

Operations Management

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UNIT - I

Concept of Productivity

Productivity

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Production = Output

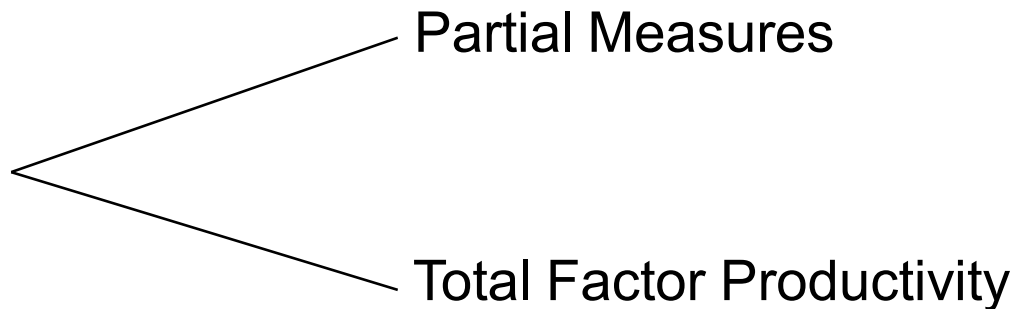
Resources

- Men (Manhours)
- Materials (KGs, Litres, Rs.)
- Machines (Machine Hours)
- Money
- Land & Building

Productivity Can be Measured For:

- Individual
- Section
- Division
- Department
- Industry
- Group of Industries
- Country as a whole

Productivity



Why Stress on Labour Productivity?

$$\text{Total Factor Productivity} = \frac{\text{Production at standard Price}}{\text{Labour} + \text{Materials} + \text{Overhead} + k (\text{Capital Invested})}$$

Where k is a fraction taking value below 1

<u>Output for a tyre mfg. company</u>			
<u>Output</u>		2004-05	2005-06
(i)	Number of Tyres Produced	16,000	20,000
(ii)	Life of a Tyre in KM	20,000	15,000
(iii)	Price of a Tyre	2,000	1,600

Assumption: Level of input same during both the years.

Productivity Measurement

(a) Number of Tyres

$$= \frac{20,000 - 16,000}{16,000} \times 100 = 25\%$$



(b) Tyre KM

$$= 320 \text{ million} \longrightarrow 300 \text{ million}$$

$$= \frac{20}{320} \times 100 = 6\%$$



(c) Monetary Terms

$$= 32 \text{ million} \longrightarrow 32 \text{ million}$$

$$= \text{No change}$$

Improvement in Labour Productivity (In Earlier Days)

- (1) Work Study
 - Method Study
 - Work Measurement (Time Study) – ‘Norms’
- (2) Job Evaluation
- (3) Job Re-Design
 - Job Enlargement / Enrichment (Multi – skilling)
- (4) Rewards & Penalties
- (5) Financial Incentives Schemes

Other Areas

(A)Materials

- (i) Inventory control – to reduce inventory from few months to few days.
- (ii) Variety reduction, simplification, standardization, value analysis / value engg. Wastage reduction.
- (iii) Reduce re-work / rejection rate (through SQC techniques)
- (iv) Improve Yields
- (v) Supply Chain Management
- (vi) Improvement in Materials handling & Plant Layout.

(B) **Machines**

- Preventive Maintenance
- Reduce Set-up Time (Single minute change of die – the shingo systems.
- Avoid idle time of machines
- Reliability Programme

(C) **Money**

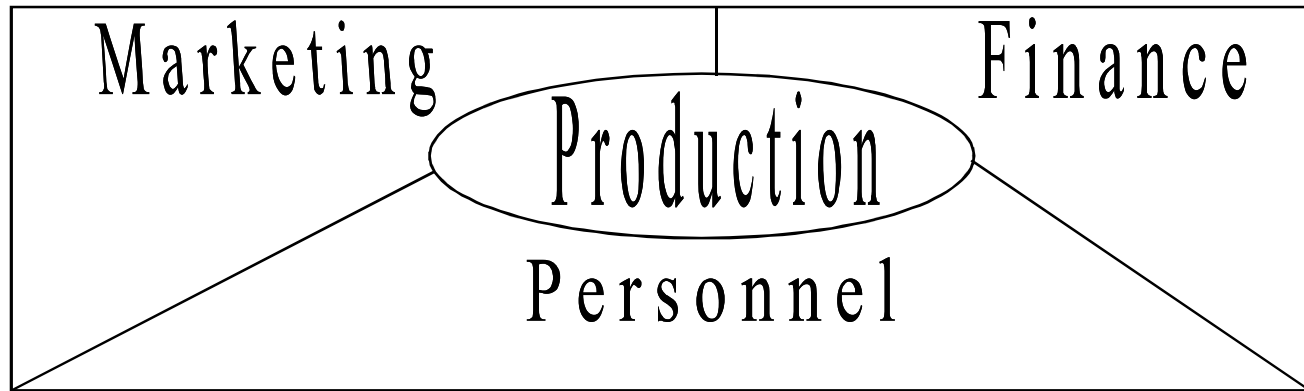
- Reduce Cycle time of manufacturing
- Improve recoveries – go to 90 days being common
- Corporate down – sizing / right – sizing
- Effective budgeting & cost control

Other Modern Techniques

- (i) Just – in – Time Manufacturing
- (ii) Computer integrated manufacturing & flexible manufacturing
- (iii) Total Quality Management
- (iv) ISO – 9000 series
- (v) Business Process Re-engineering
- (vi) Bench marking

Unit – I: Introduction to Production Management

FUNCTIONAL SUB-SYSTEMS OF ORGANIZATION



- **Marketing Function** : Secures Sales Order
- **Production Function** : Production of items or provision of services
- Production function needs to organize resources (Raw Materials, Equipments, Labour, working capital)
- **Finance Function** : Provides authorization & control to all other subsystems to utilize money more effectively through a well-designed mechanism (provides necessary & timely working capital to production function)

Personnel function is a supporting function which plans & provides manpower to all other sub-systems of the org., formulate proper recruitment & trg. Programs. It also monitors performance of employees, maintain good I.R., proper promotion policy etc.

All functional sub-systems are inter-woven by many linkages. They cannot function in isolation. Complete integration for effective functions is necessary.

CHARACTERISTICS OF MOST SERVICE SYSTEMSS

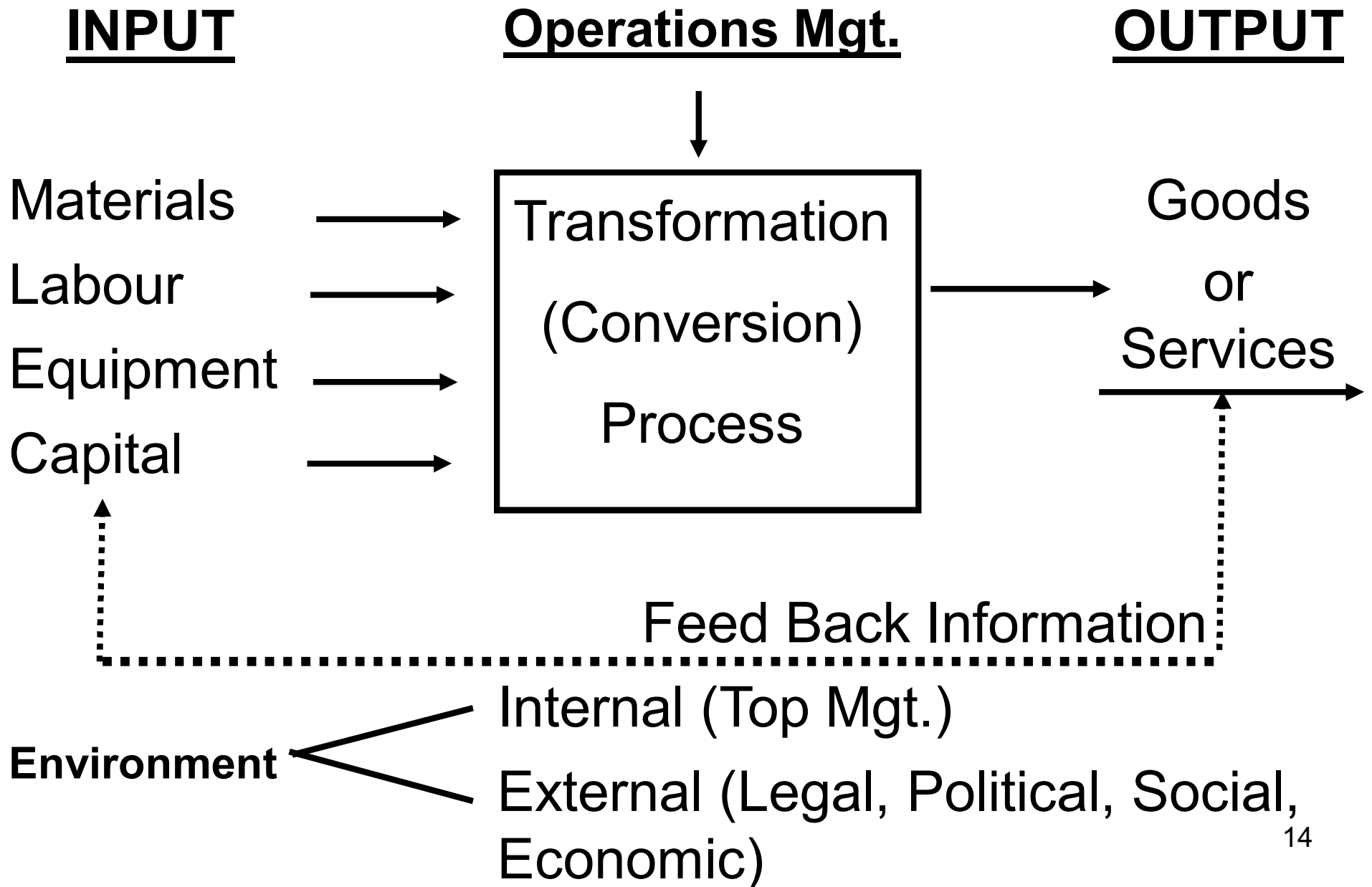
1. Intangible Items
2. Production & consumption occur simultaneously.
3. No inventory is accumulated

MANAGEMENT DECISIONS

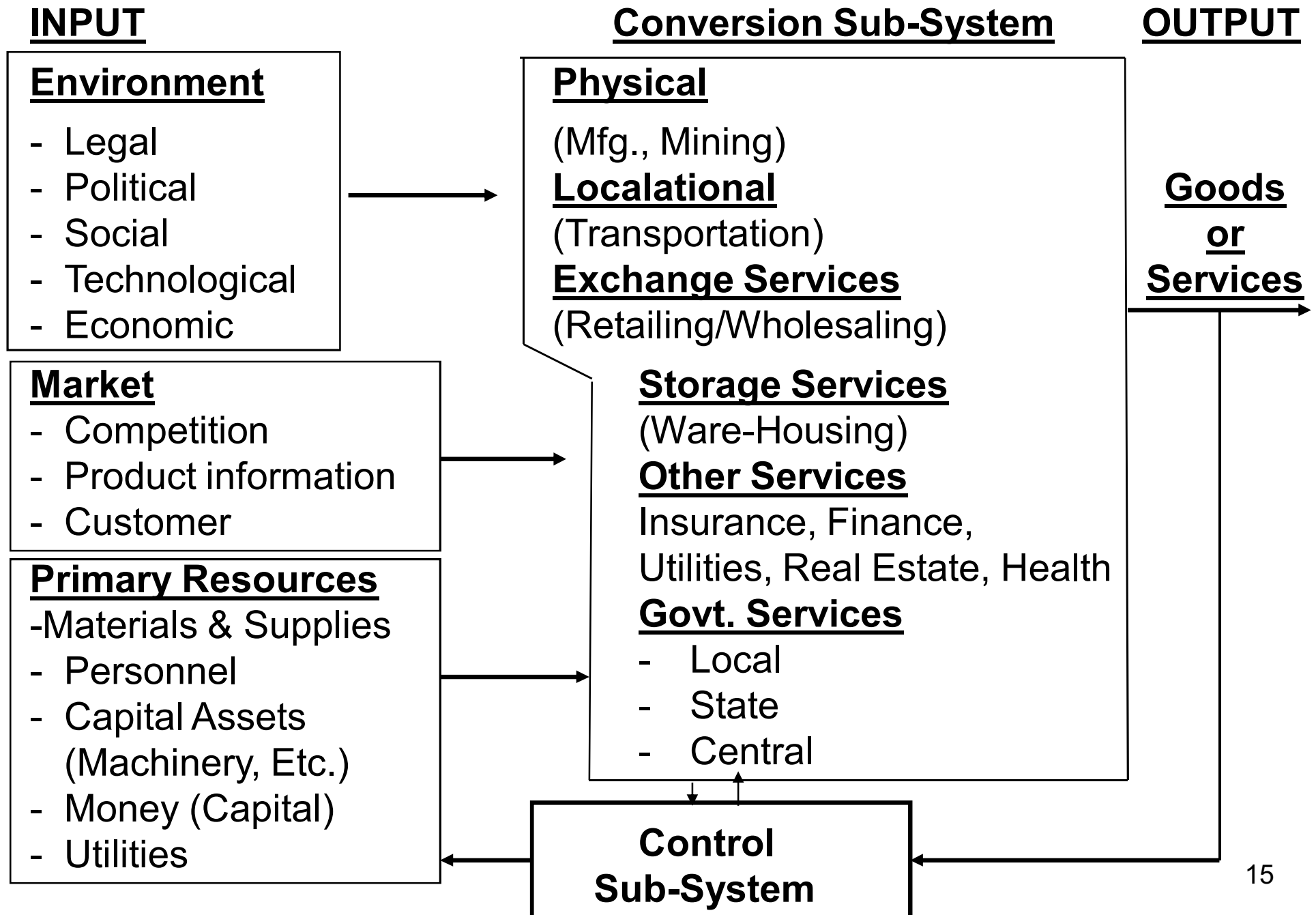
**Relative Frequency of
decisions at different
levels of Mgt.**



SYSTEMS ASPECT OF OPERATIONS/PRODUCTION FUNCTION



A PRODUCTION SYSTEM MODEL



OPERATIONS MANAGEMENT (OVERVIEW)

- Product design & process selection (Manufacturing & service)
- Plant (facility) location
- Plant Layout
- Materials handling
- Job design & work measurement
- Demand Forecasting
- Production / operations planning & control
- Aggregate planning & master production scheduling
- Materials requirements planning
- Operations scheduling
- Shop floor planning & control
- Quality control (control charts & acceptance sampling)
- Inventory control (Materials Mgt.)
- Purchasing, Materials Storing & Materials Accounting
- Productivity

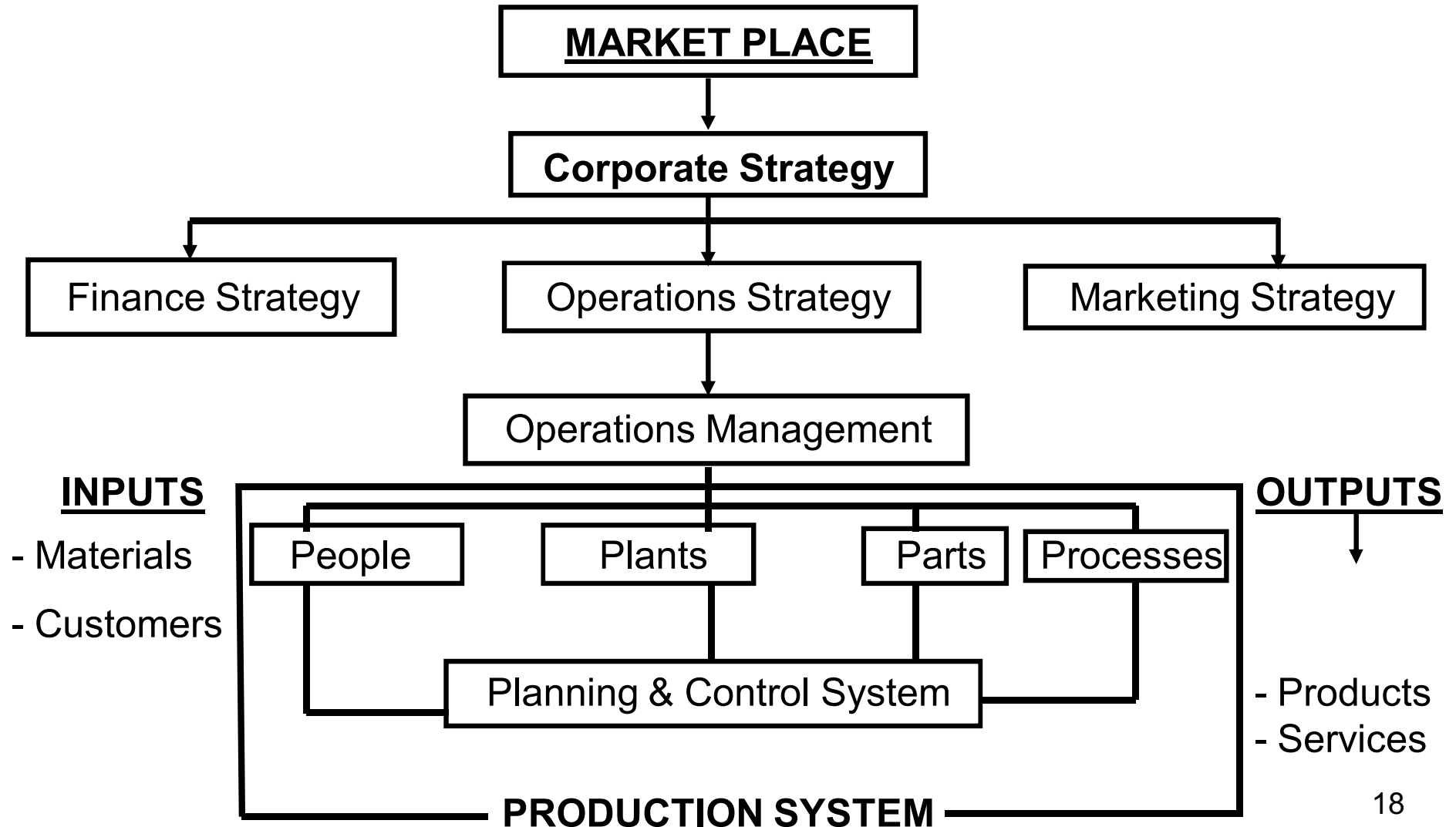
PRODUCTION SYSTEM-5P's OF PRODUCTION

A production system uses operations resources to transform inputs into some desired output. Operations resources consist of five P's of operations management.

- People
- Plants
- Processes
- Parts
- Planning & Control Systems

OPERATIONS MANGEMENT (O.M.)

OM is the design, operation and improvement of the production systems that create the firm's primary products or services. OM is a functional field of business with clear line management responsibilities.



TRANSFORMATION PROCESS

A production system uses operations resources to transform inputs into some desired output. An input may be raw material, a customer or a finished product from another system.

Operations resources consist of five p's (people, plants, parts, processes, planning & control systems) of operations management.

Transformation that takes place include the following:

- Physical as in manufacturing
- Location as in transportation
- Exchange as in retailing
- Storage as in ware-housing
- Physiological as in health-care
- Information as in tele communication

BELOW ARE SOME OF INPUT-TRANSFORMATION – OUTPUT RELATIONSHIPS

<u>System</u>	<u>Primary Inputs</u>	<u>Resources</u>	<u>Transformation Function</u>	<u>Desired Output</u>
Hospital	Patients	Doctors, Nurses, Medicines, etc.	Healthcare (Physiological)	Healthy Individuals
Automobile Factory	Sheet Metal, Engine Parts	Tools, Workers, Equipments	Fabrication and Assembly of Cars	High Quality of Cars
College or University	10+2 or Graduate s	Teachers, Books, Class Rooms	Imparting Knowledge	Educated Individuals

CHARACTERISTICS OF SYSTEMS TO PRODUCE PRODUCTS

VS. **SERVICES**

Products

1. Tangible
2. Can be produced to inventory for “off the shelf” availability
3. Minimal contact with ultimate consumer
4. Complex & inter-related processing

Services

1. Intangible & Perishable
(Consumed in the process of their production)
2. Availability achieved by keeping production system open for services
3. High contact with clients or customers
4. Simple processing

Products

5. Demand on system variable on weekly, monthly & seasonal basis
6. Markets served by production system are regional, national & international
7. Large units that can take advantage of economies of scale
8. Location of the system is in relation to regional, national & international markets

Services

5. Demand commonly variable on hourly, daily & weekly basis
6. Markets served by production system are usually local
7. Relatively small units to serve local markets
8. Location dependent on location of local customers, clients and users.

- PRODUCTION FUNCTION
- Importance (Wealth of country increases)
- Neither a capitalist or socialist, national wealth, no country can exist without it. If enough is produced, distribution will not pose much problems.

- **Areas of Productivity-Production Function**
- 1. Improving volume of production
- 2. Reducing rejection rate
- Minimizing re-work rate
- 4. Maintaining delivery schedules
- 5. Controlling idle machine & manpower hours.
- 6. Establishing / updating / improving / setting industrial engineering norms
- 7. Updating processes & procedures
- 8. Maintaining accuracy & timeliness of M.I.S.

9. Decreasing machine setup time
10. Controlling overtime
11. Good house-keeping
12. Checking absenteeism, thefts / pilferage and misconduct
13. Eliminating accidents
14. Effective grievance-handling
15. Effective training & team-building
16. Minimizing inventory & achieving better yields
17. Enhancing customer satisfaction
18. Total quality management (TQM)
19. Business process re-engineering (BPRE)
20. Automation

WHY STUDY PRODUCTION MANAGEMENT ?

Next to agriculture, factories are largest employers. Factories have unique place in our country and bring about desired changes in our socio-economic outlook. Our incomes, living standards, wants, life styles, etc. are influenced by factories.

People are common ingredients of all activities that take place in factories, however automated the factory may be. Contrary to popular belief, factory is not a sinner that has annihilated the handcrafts. Factory does not disrupt ecology, destroy traditional values, cause various kinds of pollution-need proper steps to be taken.

PROBLEMS OF PRODUCTION & HOW ARE THESE TACKLED IN PRODUCTION MANAGEMENT

Long Run Decisions

1. Selection of the product
2. Design of the product
3. Selection of equipment & processes
4. Production design of items processed
5. Job Design
6. Site of industry & business
7. Facility layout

Short Run Decisions

1. Inventory control
2. Production control
3. Maintenance & reliability of systems
4. Quality control
5. Labour control
6. Cost control & improvement

FUNCTIONS & RESPONSIBILITIES OF PRODUCTION MANAGER

- Produce goods at minimum cost & to maximum satisfaction of buyer-(cut throat competition)
 - Ensure efficient use of all resources, produce right quality at right time.
-
1. Production planning
 2. Production control
 3. Quality control
 4. Methods analysis (most efficient & economical method)
 5. Plant layout & materials handling
 6. Inventory control
 7. Work study
 8. Motivation (increase of labour productivity, incentive schemes, etc.)
 9. Cost control
- (use qualitative & quantitative methods of analysis to get desired solutions)

CURRENT ISSUES/CHALLENGES FACING OPERATIONS MANAGEMENT

(PRODUCTION MANAGEMENT)

1. Global Market Place

Globalisation has resulted in steep increase in the level of competition among manufacturing firms throughout the world

2. Production/Operations Strategy

Production/Operations Strategy becoming important for overall success of business and relating it to overall business strategy.

3. Total Quality Management (TQM)

TQM adopted to achieve customer satisfaction and never ending quest for improving quality of goods & services.

4. Flexibility

Adapt quickly to changes in demand or product mix or delivery schedules is a major competitive strategy and a competitive advantage to the firms. Also known as agile manufacturing. 28

5. **Time Reduction**

Reduction in manufacturing time and speed to market a new product gives a competitive edge, price & quality remaining same.

6. **Technology**

Integration of advanced technology in products and processes can have great impact on competitiveness & quality. Adoption of automation, computerization information & communication technology is a must for facing competition.

7. **Workers Involvement**

Employee involvement & empowerment (quality circles, use of work teams or quality improvement teams) assigns responsibility & problem solving to lower levels in the organization.

8. **Re - Engineering**

Involves concept of clean-slate approach or starting from scratch in re-designing the business processes.

9.	<u>Environmental Issues</u> Pollution control & waste disposal are key issues for protection of environment & social responsibility. There is increasing emphasis on reducing waste, recycling waste, using less toxic chemicals and using bi-degradable materials for packaging.
10.	<u>Corporate Down-Sizing (or Right-Sizing)</u> Down-sizing or right-sizing has become necessary due to competition, productivity improvements, need for profit and higher dividend payment to share-holders.
11.	<u>Supply-Chain Management</u> Management of supply - chain from suppliers to final customers reduces cost of transportation, ware-housing & distribution throughout the supply chain.
12.	<u>Lean Production</u> Production systems use minimal amount of resources to produce high volume of high quality goods with some variety. These systems use flexible manufacturing systems and multi-skilled workforce to have advantages of mass-production & job production (or craft production).

Process Flow Structures

(Types OF Production Systems)

A process flow structure refers to how a factory organizes material flow using one or more of the process technologies.

- a) Job Shop: Production of small batches of a large number of different products, most of which require a different set or sequence of processing steps. Commercial printing firms, airplane manufactures, machine tool shops, etc. & Plants that make custom-designed printed circuit boards are examples of this type of structure.
- b) Batch: Essentially, a somewhat standardized job shop. Such a structure is generally employed when a business has a relatively stable line of products, each of which is produced in periodic batches, either to customer order or for inventory. Most of these items follow the same flow pattern through the plant e.g., heavy equipment, electronic devices & speciality chemicals
- c) Assembly Line:(Mass Production) Production of discrete parts moving from work station to work station at a controlled rate, following the sequence needed to build the product. eg. Manual assembly of toys & appliances.

And automatic assembly of components on a printed circuit board when other processes are employed in a line fashion along with assembly, it is commonly referred to as a production line.

Continuous Flow

Conversion or further processing of undifferentiated materials such as petroleum, chemicals, beer, etc. as on assembly line, production follows a predetermined sequence of steps, but the flow is continuous rather than discrete. Such structures are usually highly automated and, in effect constitute one integrated machine that must be operated 24 hours a day to avoid expensive shut-downs & start-ups.

The choice of which flow to select, with the exception of continuous flow structures, is generally a function of the volume requirements for each product.

OPERATIONS CONSULTING

Operations consulting deals with assisting clients in developing operations strategies & improving production processes.

Market leadership can be attained by one of three ways:

- (i) Product Leadership
- (ii) Operational Excellence
- (iii) Customer Intimacy

An effective job of operations consulting results in an alignment in a way that enhances the business performance of the client. Companies seek operations consulting in following areas.

(A) Manufacturing (5 p's of production)

- Plant : Addition & location of new plants, relocation
- People : Setting/Revising work standards
- Parts : Make or buy decisions, vendor selection
- Processes : Technology evaluation / process improvement, Re-Engineering
- Planning & Control Systems : Supply Chain Management, MRP, Shop floor control, warehousing, distribution

In practice, all the above aspects (5p's) are inter-related to some extent, manufacturing consulting specializes in process industries, assembly or product manufacture.

(B) SERVICES :

Service operations consulting has a strong industry or sector focus

Financial Services

- Staffing
- Automation
- Quality Studies

Health Care

- Staffing
- Billing
- Office Procedures
- Phone Answering
- Layout

Transportation

- Route Scheduling
 - Reservation System
 - Baggage Handling
- } For Airlines

Hospitality

- Reservations
- Staffing
- Cost Containment
- Quality Programs

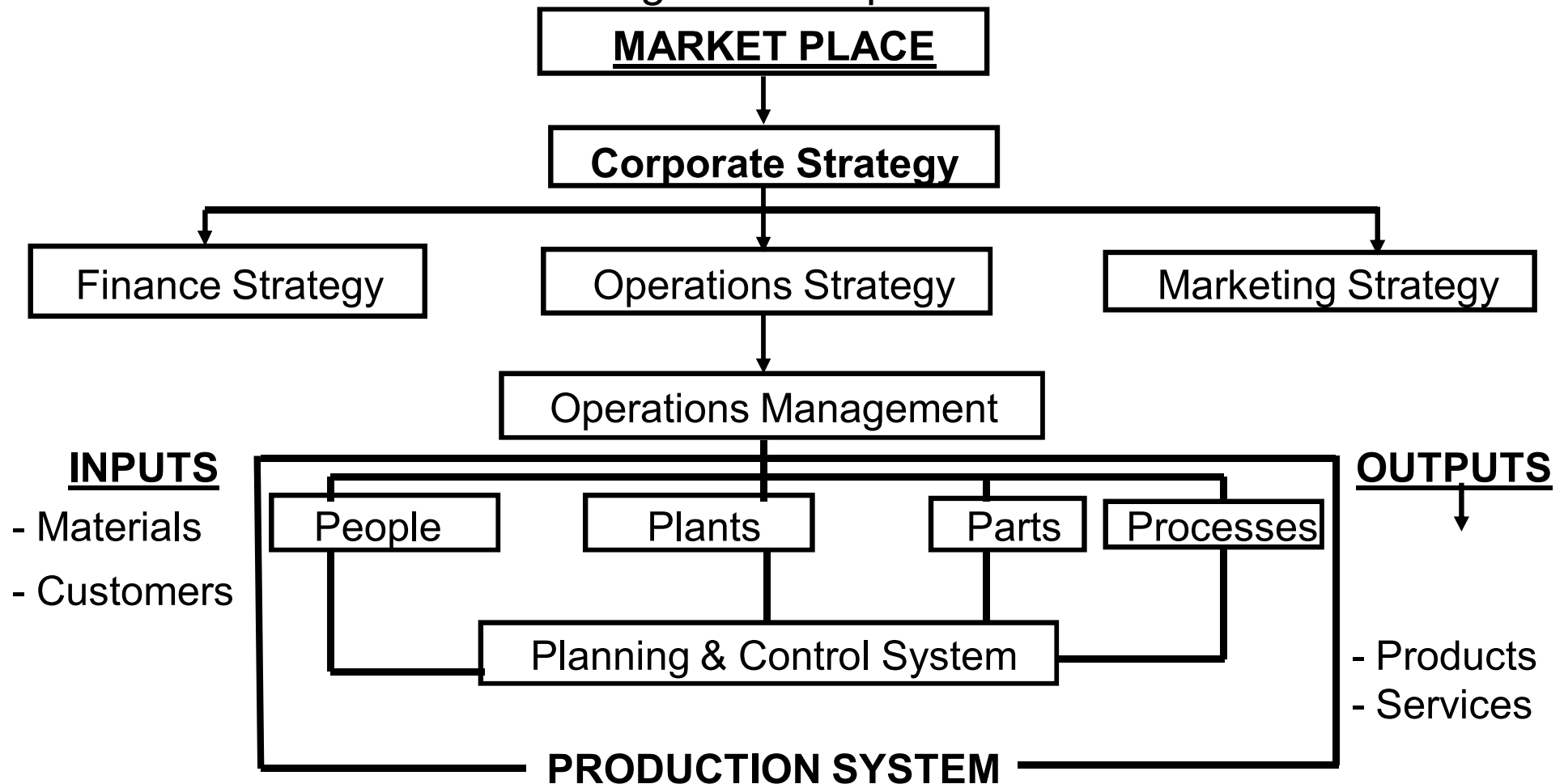
Most important area of all the service industries consulting is re-engineering.

OPERATIONS CONSULTING TOOLKIT

- Problem Definition
- Data Gathering
- Data Analysis
- Solution Development
- Cost Impact
- Pay off Analysis
- Implementation

OPERATIONS Management (OM)

O.M. is the design, operation & improvement of the production systems that create the firm's primary products or services. O.M. is a functional field of business with clear line management responsibilities.



A production system – Uses operations resources to transform inputs into some desired outputs

UNIT - II

Product Design & Process Selection - Manufacturing
PRODUCT DESIGN & ANALYSIS
(TANGIBLE PRODUCTS)
(MANUFACTURING)

PRODUCT DESIGN

It is the first step immediately after accepting the concept of a product. Product design has direct bearing on plant layout & in-process materials flow.

Critically analyze different design features with relevance to places of use substitute materials and plan equipment alternatives for manufacturing product.

The purpose of product design & analysis is to determine & specify products that will be profitable to manufacturers & distributors and will give human satisfaction.

Aspects in Product Design

1. Design for Function

- (a) Meet customer's expectations
- (b) Strength & durability of products & its components

2. Design for making / Manufacturing

- (a) Materials, fastening devices
- (b) Proper specifications
- (c) Using standard parts
- (d) Operational convenience of machines

3. Design for Selling

- (a) Appearance
- (b) Convenience meeting customers needs

Product Design

- (a) New Products
- (b) Modifications for existing products

New Product Development

- | | |
|-----------------|---|
| Concepts | <ol style="list-style-type: none">1. External Appearance2. Internal Components (performance, reliability, durability giving long term satisfaction)3. New product screening (evaluate potential)4. Business Analysis (estimate economic feasibility)5. Product Development (cost estimates for manufacturing, packaging, distribution)6. Testing Stage (potential market acceptance market research)7. Commercialization (introduction into market place) |
|-----------------|---|

PRODUCT DESIGN

Human factors engineering or ergonomics Endeavour to apply relevant information about human characteristics and behaviour to the design of things people use, the methods by which they are used and the environment in which people work and live.

In addition to the psychological aspects involved in designing equipments in industries / end user products, physical effects of working nature on the human beings (worker/any person using end products) should be considered while designing either equipment or end user terms like cars, two wheelers etc. Some of these effects are taken into account in the designing of equipments that workers use.

Design of physical devices/products

Since the worker (human part) cannot be redesigned reconstructed, the machine/equipment/product must be adapted to the worker. The determination of best location requires considerable understanding of human capabilities & limitations. In product / equipment, information displays properly located. In machines, levers, hand wheels be of proper size requiring minimum force / direction, etc.

PROCESS PLANNING & DESIGN

Process decisions affect cost, quality, delivery & flexibility of operations.

Process Selection

It is based on :

- (i) To customer order
or
Inventory
- (ii) High volume line or low volume batch production
- (iii) Whether to integrate forward towards the market or backwards towards suppliers.

Process Planning Design

It is a complete determination of specific technological process steps and their sequence to produce products at desired quality, quantity and cost. This is undertaken by process engineering deptt. to:

- a) Determine method of manufacturing product
- b) Sequence & type of operations
- c) Tools & equipments required
- d) Analyze how manufacturing will fit into the facilities

VALUE ANALYSIS AND VALUE ENGINEERING

Value analysis (VA) and Value Engineering can be defined as an organized and systematic approach to provide the required function at the lowest cost consistent with specific performance, quality and reliability.

Value analysis pertains to the existing product and services whereas Value Engineering is concerned to the design of new products.

The value can be increased in three ways:

- i. Retain the value but reduce the cost.
- ii. Retain the cost but increase the value.
- iii. Increase the cost if necessary, but increase the value much more than the cost.

The value analysis team is a cross-functional team. If the objective of value analysis is enhancement of the market value, then the value analysis team leader will be the head of the marketing department. If the objective of value analysis is to reduce the cost or the product innovation, then the value analysis team leader will be the head of the manufacturing.

Cost of value

The value is of two types, namely the *use value* and the *esteem value*.

Use value: The product quality is fundamentally defined as fitness for use. Value analysis is primarily concerned with the 'use value'. This is also known as the primary or the basic value of the product.

Esteem value

The esteem value is the enhanced value associated with a brand or a product created by smart marketers. This is a notional or snob value for which the customer is ready to pay higher. This is also known as the secondary value associated with the product.

Steps in Value Analysis

The following steps are to be followed for the value analysis.

1. Collect data about cost function, customer needs, history and likely future developments related to the product and its use. Determine the function of the product.
2. Develop alternative designs. The selected alternatives should be able to fulfill the functional requirement of the product.
3. Ascertain the cost of the alternatives.
4. Evaluate the alternatives in all respect. The alternative which fulfills all the basic or primary value considerations and maximum number of secondary value considerations is the ideal alternative subject to the cost consideration which should be minimum.
5. Recommend and implement the best solution. Identify the control point and devise a plan for periodic measurement of the performance and correct the deviations if any.

Value Analysis - Areas of Improvement

In value analysis, the areas of improvements are basically identified in four areas. They are:

- a. The functional aspect of the product and services,
- b. The intrinsic cost of the materials,
- c. Manufacturing and
- d. Specification.

AIMS OF VALUE ENGINEERING

- Simplify the product
- Use cheaper & better materials
- Modify & improve product design.
- Use efficient processes
- Reduce product cost.
- Increase utility of product by economical means
- Save money or increase profits

Steps / Procedure in Value Engineering

- Identify the product
- Collect the relevant information
- Define different functions
- Define / create different alternatives
- Critically evaluate the alternatives
- Develop the best alternative
- Implement the alternative

Step I: **Identify the Product**

- ✓ Any design change should add value
- ✓ Value can be applied to a product as a whole or to its subunits

Step II: Collect relevant information

- ✓ Technical specifications with drawings
- ✓ Production processes, machines, layout, instruction sheet, etc.
- ✓ Time study details & manufacturing capacity
- ✓ Complete cost data & marketing details
- ✓ Latest developments in related products

Step III: Define different functions

- ✓ Define primary, secondary and tertiary functions
- ✓ Specify value content of each function & identify high cost areas.

