑**These distributions are called right- or left-skewed according to the direction of the tail.**

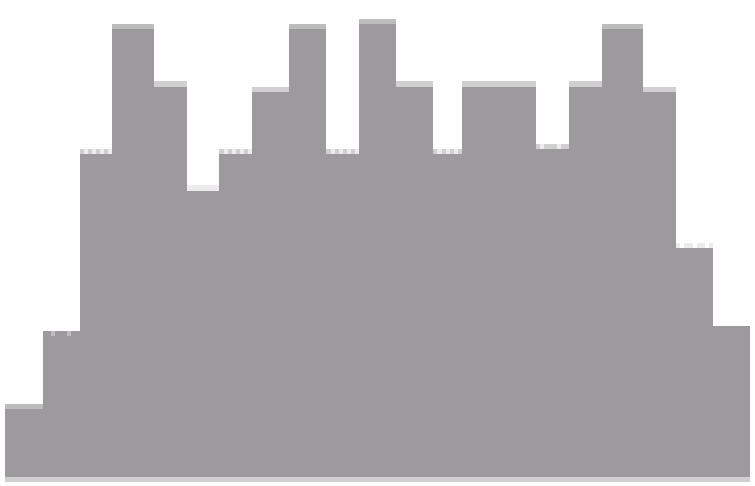


Right-skewed distribution

- **Double-peaked or bimodal.** The bimodal distribution looks like the back of a two-humped camel. The outcomes of two processes with different distributions are combined in one set of data. A two-shift operation might be bimodal.

Bimodal (double-peaked) distribution

- **Plateau.** The plateau might be called a “multimodal distribution.” Several processes with normal distributions are combined.Because there are many peaks close together, the top of the distribution resembles a plateau.



Plateau distribution

- **Dog food.** The dog food distribution is missing something—results near the average. If a customer receives this kind of distribution, someone else is receiving a heart cut, and the customer is left with the “dog food,” the odds and ends left over after the master’s meal

Pareto Chart (or) Pareto diagram (or) Pareto analysis

- **A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right.**

When to Use

- When analyzing data about the frequency of problems or causes in a process.
- When there are many problems or causes and you want to focus on the most significant.
- When analyzing broad causes by looking at their specific components.
- When communicating with others about your data.

PARETO DIAGRAM

To identify the **'VITAL FEW FROM TRIVIAL MANY'** and to concentrate on the vital few for improvement.

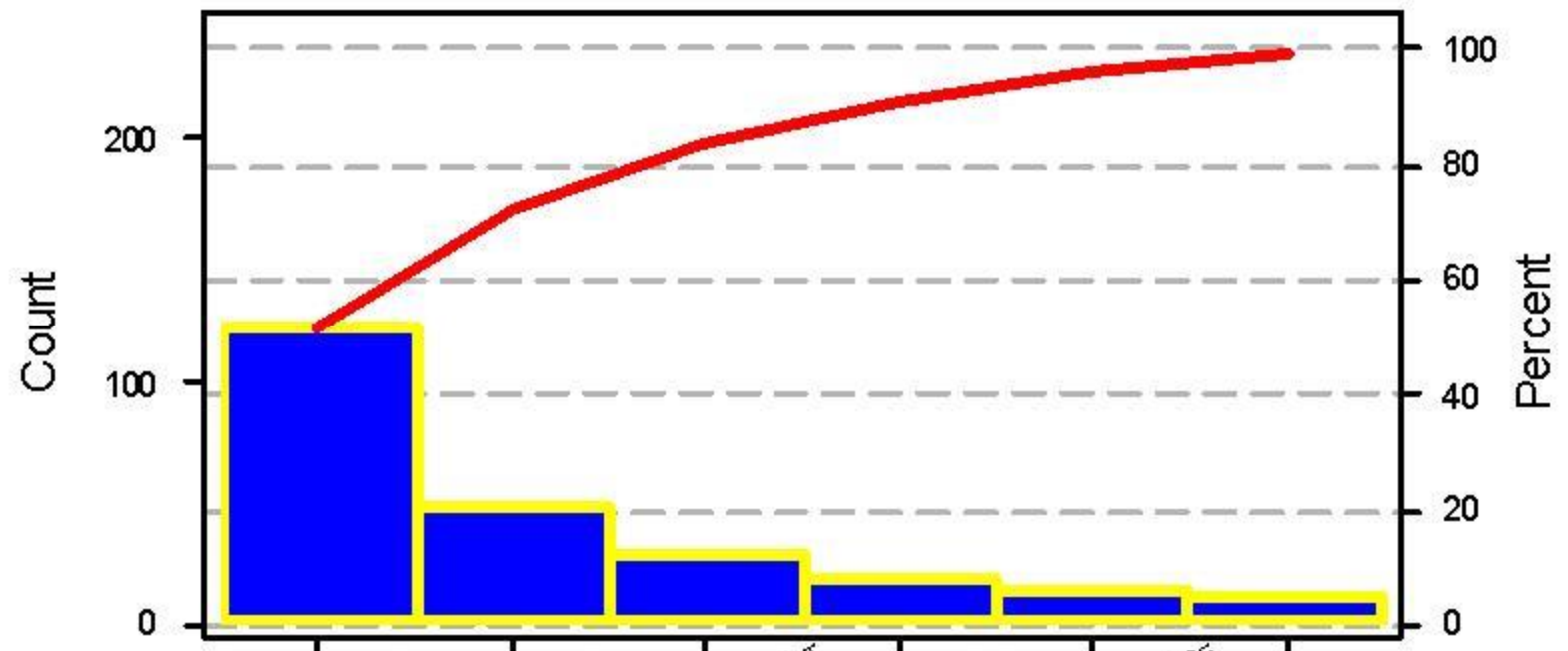
A Pareto diagram indicates which problem we should solve first in eliminating defects and improving the operation.

- **The Pareto 80 / 20 rule**

80 % of the problems are produced by 20 % of the causes.


Types of Customer Complaints
Second Quarter 2005
40
30
20
10
0
Documents
Product quality
Packaging
Delivery
Other

THREE MONTHS AVERAGE DEFECTS AT F.I IN BS 26 188 MODE



Defect	TOP COVER GAP	THROTTLE STICKY	PISTON MISALLIGMENT	PAJ DAMAGE	BOWL SCREW DAMAGE	Other
Count	123	48	27	18	12	9
Percent	51.9	20.3	11.4	7.6	5.1	3.8
Cum %	51.9	72.2	83.5	91.1	96.2	100.0

Scatter Diagram (or) Scatter plot (or) X–Y graph

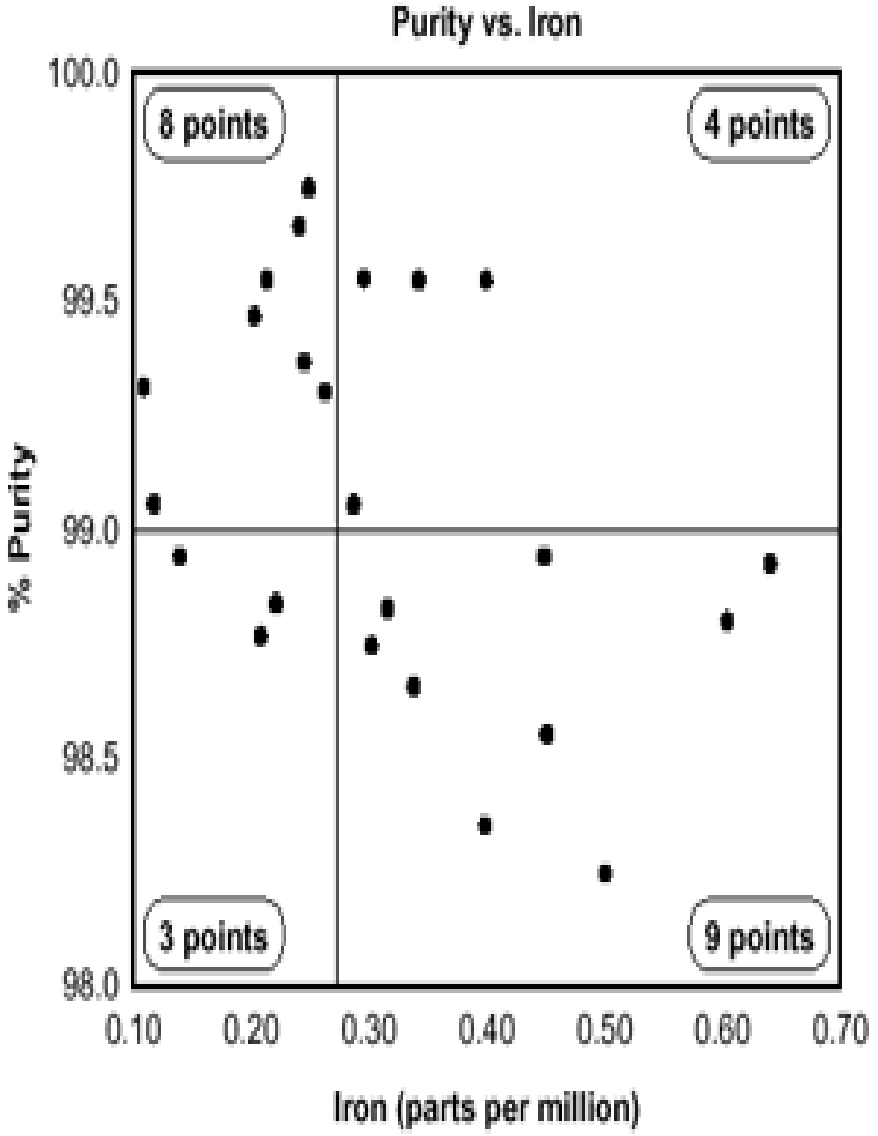
- **The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.**

When to Use

- When you have paired numerical data.
- When your dependent variable may have multiple values for each value of your independent variable.
- When trying to determine whether the two variables are related, such as when trying to identify potential root causes of problems.
- After brainstorming causes and effects using a fishbone diagram, to determine objectively whether a particular cause and effect are related.

Table 5.18 Trend test table.

N	Limit	*N*	Limit
1–8	0	51–53	18
9–11	1	54–55	19
12–14	2	56–57	20
15–16	3	58–60	21
17–19	4	61–62	22
20–22	5	63–64	23
23–24	6	65–66	24
25–27	7	67–69	25
28–29	8	70–71	26
30–32	9	72–73	27
33–34	10	74–76	28
35–36	11	77–78	29
37–39	12	79–80	30
40–41	13	81–82	31
42–43	14	83–85	32
44–46	15	86–87	33
47–48	16	88–89	34
49–50	17	90	35



