INDUSTRIAL MANAGEMENT

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What is Industrial Management?

- It is the combination of two words

- *Industrial : "the application of complex and sophisticated methods to the production of economic goods and services"*
- *Management : "Planning ,organizing, coordinating, controlling, directing various activities in an organization".*

- According to Henry Fayol " Management is to forecast and plan, to organize, to command, to coordinate, and to control".

- According to Oliver " the term management is commonly used to cover the formation of policy, its execution, the designing of the organizations and its employment".

- Simple working definition is “ Management is a process used to accomplish organizational goals”.

- Industrial Management may be defined as “the branch of engineering that deals with the creation and management of systems that integrates people, materials and energy in productive ways.”

Characteristics of Management

1. Management aims at reaping rich results in economic terms
2. Management also implies skill and experience in getting things done through people
3. Management is a process
4. Management is a universal activity
5. Management is a Science as well as an art
6. Management is a profession

7. Management is an endeavor to achieve pre-determined objectives

8.Management is a group activity

9. Management is a system of authority

10 Management involves decision-making

11. Management implies good leadership

12. Management is dynamic and not static

13. Management draws ideas and concepts from various disciplines.
14. Management is goal oriented
15. Different levels of Management
16. Need of Organization
17. Management need not be own
18. Management is intangible.

Functional areas of Management

- 1. Financial Management
- 2. Human Resource Management
- 3. Marketing Management
- 4. Production Management
- 5. Material Management
- 6. Purchasing Management
- 7. Maintenance Management
- 8. Office Management

Is Management a Science or an Art

- Management is both Science as well as art
- Why Science :
- Why Art:

Evolution of Management Thought

- Evolution of management thought may be divided into four stages

1. Pre-scientific management period
2. Classical Theory
   - (a) Scientific Management of Taylor
   - (b) Administrative Management of Fayol
   - (c)Bureaucratic Model of Max Weber
3. Neo-classical Theory or Behaviour Approach
4. Modern Theory or Systems Approach

1. Pre-scientific management period

- The advent of industrial revolution in the middle of the 18th century had its impact on management.
- Industrial revolution brought about a complete change in the methods of production, tools and equipments, organization of labour and methods of raising capital.
- Traditional, conventional or customary ideas of management were slowly given up and management came to be based on scientific principles.

- During the period following the industrial revolution, certain pioneers tried to challenge the traditional character of management by introducing new ideas and character of management by introducing new ideas and approaches. The notable contributors of this period are:

1. **Professor Charles Babbage (UK 1729 -1871)** :
   He advocated the use of accurate observations, measurement and precise knowledge for taking business decisions.

2. **James Watt Junior (UK 1796 – 1848) Mathew Robinson Boulton (1770 - 1842):**

James Watt Junior and Mathew Robinson Boulton contributed to the development of management thought by following certain management techniques in their engineering factory at Soho in Birmingham. They are:

- Production Planning
- Standardization of Components
- Maintenance
- Planned machine layout
- Provision of welfare for personnel
- Scheme for executive development
- Marketing Research and forecasting
- Elaborate statistical records

3. Robert Owens (UK 1771 - 1858):

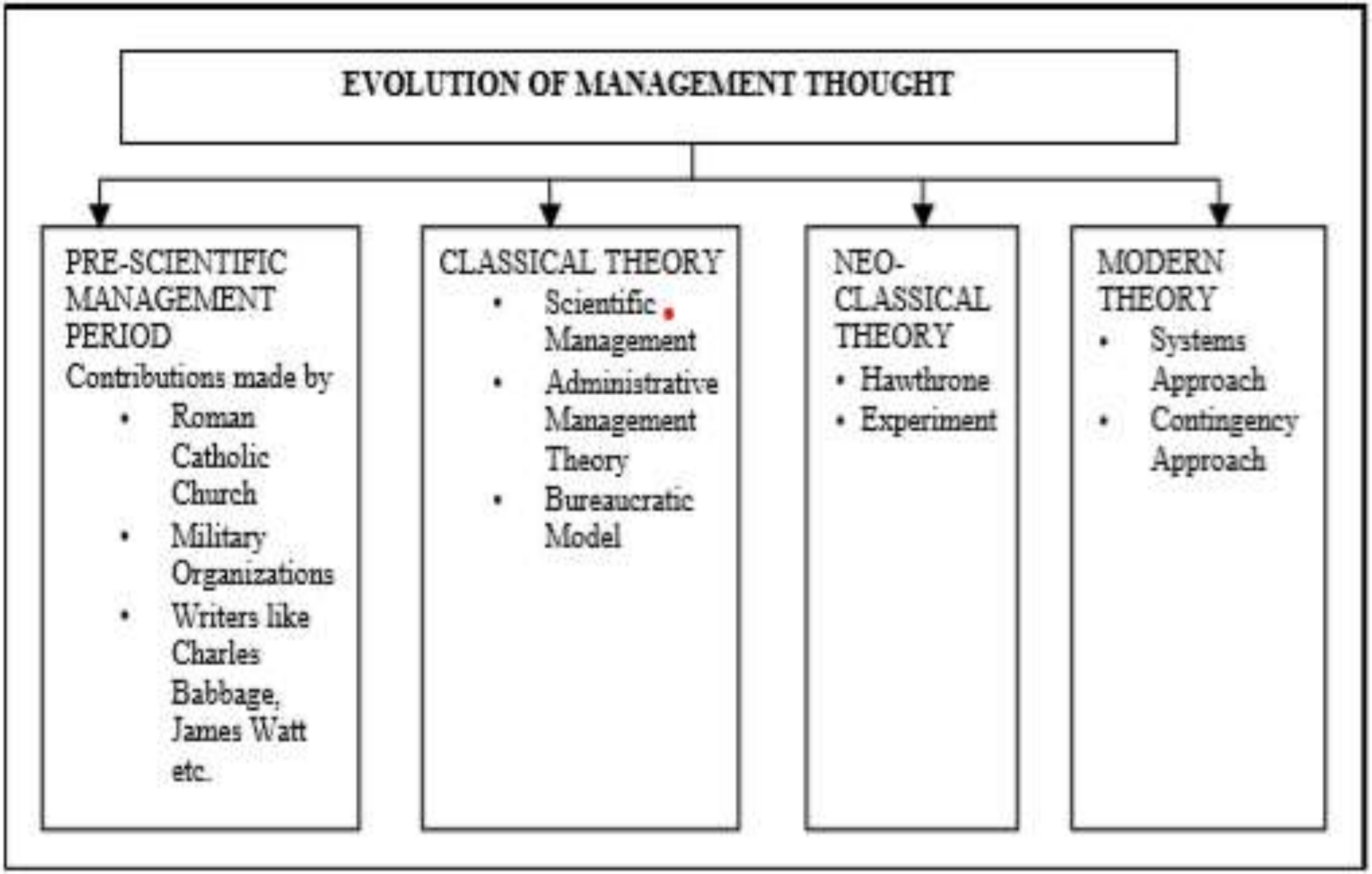
emphasized the recognition of human element in industry. He firmly believed that workers' performance in industry was influenced by the working conditions and treatment of workers. He introduced new ideas of human relations - shorter working hours, housing facilities, training of workers in hygiene, education of their children, provision of canteen etc.

4. **Henry Robinson Towne (USA 1844 -1924):** H.R Towne was the president of the famous lock manufacturing company "Yale and Town". He urged the combination of engineers and economists as industrial managers.

- This combination of qualities, together with at least some skill as an accountant, is essential to the successful management of industrial workers.

- **Seebohm Rowntree (UK 1871- 1954):** Rowntree created a public opinion on the need of labour welfare scheme and improvement in industrial relations.

Evolution of Management Thought



2. Classical Theory

- Prof. Charles Babbage, James Watt Junior and Mathew Robinson Boulton, Robert Owen, Henry Robinson Towne and Rowntree were, no doubt, pioneers of management thought.

- But, the impact of their contributions on the industry as a whole was meagre. The real beginning of the science of management did not occur until the last decade of the 19th century.

- During this period, stalwarts like F.W. Taylor, H.L. Gantt, Emerson, Frank and Lillian Gilberth etc., laid the foundation of management, which in due course, came to be known as scientific management.

Taylor Scientific Management Approach

- Frederick Winslow Taylor (1856-1915)
- American Mechanical Engineer
- Theory of Management developed - Scientific Management
- First to recognize and emphasize the need for adopting a scientific approach to the task of managing an enterprise.
- The scientific method consists essentially of

  (a) Observation

  (b) Measurement

  (c) Experimentation and

  (d) Inference.

- Scientific Management:

- Managers earlier followed - Rule of thumb

- So scientific management was proposed- applying standardizing methods and tools to increase the output, quality & reduce cost and wastage

- Taylor words " scientific management means knowing exactly what you want men to do and seeing that they do it in the best and cheapest way"

He summed up his approach in these words:

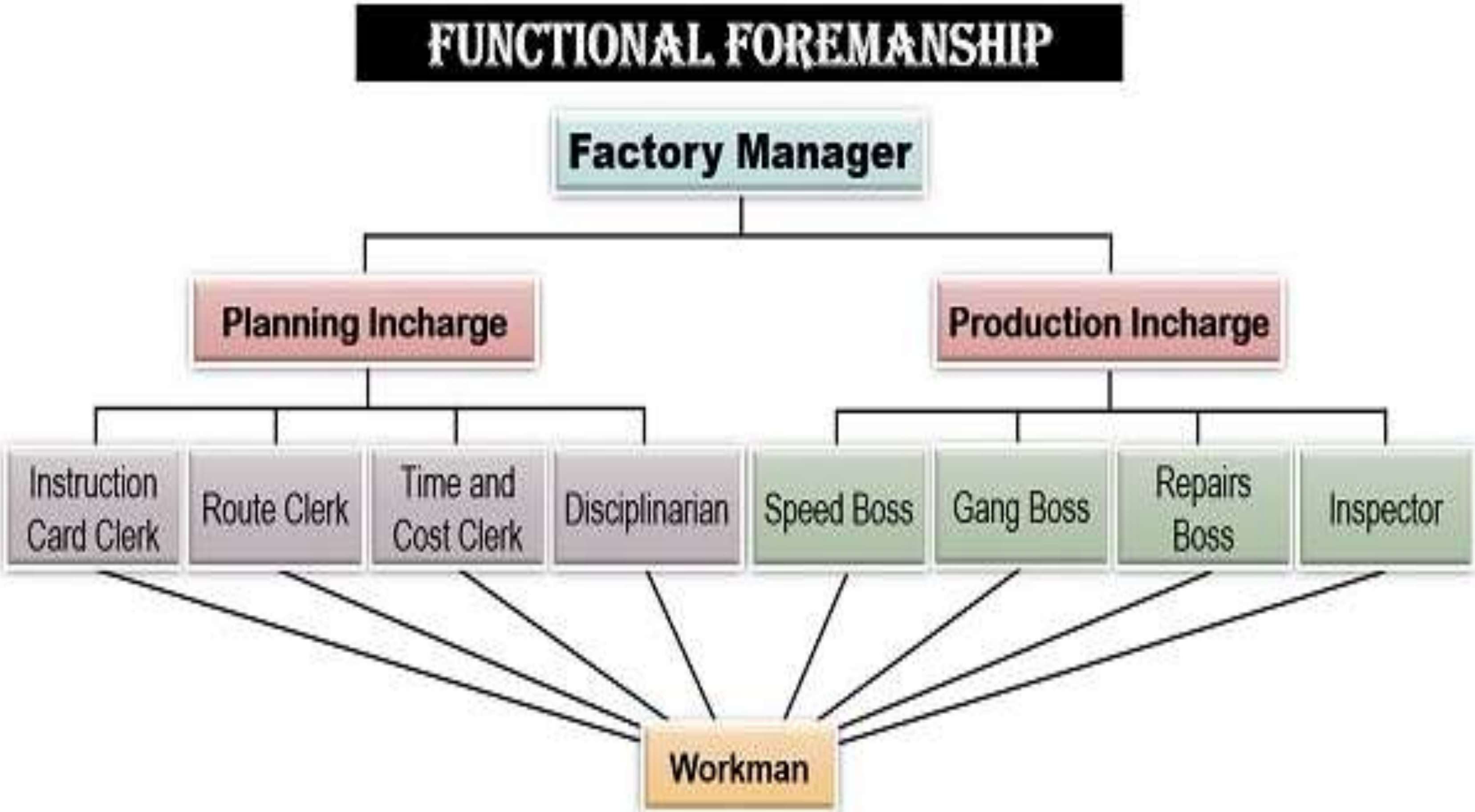
- Science, not rule of thumb
- Harmony, not discord
- Co-operation, not individualism
- The development of each man to his greatest efficiency and prosperity.

Elements/ Techniques of Scientific Management:

1. 1. Functional foremanship
2. 2. Standardization & simplification of work
3. 3. Work study techniques
4. 4. Differential piece wage system
5. 5. mental revolution

1. functional foremanship (Specialization) :

- Functions of ‘Planning’ and ‘doing’ are separated.
- Single person can not be master of all task - specialization
- Advocated appointment of eight foremen


FUNCTIONAL FOREMANSHIP
Factory Manager
Planning Incharge
Production Incharge
Instruction Card Clerk
Route Clerk
Time and Cost Clerk
Disciplinarian
Speed Boss
Gang Boss
Repairs Boss
Inspector
Workman

- Planning Incharge:
  - Route clerk: specify route of production
  - Instruction card clerk: Give instructions to workers
  - Time & cost clerk: prepare time & cost sheets
  - Disciplinarian: Maintain discipline among workers
- Production Incharge:
  - Speed boss: Timely completion of time
  - Gang boss: Keeping machines & tools ready for work
  - Repair boss: Keeping machines & tools in proper manner
  - Inspector: maintain quality of work

2. Standardization & simplification of work:

Standardization refers to the process of setting standards to each business activity-process of bringing uniformity.

- Can be standardization of process, raw material, time , product, machinery, machines or working conditions
- **Example:** standardization of product:

- **Objectives of standardization:**
  - Maintain quality standards
  - Setting performance standards for men and machines
  - Provide interchangeability of manufactured parts and product
  - Get the production as per targets in predetermined time

Simplification aims at eliminating superfluous varieties, sizes and dimensions.

- ✓ Eliminating unnecessary diversity of products
- ✓ Helps in savings of cost of labour, machines, and tools.

3. Work study Techniques:

- Scientific management requires deep analysis of all activities of organization- producing maximum possible output with minimum possible efforts.
- Taylor conducted no. of experiments- method study, motion study, time study and fatigue study.
  - Objective- method study is to find out one best way of doing the job
  - Minimize cost of production & maximize quality and customer satisfaction
  - Ford Motor- the assembly line production would entail deciding the sequence of operations, place for men, machines and raw materials etc.

- **Work study Techniques:**
- **Motion study:**
  - Study of movements of worker while doing a task
  - Three types of movements- productive, unproductive and incidental
  - Objective- Eliminate unnecessary movement
  - Ex. Motions in bricks layering from 18 to just 5
  - Used stop watches and various symbols and colors to identify diff. motions.
  - Able to design suitable equipment and tools to educate workers on their use
- **Time study:**
  - Determine the standard time taken to do a job- use of time measuring devices
  - Helps in deciding fair day's work
  - Helps to determine incentive schemes and labour costs
- **Fatigue study:**
  - Amount and frequency of rest intervals to be given to workers to complete a task
  - Helps to regain stamina
  - Reduce fatigue
  - Causes of fatigue- long working hours, doing unsuitable work, having uncardial relations with the boss or bad working conditions etc.
  - Removal of hindrances is essential

- **4. Differential piece wage system:**
  - Differentiate between efficient and inefficient worker
  - Wages under this system paid as per work done
  - Differential system must be based on the premise that efficiency is the result of the joint efforts of the managers and workers.

- **5. Mental Revolution:**
- Involves change in attitude of workers and management
- Both should realize that they require one another
- Aim to increase the size of surplus- eliminate the need for any agitation
- Management- share a part of surplus with workers
- Workers should also contribute they might so that the company makes profits.
- In the long run only workers well-being will ensure prosperity of the business

- **Benefits of Scientific Management:**

(a) Replacement of traditional rule of thumb method by scientific techniques.

(b) Proper selection and training of workers.

(c) Incentive wages to the workers for higher production.

(d) Elimination of wastes and rationalization of system of control.

(e) Standardization of tools, equipment, materials and work methods.

(f) Detailed instructions and constant guidance of the workers.

(g) Establishment of harmonious relationship between the workers.

(h) Better utilization of various resources.

(i) Satisfaction of the needs of the customers by providing higher quality products at lower prices.

- **Criticism**

1. **Worker's Criticism:**

(a) Speeding up of workers

(b) Loss of individual worker's initiative

(C) Problem of monotony

(d) Reduction of Employment:

(e) Weakening of Trade Unions

(f) Exploitation of workers:

2. Employer's Criticism:

(a) Heavy Investment

(b) Loss due to re-organization

(c) Unsuitable for small scale firms

Fayol Principles of Management

- Henry Feyol
- Born in 1841 in France and died in 1925
- French management Theorist-concerning scientific organization of labour- his theories were widly influential in 20th century
- Father of General Management
- Identified four functions of Management- Planning, Organizing, Directing and Controlling.
- Also suggested that qualities a manager must posses should be- Physical ,Moral, Education , Knowledge and experience.

14 Principles of Management

Division of Work	**Centralization and Decentralization**
Authority and Responsibility	Scalar Chain
Discipline	Order
Unity of Command	Equity
Unity of Direction	Stability of Tenure
Subordination of Individual to General Interest	Initiative
Remuneration of Employees	Espirit de corps

Division of work

- Division of work leads to specialisation

  - Helps to produce more and better work for the same effort
  - Applicable to all kinds of work-technical as well as managerial
  - Organization divided into different departments due to this reason
- **Positive effects:**
  - Leads to specialisation due to repetition
  - Less wastage of resources
  - Efficiency and effectiveness of work
- **Effects if not implemented:**
  - Lack of specialisation
  - Wastage of resources if violated.

Authority & Responsibility

- Authority- Right to give order & obtain obedience
- Responsibility- obligation to complete task on time
- Balance between the two to avoid misuse of authority & failure to achieve goals.
- **Positive effects:**
  - With proper responsibility there will be no misuse of authority.
  - Proper authority leads to timely completion of task
  - Facilitate quick decision making
- **Effects if not implimented:**
  - Misuse of authority is possible
  - Delay in decision making if balance is missing

Descipline

- Sincerity and obedience towards rules and regulations
- Good superiors at all levels, fair agreements and judicious application of penalties
- Obedience as part of workers & managers
- **Positive effects:**
  - Helps in smooth functioning
  - Improve efficiency
  - Orderliness
- **Effects if not implemented:**
  - Unhealthy relationship between managers & worker
  - Can lead to chaos

Unity of Command

- Only one superior to receive orders and to whom subordinate is reportable
- Avoids confusion & chaos

- **Positive effects:**
  - Prevents confusion & chaos
  - Avoid conflicts among supervisors
  - Clarity among relationships
- **Effects if not implemented:**
  - Conflicts among superiors
  - Chaos and confusion
  - Order and discipline gets disturbed

Unity of Direction

- One head and one plan
- **Positive effects:**
  - Ensures unity of actions
  - Helps in coordination
  - Facilitates achievement of goals
- **Effects if not implemented:**
  - Duplication of work & wastage of resources
  - Lack of coordination & failure in achievement of goals

Subordination of individual interest to general interest

- Company interest should supersede individual interest

- Larger interest of workers and stakeholders are more important than the interest of any one person

- **Positive effects:**
  - Coordination among organizational and individual goals
  - employees focused on group goals
- **Effects if not implemented:**
  - Inability to achieve organizational goals
  - Effects interest of stakeholders & employees (long run)

Remuneration of employees

- Quantum and methods of remuneration payable should be fair and reasonable.
- Satisfactory , provide reasonable standard of living & within paying capacity

- **Positive effects:**
  - Keep employees motivated
  - Reduces labour turnover
  - Improves relation among managers & workers
- **Effects if not implemented:**
  - Dissatisfaction increases employee turnover & recruitment cost
  - Unhealthy relations

Centralization & Decentralization

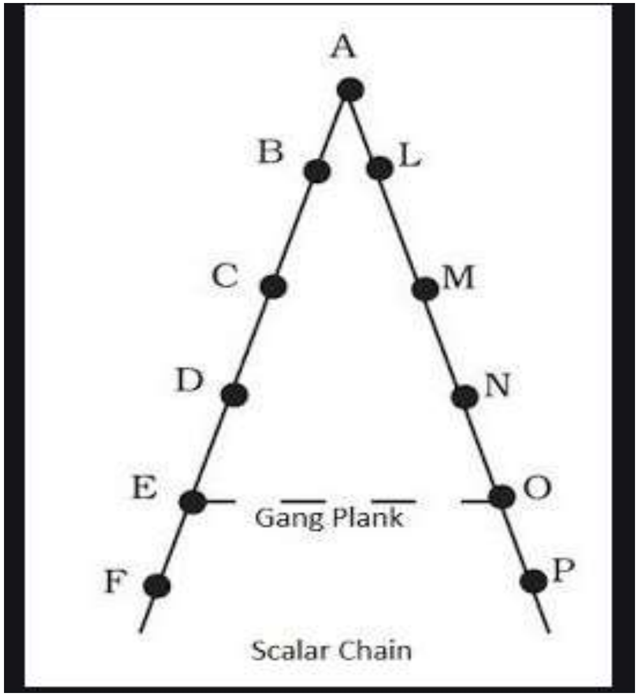
- Centralization: concentration of decision making authority
- Decentralization: its dispersal among more than one person the circumstances

- Need to balance: subordinate involvement through decentralization with managers retention of final authority through centralization.
- Degree of centralization depends upon the circumstances in which the company is working
- Example: Panchayats

- **Positive effects:**
  - Facilitates quick decision making- avoid delay in operations
  - Avoid misuse of authority
  - Optimal decision-making in core matters
- **Effects if not implemented:**
  - Delay in decision-making
  - Misuse of authority

Scalar chain

- Chain of authority & communication –runs from top to bottom
- Gank plank: If 'E' has to communicate with 'O' who is at the same level of authority then she/he has to traverse the route E-D-C-B-A-L-M-N-O
- **Positive effects:**
  - ✓ Smooth flow of communication
  - ✓ Unity of command followed
  - ✓ Avoids confusion of dual subordination
- **Effects if not implemented:**
  - ✓ Multiplicity of command
  - ✓ Lack of clarity
  - ✓ Miscommunication



Order

- Orderly arrangement of men & material
- Place for every thing
- **Positive effects:**
  - Reduces time & wastage
  - No obstacles in smooth running of operations
  - Increased efficiency & productivity
- **Effects if not implemented:**
  - Wastage of time
  - Unnecessary efforts

Equity

- Emphasizes kindliness & justice in the behaviour of managers towards workers
- Bring loyalty & devotion

- **Positive effects:**
  - Loyalty
  - Cordial relation
  - Congenial atmosphere
- **Effects if not implemented:**
  - Poor relations
  - Dissatisfaction among workers

Stability of tenure

- Minimize employee turnover
- Personnel: selected and appointed after due and rigorous procedure. Once selected- should be kept at their post /position for a minimum fixed tenure

- **Positive effects:**
  - Job security
  - Increased motivation
  - Reduces employee turnover & expense on recruitment cost
- **Effects if not implemented:**
  - Increases employee turnover & recruitment cost
  - Job insecurity

Initiative

- Employees- initiative without force
- Should be encouraged to develop & carry out plans for improvements

- **Positive effects:**
  - Motivation of employees
  - Increased efficiency & effectiveness
  - Improvements in operations
- **Effects if not implemented:**
  - Frustration & dissatisfaction
  - No motivation towards improvements

Espirit de corps

- Union is strength
- Employee should consider himself part of team
- Replace 'I' with 'We'

- **Positive effects:**
  - Helps in developing feeling of trust & belongingness
  - Facilitate achievements of goals
- **Effects if not implemented:**
  - Lack of coordination
  - Inability to achieve goals

3. Max Weber Bureaucratic Theory

- German sociologist
- Developed Bureaucratic Theory
- Bureaucracy “a system for controlling or managing a country, company or organization that is operated by a large number of officials employed to follow rules”

Principles of Bureaucratic Management

1. **Authority of Hierarchy :** Hierarchical organizational structure
   - Each level controls levels below and is controlled by level above.
   - Authority & responsibility are clearly defined for each position.
2. **Formal rules and regulations:**
   - Rules & regulations are documented to ensure reliable and predictable behaviour.
   - Managers must depend on the formal organizational rules in employees relations.

3. Division of labour:

- Tasks are clearly defined and employees become skilled by specializing in doing one thing.

4. Formal selection process:

- Employee selection and promotion are based on their experience, competence and technical qualification.

5. Career orientation:

- Management is separate from ownership and managers are career employees. Protection from the arbitrary dismissal is guaranteed.

6. Impersonality:

- Rules are applied uniformly to everyone. There is no preferential favoritism.

Neo-classical theory of Management thought

- **Human relations approach**
- **Behavioral science approach**

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Neo classical theory

- The behavioral science approach/ neo classical theory emerged since the classical approach did not achieve sufficient production efficiency and work place harmony
- Thus, there was more interest in helping the managers to deal more effectively with people side of their organization
- Emphasized understanding human behavior, needs, and attitudes in the workplace
- The focus is on “people” who staff for, and manage the organization

Hawthorne studies

- Hawthorne Studies gave rise to a new movement which is known as **human relations movement.**
- Researchers started investigating the reasons for human behavior at work
- The credit for the development of the human relations approach is given to **Elton Mayo**
- Other individuals who contributed are Maslow and McGregor

Hawthorne Experiment

- For Human Relations Approach, there are many contributors
- But the first intensive and systematic analysis of human factor in organizations was made in the form of **Hawthorne experiments**
- Hawthorne studies were conducted by **Elton Mayo** and **Fritz Roethlisberger** in the 1920s with the workers at the Hawthorne plant of Western Electric Company

- The Hawthorne plant of Western Electric Company was manufacturing telephone system bells

- It employed about 30,000 employees at the time of experiments

- Although company provided benefits like pension, sickness benefits and other recreational benefits, there was great deal of dissatisfaction among the workers and productivity was not up to the mark

- In 1924, a team led by Elton Mayo (psychologist) and Roethlisberger (Sociologist) investigated the real causes behind this phenomenon

- They conducted various researches in 4 phases from 1924 – 32

Hawthorne Experiment

- **Place:** Hawthorne works- A Western Electric Factory outside Chicago
- **Conducted by**: Elton Mayo & his team
- **Reason for conducting it:** To know the factors that brings fluctuation in workers productivity

4 parts of Hawthorne experiments

- Part 1- Illumination experiments (1924 -27)
- Part 2- Relay assembly test room study (1927 -29)
- Part 3 – Mass Interviewing program (1928- 30)
- Part 4- Bank wiring observation room experiment (1932)

Part 1 : Illumination Experiment

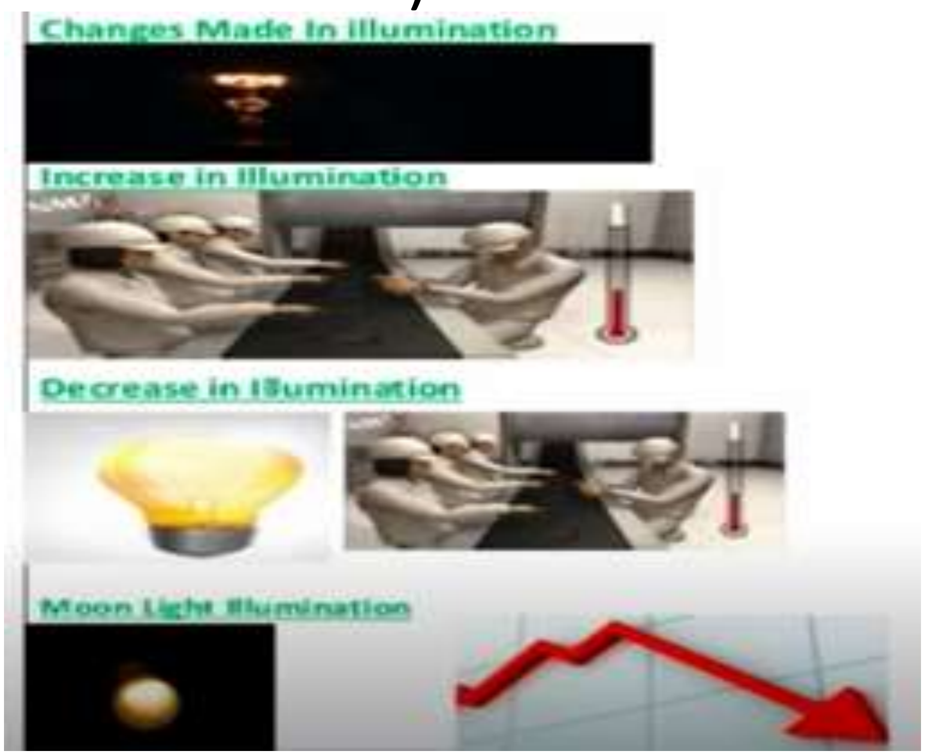
- Illumination experiments were conducted to find out how varying levels of amount of light at the workplace (a physical factor) affected productivity.

- Assumption was that higher illumination increases productivity.

Part 1 : Illumination Experiment

- **Experimental group**

(exposed to varying illumination)



- **Control group** (constant illumination)

Part 1 : Illumination Experiment

- The researchers found that as they increased the illumination in the experimental group, both groups increased production
- When the intensity of illumination was decreased, the production continued to increase in both the groups
- The production in the experimental group decreased only when the illumination was decreased to the level of moonlight.
- Thus , it was concluded that illumination did not have any effect on productivity
- But something else was interfering with the productivity
- Therefore, another phase of experiments was undertaken

Part 2: Relay Assembly Test Room Experiments

- It was designed to determine the effect of changes in various job conditions on the group productivity
- Researchers set up a relay assembly test room, which involved assembly of telephone relays
- A group of 6 women were selected
- The output depended on the speed and continuity with which the women worked.
- The experiment started with introducing various changes (duration ranged from 4 - 6 weeks)

Part 2: Relay Assembly Test Room Experiments

- **<u>Changes :</u>**

1. Incentive system was changed

- Each girl's extra pay was based on the other 5 rather than output of the large group
- Productivity increased as compared to before

Part 2: Relay Assembly Test Room Experiments

2. Two, five minute rests - one in morning session and other in evening session were introduced

- It was later increased to 10 minutes
- The productivity increased

Part 2: Relay Assembly Test Room Experiments

- **Changes :**

3. The rest period was reduced to 5 minutes but frequency was increased

- the productivity decreased slightly
- The girls complained that frequent rest intervals affected the rhythm of work

Part 2: Relay Assembly Test Room Experiments

- **Changes:**

4. The number of rest was reduced to two of 10 min. each

- But in the morning coffee or soup was served with sandwich
- And in the evening, snack was provided
- Productivity increased

Part 2: Relay Assembly Test Room Experiments

- **<u>Changes:</u>**

5. Changes in working hours and workday were introduced

- Like eliminating Saturday work
- Allow women to leave one hour early from 5.00 PM to 4.00 PM
- Productivity increased

Part 2: Relay Assembly Test Room Experiments

- As each change was introduced , absenteeism decreased, morale increased and less supervision was required
- Now, the researchers decided to revert back to original position, that is no rest and no benefits
- Surprisingly, productivity increased further instead of going down
- It was concluded that productivity increased not because of positive changes in the physical factors but because of a change in the girls attitude towards work and their work group
- They developed a feeling of stability and sense of belongingness
- They developed a sense of responsibility and self-discipline

Part 3: Mass interviewing program

- **Reason for conducting**: To study the human in the company
- **No . of interviews conducted:** with about 20,000 employees
- **Theme:** determine employees attitude towards company, supervision, insurance plans, promotion, and wages

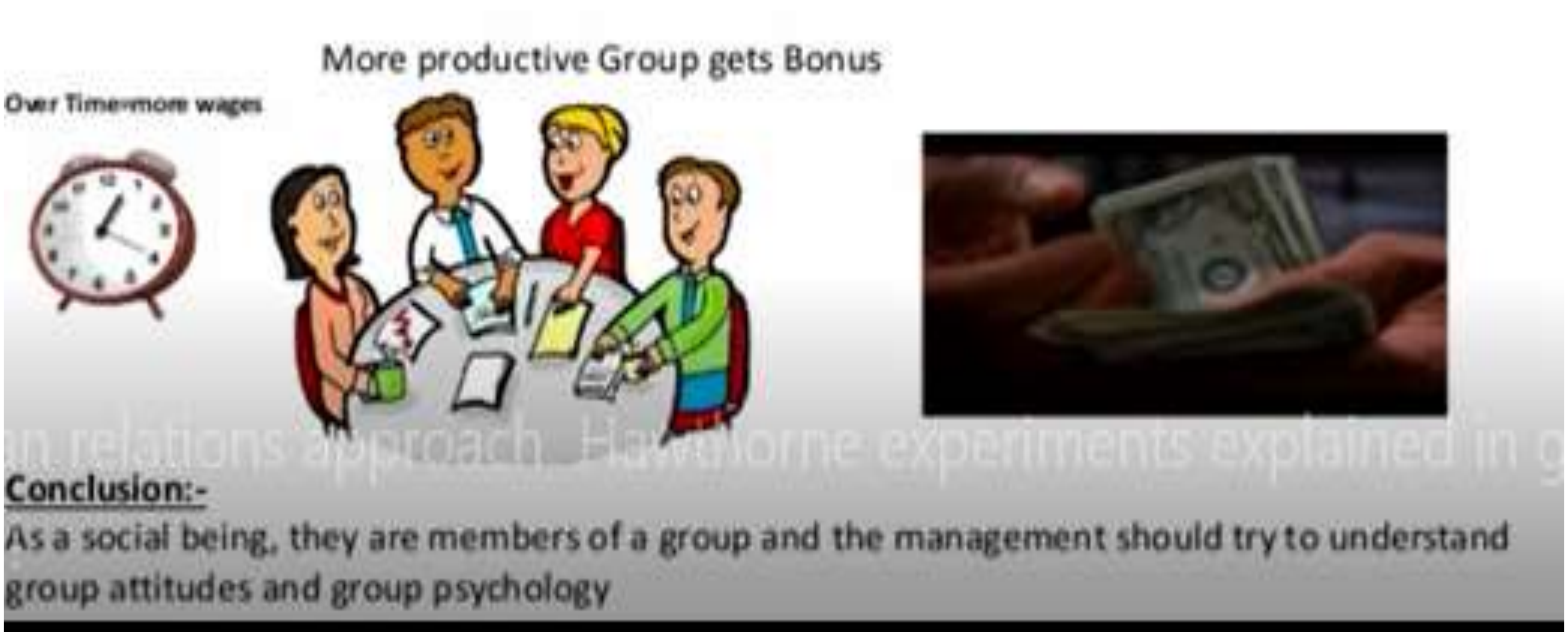
Part 3: Mass interviewing program

- The method was changed from direct interviewing to non directive interviewing
- Here, interviewer asked to listen instead of talking, arguing, or advising
- The interview program gave valuable insights about human behavior in the company like

1. worker's behavior was influenced by group behavior
2. The position of worker is a reference from which the worker gives meaning to events, features like hours of work, wages, etc
3. The social demands of a worker are influenced by social experience in groups both inside and outside the work plant

Part 4: Bank Wiring observation room experiments

- Workers involved in experiment : 14 male workers
- Work given : the men were engaged in the assembly of terminal banks for the use in telephone exchanges



Part 4: Bank Wiring observation room experiments

- It was conducted to analyze the functioning of small group and its impact on individual behavior
- The hypothesis was that in order to earn more, workers would produce more
- Also to get the group bonus , they would help each other to produce more
- However, this hypothesis did not hold valid
- Workers decided the target for themselves which was lower than the company target
- This study suggested that informal relations are an important factor in determining the human behavior

Part 4: Bank Wiring observation room experiments

- The workers gave restricted output due to the following reasons

1. Fear of unemployment: if there would be more production per head, some of the workers would be put out of unemployment

2. Fear of raising the standards: workers thought if they reached the standard set by management, they would again raise the standard

3. Protection of lower workers: the workers were friendly on and off the job. The faster workers protected the slower workers by not over-producing

4. Satisfaction on the part of management: management seemed to accept lower production rate as no one was fired for restricted output

Characteristics of human relations approach

- Organization is a social system
- System is composed of many interacting groups
- Many informal groups emerge at work place
- They have great impact on the behavior of the members
- Workers don’t always behave rationally (emotions, feelings, values play an important role)
- Monetary gains alone cannot motivate workers
- Worker’s participation in decision-making boosts morale and productivity

From Human Relations to Behavioral Science Approach

- Human relations is frequently used as a term to describe the ways in which the managers interact with their employees

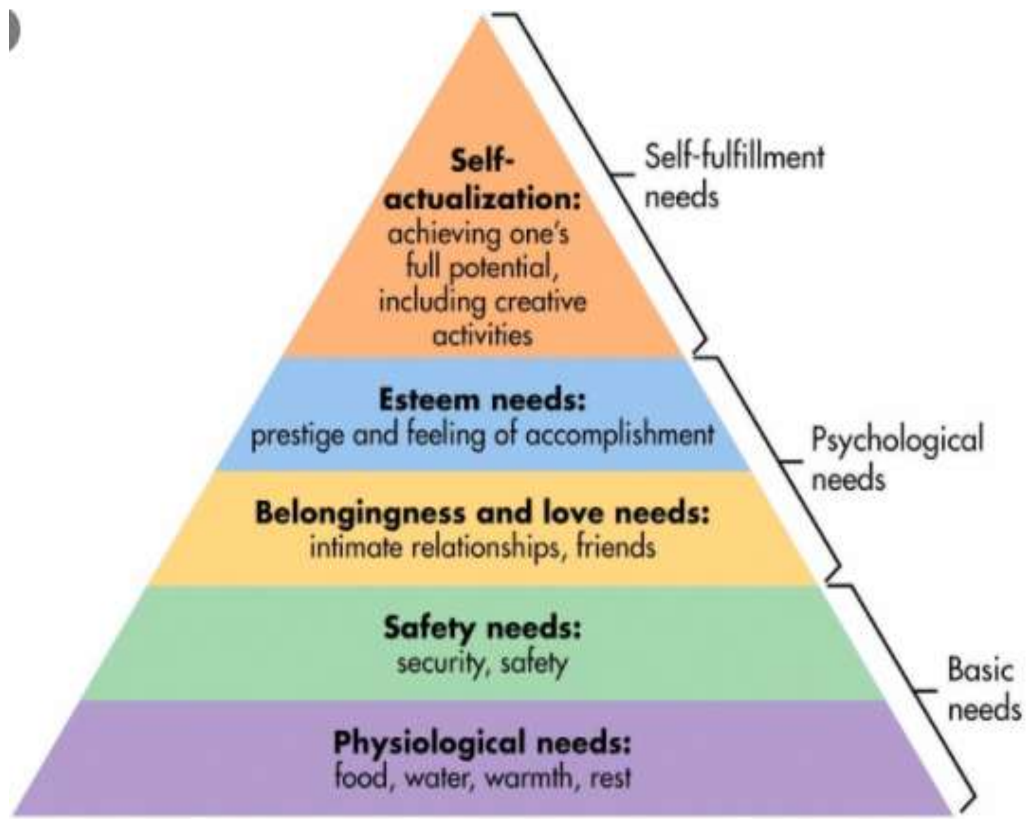
- This approach thus evolved from the Hawthorne experiments.

- The later researchers more rigorously trained in the social science (psychology, sociology, and anthropology) used more sophisticated research methods and came to be known as behavioral scientists rather than the human relations theorists.

- Important aspects of the behavioral science approach:
- Communication
- Employee development
- Leadership
- Employee motivation
- Organization as social system

Maslow’s Needs Hierarchy Theory

- Abraham Maslow (1908- 1970)



Theory X and Theory Y

- Douglas McGregor (1906-1964)
  - Two objectives:
    - Predict and control behavior
    - Tap unrealized potential

Theory X & Theory Y

- **<u>Theory X Assumptions</u>**
- Dislike work –will avoid it
- Must be coerced, controlled, directed, or threatened with punishment
- Prefer direction, avoid responsibility, little ambition, want security

- **<u>Theory Y Assumptions</u>**
- Do not dislike work
- Self direction and self control
- Seek responsibility
- Imagination , creativity widely distributed
- Intellectual potential only partially utilized

Conclusion

- Organizations are socio-technical system. The management must integrate both the systems.
- Work and interpersonal behavior of people in the organization is influenced by many factors.
- Employees are motivated not only by physiological needs but also by social and psychological needs.
- Different people have different perceptions, attitudes, needs and values. These differences must be found out and recognized by management.
- In an organization conflicts are unavoidable.
- Personal goals and organizational goals must be joined together.

Lessons from the Behavioural Approach

- People are the key to productivity
- Success depends on motivated and skilled individuals committed to the organization.
- Managerial sensitivity to employees is necessary to foster the cooperation needed for high productivity.

Differcnce between Classical Theory and Neo-classical Theory

	Basis	*Classical Theory*	*Neo-classical Theory*
1.	Structure	Impersonal, mechanical	Organisation is a social system.
2.	Focus	On work and economic needs of workers	On small groups. On emotional and human qualities of employees
3.	Emphasis	On order and rationality	On personal, security, and social needs of workers while achieving objectives of the organisation.
4.	Behaviour	Orgnisational behaviour is a product of rules and regulations	Behaviour is a product of feelings and sentiments and attitudes.
5.	Practices	Authoritarian practices, elaborate rules and regulations to obtain results.	Democratic practices. Involvement of employees in decision-making. Recognises the importance of human dignity and values.
6.	Results	Work alienation, dissatisfaction	Happy and satisfied employees trying to increase production.

Modern Theory

- Quantitative Management approach
- Systems approach
- Contingency theory

The Quantitative Management approach

- During World War II, mathematicians, physicists, and other scientists joined together to solve military problems.
- The quantitative approach to management involves the use of quantitative techniques, such as statistics, information models, and computer simulations, to improve decision making.

Management Science

- To day, this view encourages managers to use mathematics, statistics, and other quantitative techniques to make management decisions.

- Managers can use computer models to figure out the best way to do something saving both money and time

- **Mathematical forecasting** helps make projections that are useful in the planning process.
- **Inventory modeling** helps control inventories by mathematically establishing how and when to order a product.
- **Queuing theory** helps allocate service personnel or workstations to minimize customer waiting and service cost

2. Systems Approach

- Taken from a Greek word which means to bring together or to combine.
- Father of systems approach: Ludvig von Bertalanffy
- According to Ludvig Von Bertalanffy, “in order to understand an organized whole, we must know both the parts as well as relations between them”.

Elements of Systems Management

- A system is an interelated set of elements functioning as a whole.

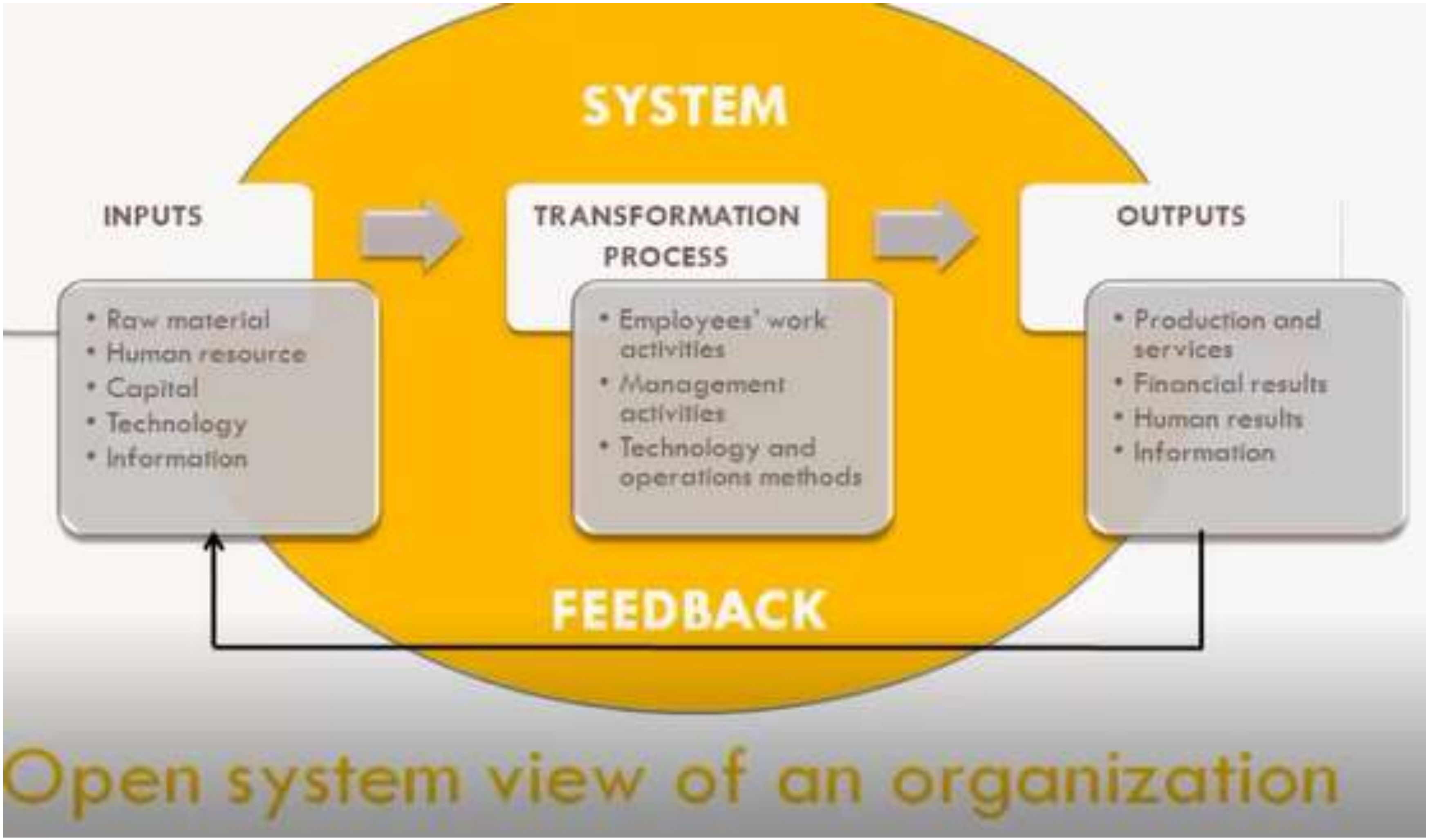
- It has subsystems which have synergy between them. Each subsystem has its defined boundaries.

Classificaiton of Systems

- **Open systems:** an open system actively interacts with its environment. By interacting with other systems , it tries to establish exchange relationships.

- **Close systems:** it is self contained and isolated from the environment. It is a non adaptive system. It does not receive inputs from other systems and does not trade with the outside world.

System Theory



- Under this systems approach , managers have a good view of the organizations.

- It gives importance to interdependence of the different parts of the organization and its environment.

Contingency Approach

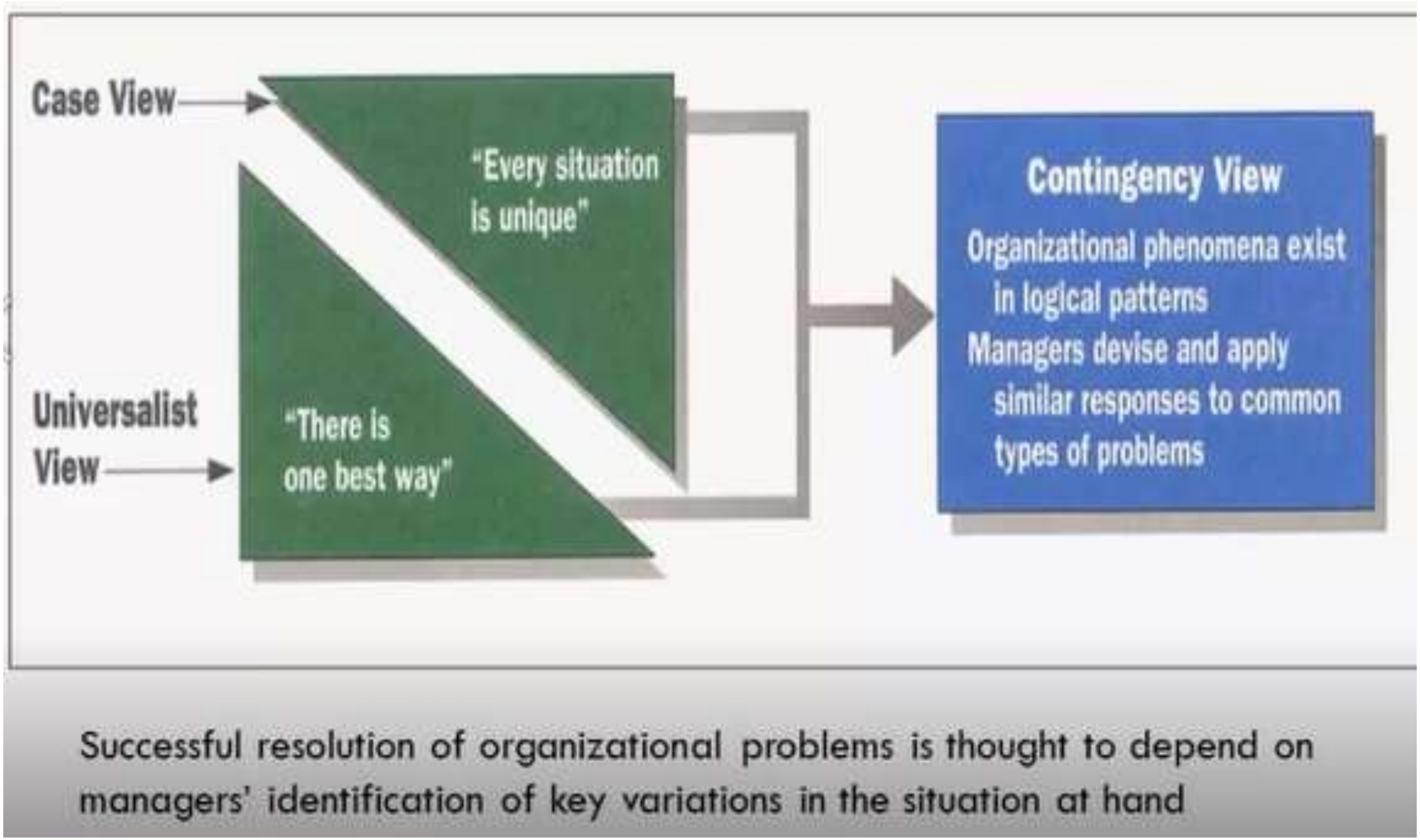
- Contingency view is also known as situational view
- It emphasizes that there is no best way to manage. It is an “it all depends” approach.
- The appropriate management actions and approaches depend on the situation.
- Managers with a contingency view use a flexible approach, draw on a variety of theories and experiences, and evaluate many options as they solve problems.
- It tries to identify the best technique that will be effective in a particular situation at a particular time.
- This attempts to integrate all the management approaches.

Contingency Approach

- Organizations are individually different, face different situations (contingency variable), and require different ways of managing.

- Popular Contingency Variables
- Organization size
- Routineness of task technology
- Environmental uncertainty
- Individual differences

Contingency Theory



Relationship b/w Systems and Contingency Approaches

- Contingency management school has emerged out of systems management school

- Since the system approach is too abstract to apply certain modifications can be made and then applied for managerial action.

- The systems approach may specify situations under which an organization can function, whereas , the organization may try to adapt its environment.