Step IV: Create different alternatives

- ✓Through brainstorming sessions based on details available from above, create different alternatives
- ✓All feasible and non-feasible suggestions are recorded without any criticism rather participants are encouraged to express their views freely

Step V: Critically Evaluate the Alternatives

- ✓Compare, evaluate, critically assess for their suitability & feasibility as regards their financial & technical requirements. Ideas technically sound and having lesser costs are further developed

Step VI: Develop the best alternative

Development plans comprising of drawing sketches, building of models, conducting discussions with purchase section, finance section & marketing division etc.

Step VII: Implement the Alternative

✓The best alternative is converted into a proto-type manufacturing model which ultimately alternately goes into operation and its results are recorded.

Advantages o Value Engineering

- ❖It is a much faster cost reduction technique.
- ❖It is less expensive technique.
- ❖Reduces production costs and adds value to sales income of the product

Applications of value engineering

- ❖Machine tool Industries.
- ❖Auto Industries
- ❖Import substitutes, etc

DFMA (Designing Products for Manufacture & Assembly)

In the Traditional system, the designer was designing the product without consulting / involving the manufacturing engineers resulting in problems in manufacturing & assembly requiring design changes. Often, these design changes were major resulting in considerable additional expense & delays. To overcome these problems, is to consult manufacturing engineers during the design stage. These concurrent engineering teams require analysis tools to help them study proposed designs & evaluate them from the point of view of manufacturing difficulty & cost.

The greatest improvements related to DFMA arise from simplification of the product by reducing the number of separate parts – the guidance to the designer provides following three criteria against which each part must be examined as it is added to the product during assembly.

- (i) During the operation of the product, does the part move relative to all other parts already assembled?
- (ii) Must be part be of a different material than or be isolated from other parts already assembled.
- (iii) Must the part be separate from other parts to allow disassembly of the product for adjustment or maintenance.

Thus, the new product would be much simpler to assemble. In addition, it should be much less expensive due to reduced number of parts.

Process Selection

Process selection refers to strategic decision of selecting which kind of production processes to have in the plant. eg. For high volumes, assembly line would be appropriate.

Types of Processes

- a) Conversion Processes Changing iron ore into steel or making tooth-paste from various ingredients.
- b) Fabrication Processes Changing raw materials into some specific form e.g. making sheet-metal into body of a car or forming gold into crown for a tooth.
- c) Assembly Processes Assembling car, putting toothpaste tubes into a box, fastening dental crown in somebody's mouth.
- d) Testing Processes Testing of various products by various means for strength or defects etc.

Quality Function Deployment (QFD)

QFD is the approach to getting the voice of the customer into the design specifications of a product. This approach which uses inter-functional teams from marketing, design engineering and manufacturing helps in regarding costs & significantly shortening design times.

QFD process begins with studying & listening to customers to determine characteristics of a superior product through market research. Consumer's product needs & preferences are defined & broken down into categories called customer requirements. These requirements are weighted based on their relative importance to the customer. Next, the consumer is asked to compare & rate the company's products with the products of competitors. This process helps the company determine the product characteristics that are important to the consumer & to evaluate its product in relation to others.

The end result is a better understanding and focus on product characteristics that require improvement.

Customer requirement information forms, the basis for a matrix called the house of quality. By building a house-of-quality matrix, the cross-functional QFD team can use customer feed-back to make engineering, marketing & design decisions & focus on product that satisfies customers.

Process Flow Design

Process flow design focuses on the specific processes that raw materials, parts & sub-assemblies follow as they move through the plant. The most common production management tools used in planning the process flow are assembly drawings, assembly charts, route sheets & flow process charts. These charts can be used to improve productive system. These charts are the “Organization Charts” of manufacturing system.

Assembly Drawing: It is an exploded view of the product showing its component parts.

Assembly Chart uses the information presented in the assembly drawing & defines how parts go together, their order of assembly and the overall material flow pattern.

Operation & Route sheet Specifies operations & process routing for a particular part. It conveys such information as the type of equipment, tooling & operations required to complete the part.

A Flow Process Chart uses symbols to denote what happens to the product as it progresses through the productive facility. Symbols used are explained at the side of char. As a rule, fewer the delays & storages in the processes, the better the flow.

Process Analysis

Detailed process planning entails planning the steps of the process itself, a process usually consists of:

- (i) A set of tasks
- (ii) Flow of material & information that connect the set of tasks.
- (iii) Storage of material & information.

Task: Each task in a process accomplishes, to a certain degree, the transformation of input into the desired output.

Flow: The flow in a process consists of flow of material as well as flow of information. The flow of material involves the transfer of a product from one task to its next task. The flow of information helps in determining how much of the transformation has been done in the previous task and what exactly remains to be completed in the present task.

Storage: When neither a task is being performed nor a part is being transferred, the part has to be stored. Goods in storage, waiting to be processed by the next task, are often called work-in-process inventory

UNIT - III

Product Design & Process Selection – Services

The Nature of Services

Seven Generalizations about services

- (i) Everyone is an expert on services
- (ii) Services are idiosyncratic – what works well in providing one kind of service may prove disastrous in another.
- (iii) Quality of work is not quality of service.
- (iv) Most services contain a mix of tangible & intangible attributes that constitute A Service Package. This package requires different approaches to design & management than the production of goods.
- (v) High-contact services are experienced whereas goods are consumed.
- (vi) Effective management of services requires an understanding of marketing & personnel as well as operations.
- (vii) Services often take the form of cycle of encounters involving face to face, phone, mail interactions, etc.

Service Businesses and Internal Services **(Types of Services)**

Two Types:

(i) Service Business

It is the management of business organizations requiring interaction with customer to produce the service. These include services such as Banks, Airlines, Hospitals, Retail Stores, Restaurants, etc. These are:

- Facilities – Based services (customer to go to facility)
- Field – Based services (Production & consumption at customer environment)
- Technology has enabled transfer of facility – Based services to field – Based, auto-repair mobile shops, telemarketing brings shopping – centre to your TV-screen.

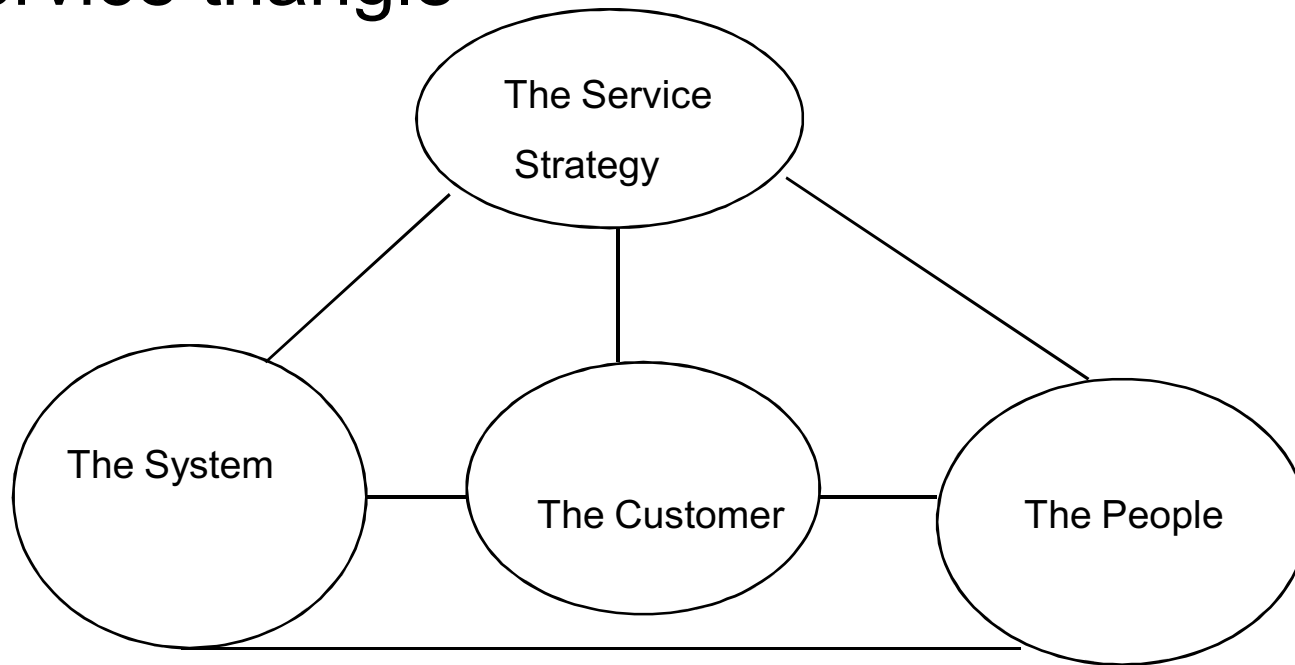
(ii) Interval Services

Management of services required to support the activities of various depts. of a large organization e.g. Data processing, Accounting, Engg. & Maintenance. An internal service can start marketing its services outside the parent organization & become a service business itself.

Customer Contact

Customer contact refers to presence of customer in the system and creation of service refers to the work process in providing the service itself. Extent of contact is the percentage of time the customer be in the system relative to the total time it takes to perform the customer service. Greater the percentage of time, greater the degree of interaction between the two during production process.

A contemporary view of service management – the service triangle



- The customer is the focal point of all decisions and actions of the service organization.
- Also, how the management treats the worker is how the worker will treat the public
- Operations (customer management) is responsible for service systems (procedures, equipment & facilities) & is responsible for managing the work of the service work force.

High degree of customer contact: Service systems are more difficult to control and can affect the time of demand, the quality, the exact nature of service since customer is involved in the process.

Low degree of customer contact : Means that work is done behind the scene & customer is not present during service delivery e.g. Bank's processing centre

Designing service organizations: Unlike manufacturing, we cannot inventory services. In services thus capacity becomes a dominant issue. What capacity to AIM? Waiting line models help e.g. How many tellers in a Bank? How many phone lines in an enquiry system & staff to man these, etc.

Designing involves four elements.

- i. Identification of target market.
- ii. Service concept (how do we differentiate our service in the market)
- iii. Service strategy (Service package & operating focus of our service)
- iv. Service delivery system (Actual processes, staff & facilities by which service is created)

Choosing a target market and developing the service package are top management decisions.

Service Strategy: Focus & advantage

- 1) Treatment of the customer in terms of friendliness and helpfulness.
- 2) Speed and convenience of service delivery
- 3) Price of the service
- 4) Variety of services (essentially one-stop shopping philosophy)
- 5) Quality of the tangible goods that are central to or accompany the service. E.g. eyeglasses made while you wait
- 6) Unique skills that constitute the service offering, such as hair styling, brain surgery, etc

Service Focus: Compete on relatively few dimensions i.e. items “most” emphasized

Items “Most” Emphasized

Items mean (out of 5)

(out of 55)
Accessibility

Openness to employees

Leadership

Listening to customer

Service Tangibles

Employee handling of service failures

Competitive positioning

Quality values

Consistently meeting customer needs

Customer orientation

Management involvement in Quality

4.02

3.91

3.87

3.81

3.79

3.79

3.72

3.68

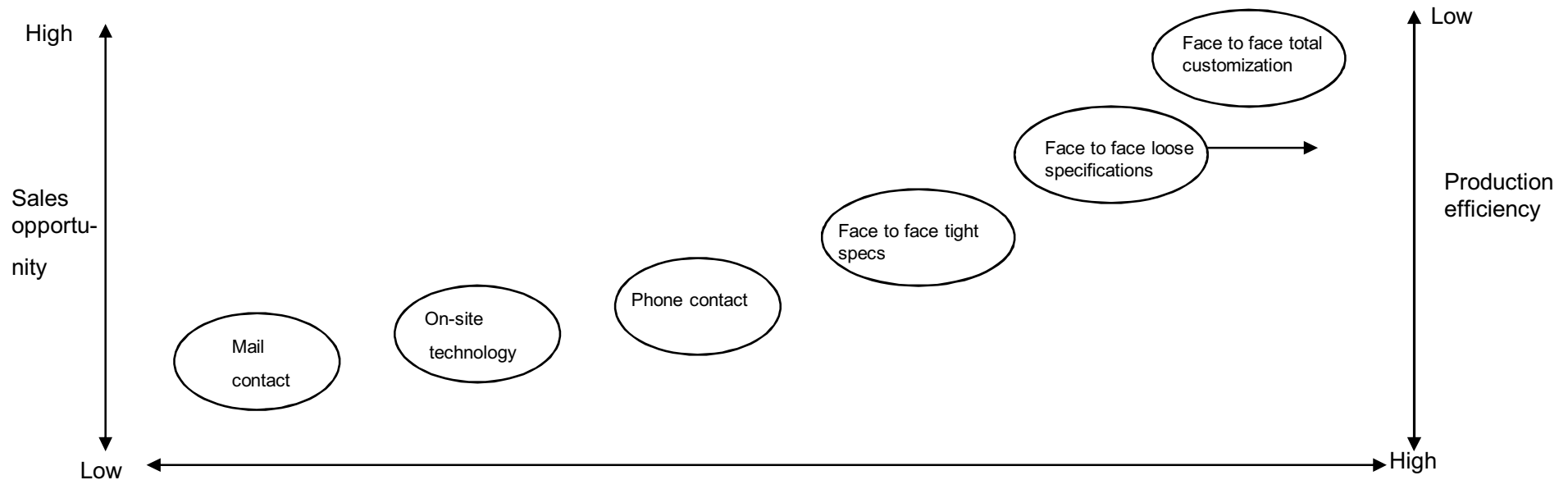
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3.66

- **Service – System Design Matrix**
- **Degree of Customer / Server contact**

Buffered core (none)	Permeable system (some)	Reactive system (much)
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The left side is logical marketing proposition i.e. the greater the amount of contact, greater the sales opportunity. The right side shows the impact on production efficiency as the customer exerts more influence on the operation.

The entries within the matrix list the ways in which service can be delivered, production efficiency decreases as the customer has more contact. To offset this, face to face contact provides high sales opportunity to sell additional products, conversely low contact such as mail allows system to work efficiently but little sales opportunity.

Service Blueprint

The standard tool for service process design is the Flow Chart – Also termed as service Blue-Print. A unique feature of service Blue Print is the distinction made between the high customer contact aspects of the service (i.e. that part of the process which the customer sees) and those activities which the customer does not see. This distinction is made through a “Line of Visibility” on the Flow Chart.

Basic Blue-Printing describes the features of the service design but does not provide any direct guidance as to how to make process conform to the design. Poka –Yokes (Japanese Term meaning to “Avoid Mistakes”) are common in factories and consist of steps/ fixtures to ensure right attachments/ fixtures are used .i.e. parts that can be attached the right way.

Three Contrasting Service Design

Production line approach (made famous by McDonald's corporation)

Self-service approach (Made famous by ATM's & Gas stations)

Personal attention approach (Made famous by Nordstrom Deptt stores & Ritz-Carlton Hotel co)

The Production Line Approach

McDonald treated the delivery of fast food as a manufacturing process rather than a service process. This is based on the premise that manufacturing focusses on the products rather than people and does away with the concept that service implies insubordination of the server to the served. Thus, in manufacturing and at McDonald's, the orientation is towards the efficient production of results & not on the attendance on others.

The systematic substitution of equipment for people & planned use of technology resulted in rapid delivery of uniform, high quality mix of prepared foods in a clean environment.

There has been extensive use of what are called Poka-Yokes in total design & facilities planning. The only choice available to the attendant is to operate as the designers intended. This is categorized as face-to-face tight specification service.

The Self-Service Approach

The service process is enhanced by having the customer take a role in the production of the service. Automatic Teller Machines, Self-Service Gas stations, in-room coffee making equipment, etc are examples that shift the service burden to the consumer. This is the use of on-site technology many customers like self-service because it puts them in control.

It turns customers into “Partial Employees” who must be trained what to do and are “Fail-Safed” in case of mistake.

It is often most profitable to provide both full service & self-service at the same facility. With the reduced prices of self-service Gasoline, the sales increased as well as profitability of dealers.

The Personal Attention Approach

An interesting contrast in the way personal attention is provided can be seen in Nordstrom Deptt. Stores & Ritz-Carlton Hotel Co.

At Nordstrom, rather loose, unstructured process relies on developing relationship between the individual sales person & the Customer (This is Face-to Face with total customization service). At Ritz-Carlton, the process is systemised in such a way that information system rather

Than the employees keep track of guest's personal preferences. This is Face to Face loose specification example.

Nordstrom, the speciality clothing retailer has sales five times per Sq. Foot compared to a Typical Deptt. Store. Sales person religiously carry a “Personal Book” where they record voluminous information about each of their customers, Sales person can send cards, flowers & can even assist customers to any Deptt. Store for shopping to build personal report with each customer.

No matter what approach is taken, the need for following service characteristics (seven characteristics of a well designed service system) be adopted

1. Each element of service system is consistent with the operating focus of the firm. (For example if focus is on speed of delivery, each step in the process should help to foster speed)
2. It is user-friendly.
3. It is Robust i.e. it can cope effectively with variations in demand and resource availability.
4. It is structured so that consistent performance by its people & systems is easily maintained.

5. It provides effective links between the back office and the front office so that nothing falls between the cracks.
6. It manages the evidence of service quality in such a way that customers see the value of service provided. (The improvement communicated explicitly to customer).
7. It is cost effective . (There is minimum waste of time & resources in delivering the service)

Service Guarantees

Many companies have launched service guarantees as a marketing tool designed to provide peace of mind for customers unsure about trying their service. An improvement tool which would be used at a design stage and operation's stage and delivery system to satisfy customer.

The following are elements of good service guarantee:-

- i. Unconditional (No small print)
- ii. Meaningful to customer (Full coverage of pay-off)
- iii. Easy to understand & communicate (for employees & customers)
- iv. Painless to invoke (given proactively)

Conclusion

- Service Businesses in many ways similar to manufacturing businesses.
- Focus is important for success.
- Flow diagrams, service system design matrix similar to product –process matrix and also capacity analysis.

Differences with Manufacturing

- High degree of personalization required.
- Speed of delivery needed.
- Direct customer contact.
- Inherent variability of service encounter.
- Services generally require higher levels of capacity relative to demand.
- Greater need for flexibility on the part of workers.

Scheduling Personnel in Services

Four approaches:-

1. Use of waiting lines (based on first come first served) as a buffer for the difference between customer demand and system capacity (when demand is more than capacity)
2. Use of appointment schedules to level out the demand for services e.g. Medical, Legal & other professional services. Priority for emergency patients.
3. Personnel schedules are developed to allow system capacities which almost match the pattern of customer demand. The system capacity is varied by varying the number of personnel scheduled to work during each hour of the day. Part time personnel may be employed during peak hours.
4. For emergency services such as Fire or Police Departments scheduling of personnel is done on 24 hour full crew coverage. During peak demand periods, off-duty personnel are called-in and are compensated with overtime payment or compensating time off.

Three Difficulties

- [A) Demand variabilites
- [B) Service-time variability
- [C) Availability of personnel when they are needed

Various approaches when demand varies

- (a) Managed through overtime or use of waiting lines to arrive at a balance.
- (b) Managed to ensure availability of part-time employees at short notice.
- (c) To use Full-time employees exclusively.
- (d) To use Full-time & some part time employees.

The nature of demand would decide whether appointment scheduling can be applied or not.

UNIT - IV

Business Process Re-engineering

Michael Hammer, Management Expert defines re-engineering as

“The fundamental re-thinking & radical re-design of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service, speed etc”

Principles of Business Process Re-engineering (BPR)

Re-engineering is about achieving significant improvement in processes so that customer requirements of quality, speed, customization & service are met.

Seven rules of doing work proposed by Hammer:

1. **Organize around outcomes, not tasks**

Combine several tasks performed by different people into a single job having well-defined outcome. This results in greater speed, productivity & customer responsiveness.

2. **Have those who use the output of the process perform the process**

- * Employees can make their own purchases.
- * Customers can perform simple repairs themselves.
- * Suppliers to manage parts inventory.

The above eliminates need to coordinate performers & users of the process.

3. **Merge information processing work into real work that produces the information**

People who collect information should be responsible for processing it. e.g. accounts payable deptt. for purchases.

. **Treat graphically dispersed resources as though they were centralized**

It makes the control of hybrid centralized / decentralized operations a reality. It facilitates parallel processing of work. For instance centralized data bases & telecommunication networks now allows companies to link with separate units of individual field personnel providing them with economies of scale while maintaining their individual flexibility & responsiveness to customers.

5. **Link parallel activities instead of integrating their results**
Parallel activities should be linked continually & co-ordinated during the process in order to avoid re-work, high costs & delays in final outcome of the overall process.
6. **Put the decision point where the work is performed & build control into the process**
Controls be made part of the process & organizations made flatter (removing or reducing levels) & more responsive.
7. **Capture information once – at the source**
Information should be collected & captured in the company's on-line information system only once – at the source where it was created. This approach avoids erroneous data entries & costly re-entries. By creating a new process & sustaining improvement requires more than a creative application of information technology.

By cross functional process evaluation team

Identify the process

The need for improvement of major processes which are problematic, having greatest impact on company customers, offering potential for re-designing & improvement, state of technology etc.

Evaluate enablers

Information technology & human/organization issues act as enablers of re-engg, process. Technology evaluation is a core competency of all companies.

Current organization culture to be evaluated in the light of impending change to be brought about by re-engineering . Issues such as compensation, career paths, work environment, new skills training should be addressed.

Understanding the current process

The current process must be studied to understand activities essential for completion. All work activities to be classified into three types:

- i. Value-adding work: for which customer is willing to pay
- ii. Non-value adding work: required to get value adding work done.
- iii. Waste: Neither adds nor enables value.

Advantages of Re-Engg. (Positive impact)

1. Improvement in entire organization as a whole.
2. Better system & management improvement in areas of
 - * products & services
 - * design & operations
 - * Improved system operations
3. Takes advantages of improved technology.

4. Improved application of industrial Engg. in areas of
 - * Organizational strategies
 - * Management functions
 - * Plant utilization
 - * Quality improvement
 - * Creativity & innovation
 - * Confidence in competition

5. Improvement in customer satisfaction

Non-value adding work: supervising, controlling, co-ordinating etc. (administration)

Waste work: * Erroneous work requiring re-work
* Producing reports that no one reads

Create a new process design

- Eliminate waste work
- Eliminate / minimize non-value adding work
- A major outcome is jobs become bigger & more complex
- Task involves selection of appropriate technology & specialized training for workers
- Multi-skilling (many tasks performed by one person)

Implement the re-engineered process

Involvement of senior management team as steering committee is essential throughout the entire re-engg. effort. Support of line managers is essential since it changes accountabilities, needs training of employees for additional skills, high expectations for results etc.

Negative impact of re-engineering

- Does not pay much attention to the social system of organizations relative to change processes & re-design of work.
- No consensus approach & no involvement of people lower down in the organization.
- Strained industrial relations because re-engg would result in large lay-offs & dislocation of people.

- Impact of layoffs & thus resistance to re-engg minimized through
 - * Re-training & re-deployment.
 - * Reduction through attrition
 - * Transfer to other locations
 - * Comprehensive & carefully designed out-placements programmes
 - * Early retirement inducements
 - * Adequate notice period to employees before layoffs & re-deployment.

The re-engineering process

Six-step plan for process re-engineering

Step 1: State a case for action.

Step 2: Identify the process of re-engineering

Step 3: Evaluate enablers of re-engineering

Step 4: Understand the current process

Step 5: Create a new process design.

Step 6: Implement the re-engineered process.

State a case for action

Need for change should be effectively communicated to employees through key messages

- a) A need for action (why company cannot stay at this position)
- b) A vision statement (what the company need to become)

Vision statement

Qualitative & quantitative statement of objectives – Quality, cost reduction, customer satisfaction levels, financial indication etc.

Company leader conveys message & senior management steering committee champion the change process re-design & implementation.

Re-Engineering & Total Quality Management

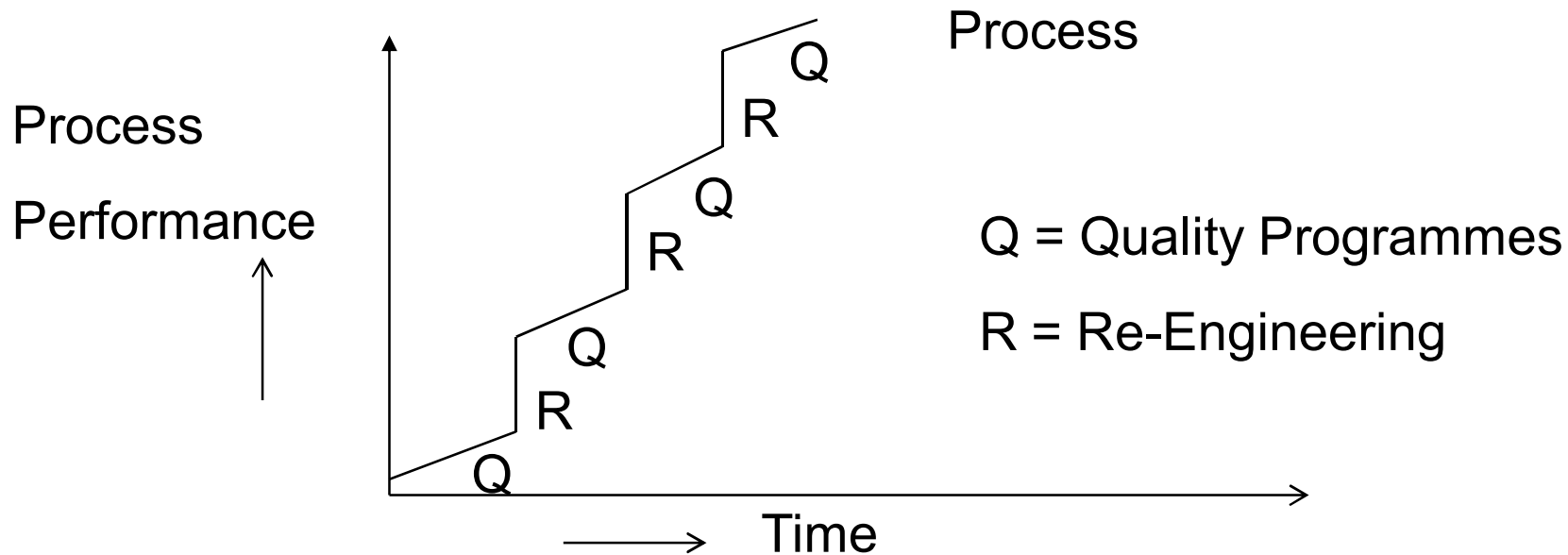
Different views. Some say that two are in fact same while others say they are incompatible.

Michael Hammer, Management expert argues that the two concepts are compatible and actually complement each other. Both concepts are centred on customer focus.

Total Quality Management (TQM)

Emphasizes continuous and incremental improvement of processes through concepts of team work, worker participation & empowerment, cross-functionality, supplier involvement & benchmarking & emphasizes "total view" of the organization.

- **Re-engineering** is about radical dis-continuous change through process innovation.



(A) Similarities	Re-engineering	TQM/ continuous improvement
Basis of analysis	Processes	Processes
Performance measurement	Rigorous	Rigorous
Organizational change	Significant	Significant
Behavioural change	Significant	Significant
Time investment	Substantial	Substantial

(B) Differences		
Level of change	Radical	Incremental
Starting point	Clean slate	Existing process
Participation	Top-down	Bottom-up
Typical scope	Broad. Cross functional	Narrow: with in functions
Risk	High	Mode rate
Primary enabler	Information technology	Statistical control
Type of change	Cultural & Structural	Cultural

Definition of Total Quality Management (TQM)

Total Quality Management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world-class competition.

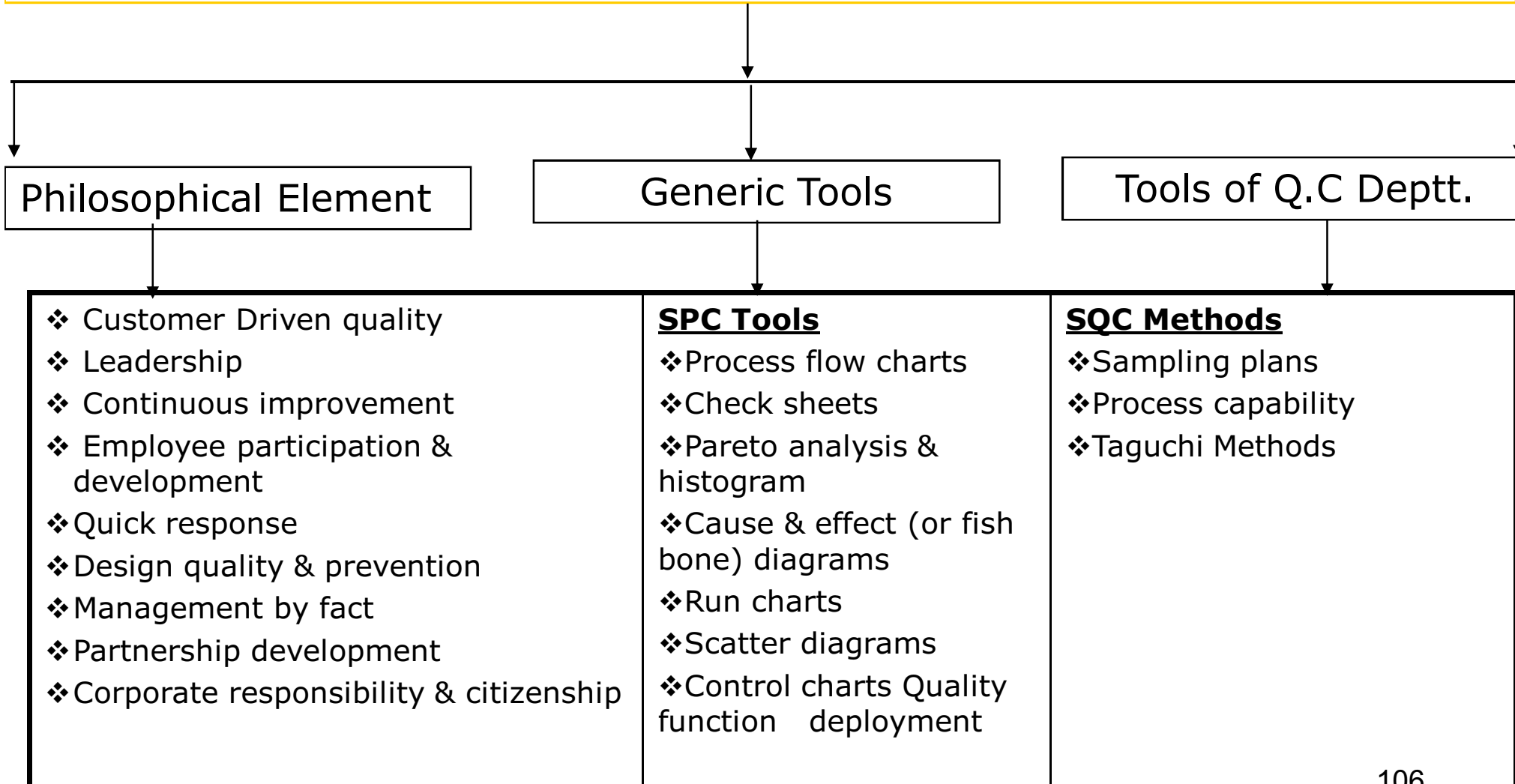
Total – Made up of the whole.

Quality – Degree of excellence a product or service provides.

Management – Act, art, or manner of handling, controlling, directing etc.

TQM

Managing the entire organization so that it excels in all dimensions of products & services that are important to the customer



Elements of Total Quality Management

SPC = statistical process control

Basic Approach of TQM requires six basic concepts:

1. A committed and involved management to provide long-term, top-to-bottom organizational support.
2. An unwavering focus on the customer, both internally and externally.
3. Effective involvement and utilization of the entire work force.
4. Continuous improvement of the business and production process.
5. Treating suppliers as partner.
6. Establish performance measures for the processes.

These concepts outline an excellent way to run an organization.

The Dimensions of Quality

Dimension	Meaning and Example
Performance	Primary product characteristics, such as the brightness of the picture
Features	Secondary characteristics, added features, such as remote control
Conformance	Meeting specifications or industry standards, workmanship
Reliability	Consistency of performance over time, average time for the unit to fail
Durability	Useful life, includes repair
Service	Resolution of problems and complaints, ease of repair
Response	Human-to-human interface, such as the courtesy of the dealer
Aesthetics	sensory characteristics, such as exterior finish
Reputation	Past performance and other intangibles, such as being ranked first

ISO – 9000 SERIES

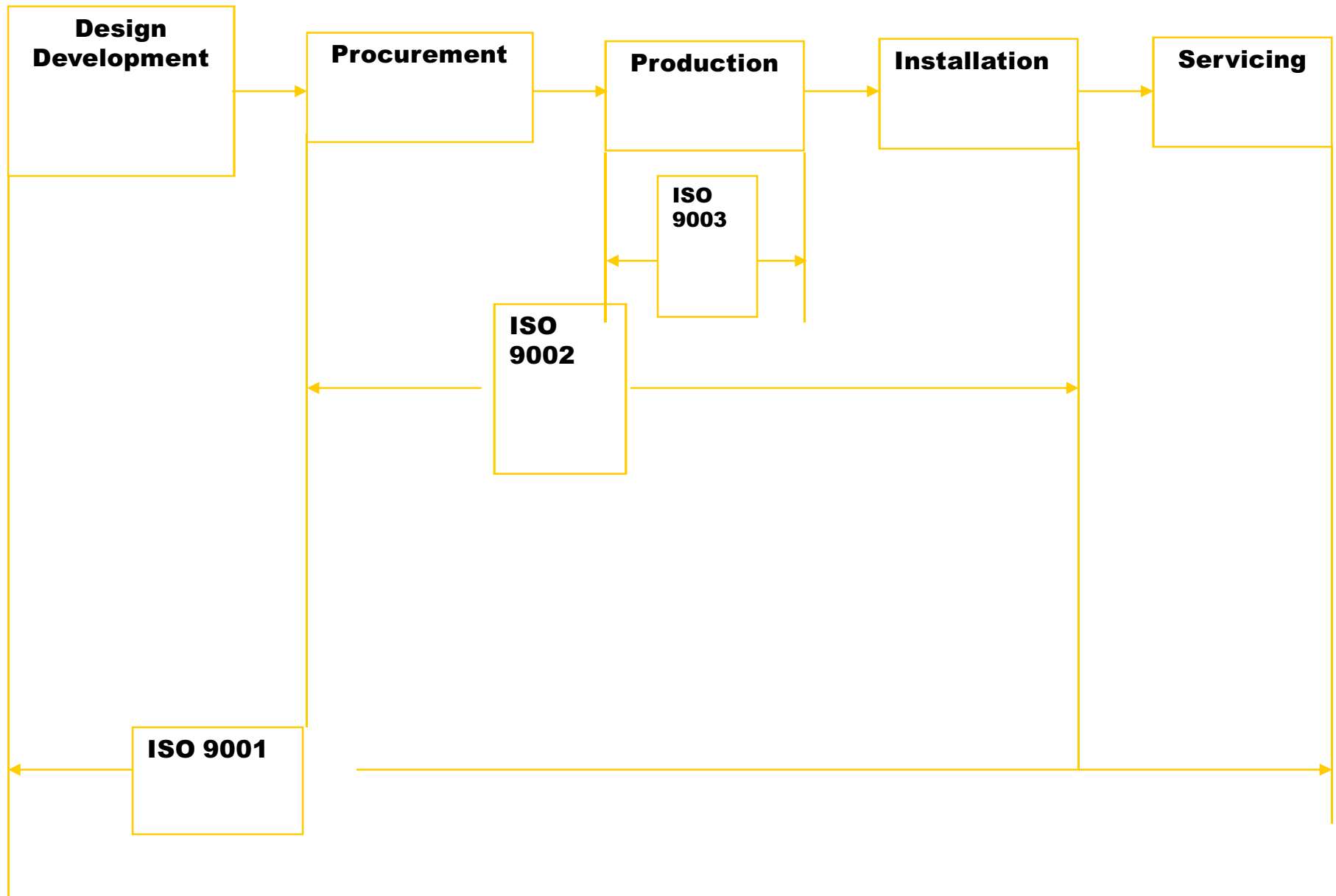
ISO 9000 is a series of standards agreed upon by the international organization for standardization (ISO) and adopted in 1987.

More than 100 countries now recognize the 9000 series for quality standards and certification for international trade. In Europe & European common market (ECM) alone, more than 50,000 companies have certified as complying with these standards.

All companies having international trade will have to adopt these standards eventually.

THE ISO 9000 SERIES

ISO 9000 consists of five primary parts numbered as 9000 through 9004



QUALITY SYSTEM – ISO

Guide line for Use:

9000 : Quality management & quality assurance standards- guidelines for selection & use.

9004 : Quality management & quality system elements – guidelines

Quality system

9001 : Model for quality assurance in design, production, installation & servicing.

9002 : Model for quality assurance in production & installation.

9003 : Model for quality assurance in final inspection test.

ISO certification can take from 3 to 6 months to as long as two years if top management is not fully committed.

Certification involves getting the proper documents, initiating the required procedures & practices and conducting internal audits.

There are three forms of certification.

- First Party : A firm audits itself against ISO 9000 standards
- Second Party : A customer audits its supplier
- Third Party : A "Qualified" national or international standards or certifying Agency serves as auditor

The best certification is by a third party and once passed, the firm can be registered & recorded as having achieved ISO 9000 status.

ISO specifies the way the firm operates as well as its quality standards, delivery times, service levels & so on. If a manufacturer wants to purchase, he can either visit / audit the supplier but it is always easier, cheaper, quicker & legally safer to select certified supplier

Benefits from ISO-9000

ISO 9000 certification has become the de-facto minimum requirement for those wishing to compete globally

All actions in preparing for ISO certification & in maintaining the certification would result in streamlining of quality management system which may lead to improvements in product quality.