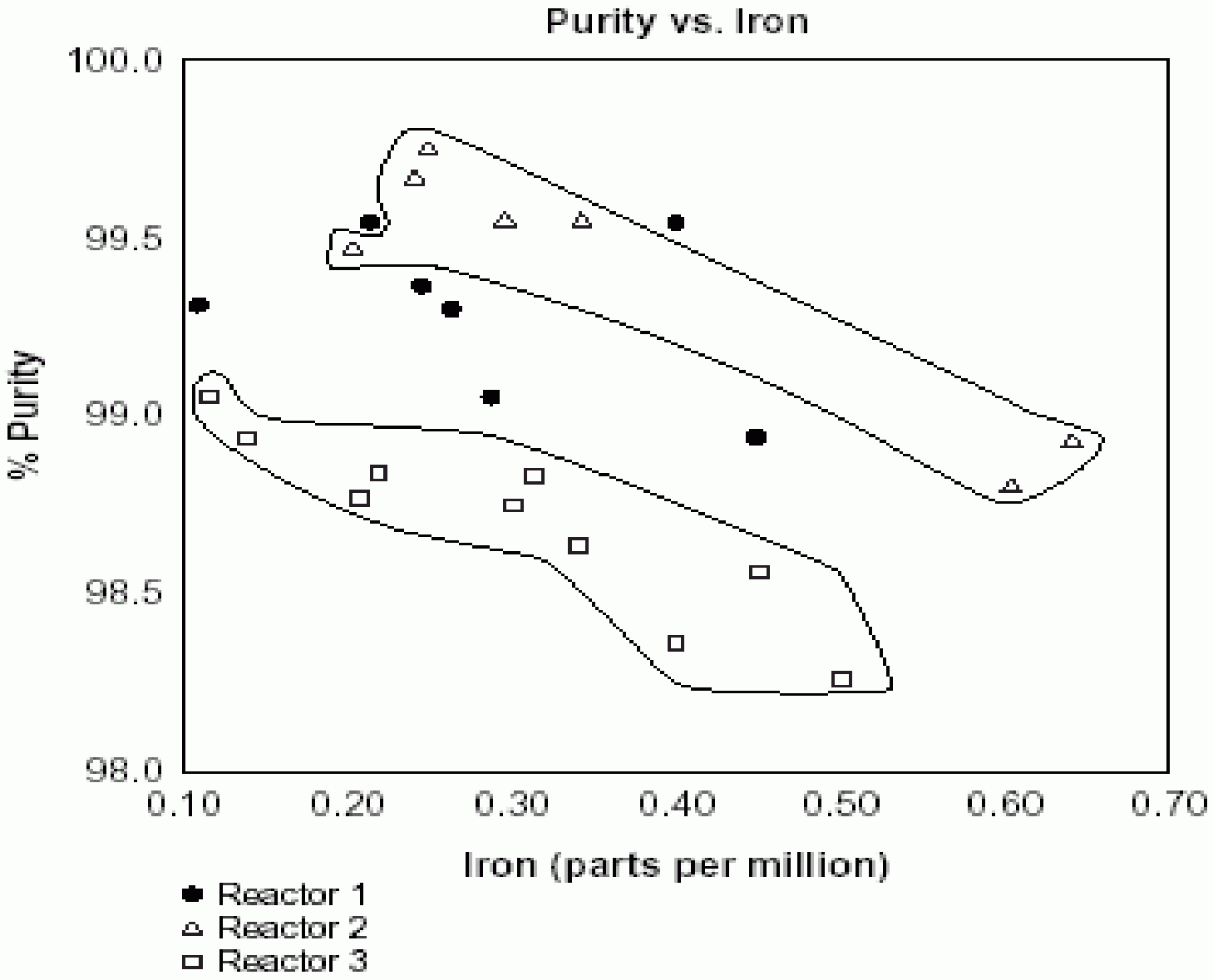
Stratification (or) Flowchart (or) Run chart

- **Stratification is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be impossible to see**

When to Use

- Before collecting data.
- When data come from several sources or conditions, such as shifts, days of the week, suppliers or population groups.
- When data analysis may require separating different sources or conditions.

- **The ZZ-400 manufacturing team drew a scatter diagram to test whether product purity and iron contamination were related, but the plot did not demonstrate a relationship. Then a team member realized that the data came from three different reactors. The team member redrew the diagram, using a different symbol for each reactor's data**


Purity vs. Iron
100.0
99.5
99.0
98.5
98.0
% Purity
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Iron (parts per million)
Reactor 1
Reactor 2
Reactor 3

Benefit from stratification.

- **Always consider before collecting data whether stratification might be needed during analysis. Plan to collect stratification information. After the data are collected it might be too late.**
- **On your graph or chart, include a legend that identifies the marks or colors used.**

Control Chart (or) Statistical process control

VARIATIONS

- Different types of control charts can be used, depending upon the type of data. The two broadest groupings are for variable data and attribute data.
- Variable data are measured on a continuous scale. For example: time, weight, distance or temperature can be measured in fractions or decimals. The possibility of measuring to greater precision defines variable data.

- **Attribute data** are counted and cannot have fractions or decimals. Attribute data arise when you are determining only the presence or absence of something: success or failure, accept or reject, correct or not correct. For example, a report can have four errors or five errors, but it cannot have four and a half errors.

Variables charts

- X and R chart (also called averages and range chart)
- X and s chart
- chart of individuals (also called X chart, X-R chart, IX-MR chart, Xm R chart, moving range chart)
- moving average–moving range chart (also called MA–MR chart)
- target charts (also called difference charts, deviation charts and nominal charts)
- CUSUM (also called cumulative sum chart)
- EWMA (also called exponentially weighted moving average chart)
- multivariate chart (also called Hotelling T2)

Attributes charts

- p chart (also called proportion chart)
- np chart
- c chart (also called count chart)
- u chart

Seven New Management and Planning Tools

Need for New Tools

- **In 1976, the Union of Japanese Scientists and Engineers (JUSE) saw the need for tools to promote innovation, communicate information and successfully plan major projects**

Affinity diagram (or) Affinity Chart (or) K-J method

- **It was created in the 1960s by Japanese anthropologist Jiro Kawakita.**
- **organizes a large number of ideas in to their natural relationships**
- **This method taps a team's creativity and intuition.**

When to Use

- When you are confronted with many facts or ideas in apparent chaos
- When issues seem too large and complex to grasp
- When group consensus is necessary

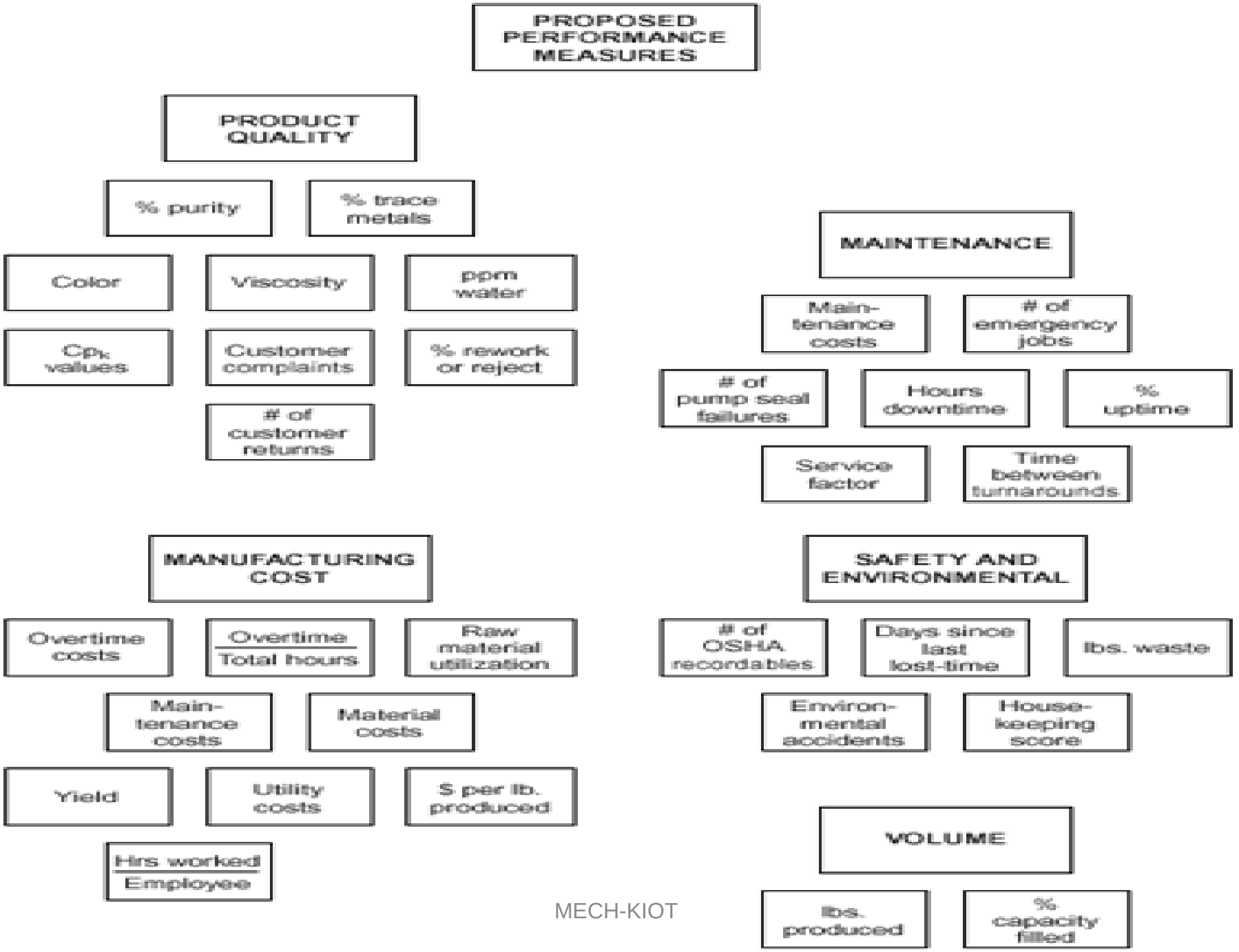
Typical situations Used

- After a brainstorming exercise

- When analyzing verbal data, such as survey results

Brainstorming for affinity diagram example

Possible Performance Measures	
% purity	# of OSHA recordables
% trace metals	# of customer returns
Maintenance costs	Customer complaints
# of emergency jobs	Overtime/total hours worked
lbs. produced	$/lb. produced
Environmental accidents	Raw material utilization
Material costs	Yield
Overtime costs	Utility cost
# of pump seal failures	ppm water
Viscosity	Color
Cp_k values	Service factor
Safety	Time between turnarounds
Days since last lost-time	Hours worked/employee
% rework or reject	lbs. waste
Hours downtime	Housekeeping score
% uptime	% capacity filled


PROPOSED PERFORMANCE MEASURES
PRODUCT QUALITY
% purity
% trace metals
Color
Viscosity
ppm water
Cp_k values
Customer complaints
% rework or reject
# of customer returns
MAINTENANCE
Main-tenance costs
# of emergency jobs
# of pump seal failures
Hours downtime
% uptime
Service factor
Time between turnarounds
MANUFACTURING COST
Overtime costs
Overtime / Total hours
Raw material utilization
Main-tenance costs
Material costs
Yield
Utility costs
$ per lb. produced
Hrs worked / Employee
SAFETY AND ENVIRONMENTAL
# of OSHA recordables
Days since last lost-time
lbs. waste
Environ-mental accidents
House-keeping score
VOLUME
lbs. produced
% capacity filled

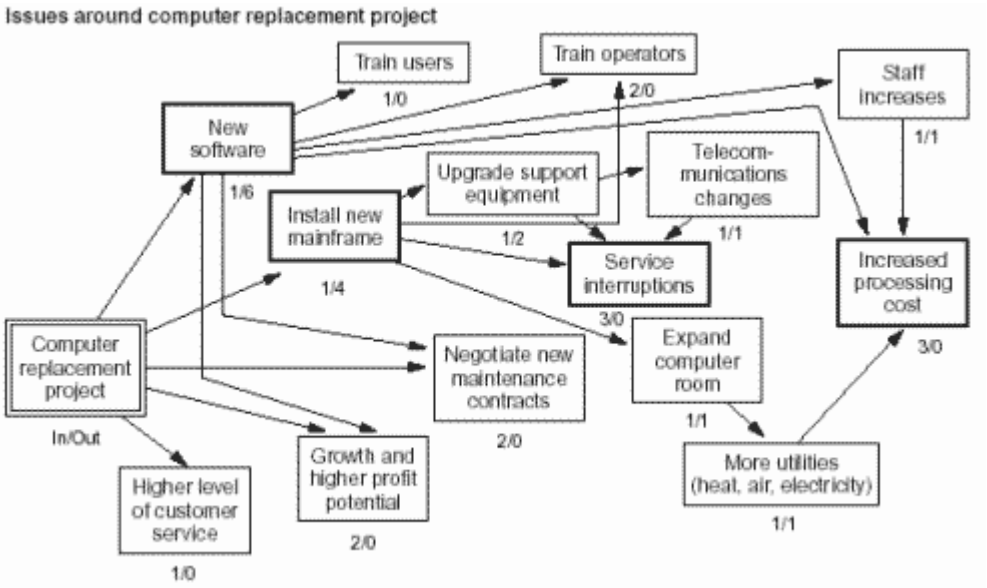
Relations Diagram (or) Interrelationship Diagram(or)Digraph(or) Network Diagram

- **The relations diagram shows cause-and-effect relationships.**
- **The process of creating a relations diagram helps a group analyze the natural links between different aspects of a complex situation.**

When to Use

- **When trying to understand links between ideas or cause-and-effect relationships, such as when trying to identify an area of greatest impact for improvement.**
- **When a complex issue and Solution is being analyzed & Implemented for causes.**
- **After generating an affinity diagram, cause-and-effect diagram or tree diagram, to more completely explore the relations of ideas.**

Example:-A computer support group is planning a major project: replacing the mainframe computer.