Organisation being a system has the following five parts:-

(i) Individual:

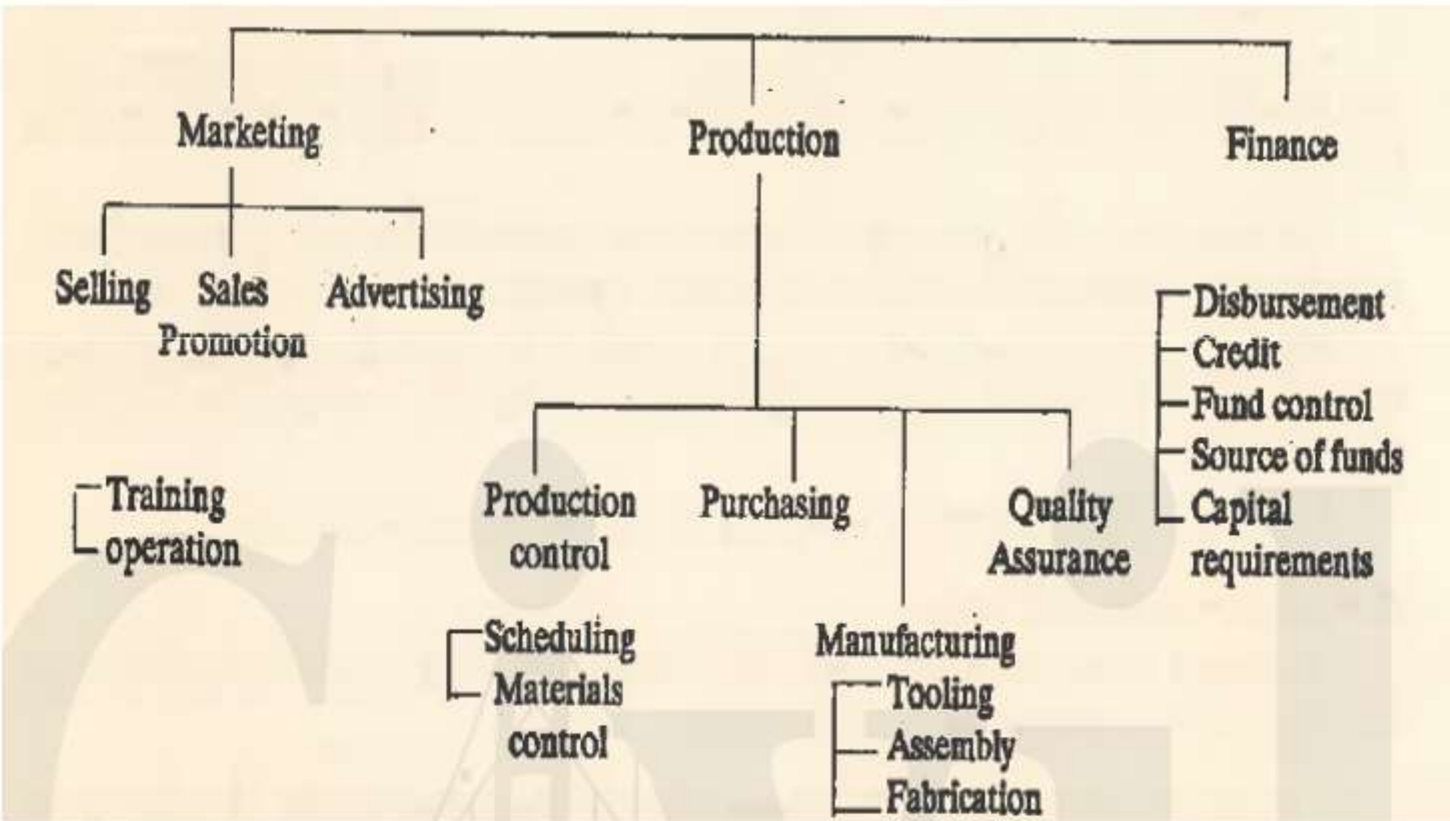
(ii) Formal Organisation:

(iii) Informal Organization:

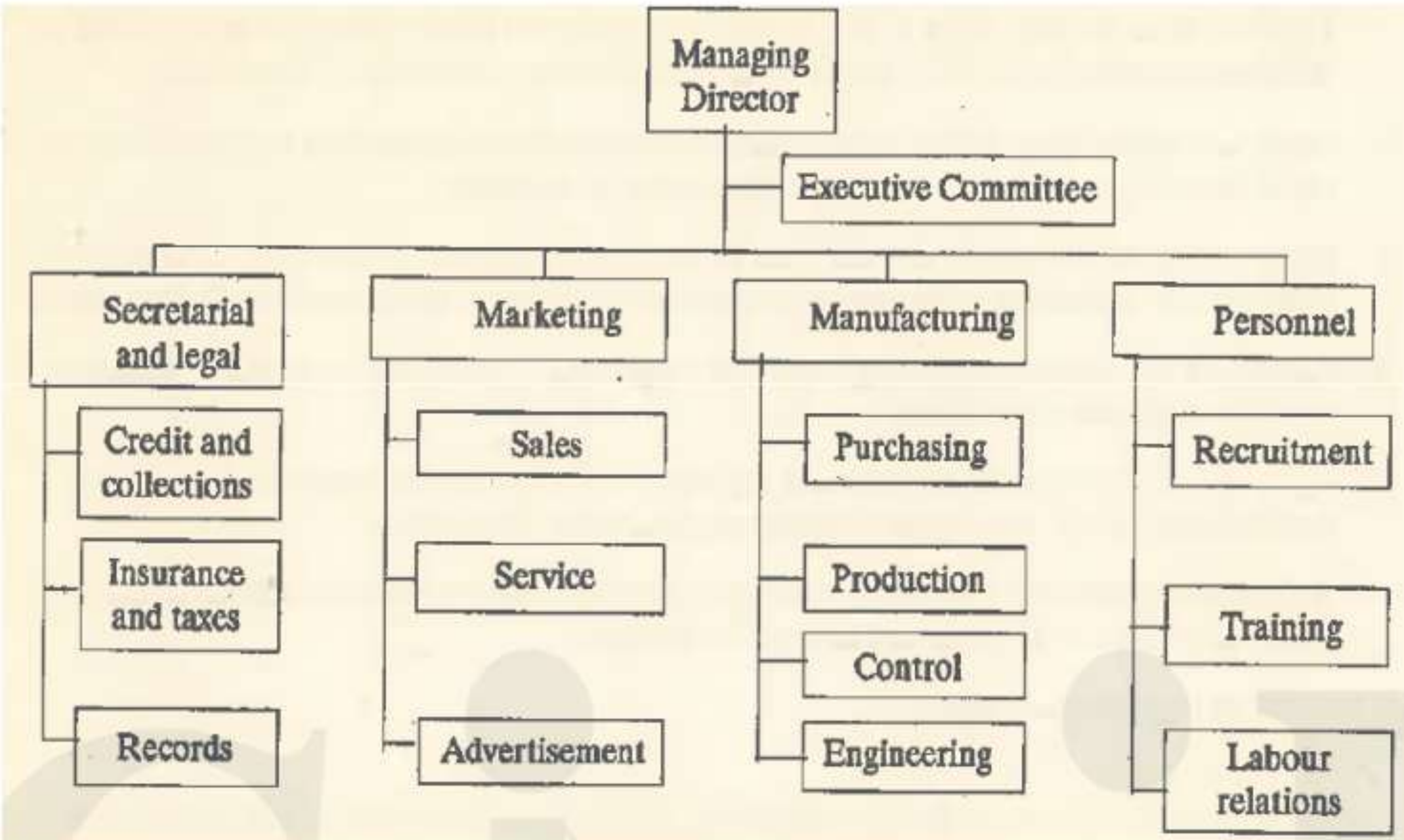
(iv) Status and Roles:

(v) Physical Setting/Environment:

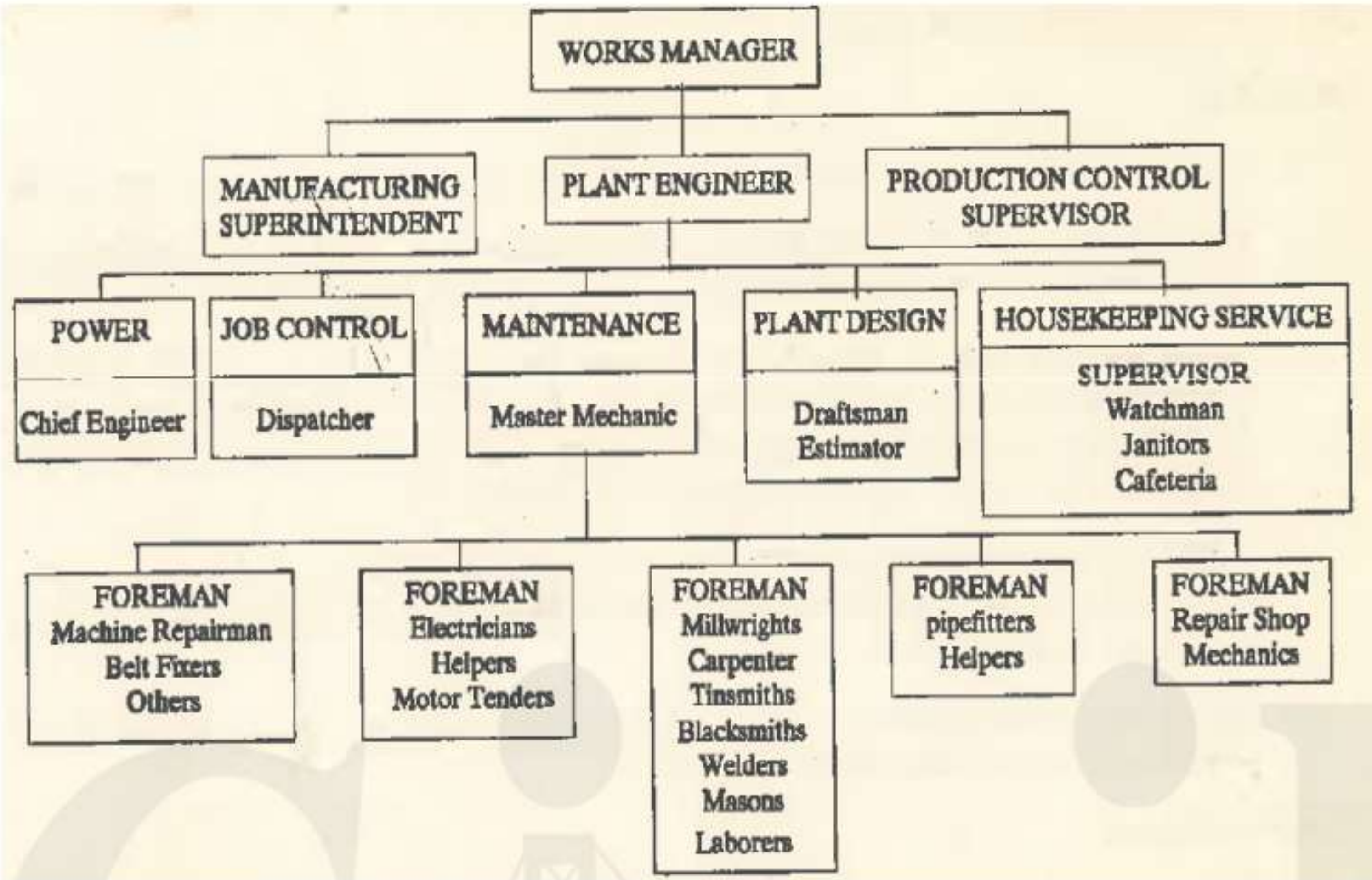
Organisation structure of Manufacturing Industry



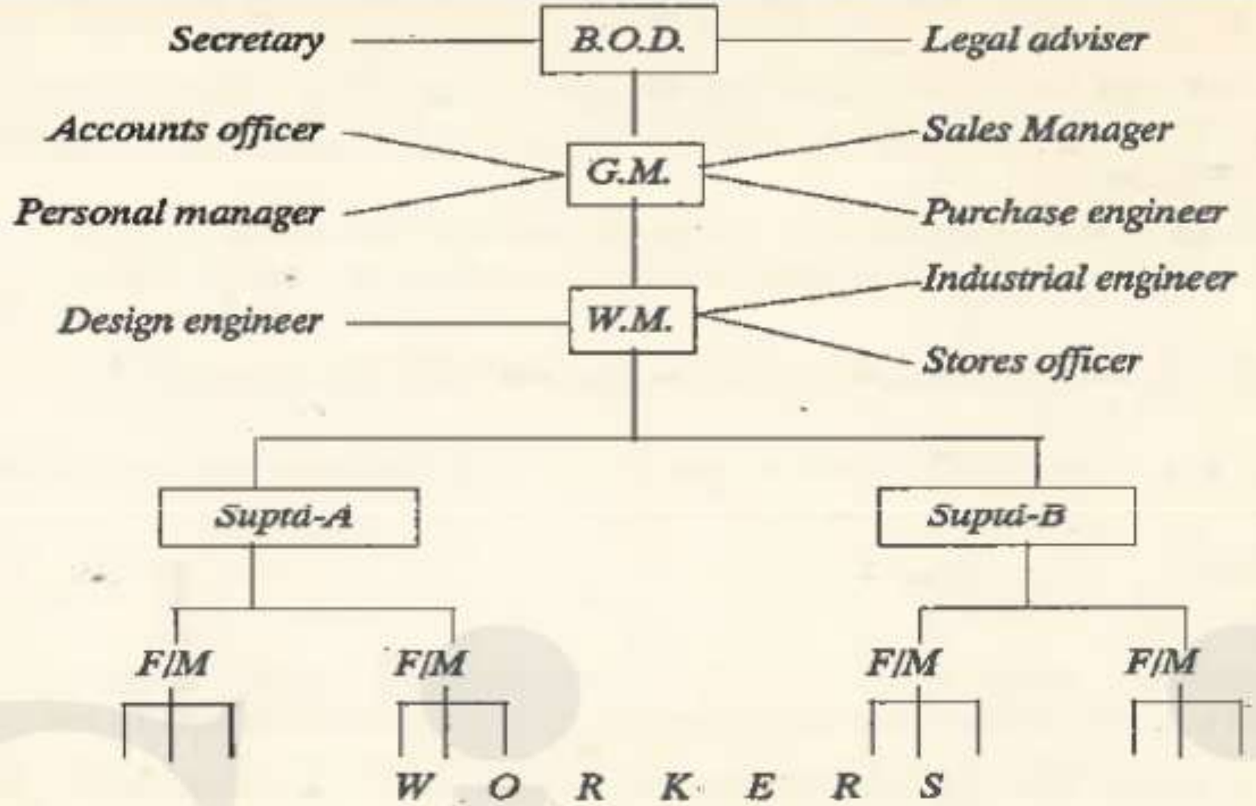
Organisation Chart



Organisation chart of Plant Maintanance



Who are Life & Staff Executives



B.O.D. : Board of Directors
G.M. : General Manager
W.M. : Works Manager
Suptd. : Superintendent
F/M : Foreman

Thank you

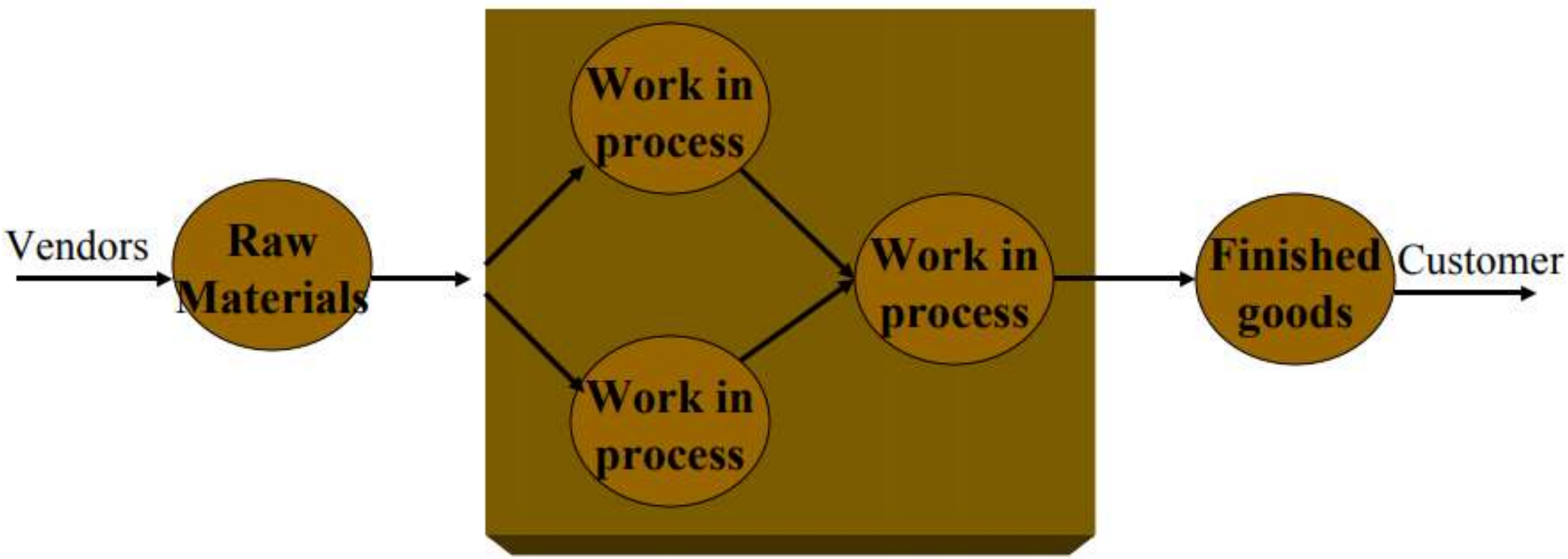
Inventory Management

Dr. Jyothi Chepur (MBA, Ph.D.)
NIT Warangal

Introduction

- A considerable amount of fund is required
- Effective and efficient management is imperative to avoid unnecessary investment
- Improper inventory management affects long term profitability and may fail ultimately
- 10 to 20% of inventory can be reduced without any adverse effect on production and sales by using simple inventory planning and control techniques

Types of Inventory



Nature of Inventories

- **Raw Materials** – Basic inputs that are converted into finished product through the manufacturing process
- **Work-in-progress** – Semi-manufactured products need some more works before they become finished goods for sale
- **Finished Goods** – Completely manufactured products ready for sale
- **Supplies** – Office and plant cleaning materials not directly enter production but are necessary for production process and do not involve significant investment.

Reasons To Hold Inventory

- Meet variations in customer demand:
  - Meet unexpected demand
  - Smooth seasonal or cyclical demand
- Pricing related:
  - Temporary price discounts
  - Hedge against price increases
  - Take advantage of quantity discounts
- Process & supply surprises
  - Internal – upsets in parts of or our own processes
  - External – delays in incoming goods

Objective of Inventory Management

- To maintain a optimum size of inventory for efficient and smooth production and sales operations
- To maintain a minimum investment in inventories to maximize the profitability
- Effort should be made to place an order at the **right time** with **right source** to acquire the **right quantity** at the **right price** and **right quality**

An effective inventory management should

- Ensure a continuous supply of raw materials to facilitate uninterrupted production
- Maintain sufficient stocks of raw materials in periods of short supply and anticipate price changes
- Maintain sufficient finished goods inventory for smooth sales operation, and efficient customer service
- Minimize the carrying cost and time
- Control investment in inventories and keep it at an optimum level

An optimum inventory level involves three types of costs

Ordering costs:-

- Quotation or tendering
- Requisitioning
- Order placing
- Transportation
- Receiving, inspecting and storing
- Quality control
- Clerical and staff

Stock-out cost

- Loss of sale
- Failure to meet delivery commitments

Carrying costs:-

- Warehousing or storage
- Handling
- Clerical and staff
- Insurance
- Interest
- Deterioration,shrinkage, evaporation and obsolescence
- Taxes
- Cost of capital

Dangers of Over investment

- Unnecessary tie-up of firm’s fund and loss of profit – involves opportunity cost
- Excessive carrying cost
- Risk of liquidity- difficult to convert into cash
- Physical deterioration of inventories while in storage due to mishandling and improper storage facilities

Dangers of under-investment

- Production hold-ups – loss of labor hours
- Failure to meet delivery commitments
- Customers may shift to competitors which will amount to a permanent loss to the firm
- May affect the goodwill and image of the firm

Functions of Inventory Management

-Track inventory

–How much to order

–When to order

Classification of inventory

- ABC Classification
- HML Classification
- XYZ Classification
- VED Classification
- FSN Classification
- SDF Classification
- GOLF Classification
- SOS Classification

ABC Classification

- In most of the cases 10 to 20 % of the inventory account for 70 to 80% of the annual activity.
- A typical manufacturing operation shows that the top 15% of the [illegible] items, in terms of annual rupees usage, represent 80% of total annual rupees usage.
- Next 15% of items [illegible]lect 15% of annual rupees
- Next 70% accounts only for 5% usage

A

B

C

XYZ Classification

- On the basis of value of inventory stored
- Whereas ABC was on the basis of value of consumption to value.
- X – High Value
- Y – Medium value
- Z – Least value

  Aimed to identify items which are extensively stocked.

HML Classification

- On the basis of unit value of item
- There is 1000 unit of Q @ Rs. 10 and 10,000 units of W @ Rs. 5.

  Aimed to control the purchase of raw materials.

  H – High, M- Medium, L - Low

VED Classification

- Mainly for spare parts because their consumption pattern is different from
  - The materials may be classified depending upon their criticality that is on functional basis.
  - The degree of criticality can be stated as whether the material is vital to the process of production, or essential to the process of production or desirable for the process of production.
  - This classification is known as VED analysis, **V** stands for **vital**, **E** stands for **essential** and **D** stands for **desirable** items.

FSN Classification

- According to the consumption pattern
- To combat obsolete items
- F – Fast moving
- S – Slow moving
- N – Non Moving

SDF & GOLF Classification

- Based on source of procurement
- S – Scarce, D- Difficult, E- Easy.

- GOLF
- G – Government, O – Ordinary, L – Local, F – Foreign.

SOS Classification

- Raw materials especially for agriculture units
- S – Seasonal
- OS – Off seasonal

Deciding on the inventory model

- Assume an analyst applies an inventory model that does not allow for spoilage to a grocery chain's ordering policy for lettuce and formulates the strategy of ordering lettuce in large amounts every 14 days. A little thought will show that this is obliviously foolish. This strategy implies that lettuce will be spoiled. However it is not a failure of inventory, it is a failure to apply the correct model.

ABC Analysis

(Always Better Control)

What is ABC analysis?

- ABC analysis is an ***inventory categorization method*** which consists in dividing items into three categories (A, B, C):
  - A being the most valuable items,
  - C being the least valuable ones.
- This method aims to draw managers' attention on the critical few (A-items) not on the trivial many (C-items).

The Pareto principle

VILFREDO PARETO (1848-1923)

- 20% of population owns 80% of nations wealth
- 20% of employees cause 80% of problems
- 20% of items accounts for 80% of firms expenditure

The ABC analysis

The ABC approach states that a company should rate items from A to C, basing its ratings on the following rules:

- ***A-items*** are goods which annual consumption value is the highest; the top 70-80% of the annual consumption value of the company typically accounts for only 10-20% of total inventory items.

The ABC analysis

The ABC approach states that a company should rate items from A to C, basing its ratings on the following rules:

- ***B-items*** are the interclass items, with a medium consumption value; those 15-25% of annual consumption value typically accounts for 30% of total inventory items.

The ABC analysis

The ABC approach states that a company should rate items from A to C, basing its ratings on the following rules:

- ***C-items*** are, on the contrary, items with the lowest consumption value; the lower 5% of the annual consumption value typically accounts for 50% of total inventory items.

The ABC analysis

- The annual consumption value is calculated with the formula:

(Annual demand) x (item cost per unit)

- Through this categorization, the supply manager can identify inventory hot spots, and separate them from the rest of the items, especially those that are numerous but not that profitable.

The ABC analysis

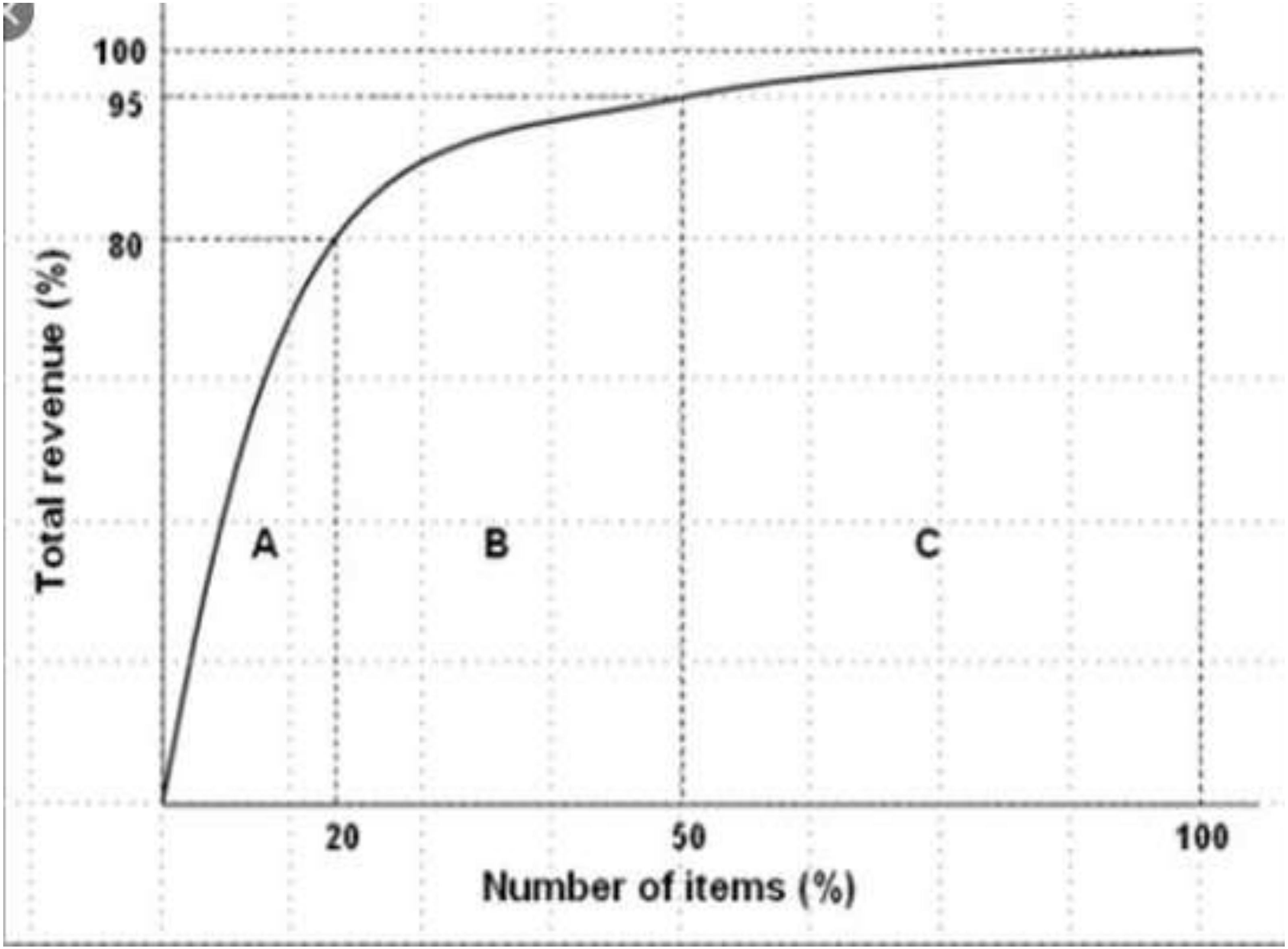
Steps for the classification of items:

1. Find out the unit cost and and the usage of each material over a given period;
2. Multiply the unit cost by the estimated annual usage to obtain the net value;
3. List out all the items and arrange them in the descending value (Annual Value);

The ABC analysis

Steps for the classification of items:

4. Accumulate value and add up number of items and calculate percentage on total inventory in value and in number;
5. Draw a curve of percentage items and percentage value;
6. Mark off from the curve the rational limits of A, B and C categories.



100
95
80
Total revenue (%)
A
B
C
20
50
100
Number of items (%)

ABC analysis

	Percentage of items	Percentage value of annual usage	
Class A items	About 20%	About 80%	Close day to day control
Class B items	About 30%	About 15%	Regular review
Class C items	About 50%	About 5%	Infrequent review

Example 1

Item number	101	102	103	104	105	106	107	108	109	110
Unit cost	5	11	15	8	7	16	20	4	9	12
Annual demand	48000	2000	300	800	4800	1200	18000	300	5000	500

	Percentage of items	**Percentage value of annual usage**	
Class A items	About 20%	About 80%	Close day to day control
Class B items	About 30%	About 15%	Regular review
Class C items	About 50%	About 5%	Infrequent review

Step 1

Calculate the total spending per year

Item number	Unit cost	Annual demand	Total cost per year
101	5	48,000	240,000
102	11	2,000	22,000
103	15	300	4,500
104	8	800	6,400
105	7	4,800	33,600
106	16	1,200	19,200
107	20	18,000	360,000
108	4	300	1,200
109	9	5,000	45,000
110	12	500	6,000
Total usage			737,900

Total cost per year: Unit cost * total cost per year

Step 2

Calculate the usage of item in total usage

Item number	Unit cost	Annual demand	Total cost per year	Usage as a % of total usage
101	5	48,000	240,000	32,5%
102	11	2,000	22,000	3%
103	15	300	4,500	0,6%
104	8	800	6,400	0,9%
105	7	4,800	33,600	4,6%
106	16	1,200	19,200	2,6%
107	20	18,000	360,000	48,8%
108	4	300	1,200	0,2%
109	9	5,000	45,000	6,1%
110	12	500	6,000	0,8%
Total usage			737,900	100%

Usage as a % of total usage = usage of item/total usage

Step 3

Sort the items by usage

Item number	Cumulative % of items	Unit cost	Annual demand	Total cost per year	Usage as a % of total usage	Cumulative % of total
107	10%	20	18,000	360,000	48,8%	48,8%
101	20%	5	48,000	240,000	32,5%	81,3%
109	30%	9	5,000	45,000	6,1%	87,4%
105	40%	7	4,800	33,600	4,6%	92%
102	50%	11	2,000	22,000	3,0%	94,9%
106	60%	16	1,200	19,200	2,6%	97,5%
104	70%	8	800	6,400	0,9%	98,4%
110	80%	12	500	6,000	0,8%	99,2%
103	90%	15	300	4,500	0,6%	99,8%
108	100%	4	300	1,200	0,2%	100%
Total usage				737,900	100%	

Step 4

Results of calculation

Cathegory	Items	Percentage of items	Percentage usage (%)	Action
Class A	107, 101	20%	81,6%	Close control
Class B	109, 105, 102, 106	40%	16,2%	Regular review
Class C	104, 110, 103, 108	40%	2,5%	Infrequent review

Additional rules for ABC analysis

Cathegory	Percentage of items	Percentage of usage
Class A items	5-25%	40-80%
Class B items	20–40%	15-40%
Class C items	40-75%	5-20%

$$A \leq B \leq C$$

Criteria	A type	B type	C Type
Quantity	10%	20%	70%
Annual Usage	70%	20%	10%
Control	Very strict	Moderate	Less
Ordering	Daily/weekly	Monthly	Yearly
Safety stock	Less	Moderate	High
Handled By	Senior officers	Middle management.	Fully delegated.

Example 2

Item number	Annual quantity used	Unit value
1	75	80
2	150,000	0,9
3	500	3,0
4	18,000	0,20
5	3,000	0,30
6	20,000	0,10
7	10,000	2

Step 1

Item number	Annual quantity used	Unit value	Usage per year
1	75	80	6,000
2	150,000	0,9	135,000
3	500	3,0	1,500
4	18,000	0,20	3,600
5	3,000	0,30	900
6	20,000	0,10	2,000
7	10,000	2	20,000
Total usage			169,000

Step 2

Item number	Annual quantity used	Unit value	Usage per year	Percentage in total usage (%)
1	75	80	6,000	3,51%
2	150,000	0,9	135,000	79,8%
3	500	3,0	1,500	0,87%
4	18,000	0,20	3,600	2,1%
5	3,000	0,30	900	0,53%
6	20,000	0,10	2,000	1,18%
7	10,000	2	20,000	11,8%
Total usage			169,000	

Step 3

Item number	Cumulative % of items	Annual quantity used	Unit value	Usage per year	Percentage in total usage (%)	Cumulative % of total
2	14%	150,000	0,9	135,000	79,8%	79,8%
7	29%	10,000	2	20,000	11,8%	91,6%
1	42%	75	80	6,000	3,51%	95,11%
4	56%	18,000	0,20	3,600	2,1%	97,21%
6	71%	20,000	0,10	2,000	1,18%	98,39%
3	84%	500	3,0	1,500	0,87%	99,46%
5	100%	3,000	0,30	900	0,53%	100%
Total usage				169,000		

Step 4

Cathegory	Items	Percentage of items	Percentage of usage (%)	Action
Class A items	2	15%	79,8%	Close control
Class B items	7, 1	30%	15,31%	Regular review
Class C items	3, 4, 5, 6	55%	4,89%	Infreque nt review

Conclusion

- The boundary between class A and class B might not be as sharply defined;
- The purpose of this classification is to ensure that purchasing staff use resources to maximum efficiency by concentrating on those items that have the greatest potential savings $\rightarrow$ selective control will be more effective than an approach that treats all items identically.

-EOQ-

ECONOMIC ORDER QUANTITY

WHAT IS EOQ?

- Economic Order Quantity is one of the technique of inventory control which minimizes total holdings and ordering cost of the year.
- This is a technique which solves the problems of a materials manager.

DEFINITION

EOQ is essentially an accounting formula that determines at which the combination of order cost and inventory carrying cost are the least. The result is the most cost effective quality to order. In purchasing this is known as order quantity, in manufacturing it is known as the production lot size.

-Dave Piasecki

CONT.

- By using this model, the companies can minimize the costs associated with the ordering and inventory holding.
- It can be a valuable tool for small business owners who need to make decisions about how much inventory to keep on hand, how many items to order each time, and how often to reorder to incur the lowest possible costs.
- There are two most important categories of inventory costs are **ordering costs and carrying costs.**

ORDERING COST

- It is the costs that are incurred on obtaining additional inventories.
- They include costs incurred on:

  communicating the order, traveling allowance and daily allowance to purchase officers, printing and stationary, salary of purchase department, cost of inspection, cost of receiving the material, transportation cost etc.

CONT.

- All above cost, other than transport costs remain unchanged per order irrespective of the order size.
- Therefore, it is assumed that ordering cost per order remain constant.
- The more frequently orders are placed, and fewer the quantities purchased on each order, the grater will be ordering cost and vice versa.

ORDERING COST CURVE

- Here we can see that when the size of the order decreases the ordering cost increases and ordering cost decreases when the size of the order increases

CARRYING COST

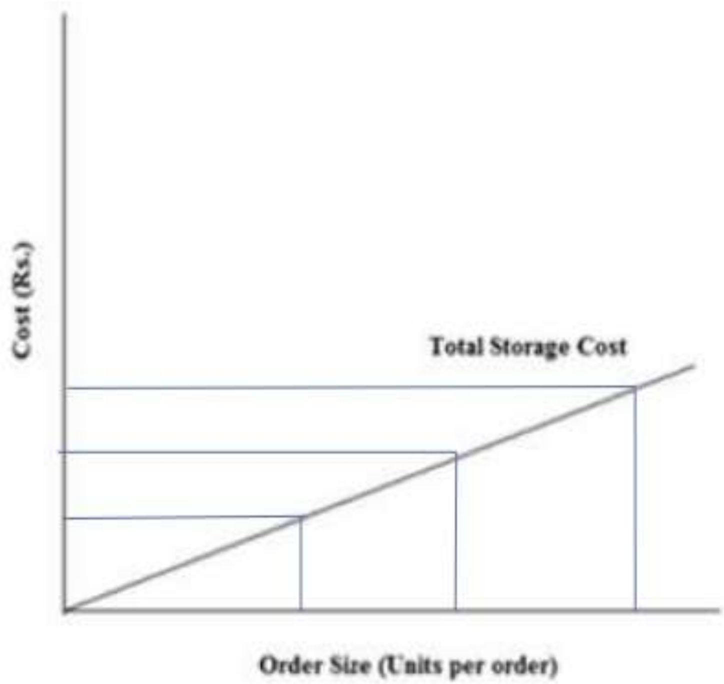
- It is the cost incurred for holding inventory in hand.
- They include

  interest on the money locked up in stocks, storage costs, spoilage costs, insurance, evaporation, godown rent, pilferage, obsolescence etc.

CONT.

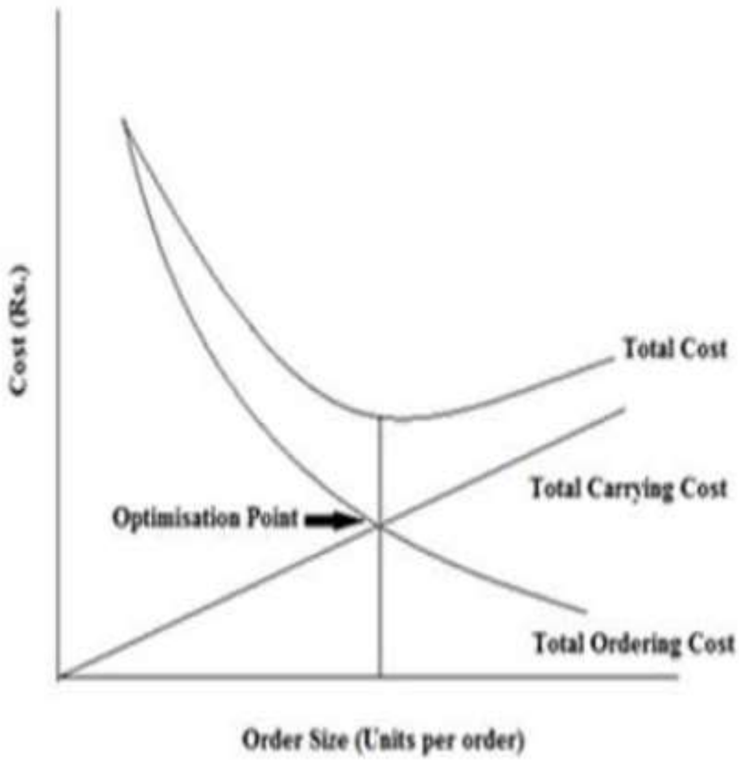
- They are assumed to be constant per unit of inventory.
- The large the volume of inventory, the higher will be the inventory carrying cost and vice versa

CARRYING COST CURVE



- Here we can see that when the order size increases the storage cost also increases and vice versa

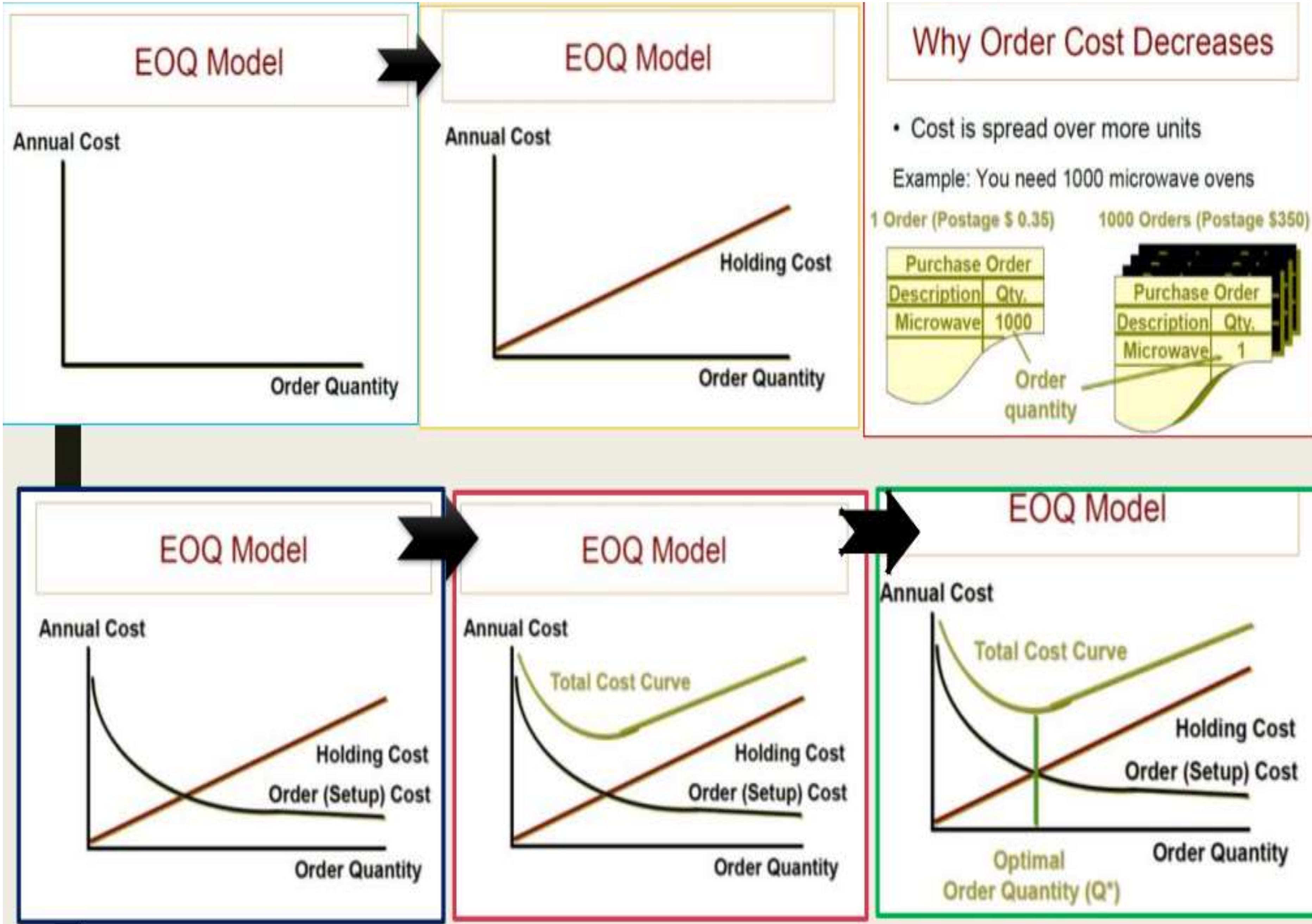
ECONOMIC ORDER QUANTITY CURVE



- Ordering costs and carrying costs are quite opposite to each other.
- If we need to **minimize carrying costs** we have to place **small order** which **increases the ordering costs**.

CONT.

- If we want **minimize ordering costs** we have to place **few orders** in a year and this requires **placing large orders** which in turn **increases the total carrying costs** for the period.
- We need to minimize the total inventory costs, Thus EOQ is determine by the intersection of ordering cost curve and carrying cost line.
- At this point total ordering cost is equal to total carrying cost, and the total of the two costs is the least.


EOQ Model
Annual Cost
Order Quantity
EOQ Model
Annual Cost
Holding Cost
Order Quantity
Why Order Cost Decreases
• Cost is spread over more units
Example: You need 1000 microwave ovens
1 Order (Postage $ 0.35)
1000 Orders (Postage $350)
Purchase Order
Description Qty.
Microwave 1000
Order quantity
Purchase Order
Description Qty.
Microwave 1
EOQ Model
Annual Cost
Holding Cost
Order (Setup) Cost
Order Quantity
EOQ Model
Annual Cost
Total Cost Curve
Holding Cost
Order (Setup) Cost
Order Quantity
EOQ Model
Annual Cost
Total Cost Curve
Holding Cost
Order (Setup) Cost
Optimal Order Quantity (Q*)
Order Quantity

EOQ Assumptions

- Known & constant demand
- Known & constant lead time
- Instantaneous receipt of material
- No quantity discounts
- Only order (setup) cost & holding cost
- No stockouts

CALCULATION OF EOQ

$$EOQ = \sqrt{\frac{2Co*A}{Cc}}$$

Where;

Co- ordering cost

Cc- carrying cost

A - annual requirement of the material in number of units

EOQ Formula Derivation

D =	Annual demand (units)
C =	Cost per unit ($)
Q =	Order quantity (units)
S =	Cost per order ($)
I =	Holding cost (%)
H =	Holding cost ($) = I x C

Number of Orders = D / Q
Ordering costs = S x (D / Q)

Average inventory
units = Q / 2
$ = (Q / 2) x C

Cost to carry
average inventory = (Q / 2) x I x C
= (Q /2) x H

Total cost = $\underbrace{(Q/2) \times I \times C}_{\textit{inv carry cost}} + \underbrace{S \times (D/Q)}_{\textit{order cost}}$

Take the 1st derivative:

$d(TC)/d(Q) = (I \times C) / 2 - (D \times S) / Q^2$

To optimize: set $d(TC)/d(Q) = 0$

$DS/ Q^2 = IC / 2$

$Q^2/DS = 2 / IC$

$Q^2 = (DS \times 2) / IC$

$\boxed{Q = \text{sqrt}(2DS / IC)}$

Economic Order Quantity

$$EOQ = \sqrt{\frac{2 \times D \times S}{H}}$$

D = Annual demand (units)
S = Cost per order ($)
C = Cost per unit ($)
I = Holding cost (%)
H = Holding cost ($) = I x C

EOQ Model Equations

$$\text{Optimal Order Quantity} = Q^* = \sqrt{\frac{2 \cdot D \cdot S}{H}}$$

$$\text{Expected Number Orders} = N = \frac{D}{Q^*}$$

$$\text{Expected Time Between Orders} = T = \frac{\text{Working Days / Year}}{N}$$

$$d = \frac{D}{\text{Working Days / Year}}$$

$$ROP = d \cdot L$$

D = Demand per year
S = Setup (order) cost per order
H = Holding (carrying) cost
d = Demand per day
L = Lead time in days

What if …

1. *Interest rates go up ?*
2. *Order processing is automated ?*
3. *Warehouse costs drop ?*
4. *Competitive product is introduced ?*
5. *Product is cost-reduced ?*
6. *Lead time gets longer ?*
7. *Minimum order quantity imposed ?*

QUESTION

- X Ltd entered into a contract with a company for purchase of 12,360 instruments at the rate of rupees 235 per unit. Carrying cost is estimated as 47 rupees per instrument. Ordering cost is estimated as 2000 rupees. Calculate EOQ.

SOLUTION

$$\text{EOQ} = \sqrt{\frac{2Co*A}{Cc}}$$

Co= RS. 2000, Cc= RS. 47 per unit,

A= RS. 12,360

$$\text{EOQ} = \sqrt{\frac{2*2000*12{,}360}{47}} = 1026$$

LIMITATIONS OF EOQ MODEL

- It is necessary for the application of EOQ order that the demands remain constant throughout the year which is not possible.
- Ordering cost per order can't be constant because it's including transport cost.

JIT

- Just-in-time (JIT) is an inventory strategy companies employ to increase efficiency and decrease waste by receiving goods only as they are needed in the production process, thereby reducing inventory costs. This method requires producers to forecast demand accurately.
- This inventory supply system represents a shift away from the older just-in-case strategy, in which producers carried large inventories in case higher demand had to be met

- A good example would be a car manufacturer that operates with very low inventory levels, relying on its supply chain to deliver the parts it needs to build cars. The parts needed to manufacture the cars do not arrive before or after they are needed; instead, they arrive just as they are needed.

JIT

Advantages

- Just-in-time inventory control has several advantages over traditional models. Production runs remain short, which means manufacturers can move from one type of product to another very easily. This method reduces costs by eliminating warehouse storage needs. Companies also spend less money on raw materials because they buy just enough to make the products and no more.

Disadvantages

- The disadvantages of just-in-time inventories involve disruptions in the supply chain. If a supplier of raw materials has a breakdown and cannot deliver the goods on time, one supplier can shut down the entire production process. A sudden order for goods that surpasses expectations may delay delivery of finished products to clients.

Inventory Models

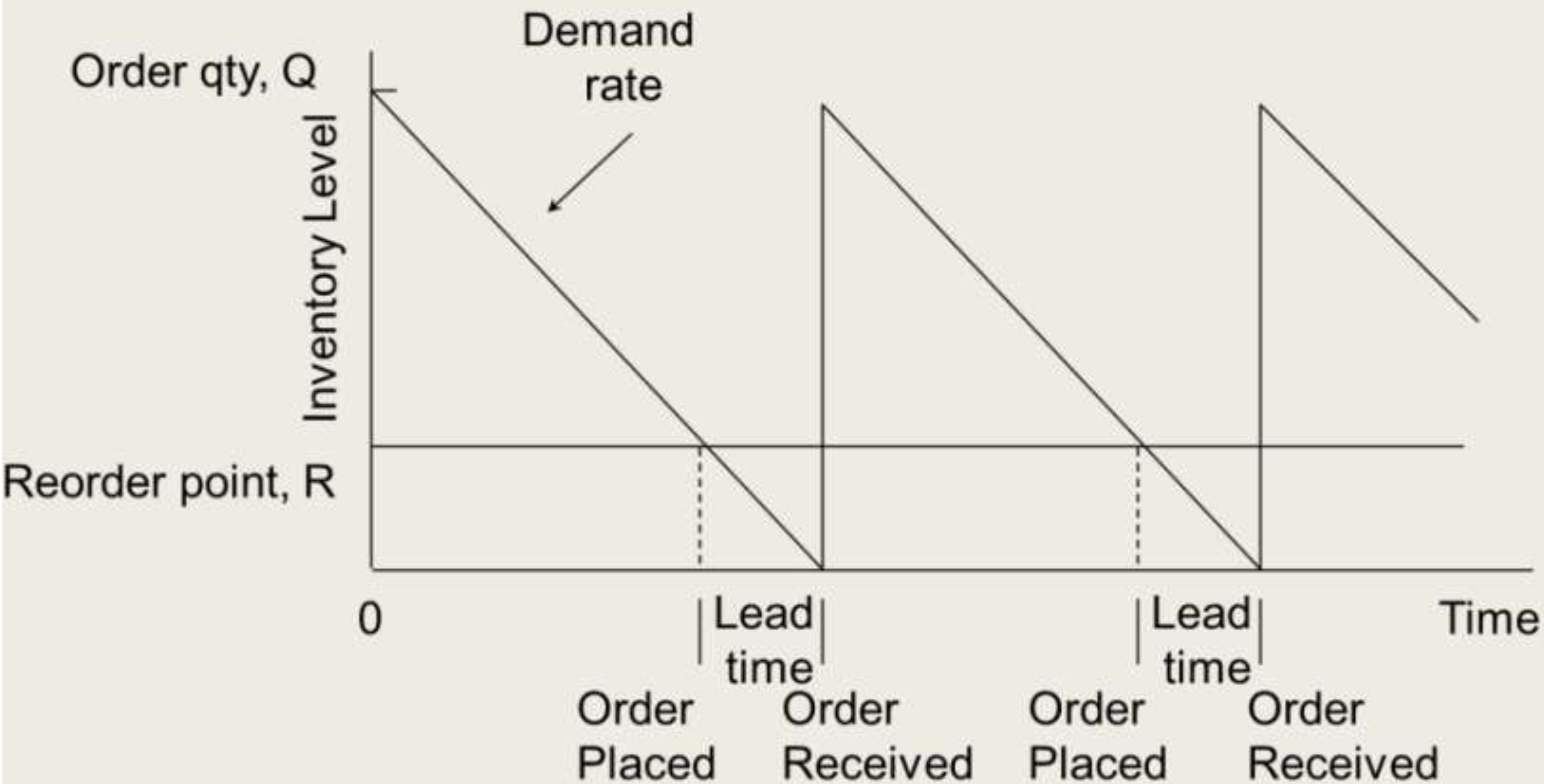
INVENTORY MODELS

Outline

- Deterministic models
  - *The Economic Order Quantity (EOQ) model*

- Probabilistic Inventory models
  - *A fixed order quantity model*
  - *A fixed time period model*

THE EOQ MODEL



Probabilistic Inventory Models

- The demand is not known. Demand characteristics such as mean, standard deviation and the distribution of demand may be known.
- Stockout cost: The cost associated with a loss of sales when demand cannot be met. For example, if an item is purchased at \$1.50 and sold at \$3.00, the loss of profit is \$3.00-1.50 = \$1.50 for each unit of demand not fulfilled.