It can also lead to significant cost reductions through reduction in rework, warranty work, repair, scrap, etc
ISO 9000 lays stress on customer orientation. This would result in better overall results for the company in addition to improving customer relations.

There may be an impetus to improve employee relations, employee empowerment and

The 20 Elements to be addressed in an ISO 9000 Quality System

1. Management Responsibility
2. quality system
3. contract review
4. design control
5. document control
6. Purchasing
7. Customer-Supply Material
8. Product Identification and Traceability
9. Process Control
10. Inspection and Testing

- 11. Inspection, Measuring, and Test Equipment
- 12. Inspection and Test Status
- 13. Control of Nonconforming Product
- 14. Corrective Action
- 15. Handling, Storage, Packaging, and Delivery
- 16. Quality Records
- 17. Internal Quality Audits
- 18. Training
- 19. Servicing
- 20. Statistical Techniques

Difference between ISO 9000 and TQM

ISO 9000

1. Not necessarily customer focused.
2. Not integrated with corporate strategy.
3. Technical systems and procedures focused.
4. Employee involvement is not necessary.
5. No focus on continuous improvement in ISO 9000 – it is a decision
6. Can be departmentally focused.
7. Quality department responsible for quality.
8. More likely to preserve the status quo.
9. Three-step maxim of ISO 9000 is: (i) document what you do, (ii) do only what you document and (iii) demonstrate that you have done it, by documentary proof.
10. ISO 9000 are technical and physical systems and standards.

TQM

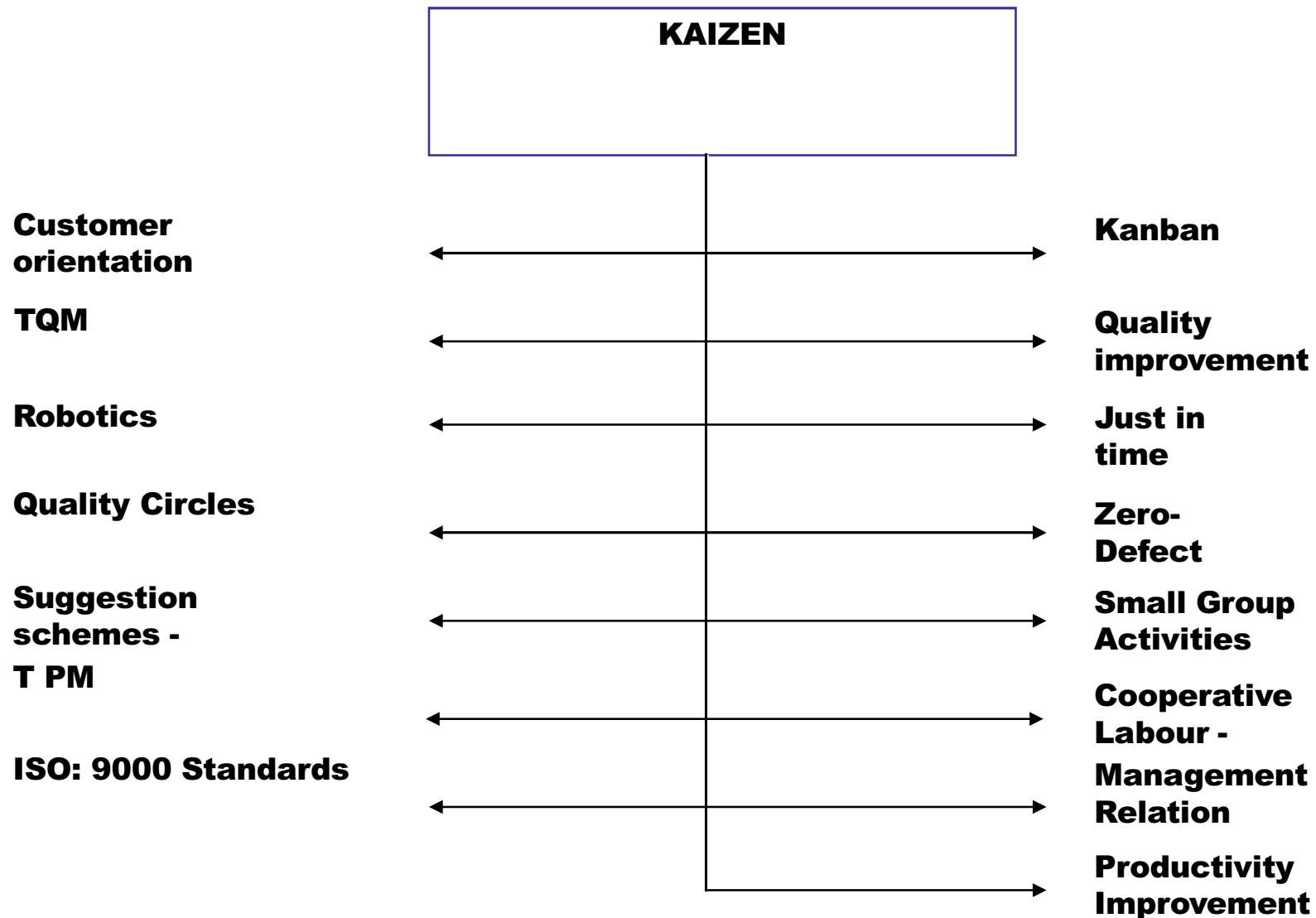
1. Definitely customer focused.
2. Integral to company strategy.
3. Philosophy, concepts, tools and techniques focused.
4. Emphasis is on employee involvement and empowerment.
5. Continuous improvement and TQM is a never-ending journey.
6. Organisation-wide focus on all departments, functions and levels.
7. Everyone is responsible for quality.
8. Involves process and culture change.
9. Customer satisfaction and economic cost are TQM two distinguishing features.
10. TQM is a philosophy where the approach is behavioural and human.

CONCEPT OF KAIZEN

Imai has brought together various management theories, philosophies and tools that have been popular in Japan over the years, as a single concept, *Kaizen*. There are many quality experts, whose principles formed the basis of the *Kaizen* concept. *Kaizen* means continuous improvement involving everybody. The philosophy advocates on-going improvement, not only in one's working life, but also in personal life, home life and social life. The term *Kaizen* originates from the Japanese words, 'Kai' that means change, whereas, 'zen' means for the better, therefore, it means 'change for the better'. It signifies constant and gradual improvement, no matter how small it is. It should be taking place all the time in every process, involving everyone from all the ranks of management and the workforce. In brief, the system includes:

- Total employee involvement starting from top management;
- Empowering people;
- Listening to them;
- Promoting zero investment improvements; and
- Focus on efforts rather than results in Kaizen evaluation and performance appraisal.
- The four phases of *Kaizen* are:
 - Motivation management;
 - Human resource development;
 - Improvement; and
 - Institutionalization.

The *Kaizen* umbrella, as shown in Figure is quite comprehensive. It is not any one technique rather a philosophy of continuous quality improvement.



COST OF QUALITY

The cost of quality (COQ) is defined as the sum of the costs of everything that would not have been necessary if everything else was done right the first time.

Types of quality costs

The cost of quality (COQ) can be classified into three major categories as given below:

1. Cost of conformance,
2. Cost of non-conformance,
3. Basic operational costs.

Cost of Conformance (COC)

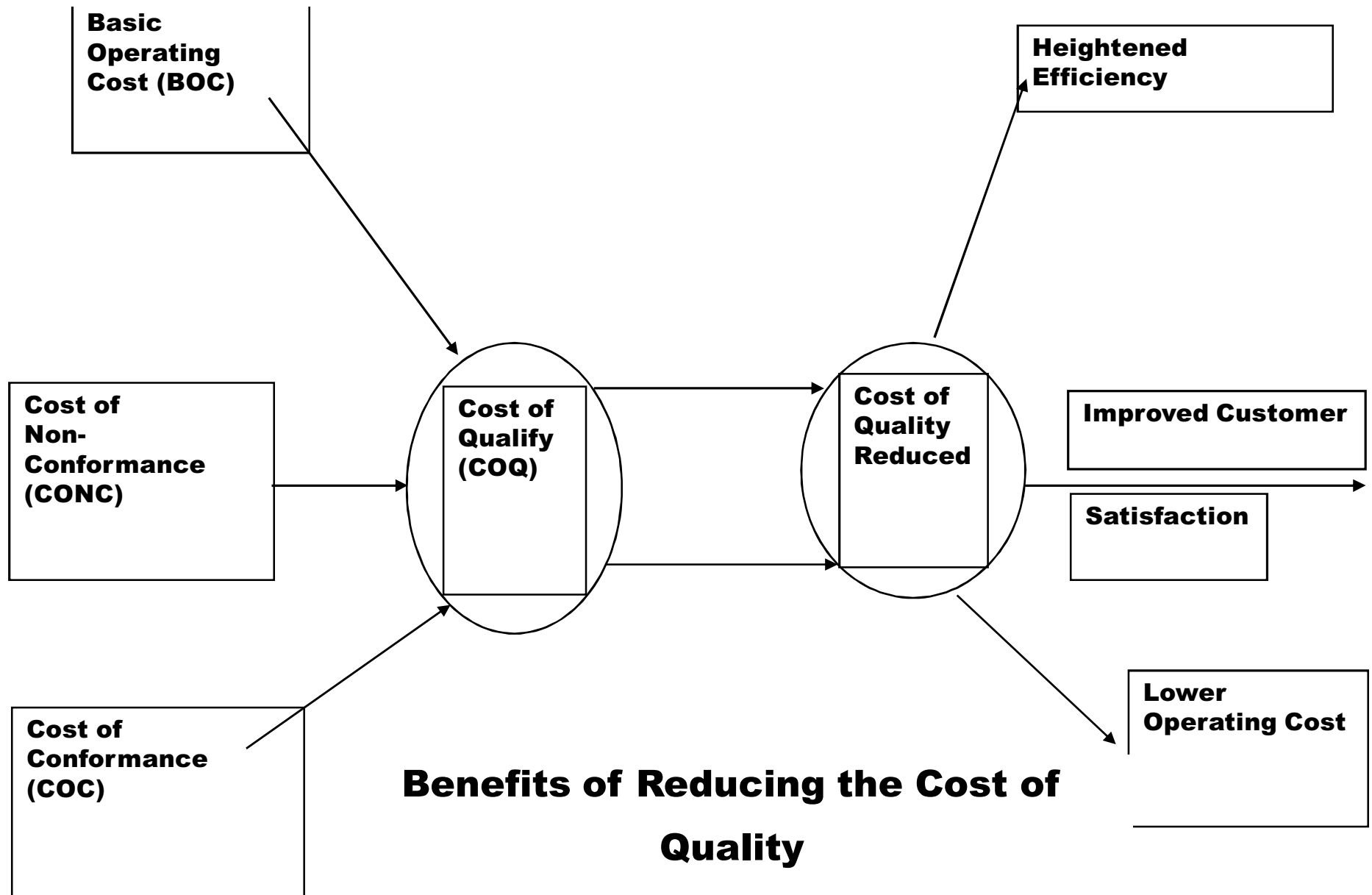
Cost of conformance (COC) is the cost which an organization incurs in meeting the requirements of its customers. A strong element of this cost is the money that a company spends on the product for preventing it from going wrong or checking the product right before it reaches the customer.

Cost of Non-conformance (CONC)

The cost of non-conformance (CONC) to customer requirements are the failure costs. These costs are incurred by a company in repairing what has gone wrong during manufacturing.

Basic Operational costs (BOC)

The basic operational costs (BOC) are those costs which an organization cannot avoid encountering during the normal performance of its business.



If all the three categories of costs are systematically reduced, several benefits can accrue to the company.

ANOTHER METHOD TO MEASURE COST OF QUALITY:

This analysis is based on following assumptions:

- i. That failures are caused
- ii. That prevention is cheaper
- iii. That performance can be measured

Four Types of costs:

1. Appraisal costs

The costs of inspection, testing & other tasks to ensure that the product or process is acceptable.

2. Prevention costs

The sum of all costs to prevent defects such as:

- a. Identify cause of defect
- b. Implement corrective action to eliminate the cause
- c. To train personnel
- d. To re-design product or system.
- e. New equipment or modifications.

3) Internal failure costs

The cost of defects incurred within the system:

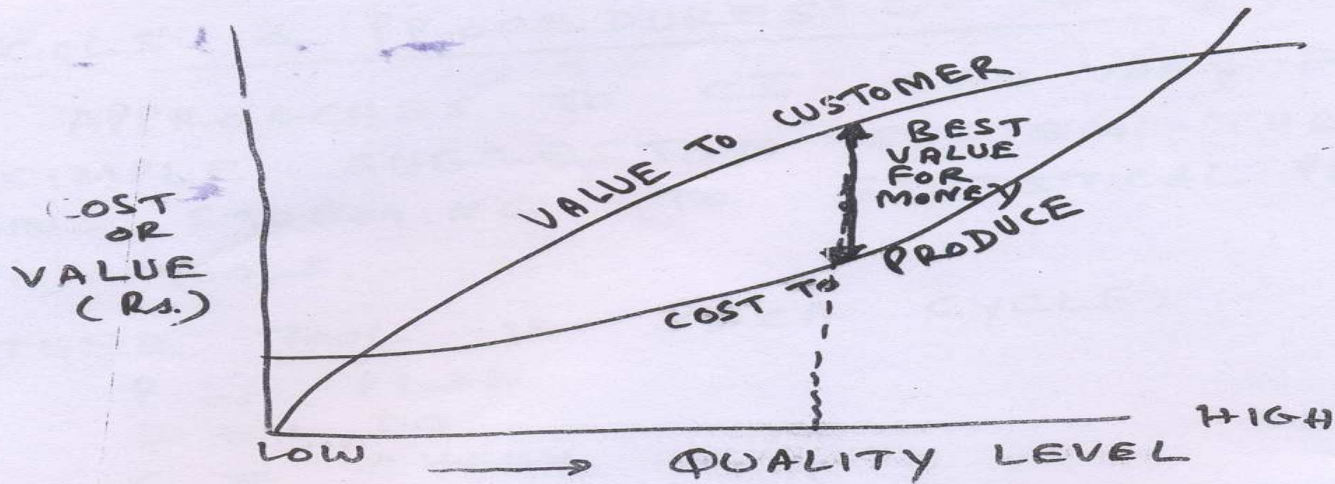
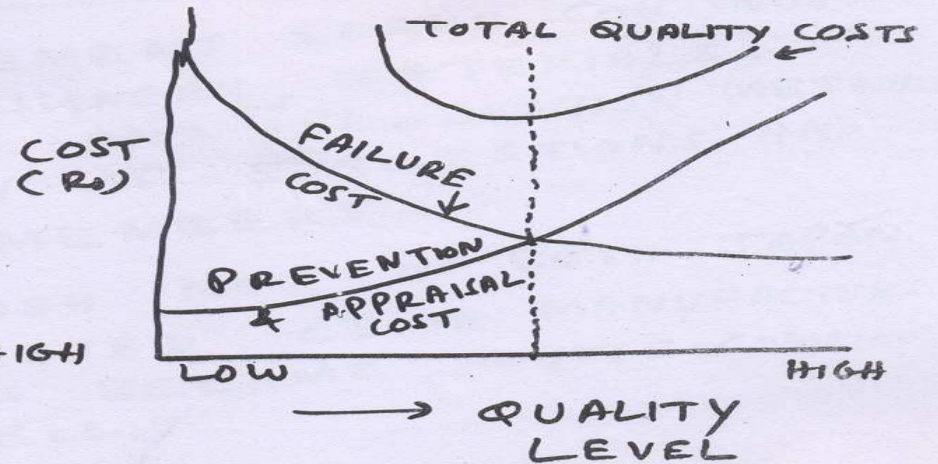
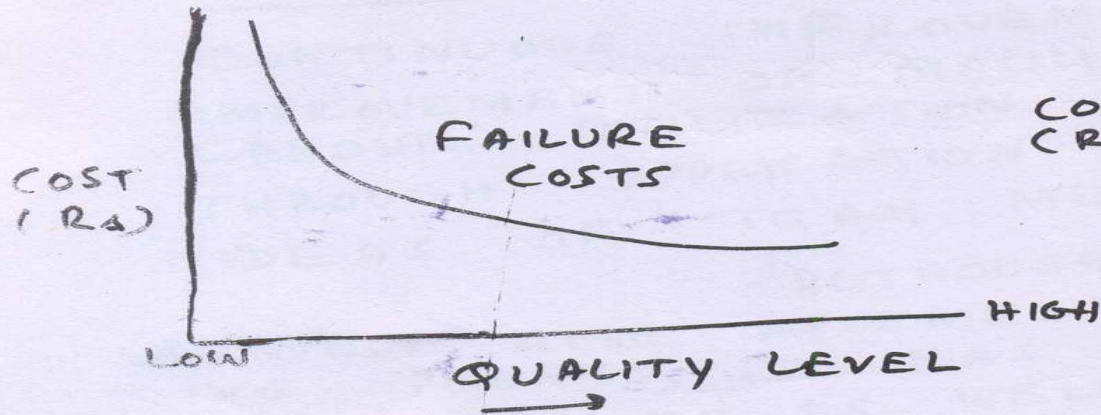
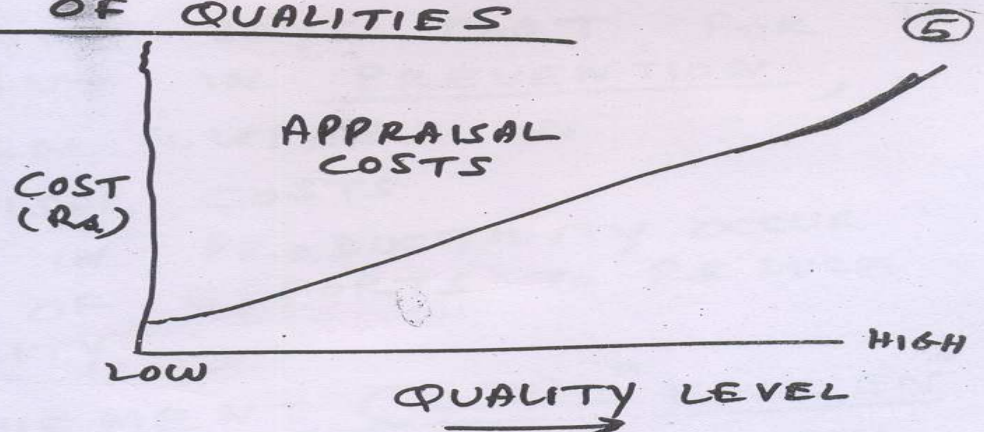
- a. Scrap
- b. Re-work
- c. Repair

4. External failure costs

The costs of defects that pass through the system:

- a. Customer warranty replacements
- b. Loss of customer or goodwill
- c. Handling complaints
- d. Product repair

COSTS & VALUES OF QUALITIES



The rule of thumb says that for every rupee spent in prevention, we can save ten rupees in failure & appraisal costs.

Often, increases in productivity occur as a by – product of efforts to reduce the cost of quality.

BENCH MARKING

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

According to Kehoe (1996) benchmarking can be defined as “measuring the performance of processes within your organization, comparing these performance levels with the best in class companies and where deficiencies exist, using the information on the best practices to improve your organisation’s own business processes.”

David Kearns defines benchmarking “as the continuous process of measuring products, services and practices against the toughest competitors or those companies recognized as industry leaders.”

There are several considerations in this definition

- i. Continuous process.
- ii. Measuring.
- iii. Products, services and practices.
- iv. Companies renowned as industry leaders

Benefits of Benchmarking

1. Best practices from any industry to be creatively incorporated into the processes of the benchmarked function.
2. Identify a technological breakthrough
3. It permits the individuals to broaden their background and experience.
4. It helps in meeting more effectively the end-user or customer requirements.
5. It supports in establishing goals (target setting) based on a concerted view of external conditions.
6. It helps in determining true measures of productivity and effectiveness.
7. It assists in attaining a competitive position.
8. It helps in becoming aware of and searching for industry's best practices.
9. Benchmarking allows individuals to see "outside the box". It provides for accelerating change and managing change

Pitfalls of Benchmarking

Statistics show that 70 percent of all process improvement initiatives fail. The most common reasons of these failures are:

- i. Lack of focus and priority;
- ii. Lack of strategic relevance;
- iii. Lack of leadership;
- iv. Lack of perseverance; and
- v. Lack of planning.

Obstacles to Benchmarking

The following are the most typical causes and obstacles preventing the smooth and fast implementation of benchmarking practices:

1. Management not “buying into” the idea.
2. No clear “owner” of the programme.
3. Failure to consider customer-requirements.
4. Change of sponsor before completion of the programme.
5. Programme taking too long and leading to loss of interest.
6. Not involving right staff in the programme.
7. Team not measuring issues it agreed to address.
8. Programme causing too much disruption of work and not seen relevant to work.
9. Conflicting objectives of the organization and those of its benchmarking partners.

Objectives of Benchmarking

The following are the three main objectives of benchmarking;

- 1.It aims at a goal setting process to facilitate comparison with the best.
- 2.It aims at motivating and stimulating company employees by continuously working for improved performance and turn their entire energy towards single focus.
- 3.It aims at external orientation of the company.

Continuous Improvement (CI)

Continuous improvement (CI) is a management philosophy that approaches the challenge of product and process improvement as a never-ending process of achieving small wins. It is an integral part of a total quality management system.

Continuous improvement seeks continual improvement of machinery, materials, labor utilization, and production methods through application of suggestions and ideas of team members. Though pioneered by U.S. firms, this philosophy has become the cornerstone of the Japanese approach to operations.

Although management in both Japan and the West historically have implemented CI in manufacturing plants, it has become quite common in services as well.

The Key features of continuous improvement strategies are:

- Accountability is built in.
- Incorporation of systematic learning (e.g., plan, do, check, act).
- Decisions based on facts.
- Diagnostic and remedial journey.
- Involvement of everyone within an organization.
- Linkage of improvement activity with organizational goal.
- Processes are divided into clear deliverables.
- Consideration of several solutions before implementing the best.

Tools & Procedures of CI

- 1.Varies from simple suggestion system based on brain storming to structured programmes utilizing statistical process control tools (SPC Tools)
- 2.Deming wheel (PDCA) cycle
- 3.Zero defect concept
- 4.Bench Marking
- 5.Six sigma

SPC Tools (Also known as Tools of TQC)

- ✓ Stratification
- ✓ Check Sheet
- ✓ Process flow chart
- ✓ Pareto analysis
- ✓ Run chart
- ✓ Histogram
- ✓ Scatter diagram
- ✓ Causes & effect diagram (Fish Bone /Ishikawa Diagram)

Deming wheel (PDCA cycle)

Another Tool is PDCA cycle:

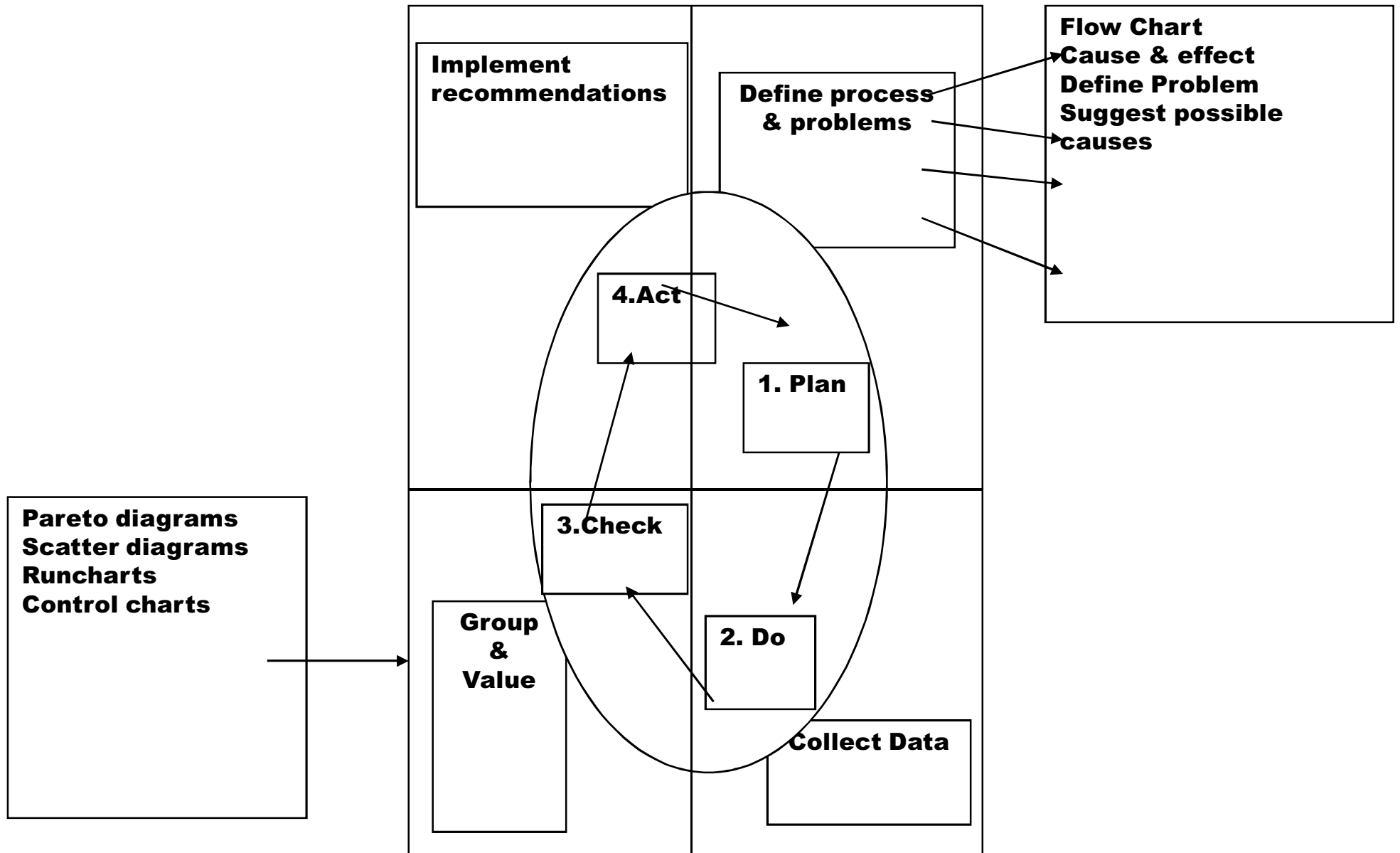
P= Plan

D=Do

C=Check

A=Act

It is often called Deming wheel



Deming wheel

'PLAN' PHASE (Also Known As Theme)

In this Phase, specific problem is identified and analysis is done using 5W2H Method

5W = - WHAT

- WHY

- WHERE

- WHEN

- WHO

2H = - HOW

- HOW MUCH

'DO' PHASE: Is implementing the change

- Should be done in a small scale first

'CHECK' PHASE: Deals with evaluating data collected during the implementation

Compare original goal vs. actual results

'ACT' PHASE: Improvement is codified as the new standard procedure & replicated in similar processes throughout the organization.

Bench – Marking For CI

Bench – Marking is to find out what industry competitors & excellent performers are doing; find out the best practices that lead to superior performance & see how it can be implemented

The Shin go system – Fail safe design

Two aspects:

- i. Single minute exchange of die (SMED)-procedures to accomplish drastic cut in set-up times
- ii. Use of source inspection and the poka-yoke system to achieve zero defects.

(poka-yoke = fail safe procedures)

Shingo argued that SQC methods do not prevent defects. The way to prevent defects from coming out at the end of the process is to introduce controls within the process. Inspection should be on 100% items of three types.

- a. Successive check inspection

By next person or group leader

- b. Self - Check

By individual worker who produces the product.

- c. Source Inspection

Worker checks for the errors that will cause defects.

POKA-YOKE (Fail Safe Procedures)

All three types of inspections described above rely on controls consisting of Fail – Safe Procedures of devices called POKA-YOKE.

POKA-YOKE includes such things as Check – Lists or special tooling that

- i. Prevents the worker from making an error that leads to a defect before starting a process.
- ii. Gives rapid Feed – Back of abnormalities in the process to the worker in time to correct it.

UNIT - V

Facility Location (Plant Location)

Plant location is the function of determining where the plant should be located for maximum operating economy & effectiveness.

The guiding principle is that the cost of raw materials, fabrication plus the cost of marketing of finished product should be minimum.

Need for selection of location

- a) New business to be started.
- b) Existing business outgrown its original facilities & expansion not possible.
- c) Lease expires & not getting renewed.
- d) Social or Economic reasons.
 - Inadequate labour supply.
 - Shifting of market
- e) Volume of business needs branches.

Location theory by Weber (1909)

Two broad categories of locational factors.

Primary Factors

Material & Labour

Secondary Factors

- Banking credit
- Insurance
- Communication
- Rents & rates

Specific Developments over 10 Decades

1. Improvements in transportation & communication facilities & speed of services.
2. Reduction in wage differentials between regions.
3. Mobility of workers & Management.
4. Improvement in construction methods & designs for plant building which make them less expensive to build.
5. Vigorous policy pursued by Govt. to remove regional imbalances & making all regions equal in attraction.
6. Improvements in processing & machine designs requiring less labour.
7. Airconditioning to counteract climatic conditions for employees & processes.
8. Expansion of markets for almost all goods & services.

Steps in Location

- a) Systematic steps in Plant location:
- b) Within the country or outside.
- c) Selection of the region.
- d) Selection of locality or community.
- e) Selection of exact site.

(a) Deciding on Domestic or International Location

- Which country would depend on :
- Political stability
- Export & Import quota
- Currency & Exchange rates
- Natural or physical conditions.

(b) Selection of Region

(i) Availability of Raw Materials

Supply of raw materials at minimum transportation cost.

Sugar, paper, iron & steel industry, oil extraction from rice bran, etc need bulky raw materials & that is the reason for their location near availability of raw materials because of :

- Reduced transportation cost
- Regular & uninterrupted supply
- Savings on storage of materials

(ii) Nearness to Market

- Reduction in cost of transportation
- Ability to render prompt service to consumers
- Provide after-sales service
- Execute replacement orders without delay

(iii) Availability of Power

Electric power available regularly & at cheap rates. For coal fired power plants, iron & steel industry should be near coal fields.

IV) Transport Facilities

A place well-connected by Rail, Road & Sea is ideal for a plant location.

V) Suitability of Climate

- Certain industries by nature of product require particular climatic conditions (humid for cotton& jute)
- Climate affects labour efficiency.

VI) Government Policy

Govt. of India has been influencing plant location in a number of ways

- Licensing Policy
- Freight Rate Policy
- Remote Area Concessions
- Institutional Finance & Subsidies

VII) Competition Between States:

- Investment Subsidies
- Sales Tax Exemptions
- Good incentive for small & medium scale industries.

(C) Selection of Locality / Community

(i) Availability of Labour

- Adequacy of labour (skilled & unskilled) at reasonable wages.
- The attitude of workers, union activities, industrial disputes discourage new industries & drive away existing factories (exodus of industrialists from Calcutta)

ii) Civic Amenities for workers

Besides good working conditions inside the factory, recreation facilities, schools, etc. should be available or need to be provided by Management.

iii) Existence of Complementary & Competing Industries

Existence of complementary industries provides following benefits:

- Can secure materials at better terms & availability of variety of materials.
- Improves labour market for employer & employees.
- Banks become familiar with type of industries & granting of loans become easy.
- Development of ancillary industries.
- Reputation built by existing units shared by new unit.
- Competing industries working together can effectively tackle problems of raw materials, labour trouble, Govt. restrictions etc. But competition should be healthy.

iv) Finance & Research Facilities

A place where facilities for raising capital are available attracts new industries. A place where research facilities are available since manufacturing has to be on the lookout for new technology and has to find solutions for problems.

v) Availability of Water & Fire fighting facilities

- Some industries require plenty of water (fertilizer, dyeing, leather, etc) & its regularity, cost & purity to be considered.

vi) Local Taxes & Restrictions

vii) Momentum of an early start

Where one or more factories existed before, these places gain prominence. Around them, a number of facilities (transportation, repair & maintenance, banking & labour) develop.

vii) Personal Factors

There are some small scale entrepreneurs who locate plants purely on personal grounds disregarding economic considerations.

(D) Selection of Site

(i) Soil, Size & Topography

(ii) Disposal of Waste: Disposal of effluents

For solid waste - Dumping ground is required

For liquid waste – Sewer connections & effective drainage system

Relative importance of location factors

S. No.	Factors	Unimportant	Neutral	Important
1.	Personal business contacts in a region	24	11	65
2.	Good communication / transport facilities	53	21	26
3.	Availability of sufficient infrastructure	47	20	33
4.	Market research indicating size of other benefits of local market	58	16	26
5.	Availability of skilled labour	70	15	15
6.	Region's promotion efforts	83	13	04
7.	Particular local/regional policies to attract business	81	09	10
8.	Lack of information on other potential areas	78	14	08

* source: Business India – 1994

Plant Location Methods

(Location Models)

Macro Analysis: Evaluation of country, region within country, sub-region, locality / community.

Micro Analysis: Evaluation of specific sites in the selected community.

- I. Techniques used to support macro analysis:
- II. Factor rating systems.
- III. Linear programming
- IV. Centre of gravity method
- V. Analytic Delphi Model

Factor Rating System / Method

1. List the most relevant factors in location decision.
2. Rate each factor (say 1 for very low & 5 for very high) according to relative importance i.e. higher the rating, the more important is the factor.
3. Rate each location (say 1 for very low & upto 10 for very high) according to its merits on each factor.
4. Compute the product of ratings by multiplying the factor rating by the location rating for each factor.
5. Compute the sum of the product of ratings for each location.

Decision: Select the location alternative which has the maximum sum of the product rating as the choice.

Factor ratings and location ratings for Location alternatives

<u>Factor</u>		<u>Factor</u>	<u>Location Rating</u>		<u>Product of Rating</u>		
		<u>Rating</u>	<u>Loc A</u>	<u>Loc B</u>	<u>Location</u>	<u>Location</u>	
					<u>A</u>	<u>B</u>	
1.	Tax advantage		4	8	6	32	24
2.	Suitability of labour skill		3	2	3	6	9
3.	Proximity to customers		3	6	5	18	15
4.	Proximity to suppliers		5	2	4	10	20
5.	Adequacy of water		1	3	3	3	3
6.	Receptivity of community		5	4	3	20	15
7.	Quality of Educational System		4	1	2	4	8
1.	Access to Rail & Air transportation		3	10	8	30	24
1.	Suitability of Climate		2	7	9	14	18
2.	Availability of Power		2	6	4	12	8

(i) Point Rating Method

A major problem with simple rating schemes (method) is that they do not account for the wide range of costs that may occur within each factor. For example, there may only be few thousand rupees difference between the best & worst locations on one factor and several lakhs difference between the best & the worst on another.

- (ii)** To deal with this problem the points possible for each factor be derived using a weighing scale based on standard deviations of costs rather than simply total cost amounts. In this way, relative costs can be considered. This method is known as Point rating method. The intangible factors can be considered if alternatives are equal based on costs.

Centre of Gravity Method

It is a technique that considers:

- a) Existing facilities
- b) The distances between them
- c) Volume of goods to be shipped

The Technique is often used to locate intermediate or distribution ware houses.

The method assumes that inbound & outbound transportations costs are equal and does not include special shipping costs for less than full loads.