Tree Diagram (or) Systematic diagram (or) Tree analysis (or) Analytical tree (or) Hierarchy diagram

Description

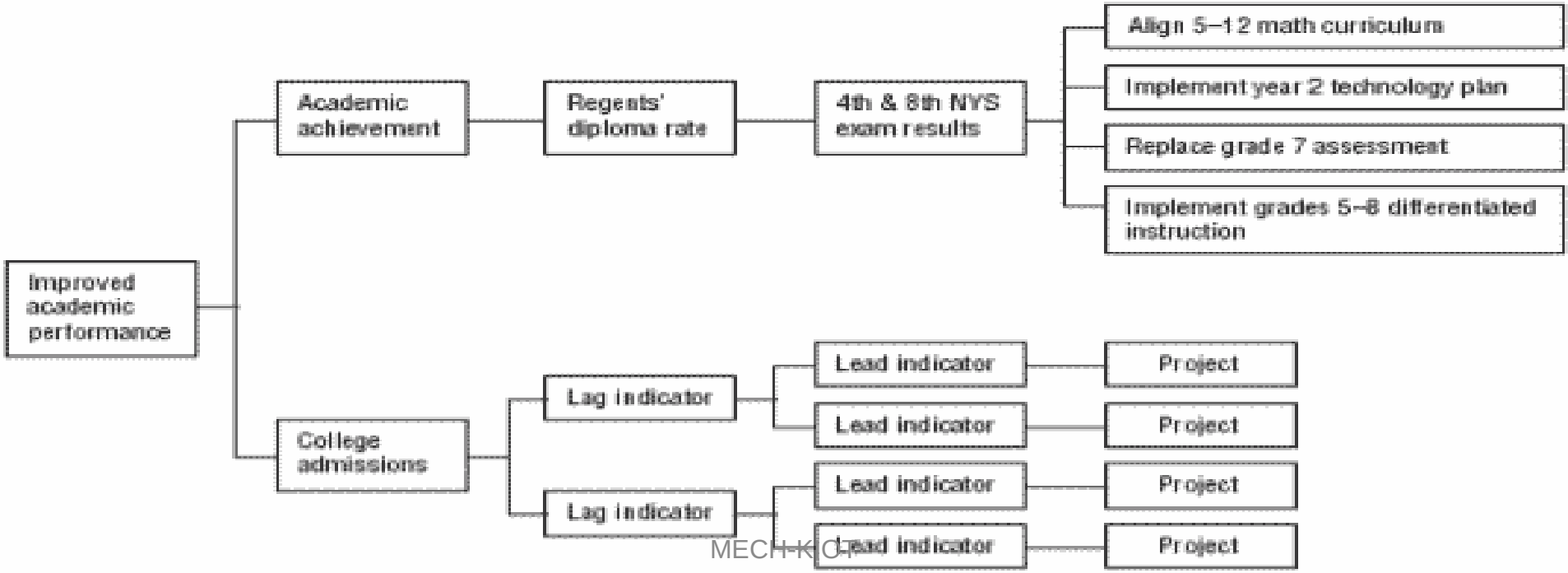
- The tree diagram starts with one item that branches into two or more, each of which branch into two or more, and so on.
- It looks like a tree, with trunk and multiple branches.

When to Use

- When an issue is known or being addressed in broad generalities.
- When developing actions to carry out a solution or other plan.
- When analyzing processes in detail.
- When probing for the root cause of a problem.
- After an affinity diagram or relations diagram has uncovered key issues.
- As a communication tool, to explain details to others

Example

- The Pearl River, NY School District, a 2001 recipient of the Malcolm Baldrige National Quality Award, uses a tree diagram to communicate how district-wide goals are translated into sub-goals and individual projects



Matrix Diagram (or) Matrix chart

Description

- **The matrix diagram shows the relationship between two, three or four groups of information. It also can give information about the relationship, such as its strength, the roles played by various individuals or measurements**

When to Use each Shape

An L-shaped matrix relates two groups of items to each other (or one group to itself).

- A T-shaped matrix relates three groups of items: groups B and C are each related to A. Groups B and C are not related to each other.

- A Y-shaped matrix relates three groups of items. Each group is related to the other two in a circular fashion.

When to Use each Shape

A C-shaped matrix relates three groups of items all together simultaneously, in 3-D.

An X-shaped matrix relates four groups of items. Each group is related to two others in a circular fashion.

A roof-shaped matrix relates one group of items to itself. It is usually used along with an L- or T-shaped matrix. (Used in QFD)

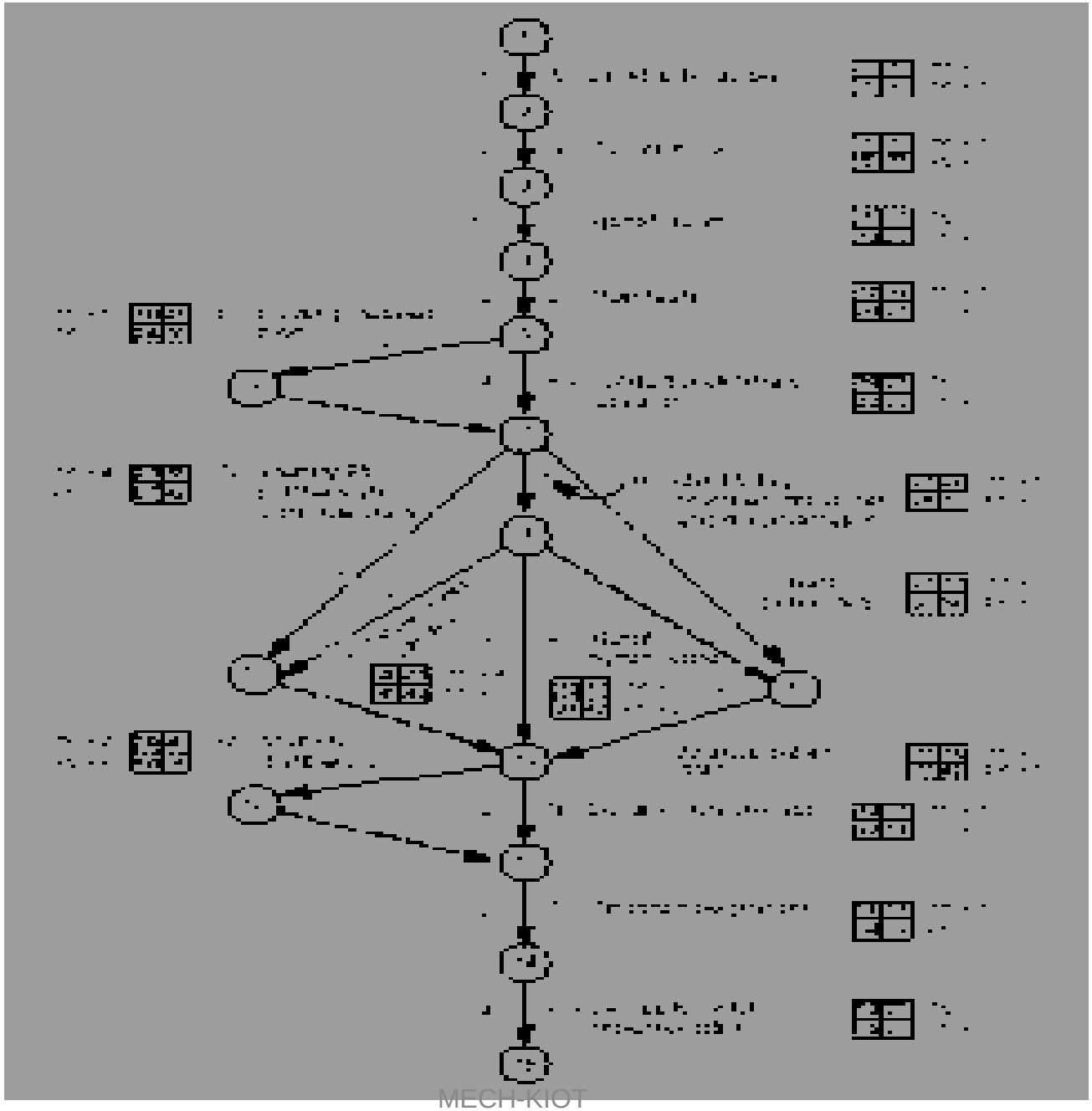
Arrow Diagram (or) Activity Network Diagram (or) Network Diagram, Activity Chart (or) Node Diagram (or) CPM (critical path method) Chart

Description

- The arrow diagram shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions.

When to Use

- **When scheduling and monitoring tasks within a complex project or process with interrelated tasks and resources.**
- **When you know the steps of the project or process, their sequence and how long each task.**
- **When project schedule is critical, with serious consequences for completing the project late or significant advantage to completing the project early.**



Process Decision Program Chart
(or) PDPC

- **The process decision program chart systematically identifies what might go wrong in a plan under development.**

- **Countermeasures are developed to prevent or offset those problems.**

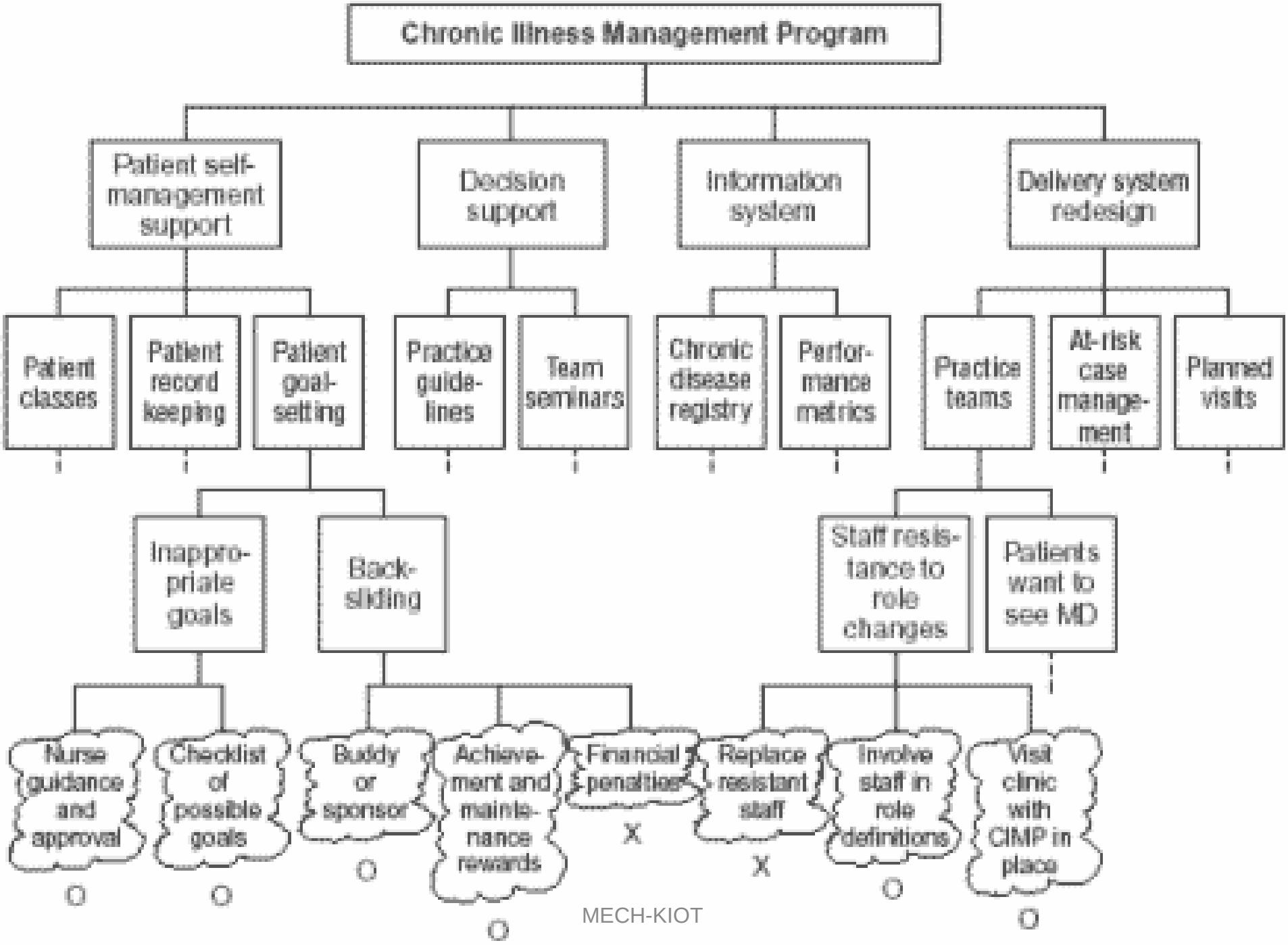
- **Using PDPC, you can either revise the plan to avoid the problems or be ready with the best response when a problem occurs.**