A FIXED ORDER QUANTITY MODEL

Purchase-order can be placed at any time

On-hand inventory count is known always

Lead time for a high speed modem is two weeks and it has the following sales history in the last 25 weeks:

Quantity/Week	Frequency
75-80	1
70-75	3
65-70	9
60-65	8
55-60	4

Will you order now if number of items on hand is:

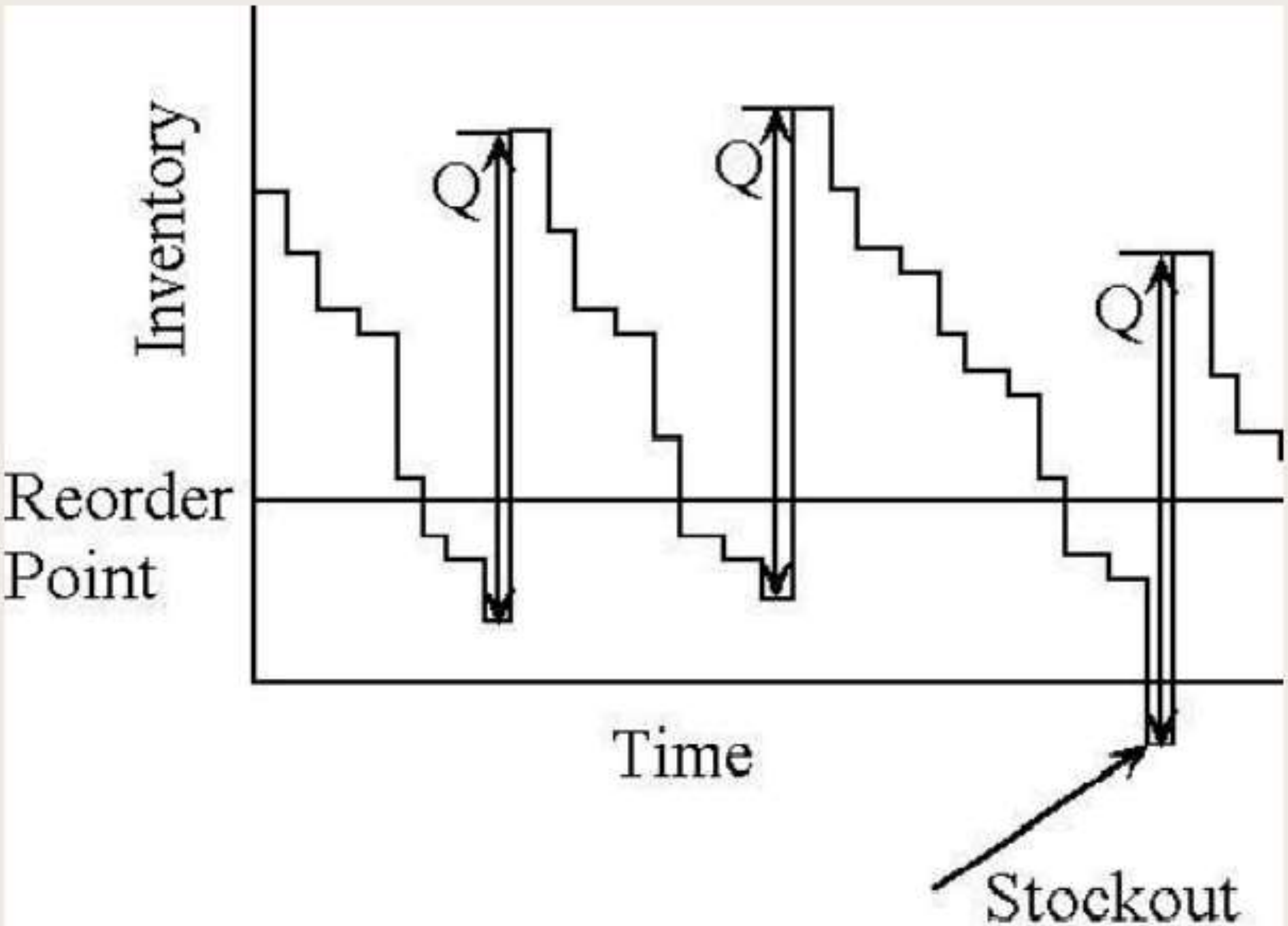
a. 200

b. 150

c. 100

A Fixed Order Quantity Model

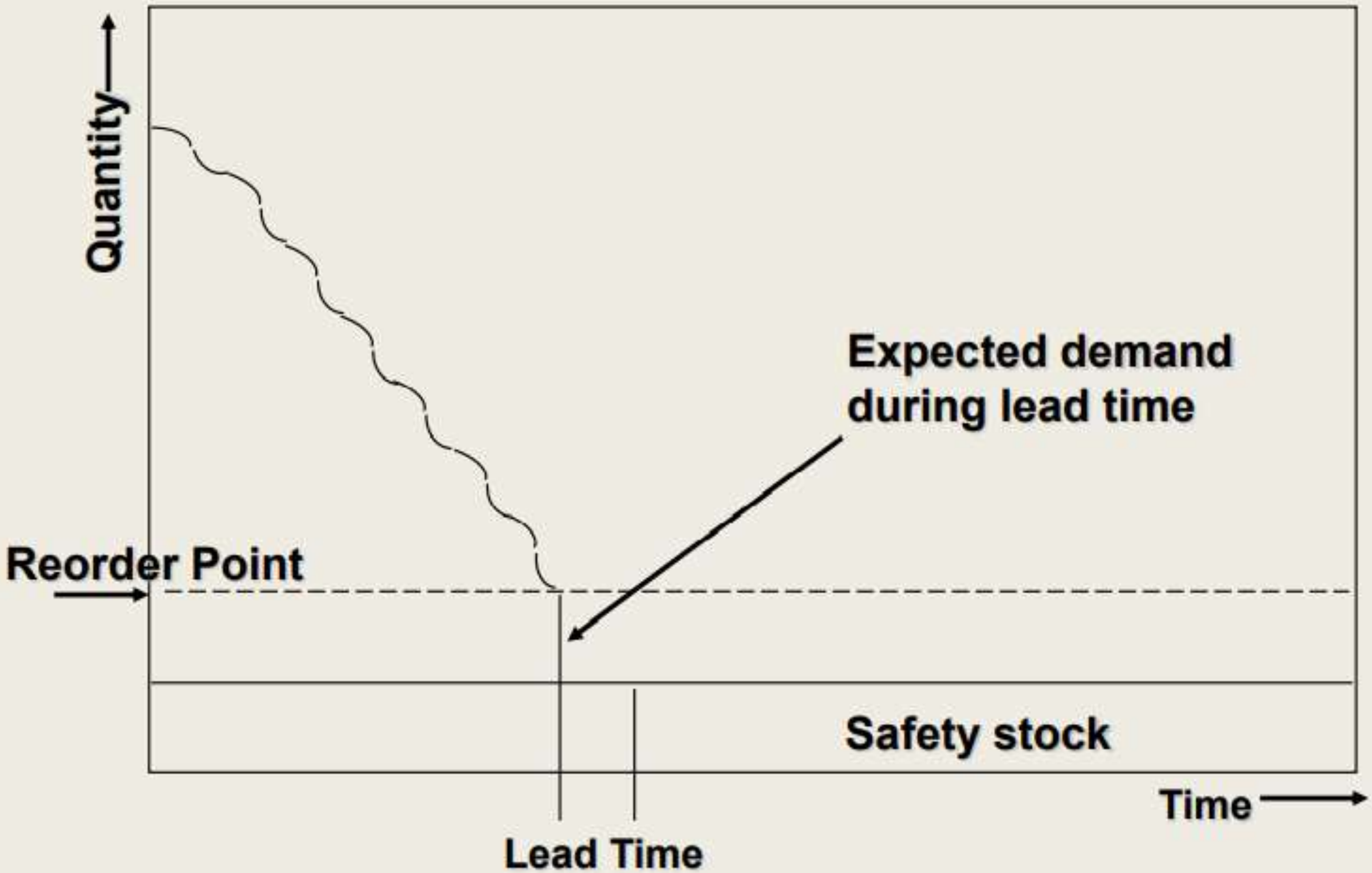
- The same quantity, Q is ordered when inventory o
hand reaches a reorder point, R



A Fixed Order Quantity Model

- An order quantity of EOQ works well
- If demand is constant, reorder point is the same as the demand during the lead time.
- If demand is uncertain, reorder point is usually set above the expected demand during the lead time
- Reorder point = Expected demand + Safety stock

Safety Stock



Trade-Off with Safety Stock

- Safety Stock - Stock held in excess of expected demand to protect against stockout during lead time.

Safety stock ↑ Holding cost ↑ Stockouts ↓

Safety stock ↓ Holding cost ↓ Stockouts ↑

Safety Stock (S):

- It is the extra stock that is always maintained to mitigate any future risks arising due to stock-outs because of shortfall of raw materials or supply, breakdown in machine or plant, accidents, natural calamity or disaster, labour strike or any other crisis that may the stall the production process.
- The quantity of safety stock is often derived by analysing historical data and is set to an optimized level by evaluating carefully the current cost of inventory and losses that may be incurred due to future risk.

Fixation of re-order level and

- **Fixed Reorder Quantity System**
- **Fixed Reorder Period System.**

Q-System

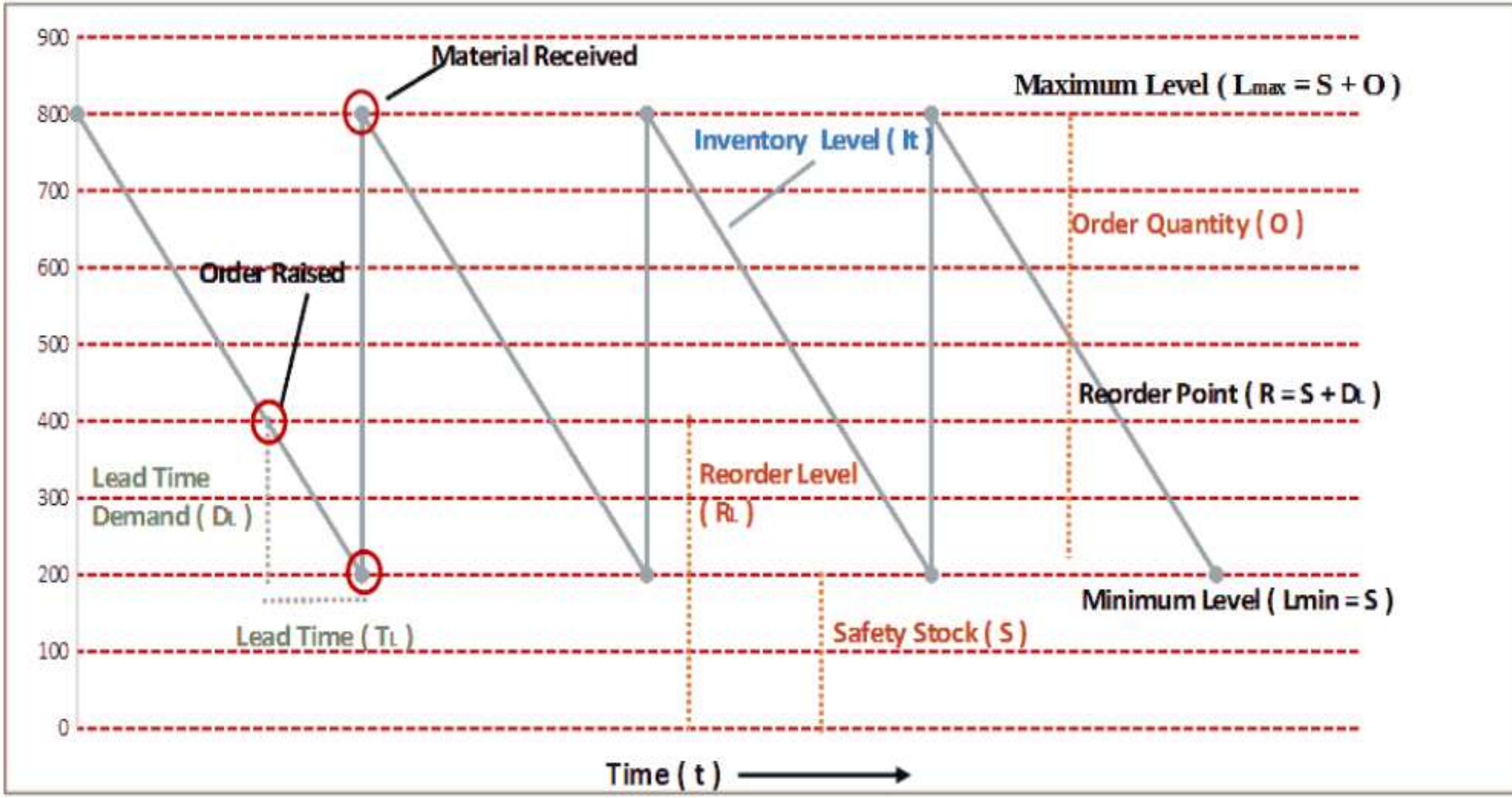
Fixed Reorder Quantity System.

- Fixed Reorder Quantity System is an Inventory Model, where an alarm is raised immediately when the inventory level drops below a **fixed quantity** and new orders are raised to replenish the inventory to an optimum level based on the demand. The point at which the inventory is ordered for replenishment is termed as **Reorder Point**. The inventory quantity at Reorder Point is termed as **Reorder Level** and the quantity of new inventory ordered is referred as **Order Quantity**.
- **Average Demand (DAv):** It is the average number of order requests made per day.
- **Average Lead Time (TL):** The time required to manufacture goods or product.
- **Average Lead Time Demand (DL):** Average number of orders requested during the Lead Time
- ***Average Lead Time Demand (DL) = Average Demand (DAv) X Average Lead Time (TL)***

Reorder Level (RL):

- Reorder level is the inventory level, at which an alarm is triggered immediately to replenish that particular inventory stock. Reorder level is defined, keeping into consideration the **Safety Stock** to avoid any stock-out and **Average Lead Time Demand** because even after raising the alarm, it would take one complete process cycle **(Lead Time)** till the new inventories arrive to replenish the existing inventory.
- ***Reorder Level (RL) = Safety Stock (S) + Average Lead Time Demand (DL)***
- **Order Quantity (O):** Order quantity is the Demand (Order requests) that needs to be delivered to the customer.
- **Minimum Level:** At least Safety Stock has to be always maintained to avoid any future stock- outs as per the standard practices of inventory management.
- ***Minimum Level (LMin) = Safety Stock (S)***
- **Maximum Level:** The maximum level that can be kept in stock is safety stock and the demand (the quantity ordered).
- ***Maximum Level (LMax) = Safety Stock (S) + Order Quantity (O)***

Inventory Model: Fixed Reorder Quantity System

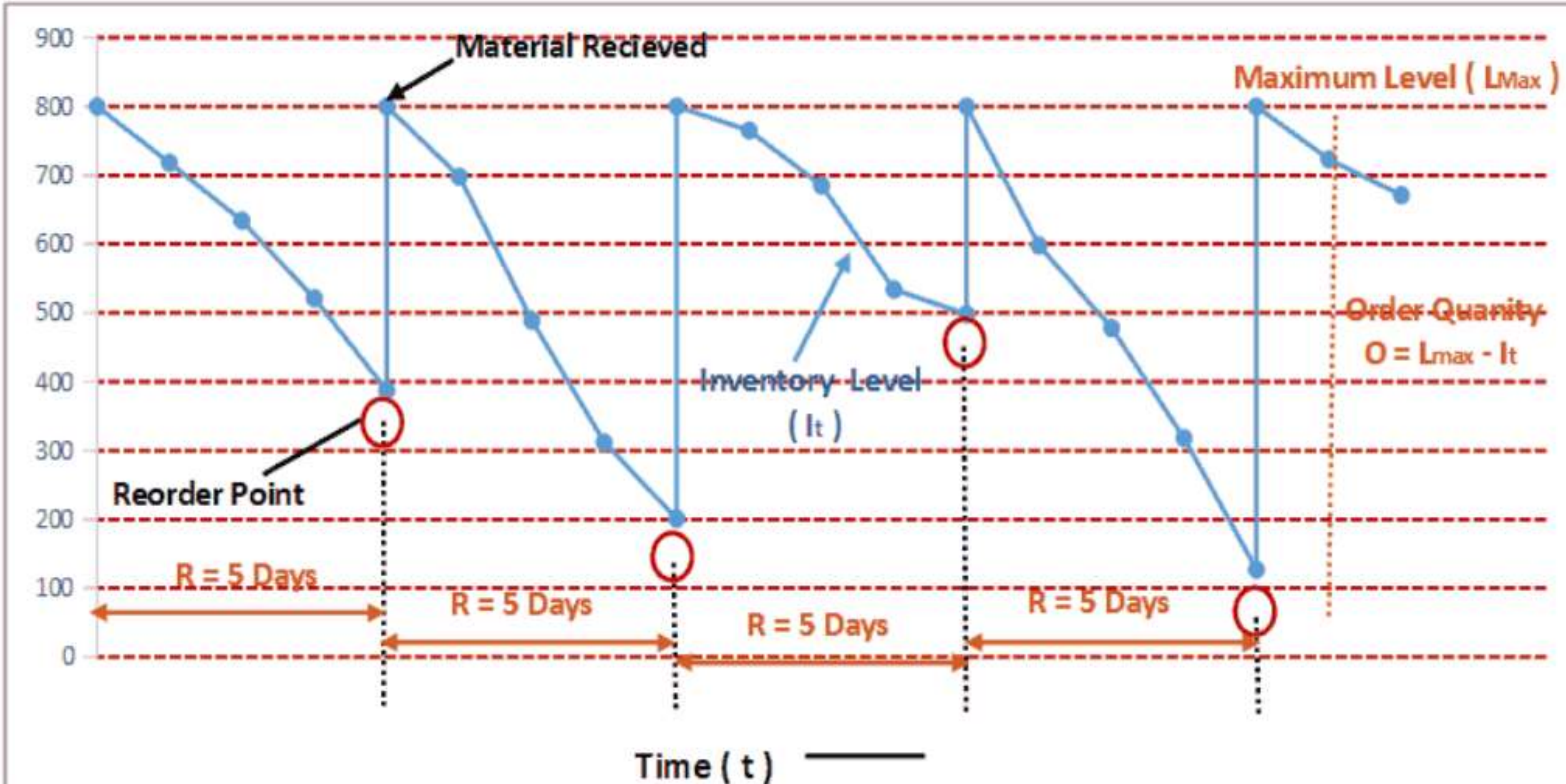


P-System

Fixed Reorder Period System.

- Fixed Reorder Period System is an Inventory Model of managing inventories, where an alarm is raised after every **fixed period of time** and orders are raised to replenish the inventory to an optimum level based on the demand. In this case replenishment of inventory is a continuous process done after every fixed interval of time.
- **Regular Intervals (R):** Regular Interval is the fixed time interval at the end of which the inventories would be reviewed and orders would be raised to replenish the inventory
- **Inventory on Hand (It):** Inventory on hand is the Inventory level measured at any given point of time.
- **Maximum Level (M):** It is the maximum level of inventory allowed as per the production guidelines. The maximum level is derived by analysing historical data.
- **Order Quantity:** In this system, inventory is reviewed at regular intervals (R), inventory on hand (It) is noted at the time of review and order quantity is placed for a quantity of (M) – (It).
- ***Order Quantity (O) = (M) – (It).***

Inventory Model: Fixed Reorder Period System



Example: Inventory is replenished at every regular interval of 5 days. The maximum allowable inventory is 800 Units. The inventory reviewed on Day-5, Day-10, Day -15 and Day -20 were 387 Units, 201 Units, 498 Units and 127 Units respectively.

- **Regular Intervals (R) = 5 Days**
- **Maximum Level (M) = 800 Units**
- **Inventory on Hand: I_5 = 387 Units, I_{10} = 201 Units, I_{15} = 498 Units and I_{20} = 127 Units**
- **Order Quantity (O) = (M) – (I_t).**
- **Order Quantity (O_5) = 800 – 387 = 413 Units**
- **Order Quantity (O_{10}) = 800 – 201 = 599 Units**
- **Order Quantity (O_{15}) = 800 – 498 = 302 Units**
- **Order Quantity (O_{15}) = 800 – 127 = 673 Units**

Inventory Management Example Problems with Solutions

1. An auto parts supplier sells Hardy-brand batteries to car dealers and auto mechanics. The annual demand is approximately 1,200 batteries. The supplier pays \$28 for each battery and estimates that the annual holding cost is 30 percent of the battery's value. It costs approximately \$20 to place an order (managerial and clerical costs). The supplier currently orders 100 batteries per month.

   a. Determine the ordering, holding, and total inventory costs for the current order quantity.

   b. Determine the economic order quantity (EOQ).

   c. How many orders will be placed per year using the EOQ?

   d. Determine the ordering, holding, and total inventory costs for the EOQ. How has ordering cost changed? Holding cost? Total inventory cost?

   Solution We are given the following information:

   annual demand: $D = 1200$ batteries per year

   item cost: $c = \$28$ per battery

   holding cost: $H = ic = 0.30(28) = \$8.40$ per battery per year

   order cost: $S = \$20$ per order

   current order quantity: $Q = 100$ batteries

   a. The current ordering and holding costs are: $\frac{D}{Q}S + \frac{Q}{2}H = \frac{1200}{100}(20) + \frac{100}{2}(8.40) = 240 + 420 = \$660$.

   b. The EOQ is $Q^* = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2\times1200\times20}{8.40}} = 75.6 \rightarrow 76$ batteries.

   c. The company will place $\frac{D}{Q^*} = \frac{1200}{76} = 15.8$ orders per year.

   d. The new ordering and holding costs are: $\frac{D}{Q^*}S + \frac{Q^*}{2}H = \frac{1200}{76}(20) + \frac{76}{2}(8.40) = 315.79 + 319.20 =$ \$634.99. The company will save \$25.01 by using the EOQ.

2. Upon closer inspection, the supplier determines that the demand for batteries is normally distributed with mean 4 batteries per day and standard deviation 3 batteries per day. (The supplier is open 300 days per year.) It usually takes about 4 days to receive an order from the factory.

   a. What is the standard deviation of usage during the lead time?

   b. Determine the reorder point needed to achieve a service level of 95 percent.

   c. What is the safety stock? What is the holding cost associated with this safety stock?

   d. How would your analysis change if the service level changed to 98 percent?

   Solution In addition to the information from the problem above, we are told:

   average demand rate: $d = 4$ batteries per day

   standard deviation of demand: $\sigma_d = 3$ batteries *per day*

   lead time: $L = 4$ days

   300 operating days per year

a. The standard deviation of demand during the lead time is $\sigma_L = \sigma_d\sqrt{L} = 3(\sqrt{4}) = 6$ batteries.

b. The reorder point is equal to the average demand expected during the lead time plus some safety stock. The service level is 95 percent. Examining the Table of Normal Demand Percentages (see the last page of this handout), we see that this corresponds to $z = 1.65$ (take the average of $z = 1.6$ and $z = 1.7$, since 95 percent is between 94.5 and 95.5 percent). In other words, we need to keep 1.65 standard deviations worth of extra inventory on hand to ensure that the probability of running out is less than 5 percent. Now we can figure out the reorder point: $R = dL + z\sigma_L = 4(4) + 1.65(6) = 16 + 9.9 = 25.9 \rightarrow 26$ batteries. We place an order for 76 batteries when the inventory level drops to 26 batteries.

c. The safety stock is the inventory in excess of the expected demand during the lead time. In other words, the safety stock is $26 - 16 = 10$ batteries. The associated holding cost is simply $10 \times H = 10 \times 8.40 = \$84.00$.

d. If the service level changes to 98 percent, then we must go back and determine a new z. Consulting the table, we see that 98 percent is between 97.7 and 98.2 percent. Averaging the two corresponding z values gives us $z = 2.05$ for a service level of 98 percent. Thus, the reorder point will be: $R = dL + z\sigma_L = 4(4) + 2.05(6) = 16 + 12.3 = 28.3 \rightarrow 29$ batteries. Place an order for 76 units when the inventory level drops to 29 units.

3. Foster Drugs, Inc., handles a variety of health and beauty aid products. A particular hair conditioner product costs Foster \$2.95 per unit. The annual holding cost rate is 20 percent. Using an EOQ model, they determined that an order quantity of 300 units should be used. The lead time to receive an order is one week, and the demand is normally distributed with a mean of 150 units per week and a standard deviation of 40 units per week.

   a. What is the reorder point if the firm is willing to tolerate a 1-percent chance of a stockout during an order cycle?

   b. What safety stock and annual safety stock cost are associated with your recommendation in part *a*?

   c. Foster is considering making a transition to a periodic-review system in an attempt to coordinate ordering of some of its products. The review period would be two weeks and the delivery lead time would remain one week. What target inventory level would be needed to ensure the same 1-percent risk of stockout?

   d. What is the safety stock associated with your answer to part *c*? What is the annual cost associated with holding this safety stock?

   e. Compare your answers to parts *b* and *d*. If you were the manager of Foster Drugs, would you choose a continuous- or periodic-review system?

Solution We are given the following information:

item cost: $c = \$2.95$ per unit

carrying "interest rate": $i = 0.20$ per unit per year

lead time: $L = 1$ week

average demand rate: $d = 150$ units per week

standard deviation of demand: $\sigma_d = 40$ units per week

current order quantity: $Q = 300$ units

a. A 1-percent stockout risk corresponds to a service level of 99 percent. Consulting the table, we see that this service level corresponds to $z = 2.3$. First, compute the mean and standard deviation of demand during the lead time: $dL = 150(1) = 150$ and $\sigma_L = \sigma_d\sqrt{L} = 40\sqrt{1} = 40$. Now we have all of the information necessary to determine the reorder point: $R = dL + z\sigma_L = 150 + 2.3(40) = 150 + 93.05 = 243.05 \rightarrow 243$ units.

b. The safety stock is 93 units, and the holding cost associated with the safety stock is $93 \times H = 93 \times ic = 93 \times 0.20(2.95) = \$54.87$.

c. We are told that the review period is two weeks so $P = 2$. Use this number, along with $L = 1$ to compute the mean and standard deviation of demand during the lead time and the review period: $d(P + L) = 150(2 + 1) = 450$ and $\sigma_{P+L} = \sigma_d\sqrt{P + L} = 40\sqrt{2 + 1} = 69.28$. The z value remains the same. The target inventory level is: $T = d(P + L) + z\sigma_{P+L} = 450 + 2.3(69.28) = 450 + 159.35 = 609.35 \rightarrow 610$ units.

d. The safety stock is 160 units (rounded up), and the holding cost associated with the safety stock is $160 \times H = 160 \times ic = 160 \times 0.20(2.95) = \$94.40$.

e. The periodic review method requires a larger safety stock, so it costs more: $94.40 - 54.87 = \$39.53$. However, using a fixed-period method facilitates ordering multiple items from a single supplier, so it is probably worth the extra cost.

Formulas for Inventory Management Problems

Fixed-Quantity System (Q System)

$$\text{EOQ: } Q^* = \sqrt{\frac{2DS}{H}} \qquad \text{TC} = \frac{D}{Q}S + \frac{Q}{2}H \qquad H = ic$$

$$R = dL + z\sigma_L \qquad \sigma_L = \sigma_d\sqrt{L}$$

Fixed-Period System (P System)

$$T = d(P+L) + z\sigma_{P+L} \qquad \sigma_{P+L} = \sigma_d\sqrt{P+L}$$

Table of Normal Demand Percentages

z	Service Level (%)	Stockout Risk (%)
0.0	50.0	50.0
0.5	69.1	30.9
1.0	84.1	15.9
1.1	86.4	13.6
1.2	88.5	11.5
1.3	90.3	9.7
1.4	91.9	8.1
1.5	93.3	6.7
1.6	94.5	5.5
1.7	95.5	4.5
1.8	96.4	3.6
1.9	97.1	2.9
2.0	97.7	2.3
2.1	98.2	1.8
2.2	98.6	1.4
2.3	98.9	1.1
2.4	99.2	0.8
2.5	99.4	0.6
2.6	99.5	0.5
2.7	99.6	0.4
2.8	99.7	0.3
2.9	99.8	0.2
3.0	99.9	0.1

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Inventory management efficiency analysis: A case study of an SME company

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Inventory management efficiency analysis: A case study of an SME company

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Abstract. The research aims to examine factors that affect inventory mismanagement in a Small Medium Enterprises (SME), which is a market leader in the Heavy Equipment Spare part Industry. Despite its status as market leader, the company deals with various inventory problems, for examples slow-moving stocks, delivery delays to customers, and so forth. Those problems, at the end, may reduce company's profit. In order to determine the main factors, this study applies quantitative and qualitative methods. Quantitative methods, specifically Pareto diagram and Inventory Turnover Ratio (ITR), are mainly used to evaluate sales and inventory management. ITR is affected by spare part quantity, warehouse area used, and the material amount. The top five ITR ratings are examined further through observation, interview, and questionnaire techniques. Meanwhile, the qualitative method is applied to evaluate the company's inventory information systems, procedures and coordinations among departments, and human resources. Our findings suggest that the unintegrated company's information system and lack of qualified human resources are the main factors affect inefficient inventory management. The research benefits to industry by suggesting the importance of information systems and human resources to inventory management. As for academics, this research enriches inventory management literature.

1. Introduction

Finished goods are one of the most important things for trading companies to meet customer demands and thus to increase customer satisfaction [1]. They must be managed efficiently and effectively [2]. Wiryawan explains that growth companies must concern with value-adding activities such as in production and procurement in order to increase companies' competitiveness [3]. One of the important activities in production and procurement is inventory management. Fail to manage inventory properly is likely to cause delays in production, unsatisfied customers, or working capital curtailment [4].

Inventory refers to the goods or materials used by a firm for the purposes of production and sale. Usually, nearly 60% of operational cash is allotted for the inventory in project [5]. Thus, good inventory management is compulsory to maintain material at optimal costs. Companies need to implement better internal control, for example establishing policy, building employee capacity, preparing planning, and so forth in order to increase inventory cost efficiency. Five factors affect inventory policy decisions [6-7], namely system structure, market characteristics, lead times, and costs.

By performing a performance measurement, companies may figure out how effective and efficient their inventory management. Prior literature suggest that the measurement of management efficiency and effectiveness can be done by using inventory turnover ratio [8,9]. Raoa and Raob states that the inventory turnover ratio measures the number of times a company sells its inventory during the year [8]. A high inventory turnover ratio indicates how good a company sale its products.

The biggest challenge in inventory management is efficiency. Okwaro, Iravo, and Berut, who conducted a study at the Kenya Seed Company, found that incompetent procurement staffs, poor inventory audit practice, outdated procurement system systems, and long bureaucratic procedures caused management inefficiency [10]. Hanson, Ackah, and Agboyi identify six activities that can improve inventory management efficiency [11]. They are top management commitment, ABC analysis, other logistics activities performance improvement, better demand forecasting, inventory management software, and postponement involves modifying or customizing products after the main manufacturing process is complete.

One of methods used to analyze the factors that affect inventory management inefficiency is fishbone diagram. Bose applied fishbone diagrams to evaluate supply chain and business processes in a hospital [12]. He found that fishbone diagram is a helpful method to examine factors that cause the occurrence of management inefficiency.

2. Research method

This study applies case study method to evaluate the practice of inventory management at PT ABCD. PT ABCD is a foreign company engaged in the heavy equipment industry for Excavator machines and Asphalt Pavers. Its machine excavator manufacturing and assembly plants is in Karawang, West Java. Meanwhile, the company still imports Asphalt Paver from Japan. The business scope is spare part sales and after-sales services.

Despite its promising performance, the company is struggled with its inventory management. Its inventory turnover is lower compare to its competitors. The inventory planning is not aligned with the sales planning either. As a result, the company suffers higher maintenance cost and frequent delivery delay

In applying case study method, we combine qualitative and quantitative approach which allow us to collect data with greater depth. We conducted observation, interview, and document analysis when we evaluate the inventory management. The interviewers are 5 key personals (1 manager and 4 supervisors). Their job descriptions are closely related with inventory management. The data collection was done in December 2018 – January 2019.

As shown in figure 1, we apply ABC analysis and Pareto diagram to classify the crucial spare parts that have to be managed. This is consistent with previous researches by Lancioni and Howard [4] and Karthick et al. [13], that used ABC analysis and Pareto diagram for inventory management. ABC analysis classifies the items into three levels, namely high, medium and low. Inventory turnover is calculated by using the following formula:

$$\frac{\text{Cost of Good Sold from Stock Sales during the Past 12 Months}}{\text{Average Inventory Investment during the Past 12 Months}} \tag{1}$$

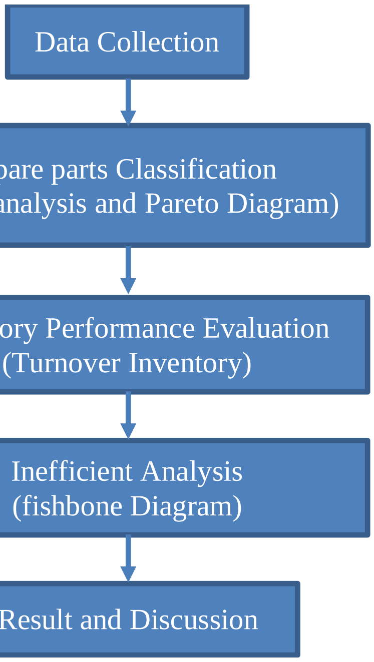

Figure 1. Research methodology.

3. Result and discussion

Our study finds that PT. ABCD manages its inventory inefficiently. The first indicator is the irregular inventory layout. There are significant amount inventories that are purchased more than what the company has planned. Those inventories have been kept in the warehouse for more than its normal turnover period. By using Pareto diagram (ABC), this study finds three material categories which significantly affect the efficiency of spare part management (see Table 1).

Table 1. Pareto analysis.

No	Category	Amount	Quantity	Space
1	**Filter**	**3**	**3**	**1**
2	Lubricant oil	12	11	5
3	Undercarriage	5	8	7
4	**Seal, O-Ring & Belt**	**2**	**1**	**3**
5	GET	11	6	8
6	Electrical Parts	7	7	4
7	**Engine Parts**	**1**	**2**	**2**
8	Attachment	4	10	11
9	Hyd Component	8	15	13
10	Hyd Inner Parts	6	9	9
11	Cabin	15	13	12
12	Common Parts/Others	14	4	6
13	Swing Device/Motor	10	12	14
14	Excavator	9	5	10
15	Paver	13	14	15

The Pareto result started from one until 15. Those numbers are the highest numbers that reveal the most significant potential factors to total inventory. Based on data above, the three most significant factors are engine parts, seal (O-Ring & Belt), and filter.

The qualitative analysis is conducted by applying the *fishbone diagram* and *why and why analysis to* determine the main factors that cause inventory cost inefficiency. Figure 2 depicts the *fishbone diagram* at Company PT ABCD. There are six main factors derived from field observation, which are *equipment, process, people, materials, environment, and management.*

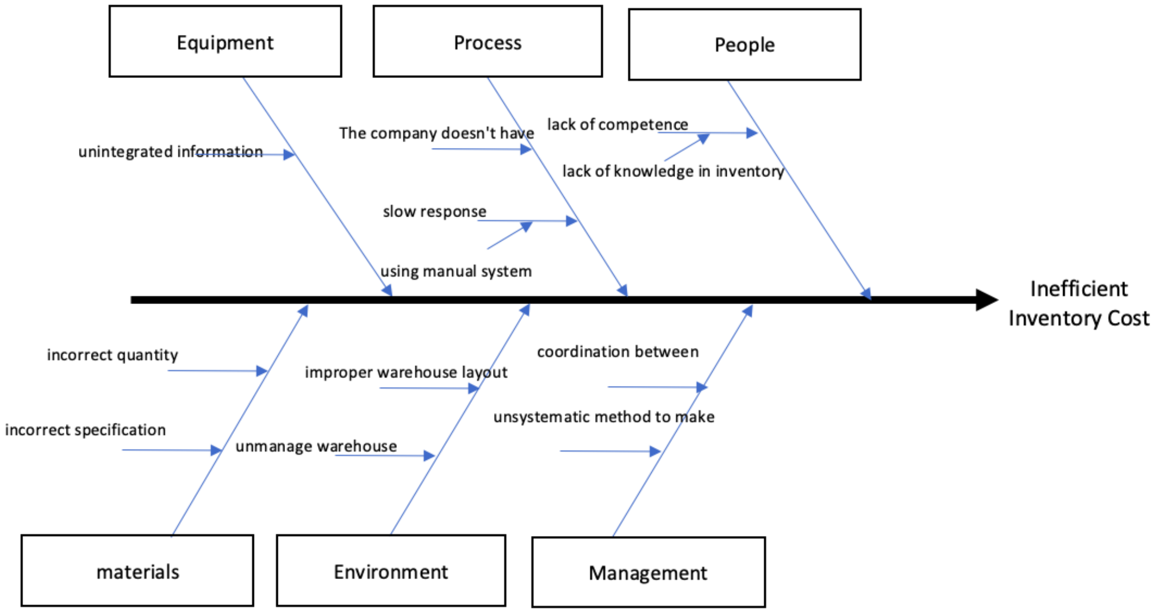

Figure 2. Fishbone diagram in company PT. ABCD.

Each factor is described below:

3.1. People
Employees who are assigned to manage inventory activities do not have any formal or informal education or training in inventory management. As a result, employees are less competent to manage material in the warehouse. Spare parts are located only based on empty (unused) space which cause inventories scattering in many places. At the end, it is very time consuming to find particular inventories when needed.

3.2. Process
PT ABCD does not have any formal Standard Operating Procedure related to inventory management that involves coordination among departments. Every department tend to work independently rather than as a team. These circumstances are worsening by unintegrated information system. Most of information process are done manually. As a result, the company tend to respond slowly to any customer-demand changes.

3.3. Equipment
Integrated system is crucial in supporting collaboration among departments so the company may respond customer demands faster. Unfortunately, PT. ABCD does not develop enterprise resource planning that may support their decision-making.

3.4. Material
PT ABCD sells imported spare parts that require longer delivery time. PT. ABCD frequently orders wrong inventory. As a result, when the spare parts ordered to supplier in terms of quantity and/or specification do not match with customers' orders, the delivery to customers are delayed significantly. Numbers of customers' complain is above the company's expectation every month.

3.5. Environment
Incorrect spare part layout causes many non-valued added activities and time inefficiency. This is caused by employees' lack of ability to manage the warehouse.

3.6. Management
At the management level, the head of department prepares sales planning unsystematically. Since they do not maintain customer data regularly, the company finds difficulty to analyse customers demand. As a result, the deviation between the sales planning and the actual sales are significant at each period.

4. Conclusion
The research aims to evaluate factors that affect inventory mismanagement in a Small Medium Enterprises (SME). Based on the above findings, this study concludes that the main factors inventory cost efficiency is the unintegrated company's information system and lack of qualified human resources. Integrated information system is very important to provide real time information for management. It also makes better coordination among departments. The implementation of integrated information system must be supported with competent human resource. Trainings and retaining competent staffs are necessary. For future studies, we suggest to examine the optimal inventory quantity and lead time delivery to maximize efficiency and customer satisfaction.

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Quality Management

What Is Quality?

- *Oxford American Dictionary*
  - a degree or level of excellence
- American Society for Quality
  - totality of features and characteristics that satisfy needs without deficiencies
- Consumer's and producer's perspective

What Is Quality: Customer's Perspective

- Fitness for use
  - how well product or service does what it is supposed to
- Quality of design
  - designing quality characteristics into a product or service
- A Mercedes and a Ford are equally "fit for use," but with different design dimensions.

Dimensions of Quality: Manufactured Products

- Performance
  - basic operating characteristics of a product; how well a car handles or its gas mileage
- Features
  - “extra” items added to basic features, such as a stereo CD or a leather interior in a car
- Reliability
  - probability that a product will operate properly within an expected time frame; that is, a TV will work without repair for about seven years

Dimensions of Quality: Manufactured Products

- Conformance
  - degree to which a product meets pre–established standards
- Durability
  - how long product lasts before replacement; with care, L. L. Bean boots may last a lifetime
- Serviceability
  - ease of getting repairs, speed of repairs, courtesy and competence of repair person

Dimensions of Quality: Manufactured Products

- Aesthetics
  - how a product looks, feels, sounds, smells, or tastes
- Safety
  - assurance that customer will not suffer injury or harm from a product; an especially important consideration for automobiles
- Perceptions
  - subjective perceptions based on brand name, advertising, etc.

Dimensions of Quality: Services

- 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

- Courtesy:
  - how are customers treated by employees?
  - are catalogue phone operators nice and are their voices pleasant?
- Consistency
  - is same level of service provided to each customer each time?
  - is your newspaper delivered on time every morning?

Dimensions of Quality: Service

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

What Is Quality: Producer's Perspective

- Quality of conformance
  - making sure product or service is produced according to design
    - if new tires do not conform to specifications, they wobble
    - if a hotel room is not clean when a guest checks in, hotel is not functioning according to specifications of its design

Meaning of Quality

What Is Quality: A Final Perspective

- Customer's and producer's perspectives depend on each other
- Producer's perspective:
  - production process and COST
- Customer's perspective:
  - fitness for use and PRICE
- Customer's view must dominate

What is Quality

Quality is the ability of a product or service to consistently meet or exceed customer expectations.

Evolution of Quality Management: Quality Gurus

- Walter Shewhart
  - In 1920s, developed control charts
  - Introduced term "*quality assurance*"
- W. Edwards Deming
  - Developed courses during WW II to teach statistical quality-control techniques to engineers and executives of military suppliers
  - After war, began teaching statistical quality control to Japanese companies
- Joseph M. Juran
  - Followed Deming to Japan in 1954
  - Focused on strategic quality planning
  - Quality improvement achieved by focusing on projects to solve problems and securing breakthrough solutions

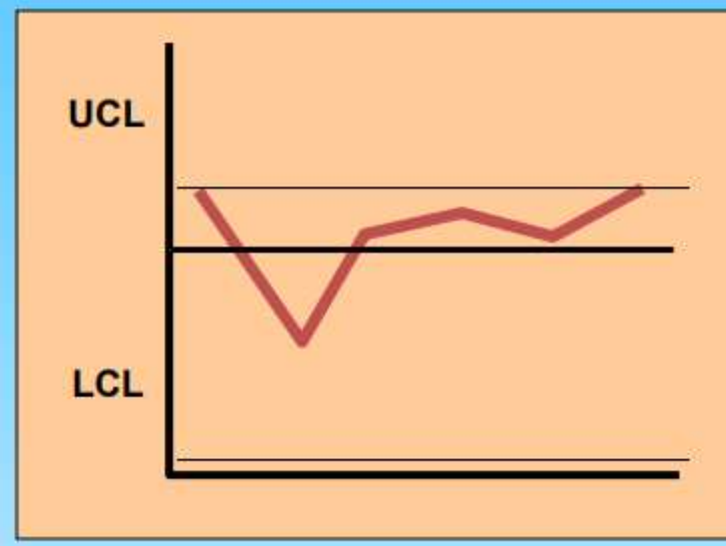
Evolution of Quality Management: Quality Gurus

- Armand V. Feigenbaum
  - In 1951, introduced concepts of total quality control and continuous quality improvement
- Philip Crosby
  - In 1979, emphasized that costs of poor quality far outweigh cost of preventing poor quality
  - In 1984, defined absolutes of quality management—conformance to requirements, prevention, and "zero defects"
- Kaoru Ishikawa
  - Promoted use of quality circles
  - Developed "fishbone" diagram
  - Emphasized importance of internal customer

Statistical Process Control

Statistical Process Control (SPC)

- Statistical Process Control
  - monitoring production process to detect and prevent poor quality
- Sample
  - subset of items produced to use for inspection
- Control Charts
  - process is within statistical control limits



Process Variability

- Random
  - inherent in a process
  - depends on equipment and machinery, engineering, operator, and system of measurement
  - natural occurrences

- Non-Random
  - special causes
  - identifiable and correctable
  - include equipment out of adjustment, defective materials, changes in parts or materials, broken machinery or equipment, operator fatigue or poor work methods, or errors due to lack of training

SPC in Quality Management

- SPC uses
  - Is the process in control?
  - Identify problems in order to make improvements
  - Contribute to the TQM goal of continuous improvement

Quality Measures: Attributes and Variables

- Attribute
  - A characteristic which is evaluated with a discrete response
  - good/bad; yes/no; correct/incorrect
- Variable measure
  - A characteristic that is continuous and can be measured
  - Weight, length, voltage, volume

Where to Use Control Charts

- Process
  - Has a tendency to go out of control
  - Is particularly harmful and costly if it goes out of control
- Examples
  - At beginning of process because of waste to begin production process with bad supplies
  - Before a costly or irreversible point, after which product is difficult to rework or correct
  - Before and after assembly or painting operations that might cover defects
  - Before the outgoing final product or service is delivered

Control Charts

- A graph that monitors process quality
- Control limits
  - upper and lower bands of a control chart
- Attributes chart
  - p-chart
  - c-chart
- Variables chart
  - mean (x bar – chart)
  - range (R-chart)

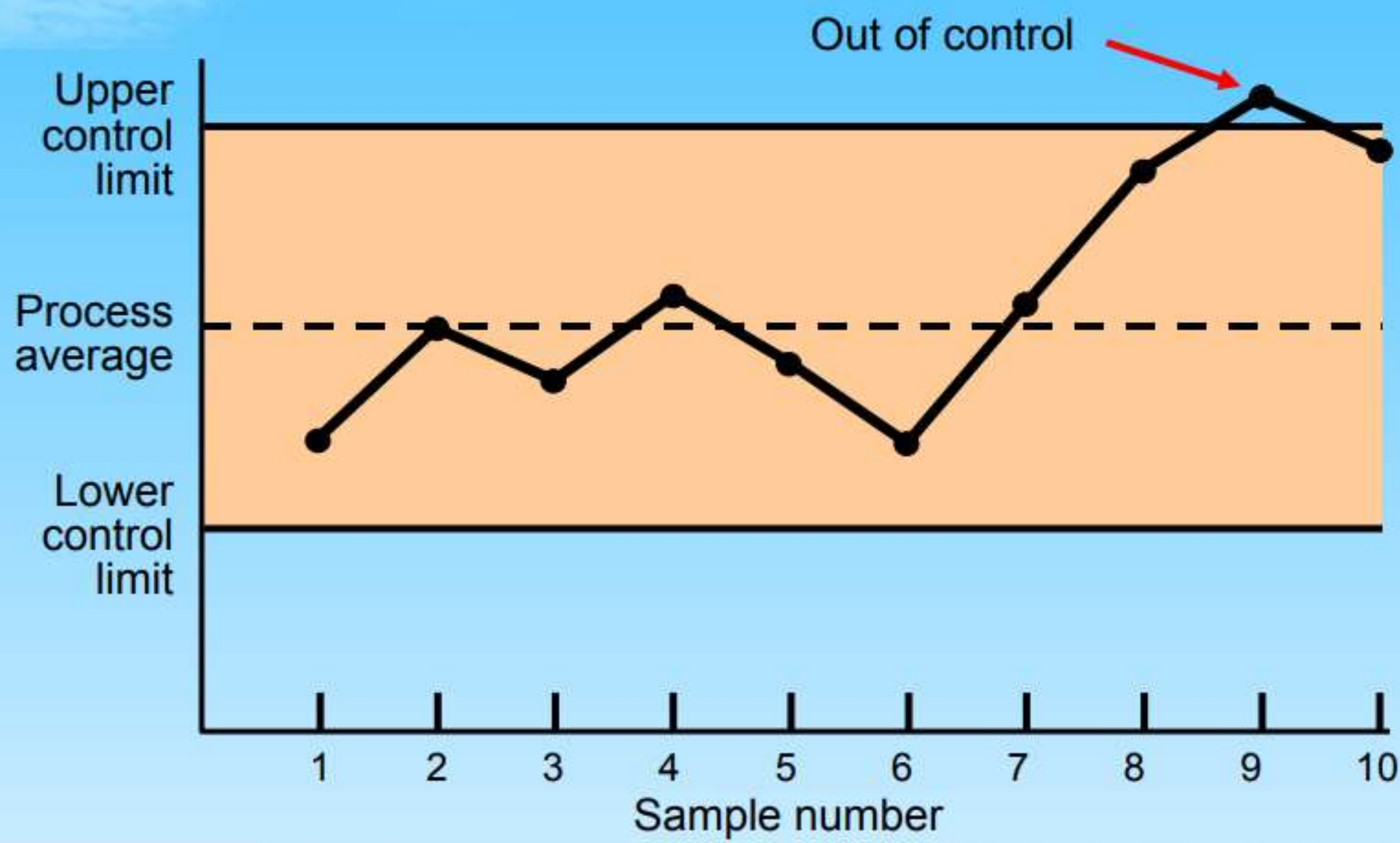
WHAT DO THESE CHARTS DO.

- It detects variations in the processing and warns if there is any departure from the specified tolerance limits.

- It is primarily a diagnostic technique.

- It depicts whether there is any change on the characteristics of items since the start of the production run.

Process Control Chart



A Process Is in Control If …

- … no sample points outside limits
- … most points near process average
- … about equal number of points above and below centerline

4. … points appear randomly distributed

Control Charts for Attributes

- p-chart
  - uses portion defective in a sample
- c-chart
  - uses number of defects (non-conformities) in a sample

DEFINITION

- The term Attribute refers to those quality characteristics that conform to specifications or do not conform to specifications.
- Attribute are used:
  1. Where measurements are not possible.
  2. Where measurements can be made but are not made because of time, cost, or need.

P CHART

- The *P* Chart is used for data that consist of the proportion of the number of occurrences of an event to the total number of occurrences.
- It is used in quality to report the fraction or percent nonconforming in a product, quality characteristic, or group of quality characteristics.

CALCULATE THE TRIAL CENTRAL LINE AND CONTROL LIMITS

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$\bar{p} = \frac{\sum np}{\sum n}$ = average of p for many subgroups

n = number inspected in a subgroup

Construction of p-Chart

SAMPLE #	NUMBER OF DEFECTIVES	PROPORTION DEFECTIVE
1	6	.06
2	0	.00
3	4	.04
:	:	:
:	:	:
20	18	.18
	200	

20 samples of 100 pairs of jeans

Construction of p-Chart

$$\bar{p} = \frac{\text{total defectives}}{\text{total sample observations}} = 200 / 20(100) = 0.10$$

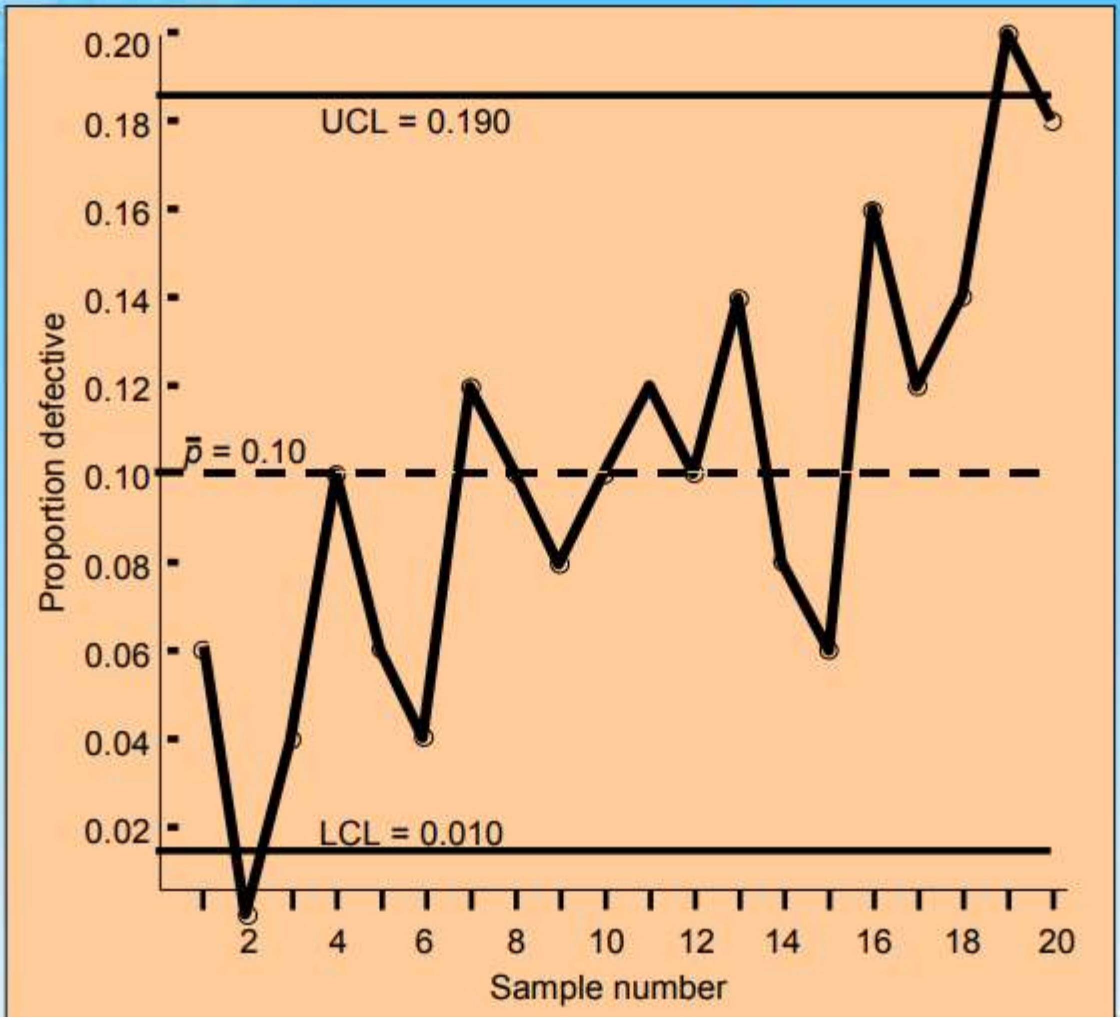
$$UCL = \bar{p} + z\sqrt{\frac{\bar{p}(1 - \bar{p})}{n}} = 0.10 + 3\sqrt{\frac{0.10(1 - 0.10)}{100}}$$

UCL = 0.190

$$LCL = \bar{p} - z\sqrt{\frac{\bar{p}(1 - \bar{p})}{n}} = 0.10 - 3\sqrt{\frac{0.10(1 - 0.10)}{100}}$$

LCL = 0.010

Construction of p-Chart



NP CHART

- The *np* chart is almost the same as the *p* chart.