The centre of gravity is found by calculating the X and Y co-ordinates that result in minimum transportation cost.

$$C_x = \frac{\sum d_{ix} v_i}{\sum v_i}$$

$$C_y = \frac{\sum d_{iy} v_i}{\sum v_i}$$

Where:

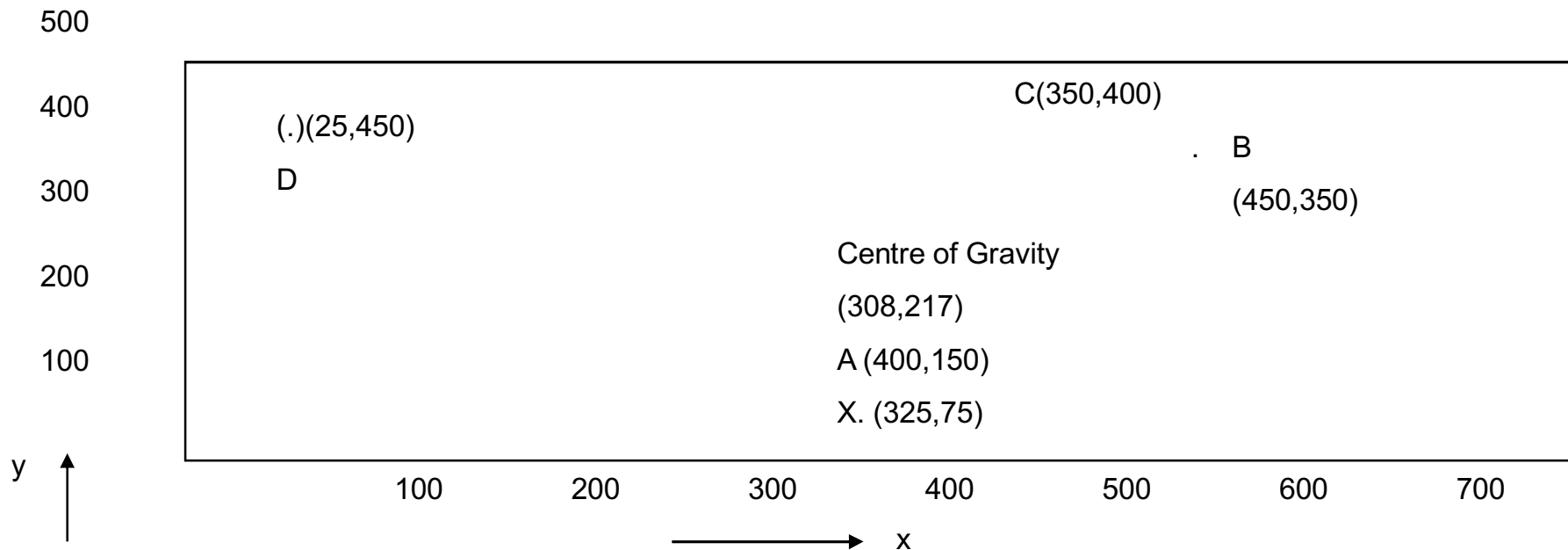
$C_x = X$ Co-ordinate of center of gravity

$C_y = Y$ - do _____

$d_{ix} = X$ – co-ordinate of i th location

$d_{iy} = Y$ – do _____

v_i = Volume of goods moved to or from I th location



<u>Location</u>	<u>Volume – Litres / Month</u>
X	1500

A	250
B	450
C	350
D	450

$$C_x = \frac{(325 \times 1500) + (400 \times 250) + (450 \times 450) + (350 \times 350) + (25 \times 400)}{1500 + 250 + 450 + 350 + 450}$$

$$= \underline{308}$$

$$C_y = \frac{(75 \times 1500) + (150 \times 250) + (350 \times 450) + (400 \times 350) + (450 \times 450)}{1500 + 250 + 450 + 350 + 450}$$

$$= \underline{217}$$

Question

<u>Plant</u>	<u>Co-ordinates</u>	<u>Volume</u>
A	(150,225)	8,500
B	(175,330)	9,500
C	(110,375)	11,000

Find best location with center or gravity method

Ans

$$\begin{aligned} C_x &= \frac{\sum v_i x_i}{\sum v_i} = \frac{(150 \times 8500) + (175 \times 9500) + (110 \times 11000)}{8500 + 9500 + 11,000} \\ &= \underline{143} \end{aligned}$$

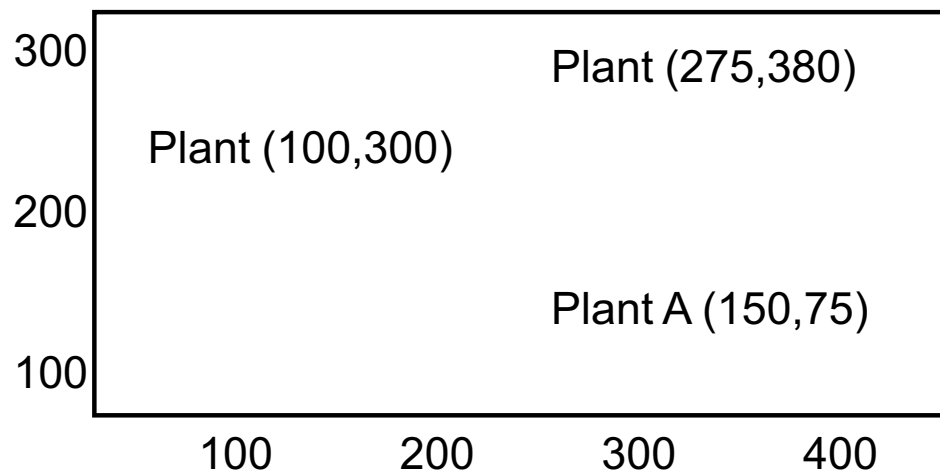
$$\begin{aligned} C_y &= \frac{\sum v_i y_i}{\sum v_i} = \frac{(225 \times 8500) + (330 \times 9,500) + (375 \times 11000)}{8500 + 9500 + 11000} \\ &= \underline{316} \end{aligned}$$

Best location is (143,316)

Center of Gravity Method

Cool Air, a manufacturer of automotive air coolers produces compressors at three different locations, Plant- A, Plant – B, Plant –C. Management decided to build all compressors, a major product component, in a separate dedicated facility at Plant -D.

Using center of gravity method & information given below to determine best location for Plant – D. Assume a linear relationship between volumes shipped & shipping costs (No premium charges)



Plant

A

B

C

Number of compressors as required per year
--

6,000

8,200

7,000

Plant D () ?

Analytic Delhi Model

Criteria: Tangible & intangible factors

- a) Minimizing travel time or distance between demand & supply points.
- b) Minimization of cost function.
- c) Minimizing the average response time.

It involves using combination of three teams.

- (i) A co-ordinating team
- (ii) The fore-casting team
- (iii) A strategic team.

Step I:

Form Two Delphi Panels

An in-house or outside consultant team acts as co-ordinator to design questionnaires & conduct Delphi inquiries. This team selects two panels from within the organization.

- One to forecast the trends in social & physical environments affecting the organization (Forecasting Delphi panel)
- Second to identify the strategic goals & priorities of the organization.

(The strategic Delphi panel) of each Dept.

The second panel should include top management & personnel of all functional areas.

Step-II:

Identify Threats & Opportunities

The co-ordinating team through several rounds of questionnaires & feed-back asks forecasting Delphi panel to identify major trends, opportunities in the market place and any threats against which organisation must safeguard. A consensus approach to be followed.

Step-III **Determine Direction (s) and Strategic goals of the organization**

The co-ordinating team conveys the findings of forecasting Delphi inquiry to the strategic Delphi panel, which then uses them in the second Delphi inquiry to determine the organization's direction & strategic goals.

Step-IV **Develop Alternative (s)**

Once, the strategic Delphi panel establishes the long-term goals, it should focus its attention on developing various alternatives. The alternatives could be

Expansion and or contraction of existing plants facilities and or developing alternative locations for some parts or the entire organization.

Step-V **Prioritize the Alternative (s)**

The set of alternatives developed in Step-IV should be presented to participants of strategic Delphi panel to obtain their subjective value judgement. If value judgements are complex, quantitative techniques can be used.

This systemic approach identifies trends, developments & opportunities, while considering organization's strengths & weaknesses. This is an integrative, team-based approach used by companies these days.

Locating Service Facilities

With relatively low cost of establishing a service facility compared to manufacturing, new service facilities are far more common. For example retail outlets, restaurants, entertainment facilities, etc.

Services need multiple sites to maintain close contact with customers. Location decision is closely tied to market selection decision.

Whereas manufacturing location decisions are made by minimizing costs, many service location decision techniques maximize the profit potential of various sites. Two analytical approaches that can be used to select good sites are:

- Regression Modeling
- Heuristic Procedure

A common problem encountered by service providing organizations is deciding how many service outlets to establish within a specific geographic area. The problem is complex because of many possible locations & options.

Facility Layout

A plant layout (facility layout) is a floor plan for determining & arranging the desired machinery & equipment of a plant, whether established or contemplated, in the one best place to permit the quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of the raw materials to the shipment of the finished products.

Another definition states that plant layout involves:

- (i) Planning & arranging manufacturing machinery, equipment & services for the first time in completely new plants.
- (ii) The improvements in the layouts already in use in order to introduce new methods & improvements in manufacturing procedures.

Objectives of Good Layout (Manufacturing)

1. Provide enough production capacity
2. Reduce material handling costs.
3. Reduce congestion that impedes the movement of people & / or materials
4. Reduce hazards to personnel
5. Reduce accidents
6. Utilize labour efficiently
7. Increase employee morale
8. Utilize available space efficiently & effectively
9. Provide for volume & product flexibility
10. Provide ease of supervision
11. Provide face to face communication, where necessary.

- 12. Provide for employee safety & health.
- 13. Allow ease of maintenance
- 14. Allow high machine / equipment utilization
- 15. Improve productivity

Principles of layout

- i) The principle of minimum travel
- ii) Principle of sequence
- iii) Principle of usage
- iv) Principle of compactness
- v) Principle of safety & satisfaction
- vi) Principle of flexibility
- vii) Principle of minimum investment

Principles of Layout

The layout selected in conformity with layout principles should be an ideal one.

- (i) **Principle of Minimum Travel**: Men & materials should travel the shortest distance between operations so as to avoid waste of labour & time and minimize cost of materials handling.
- (ii) **Principles of sequence**: Machinery & operations should be arranged in a sequential order. This principle is best achieved in product layout an efforts should be made to have it adopted in process layout.
- (iii) **Principles of usage**: Every foot of available space should be effectively utilized, especially in towns & cities.
- (iv) **Principles of compactness**: There should be harmonious fusion of all the relevant factors so that final layout is well – integrated & satisfaction.

- v. **Principle of safety & Satisfaction**: The layout should have built – in provisions for safety of workmen as well as comfort & convenience.
- vi. **Principle of Flexibility**: The layout should permit revisions with least difficulty & at minimum cost.
- vii. **Principle of minimum Investment**: The layout should result in savings of fixed capital investment by intensive use of available facilities.

Basic Production Layout Formats

(Types of Layout)

Process Layout

- Functional Layout
- Job Shop Layout
- Batch Production Layout

It involves grouping together of like machines or equipment or functions in one department. For example all lathes, drilling machines, heat treatment, painting, etc. in respective areas.

A part being worked on then travels according to established sequence of operations from area to area where proper machines are located for each operation.

Work is allotted to each deptt. in such away that no machine in any deptt. is idle. Partly finished goods would have to wait in every deptt.

This layout is best suited for intermittent type of production.

Advantages

1. Reduced investment on machines as they are general purpose machines.
2. Greater flexibility in production.
3. Better supervision through specialization
4. Greater scope for expansion
5. Better utilization of men & machines.
6. Easier to handle breakdown of equipment by transferring work to another machine or station.
7. Full utilization of equipment
8. Investment on equipment would be comparatively lower.
9. Greater incentive to individual worker to increase¹⁷⁶ his performance

Disadvantages

1. Mechanical devices for handling materials cannot be conveniently used.
2. Requires more floor space.
3. Difficulty in production control
4. More production time as work-in-progress has to travel from place to place in search of machines.
5. Accumulation of work-in-progress at different places.

Product Layout

Also called – Straight Line Layout

- Flow Shop Layout
- Layout for Serialised Manufacture

It involves the arrangement of machines in one line depending upon sequence of operations. The emphasis is on special purpose machines in contrast to general purpose machines. The grouping of machines should be based on:

- (i) All the machine tools or other items of equipment must be placed at the point demanded by sequence of operations.
- (ii) There should be no points where one line crosses another line.
- (iii) Materials may be fed where they are required for assembly but not necessarily all at one point.
- (iv) All the operations, including assembly, testing & packing should be included in the line

Product layout used in plants manufacturing standardised products on a mass scale such as:

Sugar, Chemical, Paper, Cement, Refinerises, etc.

Advantages

1. Reduction in materials handling cost
2. Production bottlenecks avoided
3. Economy in manufacturing time
4. Facilitates better production control
5. Requires less floor area per unit of production
6. Work-in-progress required
7. Early detection of badly produced items
8. Greater incentive to a group of workers to raise their level of performance.

Disadvantages

1. Inflexibility
2. Expensive
3. Difficulty of supervision
4. Expansion is difficult
5. Any breakdown of equipment along the production line can disrupt the whole system.

When to use Product or Process Layout

<u>Product Layout</u>	<u>Process Layout</u>
1. One or few standard products	•Many kinds or types of products or special orders
2.Large volume of each item over a considerable period of time.	•Relatively low volume of items.
3. Minimum inspection required during sequence of operations	•Many inspections required during sequence of operations.
4. Bulky or continuous handling by mechanical means	•Too bulky to permit mechanical means
5. Little or no occasion to use the same machine or work station for more than one operation.	•Frequent need for using the same machine or work station for two or more different operations.

Group Technology (Cellular Manufacturing) Layout – G.T. or CMS

This layout groups dissimilar machines into work centres (or cells) to work on products that have similar shapes and processing requirements. A group technology (GT) layout is similar to process layout in that cells are designed to perform a specific set of processes, and it is similar to product layout in that the cells are dedicated to a limited range of products.

Advantages

- Lower work-in-process inventories
- Reduced materials handling costs
- Shorter flow times in production simplified ppc
- Facilitates quicker set - UPS
- Improved on-time delivery

Disadvantages

- Reduced manufacturing flexibility
- Potentially increased machine-down time
- Duplicate pieces of equipment may be needed so that parts need not be transported between cells.
- Machines contained in cells may not be used all the time.

Fixed Position Layout

The Product (By virtue of its bulk or weight) remains at one location. It involves movement of men & machines to the product which remains stationary.

The movement of men & machines to the product is advisable because the cost of moving would be less than the cost of moving the product which is very bulky such as aircraft assembly, locomotives, ships, boilers, generators etc.

Advantages

- i) Men & machines can be used for a wide variety of operations producing different products.
- ii) The investment on (Layout) is very small.
- iii) The worker identifies himself with the product and takes pride in it when the work completes.
- iv) The high cost of and difficulty in transporting a bulky product are avoided.

Combined Layout

A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments. In plants involving fabrication of parts & assembly, fabrication tends to employ process layout while assembly areas often employ product layout.

Comparison of Layouts

	Types of Layouts			
Factors	Fixed Position	Product (Line)	Cellular (G.T.)	Process (Functional)
Type of Operation	Large Scale Project -Aircraft -Ship Building -Locomotives	Continuous & Repetitive	Small to Medium Batch	Job Order or Small batch
Arrangement of Facilities	Facilities move to a fixed product / project	Placed along the line of product flow	Similar parts are grouped in part family. For batch part – family, one machine cell is formed which contains all facilities needed by Part Family	Grouped by Specialty

<u>Cost of Layout</u>	Moderate to Low	Moderate to High	Moderate to High	Moderate to Low
<u>Materials Handling</u>	Moderate	Less	Less	High
<u>Material Travel</u>	Variable Path	Fixed Path	Fixed Path	Variable Path
<u>Utilization of Facilities</u>	Moderate	Very High	High	Low
<u>Operating facilities</u>	General Purpose	Special Purpose	Special Purpose	General Purpose
<u>Employee Skill</u>	Unskilled or skilled	Unskilled	Multi-skilled	Skilled
<u>Quality No. of Products (Q/P)</u>	Normally 1 As single product production	Large (Q/P)	Moderate (Q/P)	Small (Q/P)

Importance / Objectives of Efficient Layout

Economics in Handling: 30% to 40% of manufacturing costs account for materials handling.

ii Effective Use of Available Area:

- Location of equipment / services to perform multiple functions.
- Development of upto date work areas & operator job assignment for full utilization.

iii. Minimisation of Production Delays:

- Maintain delivery schedules & dead lines to retain customers.
- Layout helps in speedy execution of orders.

iv. Minimum Equipment Investment

Planned machine balance and location, minimum handling distances, general purpose machines and planned machine loading.

vi) Avoidance of Bottlenecks:

No Piling up of materials or reduced speed of production at any location-due to inadequate machine capacity, inadequate storage space or low speed by operators.

Better Production Control

A product of right type, at right time and at reasonable cost.

Better Supervision

- i) No of workers to be handed
- ii) Enabling supervisor to have a full view of shop at one glance

Improved Utilization of Labour

Time of each worker is effectively spent on productive operations.

Improved Employee Morale

Moral Depends on:

- a) Better working conditions
- b) Better employee facilities
- c) Reduced number of accidents
- d) Increased earnings

Avoidance of Un-necessary & costly changes

The incorporation of flexibility elements in the layout would help in avoidance of revisions which are costly.

Revision of Layout – Reasons (Why?)

The best layout becomes obsolete over a period of time. Revisior (minor or major) become necessary to maintain operating efficienc of plant.

Reasons for Revision

- i)Expansion
- ii)Technical Advancements
- iii)Improvement in the layout

i) Expansion

- a)Increase in the output of existing product.
- b)Introduction of a new product in the same line.
- c)Diversification of lines of activity

ii) Technical Advances

- a) Replacement of labour by machines
- b) Developments in fuel & energy
- c) Developments in process
- d) Developments in materials
- e) Improvements in product decision
- f) Advancement in information technology.

Improvement in the Layout

- a) Evils of poor layout are a hidden cost & not revealed by best accounting method.
- b) Limitations revealed but management unwilling to initiate remedial steps.

These defects may need minor alterations.

Analysing Layouts with Computers

Computers have entered the field of layout engineering in a big way. Various techniques are as follows:

For Designing Process Layout

- i) ALDEP (Computerised Layout Design Programme)
- ii) CORELAP (Computerised Relationship Layout Planning)
- iii) CRAFT (Computerised Relative Allocation of Facilities Technique)

These & other computer programmes can save time & effort in large & complex layout problems, but the plans they offer are only the beginning of a final layout.

The layout given by computers must be fine-tuned by hand and checked for logic and machines & other elements of layout must usually be hand-fitted with templates.

Line Balance

Assembly Lines

Assembly lines are a special case of product layout. Assembly line refers to Progressive Assembly linked by some material handling device. Materials handling devices could be belt or roller conveyor, overhead crane, line configuration (U-shape, straight, etc.), product mix (one or multi product), work station characteristics (workers may sit, stand, walk, etc)

Assembly Line Balance

It is to assign all tasks to a series of work stations so that each work station has no more than that can be done in the cycle time, and that the unassigned (i.e. idle) time across all work stations is minimized.

The problem is complicated by the relationships among tasks imposed by product design and process technologies. This is called Precedence Relationship, which specifies the order in which tasks must be performed in the assembly process.

Steps in Assembly Line Balancing

1. Specify the sequential relationships among tasks using a precedence diagram. Circles represent individual tasks & arrows indicate the order of task performance.
2. Determine the required cycle time (C) using the formula:

$$C = \frac{\text{Pr oduction Time Per Day}}{\text{Re quired Output Per Day (in units)}}$$

3. Determine the theoretical Minimum Number of work stations (N) required to satisfy the cycle time constraint using the formula (Rounded off to next higher interger)

$$N_t = \frac{\text{Sum of Task Times (T)}}{\text{Cycle Time (C)}}$$

4. Select a primary rule by which tasks are to be assigned to work stations, and a secondary rule to break ties.

Primary: i) Assigning Tasks that have many followers:

Secondary: ii) Are of long duration. (To break ties)

5. 5. Assign tasks, one at a time, to the first work station until the sum of task times is equal to cycle time or no other tasks are feasible because of time or sequence restrictions. Repeat the process for work station 2, work station 3 and so on until all tasks are assigned.
6. Evaluate the efficiency of the balance derived using the formula.
- $$\text{Efficiency} = \frac{\text{Sum of Task Times (T)}}{\text{Actual Number of Workstations (Na)}} \times \text{Cycle Time (C)}$$
7. If the efficiency is unsatisfactory, rebalance using a different decision rule.

Splitting Tasks

Often, the longest required task time forms the shortest cycle time for the production line. This task time is the lower time bound unless it is possible to split the task into two or more work stations

4. **Using a more skilled Worker**: If the time exceed by small percentage, a faster worker may be able to complete the task within cycle time.
5. **Work Over Time**: Complete the balance production by working overtime.
6. **Redesign**: It may be possible to redesign the product to reduce the task time slightly.

Other Possibilities to Reduce Task Time Are:

- Equipment Upgrading
- A roaming Helper to support the line
- Change of materials
- Multi-skilled workers to operate the line as a team rather than as independent workers.

Example of Assembly – Line Balancing

Model J wagon is to be assembled on a conveyor belt.

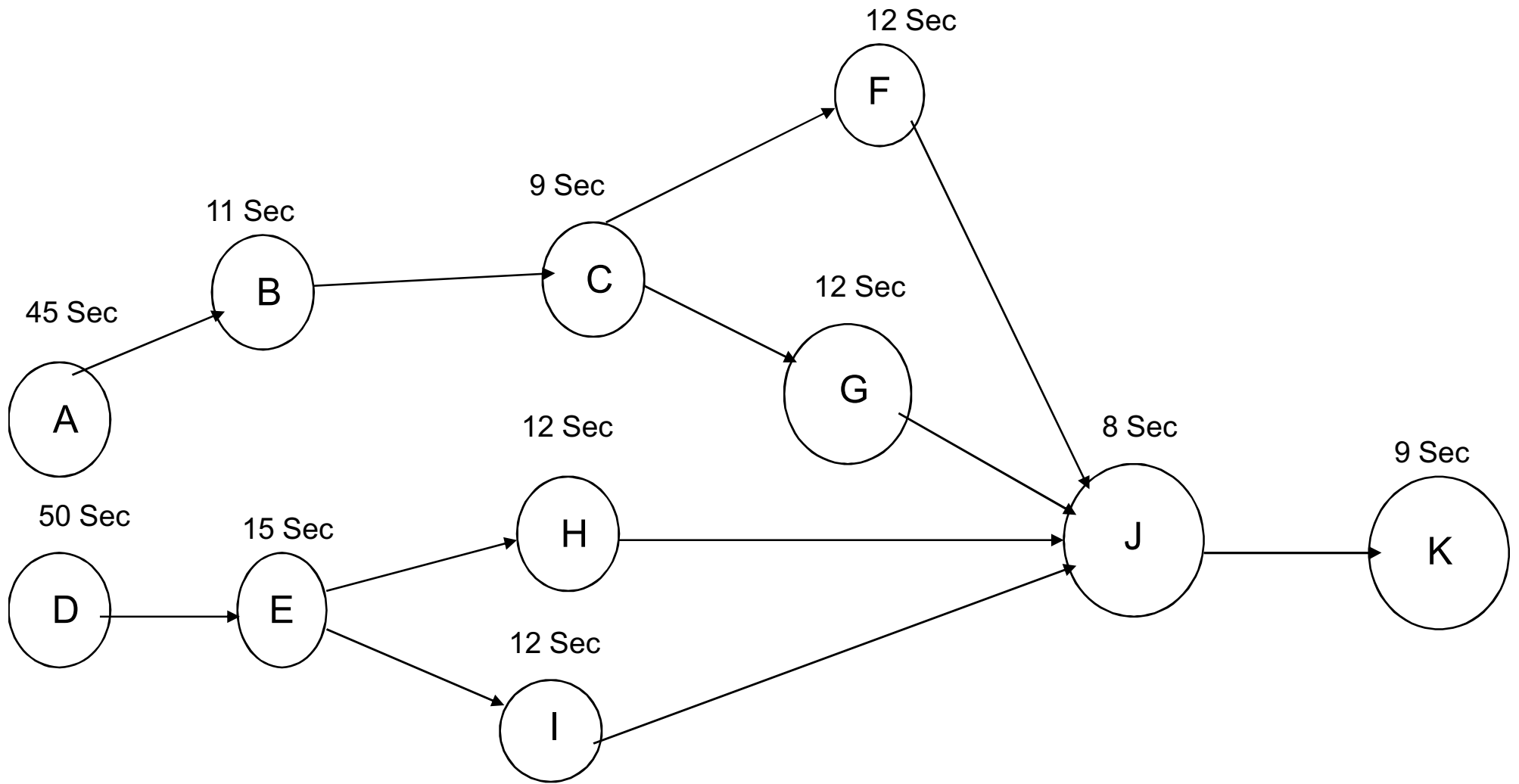
Wagons required / day = 500

Production Time / Day = 7 hrs X 60

= 420 Minutes

Find the balance that minimizes the number of work stations,
subject to cycle time & precedence constraints.

Task	Task Time (in Seconds)	Description	Tasks that Must Preceded
A	45	Position rear axle support and hand fasten four screws to nuts	-
B	11	Insert rear axle	A
C	9	Tighten rear axle support screws to nuts	B
D	50	Position front axle assembly and hand fasten four screws to nuts	-
E	15	Tighten Front Axle Assembly Screws	D
F	12	Position rear wheel # 1 & Fasten	C
G	12	Position rear wheel # 2 & Fasten	C
H	12	Position front wheel # 1 & Fasten	E
I	12	Position front wheel # 2 & Fasten	E
J	8	Position wagon handle shaft on front axle assembly	F,G,H, I
K	9	Tighten Bolt & Nut	-
Total	195		199



Precedence Graph

$$2. \text{CycleTime} = \frac{420 \text{ Minutes} \times 60 \text{ Sec.}}{500 \text{ Wagons}} = 50.4 \text{ Sec.}$$

3. **Minimum No. of Work Stations:**

$$= \frac{T}{C} = \frac{195}{50.4} = 3.87 = 4 \text{ (Rounded Off)}$$

4. **Select Assignment Rules:**

(A) **Primary:** Largest No. of Followers

<u>Task</u>	<u>No. of Following Tasks</u>
A	6
B or D	5
C or E	4
F, G, H or I	2
J	1
K	0

(B) **Secondary Rule**: Where ties exist, assign tasks in order of longest task time.

5. Make task assignments to form work station1, work station 2 and so forth until all tasks are assigned

6. Do Efficiency Calculation

$$\text{Efficiency}(\eta) = \frac{T}{N_a \times C} = \frac{195}{(5) \times (50.4)} = 0.77 = 77\%$$

7. Evaluate solution. An efficiency calculation of 77% indicates 23% idle time.

Try re-Balancing the line with rule B and break ties with rule A.

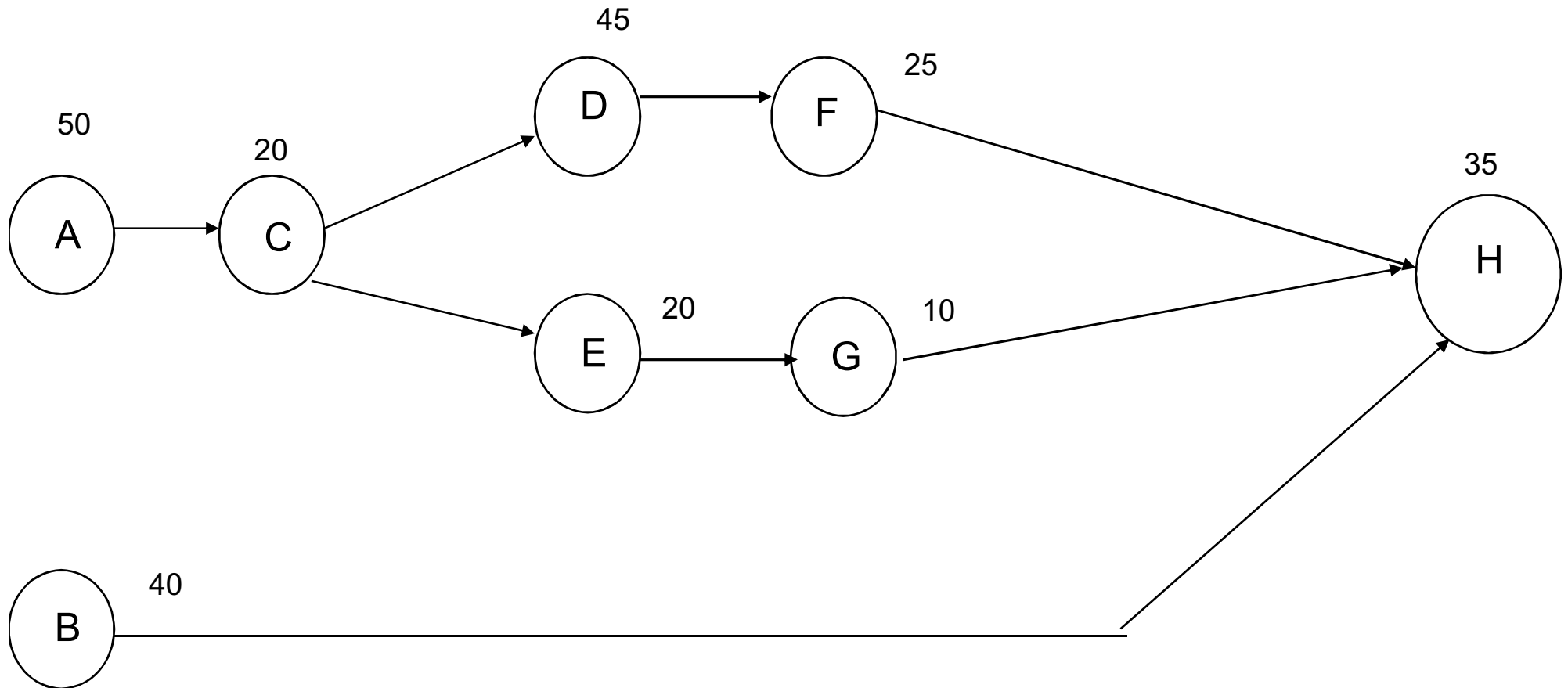
Assembly Line Balancing

The following tasks must be performed on an assembly line in the sequence & times specified.

Task	Task Time (in Seconds)	Tasks That Must Precede
A	50	--
B	40	--
C	20	A
D	45	C
E	20	C
F	25	D
G	10	E
H	35	B, F, G

- a) Draw the schematic diagram
- b) What is the theoretical minimum number of stations required to meet a forecasted demand of 400 units per 8- hour day?
- c) Use the longest task time rule and balance the line in the minimum number of stations to produce 400 units per day.
- d) Calculate Efficiency of System

Assembly Line Balancing



(a) **Schematic Diagram**

$$(b) \text{CycleTime} = \frac{8 \times 60 \times 60}{400} = 72 \text{Seconds}$$

Theoretical Minimum Number of Stations To Meet D = 400

$$\frac{50+20+45+25+35+20+10+40}{72} = \frac{245}{72} = 3.4 \text{Stns}$$

<u>Assignment of Tasks</u>				
Work Station	Task	Task Time (Seconds)	Remaining Unassigned Time	Feasible Remaining Task
1	A	50	22	C
	C	20	2	None
2	D	45	27	E, F
	F	25	2	None
3	B	40	32	E
	E	20	12	G
	G	10	2	None
4	H	35	37	None

$$\text{Efficiency of System} = \frac{245}{4 \times 72} \times 100 = 85\%$$

Practical on Line Balancing

There are five work elements in an assembly line. The assembly line works for eight hours a day and six days in a week. The demand for the product that the assembly line produces is 5000 units for a week the work elements with their predecessors and time required to complete the work element is give in table below:

Work Elements	Predecessors	Time (Seconds)
A	--	6
B	A	15
C	A, B	24
D	B	18
E	B, C, D	30

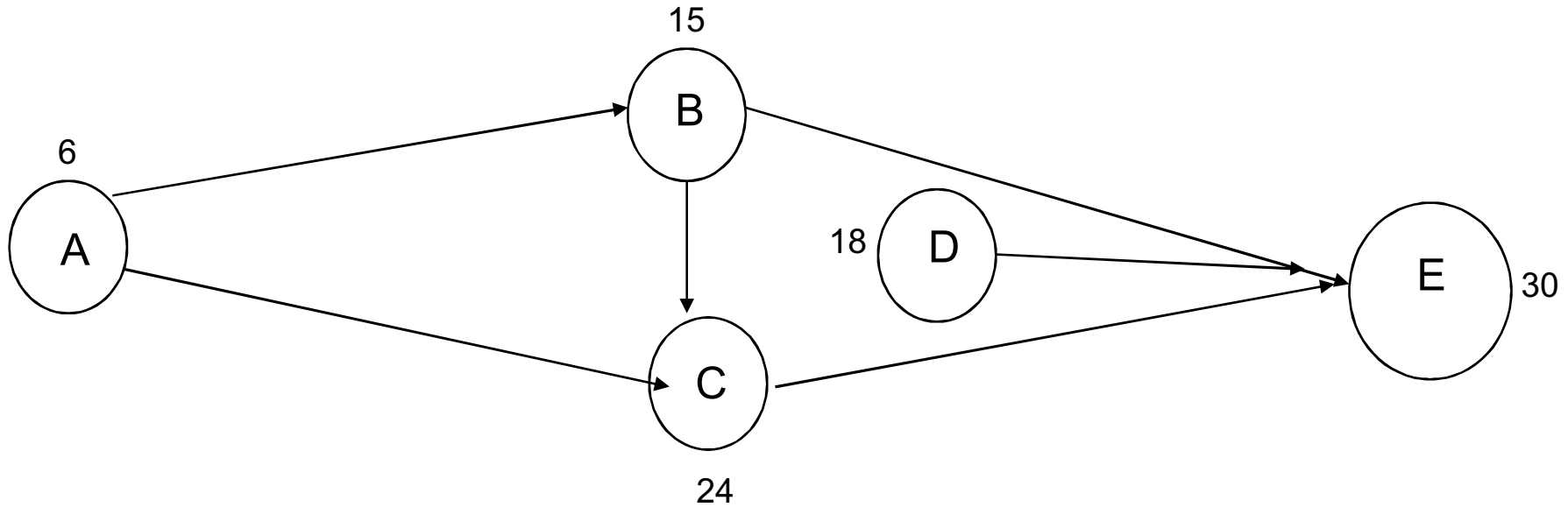
Calculate

(i) Desired cycle Time

(ii) Theoretical Minimum Number of Workstations

(iii) Efficiency of Assembly Line also, find out work elements for each station.

(Assembly Line has capacity to fulfill demand)



Theoretical Minimum Number of Workstations =

$$\frac{6 + 15 + 24 + 18 + 30}{34.56} = 2.75 = 3 \text{ Stations}$$

Efficiency of Assembly Line

$$\frac{6 + 15 + 24 + 18 + 30}{3 \times 34.56} = 91.6\%$$

Just-In-Time (JIT)

Just-in-Time (JIT) is an integrated set of activities designed to achieve high-volume production using minimal inventories of raw materials, work-in-process, and finished goods. Parts arrive at the next work station “Just in Time” and are completed and move through the operation quickly. Just-In-Time is also based on the logic that nothing will be produced until it is needed. Need is created by the actual demand of the product. When an item is sold, the market pulls a replacement from the last position in the system – final assembly in this case & the chain moves on.

To enable this pull process to work smoothly, JIT demands high levels of quality at each stage of the process, strong vendor relations and a fairly predictable demand for the end product.

“Big JIT” is the philosophy of OM that seeks to eliminate waste in all aspects of production activities:

- Human Relations

- Vendor Relations

- Technology

- Management of Materials & inventories

“Little JIT” Focuses more on scheduling goods inventories and providing service resources where & when needed.

Japanese Approach to Productivity

Elimination of waste:

- i) Waste from over-production
- ii) Waste of waiting time
- iii) Transportation waste
- iv) Inventory waste
- v) Processing waste
- vi) Waste of motion
- vii) Waste from product defects.

Seven Elements that Address Elimination of Waste are:

1. Focused Factory Networks
2. Group Technology
3. Quality At the Source
4. JIT Production
5. Uniform Plant Loading
6. Kanban Production control systems
7. Minimized setup times.

Respect for People

- Respect for people is the key to Japanese improvements
- Life time employment for permanent positions within major firms.
- All employees receive two bonus a year in good times.
- Operating decisions at the lowest level through consensus.
(bottom round management)
- Top Management concentrates on strategic planning.
- Quality circles of volunteer employees meet weekly-multi discipline teams led by a trained group leader or facilitator. These quality circles are part of consensus, bottom-round management approach.

Seven Elements that address elimination of waste are:

1. **Focused Factory Networks**: The Japanese build small specialized plants rather than large vertically integrated manufacturing facilities. They design plants for one purpose & operate these more economically employing between 30 to 1000 workers.
2. **Group Technology**: Instead of transferring jobs from one deptt. to another to specialized workers, the Japanese consider all operations required to make a part and group these machines together. Workers, however, have to be multi-skilled & flexible to run several machines & processes.
3. **Quality At Source**: It means to do it right the first time and when something goes wrong, stop the process or assembly line immediately. Factory workers become their own inspectors, personally responsible for the quality of their outputs. Workers in the group join to rectify the problem and are empowered to do their own maintenance & housekeeping until the problem is fixed

4. JIT Production: JIT means producing what is needed, when needed & no more. Anything over the minimum amount necessary is viewed as waste because effort & material expended for something not needed now cannot be utilized now. JIT is applied to repetitive manufacturing & to any repetitive segments of business. Under JIT, deal lot size is one.

5. Uniform Plant Loading: Smoothing the production flow to dampen the reaction waves that normally occur in response to schedule variations is called uniform plant loading. The only way to eliminate the problem is to make adjustments as small as possible by setting a firm monthly production plan for which the output rate is frozen.

The Japanese found they found do this by building the same mix of products every day in small quantities to respond to variations in demand.

6. Kanban Production Control Systems: A Kanban control system uses a signaling devices to regulate JIT flows Kanban means “Sign” or “instruction card” in Japanese. In a paperless control system, containers can be used instead of cards the cards or containers make up the Kanban Pull System. Possible approaches are:

- Container System
- Kanban Squares
- Coloured Golf Balls

Kanban pull approach can be used not only within manufacturing facility but between manufacturing facilities & also between manufacturers & external suppliers.

7. Minimized Set-up Times: Because small lot sizes are the norm, machine set-ups, must be quickly accomplished to produce the mixed models on the line. To achieve set-up time reduction, steps are divided into internal & external activities. Internal set-ups are done when machine is stopped while external set-ups can be done while machine is running.

JIT (JUST-IN-TIME) Philosophy

What is JIT?

- Elimination of All wastes
- Pull system through plant
- It is a mgt. philosophy

What Does JIT Do?

- Attack wastes (Time, Inventory, scrap etc.)
- Exposes problems & bottlenecks.
- Achieve streamlined production

Main Mantras of JIT

- Elimination of waste
- Pull – Type system
- Lot size reduction
- Zero Defects

What is Required in JIT?

- Employee Participation
- Small Lot size
- Total Quality Control
- Basics of industrial engg.

What is Assumed In JIT

- Stable environment
- Commitment to quality
- Reduction of waste
- Involvement at all levels of organization.

Characteristics of JIT

- ❖ Ideal lot size in JIT is one piece.
- ❖ Aims at driving all queues to zero in order to:
 - Minimize inventory investment
 - Shorten Production lead times & set-up times
 - React faster to demand change.
- ❖ Focused Factory
- ❖ Cellular (GT) manufacturing system
- ❖ Uncover any quality problem & its control at source
- ❖ Total preventive maintenance
- ❖ Cross-Trained worker & worker flexibility
- ❖ Uniform work load
- ❖ Kanban Cards
- ❖ Decentralization

JIT production system employs the Pull system rather than traditional push system.