When to Use

- **Before implementing a plan, especially when the plan is large and complex.**
- **When the plan must be completed on schedule.**
- **When the price of failure is high.**

Example

- **A medical group is planning to improve the care of patients with chronic illnesses such as diabetes and asthma through a new Chronic illness management program (CIMP). They have defined four main elements and, for each of these elements, key components**


Chronic Illness Management Program
Patient self-management support
Decision support
Information system
Delivery system redesign
Patient classes
Patient record keeping
Patient goal-setting
Practice guide-lines
Team seminars
Chronic disease registry
Perfor-mance metrics
Practice teams
At-risk case manage-ment
Planned visits
Inappro-priate goals
Back-sliding
Staff resis-tance to role changes
Patients want to see MD
Nurse guidance and approval
Checklist of possible goals
Buddy or sponsor
Achieve-ment and mainte-nance rewards
Financial penalties
Replace resistant staff
Involve staff in role definitions
Visit clinic with CIMP in place
O
O
O
O
X
X
O
O

SIX SIGMA

Six Sigma Means 3.4 Defects in 1,000,000 - MOTOROLA

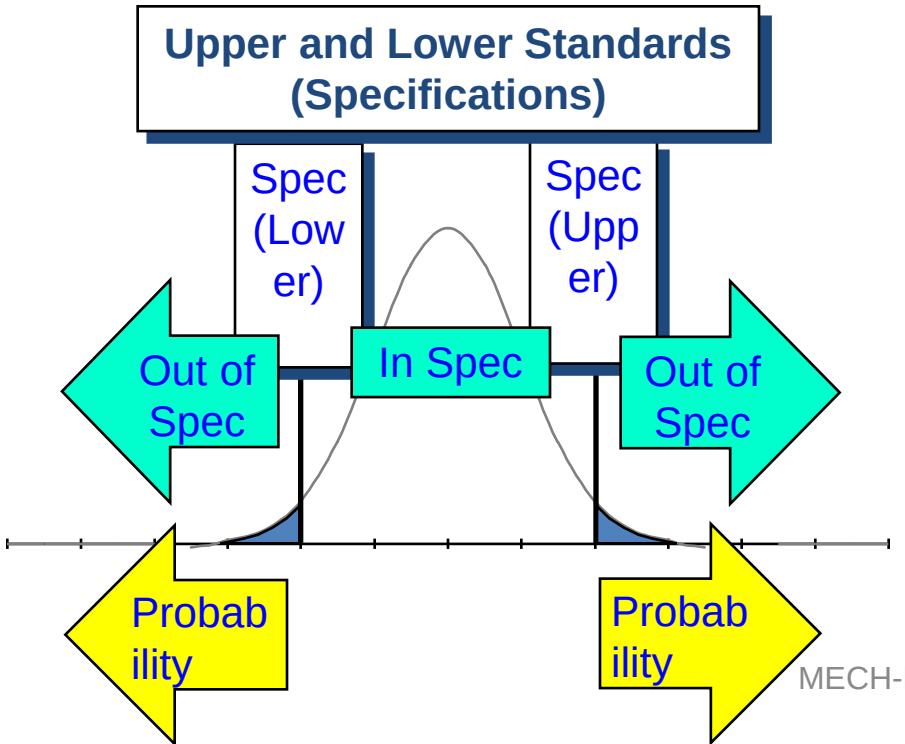
- **Six Sigma is a business concept that answers customer's demand for high quality and Defect-free Business process.**
- **Six Sigma was born in Motorola and developed by Mikel J. Harry.**
- **Motorola won Malcolm Baldridge Quality Award.**
- **Six Sigma is carried out as projects and mostly uses DMAIC method**

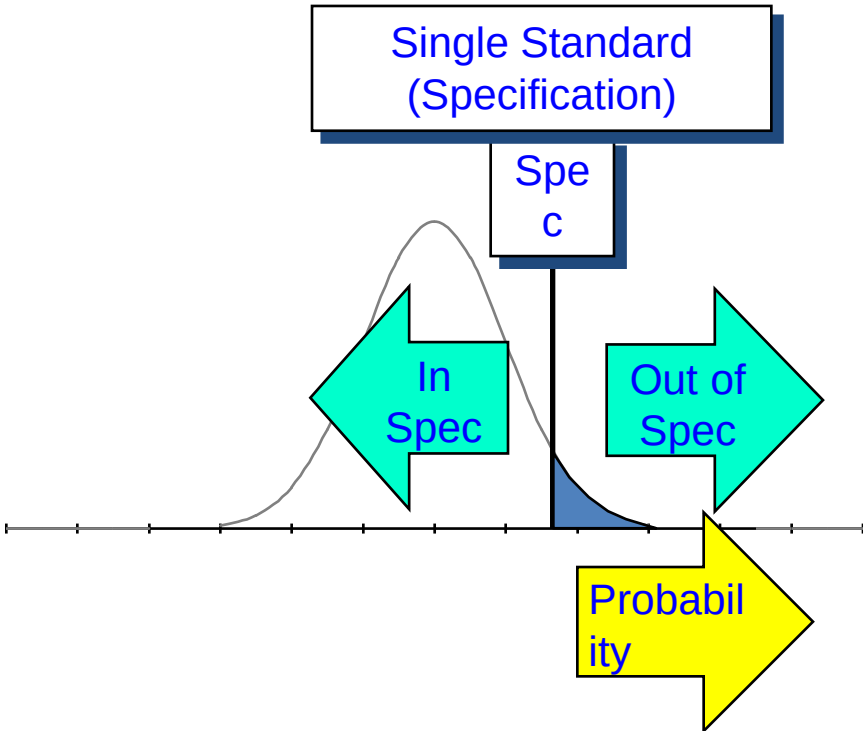
Eg: Godrej -G E Assembly Plant

- **Defective Components were coming at the rate of 3,00,000 for one Million Parts.**
- **Applying Six Sigma saved Rs 4 Crores**
- **Mr. Vijay Krishna, C.E.O, Godrej-G E. “We’re not talking about intangible savings here. Six Sigma has given us the power to measure and control costs. And that goes straight to our bottom line”**

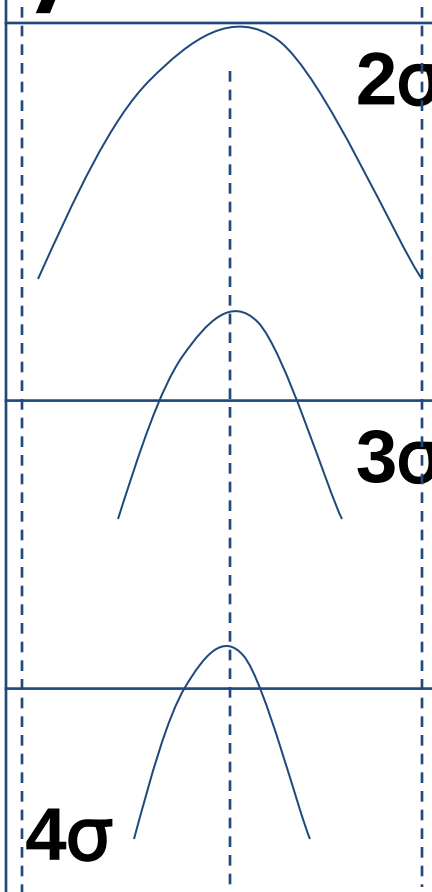
PROCESS CAPABILITY

Process capability is simply a measure of how good a metric is performing against established standard(s).

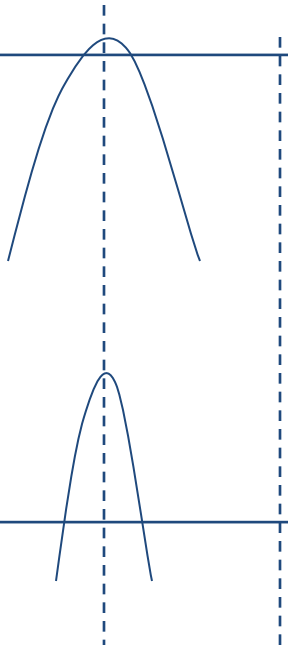




CONCEPT OF SIX SIGMA

Process Variability	Cp	Total Amount Outside Limits	Typical Action to be taken
	0.67	4.56 % (45,500 ppm)	Heavy Process Control, Sorting rework, Etc.
	1.0	2700 ppm	Heavy process Control, Inspection
	1.33	64 ppm	Reduced Inspection, Selected use

CONCEPT OF SIX SIGMA

Process Variability	Cp	Total Amount Outside Limits	Typical Action to be taken
5σ 	1.67	1 ppm	Spot Checking, Selected use of Control Charts
6σ	2.00	0.01ppm	Reduced for Control, Uniformity in process inputs

USL Process LSL
Mean

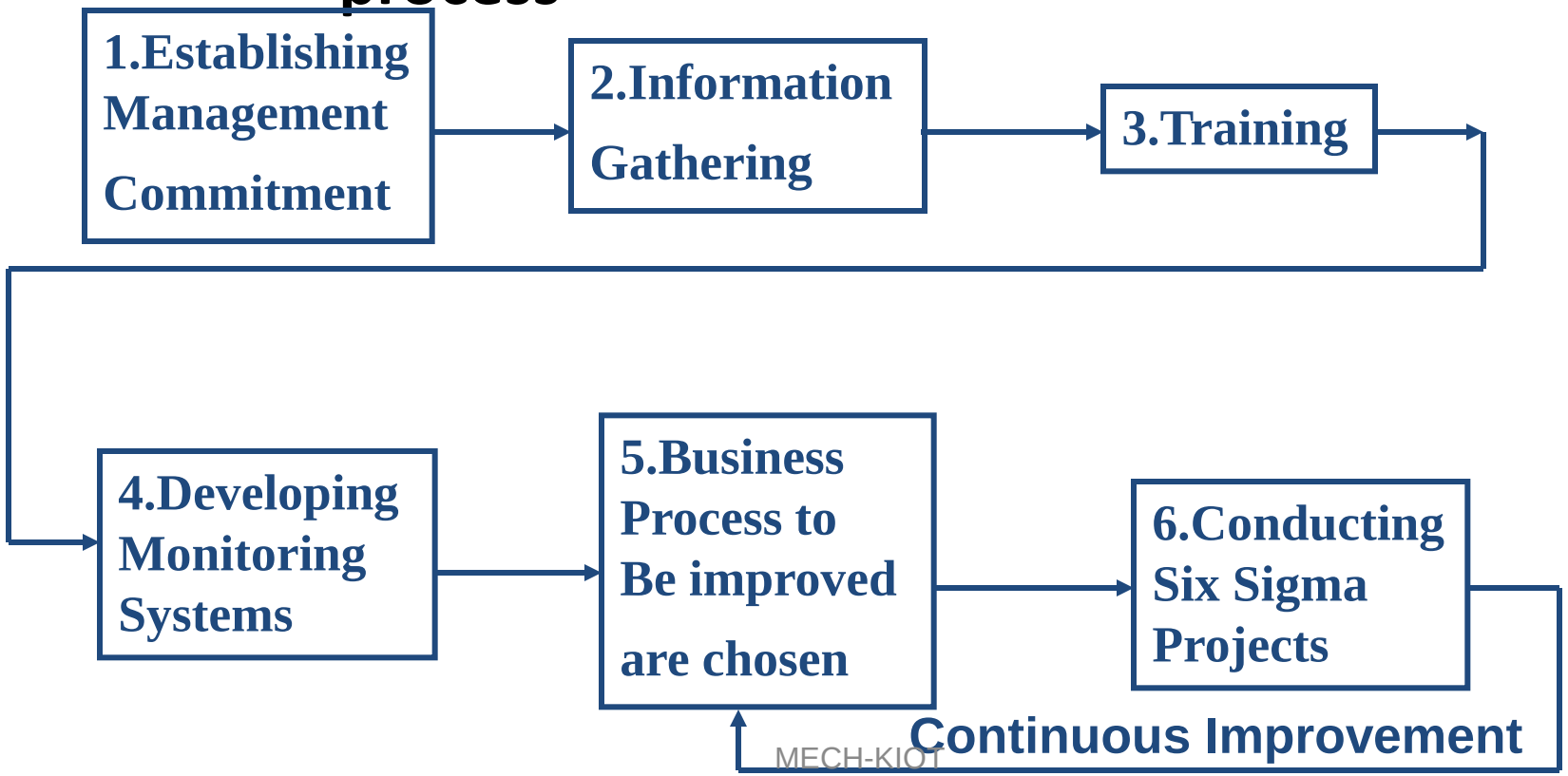
Cp = Design Width / Process Width
Cp = USL –LSL / UCL - LCL