Central line = np_o

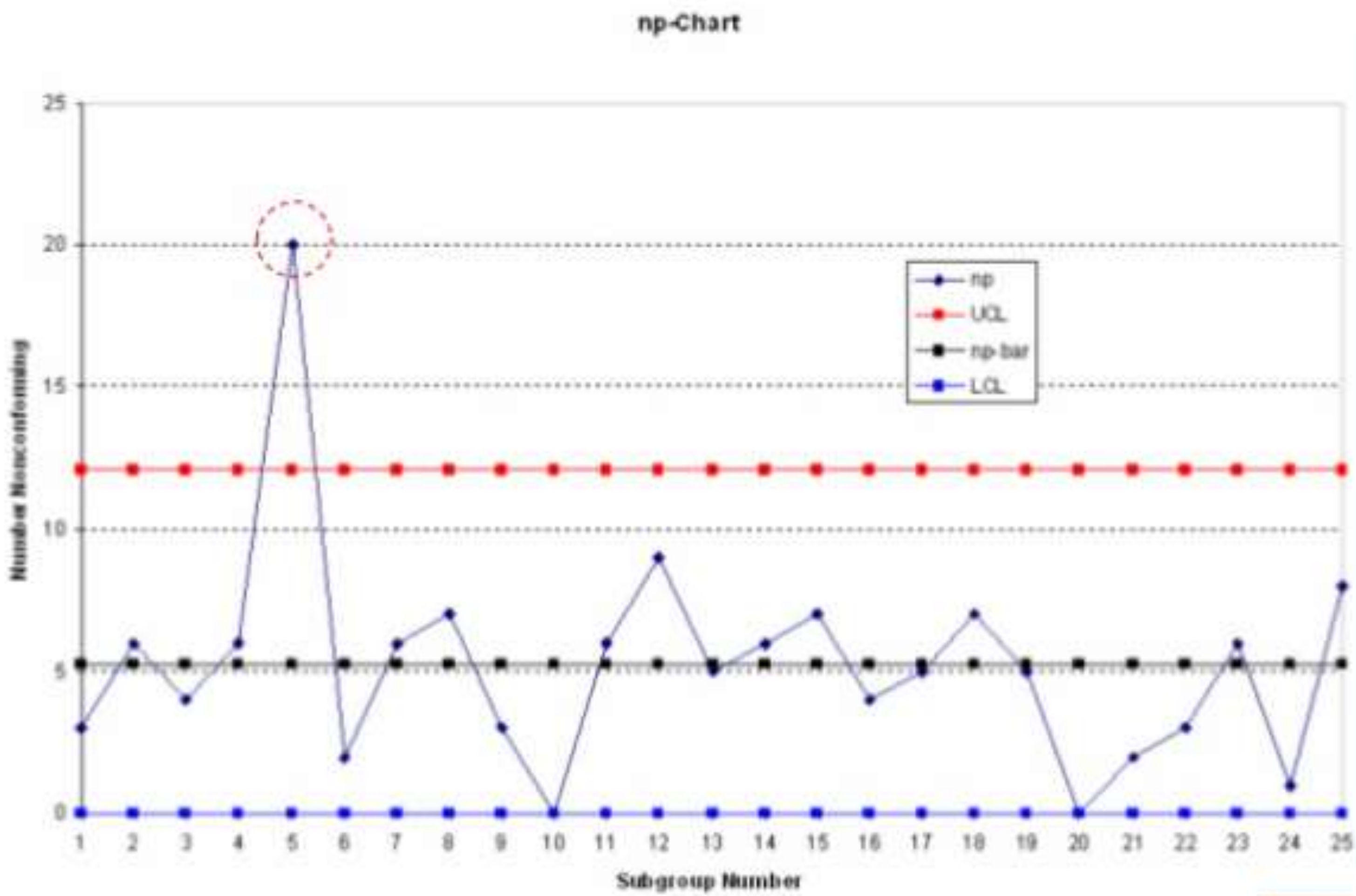
$$UCL = np_o + 3\sqrt{np_o(1 - p_o)}$$

$$LCL = np_o - 3\sqrt{np_o(1 - p_o)}$$

- If po is unknown, it must be determined by collecting data, calculating UCL, LCL.

EXAMPLE

Subgroup	*n*	*np*	UCL	*np*-bar	LCL
1	300	3	12.0	5.24	0.0
2	300	6	12.0	5.24	0.0
3	300	4	12.0	5.24	0.0
4	300	6	12.0	5.24	0.0
5	300	20	12.0	5.24	0.0
21	300	2	12.0	5.24	0.0
22	300	3	12.0	5.24	0.0
23	300	6	12.0	5.24	0.0
24	300	1	12.0	5.24	0.0
25	300	8	12.0	5.24	0.0



np-Chart
Number Nonconforming
Subgroup Number
np
UCL
np-bar
LCL
0
5
10
15
20
25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

c-Chart

$$UCL = \bar{c} + z\sigma_c$$

$$LCL = \bar{c} - z\sigma_c$$

$$\sigma_c = \sqrt{\bar{c}}$$

where

c = number of defects per sample

c-Chart

Number of defects in 15 sample rooms

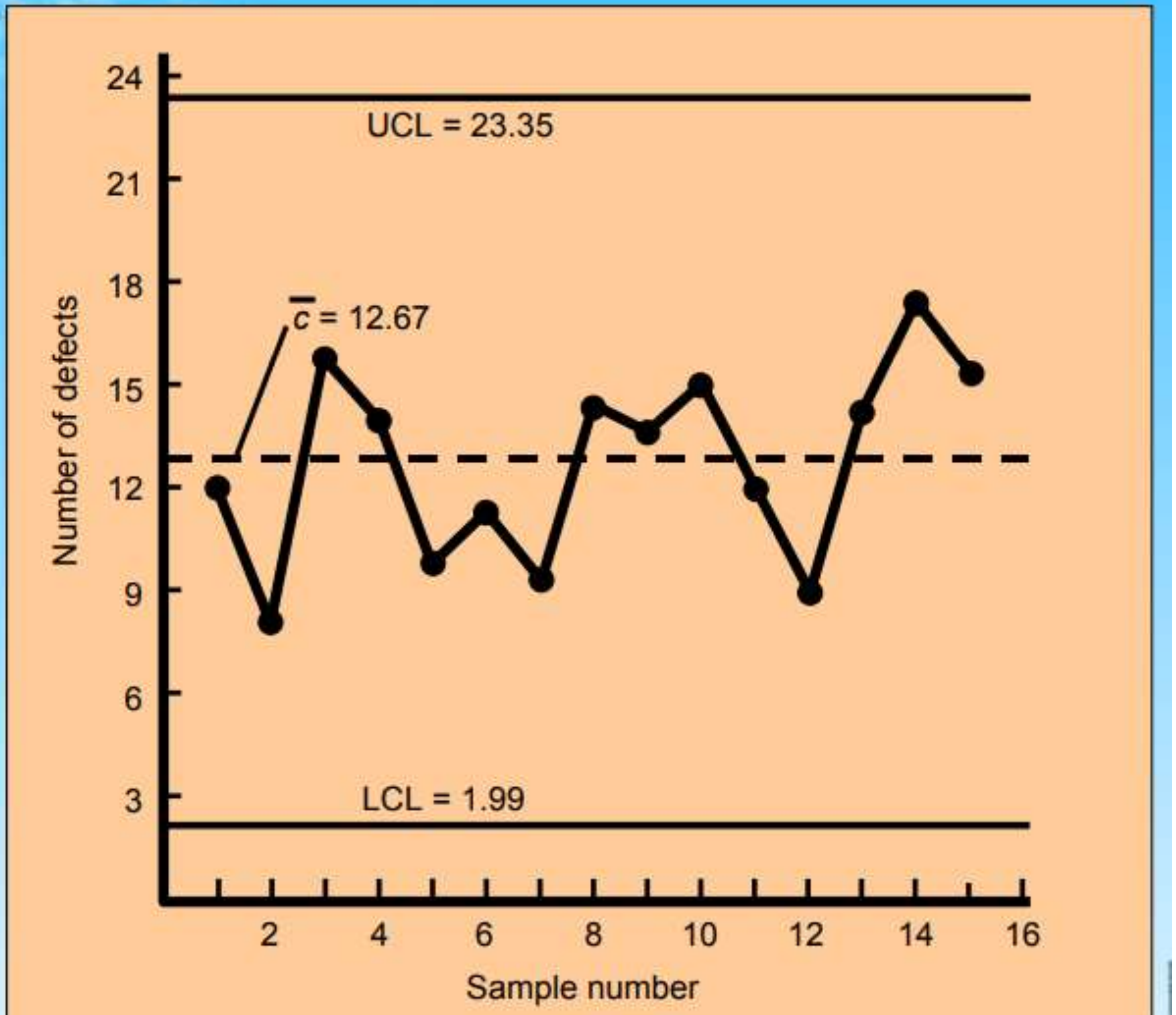
SAMPLE	NUMBER OF DEFECTS
1	12
2	8
3	16
:	:
:	:
15	15
	190

$$\bar{c} = \frac{190}{15} = 12.67$$

$$\begin{aligned} \text{UCL} &= \bar{c} + z\sigma_c \\ &= 12.67 + 3\sqrt{12.67} \\ &= 23.35 \end{aligned}$$

$$\begin{aligned} \text{LCL} &= \bar{c} - z\sigma_c \\ &= 12.67 - 3\sqrt{12.67} \\ &= 1.99 \end{aligned}$$

c-Chart



24
21
18
15
12
9
6
3
UCL = 23.35
$\bar{c}$ = 12.67
LCL = 1.99
Number of defects
2
4
6
8
10
12
14
16
Sample number

Control Charts for Variables

- Range chart (R-Chart)
  - Plot sample range (variability)
- Mean chart ($\bar{x}$-Chart)
  - Plot sample averages

x-bar Chart: σ Known

$$UCL = \bar{\bar{x}} + z\,\sigma_{\bar{x}}$$
$$LCL = \bar{\bar{x}} - z\,\sigma_{\bar{x}}$$

Where

$$\bar{\bar{X}} = \frac{\bar{x}_1 + \bar{x}_2 + \ldots + \bar{x}_k}{k}$$

σ = process standard deviation

$\sigma_{\bar{x}}$ = standard deviation of sample means $= \sigma/\sqrt{n}$

k = number of samples (subgroups)

n = sample size (number of observations)

x-bar Chart Example: σ Known

	Observations(Slip-Ring Diameter, cm) n					
Sample k	1	2	3	4	5	$\bar{x}$
1	5.02	5.01	4.94	4.99	4.96	4.98
2	5.01	5.03	5.07	4.95	4.96	5.00
3	4.99	5.00	4.93	4.92	4.99	4.97
4	5.03	4.91	5.01	4.98	4.89	4.96
5	4.95	4.92	5.03	5.05	5.01	4.99
6	4.97	5.06	5.06	4.96	5.03	5.01
7	5.05	5.01	5.10	4.96	4.99	5.02
8	5.09	5.10	5.00	4.99	5.08	5.05
9	5.14	5.10	4.99	5.08	5.09	5.08
10	5.01	4.98	5.08	5.07	4.99	5.03
						50.09

We know σ = .08

x-bar Chart Example: σ Known

$$\bar{\bar{X}} = \frac{50.09}{10} = 5.01$$

$$\begin{aligned} UCL &= \bar{\bar{x}} + z\,\sigma_{\bar{x}} \\ &= 5.01 + 3(.08 / \sqrt{10}) \\ &= 5.09 \end{aligned}$$

$$\begin{aligned} LCL &= \bar{\bar{x}} - z\,\sigma_{\bar{x}} \\ &= 5.01 - 3(.08 / \sqrt{10}) \\ &= 4.93 \end{aligned}$$

x-bar Chart Example: σ Unknown

$$UCL = \bar{\bar{x}} + A_2\bar{R} \qquad LCL = \bar{\bar{x}} - A_2\bar{R}$$

where

$\bar{\bar{x}}$ = average of the sample means

$\bar{R}$ = average range value

Control Chart Factors

Sample Size	Factor for X-chart	Factors for R-chart	
n	A2	D3	D4
2	1.880	0.000	3.267
3	1.023	0.000	2.575
4	0.729	0.000	2.282
5	0.577	0.000	2.114
6	0.483	0.000	2.004
7	0.419	0.076	1.924
8	0.373	0.136	1.864
9	0.337	0.184	1.816
10	0.308	0.223	1.777
11	0.285	0.256	1.744
12	0.266	0.283	1.717
13	0.249	0.307	1.693
14	0.235	0.328	1.672
15	0.223	0.347	1.653
16	0.212	0.363	1.637
17	0.203	0.378	1.622
18	0.194	0.391	1.609
19	0.187	0.404	1.596
20	0.180	0.415	1.585
21	0.173	0.425	1.575
22	0.167	0.435	1.565
23	0.162	0.443	1.557
24	0.157	0.452	1.548
25	0.153	0.459	1.541

Tabular values for X-bar and range charts

Subgroup Size	A_2	d_2	D_3	D_4
2	1.880	1.128	-----	3.268
3	1.023	1.693	-----	2.574
4	0.729	2.059	-----	2.282
5	0.577	2.326	-----	2.114
6	0.483	2.534	-----	2.004
7	0.419	2.704	0.076	1.924
8	0.373	2.847	0.136	1.864
9	0.337	2.970	0.184	1.816
10	0.308	3.078	0.223	1.777
11	0.285	3.173	0.256	1.744
12	0.266	3.258	0.283	1.717
13	0.249	3.336	0.307	1.693
14	0.235	3.407	0.328	1.672
15	0.223	3.472	0.347	1.653
16	0.212	3.532	0.363	1.637
17	0.203	3.588	0.378	1.622
18	0.194	3.640	0.391	1.608
19	0.187	3.689	0.403	1.597
20	0.180	3.735	0.415	1.585
21	0.173	3.778	0.425	1.575
22	0.167	3.819	0.434	1.566
23	0.162	3.858	0.443	1.557
24	0.157	3.895	0.451	1.548
25	0.153	3.931	0.459	1.541

x-bar Chart Example: σ Unknown

	OBSERVATIONS (SLIP- RING DIAMETER, CM)						
SAMPLE *k*	*1*	*2*	*3*	*4*	*5*	$\bar{x}$	*R*
1	5.02	5.01	4.94	4.99	4.96	4.98	0.08
2	5.01	5.03	5.07	4.95	4.96	5.00	0.12
3	4.99	5.00	4.93	4.92	4.99	4.97	0.08
4	5.03	4.91	5.01	4.98	4.89	4.96	0.14
5	4.95	4.92	5.03	5.05	5.01	4.99	0.13
6	4.97	5.06	5.06	4.96	5.03	5.01	0.10
7	5.05	5.01	5.10	4.96	4.99	5.02	0.14
8	5.09	5.10	5.00	4.99	5.08	5.05	0.11
9	5.14	5.10	4.99	5.08	5.09	5.08	0.15
10	5.01	4.98	5.08	5.07	4.99	5.03	0.10
					Totals	50.09	1.15

x-bar Chart Example: σ Unknown

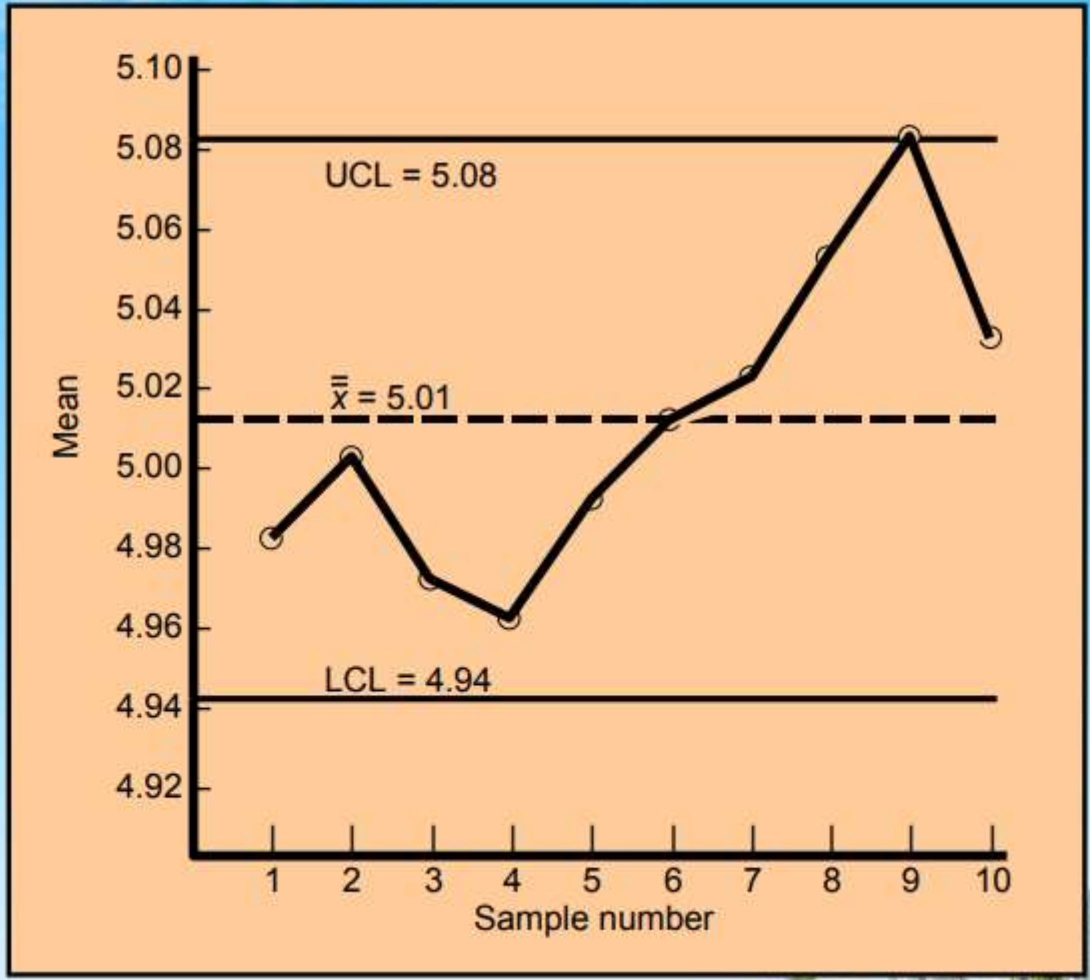
$$\bar{R} = \frac{\sum R}{k} = \frac{1.15}{10} = 0.115$$

$$\bar{\bar{x}} = \frac{\sum x}{k} = \frac{50.09}{10} = 5.01 \text{ cm}$$

$$UCL = \bar{\bar{x}} + A_2\bar{R} = 5.01 + (0.58)(0.115) = 5.08$$

$$LCL = \bar{\bar{x}} - A_2\bar{R} = 5.01 - (0.58)(0.115) = 4.94$$

x- bar Chart Example



R- Chart

$$UCL = D_4\bar{R} \qquad LCL = D_3\bar{R}$$

$$\bar{R} = \frac{\Sigma R}{k}$$

Where

R = range of each sample

k = number of samples (sub groups)

R-Chart Example

	OBSERVATIONS (SLIP- RING DIAMETER, CM)						
SAMPLE *k*	*1*	*2*	*3*	*4*	*5*	$\bar{x}$	*R*
1	5.02	5.01	4.94	4.99	4.96	4.98	0.08
2	5.01	5.03	5.07	4.95	4.96	5.00	0.12
3	4.99	5.00	4.93	4.92	4.99	4.97	0.08
4	5.03	4.91	5.01	4.98	4.89	4.96	0.14
5	4.95	4.92	5.03	5.05	5.01	4.99	0.13
6	4.97	5.06	5.06	4.96	5.03	5.01	0.10
7	5.05	5.01	5.10	4.96	4.99	5.02	0.14
8	5.09	5.10	5.00	4.99	5.08	5.05	0.11
9	5.14	5.10	4.99	5.08	5.09	5.08	0.15
10	5.01	4.98	5.08	5.07	4.99	5.03	0.10
					Totals	50.09	1.15

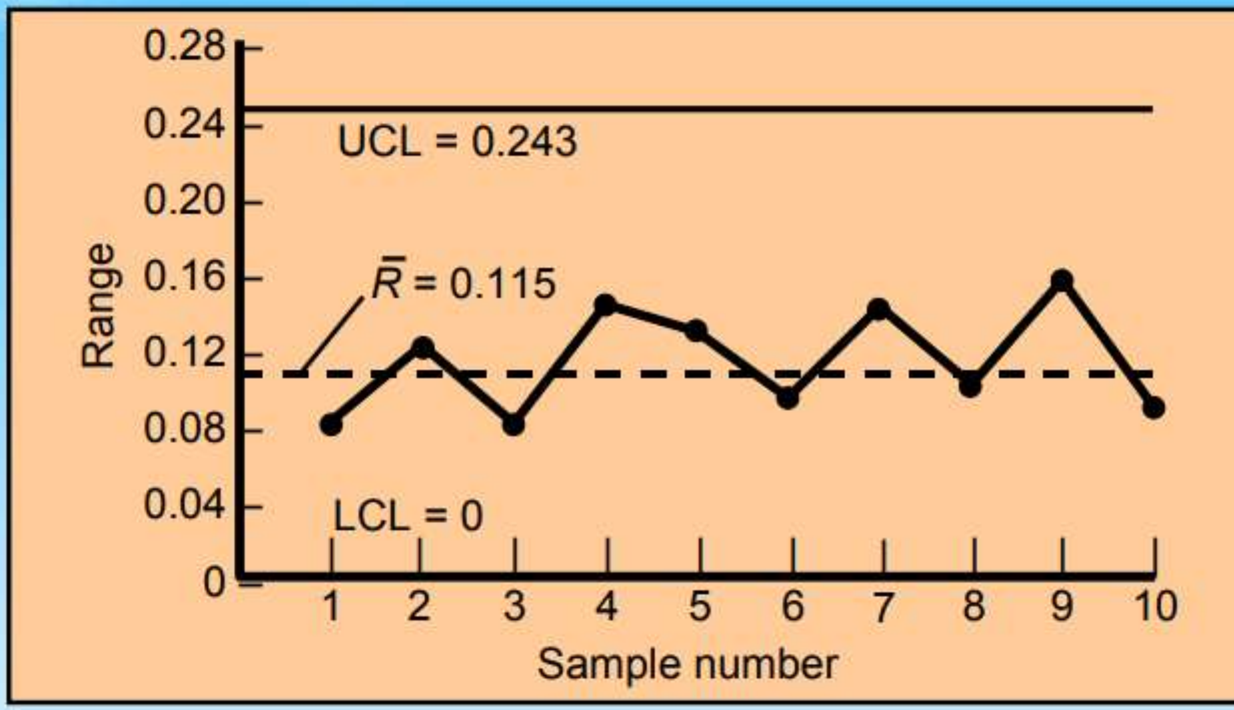
R-Chart Example

$$UCL = D_4\bar{R} = 2.11(0.115) = 0.243$$

$$LCL = D_3\bar{R} = 0(0.115) = 0$$

Retrieve chart factors D_3 and D_4

R-Chart Example



QUALITY FUNCTION DEPLOYMENT

Quality Function Deployment is:

- **Quality** → Meeting Customer Requirements
- **Function** → What Must Be Done - Focusing the attention
- **Deploymen t** → Who Will Do It, When

What is QFD?

A method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demands into design targets and major QA points to be used throughout out the production phase

Comprehensive process for reaching customer satisfaction

Systematic way to define winning business (conquering business model, products / services)

"QFD is a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase. ... [QFD] is a way to assure the design quality while the product is still in the design stage."

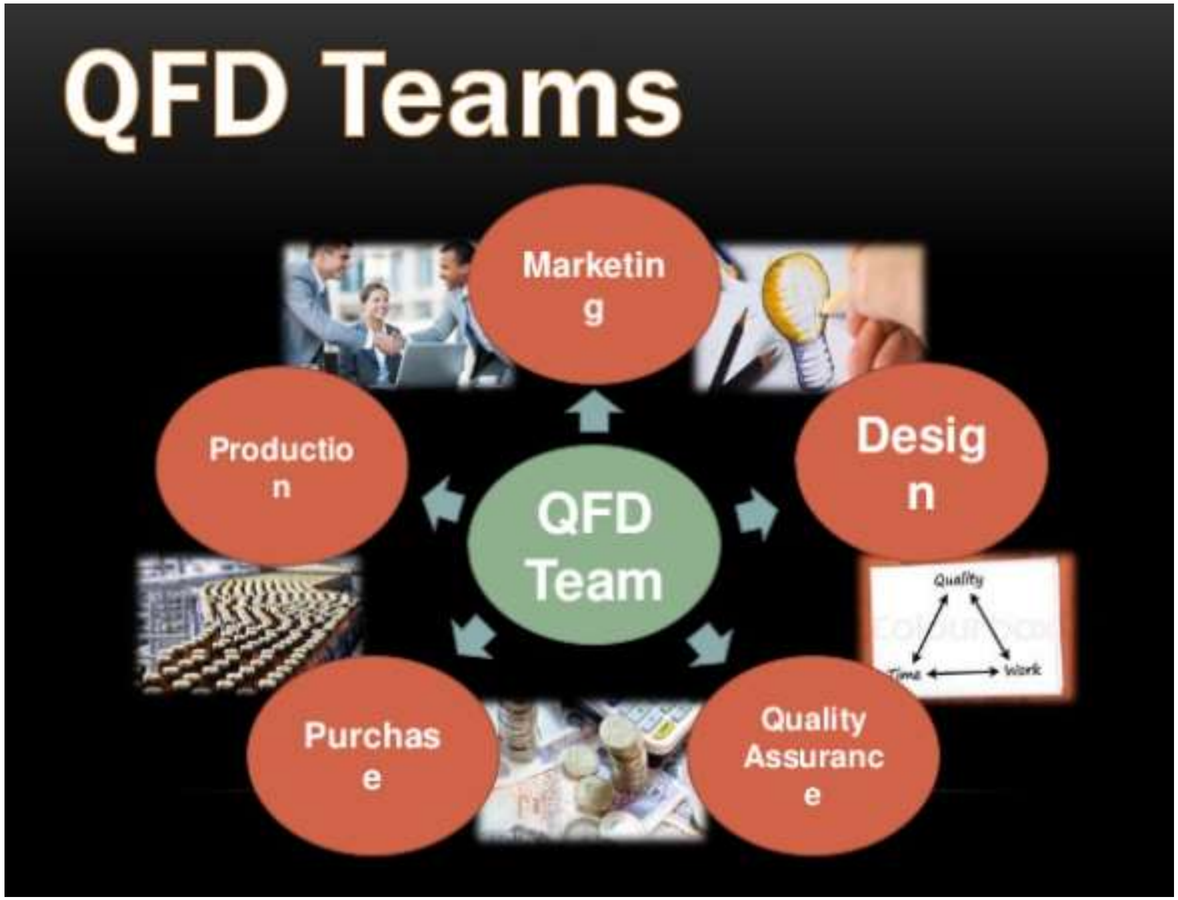
Yoji Akao

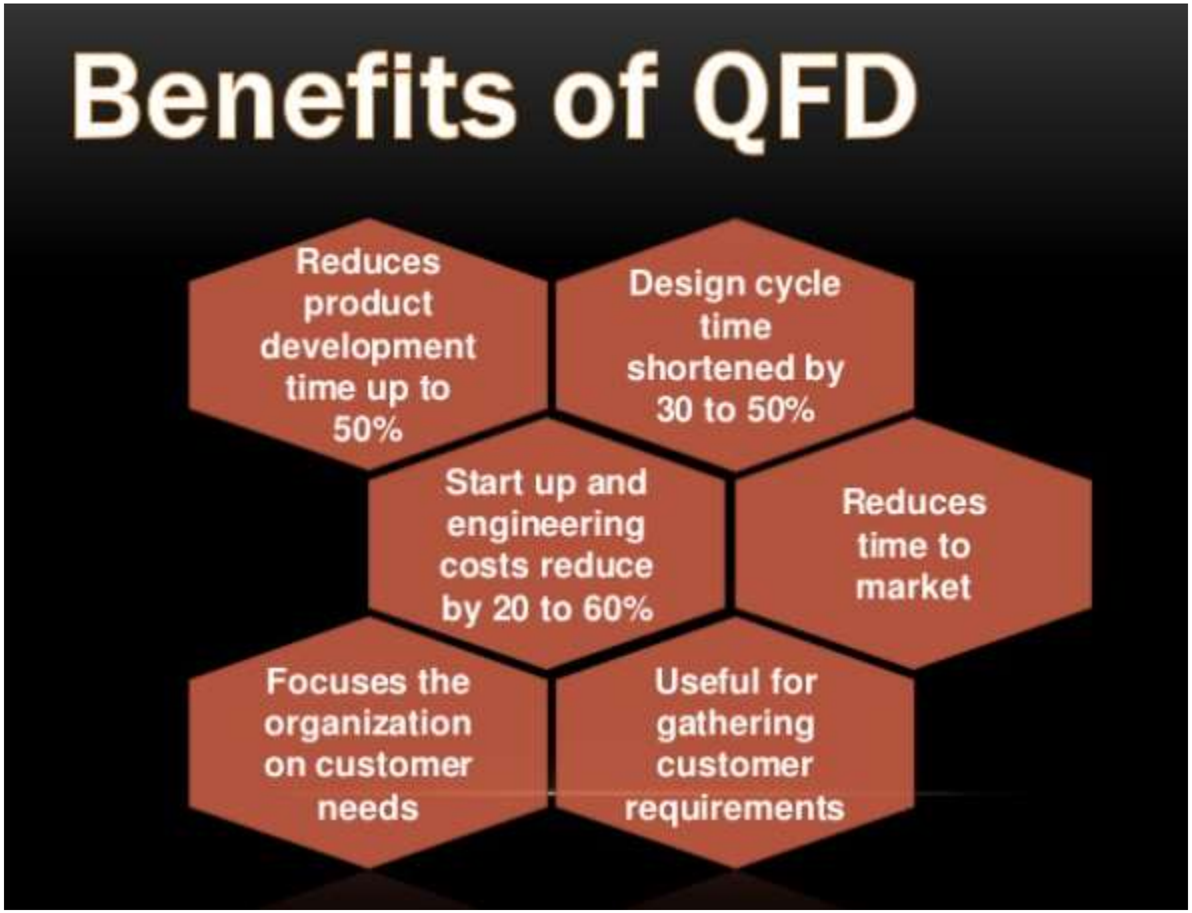
Developed QFD in Japan in 1966

History of QFD

1972	First application at Mitsubishi, Japan
1976	QFD implementation in production of mini vans by Toyota
1979	20% reduction in start up costs in launch of a new van
1982	38% reduction in costs
1984	68% cumulative reduction in costs
1984	First introduced in USA


Main Goals in Implementing QFD
Prioritize spoken and unspoken customer wants and needs
Translate these needs into technical characteristics and specifications
Build and deliver a quality product or service by focusing everybody toward customer satisfaction


QFD Teams
Marketin
g
Productio
n
Desig
n
QFD
Team
Purchas
e
Quality
Assuranc
e
Quality
Time
Work


Benefits of QFD
Reduces product development time up to 50%
Design cycle time shortened by 30 to 50%
Start up and engineering costs reduce by 20 to 60%
Reduces time to market
Focuses the organization on customer needs
Useful for gathering customer requirements

Benefits of QFD

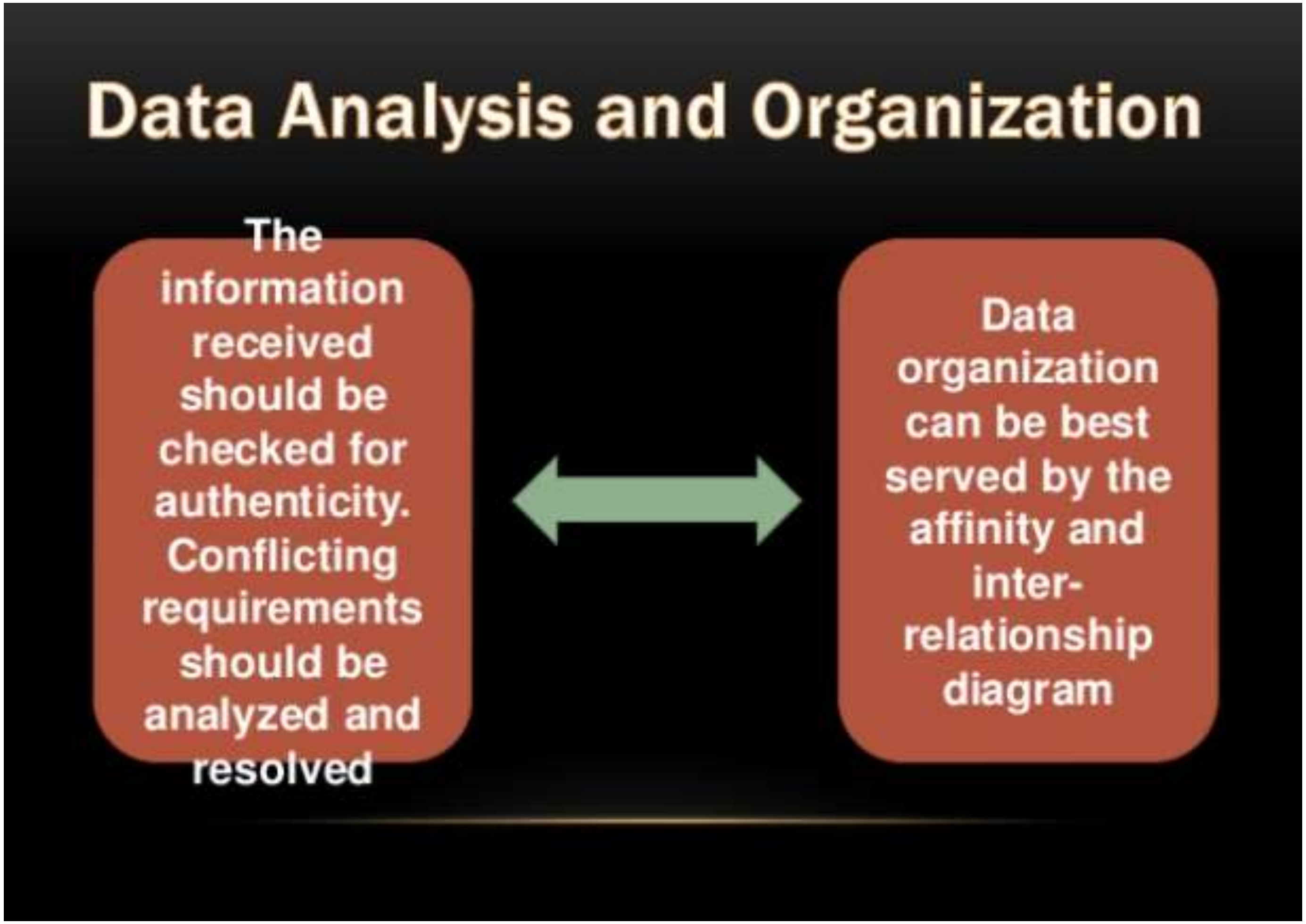

American Supplier Institute's Four Phase Approach
Customer Requirements
Product Characteristics
Part Characteristics
Process Characteristics
Production Control

The Voice of the Customer

- represents the requirements of the customers
- QFD is a technique to record every requirement expressed by the customer and take a conscious decision about the voice of the customers

Sources of Information for Finding Out Customer Requirements

- Market survey from customers
- Information from sales team
- Information from service team
- Customer complaints
- Customer feedback
- Testing of products in labs


Data Analysis and Organization
The information received should be checked for authenticity. Conflicting requirements should be analyzed and resolved
Data organization can be best served by the affinity and inter-relationship diagram

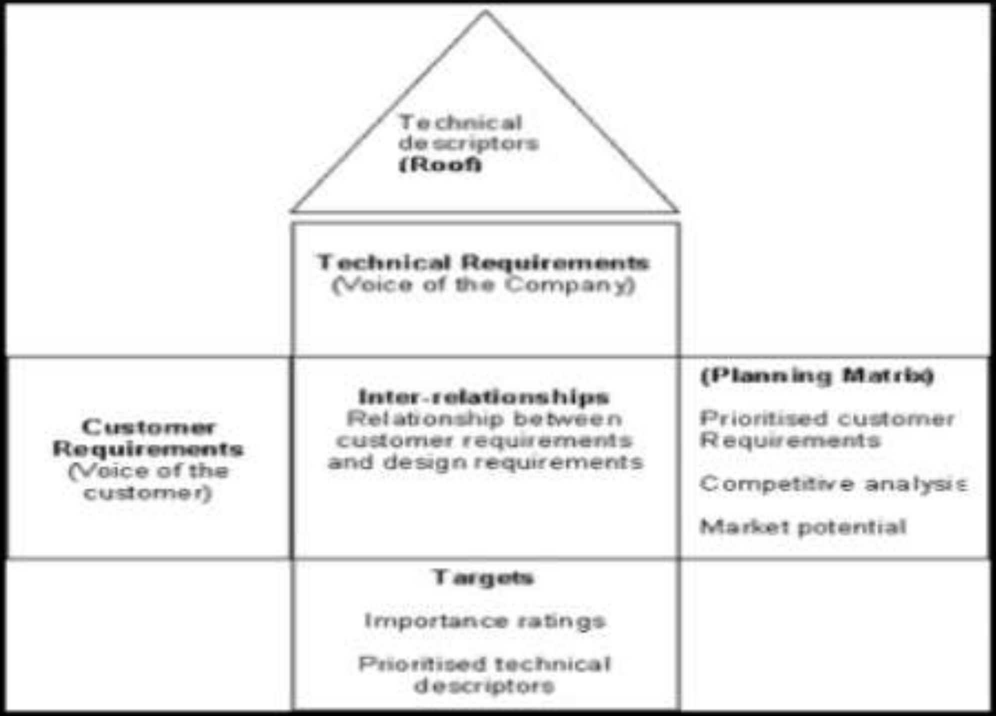
House of Quality

Translates the voice of the customer into design requirements that meet specific target values and matches those against how an organization will meet those requirements

Structure of House of Quality

Exterior walls	Customer requirements
Ceiling or second floor	Technical descriptors
Interior walls	Relationship between customer requirements and technical descriptors
Roof	Interrelationship between technical descriptors

House of Quality Example



Steps in Building a House of Quality

1. Customer Requirements (What)

- includes the list of goals/objectives
- A structured list of customer requirements
- The steps involved in identifying customer requirements:
  - Identify customers
  - Determine customer requirements/constraints
  - Prioritize customer requirements
  - Put them in house of quality

Steps in Building a House of Quality

2. Technical Requirements (How)

- A structured set of relevant and measurable product or service characteristics
- After the WHATs have been finalized, the QFD team has to identify how these requirements that will facilitate satisfying one or more customer requirements identified

Steps in Building a House of Quality

3. Inter-relationship matrix between WHAT's and HOW's

- Illustrates the QFD teams perceptions of inter-relationships between customer requirements and technical requirements
- Different symbols depicting the Degree of relationships between WHAT's and HOW's:

⊙	Strong Relationship
○	Medium Relationship
△	Weak Relationship
Empty	No Relationship

Steps in Building a House of Quality

4. Technical Correlation Matrix

- ❑ Used to identify where technical requirements support or impede each other in the product or service design
- ❑ Each technical requirement(TR) should be compared with every other technical requirement

Steps in Building a House of Quality

5. Planning matrix

- Illustrates relative importance of customer requirements, customer perception of company and competitor performance in meeting customer requirements

- The Customer Competitive Assessment and Prioritized Customer Requirements

Steps in Building a House of Quality

6. Develop Prioritized Customer Requirements

- The prioritized customer requirements make up a block of columns corresponding to each customer requirements in he house of quality to the right hand side of the customer competitive assessment

Competitive Benchmarking

A simple comparison of performances against each requirement of the customer

In this step, we have to measure the current performance of our own products against each requirement

House of Quality for _"Pressure Cooker"_

+ Positive or Reinforcing Relationship
- Negative or Tradeoff Relationship

Customer Requirements	Relative Importance or Weight	Cooking Pressure	Sealing	Shape	Size	Thermal conductivity	Release pressure if unsafe	Weight	Strength	Material	Our Service/ Product	Competing Service/ Product A	Competing Service/ Product B
Cook Fast	5	9	9	3	3	9				9	4	3	4
Alarm when cooking complete	4	9	3	3	1						4	4	3
Safe to cook	5	9	9	3	1	1	9		9	3	3	5	4
Safe to handle	5	3	3	9	3	3			3	3	3	4	5
Easy to use	4	1	1	9		1		9	1	3	4	4	3
Retain the nutrition value	4	9			9	9		9		9	4	4	3
Durable	3	3					9		9	9	4	4	5
Importance Weighting		190	121	123	75	105	72	72	91	150			
Relative Importance Weighting		19.0	12.1	12.3	7.5	10.5	7.2	7.2	9.1	15.0			
Measurement Units		Bar				W/ (m.K)	Bar	Kg	N/ m^2				
Our Value		2	3	2	2	2	1	1	1	1			
Competitor A		3	3	3	1	1	1	1	1	1			
Competitor B		2	2	2	1	1	1	1	1	1			
Target Specification Values		2	2	3	2	1	1	1	1	1			

Importance of Pressure
= (5*9) + (4*9) + (5*9)
+ (5*3) + (4*1) + (4*9)
+ (3*3)
= 190

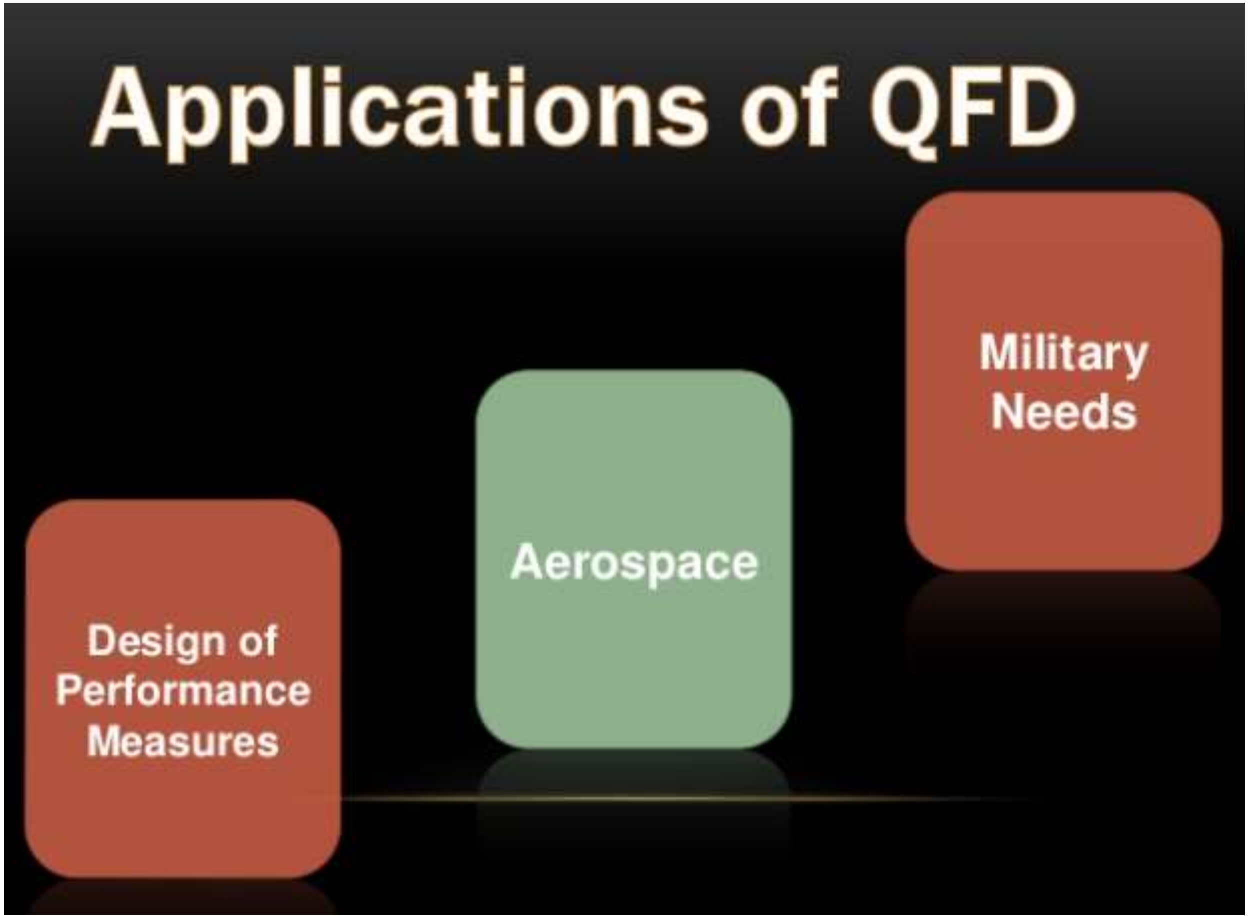
Relative importance
= (190 / 999) * 100
= 19.0

++	Strong Positive
+	Positive
	Neutral
-	Negative
- -	Strong Negative

◎	Strong	9
▲	Medium	3
●	Weak	1

Applications of QFD

- Production / Manufacturing
- Maintenance
- Design Courses and Curriculum


Applications of QFD
Design of Performance Measures
Aerospace
Military Needs

Who uses QFD?

- Nippondenso
- Honda
- Ford

Who uses QFD?

- Nissan
- Toyota
- Komatsu
- AT&T Bell Lab
- Chrysler
- HP

Tips for Success of QFD

- A consultant is needed to guide through at least the first few projects
- The activity should be a formal activity and every member should take part, fully prepared
- The meetings should be planned at regular intervals for shorter duration so as to get the best out of this exercise through maintaining focus
- Elicitation and recording customer requirements is key to success
- Belief that "we don't know all the requirement of the customers" will lead to success

Work Study – Method Study

Techniques for improving productivity

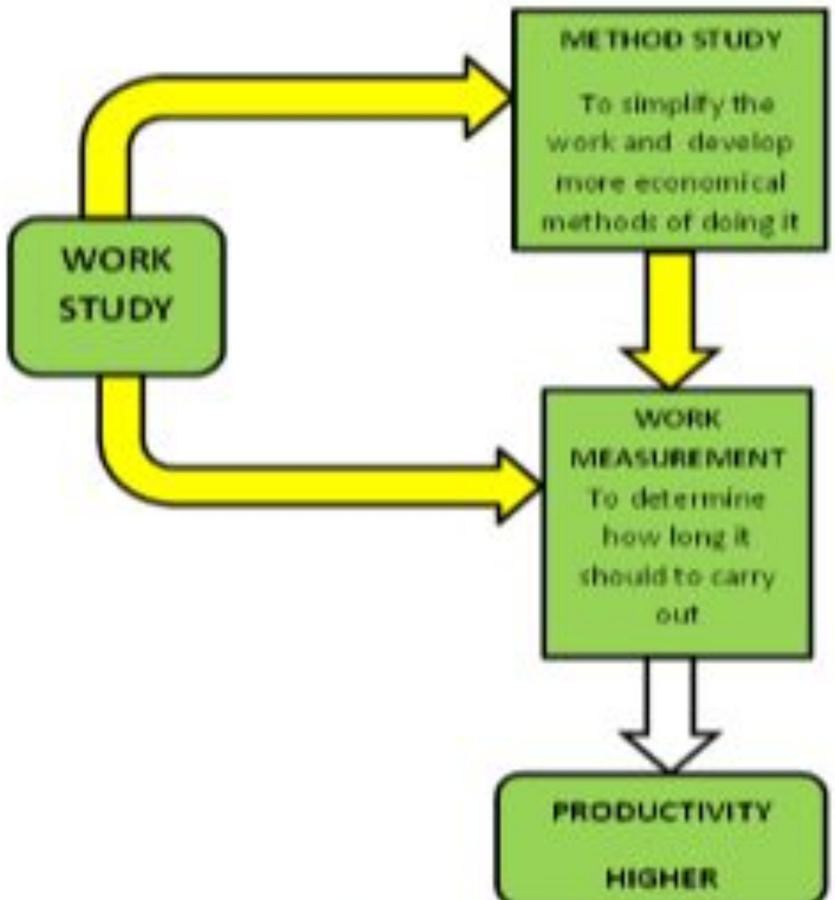
Dr. Jyothi Chepur (MBA, Ph.D.)
School of Management Studies, NITw

Outline

1. Work Study
2. Method Study
3. Various Charts

Work Study (Cont.)

WORK STUDY - TECHNIQUES



Work Study

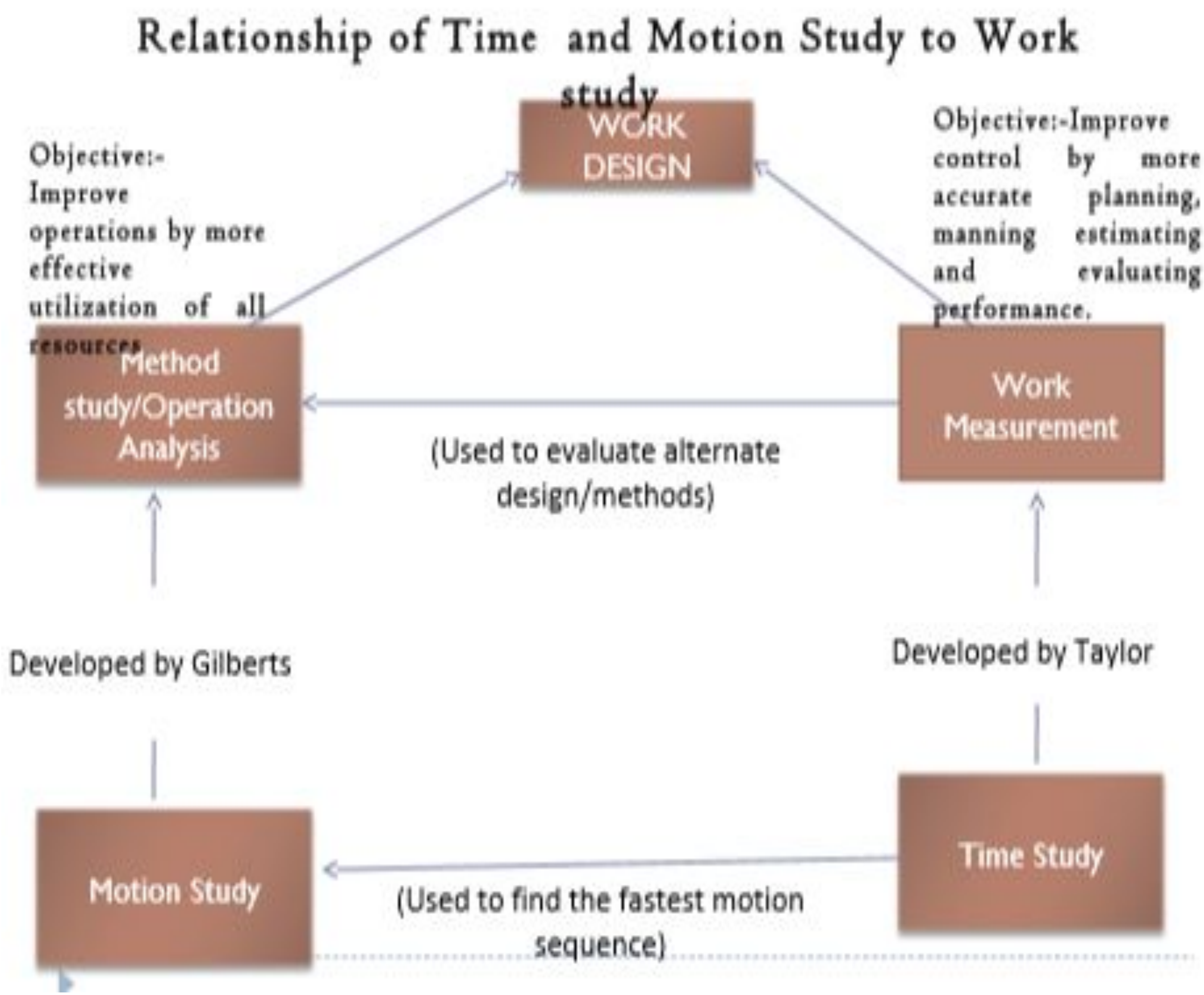
- **1.1.1 Definition of Work Study**
- According to the British Standard Institution, "Work Study is a generic term for those techniques, particularly ***Method Study*** and ***Work Measurement***, which are used in all its context, and which lead systematically to the investigation of all the factors , which affect the efficiency and economy of the situation being reviewd in order to effect improvement".