Push System: Push system of production control focuses on beginning of production line, the schedule pushing work through operations from beginning to end.

Pull System: Focuses on the end of the line and pulls work-through from preceding operations. Workers perform the required operation on the material/part, drawn from preceding work station at the necessary time with the use of a Kanban (instructions card). Thus work-in-process inventory is minimized & over – production can be eliminated. Two types of Kanban.

a) Withdrawal (withdrawal Kanban)

b) Production ordering information (Production Kanban)

Production Kanban signals the need for production of a part, other visual methods are:

- Container System

(Empty container signals the need to fill it up)

- Kanban Squares

(Marked spaces on factory floor or on a table to identify where material should be stored when square is empty, it signals authority to produce)

- Coloured Golf Balls

When a part is used, assembler rolls a coloured golf ball to signals replacement.

Kanban & Full System: Kanban means card in Japanese language. In JIT, Kanban cards are used to move material through the production. Two common types of Kanban cards are:

- i) Withdrawal kanban
- ii) Production Kanaban

Part Number _____

Part Name _____

Preceding
Process

Box Capacity	Box Type	Issue No.

Subsequent
Process

Part Number _____ Part Name _____ Stock Location at which To store: Container Capacity	Process
---	---------

Production Kanban

The withdrawal Kanban is used to release material from previous output area or vendor.

The production Kanban works as instruction to start production from a previous work centre. Thus, material is pulled from a previous unit of material processing or material supplier.

Preliminary To JIT Production

- (i) Standardize individual operations through work study so that non-value adding items are minimised.
- (ii) Provide U-shape layout so that each operator can handle more than one machine.
- (iii) Operators required to master multiple jobs.
- (iv) Reduce set-up times.
- (v) Production smoothing stabilisation of a process for multi product, small batch production.

vi) “Jadoka” (self-actuation) – when unusual event happen in production line, the work-in-charge should stop the line and take help to remove the cause of trouble.

Determining Number of Kanbans Needed: Each container represents the minimum production lot size to be supplied. The number of containers, therefore, directly controls the amount of work-in-process inventory in the system. The number of Kanban card sets is :

$$K = \frac{\text{Expected Demand During Lead Time} + \text{Safety Stock}}{\text{Size of Container}}$$

=

$$\frac{\text{Expected Demand During Lead Time} + \text{Safety Stock}}{\text{Size of Container}}$$

Where:

K = Number of Kanban Card Sets

D = Average Number of Units Demanded over some time Period

L = Lead Time to Replenish an order (expressed in the same units as demand)

S = Safety Stock Expressed as a percentage of demand during the lead time.

C = Container Size

It may be observed that a Kanban system does not produce zero inventory, rather it controls the amount of material that can be in the process at a time – the number of containers of each item. Number of Kanbans can be added or withdrawn based on requirement of operations.

A Stable Schedule – Pull System

JIT firms require a stable schedule over a lengthy time horizon. This is accomplished by

- a) Level Scheduling
- b) Freeze Windows
- c) Underutilization of capacity.

Level Schedule: Is one that requires material to be pulled into final assembly in a pattern uniform enough to allow the various elements of production to respond to pull signals.

Freeze Window: It refers to the period of time during which the schedule is fixed and no further changes are possible.

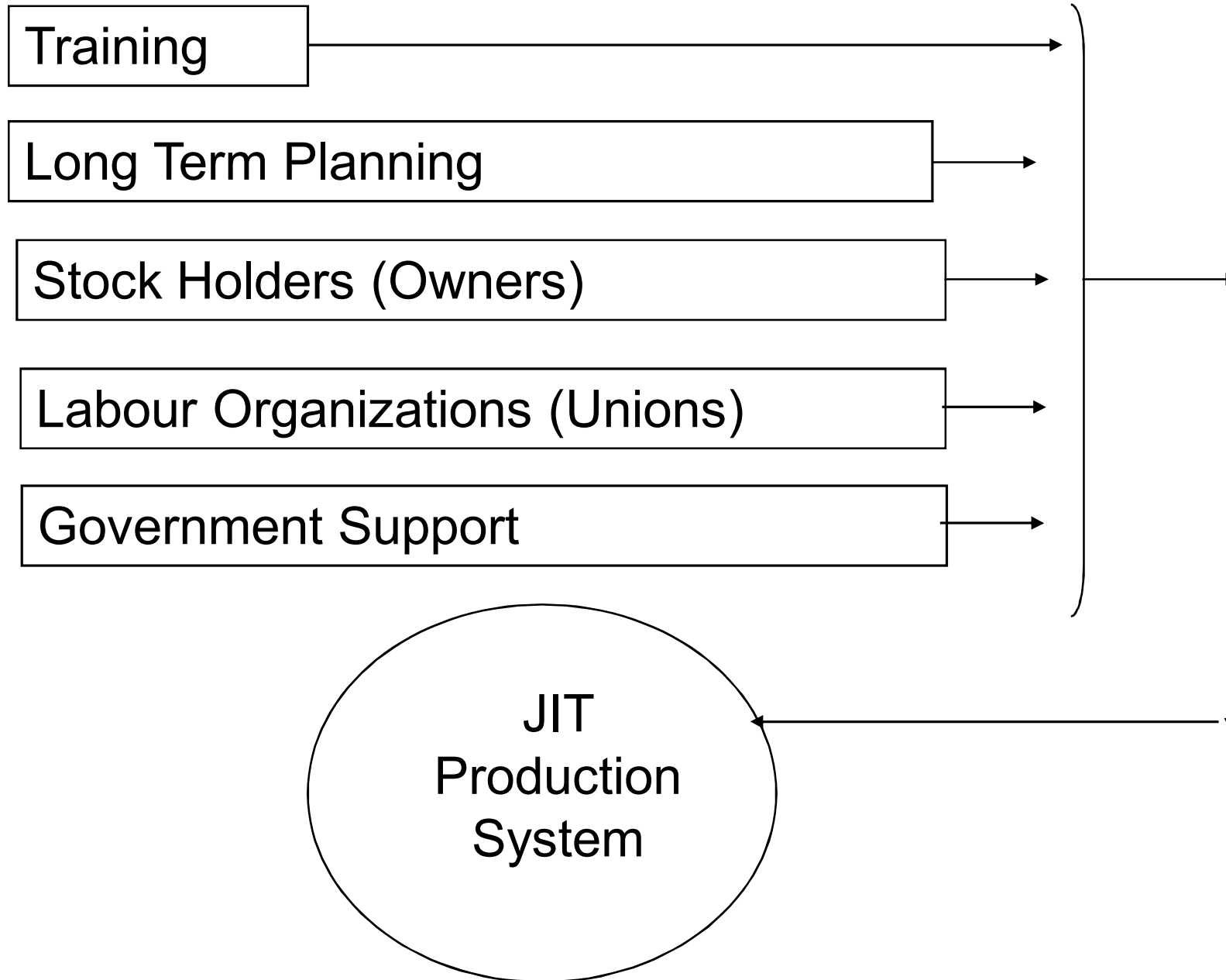
Back Flush: It is used to periodically find out an end item's bill of materials. This eliminates much of shop floor activity which is required if each part must be tracked and accounted for during production.

Under – Utilization of Capacity: The excess capacity in labour & equipment is much cheaper than carrying excess inventory. It is a controversial feature of JIT. During idle periods, personnel can be put to work on other activities such as special projects, work group activities and work station house-keeping etc.

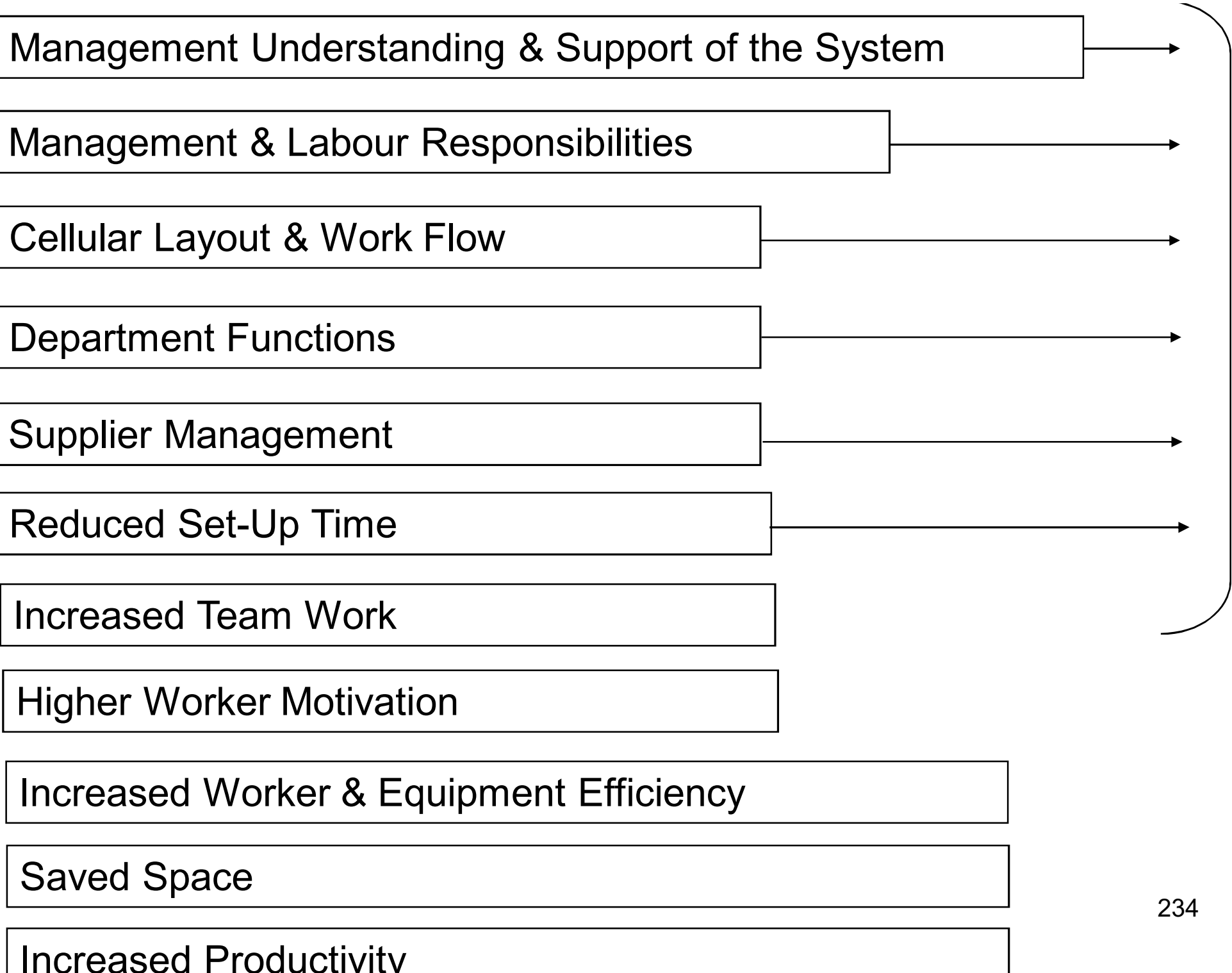
Total Quality Control (TQC): JIT & TQC have merged in theory & practice. TQC is the practice of building quality into the process & not identifying quality by inspection. It also refers to the theory of employees resuming responsibility for the quality of their own work & thus only good quality products are pulled through the system when all products are good, no “Just in case” extra inventory is needed. Thus organizations can achieve high quality & high productivity.

By using statistical quality control methods & training workers to maintain quality, inspections can be required to first & last units produced. If they are perfect, we can assume other units are perfect as well.

Some Requirements for Implementing JIT



Management Understanding & Support of the System



Management & Labour Responsibilities

Cellular Layout & Work Flow

Department Functions

Supplier Management

Reduced Set-Up Time

Increased Team Work

Higher Worker Motivation

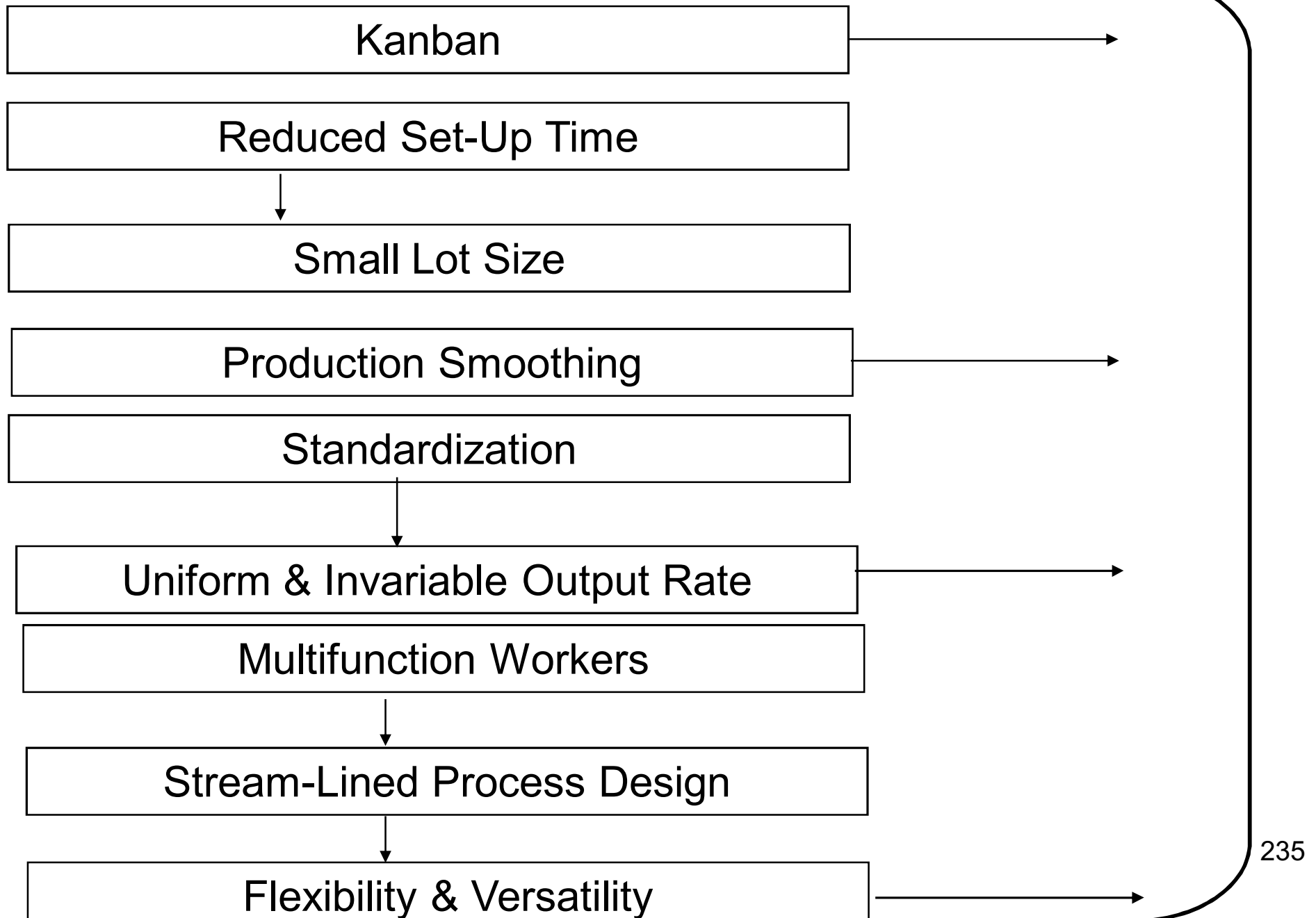
Increased Worker & Equipment Efficiency

Saved Space

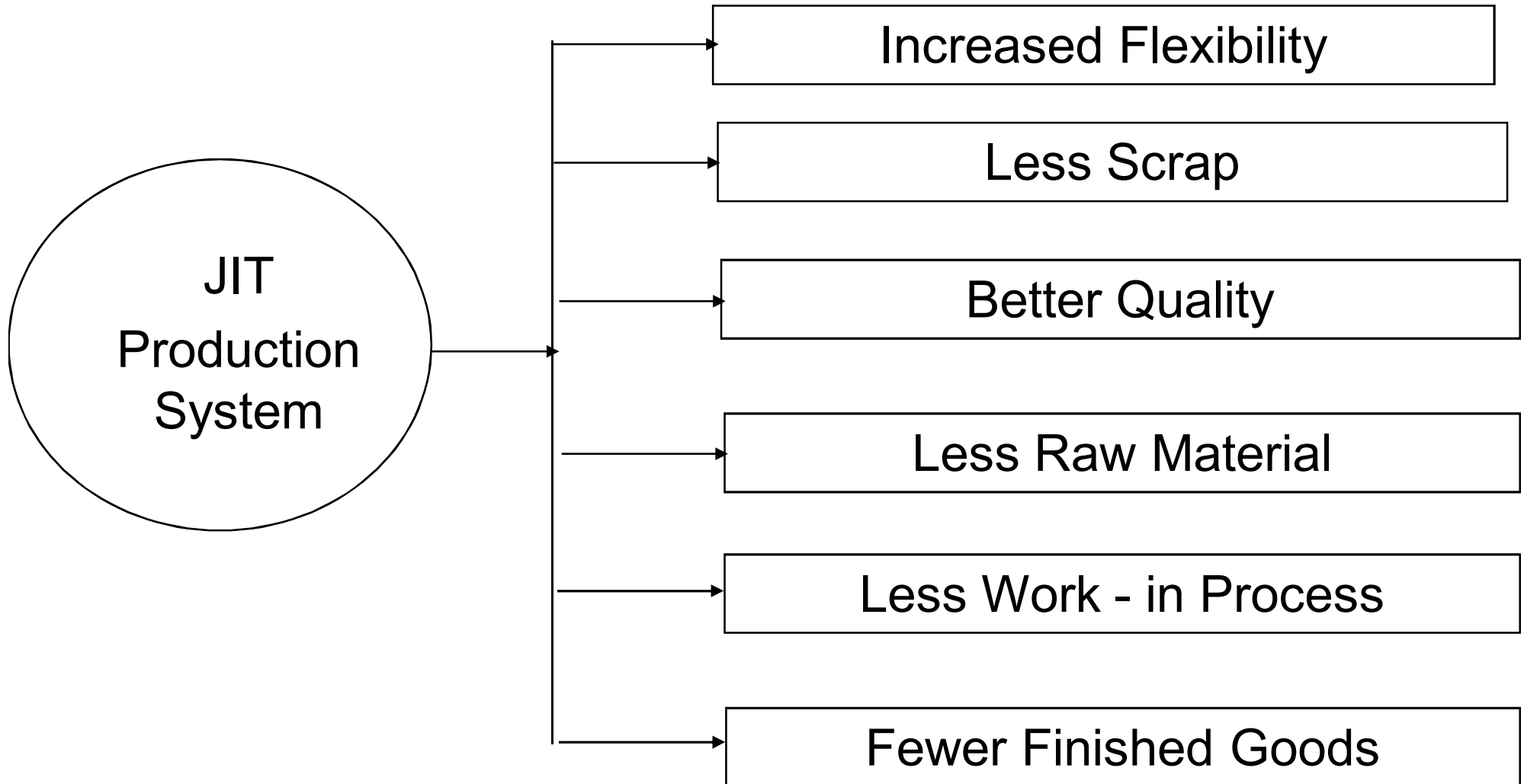
Increased Productivity

Components & Potential Benefits of JIT

Components of JIT



Benefits of JITS



Unit – VI

Ergonomics

Ergonomics is concerned with designing & shaping jobs to fit the physical abilities & characteristics of individuals so that they can perform the work more effectively. This is also known as Human Factors Engineering or Biomechanics or Engg. Psychology.

Ergonomics is the study of how human beings physically interface with their work. Ergonomics evolves guidelines on the development & adjustment of technology for rational utilization of Human Capital under the favorable environment & social conditions. This in turn enhances system safety, human comfort, effectiveness & quality of work life. The fundamental laws of ergonomics emerged from multiple disciplines such as Engg., Physiology, economics, work study etc. & other social sciences.

Four major sub-branches

- i. Human, Machine interface technology or **hardware ergonomics**
- ii. Human environment interface technology or **environmental ergonomics**
- iii. User, system, interface technology or **software ergonomics.**
- iv. Human, Machine, environment organization interface technology or **Macro Ergonomics.**

Applications of Ergonomics

Two Major Areas:

1. The physical devices or equipments people use in performing work
2. The environment in which work is performed.

The design of physical devices or equipments must take into account the reach, response, strength, height, etc & other human capabilities & limitations of average worker.

The work environment should cover noise, temperature lighting etc.

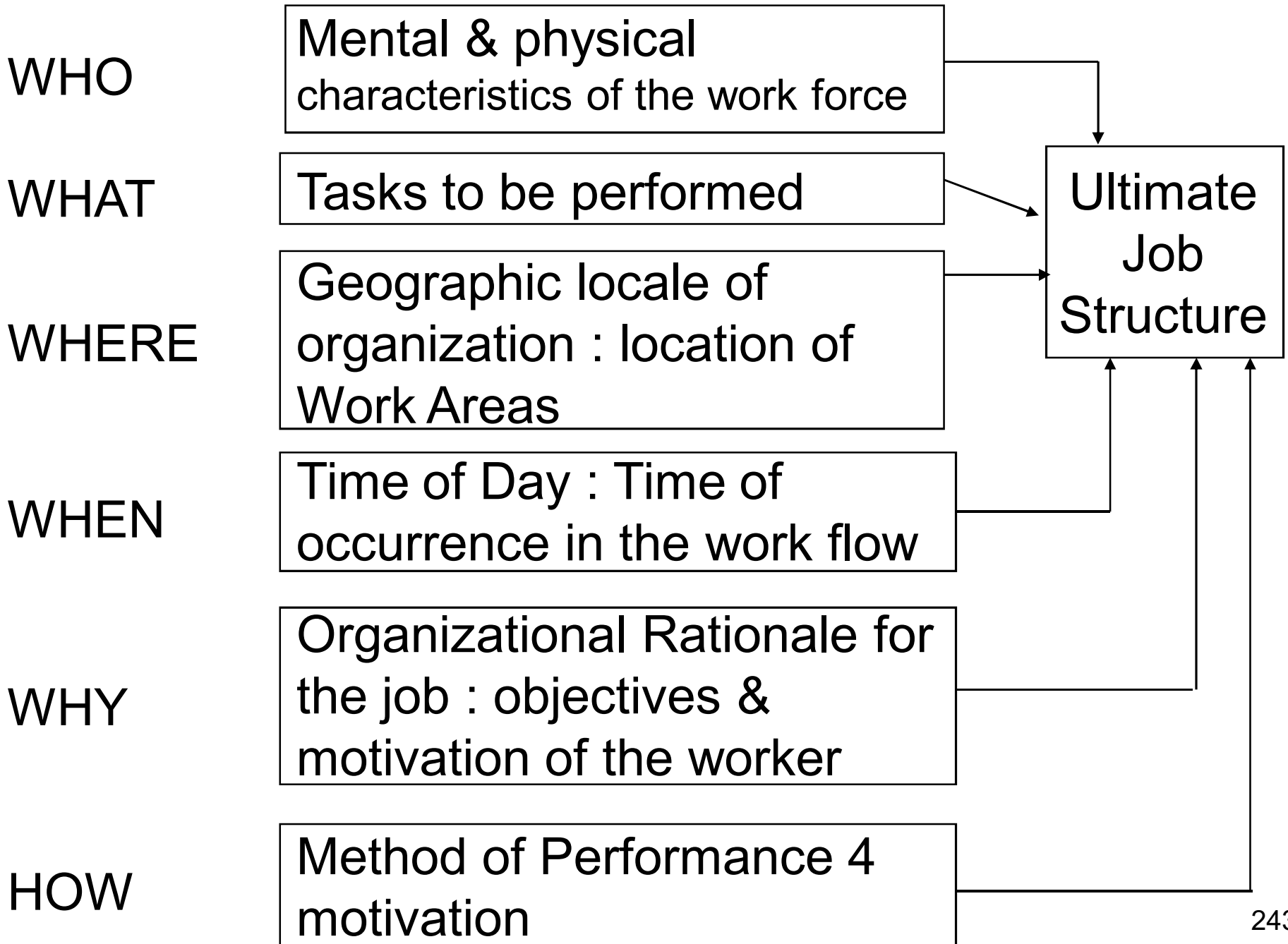
Activities involved in ergonomics of work station design are:

1. Improving the work flow.
2. Reducing repetitive physical motions
3. Adjusting illumination levels.
4. Allowing employees to personalize work area.
5. Using pleasing colours in office.
6. Creating private offices & work spaces
7. Providing lounges for rest breaks.
8. Re-arranging, adjusting or replacing equipment, parts & work spaces.
9. Placing team members close together so that they can interact easily.
10. Providing adjustable office furniture to fit varying body physiques & particular work activities.

JOB DESIGN

Job Design may be defined as a function of specifying the work activities of an individual or group in an organizational setting. Its objective is to develop job structures that meet the requirements of the organization and its technology and that satisfies the job holder's personal and individual requirements.

Job Design Decisions



Techniques of Job Design (Behavioural Considerations)

- Work Simplification
- Job Rotation
- Job Enlargement
- Job Enrichment
- Autonomous Work Group
- High Performance Work Design

Work Simplification

- Job is simplified or specialized
- Work simplification is done so that less trained & less paid employee can do these jobs.
- While specialization has made possible high speed low-cost production & enhanced our standard of living yet extreme specialization (mass production industries) results in boredom which can lead to errors & resignations.

Job Rotation

Rotating employees among different jobs can reduce boredom and monotony and exposes employees to entire production process.

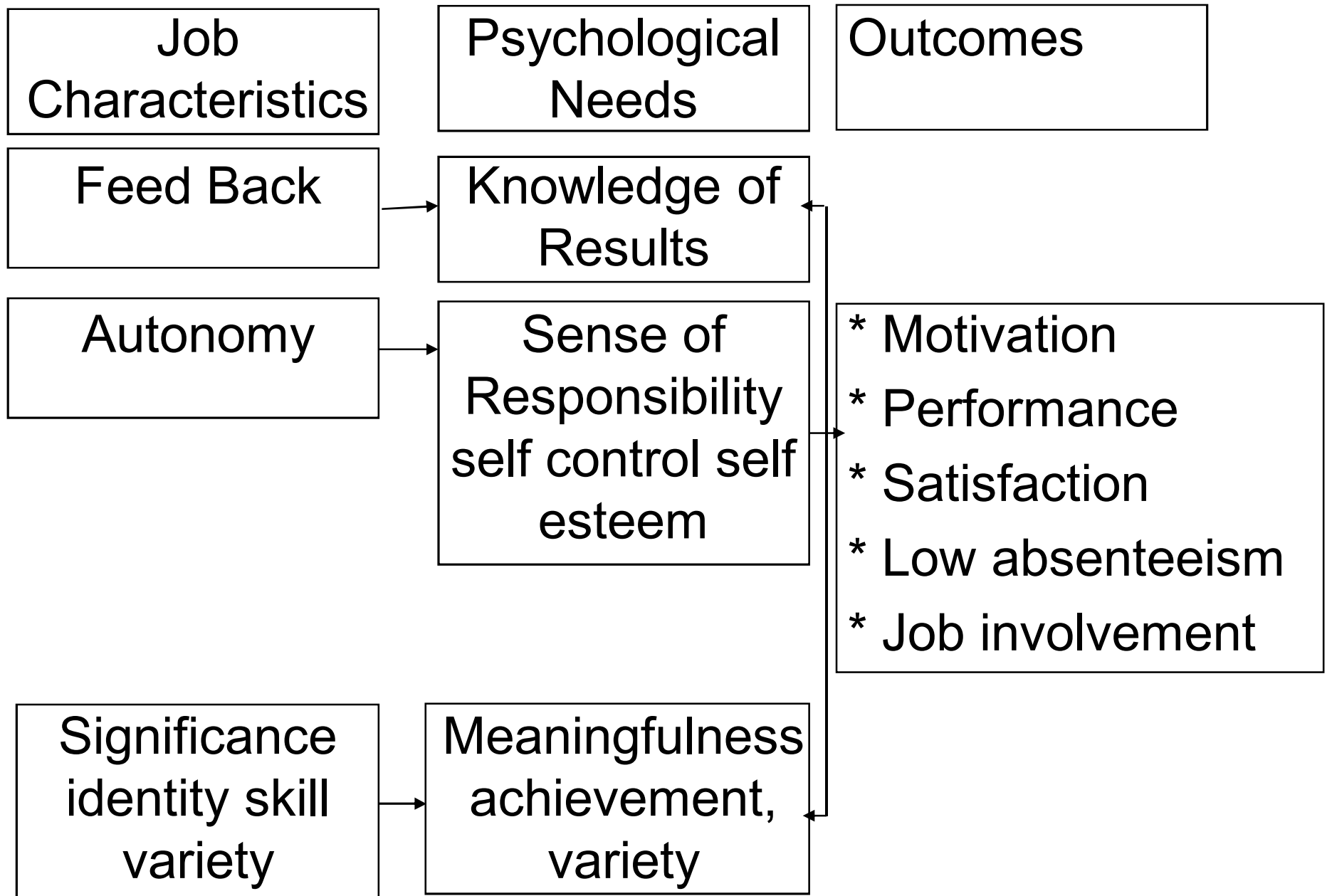
Job Enlargement

It is to increase scope & complexity of a worker's job in order to make it more appealing:

- a) More Tasks of similar nature & skill level added (horizontal enlargement).
- b) More Tasks of different nature but similar skills (vertical enlargement).

Job Enrichment

Involves redesigning jobs to give more meaning and enjoyment to the job by involving employees in managerial functions of planning, organising and controlling their work. It gives opportunity for growth and achievement beyond their current role. Both horizontal & vertical enlargement can be practiced and total approach can be termed as Job Enrichment.



Job Enrichment & Its Outcomes

These decisions are affected by following trends:

Quality control as a part of worker's job "Empowerment" to workers

- To stop production if quality is a problem
- On the spot refund if service not satisfactory

Cross-training workers to perform multi-skilled jobs

- More necessary now with downsizing
- Also for single-point service

Employee involvement & Team approaches to designing & organizing work

- All TQM programmes are team based.

"Informating" ordinary workers through telecommunication networks and computers the thereby expanding the nature of their work and their ability to do it.

- Rep. uses computer to troubleshoot serious problems.

5. Extensive use of temporary workers

- Largest private co. having five lakh workers on its roll.

6. Automation of heavy manual work

Robots – driven by safety regulations as well as economics & personnel reasons.

7. Most important of all, organizational commitment to providing meaningful & rewarding jobs for all employees.

SOCIO TECHNICAL SYSTEMS

This process / approach attempts to develop jobs that adjust the needs of the production process technology to the needs of the worker and work group.

Studies carried in weaving mills in India and coal mines in England. Studies revealed that work groups could effectively handle many production problems better than management if they were permitted to make their own decisions on scheduling, work allocation among members, bonus sharing, etc.

Other names are:

- Autonomous work groups
- Japanese style work groups
- Employee Involvement (EI) teams

Job Design Principles

Individual or work group requires a logically integrated pattern of work activities that incorporates following job design principles:

1. Task Variety
2. Skill Variety
3. Feed-Back
4. Task Identity
5. Task Autonomy

Autonomous or Self-directed Team

A self directed work team is an intact group of employees who are responsible for a “whole” work process or segment that delivers a product or service to an internal or external customer.

Every one in the team is involved in decisions affecting the groups, highly committed and follow a process that helps them plan, make decisions and ensure the quality of their work.

High Performance Work Design

High performance work design starts from the principle of an autonomous group working, the rate of innovation is high, operational flexibility is important, need to apply new skills quickly with the minimum of supervision. Such high performance work design does not work in most organizations which are caught up in bureaucratic ways.

Positive & negative outcomes of job design approaches

Work Simplification

Positive Outcome

Job highly specialised so that less trained & less paid employee can perform

Negative Outcome

Over-simplification results in boredom with attendant risks of errors & resignations

Job Rotation

Versatility of employees, enhanced inter-departmental co-operation, org. too gains, worker's self image grows

Jobs do not improve workers may feel rootless & alienated

Positive Outcome

Job Enlargement

Gives motivational impact

Negative Outcome

Adding one boring task to another. Likely to be resisted

Job Enrichment

- | | |
|---|---|
| <ul style="list-style-type: none">- Increased motivation & reduced absenteeism.- Psychological needs of employees met- Brings about empowered teams | <ul style="list-style-type: none">- May not accept new responsibilities.- If not accompanied by other job inputs will fail in its goal |
|---|---|

Positive Outcome

Autonomous Work Team

- Greater involvement of employees in decision-making.
- Involvement brings in commitment

High Performance Work Design

Works in an environment of high rate of innovation & operational freedom

Negative Outcome

There is resistance from employees, unions, supervisors & managers

May not work in large bureaucratic organizations

Physical Considerations In Job Design

Work Physiology:

To incorporate physical costs of moderate to heavy work in job design is human as work physiology.

- Five calories per minute is generally considered the maximum sustainable level throughout the work day.

Type of Activity	Energy spent in calories / minute	Required rest for each minute of work
Writing / Typing / shoe repair / machinery / ironing	<5	---
Chopping wood	7.5	1
Digging	8.9	2
Tending Furnace	12.0	3

Work Measurement & Standards

Work measurement is carried out to set time standards for a job, necessary for following reasons:

1. To schedule work and allocate capacity
2. To provide an objective basis for motivating the work force and measuring their performance.
3. To bid for new contracts and to evaluate performance on existing ones.
4. To provide bench marks for improvement.