SIGMA SCALE OF DEFECTS(1.5 σ shift)

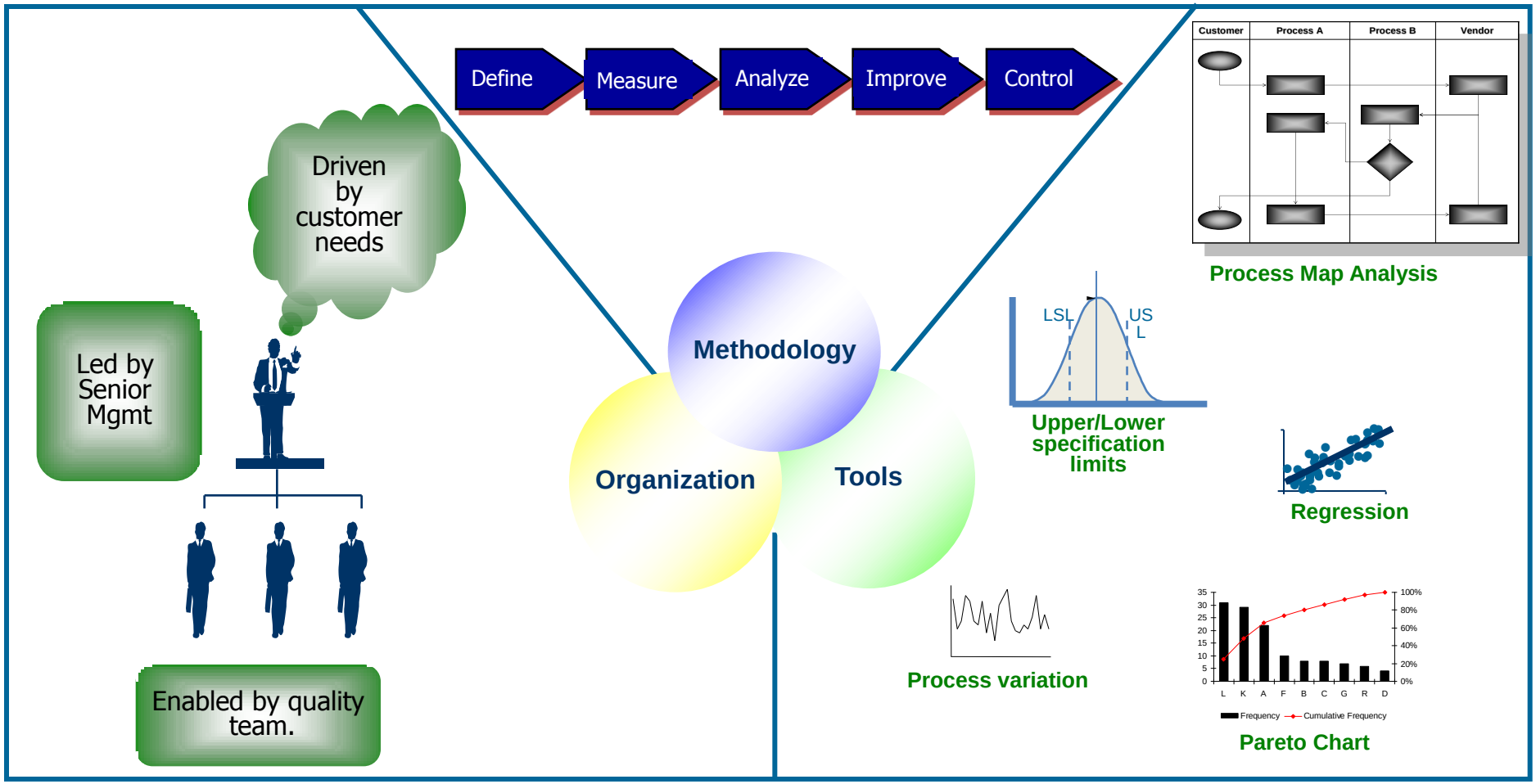
SIGMA	DEFECT RATE (PPM)	COST OF POOR QUALITY (% Sales)	Competitive Level
6σ	3.4	< 10%	World Class
5σ	233	10%-15%	World Class
4σ	6,210	15%-20%	High Quality
3σ	66,807	20%-30%	Industry Average
2σ	3,08,537	30%-40%	Industry Average
1σ	6,90,000	> 40%	Non-