Objectives of Work Study

- **Objectives of Work Study**
- To analyse the present method of doing the job in order to develop a better method.
- To measure the work content of the job by measuring the time required to do the job for a qualified worker and hence to establish the standard time.
- To increase the productivity by ensuring best possible use of human, machine and material resources and to achieve best quality product/service at minimum possible cost.
- To improve operational efficiency.

Benefits of Work Study

- **Benefits of Work study**
- Increased productivity and operational efficiency
- Reduced manufacturing cost.
- Improved work place layout.
- Better manpower planning and capacity planning
- Fair wages to employees.
- Better working conditions to employees
- Improved work flow.
- Reduced material handling cost.
- Provides a Standard of Performance to measure labour efficiency.
- Better Industrial Relations and Employee morale.
- Basis for sound incentive schemes.
- Provides better job satisfaction to employees


Relationship of Time and Motion Study to Work study
WORK DESIGN
Objective:- Improve operations by more effective utilization of all resources
Objective:-Improve control by more accurate planning, manning estimating and evaluating performance.
Method study/Operation Analysis
Work Measurement
(Used to evaluate alternate design/methods)
Developed by Gilberts
Developed by Taylor
Motion Study
Time Study
(Used to find the fastest motion sequence)

Motion and Time Study.mp4

Method Study - Introduction

- **Method Study** is a technique to reduce the work content by analysing each operation of a given piece of work very closely in order to eliminate unnecessary operations/movements by workers, materials or equipments. It includes standardization of equipment, method and working conditions, and training the operators to follow the standard method
- However, even after that, there could be substantial unnecessary time taken for the process because of lack of management control or inaction of worker.
- Method Study approaches and tools of Method Analyst:
  - Flow Diagrams & Process Charts etc.
  - Critical questioning techniques.

Method Study - Definition

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❖ **1.2.1 Definition of Method study**

❖ Method study can be defined as "Systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective method and thereby reducing costs".

Method Study Objectives

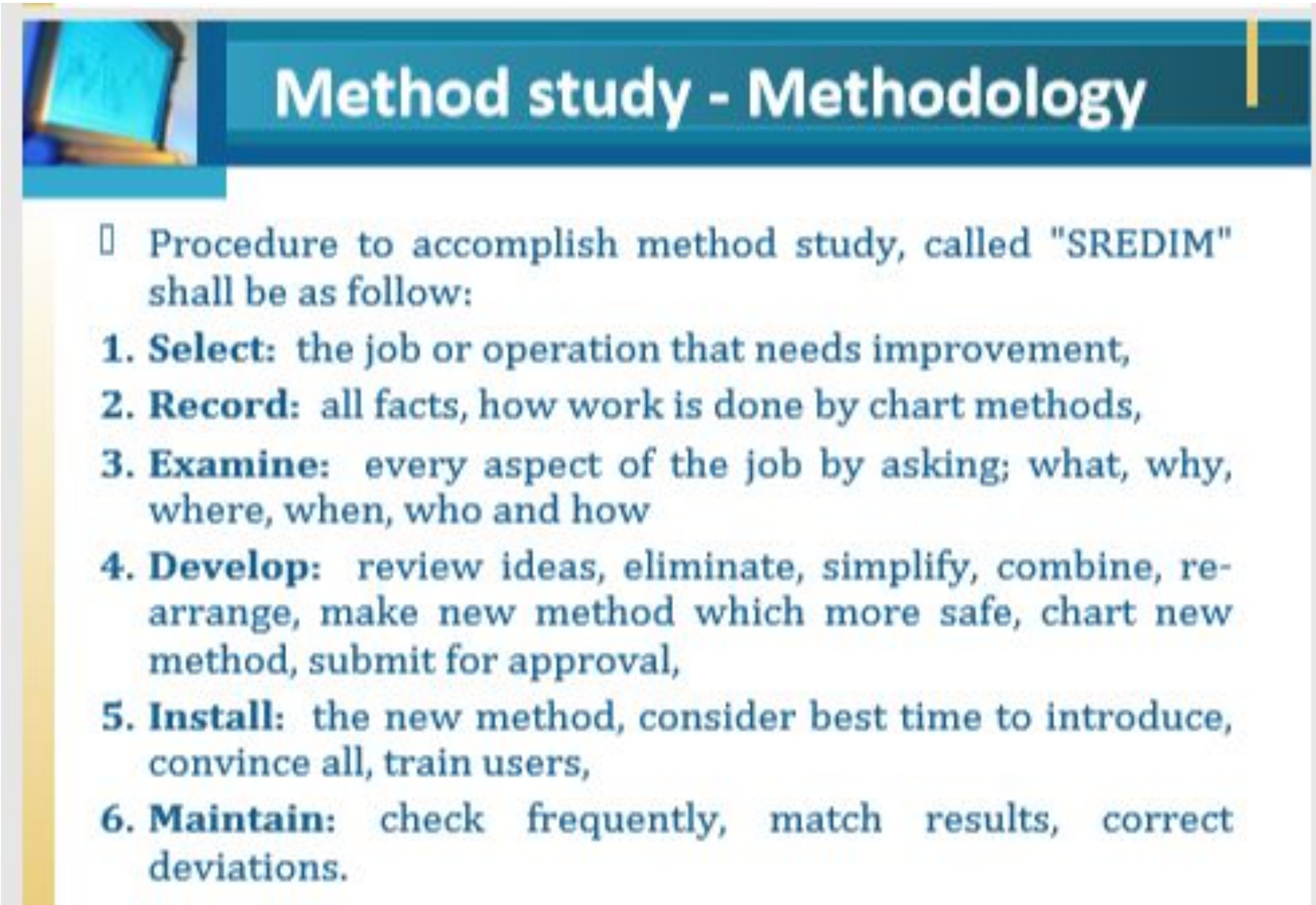
- Improvement of processes and procedures so as to improve productivity and thereby reduce operating cost.
- Improvement in the design of plant and equipment.
- Improvement of layout.
- Improvement in the use of men, materials and machines.
- Economy in human effort and reduction of unnecessary fatigue.
- To Standardise work methods or processes, machinery, equipments and tools.
- Development of better working environment.

Method Study - Benefits

1. Work Simplification
2. Improved working method
3. Better product quality
4. Improved workplace layout
5. Improved equipment Design.
6. Better working conditions/environment
7. Better materials handling and lesser material handling cost.
8. Improved work flow
9. Less fatigue to workmen.
10. Optimum utilization of all resources.
11. Shorter production cycle time.
12. Higher job satisfaction for workmen.
13. Reduced material consumption and wastages.
14. Reduced manufacturing cost and higher productivity.

Method Study – Need for Analysis

- The need for improvement is not always apparent. However, following are some of the pointers which may indicate the need for Method Study :
- Operating costs-running higher than normal or gradually increasing
- High wastage-poor use of materials, machinery, labor, space and services.
- Excessive movement and backtracking, handling of materials and men.
- Existence of production bottlenecks
- Excessive overtime
- Excessive rejections and reworks, poor quality
- Complaints from workers-poor working condition of heavy job, etc.
- Increasing number of accidents


Method study - Methodology
Procedure to accomplish method study, called "SREDIM" shall be as follow:
1. Select: the job or operation that needs improvement,
2. Record: all facts, how work is done by chart methods,
3. Examine: every aspect of the job by asking; what, why, where, when, who and how
4. Develop: review ideas, eliminate, simplify, combine, re-arrange, make new method which more safe, chart new method, submit for approval,
5. Install: the new method, consider best time to introduce, convince all, train users,
6. Maintain: check frequently, match results, correct deviations.

SELECTION: FACTORS TO BE CONSIDERED

- While selecting a job for method study, the following factors are to be considered:

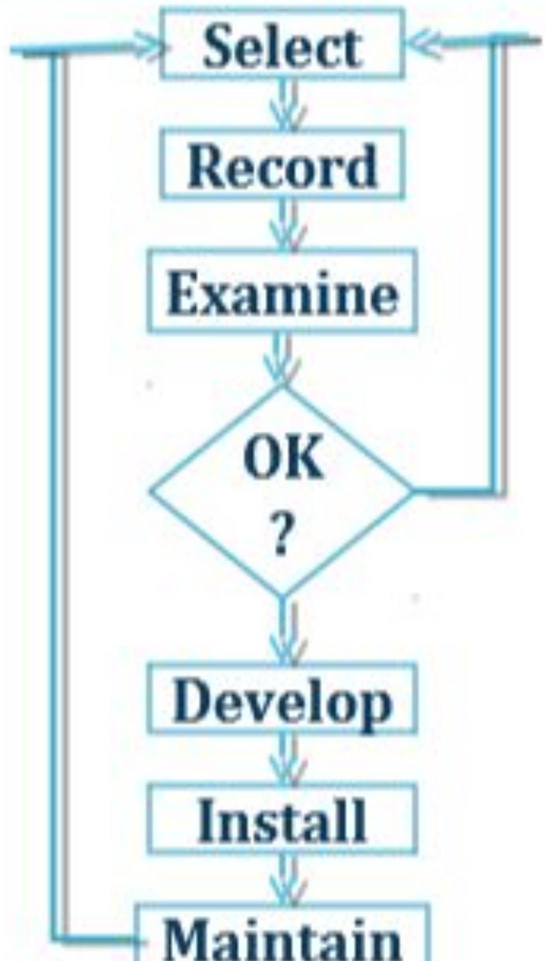
- 1) Economical considertions: The cost of study , loss of time due to investigation, costs short term and long term associated with prospective changes in the recommended working method of the job should be carefully estimated and examined . if the accumulated estimated benefits outweigh the estimated total cost, as mentioned above, then it should be taken up.
- Based on economical considerations the following jobs are selected :
- (a) Operations having bottlenecks(which hold up production)
- (b) Operations done repetitively
- (c) Operations having a great amount of manual work.
- (d) Operations where materials are moved for a long distance.

SELECTION: FACTORS TO BE CONSIDERED

- 2) Technical considerations: The important point is to make sure that adequate technical knowledge is available with which to carry out the study. Examples are:
- a) A machine tool constituting a bottleneck in production is known to be running at a speed at which the high speed or ceramic cutting tools will not operative effectively. Can it be speeded up or is the machine is itself not robust enough to take faster cut?. This calls for advice of a machine tool expert.

- 3) Human reactions : These are the most important considerations to be made, since mental and emotional reactions to investigation , and change of method has to be anticipated. Trade Union representative have to be educated on the general objectives of the method study. If however the study of a particular job is creating unrest or ill feeling amongst the workmen ,leave it alone however promising it may be for economic point of view.

Methodology (Cont.)



Method Study Tools

- **Exploratory Tools**
  - Pareto Analysis
  - Fish & Bone Diagrams
  - Gantt and PERT charts
- **Recording and Analysis Tools**
  - Outline Process Chart
  - Flow process chart
  - Flow diagram
  - Worker and Machine Process Charts
  - Gang Process charts
  - Synchronous Servicing

Recording Techniques

- **Charts**

1. **Outline process chart.**
2. **Flow process chart (man-type, material-type and equipment-type):** This is the use of symbols and description to chart the sequence of work. The process, then, show what is happening at different stages. The distances and time may be given.
3. **Two hands process charts.**
4. **Multiple activity charts:** This technique is used to solve problems where a number of items are dependent on each other. The aim is to reduce idle times by using the optimum number of each item. It depicts the occupied times-broken down into the number of different activities and the idle times both for the original and proposed methods of doing the job.

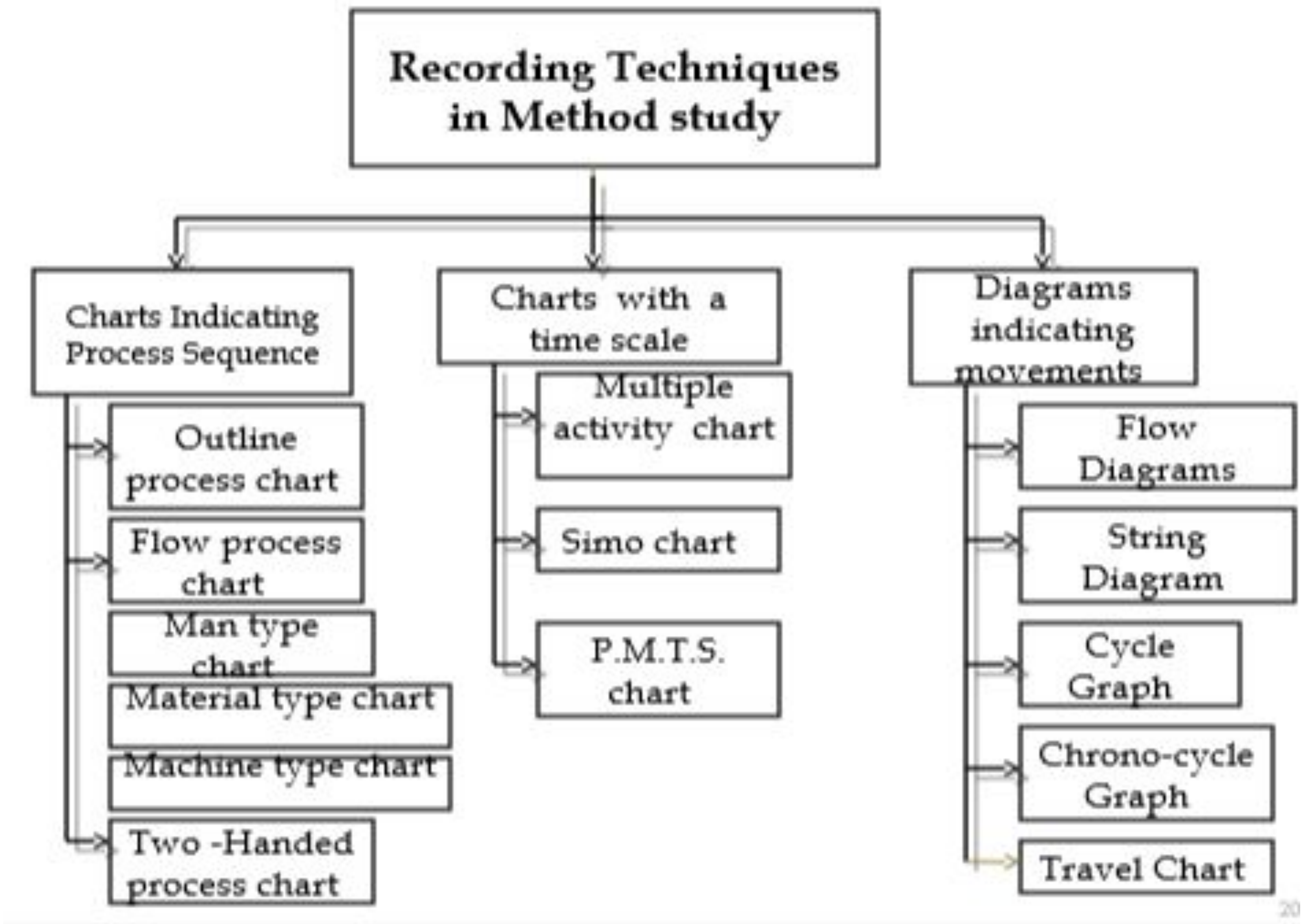
Recording Techniques (Cont.)

- **Diagrams and models (2-D and/or 3-D)**

1. **Flow diagrams,** which is the use of symbols for flow process charts, superimposed on drawings and the "descriptions" are not necessary.
2. **String diagrams,** which is used for solving movement problems since it shows congestions and excessive distances.
3. **Cut-out templates (2-D models).**
4. **3-D models.**

- **Photography**

1. **Photographs,**
2. **Films,**
3. **Video.**


Recording Techniques in Method study
Charts Indicating Process Sequence
Outline process chart
Flow process chart
Man type chart
Material type chart
Machine type chart
Two -Handed process chart
Charts with a time scale
Multiple activity chart
Simo chart
P.M.T.S. chart
Diagrams indicating movements
Flow Diagrams
String Diagram
Cycle Graph
Chrono-cycle Graph
Travel Chart

Process Chart Symbols

1.Operation

or

Indicates the main steps in a process, method or procedure. Usually the part, material or product concerned is modified

changed during the operation.

2.Inspection

Indicates an inspection for quality and / or check for quantity

3.Transport

Indicates the movement of workers, materials or equipment from place to place

4.Temporary Storage or Delay

Indicates a delay in the sequence of events : for example, work waiting between consecutive operations, or any object laid aside temporarily without record until required.

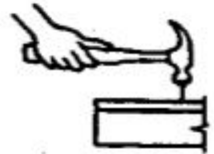
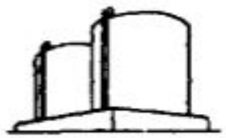
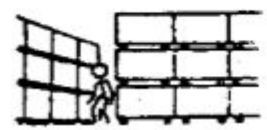
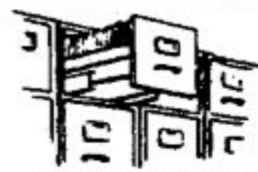
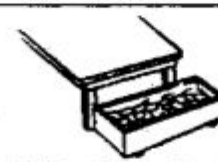
5.Permanent Storage

Indicates a controlled storage in which material is received into or issued from a store under some form of authorization; or an item is retained for reference purposes.

6.Combined Activities

Indicates a Two symbols may be combined when two activities are performed concurrently operation and inspection.

EXAPMLES

Operation ○ A large circle indicates an operation such as	 Drive nail	 Mix	 Drill hole
Transportation ⇨ An arrow indicates a transportation, such as	 Move material by truck	 Move material by conveyor	 Move material by carrying (messenger)
Storage ▽ A triangle indicates a storage, such as	 Raw material in bulk storage	 Finished stock stacked on pallets	 Protective filing of documents
Delay D A large capital D indicates a delay, such as	 Wait for elevator	 Material in truck or on floor at bench waiting to be processed	 Papers waiting to be filed
Inspection □ A square indicates an inspection such as	 Examine material for quality or quantity	 Read steam gauge on boiler	 Examine printed form for information

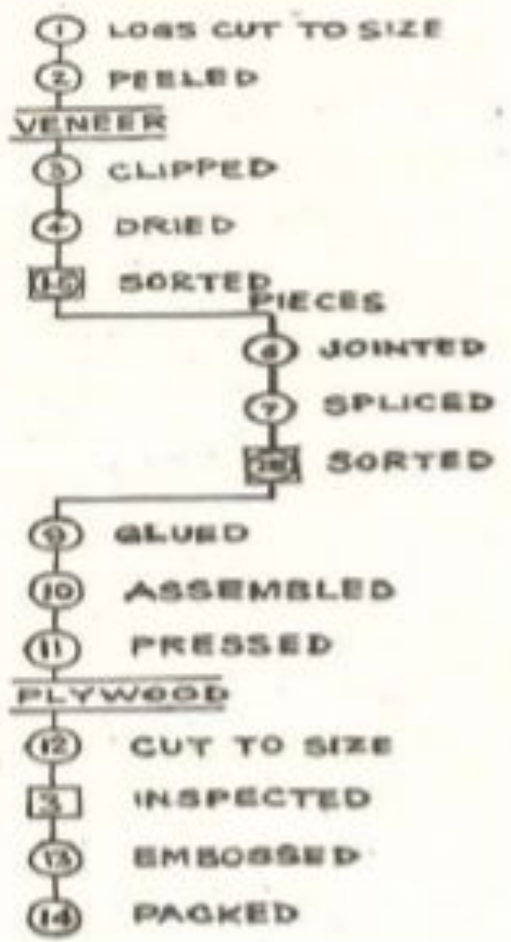
Outline Process Chart

Definition:

An outline process chart is a process chart giving an overall picture by recording in sequence only the main operations and inspections.

- While preparing the outline process chart we use Symbols of Operation and Inspection
- A brief note of the nature of each operation is made beside the symbol
- In an outline process chart, only the principal operations and the inspections carried out are recorded to ensure effectiveness

Example: Outline process chart of plywood manufacture is given



FLOW PROCESS CHART

Definition:

- **Flow process charts are graphic representations of the sequences of operations, transportation, inspections, delays and storages occurring during a process or a procedure and include information considered for analysis such as, time required and distance moved.**

- **To develop an understanding how a process or work happening and clearly documenting how a particular job is done, in addition of that mapping a process in flow chart format helps us where the process can be improved.**

Types of Flow Process Charts

- Material or product type.
- Man type.
- Machine type or equipment.

Material or product type flow process chart:-
Records what happens to the material or product i.e. the changes the material or product undergoes in location or condition (includes operation and transportation).

Man type process flow process chart:-
Records the activities of worker or operator i.e. what a worker or operator does. In this type of chart usually storage term is not applicable.

Machine or equipment type flow process charts:- Records the manner in which a machine or an equipment is used.

STANDARD FORMATS USED FOR FLOW PROCESS CHART

Flow Process Chart Page of

		Summary			
Location:		**Event**	**Present**	**Proposed**	**Savings**
Activity:		Operation			
Date:		Transport			
Operator:	Analyst:	Delay			
Circle appropriate Method and Type:		Inspection			
Method: *Present* *Proposed*		Storage			
Type: *Worker* *Material* *Machine*		Time (min)			
Remarks:		Distance (ft)			
		Cost			

Event Description	Symbol	Time (in Minutes)	Distance (in Feet)	Method Recommendation

Man type flow process chart

Job:- Writing a letter using a shorthand typist

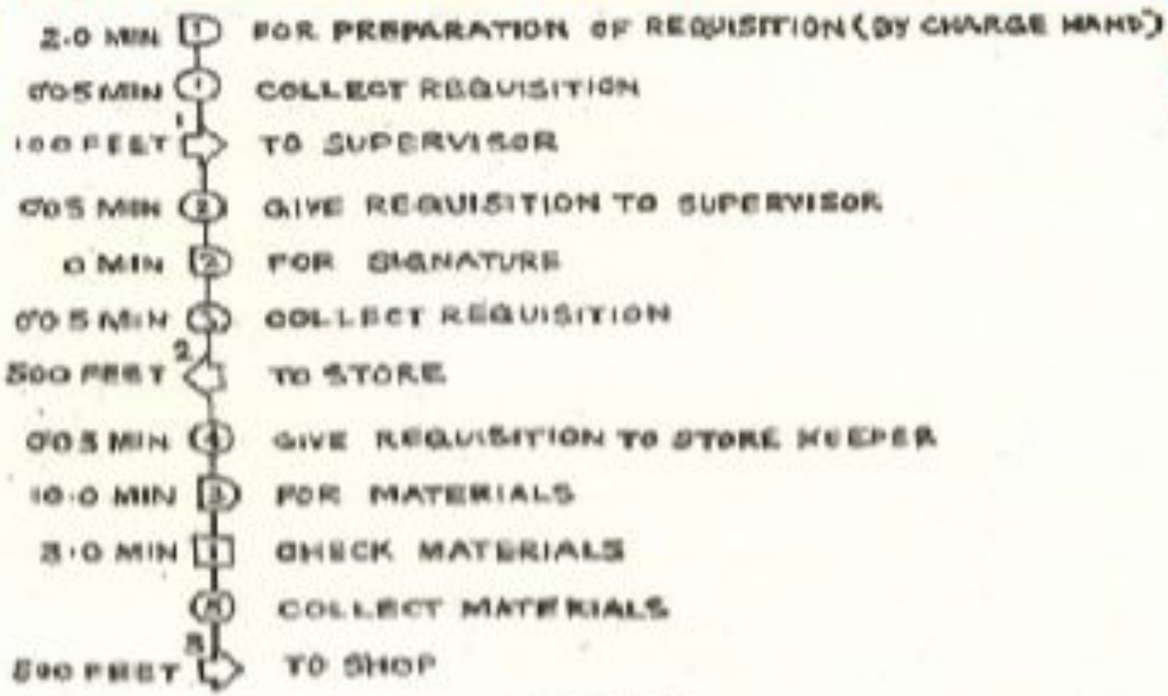
Flow Process Chart Page 1 of 1

Location: Admin Block	
Activity: Typing a letter	
Date: 20-07-2019	
Operator: Shyam	Analyst: Kavitha
Circle appropriate Method and Type: Method: Present / Proposed; Type: Worker / Material / Machine	
Remarks: Chart start :- Typist in his office [illegible] dictation. Chart end - Put copy in out tray. Typist office [illegible]	

Summary			
Event	**Present**	**Proposed**	**Savings**
Operation	09		
Transport	4		
Delay	01		
Inspection	02		
Storage	01		
Time (min)	3.5		
Distance (ft)	24		
Cost			

Event Description	Symbol	Time (in Minutes)	Distance (in Feet)	Method Recommendation
To author's office		0.1	6	
Take dictation		0.45	0	
to own office		0.1	6	
Prepare typing table		0.1	0	
Type letter & copy		2.0	0	
Remove from m/c		0.1	0	
Separate copies		0.05	0	
Check		0.2	0	
give for signature		0.1	6	
Waiting to author		0.1	0	
Reading by author		0.3	0	
Checking by author		0.1	0	
Signing by author		0.45	0	
move back to office		0.1	6	
Type envelope		0.2	0	
put letters to envelope		0.45	0	
letter copy [illegible] out tray		0.1	0	

Example: Collection of materials from store (Man Type)



SUMMARY

	NO	TIME (M.T.S)	DISTANCE (FEET)
○	5	4·0	
□	1	3·0	
⇨	3	–	1100
D	3	12·0	

Flow Process Chart Job : Requisition of petty cash	Analyst ABC	Page 1 of 2

Details of method	Operation	Movement	Inspection	Delay	Storage	Distance
Requisition made out by department head	●	⇨	□	D	▽	
Put in "pick-up" flag	○	⇨	□	◗	▽	
To accounting department	○	➡	□	D	▽	10 m
Account and signature verified	○	⇨	■	D	▽	
Amount approved by treasurer	●	⇨	□	D	▽	
Amount counted by cashier	●	⇨	□	D	▽	
Amount recorded by bookkeeper	●	⇨	□	D	▽	
Petty cash sealed in envelope	●	⇨	□	D	▽	5 m
Petty cash carried to department	○	➡	□	D	▽	
Petty cash checked against requisition	○	⇨	■	D	▽	
Receipt signed	●	⇨	□	D	▽	
Petty cash stored in a box	○	⇨	□	D	▼	
	○	⇨	□	D	▽	
	○	⇨	□	D	▽	
	○	⇨	□	D	▽	
	○	⇨	□	D	▽	

	Summary	Distance
Operations	6	
Inspections	2	
Transport	2	15 m
Delays	1	
Total	11	

Material Type - Example

Flow Process Chart Page 1 of 1

Location: Dorben Ad Agency	**Summary**			
Activity: Preparing Direct Mail Ads	**Event**	**Present**	**Proposed**	**Savings**
Date: 1-26-98	Operation	4		
Operator: J.S. Analyst: A.F.	Transport	4		
Circle appropriate Method and Type: **Method:** *Present* *Proposed*	Delay	4		
	Inspection	0		
Type: *Worker* *Material* *Machine*	Storage	2		
Remarks:	Time (min)			
	Distance (ft)	340		
	Cost			

Event Description	Symbol					Time (in Minutes)	Distance (in Feet)	Method Recommendation
stock room	○	⇨	D	□	▼			
to collating room	○	➡	D	□	▽		100	
collating rack by type	○	⇨	◗	□	▽			
collate 4 sheets	●	⇨	D	□	▽			
stack	○	⇨	◗	□	▽			
to folding room	○	➡	D	□	▽		20	
jog, fold, crease	●	⇨	D	□	▽			
stack	○	⇨	◗	□	▽			
to angle stapler	○	➡	D	□	▽		20	
staple	●	⇨	D	□	▽			
stack	○	⇨	◗	□	▽			
to mail room	○	➡	D	□	▽		200	
addressing	●	⇨	D	□	▽			
mailbag	○	⇨	D	□	▼			

Machine type flow process chart

Location: Assembly Shop		**Summary**			
Activity: Assembly of flange & Bush		**Event**	**Present**	**Proposed**	**Savings**
Date: 24/8/2011		Operation	5		
Operator: Rajesh	Analyst: Pankaj	Transport	4		
Circle appropriate Method and Type:		Delay	01		
Method: *Present* *Proposed*		Inspection	01		
Type: *Worker* *Material* *Machine*		Storage	01		
Remarks:		Time (min)	13		
		Distance (ft)	30		
		Cost			

Event Description	Symbol	Time (In Minutes)	Distance (In Feet)	Method Recommendation
Flange from chemical shop	○ ⇨ D □ ▽	2.0	10	
Waiting for setup	○ ⇨ D □ ▽	1.0	0	
grinding of flange	○ ⇨ D □ ▽	1.0	0	
flange moves to shrink fitting m/c	○ ⇨ D □ ▽	2.0	5	
flange tempr raised upto 180°c	○ ⇨ D □ ▽	1.0	0	
flange moved to valve valve pressing stn	○ ⇨ D □ ▽	0.5	5	
valve bush pressed into flange	○ ⇨ D □ ▽	0.5	0	
assembly under cooling	○ ⇨ D □ ▽	0.5	5	
~~press out load check~~	~~○ ⇨ D □ ▽~~			
Cooling	○ ⇨ D □ ▽	2.0	0	
press out load check	○ ⇨ D □ ▽	0.5	0	
unloading	○ ⇨ D □ ▽	1.0	0	
Storage	○ ⇨ D □ ▽	1.0	5	

Two Hand Process Chart

Two-Handed Flow Process Chart, is a motion study where the study is done to analyse the motions used by the worker in performing an activity.

In this chart the activities of a worker's hands (or limbs) are recorded in their relationship to one another.

A Two-Handed Process Flow Chart individually shows the movement of each hand in a manual process. It is typically used for repetitive operation when analyzing a manual assembly process, to help make it easier to perform.

Two-Hand Process Charts

- Useful in analyzing the work performed by one person at one specific workstation. As the name implies, the chart follows the motion of the left and right hands of one operator .
- Each hand of the worker is treated as an activity.
- Each hand's activities are broken into work elements and plotted side by side on a time scale.

Two-Handed Charts (Cont.)

Lists the work performed simultaneously by each hand

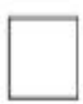
- To assist in finding a better method of performing the task and
- To train the operator in the preferred method.

Two Hand Process Chart

The objective of this investigation is to eliminate or reduce the unwanted motions and to arrange the remaining motions in a best sequence. A two-handed process chart is made up of two columns in which the activities of the left hand and right hand and the appropriate symbols are respectively recorded in sequence.

- The activities of the two hands are inter-related by aligning the symbols on the chart so that movements by both hands appear opposite to each other.
- Additional columns can be designed to record the activities of the other parts of the body whenever necessary.

Two Hand Process Chart

Operation		An operation occurs when the hand grasps, releases or assembles tool, material, component etc.
Transport		Transport occurs when the hand moves from one position to another at the work place.
Delay		Delay occurs when the hand is Idle in the sense that it is not performing any activity.
Hold		The term storage is not used in connection with the two handed process chart. Instead the symbol is re designated as hold. A hold occurs when the hand holds an object so that the other hand may be able to do something to that object.
Inspection		This symbol is not generally used in this.

Standard format of a Two-handed process flowchart

Two-Hand Process Chart

Page of

Operation:	Part:	**Summary**	Left Hand	Right Hand
Operator Name and No.:		Effective Time:		
Analyst:	Date:	Ineffective		
Method (circle choice): *Present* *Proposed*		Cycle Time =		
Sketch:				

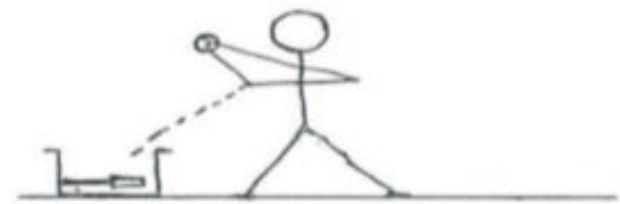
Left Hand Description	Sym-bol	Time		Time	Sym-bol	**Right Hand Description**

Fig. 1. Example of a Two-handed process flowchart
Fixing Screw on a Assembly

Two-Hand Process Chart Page 1 of 1

Operation: FIXING SCREW ON ASSEMBLY	Part: 12	Summary	Left Hand	Right Hand
Operator Name and No.: Sh. RAMLAL, # 1728		Effective Time:	7	6
Analyst: Sh. MANOHAR	Date: 9/8/2011	Ineffective	0	1
Method (circle choice): Present Proposed		Cycle Time =	7 sec	

Sketch:

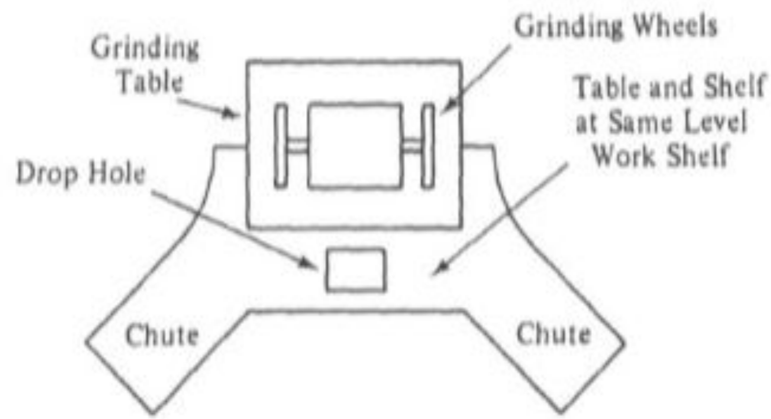


Left Hand Description	Symbol	Time	Time	Symbol	Right Hand Description
PICK SCREWDRIVER FROM RACK	⇦	1	1	○	INSERT SCREW IN HOLE
BRING SCREW DRIVER TO SCREW	⇨	1	1	D	HAND IDLE
TIGHTEN SCREW	○	5	5	▽	HOLD SCREW TO HOLE

Two Handed Chart (An Example)

Operation Grinding Burrs   Name Ara Smith   Date 7/30

Existing ______   Proposed X



Left-hand Activity			Right-hand Activity
1. Reach to and Preposition Handle			1. Reach to and Preposition Handle
2. Slide to Grinder			2. Slide to Grinder
3. Grind	○	○	3. Grind
4. Slide to Center and Drop			4. Slide to Center and Drop

MULTPLE ACTIVITY CHART

Definition:

A Multiple activity chart is a form of process chart recording the related sequence of work of a number of operators and/or machines on common time scale. In it, the activities of more than one item, worker, machine or equipment are recorded on a common time scale to show their inter relation ship.

- **Multiple Activity Charts are very useful tool for understanding the flow of work in a cyclic process and as a consequence understanding which resource is controlling the overall progress of the work.**

- **The tool can be used to model different scenarios to determine the optimum mix of resources for the work.**

Multiple Activity Charts

- Also known as Gang Process Charts
- Used when several workers operate a single machine or render a single service
- Used when a single worker is operating several machines
- Used to show the exact relationship between idle and operating times of both workers and machines

Multiple Activity Charts (Cont.)

- An operation performed by one member of the group may continue while another member is performing more than one operation.
- The chart should cover the complete cycle for the longest performing member.

MULTIPLE ACTIVITY CHART

A Chart in which the activities of more than one item are recorded on a common time scale to show their inter-relationship. Man machine chart is the type of multiple activity charts.

TYPES:

- *Man - Machine chart: One man handling one job or one machine.*
- *Man - Multi machine chart: One man handling a numbers of machines.*
- *Machine Multi - man chart: A group or gang doing collectively one job as in riveting.*
- *Multi – Man - Machine chart: A number of persons working on a computer system.*

MULTIPLE ACTIVITY CHART

- Multiple activity chart brings out the comparative utilisation of men and machines very clearly and helps to synchronise the various activities and improve the situation. It is a useful tool for planning team work and determining the staffing pattern.

- The multiple activity charts shows up clearly the periods of ineffective time and by rearrangement of work it becomes possible to eliminate or reduce the injective time

- Activities of the machines are recorded in relation to that of the operator, the chart is sometimes called as the man machine chart; This is only a special variant of the multiple activity chart

Example on Man Machine Chart (Present Method)

TIME (MIN)	MAN	MACHINE	TIME (MIN)
0.2	Remove finished casting cleans with compressed air	IDLE	0.2
0.4	Gauge depth of slot on surface plate	IDLE	0.4
0.8	PLACE in a box obtains new casting	IDLE	0.8
1.0	Cleans machine with compressed air	IDLE	1.0
1.2	Locates castings in fixture, starts machine	IDLE	1.2
1.4	IDLE	Cutting slot 1	1.4
1.6	IDLE	Cutting slot 2	1.6
1.8	IDLE	Cutting slot 3	1.8
2.0	IDLE	Cutting slot 4	2.0

EXAMPLE ON MAN MACHINE CHART
(Summary of Present method)

CYCLE TIME(MIN)= 2.0

Man – Machine	Working Time (min.)	Idle Time (min.)	Utilization (%)
MAN	1.2	0.8	60%
MACHINE	0.8	1.2	40%

Flow Diagrams

- A flow diagram is essentially a flow process chart drawn to:

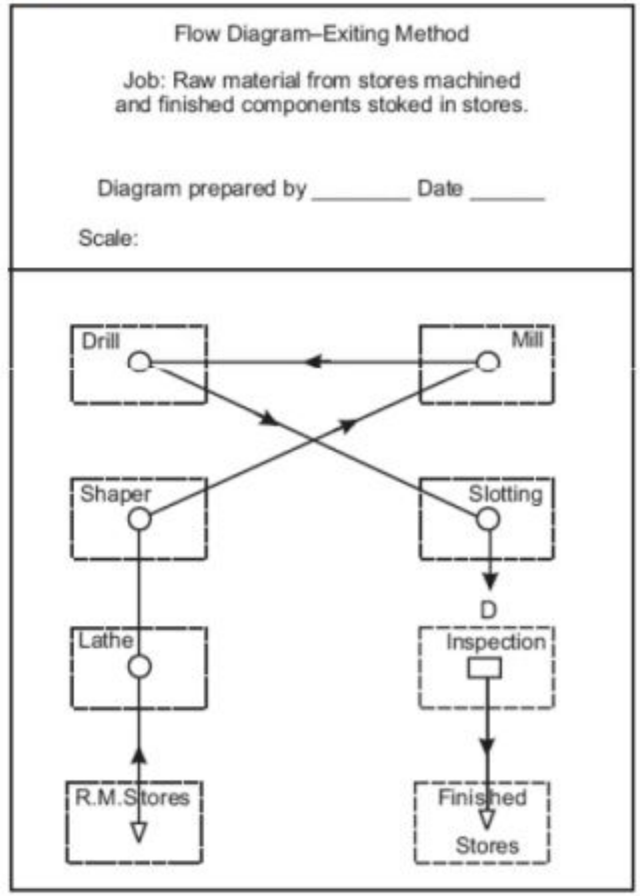
1. Show the layout of a facility.
2. Show the flow of work through that area
3. Show overcrowding areas, crossing worker paths, total travel.
4. Identify how layout can be redesigned to reduce travel, motion, collisions, etc.
5. Store materials near where they are used.
6. Increase efficiency and safety.

- Usually, the objective is to look for spatial relationships.
- It depicts the probable movement of materials in the floor plant. The movement is represented by a line in the plant drawing.

Flow Diagram

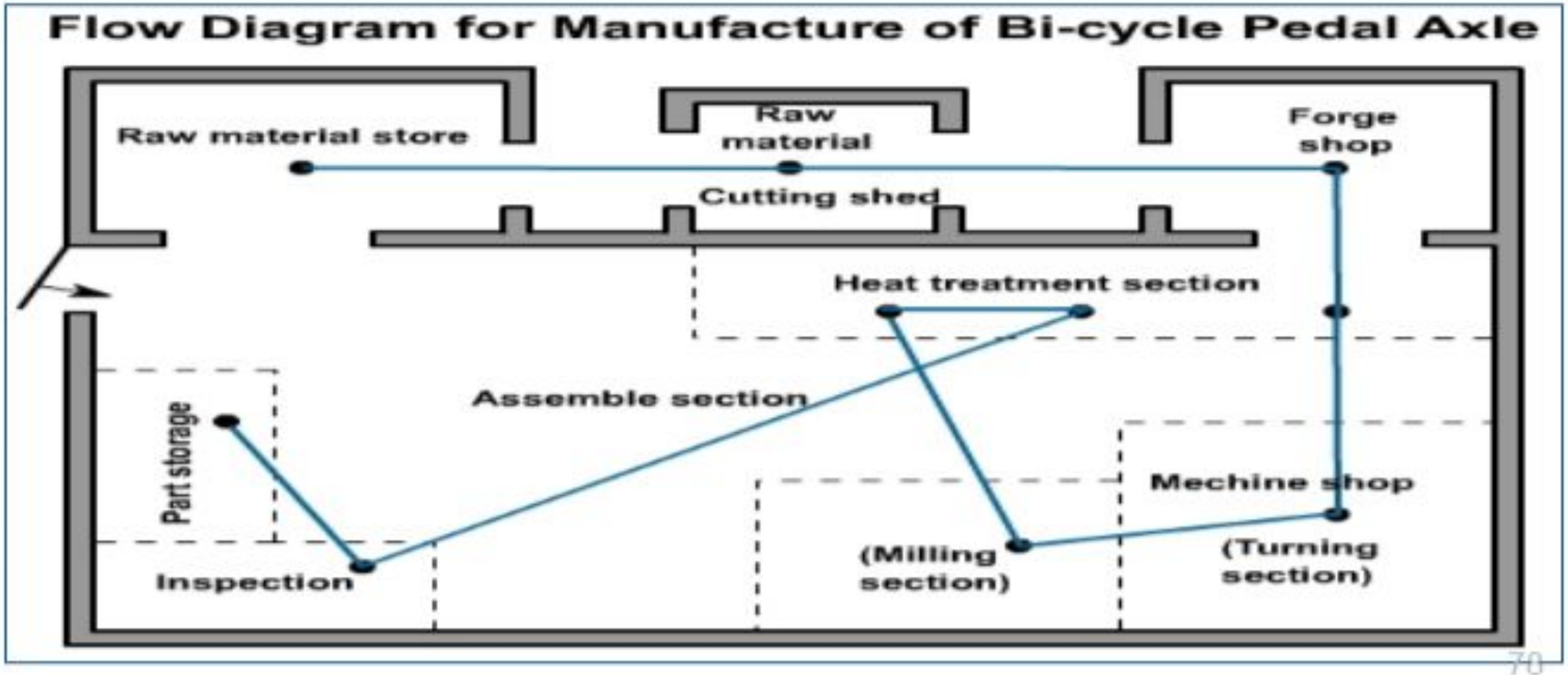
- In any production shop, repair shop or any other department, there are movements of men and material from one place to another. Process charts indicate the sequence of activities.
- They do not show the frequent movements of men and material.
- If these movement are minimized, a lot of savings can be achieved in cost and effort
- The flow diagram are used for the following purposes:

  1. To remove unwanted material movement.
  2. To remove back tracking.
  3. To avoid traffic congestion.
  4. To improve the plant layout.

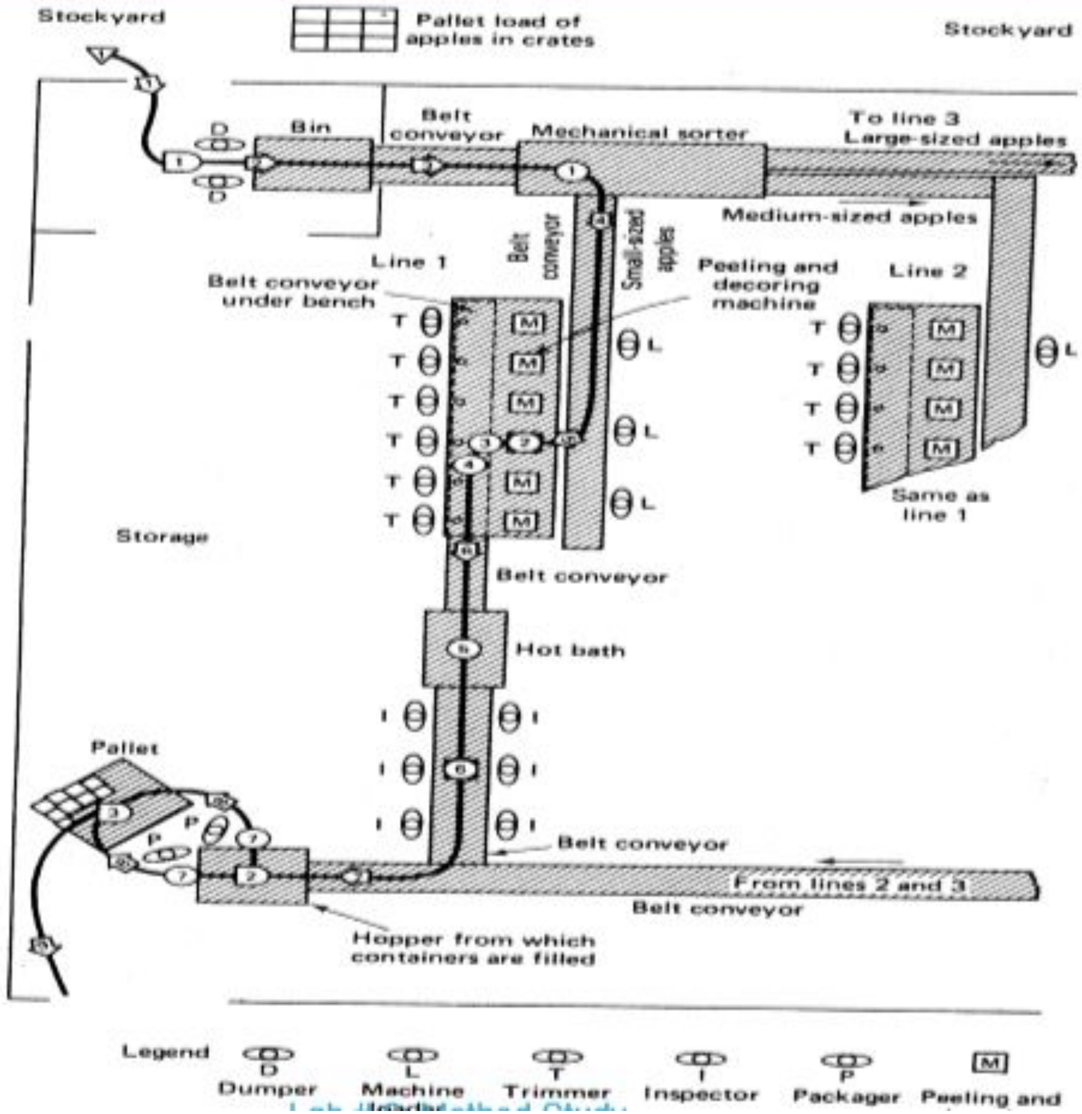


Flow diagram

- It's a top view of the work area correctly indicating the positions of machining and other locations affecting the movement of subject.
- Therefor it gives "on-the-spot observation" of the paths of movement of product sometimes using symbols of process



Flow Diagram (Cont.)



STRING DIAGRAM

STRING DIAGRAM

We make use of flow diagram for recording the movement of men or material when the movement is simple and the path is almost fixed. But when the paths are many and are repetitive, it may not be possible to record them in a flow diagram. Here a string diagram is used.

String diagram is a scaled plan of the shop. Location of machines and various facilities are drawn to scale in a drawing sheet. Pins are fixed at the various work centres in the drawing sheet. A continuous coloured thread or string is taken round the pins where the material or worker moves during the process.

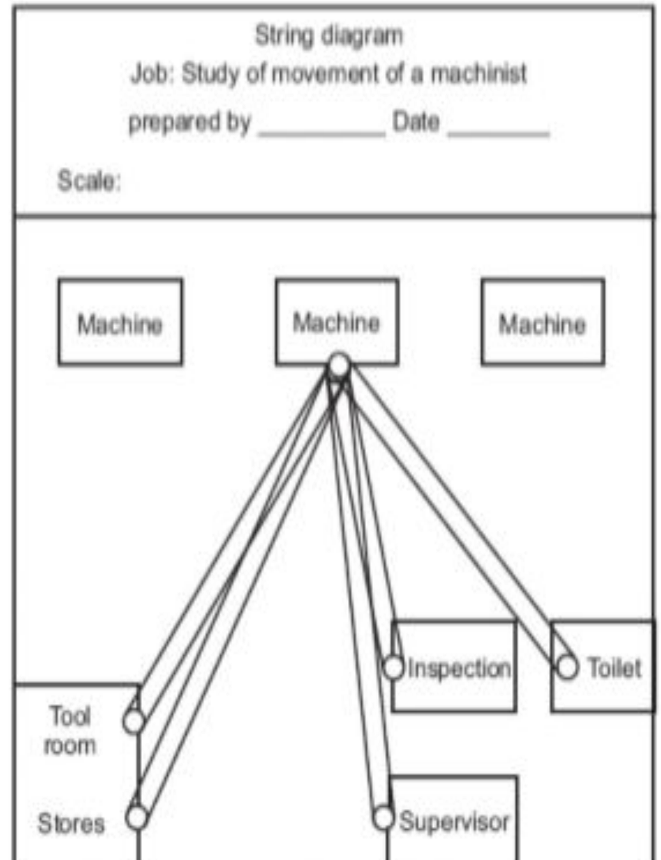


Fig. 1.7: String diagram

STRING DIAGRAM

Constructions

1\. Draw the layout of the shop to scale in a drawing sheet.

2. Mark the various work centres like machines, stores, work bench etc. in the diagram.
3. Hold the drawing sheet on a soft board and fix pins at the work centres.
2. Tie one end of a coloured string to the work centre from which the movement starts.
2. Follow the path of the worker to different work centre and accordingly take the thread to different points on the drawing board.

6.At the end of the session note down the number of movements from one work centre to another.

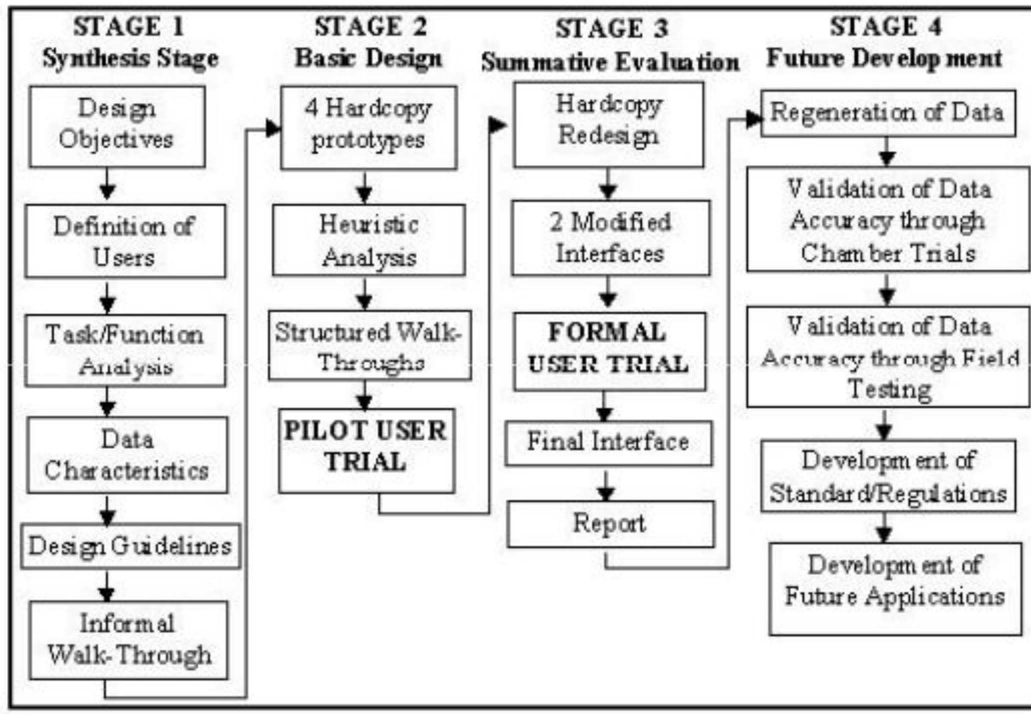
6.Remove the string and measure the total length of the string. Multiply by the scale and get the actual distance of movement.