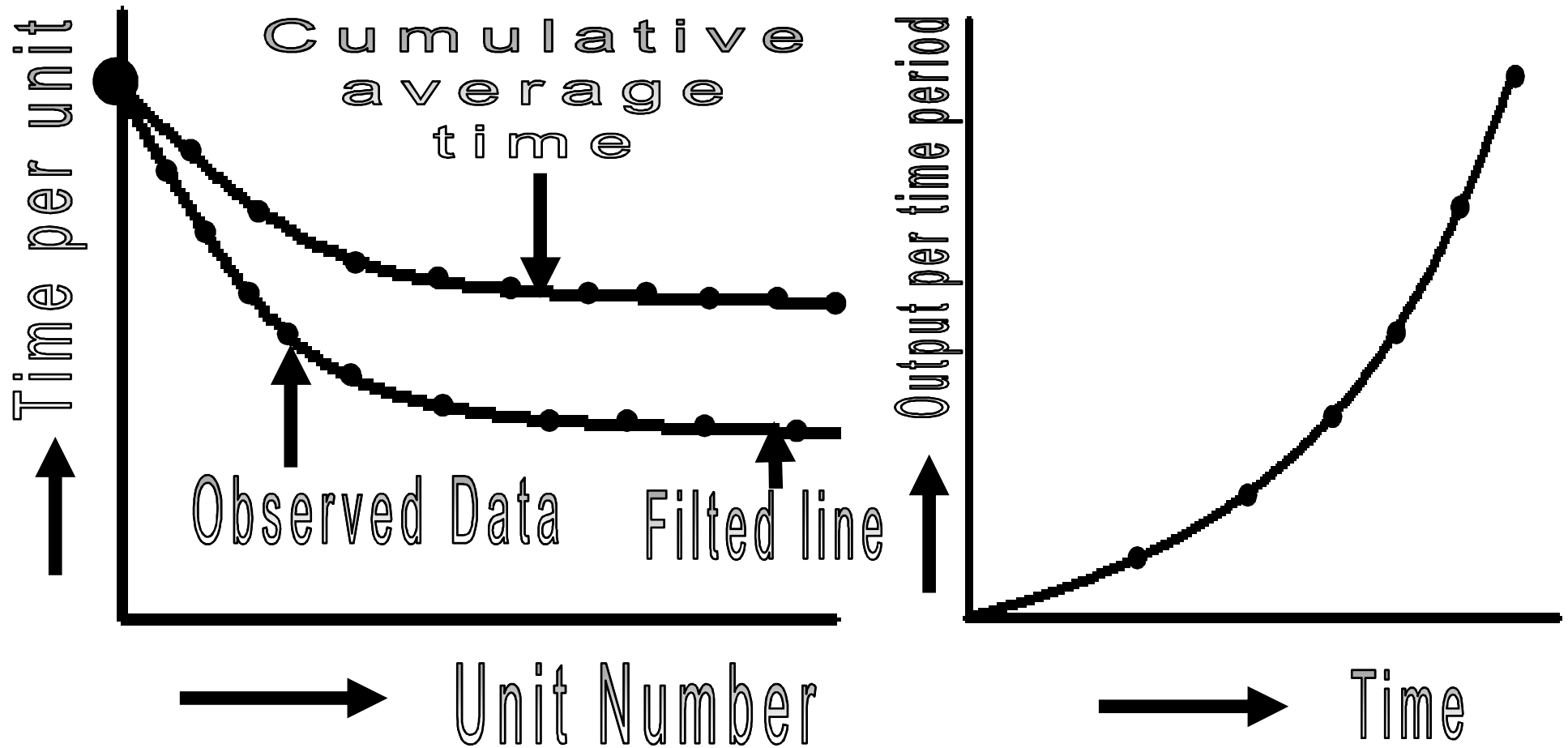
Comparison of Common Reward / Incentive Plans

<u>Type of Plan</u>	<u>Application</u>	<u>Advantages</u>	<u>Disadvantages</u>
Merit Pay	Individual	• Target specific behaviour	• can be arbitrary • not tied to business goals
Profit Sharing	Group	• Ties business performance to employee reward	• Often individual or group behaviour is not co-related to business performance
Gain Sharing	Group	• Specific group performance is directly related to employee	• Excessive focus on cost control • Does not apply to strategic changes

Type of Plan	Application	Advantages	Disadvantages
Lump Sum bonus & Individual bonuses	Either	• Vary criteria or magnitude of reward to target specific actions & behaviour.	• Seen as deferred payment • Not tied to business goals/performance
Pay for knowledge	Individual	• Target specific types of skills & personal growth	• May not target business performance unless correct & new skills are targeted.
Piece-Rate	Either	• Target specific output goals	• May lead to undesirable competition among workers • Standards must

LEARNING CURVES

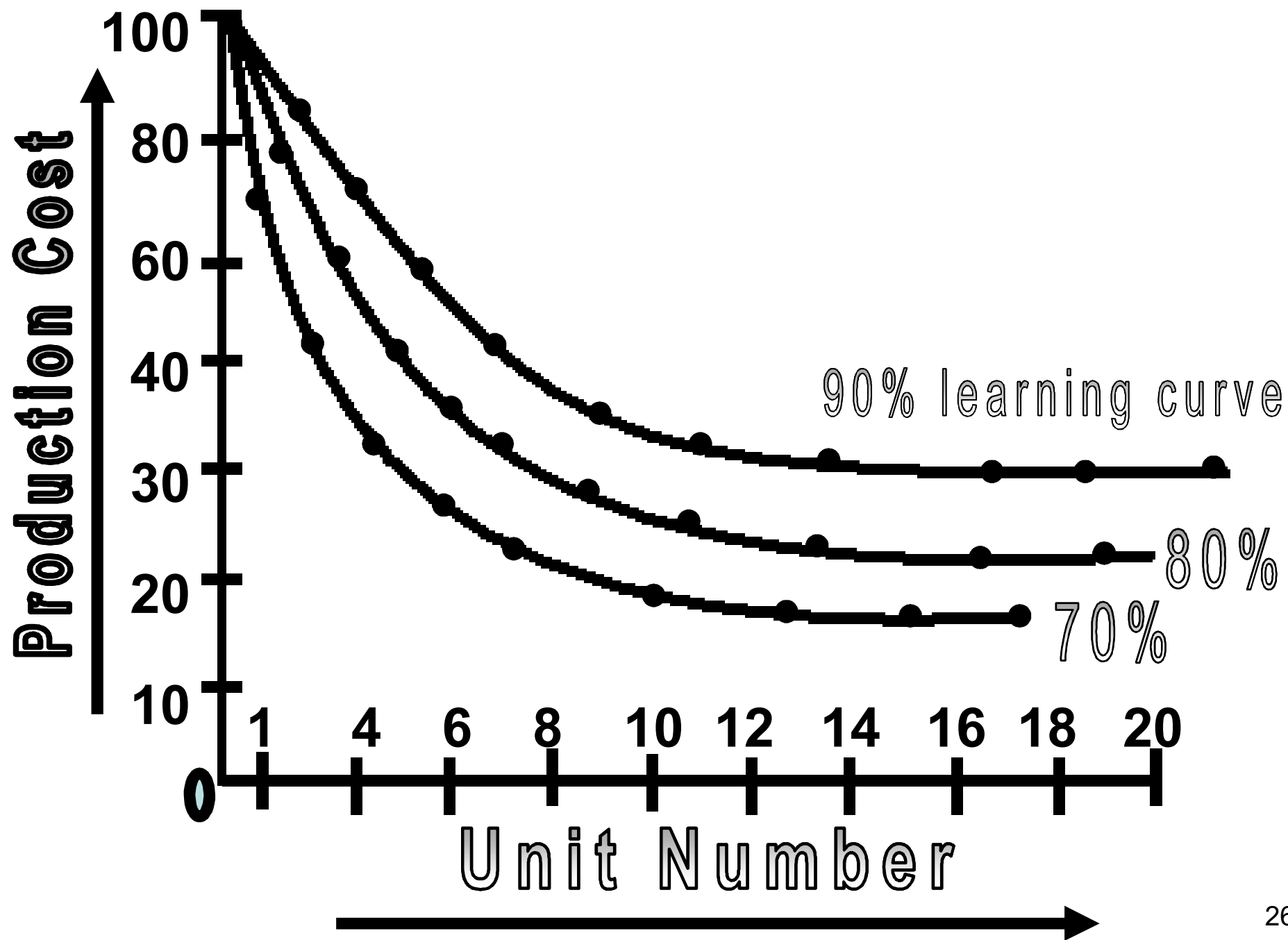
A learning curve is a line displaying the relationship between unit production time and the cumulative number of units produced.



Learning curve theory is based on three assumptions

1. The amount of time required to complete a given task or unit of a product will be less each time the task is undertaken
2. The unit time will decrease at a decreasing rate.
3. The reduction in time will follow a predictable pattern.

(80% learning curve)			
Unit No.	Unit direct Labour hours	Cumulative direct labour hours	Cumulative average direct labour hours
1	10	10	10
2	8	18	9
3	6.4	24.4	8.1
4	5.1	29.5	7.4



How Long Does Learning Go On ?

Some areas can be shown to improve continually – computers, electronic devices, communication, etc.

General Guidelines for Learning

1. Proper selection of workers
2. Proper Training
3. Motivation
4. Work Specialization
5. Do one or very few jobs at a time.
6. Use proper tools/equipment that assists performance
7. Provide quick & easy access for help.
8. Allow workers to help redesign their tasks.

Organizational Learning

- Sum-total of individual learning
- Knowledge in technology, structure of the organization (decentralization), Toolings, software

Work Study

Work study is a general term for those techniques particularly method study & work measurement which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

Method Study

Method study is the systematic recording & critical examination of existing & proposed ways of doing work, as a means of developing and applying easier & more effective methods and reducing costs.

Work Measurement

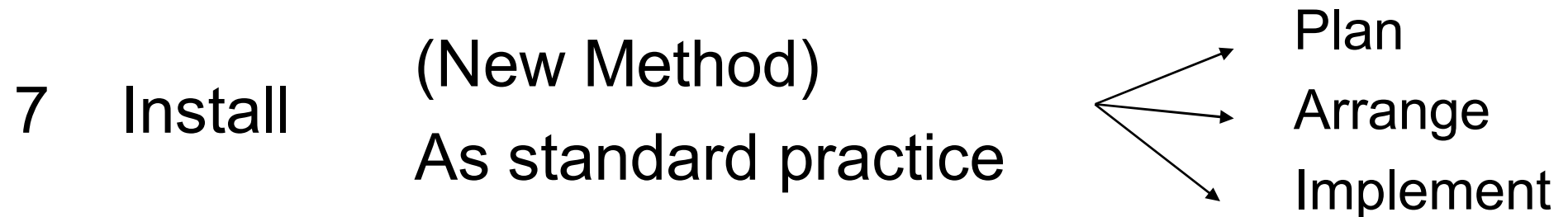
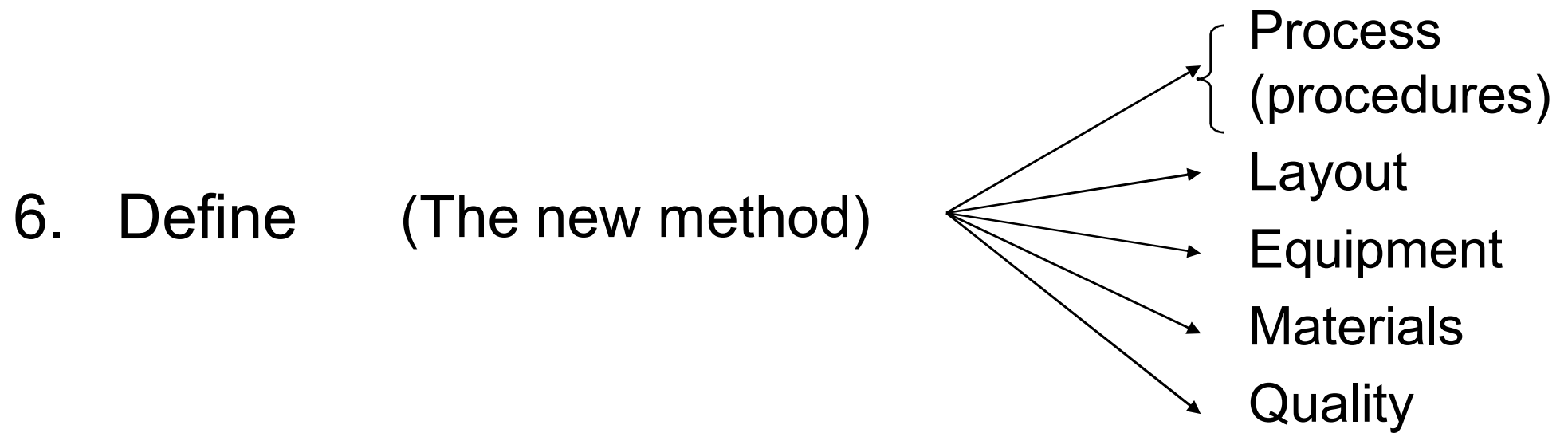
Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level or performance.

Notes:

Method study should precede work measurement so as to standardize the method of doing work.

Basic steps for work study procedure

1.	Select	(Job/Process)
2.	Record	(All relevant facts using suitable charts)
3.	Examine	(Critically examine all recorded facts & challenge) Purpose-Place-sequence-person-means ↓ Eliminate / Simplify / Combine or change
4.	Develop	(New method for job/process/operation)
5.	Measure	(Work content & establish standard time)



8. Maintain (Verify at regular intervals)

Objectives of work study

1. Analyse present method systematically in order to develop new & better method.
2. Measure work content required for a qualified worker to establish standard time.
3. Increase productivity by ensuring best use of resources to achieve best quality product / service at minimum possible cost.
4. To improve operational efficiency.

Benefits of Work Study

1. Increased productivity & operational efficiency
2. Reduced manufacturing costs
3. Improved work place layout
4. Better manpower planning & capacity planning
5. Fair wages to employees
6. Improved work flow
7. Better working conditions
8. Reduced material handling costs
9. Provides a standard of performance to measure labour efficiency.
10. Better industrial relations & employee morale.
11. Basis for sound incentive schemes.
12. Provides better job satisfaction to employees

Selection of Job for Method Study

i) Economic Considerations

- a) Bottlenecks holding up productions
- b) Movement of materials over long distances
- c) Operations involving repetitive work

ii) Technical Considerations

Ensure adequate technical knowledge is available to carry out study

- a) Machine tool running at below recommended speed of ceramic tool.
- b) Loading of unfired ware into a pottery

iii) Human Reactions

Trade union representatives/workers might resist investigations. Tackle other jobs successfully and then convince for original choice of job resisted to earlier.

Work Measurement

Used to determine length of time a job should take for completion.

Why time is required to be determined ?

- (i) Helps in manpower planning
- (ii) Helps in estimating labour cost
- (iii) Helps in scheduling activities
- (iv) Helps in budgeting
- (v) Helps in designing incentive scheme

Purposes of Work Measurement

(A) Definition of work measurement

“Work measurement is the application of techniques to establish the time for a qualified worker to carry out a specific job at a defined level of performance”. I.L.O.

Uses of work Measurement (Time Standards)

(i)	To evaluate leabour performance.
(ii)	For planning the need of workforce.
(iii)	For determining available capacity.
(iv)	For comparing work methods
(v)	For facilitating operation – scheduling.
(vi)	For determining price or cost of a product or output involving human labour.
(vii)	For establishing wage incentive schemes.
(viii)	For determining standard time for various operations. (Standard time is necessary for determining machine capacity, production targets, manpower planning, etc.)

(ix)	For determining idle or rest time of an operator. (Idle time information is used for planning “one operator-multiple machines” type of manufacturing system).
(X)	For generating necessary input information for decisions related to estimating, tendering, pricing, etc.
(Xi)	For generating information related to line-balancing in assembly line.
	- Repetitive jobs <u>Criteria for work measurement</u> - Identifiable jobs (in terms of number of units) - Consistent jobs (in terms of accomplishing the job).

Performance Rating

“Rating is the assessment of worker’s rate of working relative to the observer’s concept of the rate corresponding to the standard pace”.

--- I.L.O.

The rating of the worker gives the comparison of the rate of working observed with respect to standard level, which is the average rate of a qualified worker, when he uses correct methods and when he is motivated to apply himself to the work.

Standard Performance

It is the rate of output which qualified workers will naturally achieve without over-exertion as an average over the working day or shift, provided they know & adhere to the specified method and provided they are motivated to apply themselves to their work. The standard performance is denoted as 100 on the standard rating and performance scales.

Work Content

Work content of a job or operation is =

Basic Time + Relaxation allowance

+ Personal needs allowance

+ Any allowance for additional work

Relaxation Allowance

To provide the worker with opportunity to recover from physiological & psychological effects of carrying out specified work under specified conditions –

Minimum = 4% (sitting & light work)

Personal Needs

To allow for personal needs & it depends on layout / distances involved – 5% to 7%

Contingency Allowance

A small loss of time which may be included in the standard time to meet legitimate and expected items of work delays, the precise measurement of which is (Uneconomical) because of their infrequent or irregular occurrence. Less than 5%

Policy Allowance

A policy allowance is an increment other than bonus increment, applied to standard time (or to some constituent part of it eg. Work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances.

It may be applied as a factor to work content or to standard time or as a temporary arrangement for imperfect functioning of plant, etc.

Special Allowance

Special allowance may be given for any activities, which are not normally part of operation cycle. But which are essential to the satisfactory performance of work.

- e.g.
- Set-up time;
 - Inherent rejection in the process
 - Job/batch change over allowance

Techniques of Work Measurement

(i)	Work sampling
(ii)	Stop watch study
(iii)	Pre-determined Motion Time Standards (PMTS) or MTM (Methods Time Measurement)
(iv)	Standard Data

Basic Procedure of Work Measurement

Select	:	Work to be studied
Record	:	All relevant data about job, operator & surrounding conditions – Record complete work description
Examine	:	Examine the recorded data critically to ensure that the most effective methods & motions are being used and that unproductive & foreign elements are separated from productive elements. Break down operation into elements.

Measure	:	Measure the quantity of work involved in each element, in terms of time, using the appropriate work measurement technique
Compile	:	The standard time for operation, which in case of stop watch time study will include time allowances to cover relaxation, personal needs, etc. Basic Time $= \frac{\text{Observed Time} \times \text{Rating Observed}}{\text{Standard Rating}}$

Standard Time

It is the total time in which a job should be completed at standard performance. It is the sum of standard times of all elements including contingency allowance.

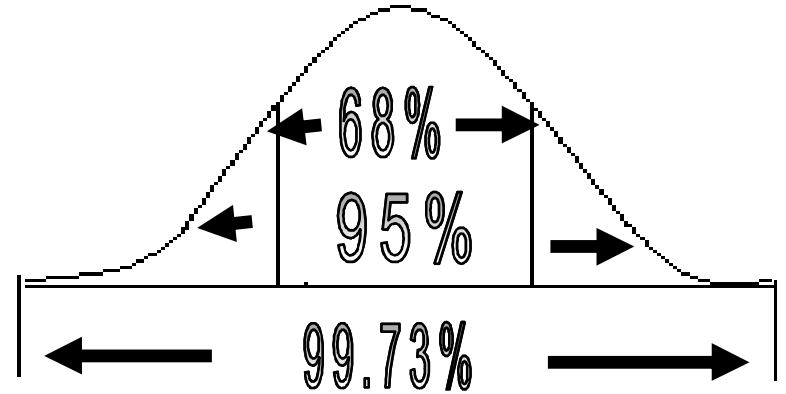
Work Sampling

Work sampling is a method of finding the percentage occurrence of a certain activity by statistical sampling & random observations.

1. Useful for intermittent work
2. Work of long cycle times
3. A starting point like preliminary investigations.

Sample – Size for Work Sampling

$$n = \frac{k^2(p)(1-p)}{(sp)^2} = \frac{k^2 p(1-p)}{(h)^2}$$



p = Idle time estimate

n = Sample size (number of observations required for the desired confidence level & margin of error.)

s = Error (desired accuracy) in fraction

k = A factor depending on confidence level

k = 1 for confidence level of 68%

k = 2 for confidence level of 95%

k = 3 for confidence level of 99.7%

sp = h = Half of accuracy interval

Setting Time Standards Using Work Sampling

For this, analyst (observer) must record the performance rate along with working observations.

Advantages of work sampling over time study

- | | |
|----|---|
| 1. | Several work sampling studies may be conducted simultaneously by one observer. |
| 2. | The observer need not be a trained analyst unless the purpose of the study is to determine a time standard. |
| 3. | No timing devices are required. |
| 4. | Work of a long cycle time may be studied with a fewer observer hours. |

4.	Work of a long cycle time may be studied with a fewer observer hours.
5.	The duration of study is longer, which minimizes effects of a short period variations.
6.	The study may be temporarily delayed at any time with little effect.
7.	Because work sampling studies need only instantaneous observations (made over a longer period), the operator has less chance to influence the findings by changing his or her method.

Motion Study

Objectives

- | | |
|---|---|
| - | To eliminate all non-productive, ineffective & superfluous motions. |
| - | To develop & substitute more effective patterns of movements. |
| - | To modify tools, shapes of work locations, lighting & other factors in optimizing the effects of motions. |

Therbligs

It is the name given to basic motion activities of human beings at work place. These are 17 such activities.

- | | |
|-------------------|---------------------|
| - Grasp | - Transport Loaded |
| - Position | - Select |
| - Pre-position | - Hold |
| - Use | - Unavoidable Delay |
| - Assemble | - Avoidable Delay |
| - Disassemble | - Rest |
| - Release Load | - Plan |
| - Transport Empty | - Inspect |

<u>Rules of Human Motions as Presented by Gilbreth</u>	
--	--

	Work should be performed by machines if machines are more suitable or if work is unsafe for humans.
--	--

<u>Uses of PMTS & MTM (Pre-Determined Motion Time Standards)</u>	
--	--

- | | |
|----|---|
| 1. | They enable development of standards before job is started. |
| 2. | They have been tested extensively in the laboratory and field. |
| 3. | They include performance rating in the times given in the tables, so users need not calculate them. |
| 4. | They can be used to audit time studies for accuracy. |
| 5. | They are accepted as part of many union contracts. |

Method Time Measurement (MTM)

MTM tables provide basic data in which unit of time (TMU-Time Measurement Unit) which is equivalent to one hundred thousand of an hour (or 1TMU = .0006 minute).

Arguments Against Time Standards

- | | |
|---|--|
| - | Union argue that management often sets standards (time standards or standard times for various jobs) that cannot be achieved on regular basis. |
| - | Work standards & quotas inhibit (prevent) process improvement and tend to focus worker's efforts on speed rather than quality. |

What is Standard Time ?

- Observed Time
- Rating

$$\text{Normal Time} = \text{Observed Time} \times \frac{\text{Rating}}{100}$$

(BasicTime)

- Allowances (Relaxation & other allowances as a percentage of normal time).

$$\text{Standard Time} = \text{Normal Time} + \text{Normal Time} \times \text{Allowances}$$

Time Study

Q Calculate the standard production per shift of 8 hours duration with the following data:
Observed time per unit = 5 minutes
Rating factor = 120%
Total allowances = $33\frac{1}{3}$ % of normal time

Ans. Normal time per unit
= Observed Time / Unit X Rating Factor
 $= 5 \times \frac{120}{100} = 6$ minutes
Allowances = $33\frac{1}{3}$ % of Normal Time = $6 \times \frac{33.33}{100} = 2$ minutes

Standard Time / Unit

= Normal Time Per Unit + Allowances

= 6 + 2 = 8 minutes

Standard Production
in Shift of 8 hours } $= \frac{8 \times 60}{8} = 60 \text{ units}$

Q.

Time Study

An 8 hours work measurement study in a plant reveals the following :

Units Produced = 320 Nos.

Idle Time = 15%

Performance Rating = 120%

Allowances = 12% of normal time

Determine the standard time per unit produced.

Ans.

Observed time for 320 units

= Working Time – Idle Time

$$= 8 - 8 \times \frac{15}{100} = 8 - 1.2 = 6.8 \text{ hours} = 408 \text{ minutes}$$

$$\text{Observed Time Per Unit} = \frac{408}{320} = 1.275 \text{ minutes}$$

$$\text{Normal Time Per Unit} = \frac{\text{Observed Time}}{\text{Unit}} \times \frac{\text{Observed Rating}}{\text{Standard Rating}}$$

$$= 1.275 \times \frac{120}{100} = 1.53 \text{ minutes}$$

Standard Time Per Unit

$$= \text{Normal/Unit} + \text{Allowances}$$

$$= 1.53 + 12\% \text{ of } 1.53 \text{ minutes}$$

$$= 1.53 + \frac{12}{100} \times 1.53$$

$$= 1.53 + 0.184 = 1.714 \text{ minutes}$$

Time Story

- Q. A work sampling study shows following =
Total no. of observations = 2500
Number of working observations = 2100
Number of units produced in 100 hours duration = 6000 nos.
Proportion of manual labour = $\frac{2}{3}$
Proportion of machine time = $\frac{1}{3}$
Observed rating factor = 115%
Total allowances = 12% of normal time

Sol. Actual working time in
The duration of 100 hours $= 100 \times \frac{2100}{2500} = 84$ hours

Time taken per article $= 84 \times \frac{60}{6000} = 0.84$ minutes

Observed manual labour time per article $= 0.84 \times \frac{2}{3} = 0.56$ minutes

Observed machine time per article $= 0.84 \times \frac{1}{3} = 0.28$ minutes

Normal labour time per unit =

Observed Time / Unit x Rating Factor

= 0.56 x 1.15 = 0.66 minutes

Standard labour time per unit = $0.644 + \frac{12}{100} \times 0.644$

Standard time per unit of article produced = $0.721 + 0.28$

= 1.0 minute

$$= DP + \frac{D}{Q} C_o + \frac{Q}{2} PC_i$$

$$= 18000 \times 25 + \frac{18000}{1200} \times 250 + \frac{1200}{2} \times 25 \frac{25}{100}$$

Total Cost T_c (EOQ) = Rs. 4,57,500

Unit – VII

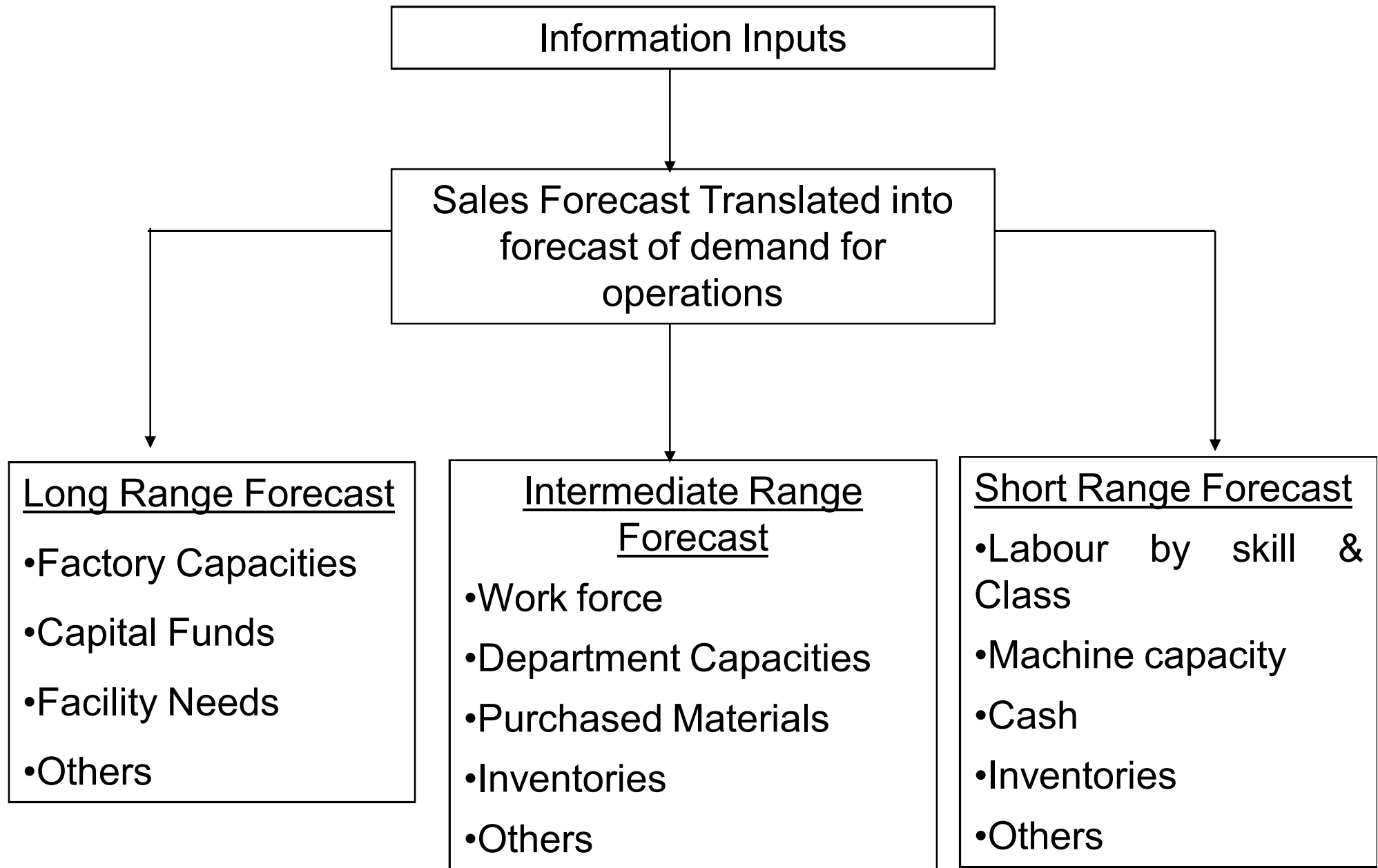
Forecasting

Forecasting is estimating the future demand for products & services and the resources necessary to produce these outputs.

Forecasting is the basis of corporate long-range planning. Forecasts are vital to every business organization and for every significant management decision.

Perfect forecast is usually impossible since many factors in business environment cannot be predicted with certainty.

Forecasting Model



- Short Term = < 3 Months
- Medium (Intermediate) = 3 Months to 2 years
- Long Range / Term = > 2 Years.

Demand Management: The purpose of demand management is to co-ordinate & control all of the sources of demand so that productive system can be used efficiently and product delivered on time.

Dependent Demand: It is the demand for a product or service caused by the demand for other products or services. It is internal demand in a firm.

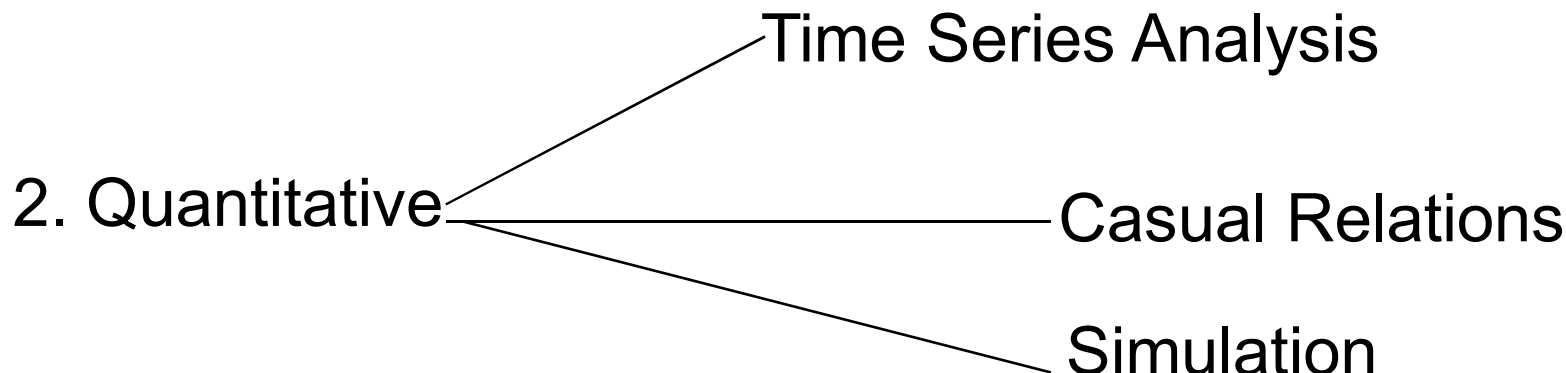
Independent Demand: Its demand cannot be derived directly from that of other products.

The firm can do following about independent demand

1. **Take an active role to influence demand**: Sales efforts, price reduction, etc.
2. **Take a passive role and simply respond to demand**
 - Running full capacity
 - Expensive Advertising
 - Fixed size market
 - Environmental, ethical, legal reasons

Types of Forecasting (Methods of Forecasting)

1. Qualitative



Qualitative Techniques

These are subjective or judgmental and are based on estimates and opinions.

(A)Grass Roots: Derives a forecast by compiling input from those at the end of hierarchy who deal with what is being forecast. For example, an overall sales forecast may be derived by combining inputs from each sales person, who is closet to his or her own territory.

(B)Market Research: Sets out to collect data in a variety of ways (surveys, interviews, etc.) to test hypothesis about the market. This is typically used to forecast long-range & new-product sales.

(C)Historical Analogy: Ties what is being forecast to a similar item, important in planning new products where a forecast may be derived by using the history of a similar product.

Panel Consensus: Free open exchange at meetings the idea is that discussion by the group will produce better forecasts than any one individual participants may be executives, sales people or customers.

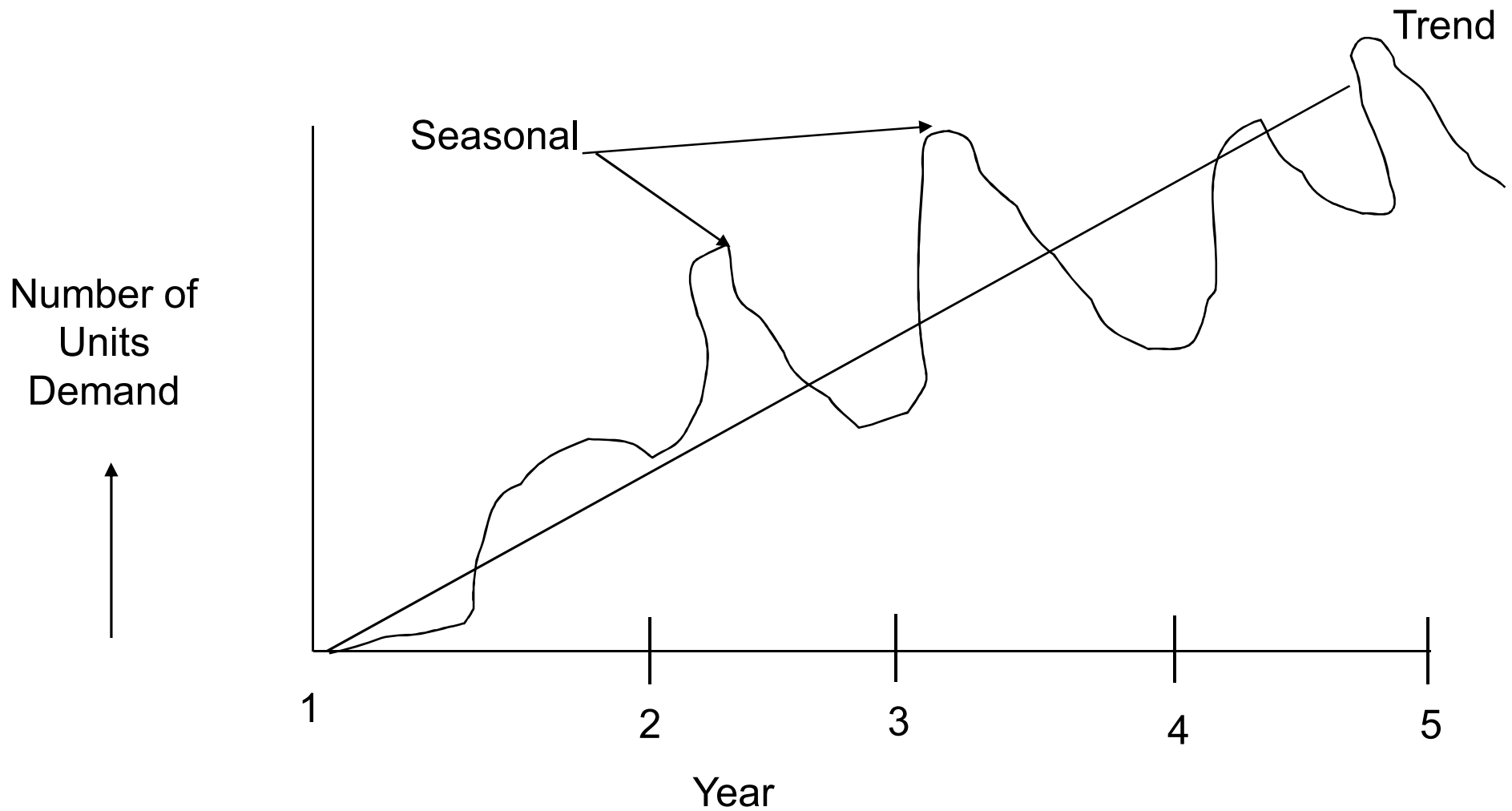
Delphi Method: Groups of experts respond to questionnaire which is submitted to the group. Thus, there is a learning process for the group as it receives new information and there is no influence of group pressure or dominating individual.

Executive Judgment: When decisions in forecasting are at a broader & higher level (as when introducing a new product line or concerning strategic product decisions such as new marketing areas), The term executive judgment is used.

Components of Demand

Demand for products or services can be broken down into six components:

- Average demand for the period
- A Trend
- Seasonal Element
- Cyclical Elements
- Random Variation
- Auto Correlation



Historical Product Demand consisting of growth trend & seasonal demand

Diagram

Linear: Straight Continuous relationship

S-Curve: Product Growth & Maturity Cycle

Asymptotic: Highest demand growth in the beginning but then tapers off. Enters existing market & captures a large share.

Exponential: Sales will continue to increase – assumption not safe to make.

Sometimes the data do not seem to fit any of the standard curves. This may be due to several causes at the same time. For such cases, a simplistic but often effective forecast can be obtained by simply plotting the data.

Time Series Analysis: Time series forecasting models try to predict the future based on past data.

(A) Simple Moving Average: A time period containing a number of data points is averaged by dividing the sum of the point values by the number of points. Each, therefore, has equal influence.

When demand for a product is neither growing or declining and if it does not have seasonal characteristics, a moving average.

$$F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3} \dots \dots \dots A_{t-n}}{n}$$

Where: F_t = Forecast for the coming period

n = Number of Periods to be averaged

A_{t-1} = Actual occurrence in the past period

A_{t-2} , A_{t-3} and A_{t-n} = Actual occurrences two periods ago, three periods Ago & soon upto n periods ago.

Weighted Moving Average: Whereas the simple moving average gives equal weight to each component of the moving average data base, a weighted moving average allows any weights to be placed on each element, provided, ofcourse, the sum of all weights equals 1.

While many periods may be ignored (ie. their weights are zero) and the weighting scheme may be in any order (eg. The more distant data may have greater weights

Than more recent data), the sum of all weights must equal 1.

AF Formula for weighted average is

$$F_t = W_1 A_{t-1} + W_2 A_{t-2} + \dots W_n A_{t-n}$$

Where:

W_1 = Weight to be given to actual occurrence for the period t-1

W_2 =do.----- t-2

W_n =do -----t-n

n = Total number of periods in forecast

Choosing Weights

Based on experience trial & error and on a general rule that the recent past is the most important indicator of what to expect in the future. Seasonality to be given appropriate weightage.

Exponential Smoothing

This is based on the premises that importance of past data diminishes as past becomes more distant. It is called exponential because each increment in the past is decreased by $(1-\alpha)$.

If α is .05 then weights.

For various periods would be:

$$\text{Most recent weighting} = \alpha (1-\alpha)^0 = 0.0500$$

$$\text{Data Onetime period older} = \alpha (1-\alpha)^1 = 0.0475$$

$$\text{Data two time periods older} = \alpha (1-\alpha)^2 = 0.0451$$

$$\text{Data three time periods older} = \alpha (1-\alpha)^3 = 0.0429$$

So exponents 0,1,2,3,& so on give it its name

It is most used technique & integral part of all computerized forecasting programmes it is widely used in inventory for retail firms whole sale companies & service agencies.

Six Major reasons for wide acceptance of exponential smoothing

1. Exponential models are surprisingly accurate
2. Formulating an exponential models relatively easy.
3. The user can understand how the model works.
4. Little computation is required to use the model.
5. Computer storage requirements are small because of limited use of historical data.
6. Tests for accuracy as to how well the model is performing are easy to compute.

Smoothing Constant (α) Alpha

In exponential smoothing only three pieces of data are needed to forecast the future.

- i) The most recent forecast
- ii) The actual demand that occurred for that period
- iii) A smoothing constant (α)

This smoothing constant determines the level of smoothing and speed of reaction to differentiate between forecasts and actual occurrences. The more rapid the growth, the higher the reaction rate should be.

Trend Effects in Exponential Smoothing

The higher the value of α , the more closely the forecast follows the actual. An upward or downward trend in data collected over a sequence of time periods causes the exponential forecast, to lag behind (be above or below) the actual occurrences.

Exponentially smoothed forecasts can be corrected somewhat by adding in a trend adjustment. Thus, besides α , smoothing constant delta (ζ) is used. Thus delta reduces the impact of error that occurs between the actual & the forecast.