Six Sigma Implementation

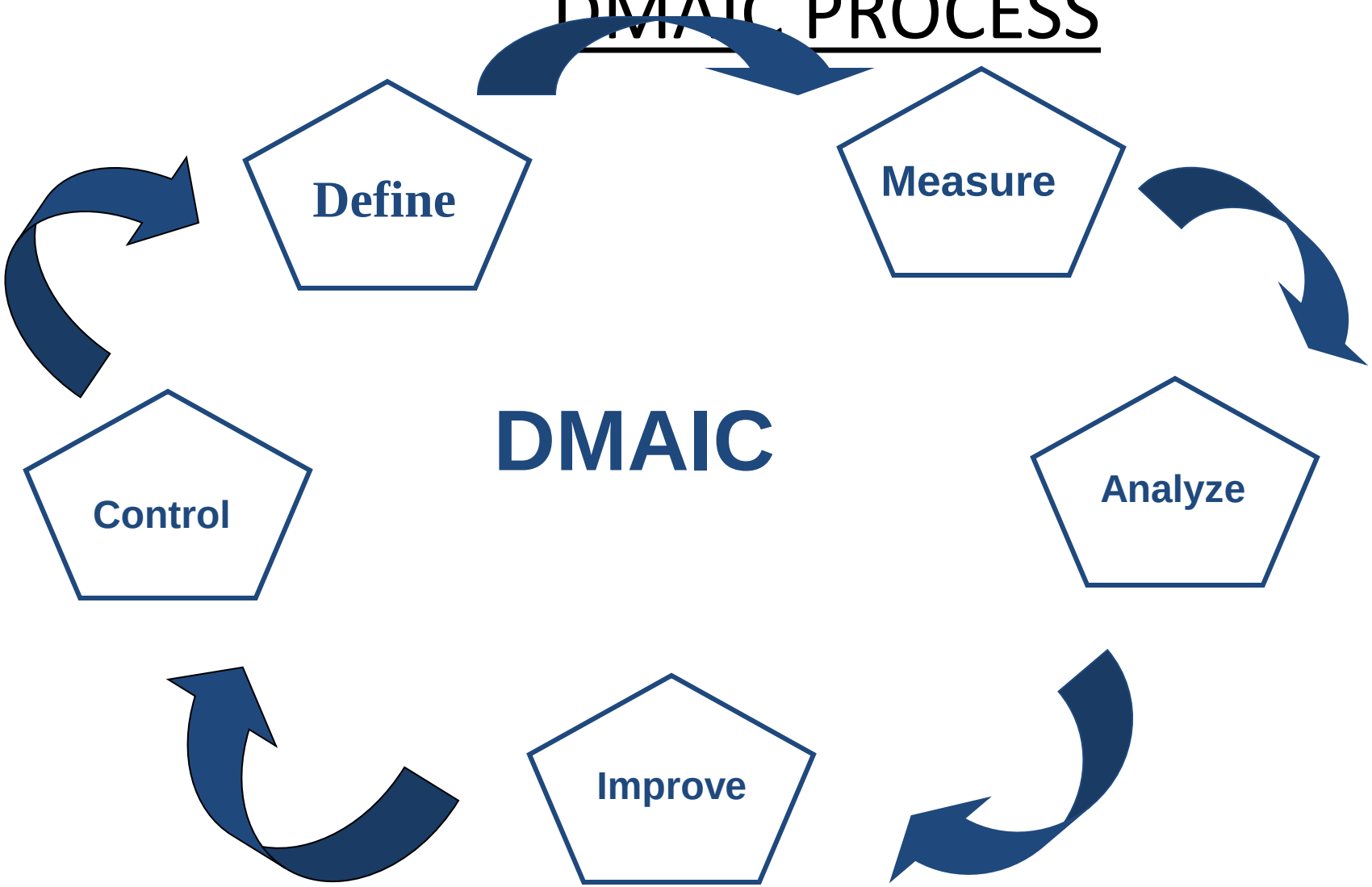
- **Five-phases process**



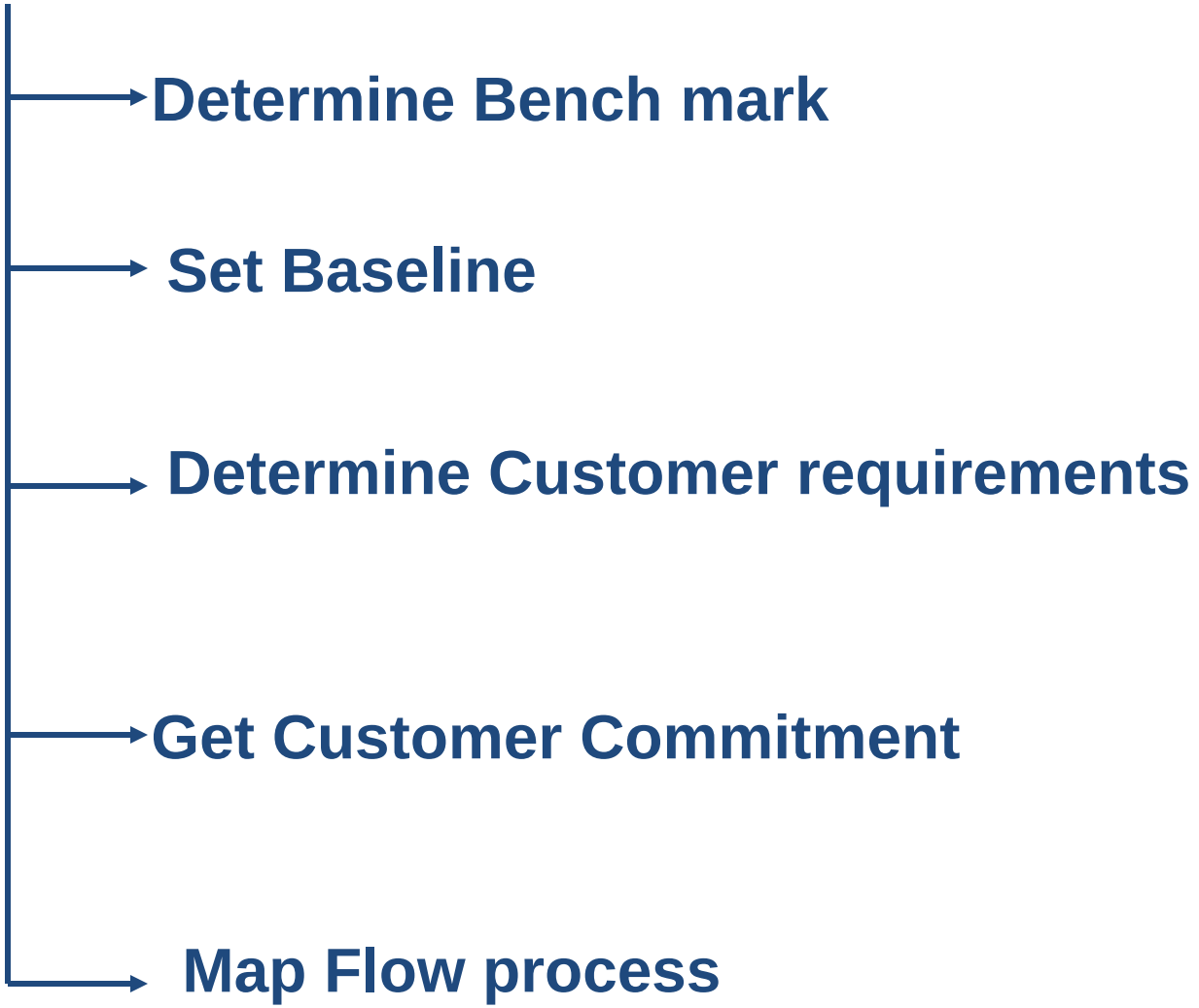
Six Sigma - Three Dimensions



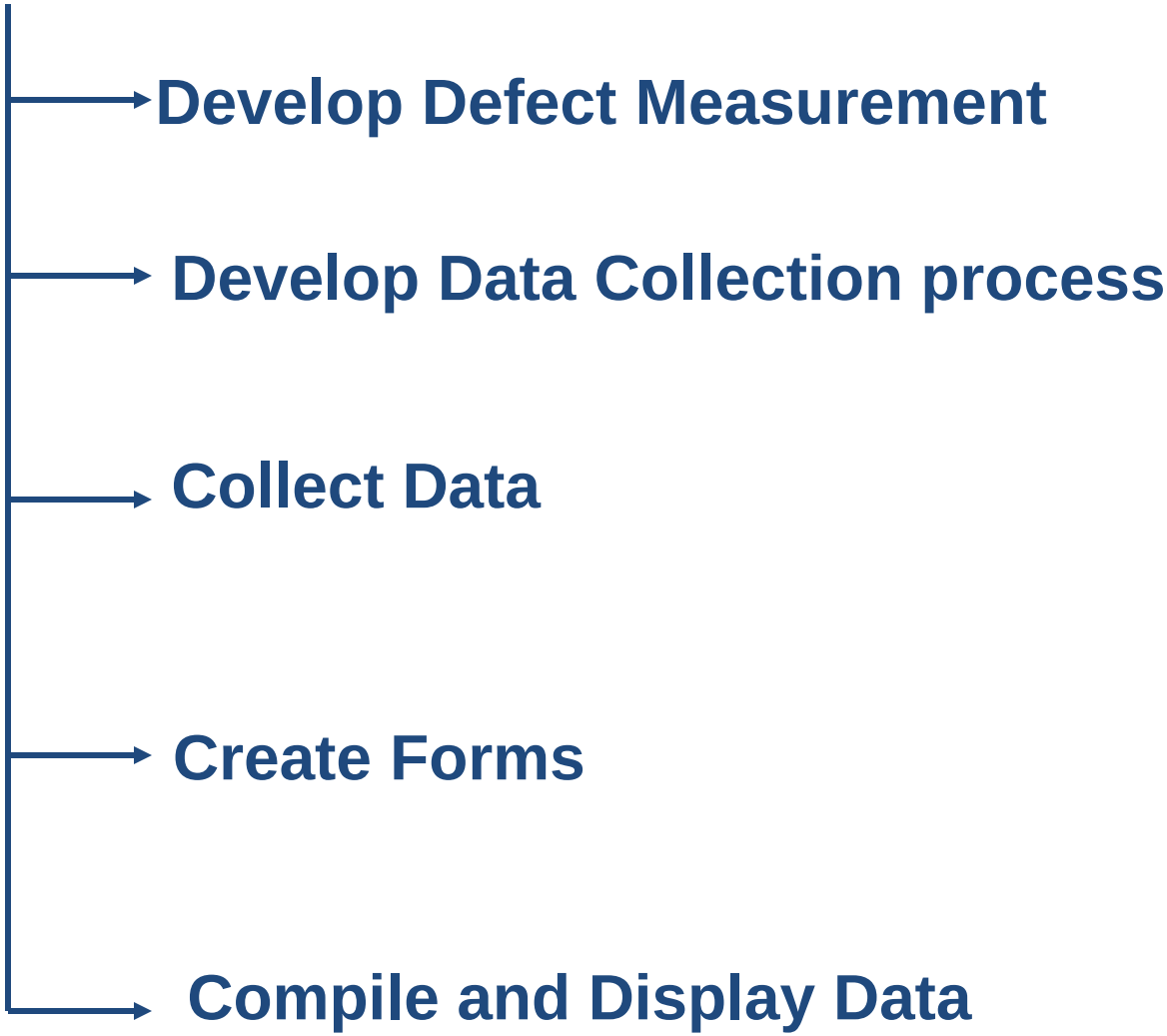
DMAIC PROCESS



DEFINE


Determine Bench mark
Set Baseline
Determine Customer requirements
Get Customer Commitment
Map Flow process

MEASURE


Develop Defect Measurement
Develop Data Collection process
Collect Data
Create Forms
Compile and Display Data

ANALYSE


Verify Data
Draw Conclusions From Data
Test Conclusions
Determine Improvement Opportunities
Determine Root Causes

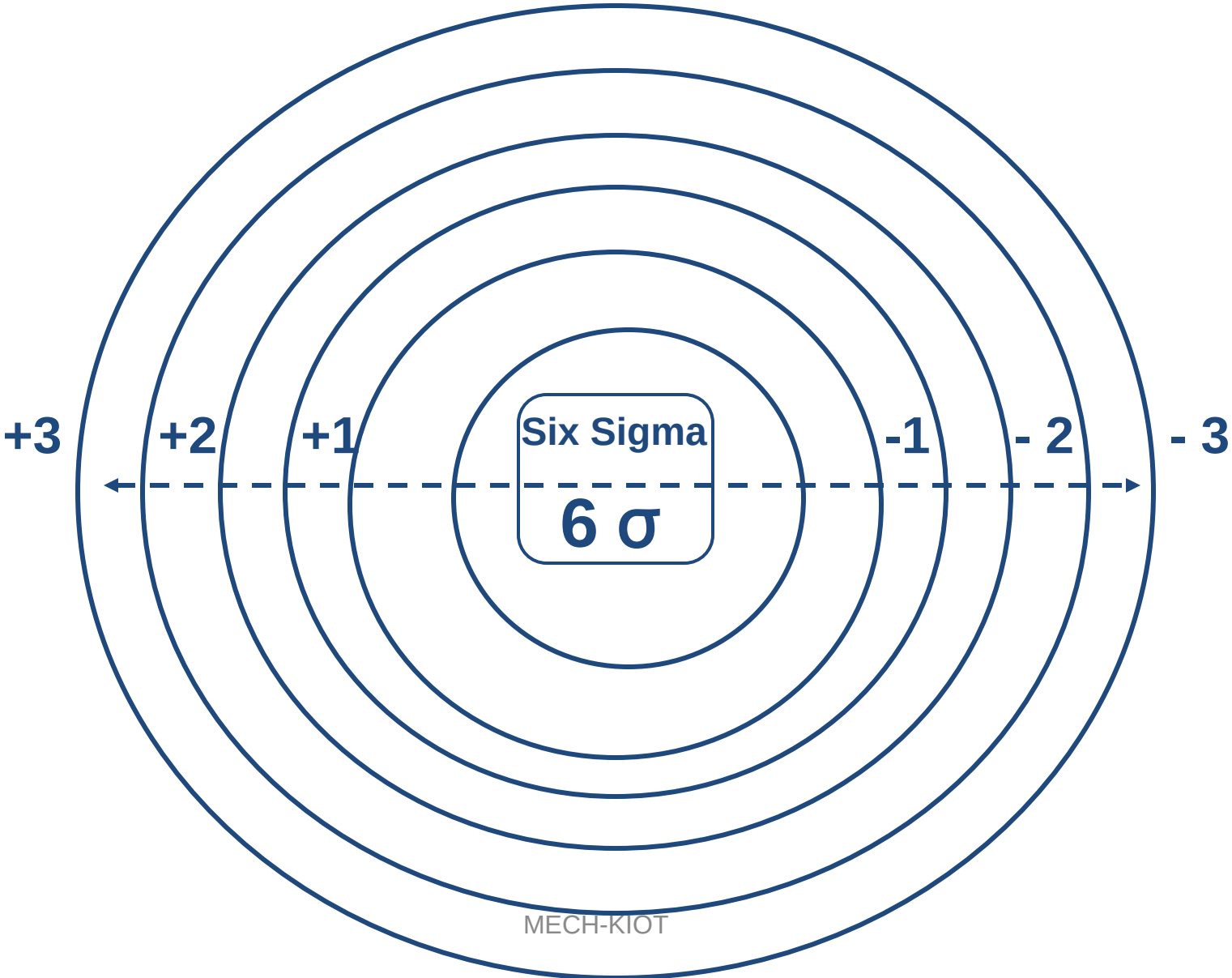
IMPROVE


Create Improvement Ideas
Create Models
Experiment
Set Goals
Create Problem Statement
Create Solution Statement
Implement Improvement Methods

CONTROL


Monitor Improvement Progress
Measure Improvement Statistically
Assess Effectiveness
Make Needed Adjustments