Applications

1. It is used for recording the complex movements of material or men.
2. Back tracking, congestion, bottlenecks, under utilized paths are easily found out.
- It is used to check whether the work station is correctly located.
2. Used to record irregular movements.
- Used to find out the most economical route

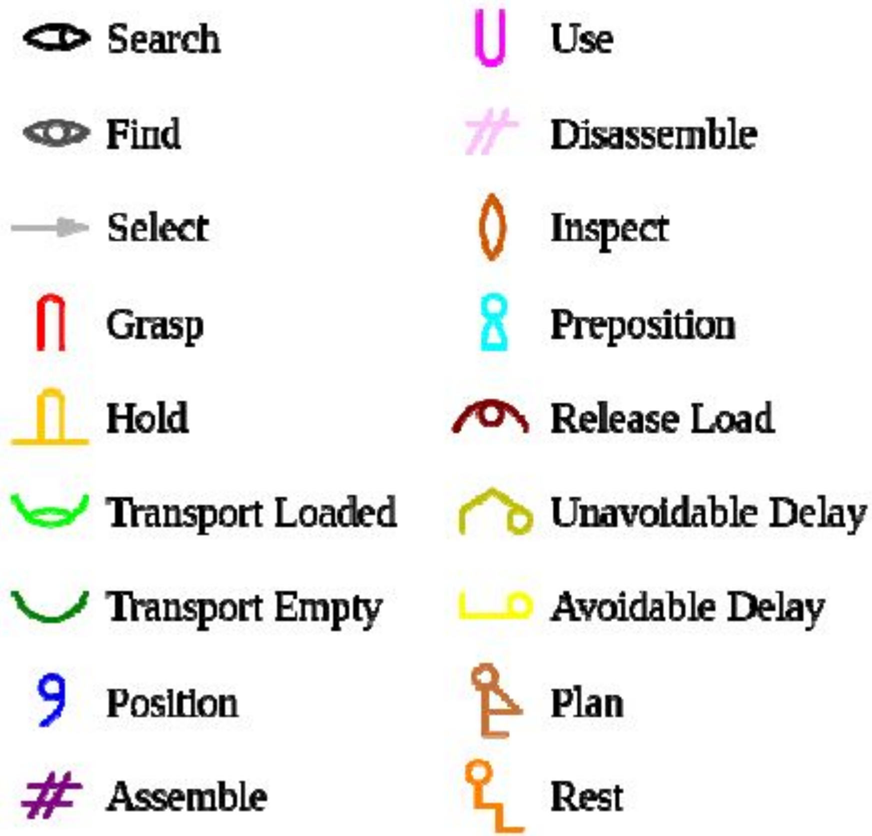
SIMO Charts

- A basic motion-time chart used to show the simultaneous nature of motions;
- Commonly a therblig chart for two-hand work with motion symbols plotted vertically with respect to time, showing the therblig abbreviation and a brief description for each activity, and individual times values and body-member detail.
- Also known as simultaneous motion-cycle chart.



Therbligs

- Therbligs are 18 kinds of elemental motions used in the study of motion economy in the workplace.
- A workplace task is analyzed by recording each of the therblig units for a process, with the results used for optimization of manual labor by eliminating unneeded movements.



Principles of Motion Economy

- The **principles of motion economy** form a set of rules and suggestions to improve the manual work in manufacturing and reduce fatigue and unnecessary movements by the worker, which can lead to the reduction in the work related trauma.
- The principles of motion economy can be classified into three groups:
  - Principles related to the use of *human body*,
  - Principles related to the arrangement of the *work place*,
  - Principles related to the *design of tools and equipment*.

Use of Human Body

- The two hands should begin motions at the same time.
- The two hands should not be idle at the same time except during rest periods.
- Motions of the arms should be made in opposite and symmetrical directions and should be made simultaneously
- Hand motions should be confined to the lowest classification with which it is possible to perform the work satisfactorily:
  - Finger motions
  - Wrist motions
  - Forearm motions
  - Upper arm motions
  - Shoulder motions
- Momentum should be employed to assist the worker whenever possible, and it should be reduced to a minimum if it must be overcome by muscular effort.
- Smooth continuous motions of the hands are preferable to zigzag motions or straight-line motions involving sudden and sharp changes in direction.

Arrangement of the Work Place

- There should be a definite and fixed place for all tools and materials.
- Tools, materials, and controls should be located close in and directly in front of the operator.
- Drop delivers should be used whenever possible.
- Materials and tools should be located to permit the best sequence of motions.
- Arrange the height of the workplace and chair for alternate sitting and standing, when possible.
- Provide a chair of the type and height to permit good posture.

Design of Tools and Equipment

- Combine tools whenever possible.
- Preposition tools and materials.
- Where each finger performs some specific movement, the load should be distributed in accordance with the inherent capacities of the fingers.
- For light assembly, a screwdriver handle should be smaller at the bottom.
- Momentum should be used to help the worker in doing their task not to increase their task.

DEVELOPMENT

- The shortcomings of the present process are brought out by the systematic questioning process that is combined with a knowledge relevant to the process being examined.
- Industrial may have the knowledge required or may not have the adequate knowledge.
- They need to have a knowledge library to support their effort as well as access to the experts during the study period.
- Alternatives to the current activities which have the shortcomings are to be generated during this stage.

IMPLEMENTATION

- Industrial engineers of methods study persons have to train the operators and their supervisors in the new method and participate in installing the method.
- Industrial engineers have to conduct a periodic review of methods to observe modifications brought into the installed methods by operators and supervisors and if they are beneficial, they have to be made part of standard operating procedure (SOP).

Work measurement

- **Work measurement** is the application of techniques designed to establish the time for an average worker to carry out a specified manufacturing task at a defined level of performance.
- It is concerned with the length of time it takes to complete a work task assigned to a specific job.

Time study

- Time study is a direct and continuous observation of a task, using a timekeeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera) to record the time taken to accomplish a task and it is often used when
  - there are repetitive work cycles of short to long duration,
  - wide variety of dissimilar work is performed, or
  - process control elements constitute a part of the cycle.

Work sampling

There are several recommended steps when starting to prepare a work sampling study:

- Define the manufacturing tasks for which the standard time is to be determined.
- Define the task elements. These are the defined broken-down steps of the task that will be observed during the study. Since a worker is going to be observed, additional categories will likely be included as well, such as "idle", "waiting for work", and "absent".
- Design the study. This includes designing the forms that will be used to record the observations, determining how many observations will be required, deciding on the number of days or shifts to be included in the study, scheduling the observations, and finally determining the number of observers needed.
- Identify the observers who will do the sampling.
- Start the study. All those who are affected by the study should be informed about it.
- Make random visits to the plant and collect the observations.
- After completing the study, analyze and present the results. This is done by preparing a report that summarizes and analyzes all data and making recommendations when required.

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Research Article

Improving Productivity in a Paint Industry using Industrial Engineering Tools and Techniques

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Abstract

Effective planning and designing of manufacturing processes and equipment helps in achieving optimum productivity through maximum utilization of the resources available leading to least possible industrial wastage thus resulting in low production cost. The aim of this paper is to study the implementation of industrial engineering tools in a paint industry. This study started with observing the standard operation procedures and understanding the existing process flow. At the same time, observations at the production line were made to identify problems and areas of possible improvements. Time study, method study and layout study techniques formed an integrated platform to help identify and rectify the time lost in unnecessary movements of labor and tools which resulted in long machine idle time. The packaging method used was conventional and time consuming which was simplified. There were suggestions proposed how redesigning of the process flow and efficient material handling could save idle time for machines, how replacing the old packaging method with use of zip ties would require less manpower and could help mitigate the non-value added activities, thereby resulting in improved productivity of the industry.

Keywords: *Work Study, Method Study, Time Study, Layout Study, Productivity, Material Handling Improvement.*

1. Introduction

International Labor Organization defines work study as the technique of method study and work measurement employed to ensure the best possible use of human and material resources in carrying out a specified activity. It is also a management service based on method study and work measurement used in examination of human work leading to investigation of all the resources that effect efficiency and economy of situation to affect improvement. Further ILO states that work study is to minimize cost either by designing the work for high productivity or by improving productivity in existing work through improvements in current methods by reducing ineffective and wasted time. Therefore, it can be said that it is a direct means of raising the productivity. It is most frequently used to increase the amount of production from a given quantity of resources with little or no further capital investment and hence work study has direct relation to productivity improvement.

Lean manufacturing is a production practice that considers the expenditure of resources from any goal other than the value for the end customer to be wasteful, and thus a target for elimination (Shashikant Shinde *et al*, 2014). Working from perspective of the customer who consumes a product or a service Value is defined as any action or process that a customer would be willing to pay for. SMED is one of the techniques from lean manufacturing. Set up time reduction is done in this case study. Plant efficiency can be improved due to Systematic Layout Planning (Varsha Karandikar *et al*, 2014). By improving the layout it was shown that the material flow lead time can be brought down. Similar concept is used in this case study.

This project was taken up in the Company X, mainly into manufacturing products such as acrylic distemper, water based primer and water based putty, situated in Parvati Industrial Estate, Pune, India. Company was keen to change the flow process and adopt concepts of lean manufacturing aiming to increase production turnover in a healthy manufacturing environment.

Having observed the current manufacturing flow process it was noted that the shop floor has two identical machines in which all the three products are manufactured. Apart from the main machines there is a heavy duty platform scale, weighing machines, portable drum stirrer, manual pallet jack, floor hand truck, manual forklift, pallets, containers, drums, racks, stitching machines and the other basic industrial tools.

The main objective of this project was to achieve efficient production by comprehensive approach to minimize wastes by eliminating redundant movement of material, waiting and delays, over processing, excess worker motion and the need of rework and corrections.

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Each step of the manufacturing process was weighed against what value did it add to the whole process flow and was eliminated, combined, rearranged or simplified accordingly like unnecessary movements of operator and material. Working on improved material handling could act as catalyst in reducing the total time considerably. It also helped to provide ergonomic benefits by reducing human effort and thereby fatigue. Applying Layout study concepts, it helped in identifying unsystematic placement of materials which was shifted to new locations for better and faster accessibility.

Objectives of the Research

- To identify areas for potential productivity improvement.
- To have higher level of output through wastage reduction.

2. Methodology

To have a first-hand knowledge of the production flow and to be familiar with the activities being performed at the floor shop, the researcher went through the facility and identified each operation process involved from raw materials to finished goods, identified all the places where inventory is stored between the processes, and observed how the material flowed from one operation to another.

There are a number of techniques in Industrial Engineering which are suitable for eliminating wastes. Amongst these techniques the researcher opted for Work Study techniques which are Method Study and Work Measurement. Following the basic procedure of Method Study, the first challenge was to select the product to be studied.

2.1. Selection of Product

The manufacturing and packaging procedure for all the three products are almost identical. The characteristic which is responsible to distinguish between them is their chemical composition. Due to this selecting the job on the basis of economic, technical and human considerations was not possible. To overcome this problem the researcher used the other criteria to select the product to be studied. Amongst the three main products manufactured by the company the demand for water based putty was the highest as compared to the other products; therefore its batches were manufactured in greater number. So water based putty was selected as it would become easier for the researcher to proceed with the next step that was to collect data and the other relevant facts.

2.2. Recording the Facts

Data recording was the most crucial step as the success of the whole procedure depended entirely on the accuracy with which the facts were recorded, the basis of which would provide critical examination and the development of the improved method. Recording was done with the help of Flow Process Chart- Man Type and String diagram. But before any of these charts could be constituted it was required for the researcher to do the time study. The first step of time study involved a detailed analysis of the operation flow by direct observation. The entire process was broken down into elements. This was required to identify the non-productive activities and separate them from the productive ones. However it was not possible to segregate the process into elements at once so it took many attempts to successfully separate out all the elements. After this time taken by the operator to perform each element of the operation was measured using a stopwatch and was recorded in time study sheet (Refer to Fig.1). A total of 150 elements were identified which were done by the operator.

Time study was done for two processes.

- Batching and Mixing of the paint product
- Packaging of the paint product

Time study for the former process was done to find the time required by the operator to do the operations which involved setting up of the machine, mixing of chemicals, powders and other ingredients to prepare the product. These elements were basically operation, transport, inspection, delay, or storage. Therefore with the help of time study the total time required to prepare the machine was found out to be 25.5 minutes.

Similarly the second part was to do time study for packaging of products and the total time required to package the product was found out to be 56.2 minutes. In between an addition of 30 minutes was utilized by the machine for mixing of the constituents. Time for a total of 150 elements was recorded in the Time Study sheet (Refer to Fig.1).

15	Time Study Sheet			
16	S. No.	Elements	Distance (metres)	Time (seconds)
17	1	Walk to Rest Platform	9.70	6.00
18	2	Bring Rest Platform	3.00	3.00
19	3	Walk to sitting stool	3.00	7.00
20	4	Move away sitting stool	4.00	9.00
21	5	Walk to Powder Trolley	11.00	28.00
22	6	Bring Powder Trolley Near M/c	10.25	4.00
23	7	Walk to Forklift	1.30	3.00
24	8	Insert Forklift into the trolley	~	4.00
25	9	Walk to M/c	2.00	6.00

Fig.1- Time Study Sheet

After categorizing the elements properly as operation, transport, delay, storage and inspection elements in the flow process chart (Refer to Fig.2), the researcher found a total of 56 transport elements and 94 operation elements involved in the present method. Subsequently these elements were transformed into 53 transport elements and 84 operation elements summing up to a total of 137 elements.

15	Flow Process Chart									
16	S. No.	Repeating Elements	Sequence	Elements	Distance (metres)	Time (seconds)	○	⇨	D	□
17	1		1	Walk to Rest Platform	9.70	6.00				
18	2		2	Bring Rest Platform	3.00	3.00				
19	3		3	Walk to sitting stool	3.00	7.00				
20	4		4	Move away sitting stool	4.00	9.00				
21	5		5	Walk to Powder Trolley	11.00	28.00				
22	6		6	Bring Powder Trolley Near M/c	10.25	4.00				
23	7		7	Walk to Forklift	1.30	3.00				
24	8		i	Insert Forklift into the trolley	~	4.00				
25	9	v	8	Walk to M/c	2.00	6.00				

Fig.2- Flow Process Chart

2.3. *Examining of Facts*

All the elements which were found during the recording stage were now carefully categorized as either 'make ready' or 'do' or 'put away' activities. The objective was to have a high proportion of 'do' activities since these were the operations which would carry the product progressively towards its completion. Examining consists of two rounds of questioning techniques. The first round is the primary questioning round which is then followed by secondary questioning round. These questions were systematically asked with reference to purpose, place, sequence, person and means of the activities recorded and to nominate alternatives for them. The objective behind this was to implement the principle of 'ECRS' to get an improved method by eliminating, combining, reducing and simplifying, all the unnecessary movement.

High level Problems identified in a nut shell

- Improper Layout leading to excessive movements
- Improper placement of tools
- Non-productive activities adding no end value
- Improper Material handling
- Traditional and time consuming methods of packaging
- Traditional methods and equipment of manufacturing
- Poor ergonomics

2.4. *Developing the Improved Method*

This stage of method study is about establishing the most practical, economic and effective method by taking into accounts all the circumstances. Categorizing the identified problems the proposed solution are as follows.

2.4.1. *Developing of Improved Layout*

The way of arrangement of material and machinery define the layout in that area. A careful analysis of the flow was done before concluding to changes in the present layout since changing the layout is a costly process as it involves movement of heavy duty machineries and stoppage of production.

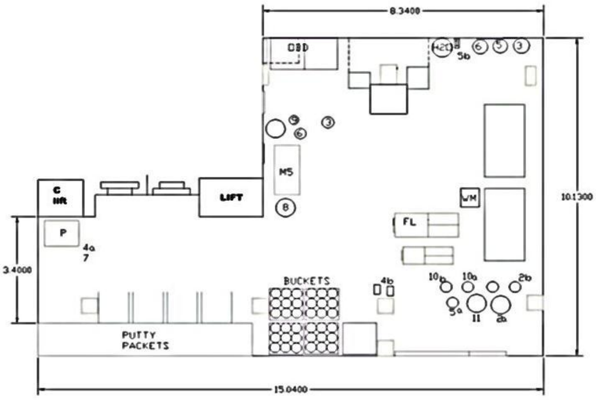

Fig.3- Original Layout

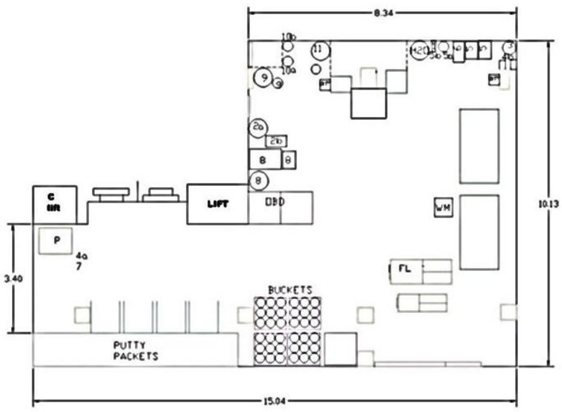

Fig.4- Proposed Layout

With the help of flow process chart (Refer to Fig.2) and string diagram (Refer to Fig.12) the researcher identified the following problems:

- All chemicals are placed far from the machine.
- Chemicals which require water are kept far away from the tap.
- The weighing machine is kept away from all preparation centers.
- There is no space for maintenance of MCB.

To reduce the worker's fatigue, improve mobility of materials, ameliorate material accessibility, increase free space and improve worker and materials's safety in accordance to convenience, the following suggestions were made (Refer to Fig. 3 & 4) :

- Rellocating the chemicals and bonds so that free space is available.
- Chemicals which require water would be kept near the tap.
- Addition of two more weighing machines for better feasibility.
- Allocation of free space for maintenance of MCB.
- Allocation of free space near containers for easier accessibility.
- Reallocation of raw materials to minimize the intrusion in the other machine set up process.
- Reallocation of packaged good near the lift area for easier accessibility.

2.4.2. Improvement in Material handling

Movement and handling of materials from one point to another in the course of processing involves significant time and effort. Although it is costly and adds no end value to the product, it cannot be eliminated completely but can be reduced substantially if appropriate methods and equipments at lowest possible cost are implemented with regard to safety. To eliminate supererogatory worker's motion and redundant movement of material the following changes the researcher proposed:

I. Overhead wiring of Manual forklift

In the present condition (Refer to Fig.5) the wiring of the manual forklift lies on the floor in a haphazard manner. Due to this the probability of the operator's feet entangling with the wire increases also restricting the motion of the manual forklift. To overcome this problem the researcher proposed overhead wiring (Refer to Fig.6) with an air tool stand including a spiral hose.

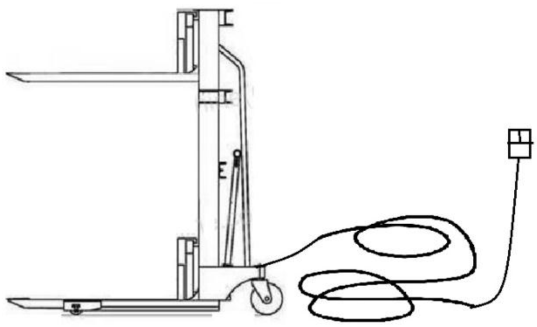

Fig.5- Present Arrangement

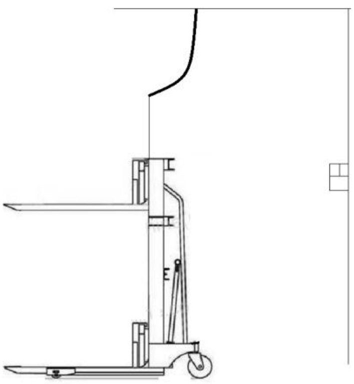

Fig.6- Proposed Arrangement

Benefits of the proposed idea area as follows:

- No obstructions in the movement of manual forklift
- Less chances of wire damage which leads to less chances of electrocution
- No restrictions in the movement of powder trolley
- Better handling techniques of manual forklift i.e., straight motion rather than radial motion

II. Barrel Stand

Bond, an ingredient for manufacturing water based putty is stored in two barrels each about 250kg in weight. To extract bond from the barrel which is placed vertically, it has to be tilted horizontally. Since the barrel is heavy it is required of the worker to use the manual forklift. This operation is broken into the following elements:

1) Bring the manual forklift near the barrel.
2) Walk from manual forklift to bucket.
3) Bring the bucket near the manual forklift.
4) Place the barrel on the manual forklift.
5) Adjust the barrel and manual forklift height in accordance to bucket.
6) Loosen the lid of the barrel by tool.
7) Now open the lid by hand.
8) Pour bond from barrel into the bucket.
9) Close the lid by hand.
10) Close the lid by tool.
11) Walk behind manual forklift.
12) Pull manual forklift back.
13) Drop the manual forklift.
14) Place barrel on its original place.

The movement of barrel (Refer to Fig.7) demands a lot of worker's fatigue so the researcher came up with solution of eliminating the movements involved with barrel by introducing a barrel stand (Refer to Fig.8).

Fig.7- Present Arrangement

Fig.8- Proposed Arrangement

With the introduction of barrel stand the position of the barrel now became horizontal due to which the original operation got reduced from 16 elements to 7 elements:

1) Walk to the bucket.
2) Bring the bucket near the barrel stand containing the barrel.
3) Loosen the lid of the barrel by tool.
4) Now open the lid by hand.
5) Pour bond from barrel into the bucket.
6) Close the lid by hand.
7) Close the lid by tool.

Benefits gained by the barrel stand are as follows

- Elimination of efforts in handling big bond barrel hence improvement in ergonomics.
- Elimination of the unnecessary movement of manual forklift (Refer to the shaded region in Fig.12 & 13)
- Elimination of efforts in moving the manual forklift.
- Reduction in time for extraction of bond from the barrel.

III. Rollers

Packaging of putty is done in a plastic bag which is then placed either inside a bucket or in a heavy duty plastic bag. After batching of the product is over it is extracted from a tapping spout which is positioned underneath the machine exactly in the center of it. The worker temporarily places the plastic bag in a bucket (for easy handling) beneath the tapping spout. After it is filled the worker pulls the bag outside, weighs it and then forwards it further to the other worker for sealing it.

When the bag is full, it weighs around 20 kg and to pull it outside it requires considerable time and effort. To make it easier the researcher proposed a roller conveyor (Refer to Fig.9) to be installed beneath the tapping spout for easier handling and hence improving ergonomics.

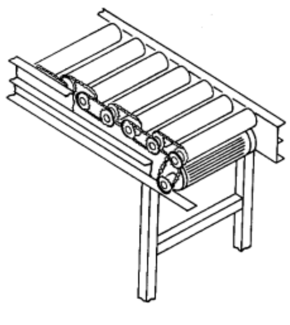

Fig.9- Roller

IV. Zip ties

After pulling the plastic bag out from beneath the machine it is weighed and then sealed with the help of a jute rope (Refer to Fig.10). The researcher found this as a conventional way of sealing and hence proposed another type of fastener which is a zip tie (Refer to Fig.11). This resulted in elimination of unnecessary elements and hence faster packaging of each bag. It also enhanced the aesthetic appearance of the bag.

Fig.10- Present Jute Rope

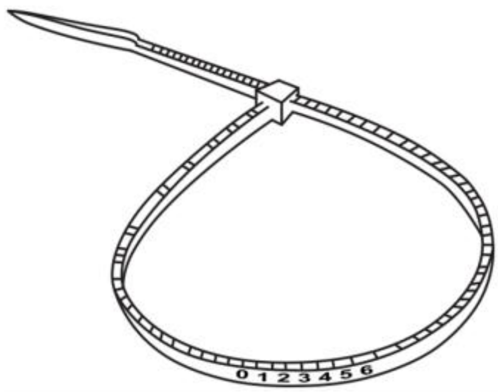

Fig.11- Proposed Zip Tie

V. Stools for the workers and support for stitching

There is no stool for the worker to sit during the packaging operation. Hence with respect to ergonomics the researcher proposed the idea of providing proper stool for the worker including a proper heighted support for resting the stitching machine.

This will help improve the durability of the stitching machine as previously the operator was dropping the stitching machine on the floor from a particular height which lead to frequent breakdowns. Also the introduction of the stool will reduce the probability of back problems for the worker.

The developed methods enabled the researcher to finish with the Flow Process Chart and String Diagram (Refer to Fig.12 & 13) arraying the current and proposed sequence of procedure by recording all the events under review using appropriate chart symbols. As can be seen in the figures the shaded regions depict the area utilized by the manual forklift according to the present and proposed methods respectively. From the proposed string diagram we can conclude how confining the process only to a required area thereby reducing the walking distance of the operator would inturn reduce the fatigue hence would reduce the stress of the operator.

Table 1

S.N	Manufacturing with:	Batching time	Mixing Time	Packaging time	Total Time (hours)	Total time (minutes)	Time Saved
1	Present Method	25.05 min	30 min	56.21 min	1 hr 51.26 min	111.26	17.65 min
2	Proposed Method	22.11 min	30 min	41.50 min	1 hr 33.61 min	93.61	

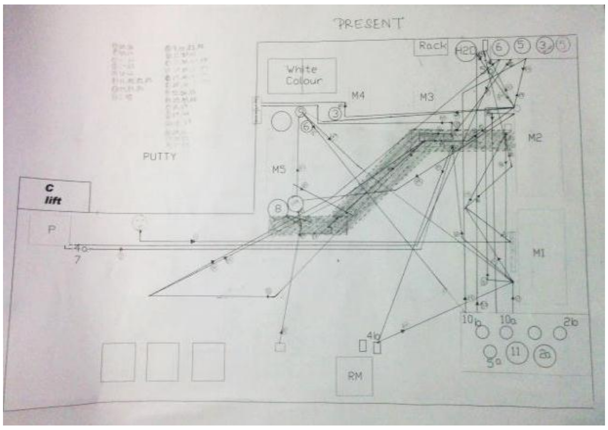

Fig.12- String Diagram of Original Layout

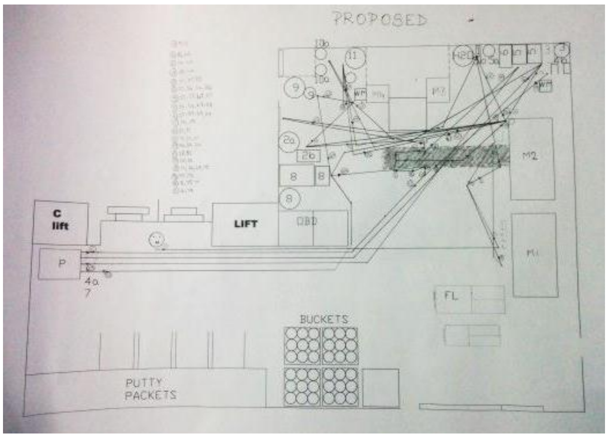

Fig.13- String Diagram of Proposed Layout

2.5. Evaluation of developed methods

a) Time saved after improvement in layout = 1.84 min.
b) Time saved after improvement in material handling= 1.1 min.
c) Time saved after improvement in packaging = 14.71 min.

Therefore, total time saved in 1 batch= 17.65 min.

- Shift Timings 9:30am to 5:30am including lunch break of 30 minutes.
- Total Available time = 450 minutes
- Number of paint bags produced and packed per batch= 52
- Number of working days in a month= 25

With Present Method

- Number of batches that can be performed is

$$\frac{450}{111.26} = 4.04\ batches$$

- Number of paint bags that can be produced and packed in 4.04 batches is

$$4.04 * 52 = 210.08\ paint\ bags$$

- Number of paint bags that can be produced per month is

$$210.28 * 25 = 5{,}252\ paint\ bags$$

With Proposed Method

- Number of batches that can be performed

$$\frac{450}{93.61} = 4.8\ batches$$

- Number of paint bags that can be produced and packed in 4.8 batches

$$4.8 * 52 = 249.6\ paint\ bags$$

- Number of paint bags that can be produced per month= 249.6 x 25= 6,240 paint bags

$$249.6 * 25 = 6{,}240\ paint\ bags$$

- Increment in production of paint bags is
$$6240 - 5252 = 988\ paint\ bags$$

- Therefore, increment in productivity is

$$\frac{988}{5252} * 100 = \mathbf{18.81}\%$$

3. Discussions and Conclusions

This study analyzed the existing state of manufacturing and proposed improved methods, the implementation of which resulted in increased production capacity, improved productivity and reduced human efforts. With the implementation of work study principles, the results of the study were a success. Production operators were instrumental to the success of each improved methods. By applying their knowledge to the processes allowed the researcher to provide the best solutions to the issues within the process. With the increase in productivity by approximately 19% shows the correct application of industrial engineering techniques can have a positive impact within any company.

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Varsha Karandikar, Shriram Sane, Rahul Pulkurte, Improvement in Line Feeding System in Assembly Plant using Lean Manufacturing Technique, *International Journal of Current Engineering and Technology*, E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.

FISHBONE DIAGRAM

Category: Analysis Tool

ABSTRACT

The Fishbone Diagram(G) is a tool for analyzing process dispersion. It is also referred to as the "Ishikawa diagram," because Kaoru Ishikawa developed it, and the "fishbone diagram," because the complete diagram resembles a fish skeleton. The diagram illustrates the main causes and subcauses leading to an effect (symptom).

It is a team brainstorming tool used to identify potential root causes(G) to problems. Because of its function it may be referred to as a cause-and-effect diagram.

In a typical Fishbone diagram, the effect is usually a problem needs to be resolved, and is placed at the "fish head". The causes of the effect are then laid out along the "bones", and classified into different types along the branches. Further causes can be laid out alongside further side branches. So the general structure of a fishbone diagram is presented below.

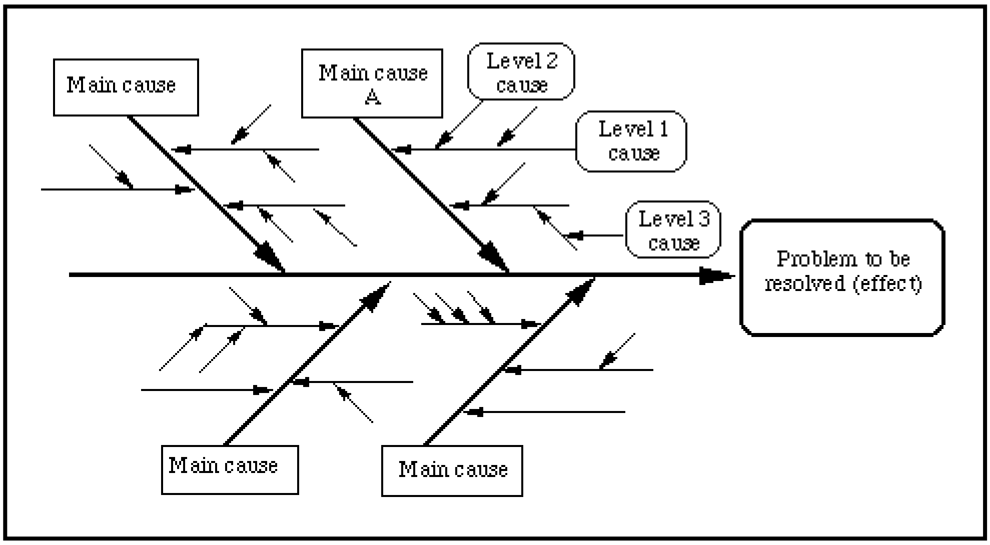


Figure 1: Fishbone Diagram - Structure

KEYWORDS

Cause-and-Effect Diagram, Ishikawa diagram, Fishbone diagram, Root Cause Analysis.

OBJECTIVES

The main goal of the Fishbone diagram is to illustrate in a graphical way the relationship between a given outcome and all the factors that influence this outcome. The main objectives of this tool are:

- Determining the root causes[(G)] of a problem.
- Focusing on a specific issue without resorting to complaints and irrelevant discussion.
- Identifying areas where there is a lack of data.

FIELD OF APPLICATION

The Fishbone diagram could be applied when it is wanted to:

- Focus attention on one specific issue or problem.
- Focus the team on the causes[(G)], not the symptoms.
- Organize and display graphically the various theories about what the root causes[(G)] of a problem may be.
- Show the relationship of various factors influencing a problem.
- Reveal important relationships among various variables and possible causes[(G)].
- Provide additional insight into process behaviors.

RELATED TOOLS

Pareto chart, Scatter diagram, Flowcharts Checksheets

DESCRIPTION

Dr. Kaoru Ishikawa, a Japanese quality control statistician, invented the fishbone diagram. It is often also referred to as the Ishikawa diagram. The fishbone diagram is an analysis tool that provides a systematic way of looking at effects and the causes that create or contribute to those effects. Because of the function of the fishbone diagram, it may be referred to as a cause-and-effect diagram. The design of the diagram looks much like the skeleton of a fish. Therefore, it is often referred to as the fishbone diagram. A cause-and-effect diagram can help identify the reasons why a process goes out of control. Often the fishbone diagram can be used to summarize the results of a brainstorming session, identifying the causes of a specified undesirable outcome. It helps to identify root causes[(G)] and ensures a common understanding of the causes.

The steps for constructing and analyzing a Cause-and-Effect Diagram are outlined below:

Step 1 - Identify and clearly define the outcome or effect to be analyzed[2].

Formulate the problem and write it in a box on the right side of the diagram. Everyone must clearly understand the nature of the problem and the process/product being discussed. If everyone is not clear on the purpose of the session, the session will not resolve the problem. In this step the following rules have to be be applied:

- Decide on the effect to be examined. Effects are stated as particular quality characteristics, problems resulting from work, planning objectives, and the like.

- Use Operational Definitions. Develop an Operational Definition of the effect to ensure that it is clearly understood.

- Remember, an effect may be positive (an objective) or negative (a problem), depending upon the issue that's being discussed.

    - ✓ *Using a positive effect which focuses on a desired outcome tends to foster pride and ownership over productive areas.* This may lead to an upbeat atmosphere that encourages the participation of the group. When possible, it is preferable to phrase the effect in positive terms.

    - ✓ *Focusing on a negative effect can sidetrack the team into justifying why the problem occurred and placing blame.* However, it is sometimes easier for a team to focus on what causes a problem than what causes an excellent outcome. While you should be cautious about the fallout that can result from focusing on a negative effect, getting a team to concentrate on things that can go wrong may foster a more relaxed atmosphere and sometimes enhances group participation.

You must decide which approach will work best with your group.

Step 2 - Use a chart pack positioned so that everyone can see it, draw the spine and create the effect box.

- Draw a horizontal arrow pointing to the right. This is the spine.

- To the right of the arrow, write a brief description of the effect or outcome which results from the process.

- Draw a box around the description of the effect.

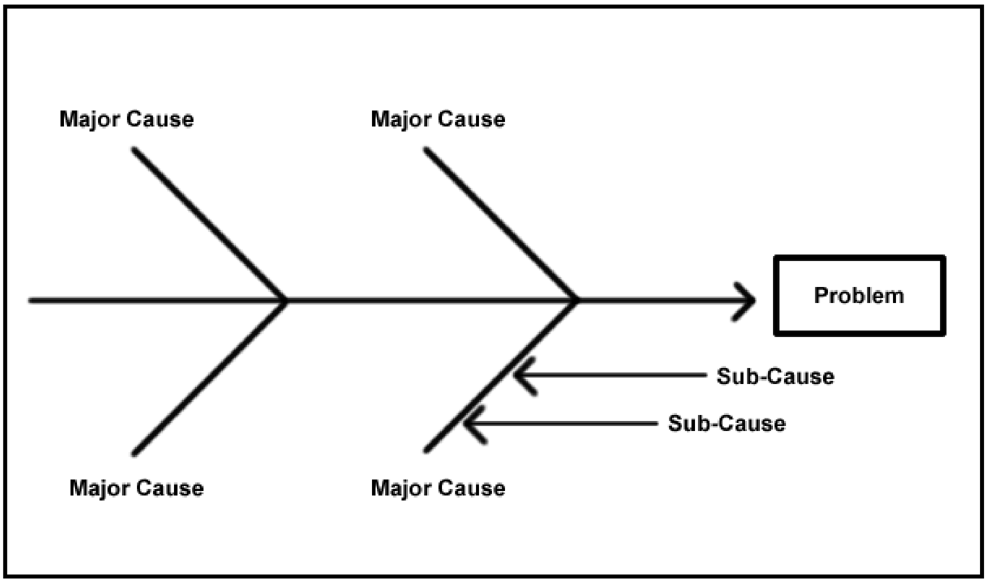
Step 3 - Identify the main causes(G) contributing to the effect being studied.

These are the labels for the major branches of your diagram and become categories under which to list the many causes related to those categories.

- Establish the major causes, or categories, under which other possible causes will be listed. You should use category labels that make sense for the diagram you are creating.

- Write the main categories your team has selected to the left of the effect box, some above the spine and some below it.

- Draw a box around each category label and use a diagonal line to form a branch connecting the box to the spine.



Step 4 - For each major branch, identify other specific factors which may be the causes of the effect

- Identify as many causes or factors as possible and attach them as subbranches of the major branches.

- Fill in detail for each cause. If a minor cause applies to more than one major cause, list it under both.

Step 5 - Identify increasingly more detailed levels of causes and continue organizing them under related causes or categories. You can do this by asking a series of why questions.

You may need to break your diagram into smaller diagrams if one branch has too many subbranches. Any main *cause* (3Ms and P, 4Ps, or a category you have named) can be reworded into an *effect*.

Step 6 - Analyze the diagram. Analysis helps you identify causes that warrant further investigation. Since Cause-and-Effect Diagrams identify only Possible Causes, you may want to use a Pareto Chart to help your team determine the cause to focus on first.

- Look at the "balance" of your diagram, checking for comparable levels of detail for most of the categories.

    - ✓ A thick cluster of items in one area may indicate a need for further study.

    - ✓ A main category having only a few specific causes may indicate a need for further identification of causes.

    - ✓ If several major branches have only a few subbranches, you may need to combine them under a single category.

- Look for causes that appear repeatedly. These *may* represent root causes.

- Look for what you can measure in each cause so you can quantify the effects of any changes you make.

BENEFITS

- Helps determine root causes
- Encourages group participation
- Uses an orderly, easy-to-read format to diagram cause and effect relationships
- Indicates possible causes of variation
- Increases knowledge of the process by helping everyone to learn more about the factors at work and how they relate
- Identifies areas for collecting data

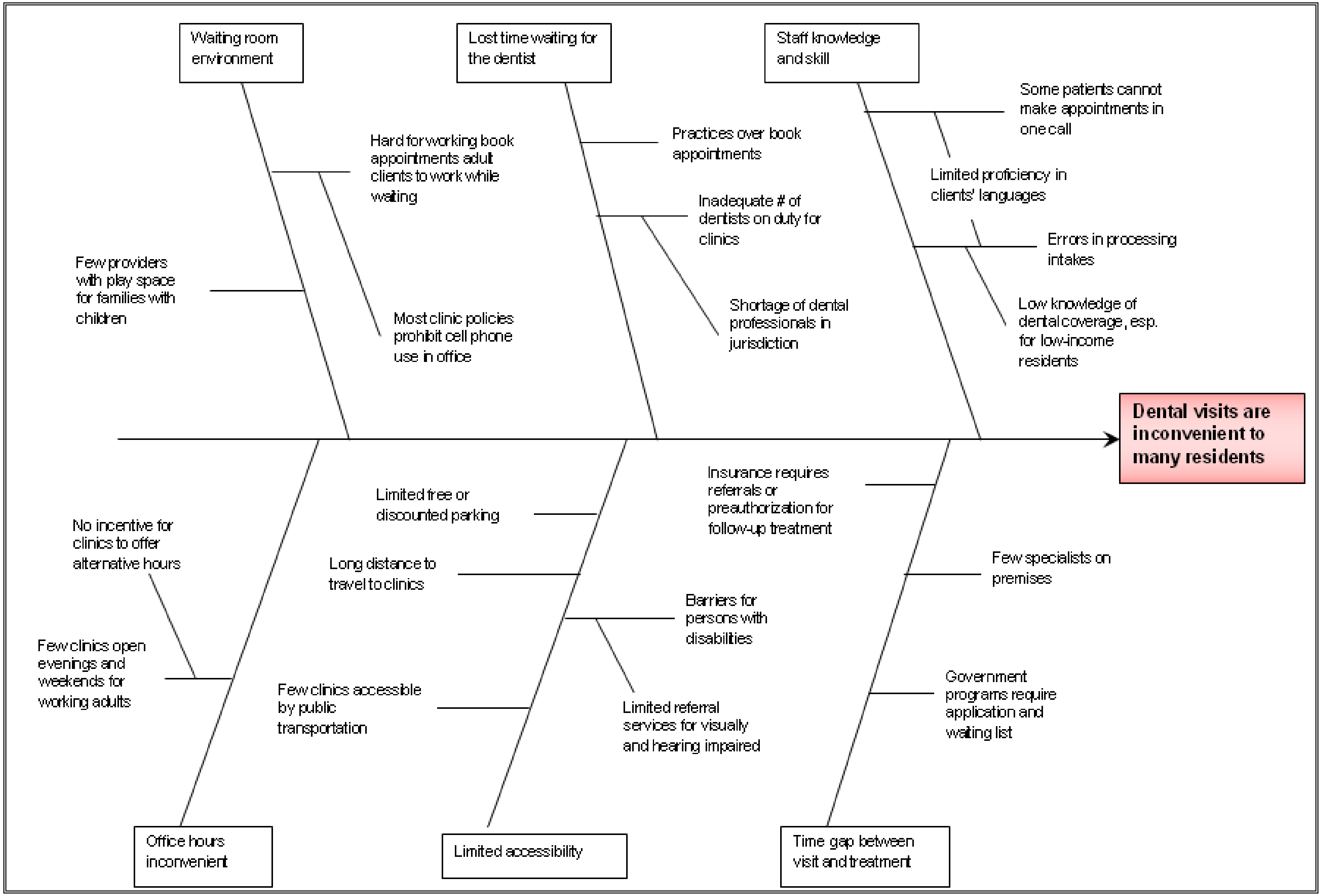
PREREQUISITES

- A problem is composed of a limited number of causes, which are in turn composed of sub causes.
- Distinguish these causes and sub causes is a useful step to deal with the problem.

EXAMPLES – CASE STUDY

Example problem: Low utilization of dental services by adults[5]

The following Fishbone Diagram shows how a public health team could delve into one potential root cause of low utilization of dental services by adults throughout the jurisdiction: "Dental visits are inconvenient to many residents."


Waiting room environment
Lost time waiting for the dentist
Staff knowledge and skill
Some patients cannot make appointments in one call
Practices over book appointments
Hard for working book appointments adult clients to work while waiting
Limited proficiency in clients' languages
Inadequate # of dentists on duty for clinics
Errors in processing intakes
Few providers with play space for families with children
Shortage of dental professionals in jurisdiction
Low knowledge of dental coverage, esp. for low-income residents
Most clinic policies prohibit cell phone use in office
Dental visits are inconvenient to many residents
Insurance requires referrals or preauthorization for follow-up treatment
Limited free or discounted parking
No incentive for clinics to offer alternative hours
Few specialists on premises
Long distance to travel to clinics
Barriers for persons with disabilities
Few clinics open evenings and weekends for working adults
Government programs require application and waiting list
Few clinics accessible by public transportation
Limited referral services for visually and hearing impaired
Office hours inconvenient
Limited accessibility
Time gap between visit and treatment

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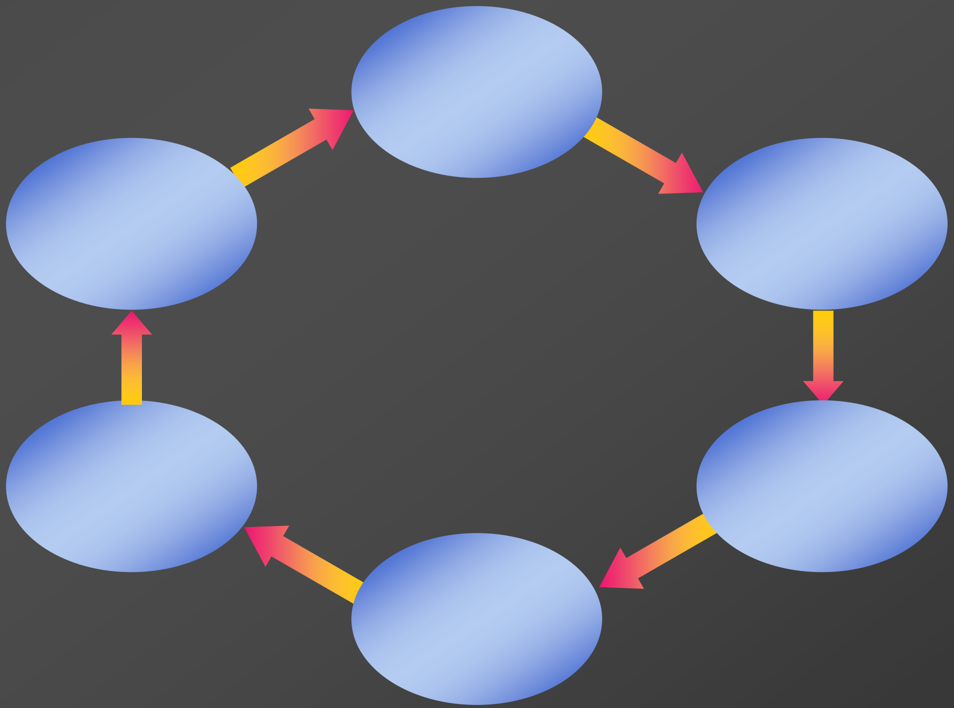
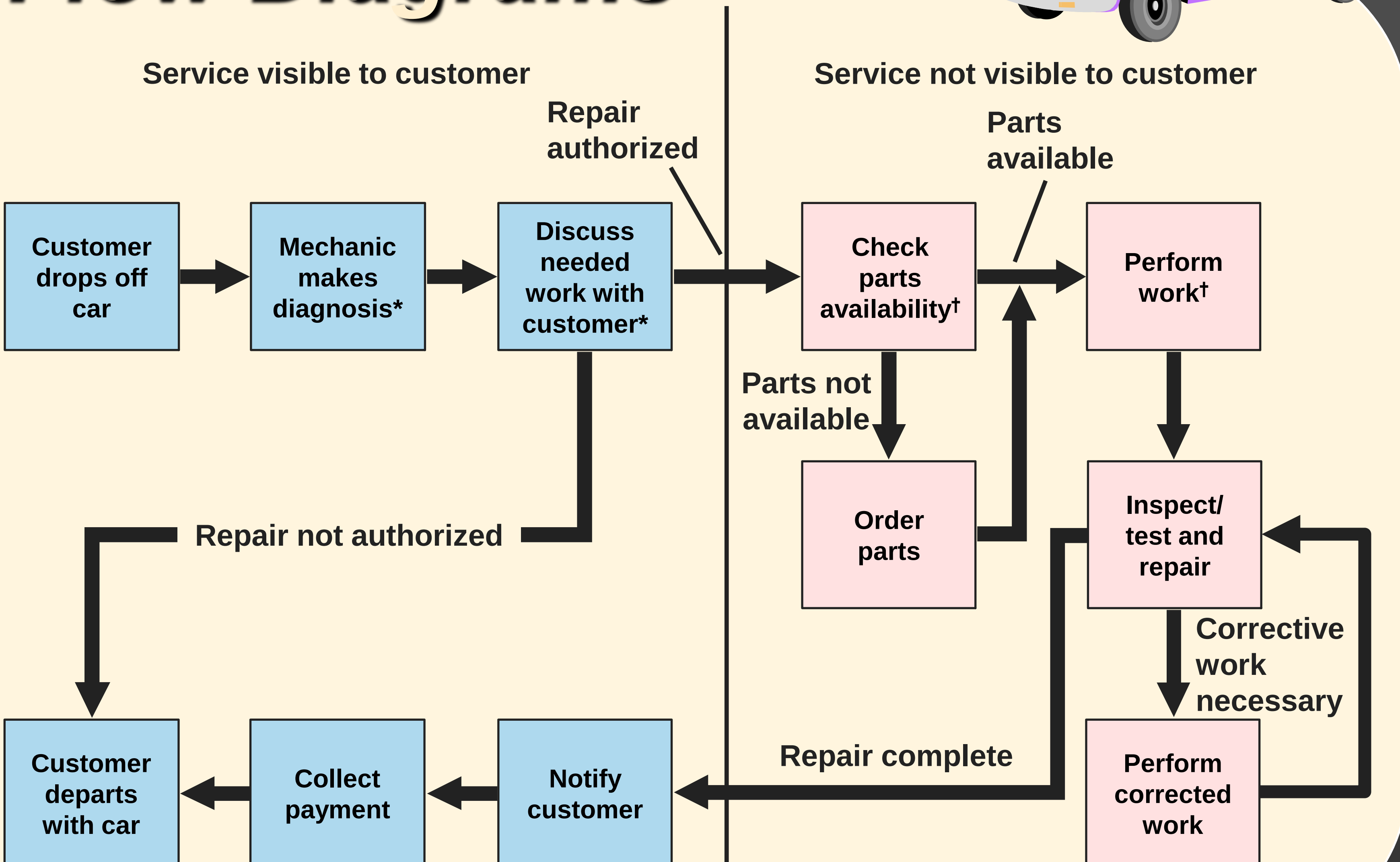
5. Public Health Infrastructure, *Fishbone (Ishikawa) Diagram (Example)* http://www.phf.org/infrastructure/PublicHealthFishbone.pdf (accessed on 8/8/2007)

Process Analysis



Flow Diagrams



* = Points critical to the success of the service

† = Points at which failure is most often experienced

Process Charts

Process: *Emergency room admission*
Subject: *Ankle injury patient*
Beginning: *Enter emergency room*
Ending: *Leave hospital*

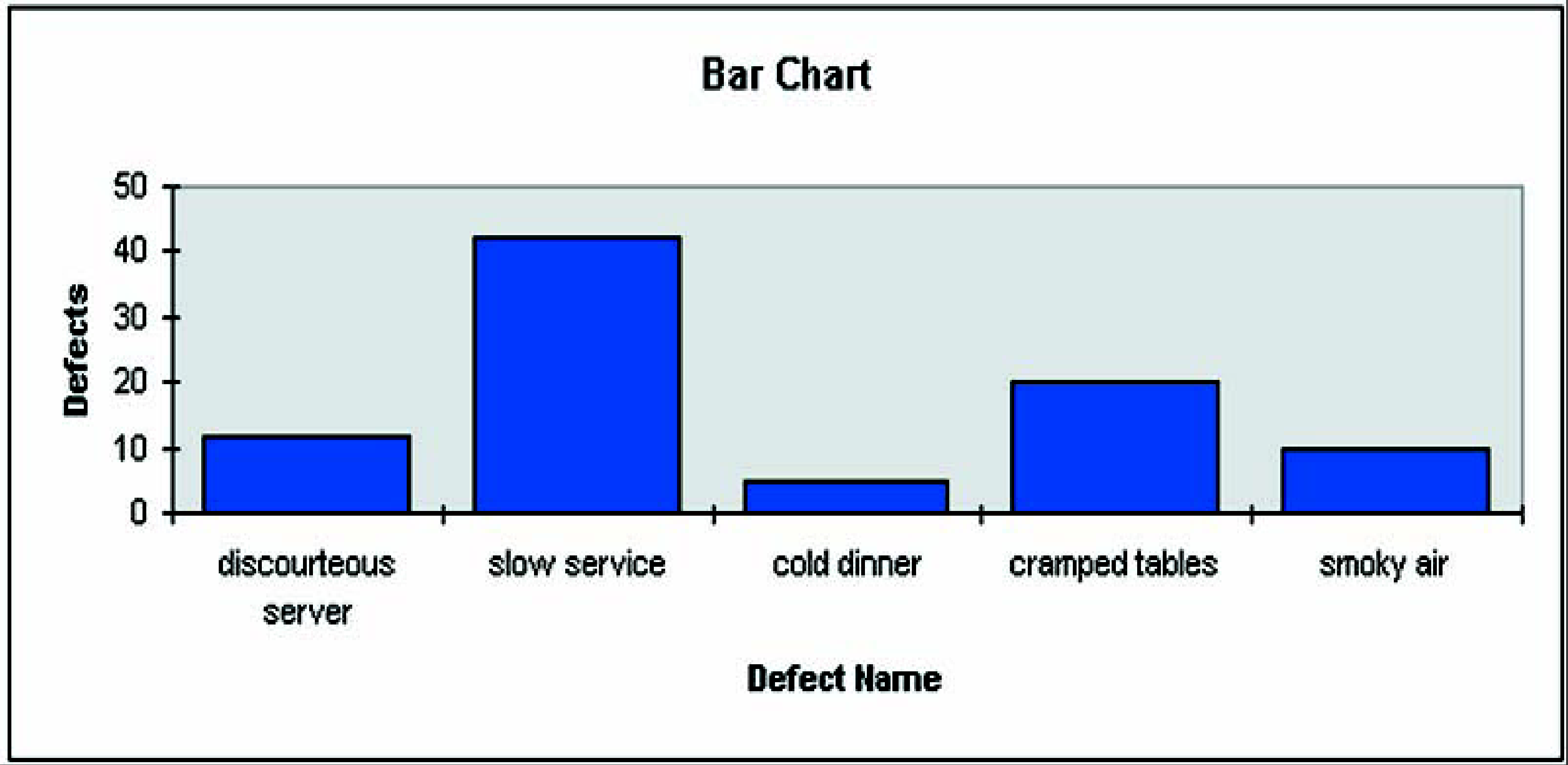
Insert Ste
e Step

Summary

Activity		Number of steps	Time (min)	Distance (ft)
Operation	●	5	23	—
Transport	➡	9	11	815
Inspect	■	2	8	—
Delay	D	3	8	—
Store	▼	—	—	—