This is known as adaptive forecasting

Choosing the appropriate value for alpha: Smoothing constant α be given a value between 0 & 1. If real demand is stable (Demand for electricity, food, etc.), small α value would be to lessen the effect of short or random changes. If real demand is rapidly changing (fashion items, new small appliances), a large value of α would be used to keep up with the change.

Adaptive Forecasting: Two approaches for controlling value of α .

1. **Two or more predetermined values of alpha**: The amount of error between the forecast and the actual demand is measured. Depending on the degree of error, different values of α are used. If the error is large, α is 0.8 and if the error is small, α is 0.2
2. **Computed Values for Alpha**: A tracking alpha computes whether the forecast is keeping pace with genuine upward or downward changes in demand (as opposed to random changes). Tracking α (tracking signal) is defined as exponentially smoothed actual error divided by exponentially smoothed absolute error. α changes from period to period from 0 to 1.

Linear Regression Analysis: Regression is defined as a functional relationship between two or more co-related variables. It is used to predict one variable given the other.

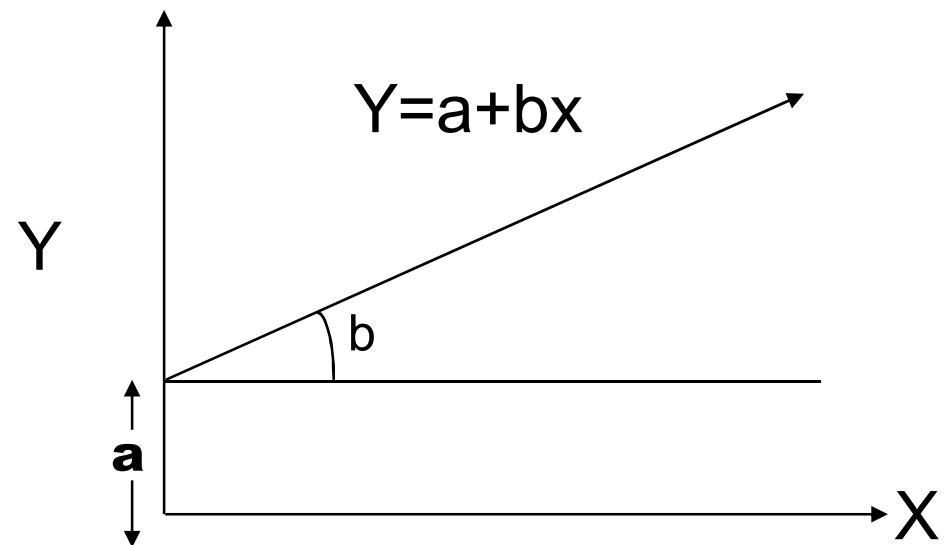
$$Y = a + bx$$

Y = Dependent Variable

a = y – intercept

b = slope

x = independent variable



(In time series x is time)

The major restriction in using linear regression forecasting is (as the name applies), that past data and future projections are assumed to fall about a straight line. Although, this limits its application, but if used for a short period of time, linear regression analysis can still be used.

Linear regression is used both for time series forecasting and for casual relationship forecasting.

Time Series: When dependent variable (vertical axis) changes with time. (Horizontal axis), it is time series

Casual Relationship: If one variable changes with change in another variable, this is casual relationship. (Number of deaths from lung cancer increasing with the number of people who smoke)

Strategic Capacity Planning (Capacity Planning)

Capacity: is the amount of resource inputs available relative to output requirements over a particular period of time. (or capacity is the rate of productive capacity of a facility)

This definition makes no distinction between efficient & inefficient use of capacity.

Measurement of Capacity

- Number of vehicles per month
- Million of tonnes of steel per month
- Metres of cloth per day

For Multiple Products:

1. Design Capacity

Planned rate of output of goods or services under normal or full scale operating conditions

2. System Capacity

It is the maximum output of specific product mix with available men & machines producing as an integrated whole system capacity can be less or at most equal to design capacity.

Actual Output It is still less because of short term effects such as breakdown of equipment, inefficiency of labour etc.

$$\text{System Efficiency} = \frac{\text{Actual Output}}{\text{System Capacity}}$$

Licensed Capacity: Limitation of output exercised by various regulatory agencies or govt.

Installed Capacity: Capacity provided at the time of installation of plant.

Rated Capacity: Capacity based on highest production rate established by actual trials.

Strategic Capacity Planning: It is to provide an approach for determining the overall capacity level of capital intensive resources – facilities, equipment and overall labour force size – that best supports the company's long – range competitive strategy.

The capacity level selected has a critical impact on the firm's response rate, its cost structure, its inventory policies and its mgt. & staff support requirements.

Best Operating Level: This is the level of capacity for which the process was designed and is the volume of output at which average unit cost is minimum.

$$\text{Capacity utilization rate} = \frac{\text{Capacity Used}}{\text{Best Operating Level}}$$

Capacity Flexibility: It means having the ability to rapidly increase or decrease production levels or to shift production capacity quickly from one product or service to another.

The ultimate in plant flexibility is the “Zero-Changeover – Time” plant. (Flexible Plant)

Flexible Workers: They have multiple skills and have ability to switch easily from one kind of task to another.

Capacity Planning: Three important issues to be considered when adding capacity.

- a) Maintaining system balance
- b) Frequency of capacity additions
- c) Use of external capacity

Maintaining System Balance: Stagewise imbalances can be dealt with.

- (i) Add capacity to those stages which are bottle necks (Through overtime, leasing equipment or sub contracting.)
- (ii) Use of buffer inventories in front of bottleneck stage.
- (iii) Duplicating facilities of one department on which another is dependent.

Frequency of Capacity Additions

Two types of costs to be considered.

- a) Cost of upgrading too frequently which is expensive & involves training of employees.
- b) Upgrading too infrequently means subcontracting which could be expensive.

Use of External Capacity: It could be through sub-contracting or sharing capacity

Determining Capacity Requirements

1. Use forecasting techniques to forecast sales for individual products within each product line.
2. Calculate equipment & labour requirements to meet product line forecasts.
3. Project labour and equipment requirements over the planning horizon.

Capacity Cushion

Capacity cushion is an amount in excess of capacity demand. Often the firm decides on some capacity cushion that will be maintained between the projected requirements and the actual capacity.

For Example:

Expected Annual Demand = 10,000 units / year

Design capacity = 12,000 units / year

Capacity Cushion = $\frac{2,000}{10,000} = 20\%$

Utilization Rate = $\frac{10,000}{12,000} \times 100 = 83\%$

Factors Influencing Effective Capacity

1. **Forecast of Demand**: Demand forecast influences capacity plan in a significant way. It is difficult to forecast demand with accuracy as it changes significantly with the product life cycle stage, number of products. Products with long life-cycle usually exhibit steady demand growth compared to one with shorter life-cycle. Thus accuracy of forecast influences the capacity planning.
2. **Plant & Labour Efficiency**: The plant efficiency varies from equipment to equipment and from organization to organization. The actual efficiency of labour should be considered for calculating efficiency. Plant & labour efficiency are essential to arrive at realistic capacity planning.

3. **Sub-Contracting**: Sub-contracting refers to off-loading some of the jobs to outside vendors thus hiring capacity to meet requirements of the organization. A careful analysis of “make or buy” should be done & economic considerations should be deciding factor.
4. **Multiple Shift Operation**: Multiple shifts enhance capacity utilization. In process industries where investment is high, it is recommended to have multiple shifts.
5. **Management Policy**: The management policy with regard to sub-contracting, multiplicity of shifts, machine replacement policy, etc. are going to affect the capacity planning.

Factors Favouring Over-Capacity and Under Capacity

It is very difficult to forecast demand because of uncertainty. The forecasted demand will be either higher or lower. So there is always risk involved based on projected demand. This gives either over-capacity or under – capacity.

Over-Capacity is Preferred when:

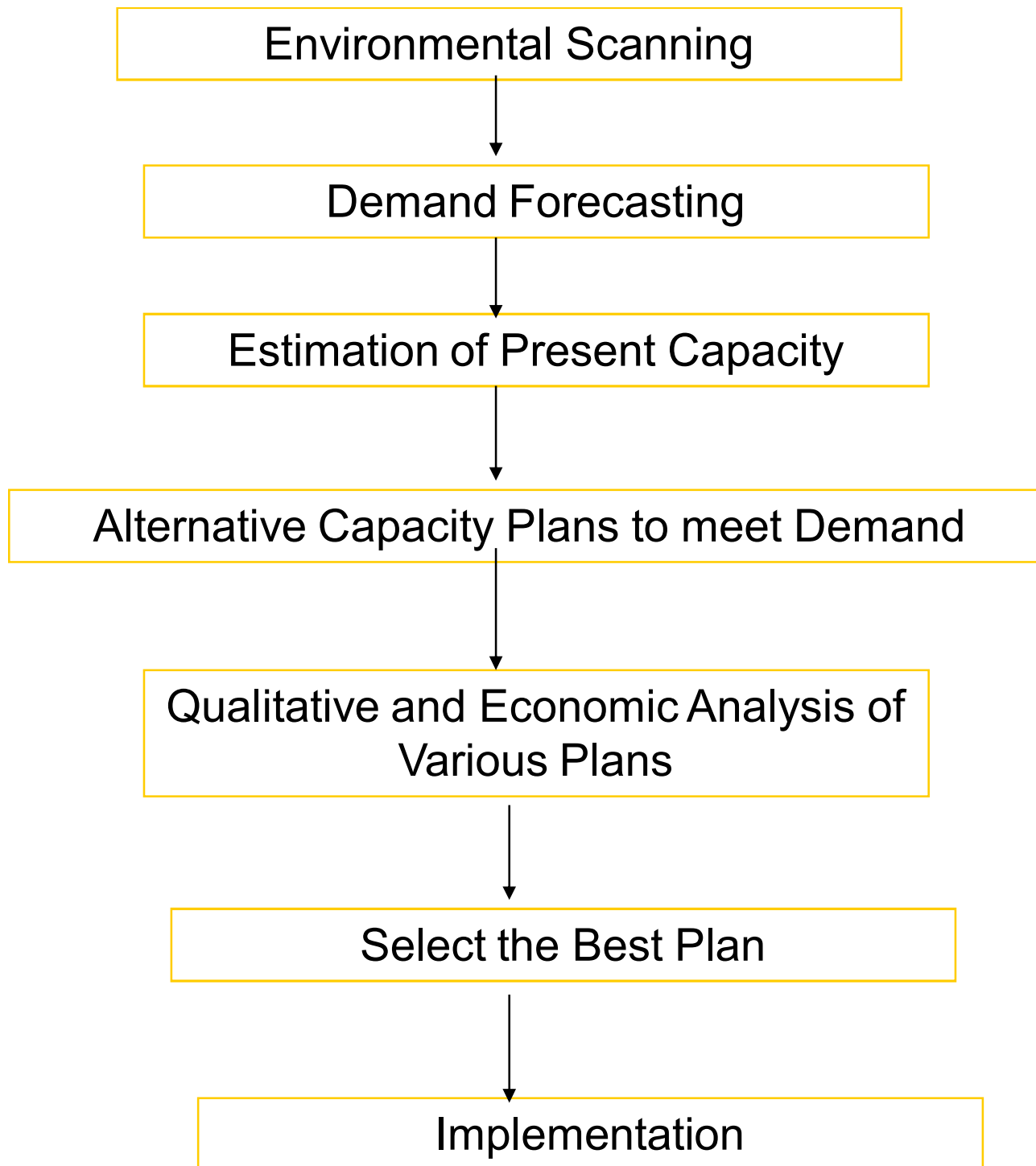
- a) Fixed cost of the capacity is not very high.
- b) Sub-Contracting is not possible because of secrecy of design and / or quality requirements.
- c) The time required to add capacity is long.
- d) The company cannot afford to miss the delivery and cannot afford to lose customers.
- e) There is a economic capacity size below which it is not economical to operate the plant.

The Under – Capacity is preferred when:

- a) The time available to build capacity is short.
- b) Shortage of products does not affect the company i.e. lost sales can be compensated.
- c) The technology changes fast i.e. the rate of obsolescence of plant & equipment is high.
- d) The cost of creating capacity is prohibitively high.

Capacity Planning

It is concerned with deciding the long term & the short term needs of an organization and determining how these needs would be satisfied. The process of capacity planning is given below:



Estimating Future Capacity Needs

Capacity requirements can be evaluated from two perspectives:

- Long – Term Capacity strategies
- Short – Term Capacity strategies

Long Term Capacity Strategies

Long-Term capacity requirements are more difficult to determine because the future demand & technology are uncertain. Forecasting for five or ten years is more risky & difficult.

Even the company's products may not be existing in future. Long-Range capacity requirements are dependent on marketing plans, product development & life-cycle of product.

Multiple Products: Companies produce multiple products to increase profits as well as to reduce risk of failure. Multiple products help planners to do a better job because products are in different stages of their life cycles. It also helps to achieve maximum capacity utilization.

Capacity Planning

Phase in Capacity

In high technology industries & where technological developments are very fast, the rate of obsolescence is high. The products should be brought into the market quickly & time to construct facilities will be long. Some commitment is made for building funds & men towards facilities over a period of 3-5 years and is an effective way of capitalising on technological breakthrough.

Phasing out Capacity

The outdated manufacturing facilities cause excessive plant closures & down time. Thus phasing out is done with humanistic considerations like alternate jobs, compensation, etc.

Short-Term Capacity Strategies

For short-term periods upto one year, fundamental capacity is fixed. Major facilities will not be changed. Many short-term adjustments for increasing or decreasing capacity are possible.

The adjustments to be required depend upon the conversion process like whether it is capital intensive or labour intensive or whether product can be stored as inventory.

In labour intensive processes, short term capacity can be changed by laying off or hiring people or by overtime to workers the strategies for changing capacity also depends upon how long the product can be stored as inventory.

Short Term Capacity Strategies:

1. **Backlogs**: During peak periods, the willing customers are required to wait & their orders fulfilled after peak demand period.
2. **Inventories**: Stock finished goods during slack periods to meet demand during peak periods.
3. **Employment Level (Hiring & Firing)**: Hire additional employees during peak demand period and layoff employees as demand decreases.
4. **Employee Training**: Develop multi-skilled employees through training so that they can be rotated among different jobs.
5. **Workforce Utilization**: Employees are made to work extra hours during peak demand periods & work fewer hours during slack period (flexible work hours).

6. **Sub – Contracting** : During peak periods, hire the capacity of other firms temporarily to make components, & products.
7. **Process Design**: Change job content by redesigning the job.
8. **Maintenance**: Temporarily discontinue routine maintenance so that this time could be utilised for production.

Out-Sourcing

In manufacturing, purchased items & services account for 60% to 70% of cost of goods sold. Out-sourcing is the term used to describe when a firm purchases materials, assemblies & other services that were initially done within the company & now decides to obtain from outside sources.

Outsourcing allows the company to focus on activities that represent its core competencies. Outsourcing is based on various decisions/ consideration of “Make or Buy” decisions including cost considerations.

This is also known as sub-contracting. Major reasons for outsourcing could be:

- i. 'Down-sizing' or 'Right-sizing'
- ii. Focus on value added activities and core competencies in order to survive or prosper.
- iii. Employees not preferring to carry out such functions such as Janitorial, Canteen, security services etc.
- iv. Information system & software development are some of the activities that have received much attention for out-sourcing e.g. "Call Centres" or "Back Offices"

Reasons for / risks of outsourcing

Reasons for out-sourcing

- (i) Cost –reduction
- (ii) 'Down-sizing' or 'Right sizing'
- (iii) Focus on core competencies
- (iv) Minimize inventory, material handling & other non-value added costs.
- (v) Reduce development & production cycle times.
- (vi) Improve efficiency

Risks of out-sourcing

- (i) Loss of control
- (ii) Exposure to supplier risks such as financial strength, loss of commitment to out-sourcing, promised features not available, lack of responsiveness, delay in supply, poor quality
- (iii) Difficulty in quantifying economies
- (iv) Supply restrictions
- (v) Possibility of being tied to obsolete technology
- (vi) Concern with long-term flexibility & meeting changing business requirements.

Make or Buy Decisions

When to Make?

Higher purchase price

Assurance of timely availability

Availability of required facilities & capacities in-house

Better control on qualities

Need to preserve trade design secrets

Savings on transportation costs

When to Buy?

Less purchase price including transportation cost.

Requirement is low & does not justify investments.

Higher quality, lower cost & faster delivery.

Outsiders hold a patent

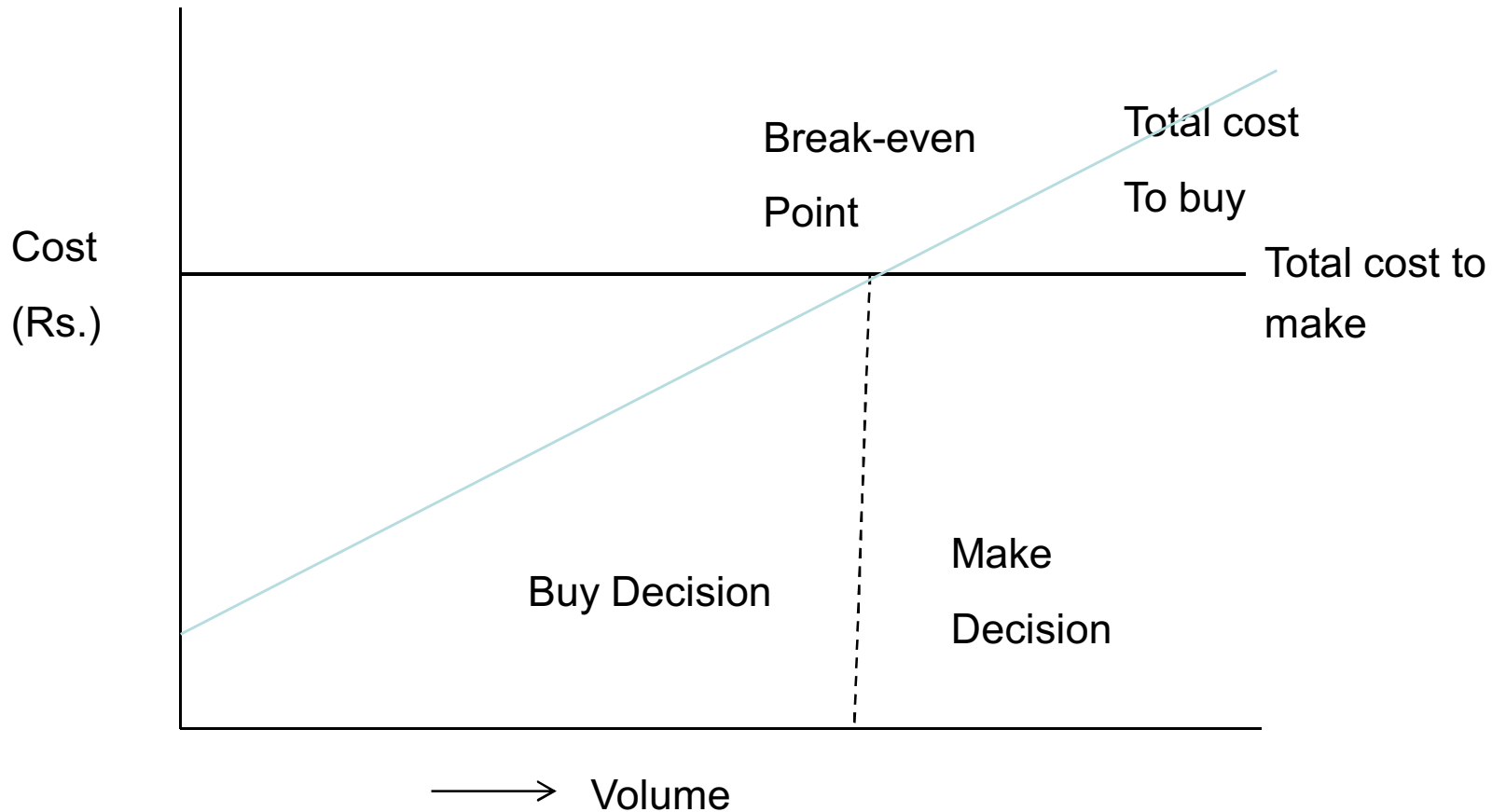
Higher opportunity cost

No design secret problems

Not enough capacity in-house

Item's requirement is temporary.

Make or Buy Decision



Aggregate Planning

Aggregate planning involves translating annual & quarterly business plans into broad labour & output plans for the intermediate term (6 to 18 months).

Its objective is to minimize the cost of resources required to meet demand over that period.

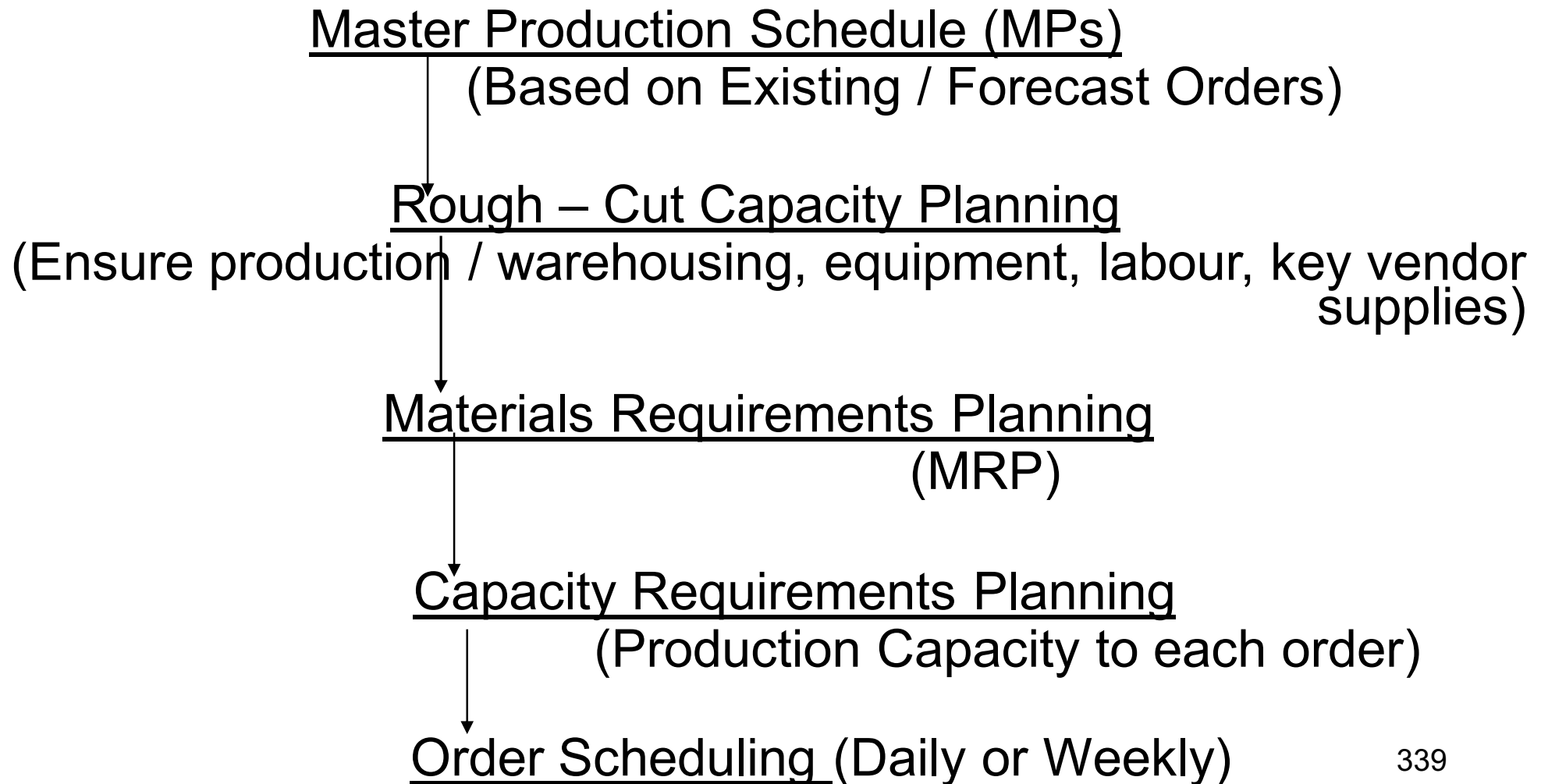
Long Range Planning = { Annual Plans with Horizon > one year Generally 3 to 5 years.

Intermediate Range Planning : Covers 6 to 18 months.

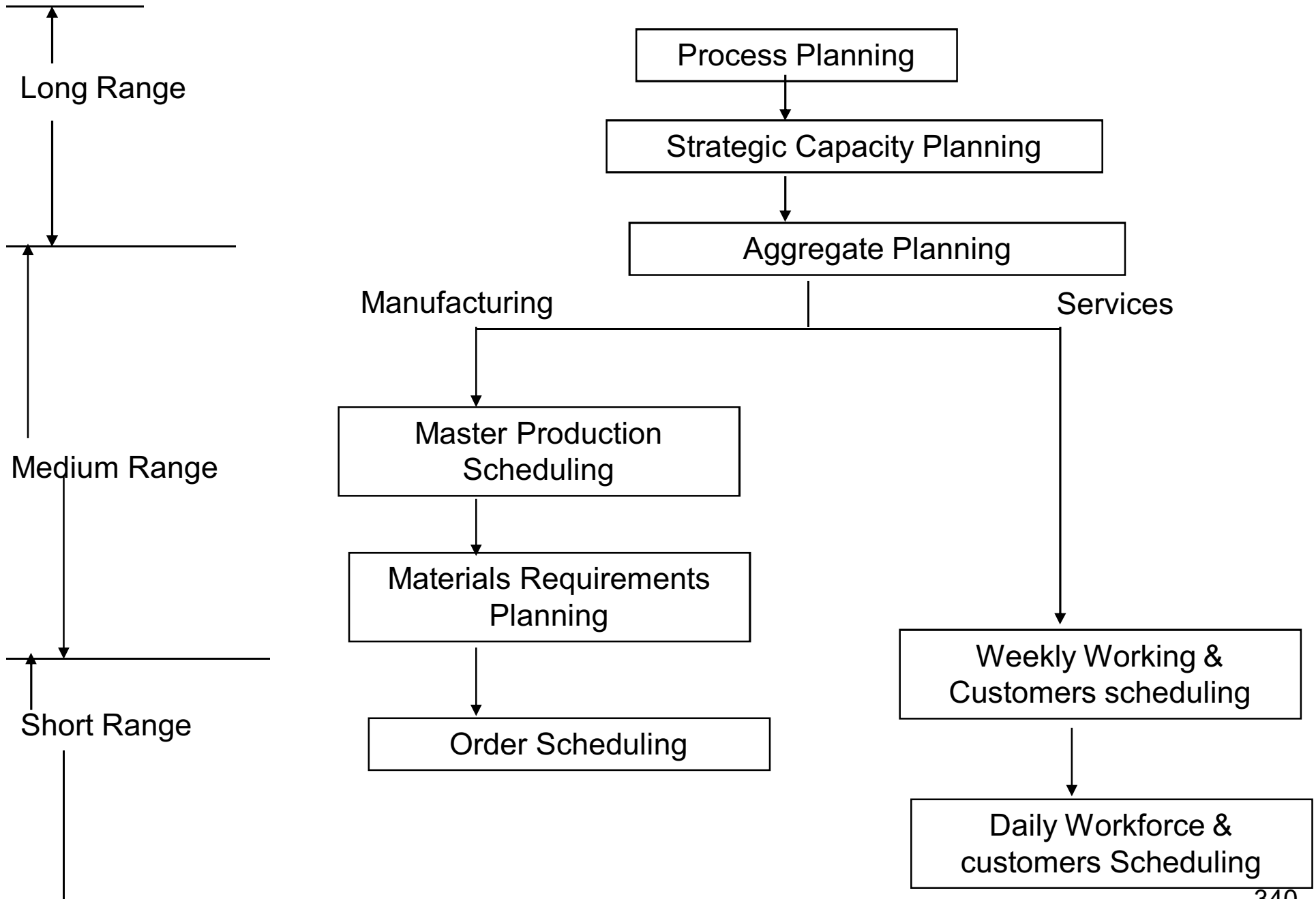
Short – Range Planning : One day to less than 6 months.

Process Planning: It deals with determination of specific technologies and procedures required to produce a product or service.

Planning Process: (Manufacturing)



Major Operations Planning Activities



In Services: Once the aggregate staffing level is determined, the focus is on workforce & customer scheduling during the week or even hour by hour during day. Many service jobs have unique time & legal restrictions affecting scheduling e.g. airline flight crews.

Aggregate Production Planning: The main purpose of the aggregate plan is to specify the optimal combination of production rate, the workforce level and inventory on hand.

Production Rate: Number of units completed per unit of time.

Workforce Level: Number of workers needed for production.

Inventory on hand: Balance of unused inventory carried over from the previous period.

The corporate annual plan contains a section on manufacturing that specifies how many units in each major product line need to be produced over the next 12 months to meet the sales forecast.

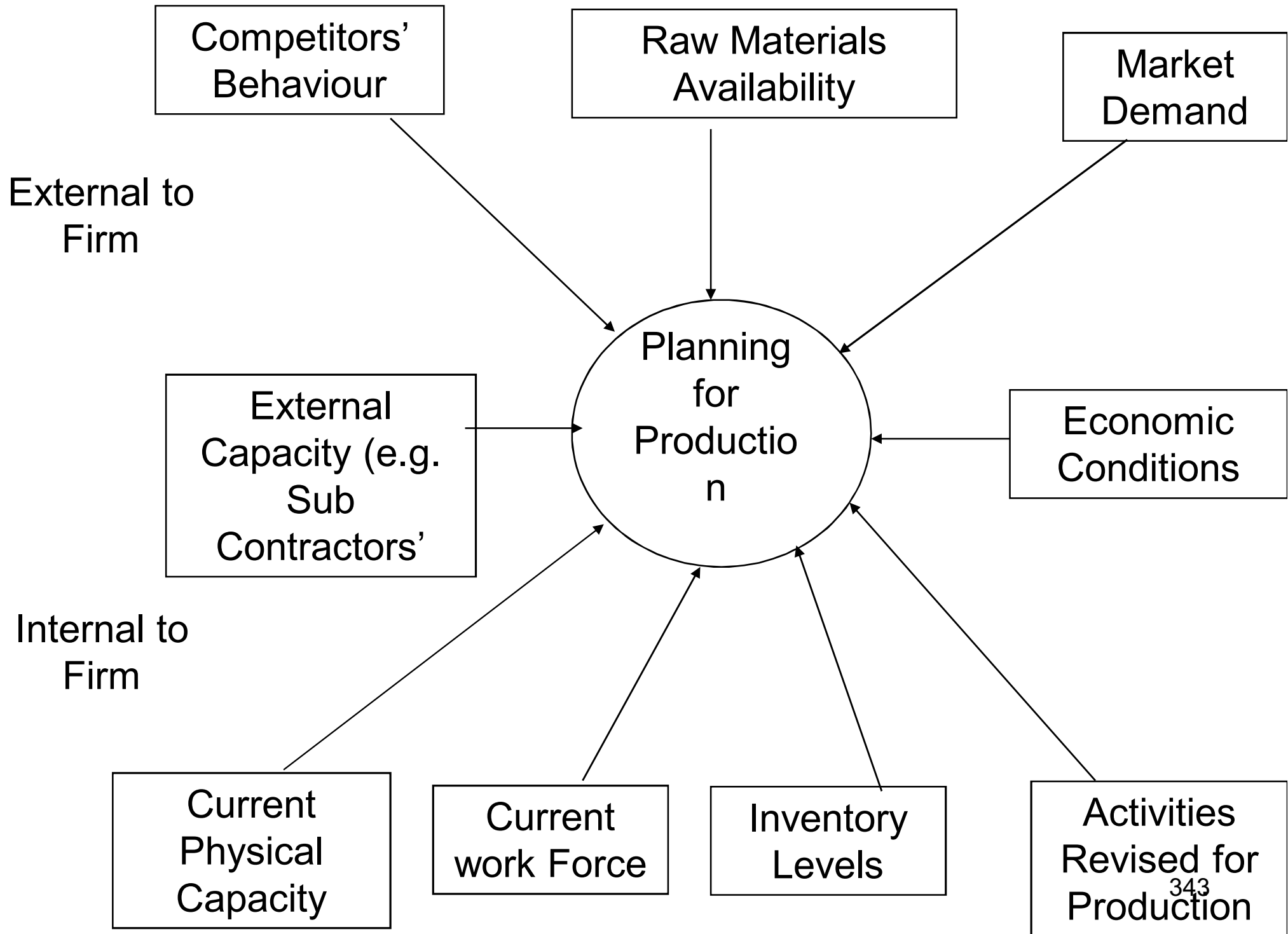
Another approach is to develop the aggregate plan by simulating various master production schedules and calculating corresponding capacity requirements to see if adequate labour and equipments exist at each work centre. If capacity is inadequate, then steps are taken such as:

- Overtime
- Sub – contracting
- Extra workers, etc.

Work out a rough-cut plan to develop lower cost plan.

Production Planning Environment

- i) Internal Environment
- ii) External Environment



Demand Management

Two Means

- i) Pricing & Promotion
- ii) Complementary Products

- i) Vary Prices, undertake promotional activities
 - ii) Complementary products for cyclic / seasonal demand
- These would have limitations.

Production Planning Strategies

- These are trade – offs among
- a) Work force size
 - b) Work Hours
 - c) Inventory
 - d) Backlogs

(A) **Chase Strategy:**

- Match the production rate to the order rate by hiring & laying off employees as the order rate varies.
- Success would depend on availability of applicants when volume increases.
- Employees slow down if orders completed.

(B) **Stable workforce – Variable working hours.**

- Vary the output by varying working hours.
(Flexible work schedule or overtime)
- Problems of hiring / firing avoided

(c) **Level Strategy**

- Maintain a constant output rate with a stable workforce.
- Shortages & surpluses absorbed by fluctuating inventory levels, order back-logs and lost sales.
- Stable work hours but at the cost of decreased customer service & increased inventory costs.
- Also inventory of products can become obsolete.
- Pure strategy**: Using one of the above strategies.
- Mixed strategy**: Using two or more in combination

(d) **Sub-Contracting**: (4th Strategy)

- Maintain stable relationship with supplier to meet demand fluctuations.
- Better than chase strategy

Relevant Costs to aggregate production Planning:

1. **Basic Production Costs**: Fixed + variable costs including direct & indirect costs.

2. **Costs Associated with Changes in the Production Rate**

- Hiring, Training, Laying off personnel

3. **Inventory holding costs**

- Capital blocked

- Storing, insurance, spoilage, obsolescence, etc.

4. **Backordering Costs**

(Lost Customer / Unfilled Order Costs)

- Cost of Expediting

- Loss of Customer Goodwill

- Loss of Sales Revenue

(Hard to measure the cost)

Level Scheduling (Uniform Plant Loading)

The just-in-Time approach concentrates on a level production schedule. A level schedule holds production constant over a period of time. It is combination of strategies. For each period, it keeps the workforce constant and inventory low and depends on demands to pull products through.

Level production has a number of advantages:

1. The entire system can be planned to minimize inventory & work-in-process.
2. Product modifications are up to-date because of low amount of work-in-process.
3. There is a smooth flow throughout the production system.
4. Purchased items from vendors can be delivered when needed and, in fact, often directly to production line.

Conditions for using Level Scheduling

1. Production should be repetitive (Assembly Line)
2. System must contain excess capacity
3. Output fixed for a period (preferably a month)
4. Smooth relationship between purchasing, marketing & production.
5. Cost of carrying inventory must be high.
6. Equipment costs may be low.
7. Workforce to be multi-skilled.

Mathematical Techniques: Like linear programming. If costs have linear relationships & demand can be treated as deterministic – simplex method for general use.

Operations Scheduling

Work flow equals cash flow and work flow is driven by the schedule

A Schedule is a timetable for performing activities, utilizing resources or allocating facilities.

Work Centre is an area in a business (or firm) in which productive resources are organized & work is completed. A work centre maybe a single machine, a group of machines or an area where a particular type of work is done. These work centres can be organized based on different types of layout

- Product layout
- Process layout
- GT (Group Technology) cellular layout
- Fixed Position layout
- Assembly line

Scheduling System Can use either infinite loading or finite loading.

Infinite Loading When work is assigned to a work centre simply based on what is needed overtime with no consideration to available capacity of resources.

Finite Loading

This approach actually schedules in detail each resource using the set-up & run time required for each order.

Scheduling Systems

Can be generated forward or backward in time.

Forward Scheduling

It is most common. In this, the system takes an order and then schedules each operation that must be completed forward in time. It can tell the earliest date that an order can be completed.

Backward Scheduling

It starts from some date in future (possibly a due date of an order) and schedules the required operations in reverse sequence. It tells when an order must be started in order to be done by a specific date.

A MRP (Material Requirement Planning) is an example of infinite, backward scheduling system for materials .

Processes are either & not both

Machine –Limited: Equipment is the critical resource that is scheduled.

Labour-Limited: People are the key resource that is scheduled.

Scheduling & Control Functions –Steps **(Production Planning & Control) (PPC)**

Loading

The assignment of specific jobs to each operational facility during a planned period is known as loading.

Sequencing

The decision regarding order in which jobs-in-waiting are processed on an operational facility or work-centre is called as sequencing.

Detailed Scheduling

It encompasses the formation of starting & finishing time of all jobs at each operational facility.