ENIGMA OF SIX SIGMA



SIX SIGMA BENCHMARKS

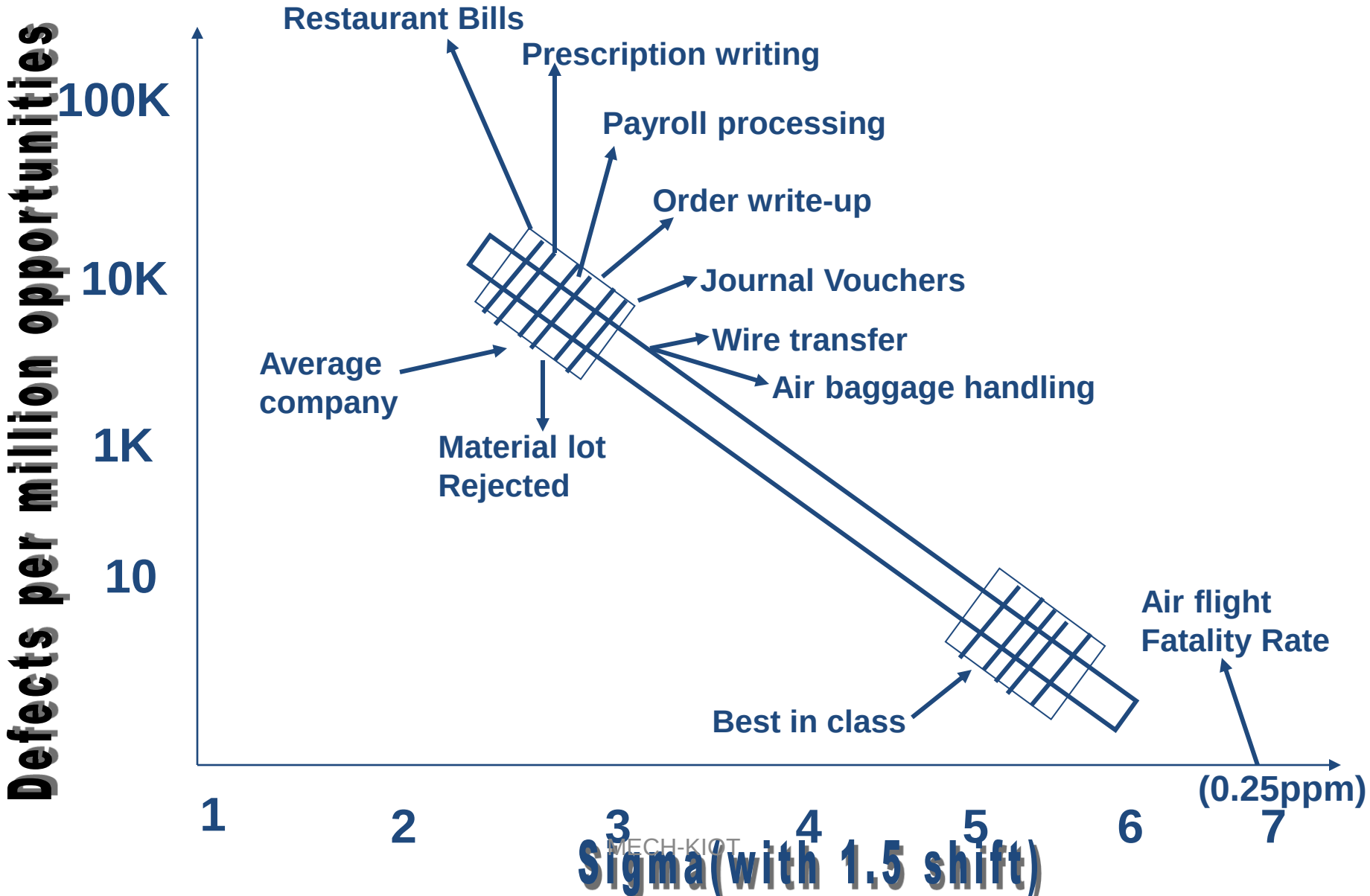


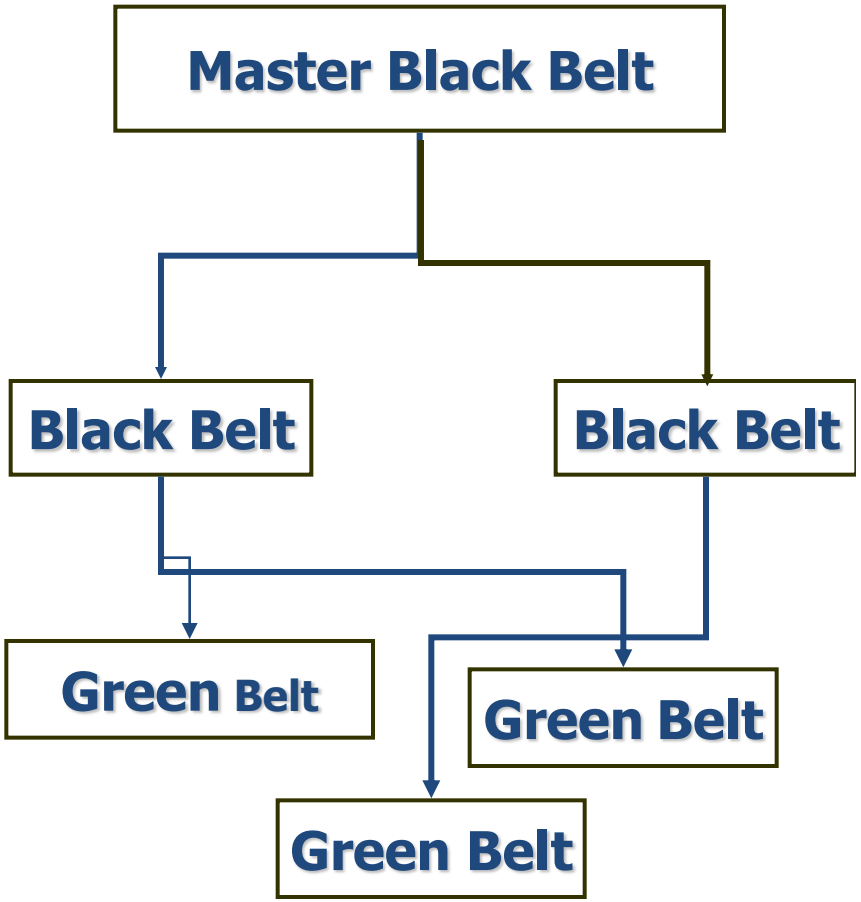
Table 1: Companies And The Year They Implemented Six Sigma	
Company Name	**Year Began Six Sigma**
Motorola (NYSE:MOT)	1986
Allied Signal (Merged With Honeywell in 1999)	1994
GE (NYSE:GE)	1995
Honeywell (NYSE:HON)	1998
Ford (NYSE:F)	2000

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]	3.3
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

Key:
$B = $ Billions, United States
(e) = Estimated, Yearly Revenue 1986-1992 Could Not Be Found
ND = Not Disclosed
Note: Numbers Are Rounded To The Nearest Ten

The Quality Team



- Thought Leadership
- Expert on Six Sigma
- Mentor Green and Black Belts

- Backbone of Six Sigma Org
- Mentor Green Belts
- Full time resource
- Deployed to complex or "high risk" projects

- Part time or full time resource
- Deployed to less complex projects in areas of functional expertise

Scope of Six Sigma

- Manufacturing
- Service Industries
- Hospitals
- Insurance
- Call Centre

BENCHMARKING

SUN TZU,
A CHINESE GENERAL IN 500 B.C.

If you know your enemy and know yourself, you need not fear the results of a hundred battles.

Japanese DANTOTSU word has the meaning of striving to be the 'BEST OF BEST'. This is the essence of BENCHMARKING

Bench Marking

❖Benchmarking is a systematic method by which organization can measure themselves against the best industry practices.

❖Essence of BM is the process of borrowing ideas and adapting them to gain competitive advantage.

BM Defined

Bench Mark is the systematic search for best practice, innovative ideas and highly effective operating procedure

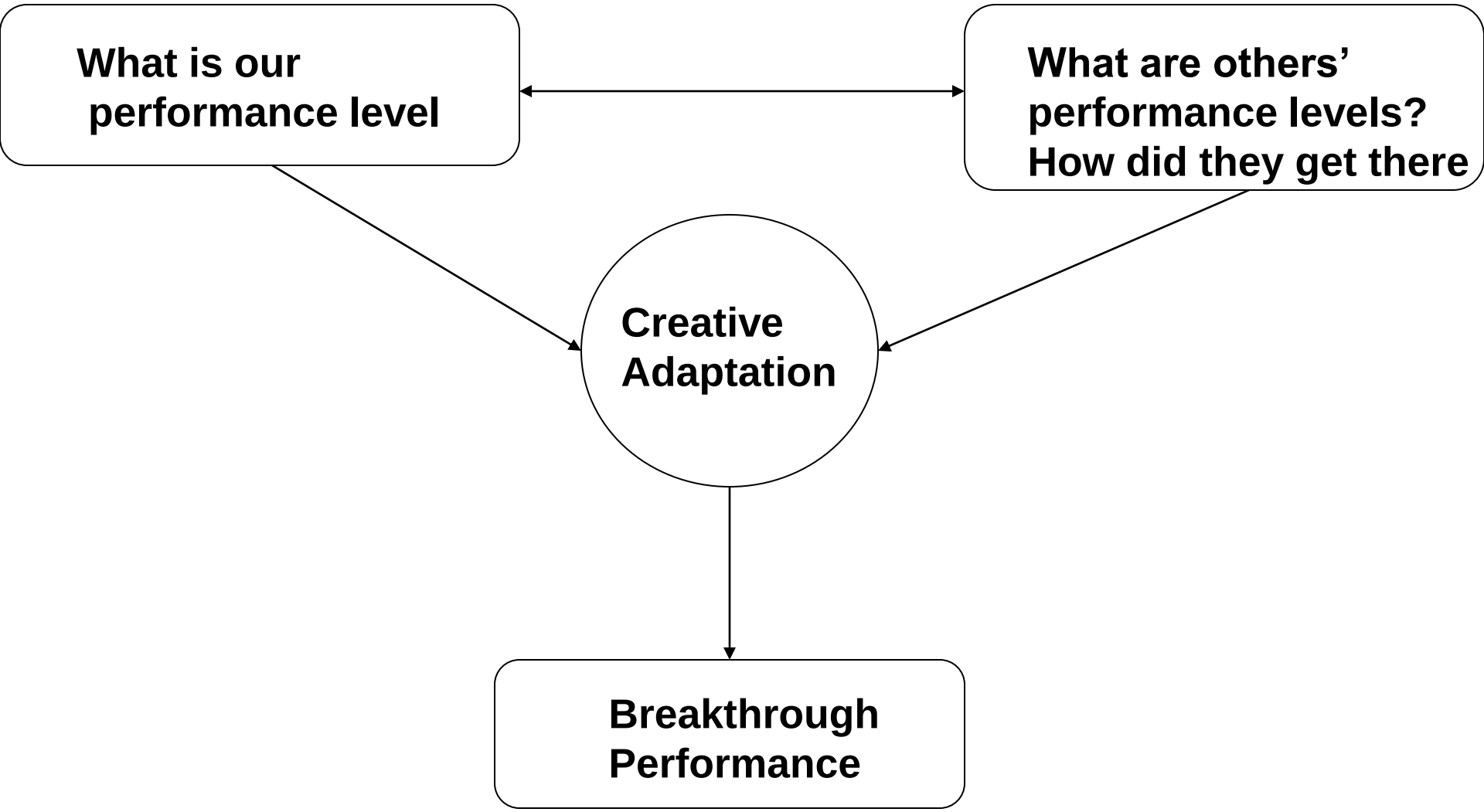
W. Edward Deming

It is Hazard to copy .It is necessary to understand the theory of what one wishes to do.

Definition By ROBERT CAMP

- **“It is the search for the industry best practices that lead to superior performance.**

BENCHMARKING CONCEPT



Reasons for Bench Marking

- To achieve Business & Competitive Objectives.
- Goals & Objectives Based on External Environment.
- Cost Efficient.
- Continuous Improvement & New Development.

Bench Marking Process

Phases	S.no	Steps
Planning	1	Earmark what is to be Bench Marked ?
	2	Identify the best competitor
	3	↓ Determine the data collection method and start collecting data
Analysis	4	Determine the current performance GAP
	5	↓ Project future performance levels