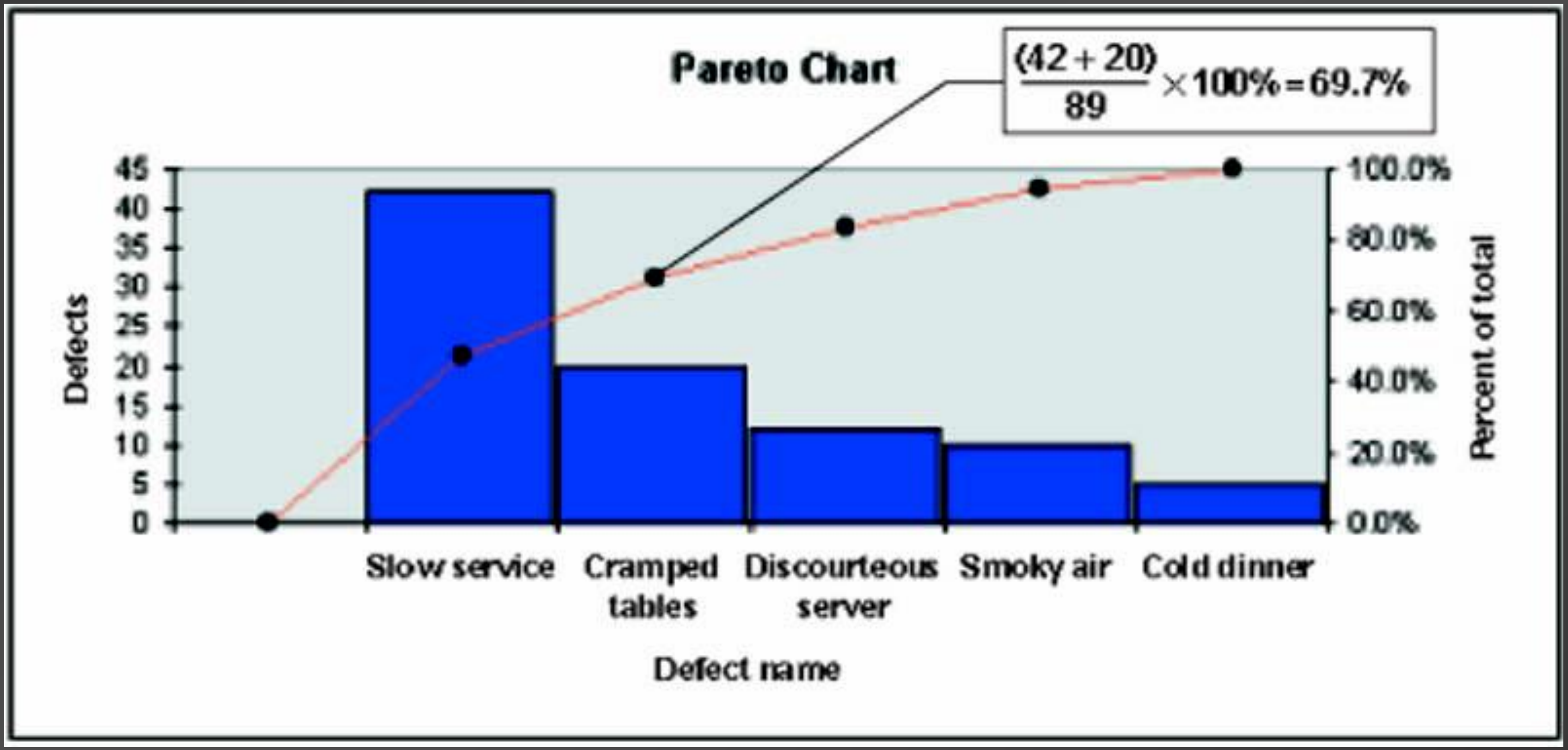
Step no.	Time (min)	Distance (ft)	●	➡	■	D	▼	Step description
1	0.50	15		X				Enter emergency room, approach patient window
2	10.0	-	X					Sit down and fill out patient history
3	0.75	40		X				Nurse escorts patient to ER triage room
4	3.00	-			X			Nurse inspects injury
5	0.75	40		X				Return to waiting room
6	1.00	-				X		Wait for available bed
7	1.00	60		X				Go to ER bed
8	4.00	-				X		Wait for doctor
9	5.00	-			X			Doctor inspects injury and questions patient
10	2.00	200		X				Nurse takes patient to radiology
11	3.00	-	X					Technician x-rays patient
12	2.00	200		X				Return to bed in ER
13	3.00	-				X		Wait for doctor to return
14	2.00	-	X					Doctor provides diagnosis and advice
15	1.00	60		X				Return to emergency entrance area
16	4.00	-	X					Check out
17	2.00	180		X				Walk to pharmacy
18	4.00	-	X					Pick up prescription
19	1.00	20		X				Leave the building

Pareto Charts

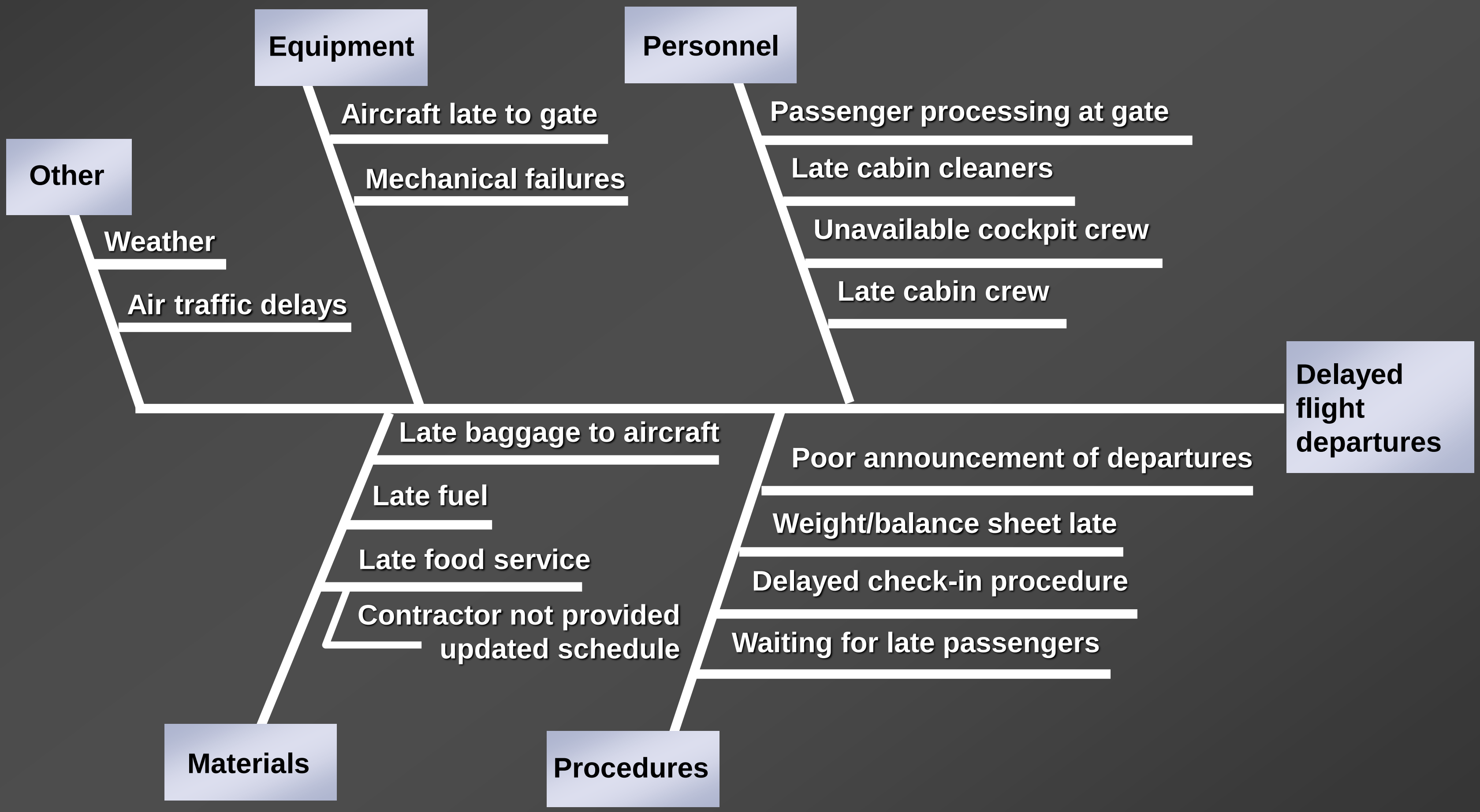


- The 80/20 rule can be applied to almost anything:
- 80% of customer complaints arise from 20% of your products and services.
- 80% of delays in the schedule result from 20% of the possible causes of the delays.
- 20% of your products and services account for 80% of your profit.
- 20% of your sales-force produces 80% of your company revenues.
- 20% of a systems defects cause 80% of its problems.

Pareto Charts



Checker Board Airlines



Source: Adapted from D. Daryl Wyckoff, "New Tools for Achieving Service Quality." *The Cornell Hotel and Restaurant Administration Quarterly*, November 1984, pg. 89. © 1984 Cornell H.R.A. Quarterly. Used by permission. All rights reserved.

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Tools for Improving Quality

- ✓ Step 1—Checklist
- ✓ Step 2—Pareto chart
- ✓ Step 3—Cause-and-effect diagram
- ✓ Step 4—Bar chart

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Checklists

Headliner Defects		
Defect type	**Tally**	**Total**
A. Tears in fabric		
B. Discolored fabric		
C. Broken fiber board		
D. Ragged edges		
	Total	

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Checklists

Headliner Defects		
Defect type	**Tally**	**Total**
A. Tears in fabric		
B. Discolored fabric		
C. Broken fiber board	/	
D. Ragged edges		
	Total	

Wellington Fiber Board Co.

Checklists

Headliner Defects		
Defect type	Tally	Total
A. Tears in fabric		
B. Discolored fabric		
C. Broken fiber board	//	
D. Ragged edges		
	Total	

Wellington Fiber Board Co.

Checklists

Headliner Defects

Defect type	Tally	Total
A. Tears in fabric	/	
B. Discolored fabric		
C. Broken fiber board	//	
D. Ragged edges		
	Total	

Wellington Fiber Board Co.

Checklists

Headliner Defects

Defect type	Tally	Total
A. Tears in fabric	/	
B. Discolored fabric		
C. Broken fiber board	//	
D. Ragged edges	/	
	Total	

Wellington Fiber Board Co.

Checklists

Headliner Defects

Defect type	Tally	Total
A. Tears in fabric	////	4
B. Discolored fabric	///	3
C. Broken fiber board	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ /	36
D. Ragged edges	~~////~~ //	7
	Total	50

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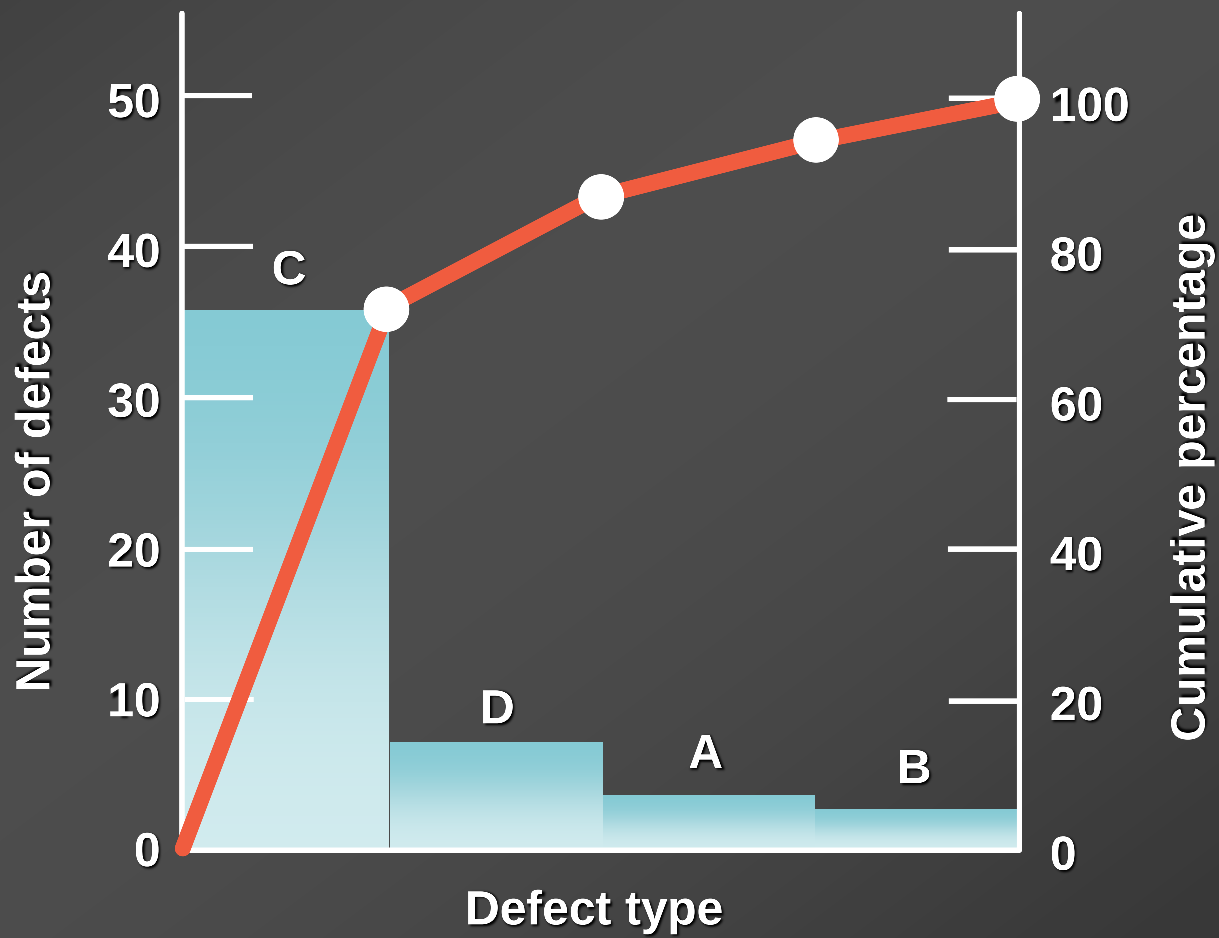
Pareto Chart



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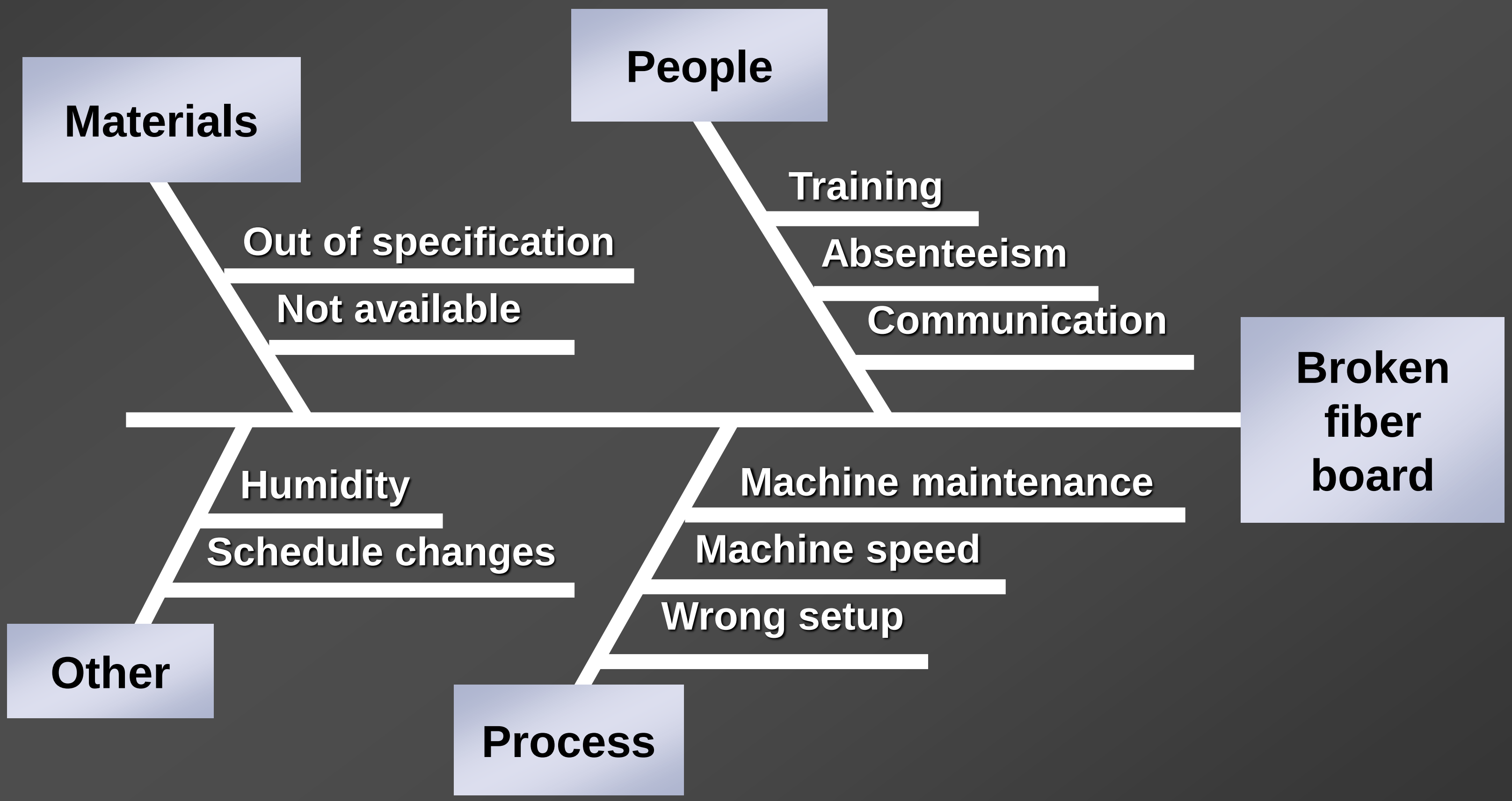
Cause-and-Effect Diagram



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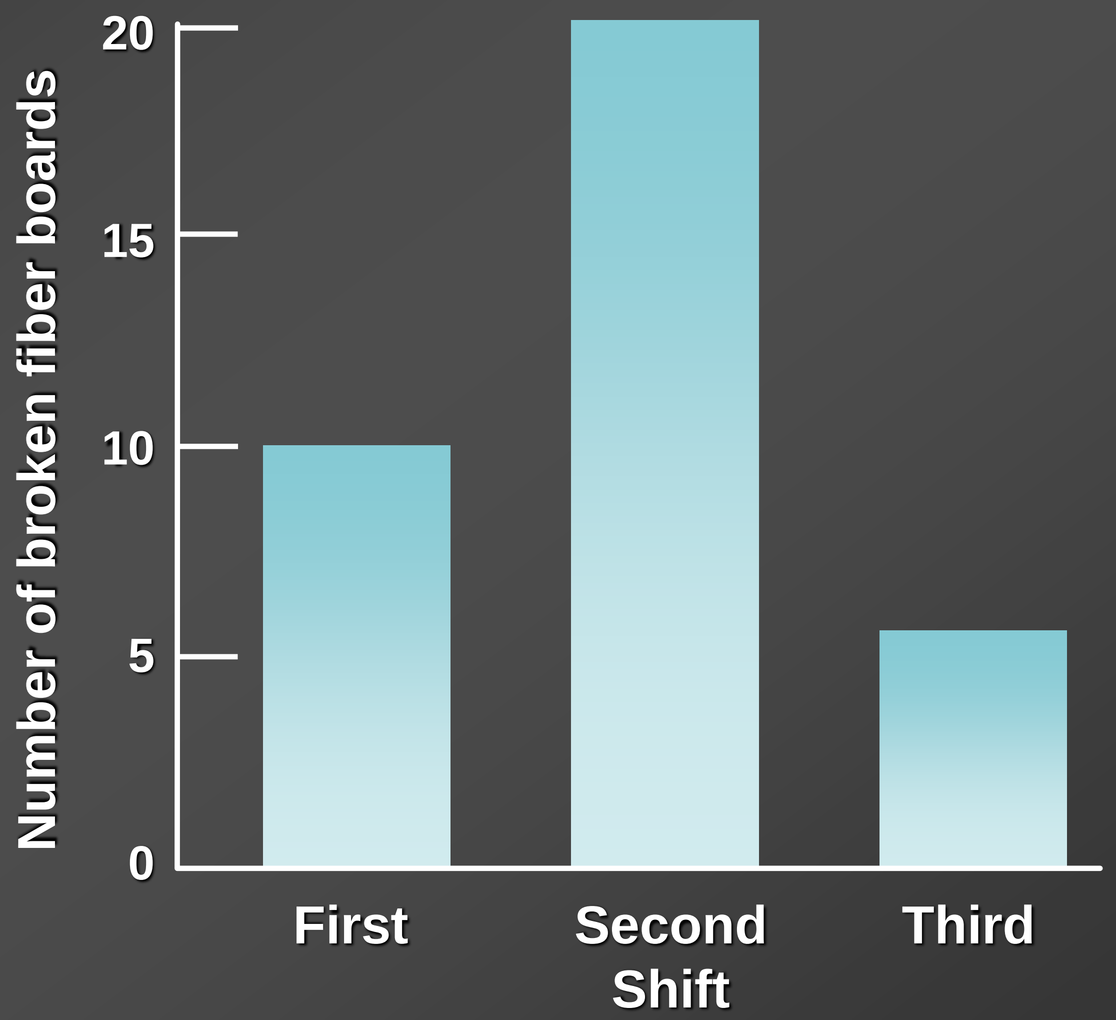
Bar Chart



Basic Functions of Business

- What are the three basic functions of a firm?

  ☑ Marketing – generates demand
  ☑ Production/operations – creates the product
  ☑ Finance/accounting – tracks how well the organization is doing, pays bills, collects the money

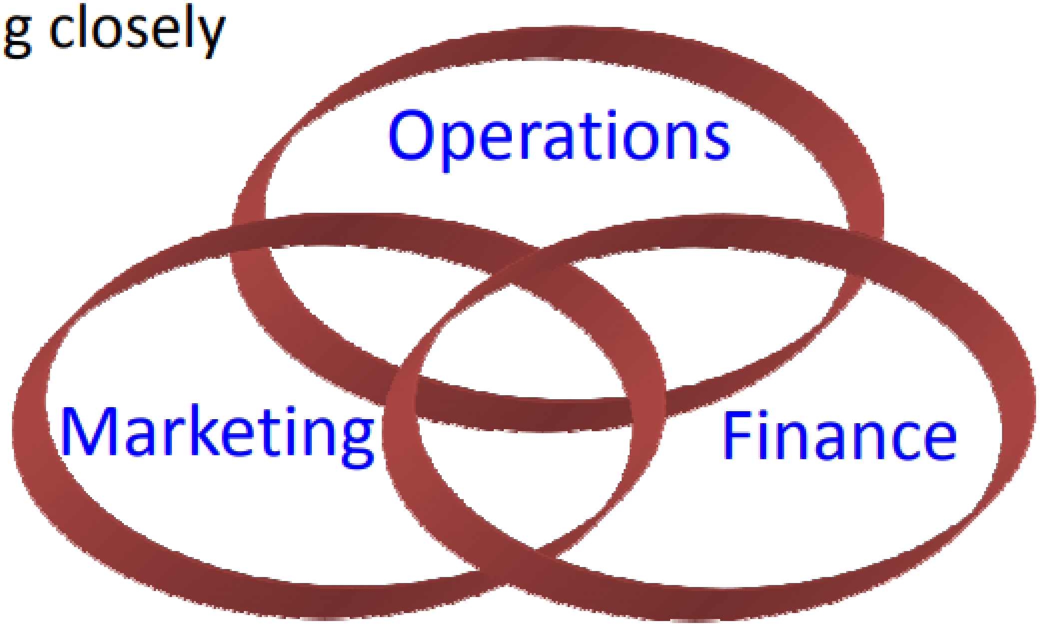
- Core of all business organizations
- Many areas interrelated
- Management of operations is critical to create and maintain competitive advantages

Organization of Businesses

- Three basic functions
  - Operations/Production
    - Goods oriented (manufacturing and assembly)
    - Service oriented (health care, transportation and retailing)
    - Value-added (the essence of the operations functions)
  - Finance-Accounting
    - Budgets (plan financial requirements)
    - Economic analysis of investment proposals
    - Provision of funds (the necessary funding of the operations)

Organization of Businesses (Cont.)

- Marketing
  - Selling
  - Promoting
  - Assessing customer wants and needs
  - Communicating those needs to operations
- The need for working closely



Difference between Operations & Industrial Management

- OM deals with the design and management of products, processes, services and supply chains.
- IM is concerned with the design, improvement and installation of integrated systems of people, material, information, equipment and energy.

Historical Evolution of Operations/Industrial Management

- For over two centuries operations and production management has been recognized as an important factor in a country's economic growth.

- The traditional view of manufacturing management began in eighteenth century when **Adam Smith** recognised the economic benefits of specialisation of labour. He recommended breaking of jobs down into subtasks and recognises workers to specialised tasks in which they would become highly skilled and efficient.

Historical Evolution

- Industrial revolution (1770's)
- Scientific management (1911)
  - Mass production
  - Interchangeable parts
  - Division of labor
- Human relations movement (1920-60)
  - Unemployment insurance
  - Pension plans
- Decision models (1915, 1960-70's)
- Influence of Japanese manufacturers (1970-1990)

TABLE 1.1 Historical summary of operations management

Date	*Contribution*	*Contributor*
1776	Specialization of labour in manufacturing	Adam Smith
1799	Interchangeable parts, cost accounting	Eli Whitney and others
1832	Division of labour by skill; assignment of jobs by skill; basics of time study	Charles Babbage
1900	Scientific management time study and work study developed; dividing planning and doing of work	Frederick W. Taylor
1900	Motion of study of jobs	Frank B. Gilbreth
1901	Scheduling techniques for employees, machines jobs in manufacturing	Henry L. Gantt
1915	Economic lot sizes for inventory control	F.W. Harris
1927	Human relations; the Hawthorne studies	Elton Mayo
1931	Statistical inference applied to product quality: quality control charts	W.A. Shewart
1935	Statistical sampling applied to quality control: inspection sampling plans	H.F. Dodge & H.G. Roming
1940	Operations research applications in World War II	P.M. Blacker and others.
1946	Digital computer	John Mauchlly and J.P. Eckert
1947	Linear programming	G.B. Dantzig, Williams & others
1950	Mathematical programming, on-linear and stochastic processes	A. Charnes, W.W. Cooper & others
1951	Commercial digital computer: large-scale computations available.	Sperry Univac
1960	Organizational behaviour: continued study of people at work	L. Cummings, L. Porter
1970	Integrating operations into overall strategy and policy, Computer applications to manufacturing, Scheduling and control, Material requirement planning (MRP)	W. Skinner J. Orlicky and G. Wright
1980	Quality and productivity applications from Japan: robotics, CAD-CAM	W.E. Deming and J. Juran.

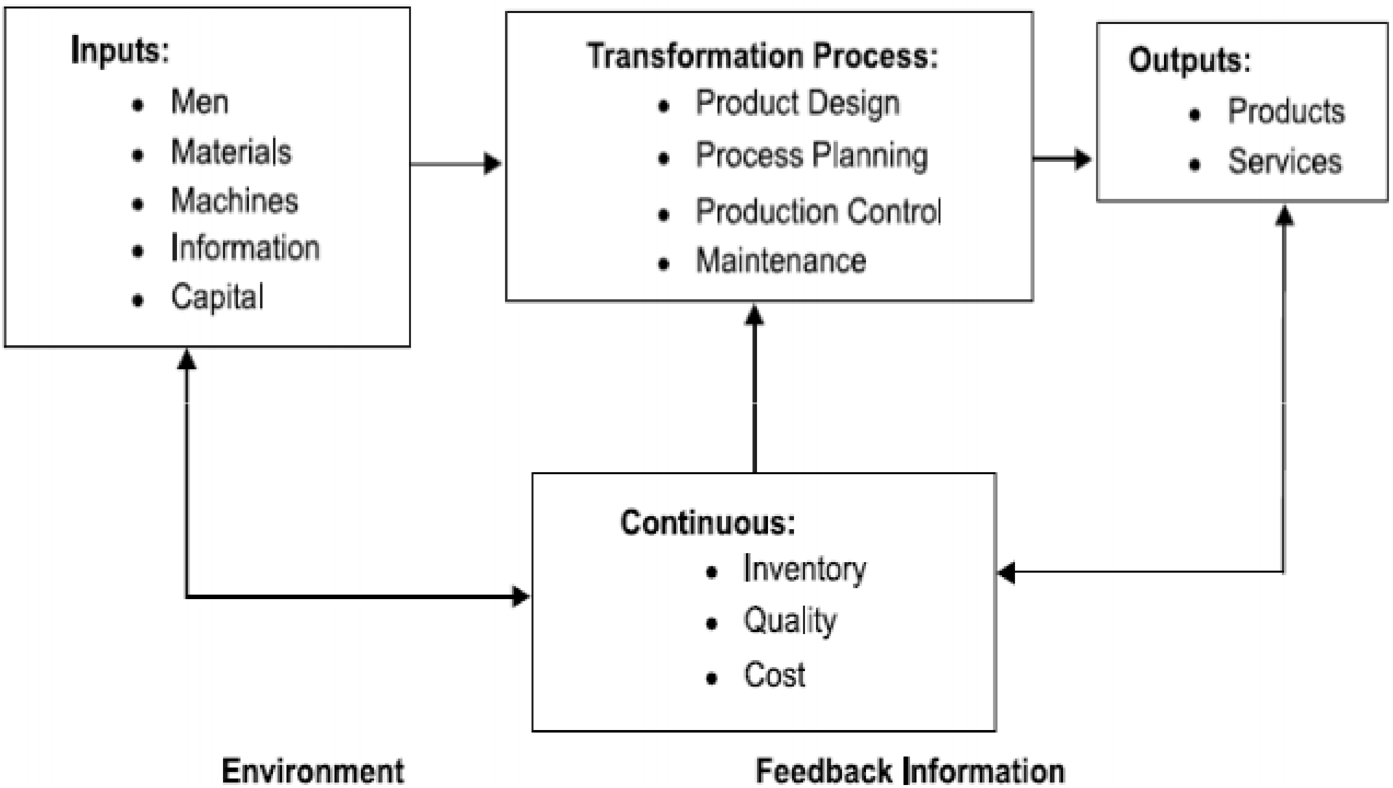
- The **Industrial Revolution** was the transition to new manufacturing processes in the period from about 1760 to sometime between 1820 and 1840.
- This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, improved efficiency of water power, the increasing use of steam power, and the development of machine tools.
- It also included the change from wood and other bio-fuels to coal.

- **Scientific management**, also called **Taylorism**, is a theory of management that analyzes and synthesizes workflows.
- Its main objective is improving economic efficiency, especially labor productivity.
- It was one of the earliest attempts to apply science to the engineering of processes and to management.
- Its development began with Frederick Winslow Taylor in the 1880s and 1890s within the manufacturing industries.

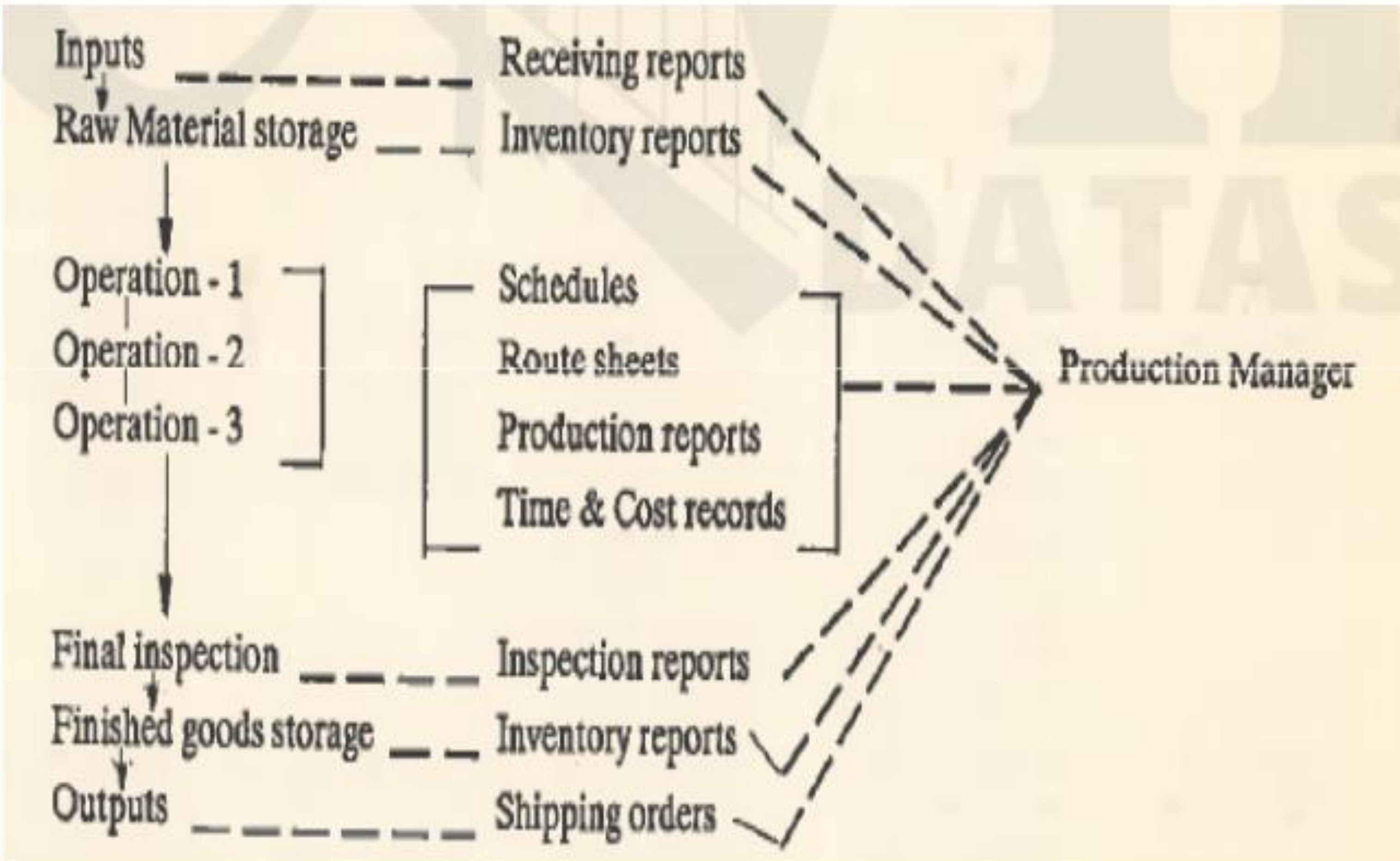
Frederick W. Taylor (1856- 1915)

- founder of scientific Management
- one of the first people to study the behavior and performance of people at work
- was a manufacturing manager
- became a consultant and taught other managers how to apply his scientific management techniques
- believed that by increasing specialization and the division of labor, the production process will be more efficient.

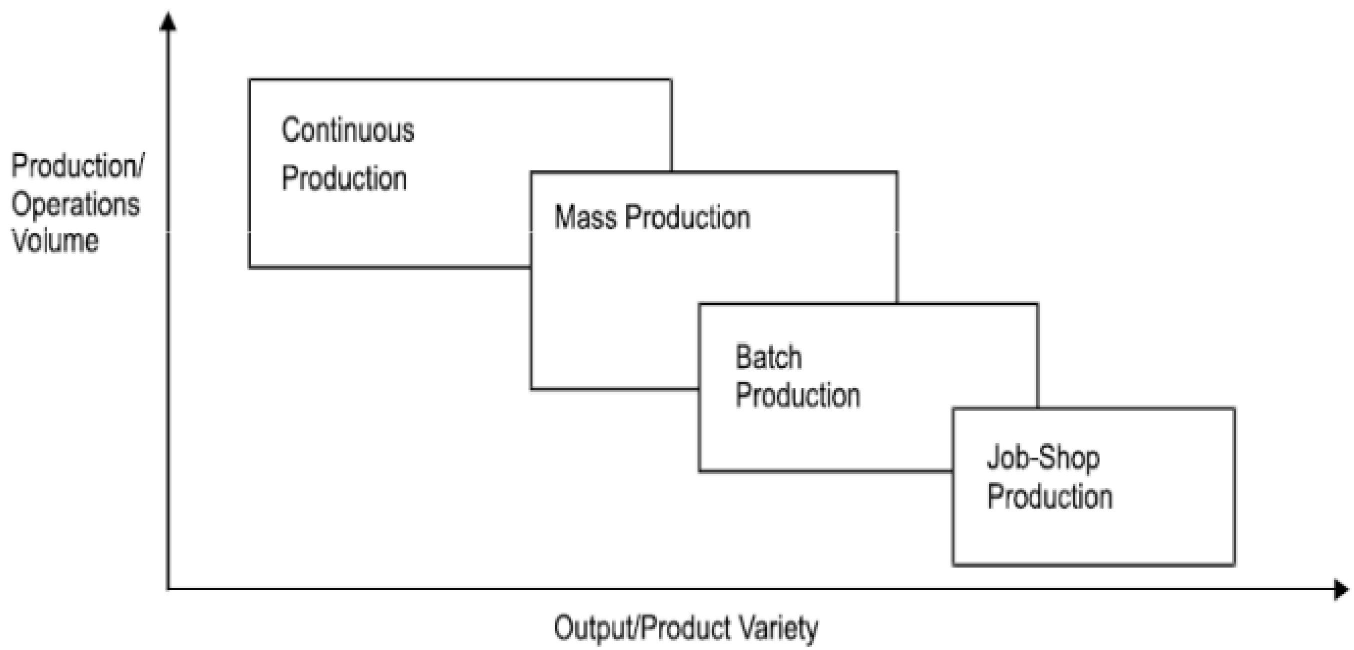
Schematic production system



Simplified Production System



Classification of Production Systems



JOB SHOP PRODUCTION

- Job shop production are characterized by manufacturing of one or few quantity of products designed and produced as per the **specification of customers** within prefixed **time** and **cost**. The distinguishing feature of this is **low volume** and **high variety** of products.
- A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

- Electronic Equipment Manufacturing
- Ceramic Manufacturing
- Software

Characteristics

- The Job-shop production system is followed when there is:

1. High variety of products and low volume.
2. Use of general purpose machines and facilities.
3. Highly skilled operators who can take up each job as a challenge because of uniqueness.
4. Large inventory of materials, tools, parts.
5. Detailed planning is essential for sequencing the requirements of each product, capacities for each work centre and order priorities.

Advantages

1. Because of general purpose machines and facilities variety of products can be produced.

2. Operators will become more skilled and competent, as each job gives them learning
opportunities.

3. Full potential of operators can be utilised.

4. Opportunity exists for creative methods and innovative ideas.

Limitations

1. Higher cost due to frequent set up changes.

2. Higher level of inventory at all levels and hence higher inventory cost.

3. Production planning is complicated.

4. Larger space requirements.

BATCH PRODUCTION

- Batch production is defined by American Production and Inventory Control Society (APICS)

"as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing."

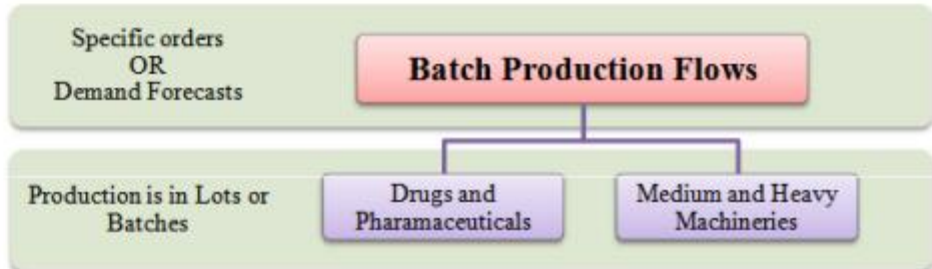
It is characterised by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

Characteristics

Batch production system is used under the following circumstances:

1. When there is shorter production runs.
2. When plant and machinery are flexible.
3. When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
4. When manufacturing lead time and cost are lower as compared to job order production.

- Textile Ind
- Furniture
- Electrical good
- News papers
- Books
- Coca cola Bottel



Example of Batch production

➢ An example of batch production might be aircraft engines for a given type of aeroplane.

Advantages

Following are the advantages of batch production:

1. Better utilisation of plant and machinery.
2. Promotes functional specialisation.
3. Cost per unit is lower as compared to job order production.
4. Lower investment in plant and machinery.
5. Flexibility to accommodate and process number of products.
6. Job satisfaction exists for operators.

Limitations

Following are the limitations of batch production:

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.
3. Work in process inventory is higher compared to continuous production.
4. Higher set up costs due to frequent changes in set up.

MASS PRODUCTION

Manufacture of discrete parts or assemblies using a continuous process are called mass production.

- This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path.

Characteristics

1. Standardisation of product and process sequence.

2. Dedicated special purpose machines having higher production capacities and output rates.

3. Large volume of products.

4. Shorter cycle time of production.

5. Lower in process inventory.

6. Perfectly balanced production lines.

7. Flow of materials, components and parts is continuous and without any back tracking.

8. Production planning and control is easy.

9. Material handling can be completely automatic.

- Car
- Glass
- Micro chips

Examples of Mass production

Examples include:

- Cars
- Chocolate bars and
- Electronic goods.

Advantages

Following are the advantages of mass production:

1. Higher rate of production with reduced cycle time.
2. Higher capacity utilisation due to line balancing.
3. Less skilled operators are required.
4. Low process inventory.
5. Manufacturing cost per unit is low.

Limitations

Following are the limitations of mass production:

1. Breakdown of one machine will stop an entire production line.
2. Line layout needs major change with the changes in the product design.
3. High investment in production facilities.
4. The cycle time is determined by the slowest operation.

CONTINUOUS PRODUCTION

- Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

Characteristics

Continuous production is used under the following circumstances:

1. Dedicated plant and equipment with zero flexibility.
2. Material handling is fully automated.
3. Process follows a predetermined sequence of operations.
4. Component materials cannot be readily identified with final product.
5. Planning and scheduling is a routine action.

Some common continuous processes are the following:

- Oil refining
- Chemicals
- Synthetic fibers
- Fertilizers
- Pulp and paper
- Blast furnace (iron)
- Metal smelting
- Power stations
- Natural gas processing
- Sanitary waste water treatment
- Continuous casting of steel
- Rotary kilns for calcining lime or cement
- Float glass
- Biscuit production

Advantages

Following are the advantages of continuous production:

1. Standardisation of product and process sequence.
2. Higher rate of production with reduced cycle time.
3. Higher capacity utilisation due to line balancing.
4. Manpower is not required for material handling as it is completely automatic.
5. Person with limited skills can be used on the production line.
6. Unit cost is lower due to high volume of production.

Limitations

Following are the limitations of continuous production:

1. Flexibility to accommodate and process number of products does not exist.
2. Very high investment for setting flow lines.
3. Product differentiation is limited.

Examples of 4 basic type production Systems

System	Example
Job Shop	Commercial Printer
Batch Processing	Heavy Equipment
Flow Shop (Production Line)	Car Assembly
Continuous Flow	Sugar Refinery

Most Processes are some where between Job shop and Flow shop

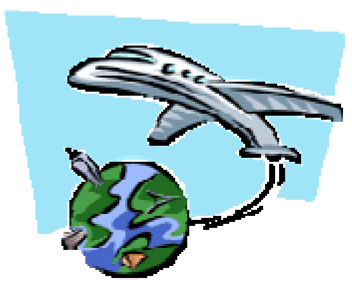
Organizational Charts

Airline

Operations
- Ground support equipment
- Maintenance
- Ground Operations
  - Facility maintenance
  - Catering
- Flight Operations
  - Crew scheduling
  - Flying
  - Communications
  - Dispatching
- Management science

Finance/ accounting
- Accounting
  - Payables
  - Receivables
  - General Ledger
- Finance
  - Cash control
  - International exchange

Marketing
- Traffic administration
  - Tariffs (pricing)
- Sales
- Advertising



Organizational Charts

Manufacturing

Operations

Facilities
- *Construction; maintenance*

Production and inventory control
- *Scheduling; materials control*

Quality assurance and control

Supply chain management

Manufacturing
- *Tooling; fabrication; assembly*

Design
- *Product development and design*
- *Detailed product specifications*

Industrial engineering
- *Efficient use of machines, space, and personnel*

Process analysis
- *Development and installation of production tools and equipment*

Finance/ accounting

Disbursements/ credits
- ***Receivables***
- ***Payables***
- ***General ledger***

Funds Management
- ***Money market***
- ***International exchange***

Capital requirements
- ***Stock issue***
- ***Bond issue and recall***

Marketing

Sales promotion

Advertising

Sales

Market research

What are 10 decision areas of operations management?

1. Product Design: What good or service should we offer?
2. Quality: How to define quality?
3. Process: What process will these products require?
4. Location: Where should we put the facility?
5. Layout: How should we arrange the facility?
6. Human Resources :How to provide a reasonable work environment?
7. **Supply Chain Management**: should we make or buy this component?
8. Inventory: How much inventory of each item should we have?
9. **Planning (aggregate and short-term):** which job do we perform next?
10. Maintenance: who is responsible for maintenance?

Responsibilities of Operations Management

- Planning
  - Capacity, utilization
  - Location
  - Choosing products or services
  - Make or buy
  - Layout
  - Projects
  - Scheduling
  - Market share
  - Plan for risk reduction, plan B?
  - Forecasting

Operations Managers

- Controlling
  - Inventory
  - Quality
  - Costs
- Organization
  - Degree of standardization
  - Subcontracting
  - Process selection
- Staffing
  - Hiring/lay off
  - Use of overtime
  - Incentive plans
  - Job assignments

PLANT MANAGER

Division of Fortune 1000 company seeks plant manager for plant located in the upper Hudson Valley area. This plant manufactures loading dock equipment for commercial markets. The candidate must be experienced in plant management including expertise in production planning, purchasing, and inventory management. Good written and oral communication skills are a must along with excellent understanding of and application skills in managing people.

Quality Manager

Several openings exist in our small package processing facilities in the Northeast, Florida, and Southern California for quality managers. These highly visible positions require extensive use of statistical tools to monitor all aspects of service timeliness and workload measurement. The work involves (1) a combination of hands-on applications and detailed analysis using databases and spreadsheets, (2) process audits to identify areas for improvement, and (3) management of implementation of changes. Positions involve night hours and weekends. Send resume.

Process Improvement Consultants

An expanding consulting firm is seeking consultants to design and implement lean production and cycle time reduction plans in both service and manufacturing processes. Our firm is currently working with an international bank to improve its back office operations, as well as with several manufacturing firms. A business degree required; APICS certification a plus.

Director of Purchasing

Well-established full-line food distributor is seeking an experienced purchasing agent to support rapidly expanding food service sales. Must have thorough knowledge of day-to-day purchasing functions, ability to review vendor programs, establish operating par levels, and coordinate activities with operations. The candidate must be prepared to work with vendors to develop Internet catalogues. Must be well versed in all food categories, a team worker, and bottom-line oriented. Salary commensuate with experience.

Supply Chain Manager and Planner

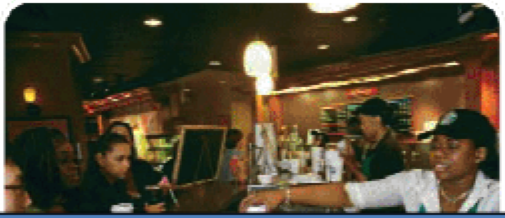
Responsibilities entail negotiating contracts and establishing long-term relationships with suppliers. We will rely on the selected candidate to maintain accuracy in the purchasing system, invoices, and product returns. A bachelor's degree and up to 2 years related experience are required. Working knowledge of MRP, ability to use feedback to master scheduling and suppliers and consolidate orders for best price and delivery are necessary. Proficiency in all PC Windows applications, particularly Excel and Word, is essential. Knowledge of Oracle business system I is a plus. Effective verbal and written communication skills are essential.

Improving Productivity at Starbucks

A team of 10 analysts continually look for ways to save time. Some improvements:

Stop requiring signatures on credit card purchases under $25	→	***Saved 8 seconds per transaction***
Change the size of the ice scoop	→	***Saved 14 seconds per drink***
New espresso machines	→	***Saved 12 seconds per shot***

Improving Productivity at Starbucks



A team of 10 analysts continually look for ways to shave time. S
improvemen

***Stop requiri
on credit ca
under $25***

***Change the
scoop***

New espres

Operations improvements have helped Starbucks increase yearly revenue per outlet by $200,000 to $940,000 in six years.

Productivity has improved by 27%, or about 4.5% per year.

per shot

Productivity

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Input used}}$$

- ☑ Measure of process improvement
- ☑ Represents output relative to input
- ☑ Only through productivity increases can our standard of living improve

Productivity Calculations

Labor Productivity

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Labor-hours used}}$$

$$= \frac{1{,}000}{250} = 4 \text{ units/labor-hour}$$

One resource input ⇨ single-factor productivity

Multi-Factor Productivity

$$\text{Productivity} = \frac{\text{Output}}{\text{Labor} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}}$$

- ☑ Also known as total factor productivity
- ☑ Output and inputs are often expressed in dollars

Multiple resource inputs ⇨ multi-factor productivity

Marketing Management

What Is Marketing?

Marketing is an organizational function and a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders.

What Is Marketing Management?

Marketing management is the
art and science
of choosing target markets
and getting, keeping, and growing
customers through
creating, delivering, and communicating
superior customer value.

Evolution of Marketing Thought

- **Production Era (1850s-1920s)**
  - Industrial revolution; mass production
  - Few products and little competition
- **Sales Era (1920s-1950s)**
  - The focus was on personal selling and advertising
  - Sales seen as the major means for increasing profits
- **Mktg Era (1950s-present)**
  - Customer orientation replaced the "hard sell" of the sales-led era
  - Determination of the needs and wants of customers before introducing products or services

Evolution of Marketing Thought

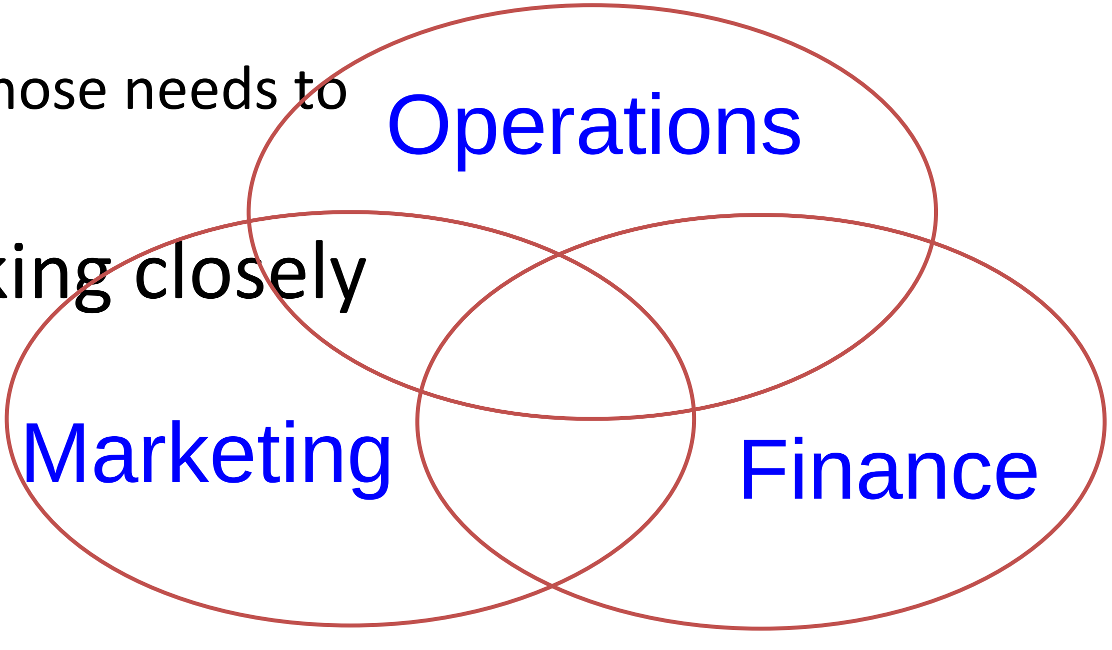
- **Relationship Marketing Era: 1990s-**
  - Marketing era has recently shifted from being "transaction-based" to **focusing on "relationships"**
  - The argument : traditional marketing practices focused on attracting new customers rather than retaining existing ones.
  - It is equally important to hang on to existing customers so that they become repeat buyers and long term loyal customers
    - » ***"customer relationship management"!***

Organization of Businesses

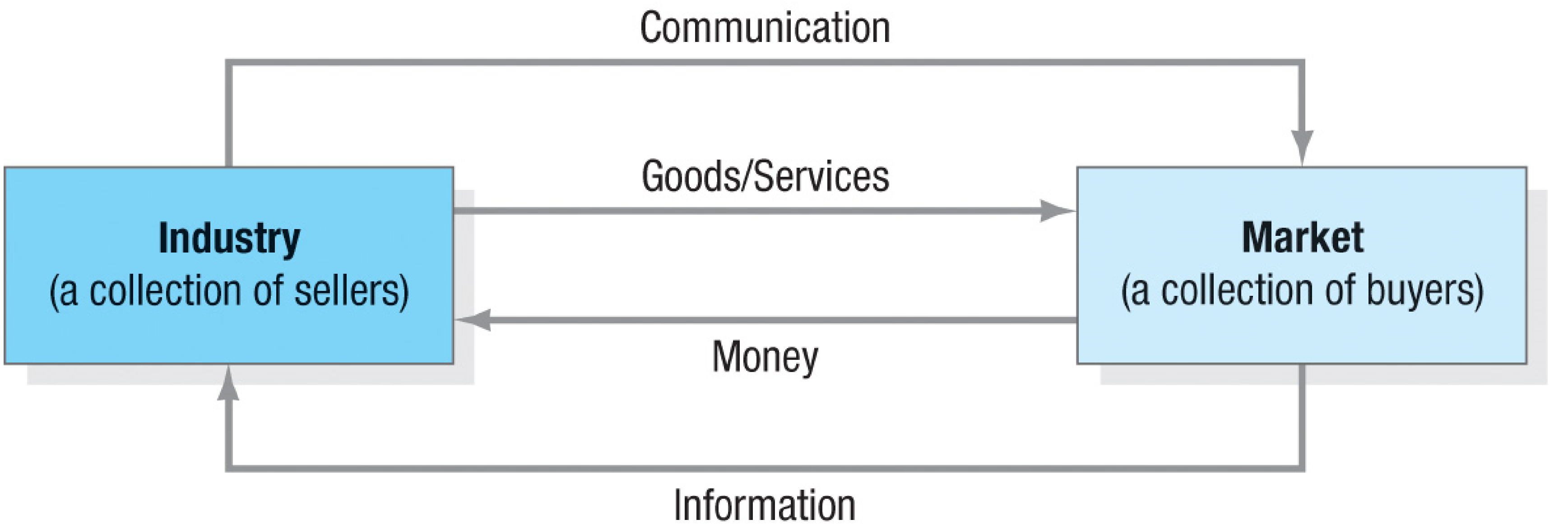
- Three basic functions
  - Operations/Production
    - Goods oriented (manufacturing and assembly)
    - Service oriented (health care, transportation and retailing)
    - Value-added (the essence of the operations functions)
  - Finance-Accounting
    - Budgets (plan financial requirements)
    - Economic analysis of investment proposals
    - Provision of funds (the necessary funding of the operations)

Organization of Businesses (Cont.)

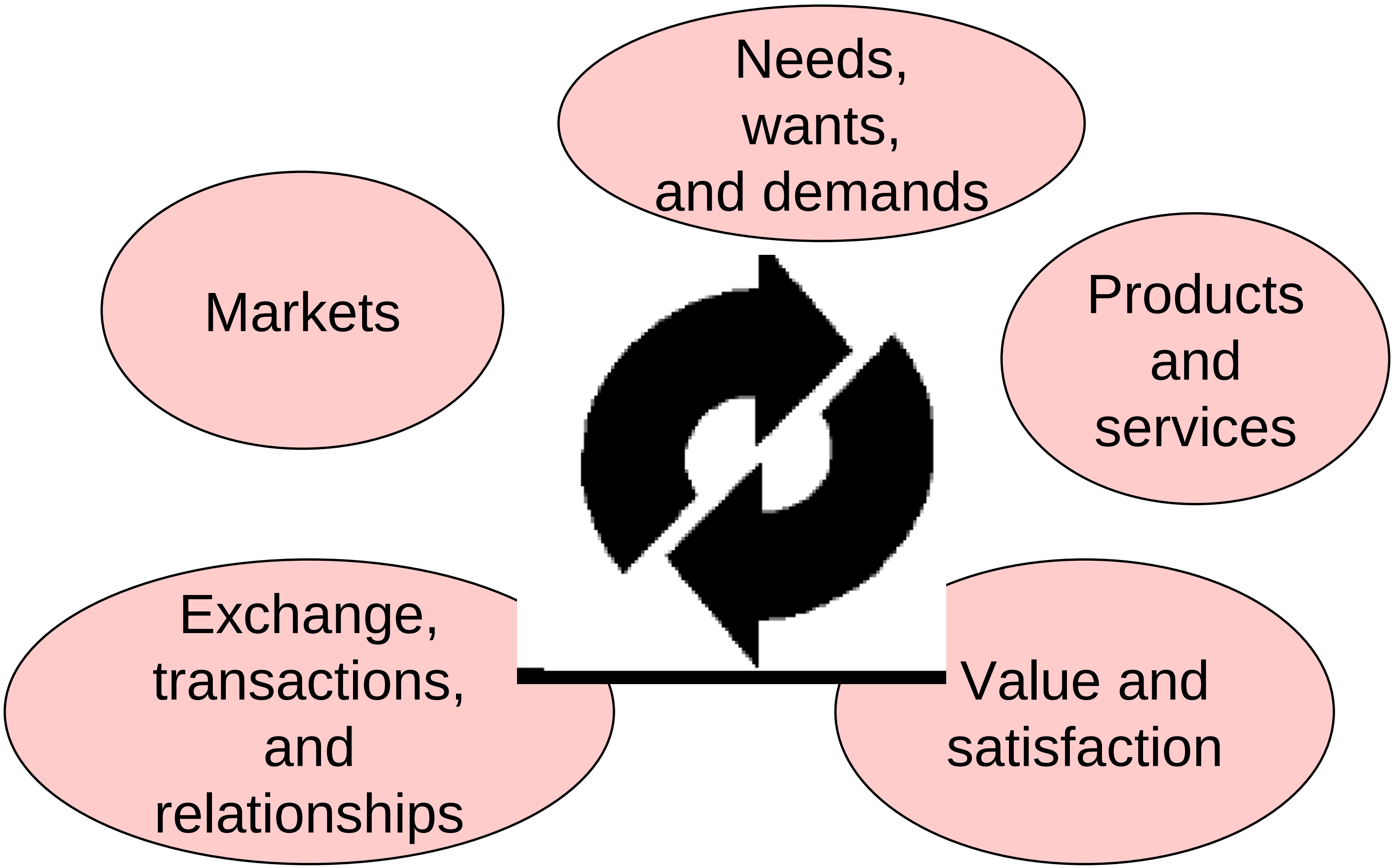
- Marketing
  - Selling
  - Promoting
  - Assessing customer wants and needs
  - Communicating those needs to operations
- The need for working closely



A Simple Marketing System



Core Concepts of Marketing



Core Concepts of Marketing

- *Needs, wants, and demands*
- *Marketing offers: including products, services and experiences*
- *Value and satisfaction*
- *Exchange, transactions and relationships*
- *Markets*

- **Need**
  - Basic human requirements
  - State of felt deprivation
    - Example: Need food
- **Wants**
  - Needs directed to specific objects
  - The form of needs as shaped by culture and the individual
    - Example: Want a Big Mac
- **Demands**
  - Wants which are backed by buying power

Core Concepts of Marketing

- *Needs, wants, and demands*
- *Marketing offers: includes products, services and experiences*
- *Value and satisfaction*
- *Exchange, transactions and relationships*
- *Markets*

- **Marketing offering**
  - Combination of products, services, information or experiences that satisfy a need or want
  - Offer may include services, activities, people, places, information or ideas
  - banking, airline, hotel, tax preparation, and home repair services

Core Concepts of Marketing

- *Needs, wants, and demands*
- *Marketing offers: including products, services and experiences*
- *Value and satisfaction*
- *Exchange, transactions and relationships*
- *Markets*

- **Value**
  - Customers form expectations regarding value
  - Marketers must deliver value to consumers
- **Satisfaction**
  - A satisfied customer will buy again and tell others about their good experience

Core Concepts of Marketing

- *Needs, wants, and demands*
- *Marketing offers: including products, services and experiences*
- *Value and satisfaction*
- *Exchange, transactions and relationships*
- *Markets*

- **Exchange**
  - The act of obtaining a desired object from someone by offering something in return
- **Transaction**
  - *Trade of values* between two or more parties
- One exchange is not the goal, *relationships with several exchanges* are the goal

- **Relationships** are built through delivering value and satisfaction
  - **Marketing network** : consists of the company and all its supporting stakeholders

Core Concepts of Marketing

- *Needs, wants, and demands*
- *Marketing offers: including products, services and experiences*
- *Value and satisfaction*
- *Exchange, transactions and relationships*
- *Markets*

- **Market**
  - Set of **actual and potential buyers** of a product
  - Marketers seek buyers that are profitable

Marketing Process

Create value *for* customers and build customer relationships

Capture value *from* customers in return

Understand the marketplace and customer needs&wants → **Design a customer-driven marketing strategy** → **Construct a marketing program that delivers superior value** → **Build profitable relationships and create customer delight** → **Capture value from customers to create profits and customer quality**

Company Orientations Towards the Marketplace

Production Concept	**Consumers prefer products that are widely available and inexpensive**
Product Concept	**Consumers favor products that offer the most quality, performance, or innovative features**
Selling Concept	**Consumers will buy products only if the company aggressively promotes/sells these products**
Marketing Concept	**Focuses on needs/ wants of target markets & delivering value better than competitors**

Production Concept

- Consumers will favor those products that are widely ***available and low in cost***.
- Managers concentrate on achieving ***high production efficiency*** *and* ***wide distribution.***

- The assumption is valid at least in 2 situations :
  - The demand for a product exceeds supply (suppliers will concentrate on finding ways to increase production)
  - The product's cost is high and has to be decreased to expand the market.

Product Concept

- Consumers will favor those products that offer the ***most quality, performance or innovative features***.
- Managers in product-oriented organizations concentrate on making ***superior products*** and improving them over time.
- The assumption: the customers will admire well-made products and can evaluate product quality and performance.

Selling Concept

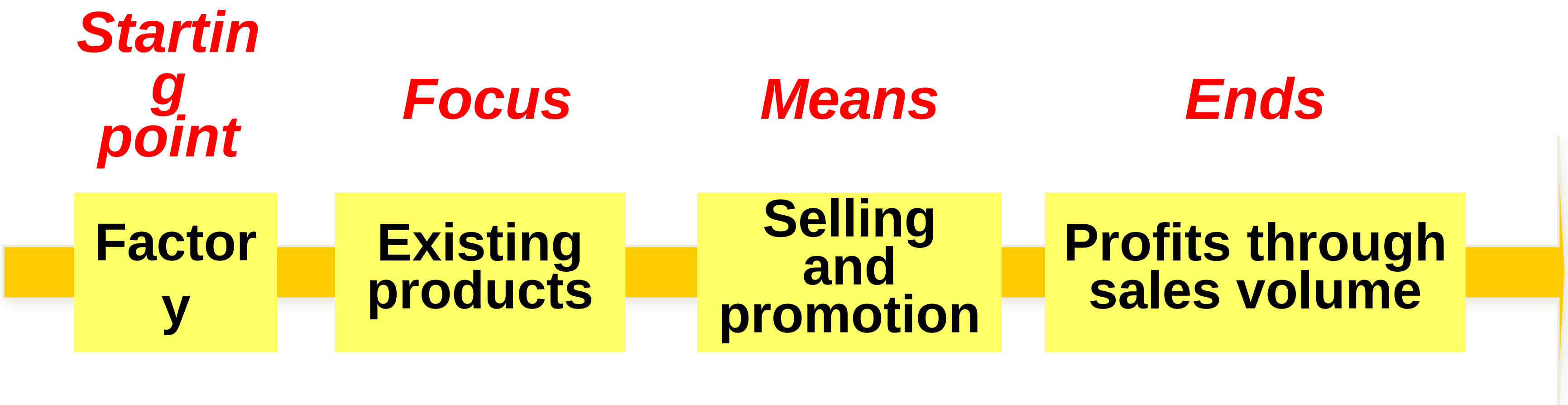
- ***Agressive selling and promotion***
- Assumptions are;
  - Consumers must be ***convinced of buying*** company products
  - Company is powerful in generating effective selling and promotion to ***stimulate more buying***
- This concept is mostly used by firms which have overcapacity.
- The aim is "*to sell what they make*" rather than "make what the market wants."
- ***Short-term profits*** are more important (customer dissatisfaction may occur)

Marketing Concept

- Key to achieving organizational goals consists of being more ***effective*** than competitors ***in creating, delivering and communicating customer value to target markets.***

- ***4 pillars of modern marketing :***
  1. **Target market**
  2. **Customer needs**
  3. **Integrated marketing**
  4. **Profitability through customer satisfaction**

Marketing and Sales Concepts Contrasted



(a) The selling concept

(b) The marketing concept

Marketing Concept *(cont.)*

1) ***Target market*** : homogenous group of customers to whom the company wishes to appeal
2) ***Customer needs***
   - Consumers may not be fully conscious of their needs
   - It may not be easy to articulate these needs
   - They may use words that require some interpretation
   - ***Customer-oriented thinking***: to define customer needs from the customer's point of view

   2) Sales revenue : New customers + Repeat customers
   - "Customer Retention" vs. "Customer Attraction"
   - Customer satisfaction is a function of the product perceived performance and buyer's expectations

Marketing Concept *(cont.)*

3) Integrated Marketing

Various marketing functions must work together for customer satisfaction (*coordination of 4Ps; marketing mix elements*)

- ***Marketing Mix*** : controllable variables (tactics) the company puts together to satisfy its target market(s).

Product: Product variety, quality, design, features, brand name, packaging, sizes, services, warranties, returns

Price: List price, discounts, allowances, payment period, credit terms

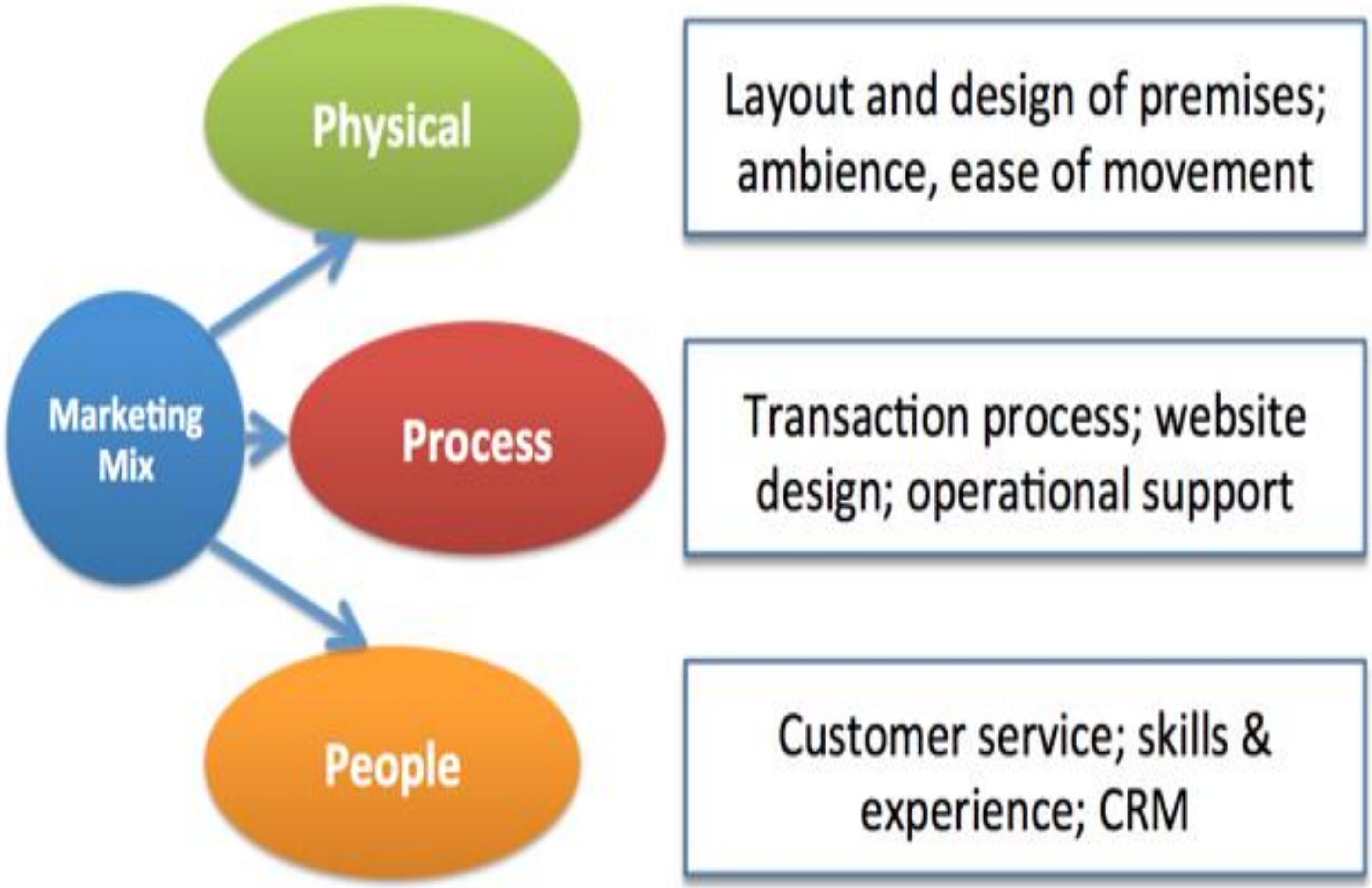
Promotion: Sales promotion, advertising, public relations, direct marketing

Place: Channels, coverage, assortments, locations, inventory, transport

Marketing Concept - The 4 P’s

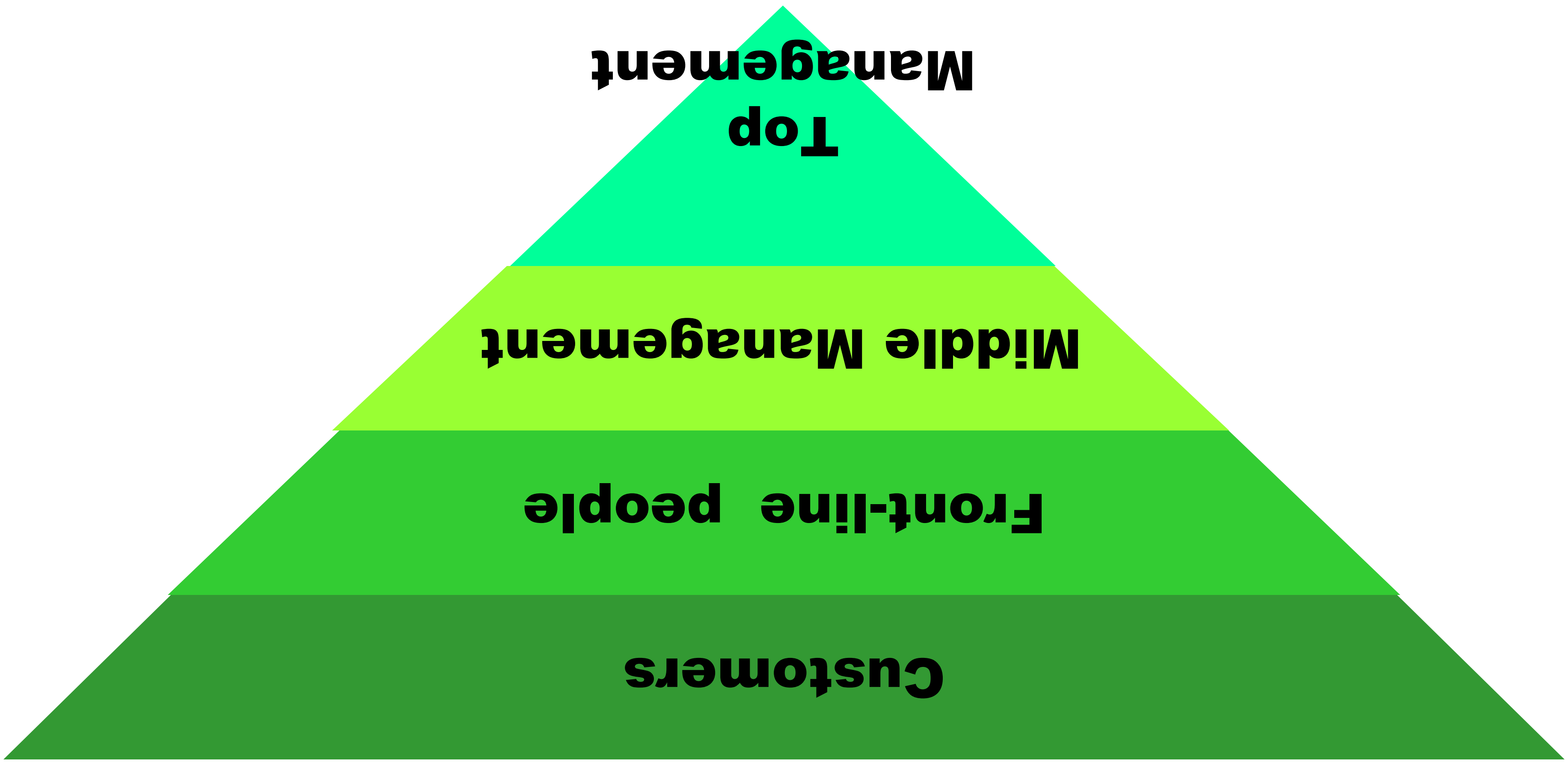
Marketing Concept - The 4 P's :The 4 Cs

Extended Marketing Mix

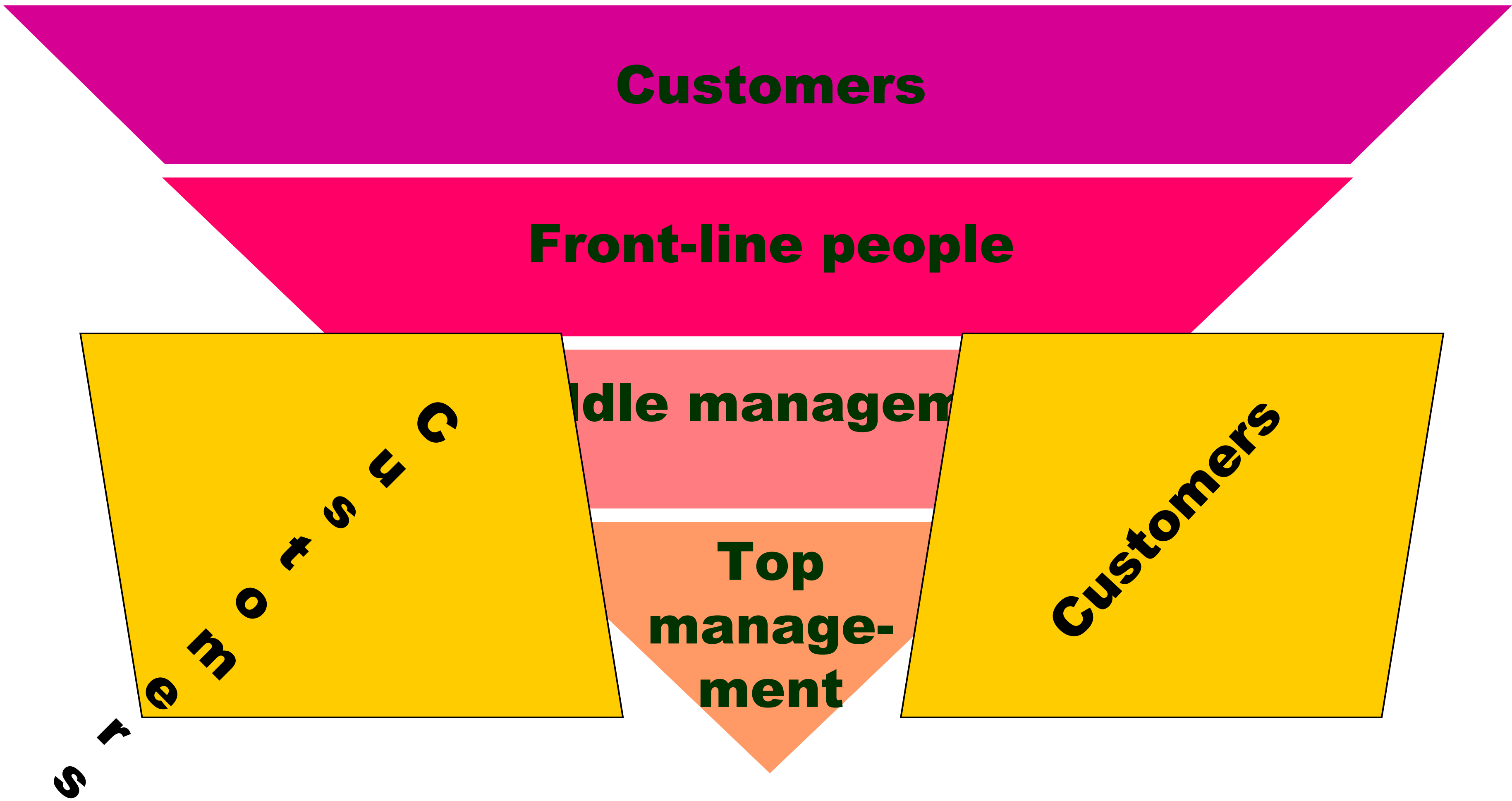


Modern Marketing Concept

Traditional Organization Chart



Modern Marketing Concept Customer-Oriented Organization Chart



Relationship Marketing Concept

- Customer Relationship Management : the overall process of building and maintaining profitable customer relationships by delivering superior customer value and satisfaction.
  - It deals with all aspects of acquiring, keeping and growing customers
  - Relationship building blocks : "customer value" and "customer satisfaction"
  - "Customer retention" and "customer loyalty"
  - The intention to gain a greater proportion of an existing customer's purchases over a long period (increase "consumer lifetime value"!)

Customer Relationship Management
Capturing Value from Customers

Key Concepts

- *Customer Loyalty and Retention*
- *Share of Customer*
- *Customer Equity*

- Customer delight leads to emotional relationships and loyalty
- Customer Lifetime Value (CLV) shows true worth of a customer

Customer Relationship Management
Capturing Value from Customers

Key Concepts

- *Customer Loyalty and Retention*
- *Share of Customer*
- *Customer Equity*

- Share of customer’s purchase in a product category.
- Achieved through offering greater variety, cross-sell and up-sell strategies.

Customer Relationship Management
Capturing Value from Customers

Key Concepts

- *Customer Loyalty and Retention*
- *Share of Customer*
- *Customer Equity*

- The combined customer lifetime values of all current and potential customers.
- Measures a firm's performance, but in a manner that looks to the future.
- Choosing the "best" customers is key

How should a business be defined

Company	Product-Oriented Answer	Market-Oriented Answer
Kodak	We make cameras & film	We help preserve beautiful memories
Amazon.com	We sell books & recordings	?
HP	We make computer printers..	?
Nordstrom	We sell clothing for families	?
Steelcase	We make office furniture	?
Caterpillar	We make construction machinery	?

Common reasons for product failures

In addition to a faulty concept or product design, some of the most common reasons for product failures typically fall into one or more of these categories:

- High level executive push of an idea that does not fit the **targeted market**.
- Overestimated **market size**.
- Incorrectly **position**ed product.
- Ineffective **promotion**, including **packaging** message, which may have used misleading or **confusing marketing message** about the product, its features, or its use.
- Not understanding the target market **segment** and the **branding process** that would provide the most value for that segment.
- **Incorrectly priced**—too high and too low.
- Excessive research and/or product development costs.
- Underestimating or not correctly **understanding competitive activity** or retaliatory response.
- Poor timing of distribution.
- Misleading **market research** that did not accurately reflect the actual consumer’s behavior for the targeted segment.
- Conducted marketing research and ignored those findings.

Marketing Planning & Marketing Planning Process

Marketing planning

- Successful companies are driven by a market orientation and strategic planning
- **Strategic plan** is only the starting point of planning
- It serves as a guide to the development of sound sub-plans or business plans to achieve the organization's objective
- These business plans are prepared for each division, product category, product, and important target markets.

Marketing planning

- The **business plan** has three purposes:

  - It serves to develop a strategy

  - It serves as the justification of the budget request

  - It provides as an instrument for monitoring ongoing progress and making corrections during the plan implementation period

Marketing planning

- **A crucial part of every business plan is the marketing plan**
- The marketing plan operates at **two levels**:

- **Strategic marketing plan (long term)**

  - develops the broad marketing objectives (MO) and strategy based on an analysis of current market situation and opportunities

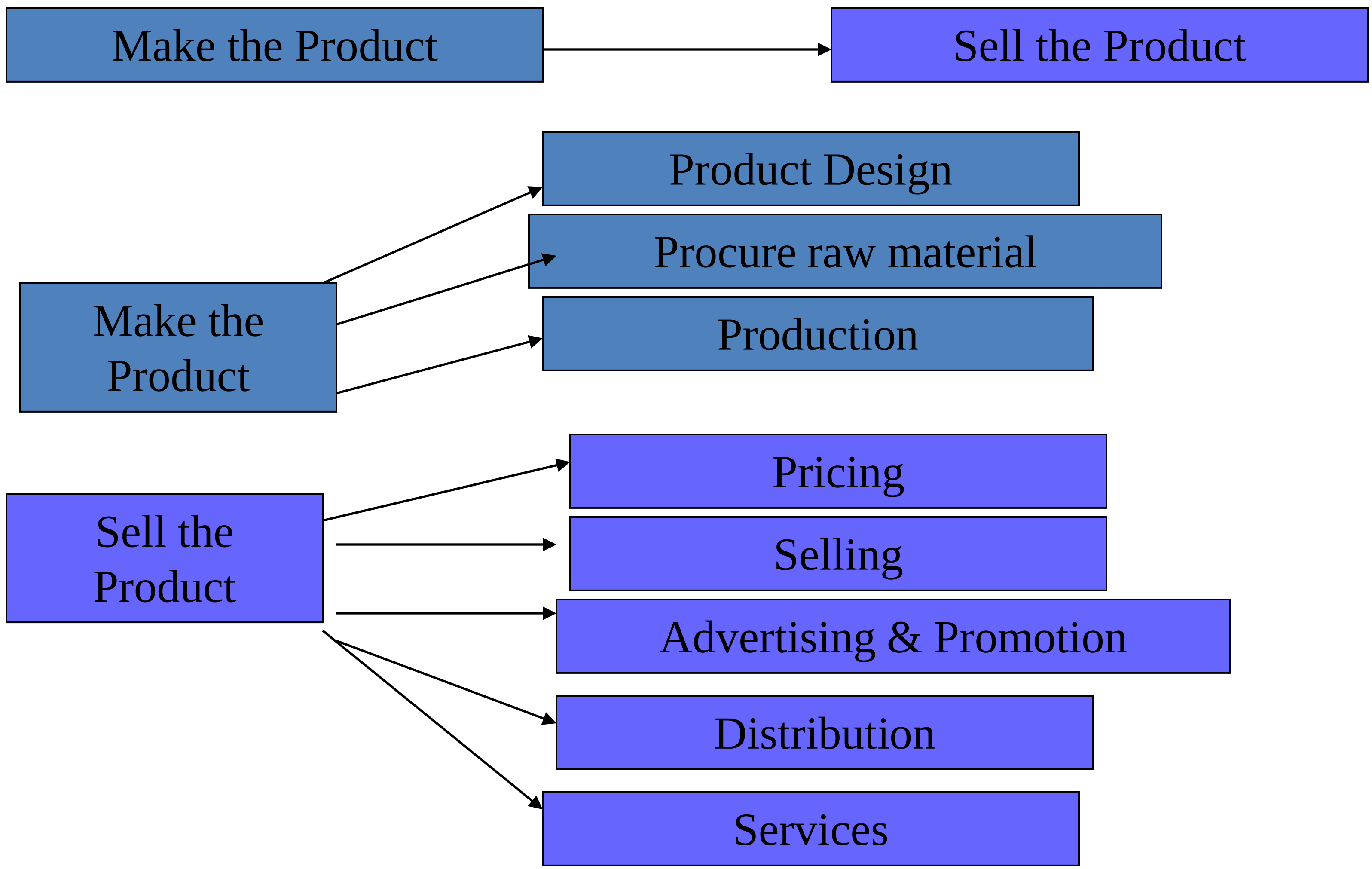
- **Tactical marketing plan (short term)**

  - outlines the specific marketing tactics for the period, including advertising, pricing, channels, services etc.

The marketing process

- Two views of the value-delivery process
- “Firm proceeds to make something and then to sell it” – **traditional view**

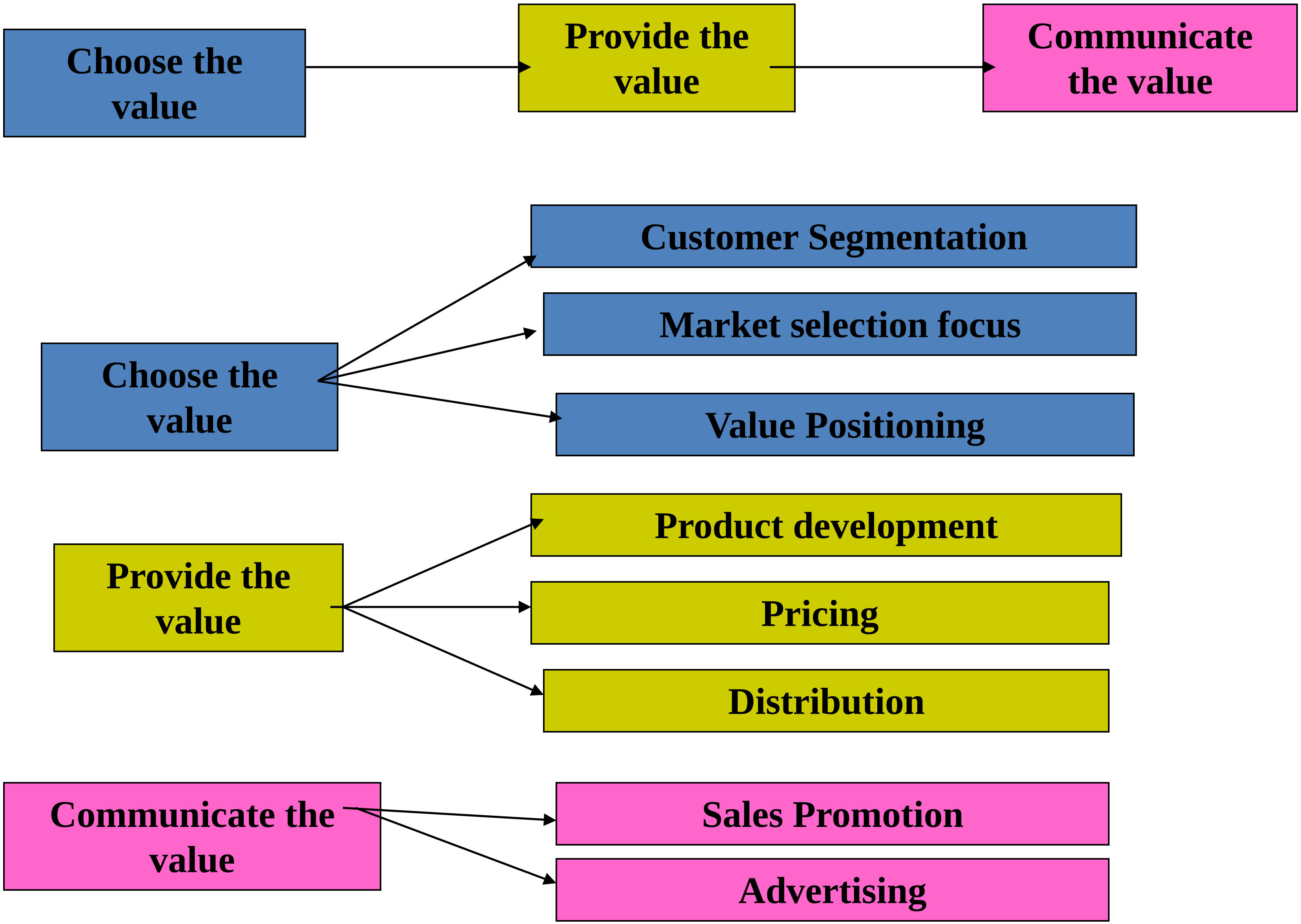
Traditional view of Marketing Process



“Marketing at the beginning of the business planning process” – **present view**

- choosing the value, providing the value and communicating the value

Present view of Marketing Process



The marketing process

- Choosing the value
  - segment the market,
  - select the appropriate target market
  - develop the offer’s value positioning
- The formula segment, target and positioning (STP) is the essence of strategic marketing

The marketing process

- Provide the value

  - product development

  - pricing

  - distribution
- Developing specific features of the product, prices and distribution are part of tactical marketing

The marketing process

- Communicate the value

  - inform the market about the offer

  - sales promotion

  - advertising

  - other promotional tasks

The marketing planning process

- The marketing planning process consists of
- analyzing market opportunities,
- selecting target markets,
- designing market strategies,
- planning marketing programs,
- organizing, implementing and controlling marketing efforts

The marketing planning process

- Analyzing market opportunities

  - analyze long run opportunities in the market for improving the performance
- Tools:

  - reliable market information system

  - marketing research (customers' needs, their locations, buying practices etc)

  - understanding company micro environment (suppliers, market intermediaries, customers, and competitors) and macro environment (demographic, economic, social/cultural, technological, political and legal forces)

The marketing planning process

- Analysis of consumer market (how many potential consumers, who buys, why do they buy, what are their preferences, where do they buy, frequency of buying)

- competitors' analysis

The marketing planning process

- Selecting target markets

  - measure and forecast the attractiveness of any given market (estimating market size, growth, profitability and risk)

  - market segmentation

The marketing planning process

- Designing marketing strategies

  - differentiating and positioning market

  - new product development, testing and launching

  - new product strategy will have to be modified at the different stages in the product life cycle (introduction, growth, maturity and decline)

The marketing planning process

- Planning marketing programs

  - making basic decisions on marketing expenditures, marketing mix, and marketing allocation

  - what level of marketing expenditure is necessary to achieve its marketing objectives? (marketing budget to sales ratio)

  - how to divide the total marketing budget among the various tools in the marketing mix?

  - allocation of marketing budget to the various products, channels, and markets?

The marketing planning process

- Organizing, implementing and controlling marketing efforts

  - Organizational set up for implementing the marketing plan

  - feedback procedures

  - control mechanisms (annual plan control, profitability control, strategic control)

The marketing planning process

- Annual plan control

  - divide the well defined goals in the annual plan for each month or quarter

  - measure ongoing performance in the market

  - determine the causes of any serious performance gaps

  - choose corrective actions

The marketing planning process

- Profitability control

  - measuring actual profitability of products, customers groups, trade channels, and order sizes

  - profitability of different marketing activities

  - how various marketing activities could be carried out efficiently?

The marketing planning process

- Strategic control

  - evaluating whether the company's marketing strategy is still appropriate to the market conditions?

  - marketing audit

Components of marketing plan

Sl	Section	Purpose
I	Executive summary	Presents a brief overview of the proposed plan for quick grasp for management
II	Current marketing situation	Presents relevant background data on the market, product, competition, distribution and macroeconomic environment
III	Opportunity and issues	Swot analysis & major issues for the product
IV	Objectives	Defines the goals the plan wants to reach (sales volume, market share, profit)
V	Marketing Strategy	Presents the broad marketing approach to be used to achieve the objectives
VI	Action programs	Answers like what will be done, who will do, when it will be done, how much it will cost
VII	Profit and loss statement	Forecast the expected financial outcomes
VIII	Controls	Indicate how the plan will be monitored

Product Life Cycle & Marketing Strategy

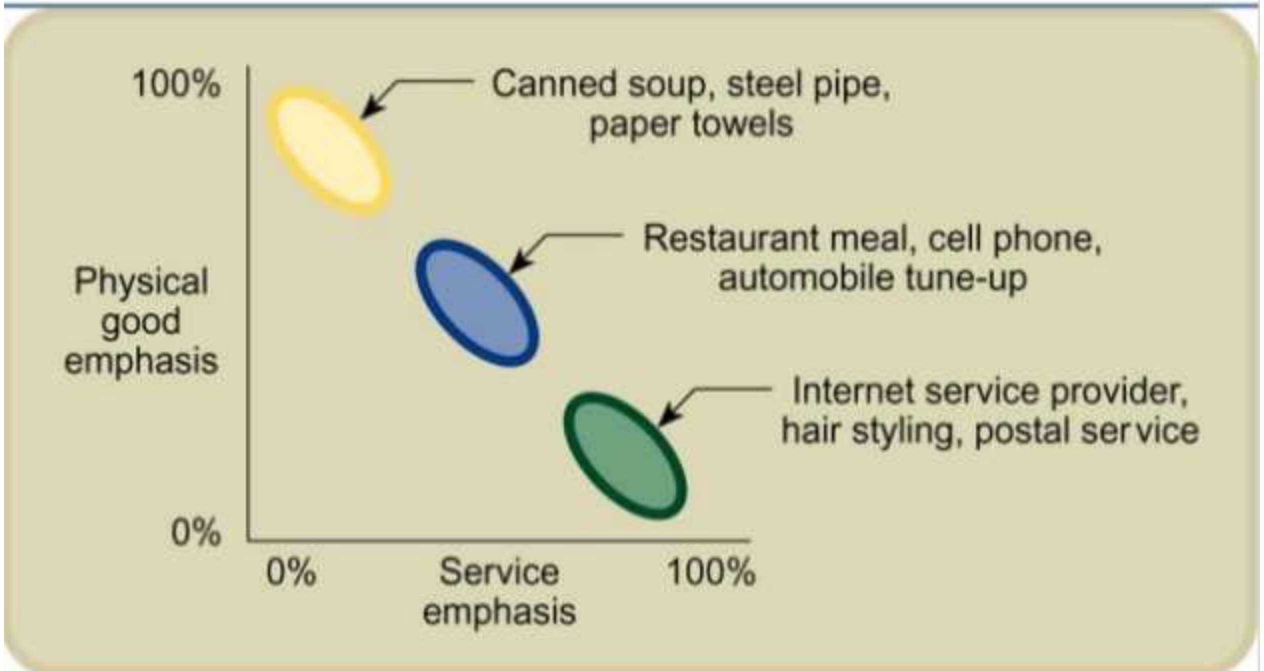
What is a product?

•Product is anything which is of value & is offered thro' voluntary exchange

•A change in feature creates a new product

•Service : Set of activities, benefits or satisfaction offered for sale
» Intangible
» May not result in ownership

Goods and/or Services Are the Product



Demand for products

What is the demand for these products in 2013 compared to 1990?

???

» Fixed phone, land-line
» Cell phones
» Umbrella
» Video cassette player
» Diabetes Insulin injections

Why would demand change?

•New products meet needs better
» Maruti 800 v/s Premier Padmini

• Technology changes
» Video conference v/s air travel

• Substitutes replace a product
» Telegrams v/s SMS, SMS v/s Mobile Chat

• Population moves to the next level in Maslow's NH
» Basic variant of a car to full loaded model

PLC Concept is Based on Four Premises

Products have a limited life.

Profits from a product vary at different stages in the life cycle.

Product sales pass through distinct stages, each with different marketing implications.

Products require different strategies at different life cycle stages.

Product Life-Cycle Strategies

PLC Stages

- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

- Begins when the company develops a new-product idea
- Sales are zero
- Investment costs are high
- Profits are negative

Product Life-Cycle Strategies

PLC Stages

- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

- Slow sales growth – cell phones 15 yrs back, Hybrid cars today, Blu-Ray technology, HD TV
- Intensive promotions, communications
- Price uncertainty
- Uncertain competition reactions
- Uncertain consumer responses
- Non-existent profits
- Negative cash flow

Product Life-Cycle Strategies

PLC Stages

- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

- Rapid sales growth – cell phones today, internet, LCD TV
- Market acceptance
- Price stabilization
- Features stabilization
- Profits start coming in
- Brand building starts
- Competition starts building

Product Life-Cycle Strategies

PLC Stages

- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

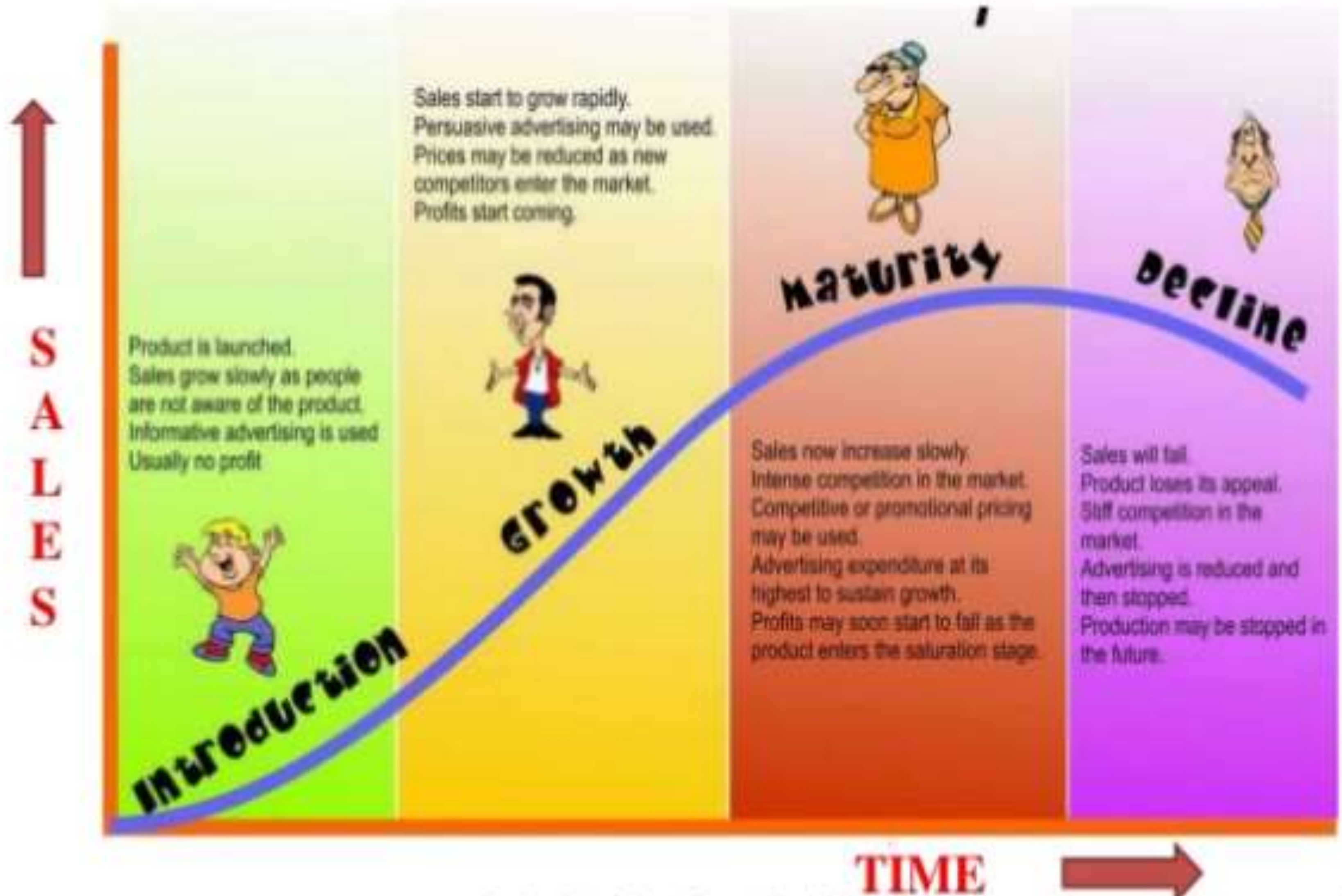
- Slow sales growth – Land lines, 100cc motorbikes, fountain pens
- Price reductions, promotions
- Features changes / reductions / new
- Profits go down
- Competitors introduce new products
- Brand sustainability is imperative in communication

Product Life-Cycle Strategies

PLC Stages

- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

- Decline in sales – audio & video cassette players, pagers
- New products meet satisfaction
- Profits erode
- Communication expenses are stopped


Sales start to grow rapidly.
Persuasive advertising may be used.
Prices may be reduced as new competitors enter the market.
Profits start coming.
Maturity
Decline
S A L E S
Product is launched.
Sales grow slowly as people are not aware of the product.
Informative advertising is used
Usually no profit
Growth
Sales now increase slowly.
Intense competition in the market.
Competitive or promotional pricing may be used.
Advertising expenditure at its highest to sustain growth.
Profits may soon start to fall as the product enters the saturation stage.
Sales will fall.
Product loses its appeal.
Stiff competition in the market.
Advertising is reduced and then stopped.
Production may be stopped in the future.
Introduction
TIME

Marketing Strategies in the PLC

	Introduction	Growth	Maturity	Decline
Marketing objectives	Create product awareness & trials	Gain market share, create strong positions	Defend market share, create profits	Reduce expenses milk brands
Product strategy	Offer basic Products Eg. Vodafone	Offer product extensions, build service differentiation	Diversify brands, items & models Eg. Blackberry	Phase out weak products
Price	Charge cost Plus	Penetration price promotions, deals Eg Dominos in India	Match pricing to strong competitors	Cut prices
Advertising & Communications	Chosen market segments are addressed	Segment awareness	Advertise differentiation	Reduce levels to retain loyalists
Place	Build Selective Distribution Eg. Hushpuppies	Build intensive distribution	Build more intensive distribution	Go Selective: Phase out unprofitable outlets

Examples of product failures

Automotive and transportation

- Cadillac Cimarron
- Pontiac Fiero
- Chevrolet Corvair
- Ford Edsel
- The DeLorean
- Crosley
- The Tucker
- The Gremlin, the Javelin and a complete line of other models by American Motors
- GM's passenger diesel engine
- Mazda's Wankel rotary engine
- Firestone 500 tire

Computer industry

- IBM's PCjr—introduced in March 1985
- Apple's Newton
- Apple's Lisa
- Coleco's Adam
- Percon's Pocketreader—hand held scanner, now operating under the company name PSC
- Bumble Bee's software version of the book "What Color is Your Parachute"

Food and beverage

- Burger King’s veal parmesan
- Burger King’s pita salad
- McRib—and still being tested and tried
- Nestle’s New Cookery—but a successor, Lean Cuisine, is a big hit
- Gerber’s Singles—dinners in jars, for adults—early ’70s
- Chelsea—“baby beer”

Entertainment

- Quadraphonic audio equipment
- World Football League
- Women’s National Basketball Association
- World League of American Football
- United States Football League
- “He and She,” “Berrengers,” every spinoff done by the former cast of “Seinfeld,” and dozens of other television shows each year.
- “Of God’s and Generals,” “Heavens Gate,” “Water World,” “The Postman” and other movies—with a disproportionately high number produced by Kevin Costner.

Other products

- DuPont's CORFAM —synthetic leather
- Mattel's Aquarius
- Timex's Sinclair
- Clairol's Touch of Yogurt Shampoo (1979)
- Sparq portable mass storage
- Rely tampons
- Relax-a-cizor—vibrating chair