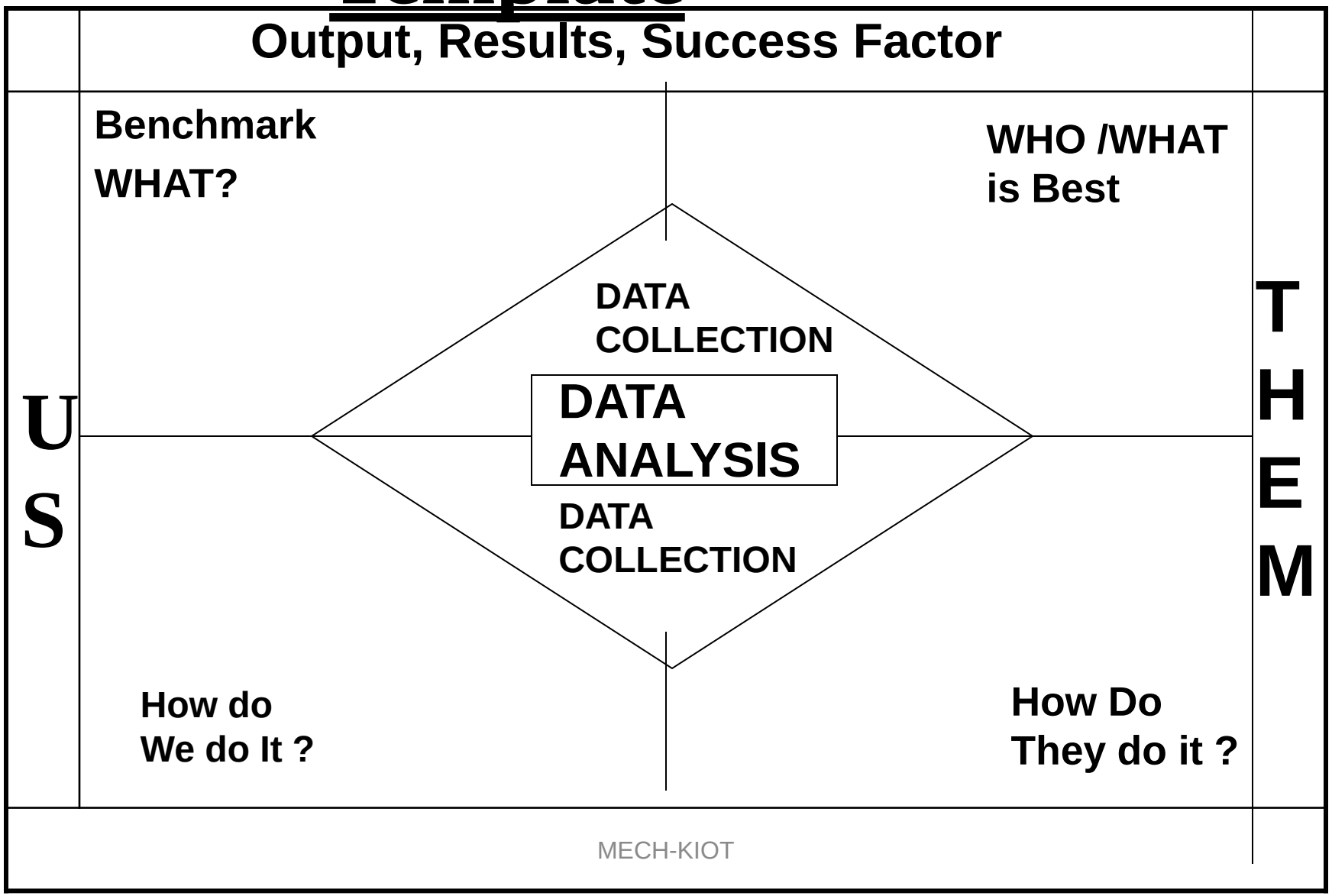
Bench Marking Process

Phases	S.no	Steps
Integration	6	Communicate bench mark findings and gain acceptance
	7	Establish Functional Goals Communicate Data For analysis Acceptance for Analysis
Action	8	Develop Action Plans
	9	Implement specific actions and monitor Progress

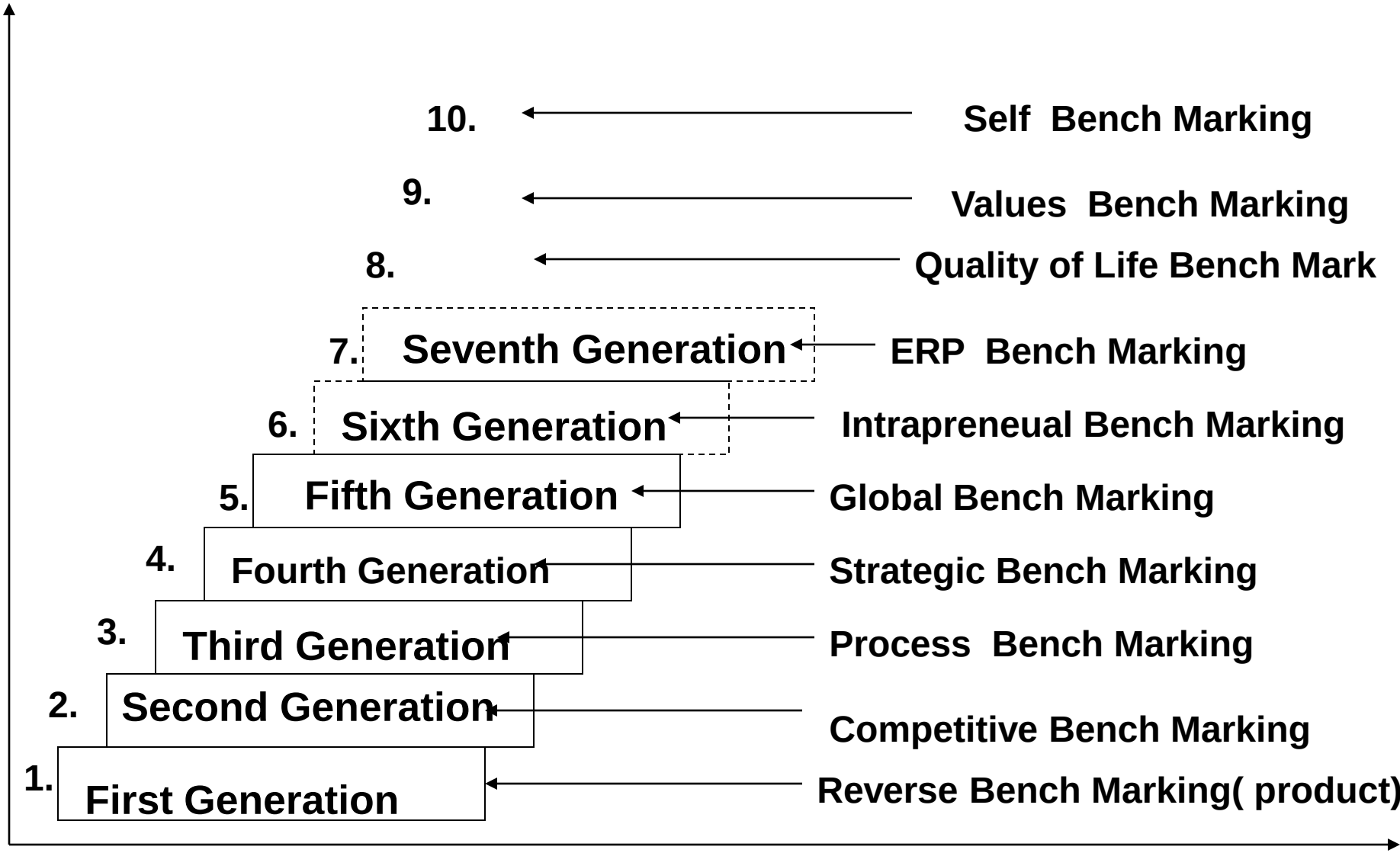
Bench Marking Process

Phases	S.no	Steps
Maturity	10	Recalibrate Benchmarks
	11	Attain the Leadership position
	12	Integrate Practice into the Process

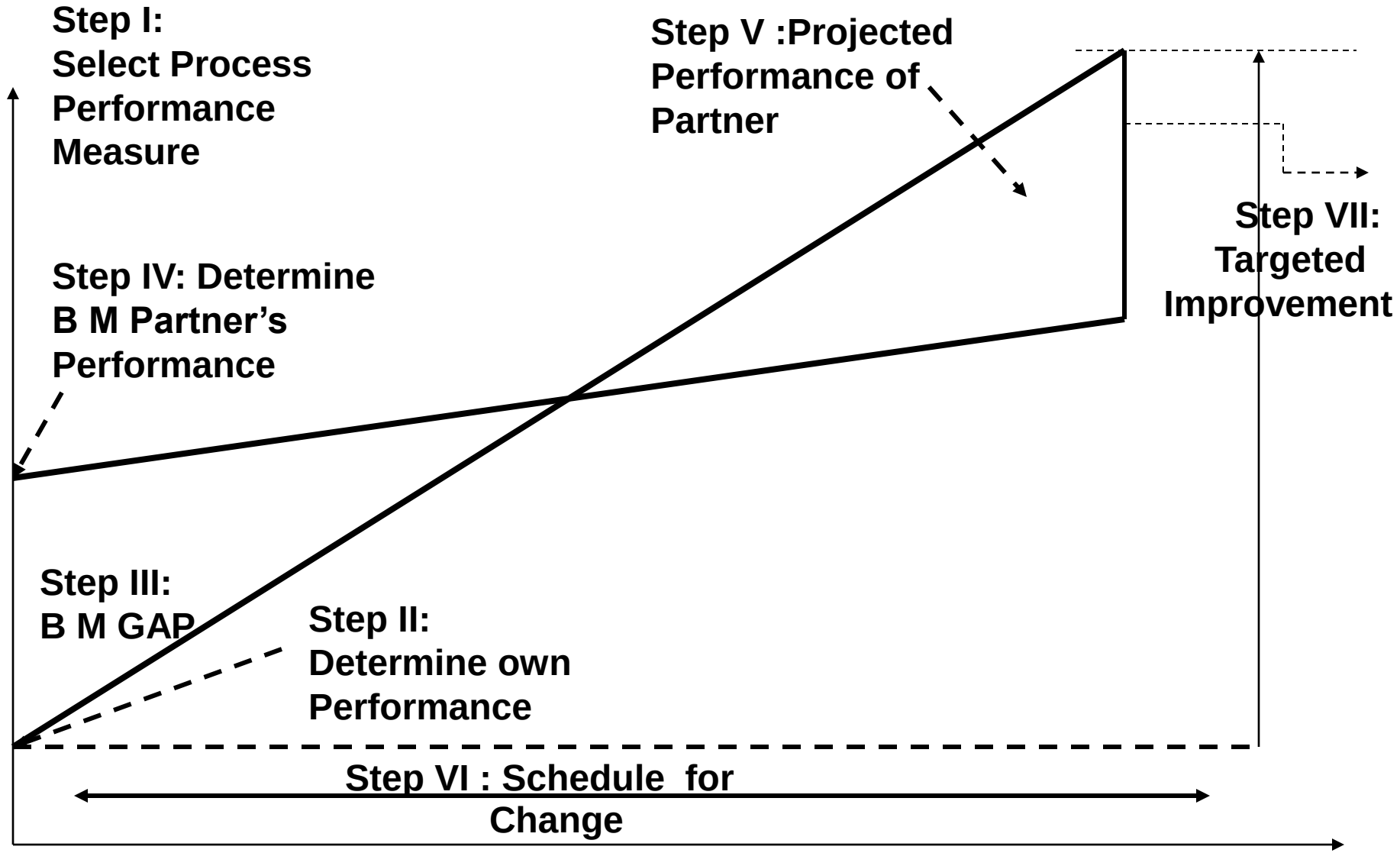
Bench Marking Template



Generation of Benchmark



Process of Gap Closing



Reasons For Bench Mark

- Defining Customer Requirements
- Establish Goals and Objectives
- Measures of Productivity
- Becoming Competitive
- Industry best practices to be achieved

Types of Bench Mark

- Internal B M

E.g. Eicher Tractor Comparison Between Units

- Competitive B M

Direct Product Competitors

- Functional B M

E.g. Best Logistics from same industries (or) Any industries

- Generic B M

Same process or functions like Customer service, order entry, regardless of industries .

BENEFITS OF B M

- Best Practices incorporated into the process
- Motivation for creativity & innovation
- Technological Breakthrough in one's industry
- Better professional growth
- Meet effectively customer requirements
- Assist in attaining competitive position

FAILURE MODE EFFECTIVE ANALYSIS (FMEA)

Introduction

- **Failure Mode Effect Analysis is an analytical technique that goes in for combining Technology and Experience of people to identify foreseen failures in a product or process and planning to eliminate the Failure.**

Definition

FMEA is a group of activities to understand and evaluate potential failure of product or process and its effects, and identify actions that eliminate or reduce the potential failures.

Types of FMEA

Major Classification

- Design FMEA
- Process FMEA

Sub Classification

- Equipment FMEA
- Maintenance FMEA
- Service FMEA
- System FMEA

- **DESIGN FMEA**

Design FMEA use in the design process by identifying known and foreseeable failures modes and ranking failures according to their impact on the product.

- **PROCESS FMEA**

It is used to identify potential process failure modes by ranking failures and establishing priorities, and its impact on the Internal or external customers.

RELIABILITY

- **Reliability is defined as the probability that the product will perform as per the expectation for a certain period of time, under the given operating conditions, and the given set of product performance characteristics.**
- **The part, assembly, or process under consideration, the reliability of each sub system and factors that contribute to failure to be found.**

FAILURE RATE

- Products follow a pattern of failure.
- There is no information about the reliability (i.e. Failure) of the product.
- Failure Rate is a constant is known period of failure can be found out using Exponential Distribution

$R_t = e^{-\lambda t}$ R_t = Reliability of survival

$R_t = e^{-t/\theta}$ t = Time for operation without failure

λ = Failure rate θ = Mean time to Failure

PROBLEM

- Failure Rate λ = .0002 per hour
- What is the probability that it will survive or reliable during the first 200 hours of operations?
- Solution

$$Rt = e - \lambda t$$

$$= e - (200)\ (0.0002)$$

$$= 96.08\ \%$$