Expediting or Follow-up

It involves continuous tracking of job's progress and taking specification action if there is a deviation from the detailed schedule. The objective of expediting is to complete the jobs as per the detailed schedule and overcome any special case causing delay, break-down, non-availability of material and disruption of detailed schedule.

Short Term Capacity (Input-Output) Control

It involves monitoring of deviation between actual & planned utilization of the capacity of an operational facility.

Objectives of work-centre scheduling

- i. To meet due dates
- ii. To minimize lead time
- iii. To minimize set-up time or cost
- iv. To minimize work-in-process inventory
- v. To maximize machine or labour utilization

Priority Rules

Priority rules are used in obtaining a job sequence.

Measures used to evaluate priority rules

1. Meeting due dates of customers or downstream operations.
2. Minimizing the flow time (the time a job spends in the process)
3. Minimizing work-in-process inventory.
4. Minimizing idle time of machines or workers.

Ten Priority Rules for Job Sequencing

1. **FCFS** (First Come, First Served)
Orders are run in the order they arrive in the department.
2. **SOT** (Shortest Operating Time)
Run the job with the shortest completion time first, next shortest second & so on. Also known as SPT (Shortest Processing Time)
3. **Due Date** (Earliest Due Date First)
Run the job with the earliest due date first, Date – when referring to the entire job.
4. **Start Date** (Due Date Minus Normal Lead Time)
Run the job with the earliest start date first)

5. **STR** (Slack Time Remaining)

This is calculated as the difference between the time remaining before the due date minus the processing time remaining. Orders with the shortest STR are run first.

6. **STR/OP** (Slack Time Remaining Per Operation)

Orders with shortest STR are run first. STR is calculated:

$$\frac{\text{STR}}{\text{OP}} = \frac{\text{Time remaining before due date} - \text{remaining processing time}}{\text{Number of remaining operations}}$$

7. **CR** (Critical Ratio):

This is calculated as the difference between the due date and the current date divided by the number of days remaining. Orders with the smallest CR are run first.

8. **QR** (Queue Ratio)

This is calculated as the Slack Time remaining in the schedule divided by the planned remaining queue time. Orders with the smallest QR are run first.

9. **LCFS** (Last come, first served)

This rule occurs frequently by default. As orders arrive, they are placed on top of stack and operator picks up from the top.

10. **Random order or whim**

The operators or supervisors usually select whichever job they feel like running.

Johnson's Algorithm

For problems with 2 machines & n jobs, Johnson developed algorithm to get optimal solution.

Steps

Step1: Find the minimum time among various tasks.

Step 2 (A): If the minimum processing time is on machine 1, place the associated job in the first available position in sequence. Go to step 3

2(B): If the minimum processing time requires machine 2, place the associated job in the last available position in sequence. Go to step 3.

Step 3: Remove the assigned job from consideration and return to step 1 until all positions in sequence are filled (ties may be broken randomly)

Q: Consider the following two machines and six jobs flow shop scheduling problem. Using Johnson's Algorithm, obtain the optimal sequence which will minimize the makespan.

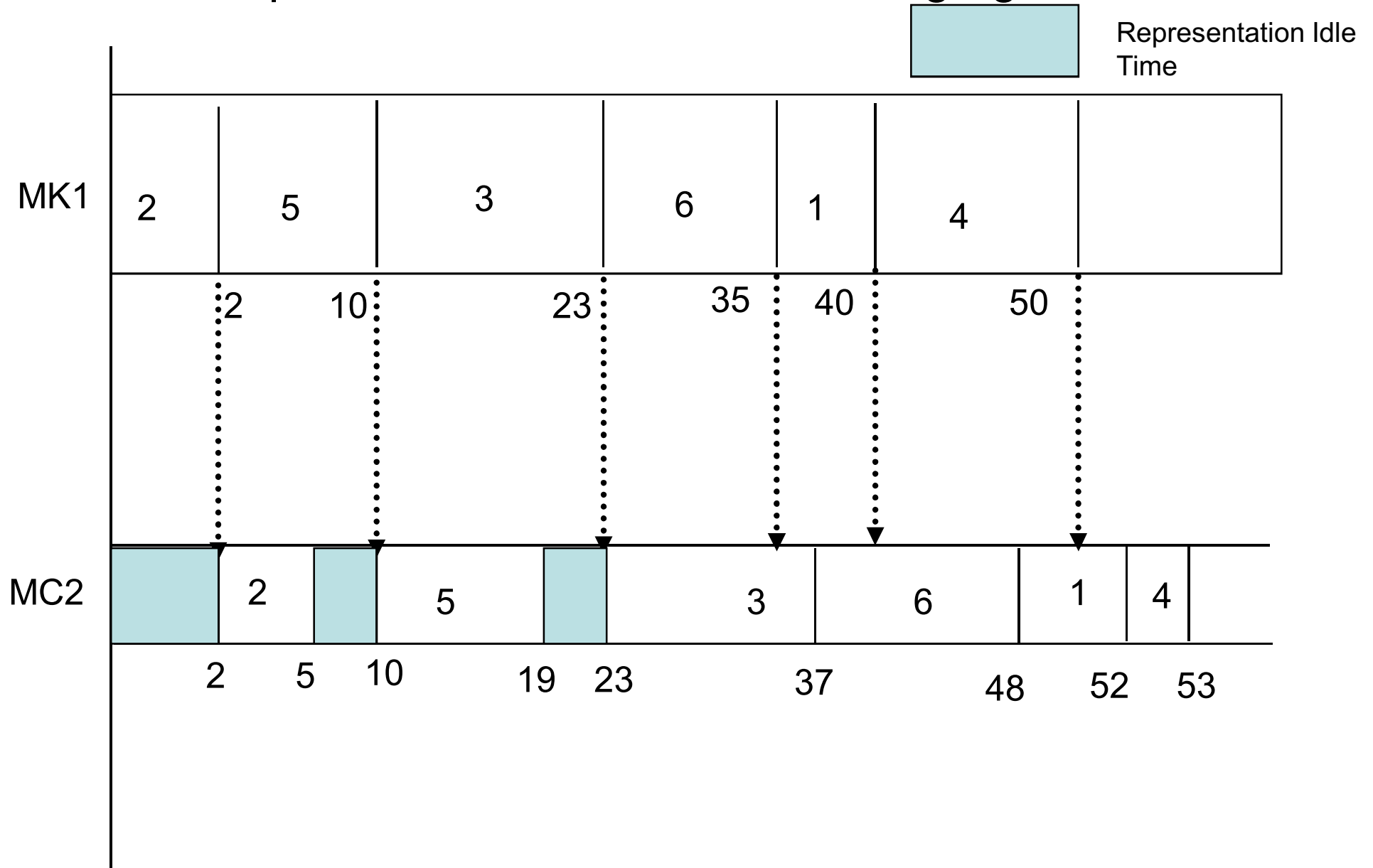
<u>Job</u>	<u>Machine</u>		<u>Number</u>	
	1	2		
1	5	4		
2	2	3		
3	13	14		
4	10	1		
5	8	9		
	12	11		

Optimal Sequence 2-5-3-6-1-4

Makespan is determined as follows:

Job	Processing Time				Idle Time on M/C 2
	M/C-1		M/C - 2		
	Time In	Time Out	Time In	Time Out	
2	0	2	2	5	2
5	2	10	10	19	5
3	10	23	23	37	4
6	23	35	37	48	0
1	35	40	48	52	0
4	40	50	52	53	0

Makespan can also be obtained through gantt. Chart



Extension of 'JOHNSON's Rule

Three Machines & n Jobs

JOB	Processing Time		
	M/C 1	M/C 2	M/C 3
1	t_{11}	t_{12}	t_{13}
2	t_{21}	t_{22}	t_{23}
3	t_{31}	t_{32}	t_{33}
⋮	⋮	⋮	⋮
n	t_{n1}	t_{n2}	t_{n3}

If following conditions are satisfied, Johnson's algorithm can be extended.

If $\min t_{i1} \geq \max t_{i2}$

Or

If $\min t_{i3} \geq \max t_{i2}$

Q.

JOB	Processing Time		
	M/C 1	M/C 2	M/C 3
1	8	5	4
2	10	6	9
3	6	2	8
4	7	3	6
5	11	4	5

Min $t_{i1} = 6$

Max. $t_{i2} = 6$

So Johnson's algorithm can be extended

JOB (i)	Processing Time	
	Machine A	Machine B
1	13	9
2	16	15
3	8	10
4	10	9
5	15	9

Sequence 3-2-5-1-4

Makespan is Determined As given below:

Job	Progressing Time							
	M/C -1		M/C – 2		M/C – 3		Idle Time	
	In	Out	In	Out	In	Out	M/C -2	M/C - 3
3	0	6	6	8	8	16	6	8
2	6	16	16	22	22	31	8	6
5	16	27	27	31	31	36	5	0
1	27	35	35	40	40	44	4	4
4	35	42	42	45	45	51	2	1

The Makespan for this problems is 51 units of time

UNIT - VIII

Inventory System (Inventory Management)

Inventory-

Is the stock of raw materials, work-in-process, finished goods, component parts, supplies and spares in order to meet an unexpected demand or distribution in the future.

Various Types of Inventories

1. Production Inventories

Raw materials, parts & components which enter the firm's product in the production process.

2. MRO Inventories

Maintenance, repair & operating supplies which are consumed in the production process but which do not become part of the product (eg. Lubricating oil, grease, machine repair parts, etc.)

3. In-Process Inventories

Semi-finished products found at various stages in the production system.

4. Finished Goods Inventories

Completed goods ready for shipment

Inventory Costs

1. Ordering Costs

(A) Costs of placing an order with a vendor of materials:

(a) Preparing a purchase order

(b) Processing Payments

(c) Receiving, counting & inspecting materials

1. **Ordering Costs**

(B) **Ordering from the plant:**

- (a) Machine set-up
- (b) Start-up scrap generated from getting a production run started.

2. **Carrying Costs**

(A) **Cost associated directly with materials:**

- (a) Obsolescence
- (b) Deterioration
- (c) Pilferage

(B) **Finance Costs**

- (a) Taxes
- (b) Insurance
- (c) Storage

(d) Interest (as the cost of capital borrowed to acquire & maintain the inventories)

3. Out-Of-Stock Costs

(A) Back-Ordering

(B) Lost Sales

4. Capacity Costs

(A) Overtime payments when capacity is too small.

(B) Lay-offs & idle time when capacity is too large

Purposes of Inventory

1. To maintain independence of operations

To minimize set-up costs, inventory allows flexibility of operations. Even in assembly lines, independence of work stations can be achieved through cushion of several parts within the work station.

2. To meet variation in product demand

Since demand is not completely known, a safety or buffer stock must be maintained to absorb variation.

3. To allow flexibility in production scheduling

A stock of inventory permits production planning for smoother flow & lower-cost operation through larger lot-size production.

4. **To provide a safeguard for variation in raw material delivery time**

Delays can occur due to various reasons : Normal variation in shipping time, shortage of material at vendor's plant, a lost order or incorrect or defective shipment, etc.

5. **To take advantage of economic purchase order size**

- (a) Larger size of each order, less overall cost
- (b) Larger order results in lower per unit cost of shipping

Benefits of Inventory Management & Control

Proper management & control of inventories will result in following benefits:

- i) Inventory control ensures an adequate supply of materials & stores, minimises stock-outs & shortages and avoids costly interruptions in operations.
- ii) It keeps down investment in inventories, inventory carrying cost and obsolescence losses to the minimum.
- iii) It facilitates economic purchasing through recorded requirements.
- iv) It eliminates duplication in ordering or in replenishing stocks by centralized purchasing.

- v) It permits better utilization of available stocks by facilitating inter-department transfers within a company.
- vi) It provides a check against the loss of materials through carelessness or pilferage.
- vii) It facilitates cost accounting activities by providing means for allocating material cost to products, deptts, or other operating accounts.
- viii) It enables mgt. to make cost & consumption comparisons between operations & periods.
- ix) It serves as a means for the location & disposition of inactive & obsolete items of stores.
- x) Perpetual inventory values provide a consistent & reliable basis for preparing financial statements.

Independent Vs. Dependent Demand

In independent demand, the demand for various items are unrelated to each other. In dependent demand, the need for any item is a direct result of the need of some other item, usually a higher-level item of which it is a part. eg. The number of wheels & tyres needed is dependent on production levels of cars. The number of cars demanded is independent & is external to automobile firm's other products.

Inventory Systems

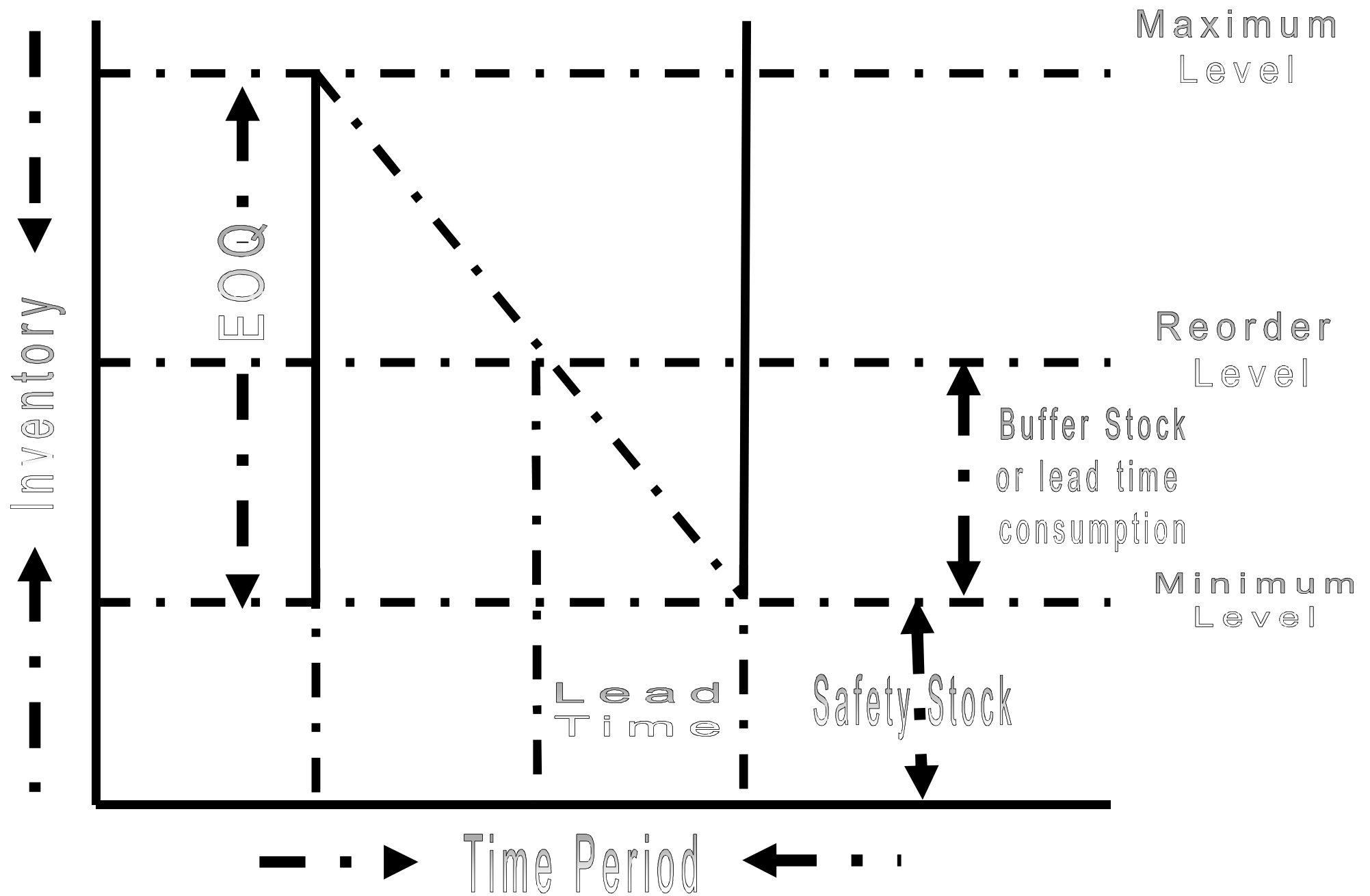
(A)	<u>Fixed-order quantity system / model also known as:</u>
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-	Economic order quantity (EOQ)
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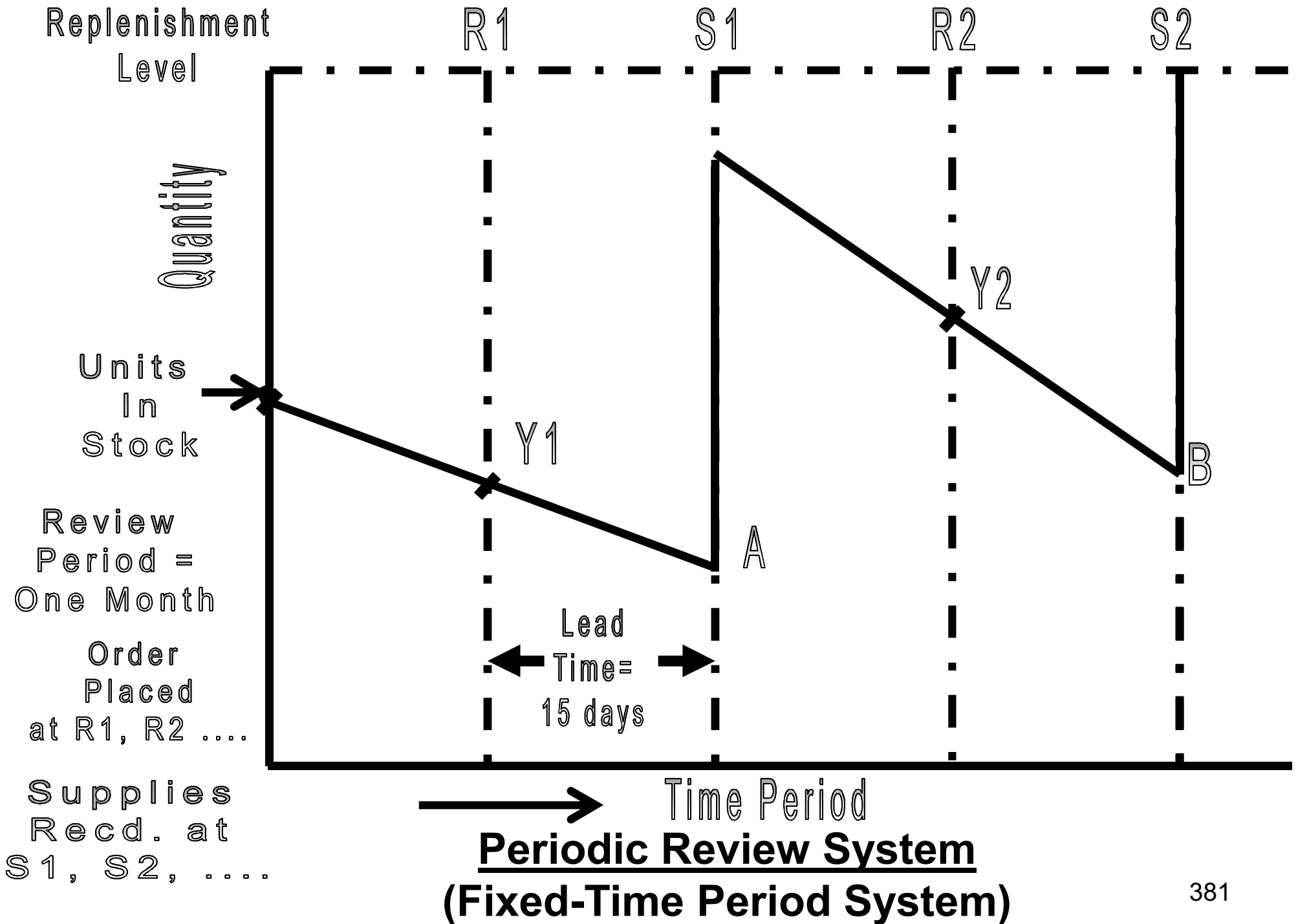
-	'Q Model' / 'Q System'
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(B) Fixed-time period system / model also referred as:

- Periodic System
- Periodic Review System
- Fixed Order Interval System
- 'P' Model / 'P' System



Fixed – Order Quantity System



Differences between fixed-order quantity and fixed-time period systems

	Q	P
Feature	Fixed-order quantity model	Fixed-time period model
Order Quantity	Q-Constant (The same amount ordered each time)	Q-Variable (Varies each time order is placed)
When to place order	R-When inventory position drops to the re-order level	T-when the review period arrives
Record-keeping	Each time a withdrawal or addition is made	Counted only at review period
Size of inventory	Less than fixed-time period model	Larger than fixed-order quantity model
Time to maintain	Higher due to perpetual record-keeping	
Type of item	Higher-priced, critical, or	

Selective Inventory Control

Selective inventory control means that the method of inventory control varies from item to item and the differentiation should be on a selective basis. The philosophy is “to put the efforts where results are worth putting the efforts”.

The importance of materials can be due to:

- i) Its costs
- ii) Consumption value
- iii) Its criticality
- iv) Its availability
- v) Its consumption

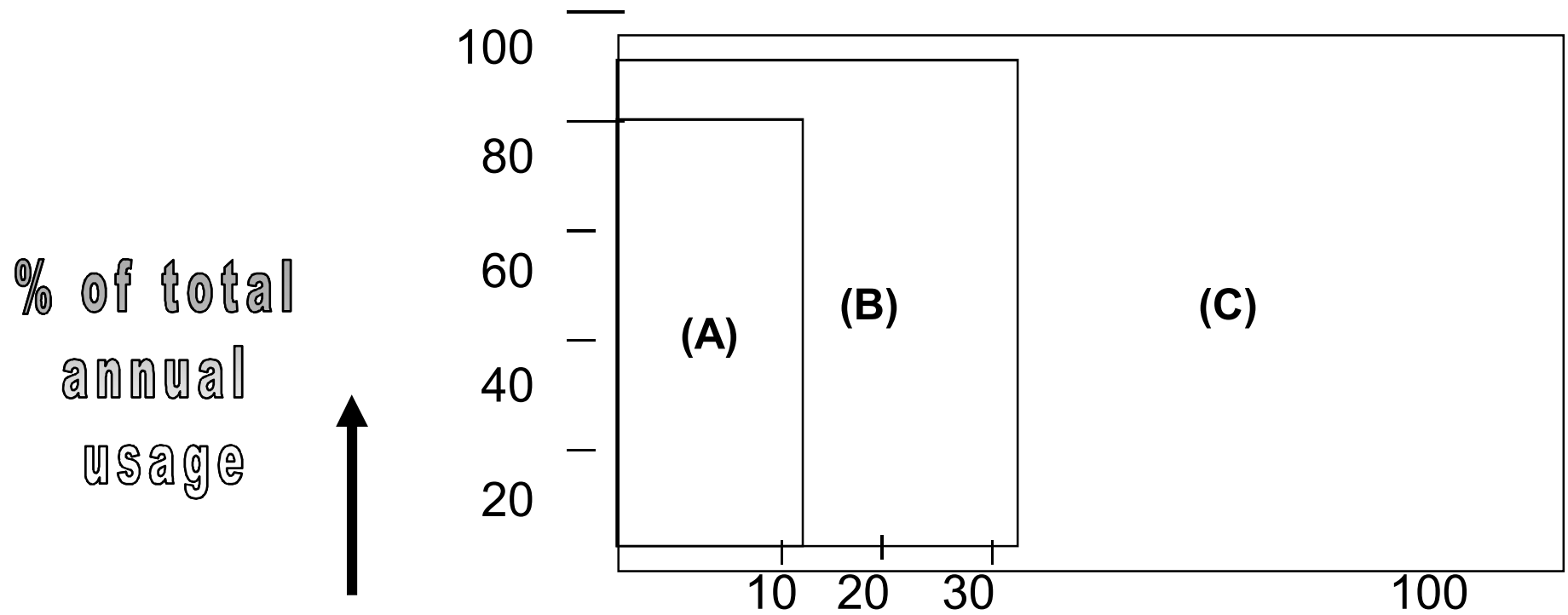
The selective control techniques are :

1. A – B – C Analysis (Always better control)
2. V – E – D Analysis / Classification
3. F – S – N Analysis / Classification
4. S – D – E Analysis / Classification
5. S – O – S Analysis / Classification

 (Seasonal & off-Seasonals)
6. H – M – L Analysis / Classification

ABC Analysis

Based on pareto's principle to inventory, it is possible & necessary to separate “vital few” from “trivial many” of the stock items for effective control which is precisely done in ABC analysis.



Class	% age of items	% age of annual consumption value
A	10%	80%
B	20%	10%
C	70%	10%

HML Classifications

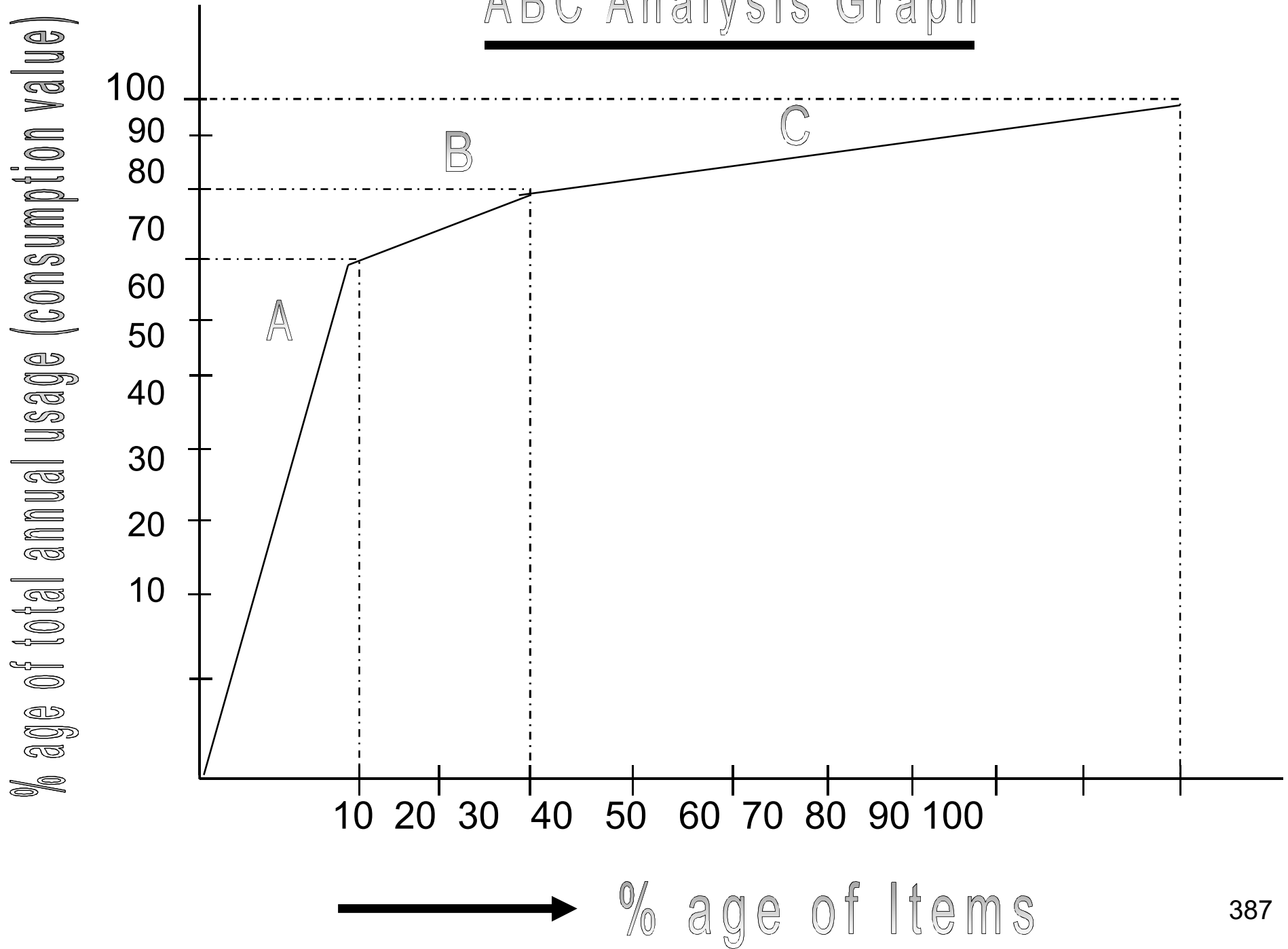
(High, medium & low) classification is based on unit value & not the annual consumption value. This analysis is useful for keeping control over consumption at departmental levels, for deciding frequency of physical verification and for controlling purchases.

VED Classification

“Vital, essential & desirable” classification in which criticality of inventories is the basis.

VED Analysis is done to determine the criticality of an item and its effect on production & other services. It is specially used for classification of spare parts. For V item, a large stock of inventory is maintained generally while for ‘D’ items, minimum stock is enough.

ABC Analysis Graph



FSN Analysis

F	=	Fast Moving
S	=	Slow Moving
N	=	Non-Moving

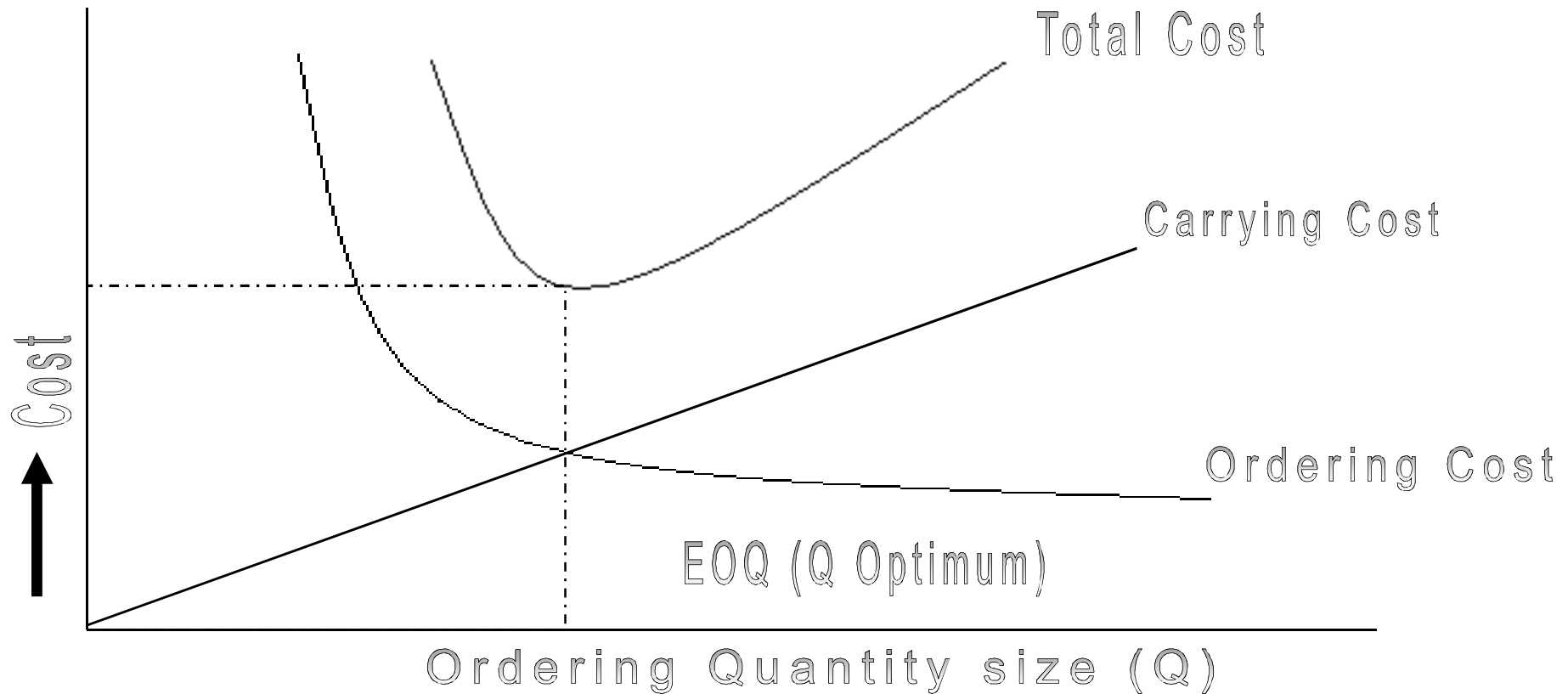
This is based on pattern of issues and is useful in controlling obsolescence. Non-moving items are examined further and their disposal can be considered.

SDE Analysis : Based on scarcity of supply.

S	=	Scarce Items (generally imported) & are in short supply.
D	=	‘Difficult’ item – Available indigenously but difficult to procure.
E	=	Easy to acquire & are available locally

•Economic Order Quantity (EOQ)

- EOQ is the order size (optimum quantity) at which the total cost comprising of ordering cost plus carrying cost is the minimum.



Cost of ordering = Cost of carrying

$$\frac{DS}{Q} = \frac{Q}{2}H$$

Where

D = Annual Demand (unit)

E = Cost of placing an order

Q = Quantity to be ordered

H = Holding cost per unit of average inventory per annum.

$$2 DS = Q^2 H$$

$$\therefore Q = \sqrt{\frac{2 DS}{H}}$$

$$\text{(EOQ) or (Q optimum)} = \sqrt{\frac{2 DS}{P \times C_i}} = \sqrt{\frac{2 DC_o}{P \times C_i}}$$

Where H = Unit Price (P)X inventory carrying charges.

C_o = Cost of placing (C) order

- Q = An auto industry purchases spark plugs at the rate of Rs. 25 per piece. The annual consumption of spark plug is 18000 nos. If ordering cost is Rs. 250 per order and carrying cost is 25% p.a; what would be EOQ ?
- (b) If the supplier of spark plugs offers a discount of 5% for order quantity of 3,000 nos. Per order, do you accept the discount offer ?

Calculation of EOQ

Annual Demand = 18,000 Nos. (D)

Unit Price (P) = Rs. 25/- (P)

Ordering Cost Per Order = Rs. 250/- (Co)

Carrying Cost (As %) = 25% (Ci)

$$EOQ = \sqrt{\frac{2 \times \text{Annual Demand (units)} \times \text{Ordering Cost Per Order}}{\text{Unit Price} \times \text{Inventory Carrying Charges (\%)}}}$$

$$= \sqrt{\frac{2DC_o}{PC_i}}$$

Where D = Annual demand in units

 Co = Ordering cost per order

 Ci = Carrying charges as % age.

 P = Unit price

$$EOQ = \sqrt{\frac{2 \times 18000 \times 250}{25 \times 0.25}} = 1200 \text{ nos.}$$

(b) Discount offer for Q = 3000

(i) EOQ Option

Total cost of materials plus cost on materials per annum.

$$= DP + \frac{D}{Q} C_o + \frac{Q}{2} PC_i$$

$$= 18000 \times 25 + \frac{18000}{1200} \times 250 + \frac{1200}{2} \times 25 \frac{25}{100}$$

$$\text{Total Cost } T_c \text{ (EOQ)} = \text{Rs. } 4,57,500$$

(ii) Discount Option

Discount offered for order quantity of 3000 nos. = 5% of unit price

Net price after discount = 0.95×25

$(P_1) = \text{Rs. } 23.75$

Total cost of materials plus cost of materials

$$\begin{aligned} Tc (\text{Discount}) &= DP_1 + \frac{D}{Q_1} C_o + \frac{Q_1}{2} P_1 C_1 \\ &= 18000 \times 23.75 + \frac{18000}{3000} \times 250 + \frac{3000}{2} \times 23.75 \times 0.25 \end{aligned}$$

$$Tc (\text{Discount}) = \text{Rs. } 4,37,906.25$$

$Tc (\text{Discount}) < Tc (\text{EOQ})$, Discount offer is acceptable

Inventory System

Q. For a given item of constant demand rate of 60,000 units per annum, the unit price is Rs. 60/-. The ordering cost per order is Rs. 600/- and the carrying cost is 30% per annum on average inventory value. What would be the total cost at optimal order quantity?

The vendor is offering a quantity discount of 5% if 20,000 units are purchased at a time. The shelf life of the item is three months.

Do you accept the discount offer? Give reasons for your decision.

Ans.
$$EOQ = \sqrt{\frac{2 \times \text{Annual Demand (units)} \times \text{Cost per order}}{\text{Price per unit} \times \% \text{ cost of carrying inventory}}}$$

$$= \sqrt{\frac{2 DC_o}{PC_i}}$$

D = 60,000 units, Co = Rs.600 / –, P = Rs. 60 / –, Ci = 30%

$$EOQ = \sqrt{\frac{2 \times 60,000 \times 600}{60 \times 0.30}} = 2000 \text{ units}$$

(A) Total cost at EOQ (Optimal Order Qty.)

$$= D \times P + \frac{D}{Q} C_o + \frac{Q}{2} P C_i$$

$$= 60,000 \times 60 + \frac{60,000}{2000} \times 600 + \frac{2000}{2} \times 60 \times 0.30$$

$$= \text{Rs. } 36,36,000$$

(B) Total cost with discount offer

$$\begin{aligned} & (Q_1 = 20,000 \text{ units}) \& (P_1 = 60 - 60 \times \frac{5}{100} = \text{Rs.}57) \\ & = 60,000 \times 57 + \frac{60,000}{20,000} \times 600 + \frac{20,000}{2} \times 57 \times 0.30 \\ & = 34,20,000 + 1800 + 1,71,000 \\ & = 35,92,800 \end{aligned}$$

(c) **Consumption During Shelf Life** = 1500
= 15000 units
Order Qty. / Order = 20,000 units
Loss due to obsolescence = 20,000 - 15,000
= 5000 units
= 5000 x Rs. 57
= 2,85,000

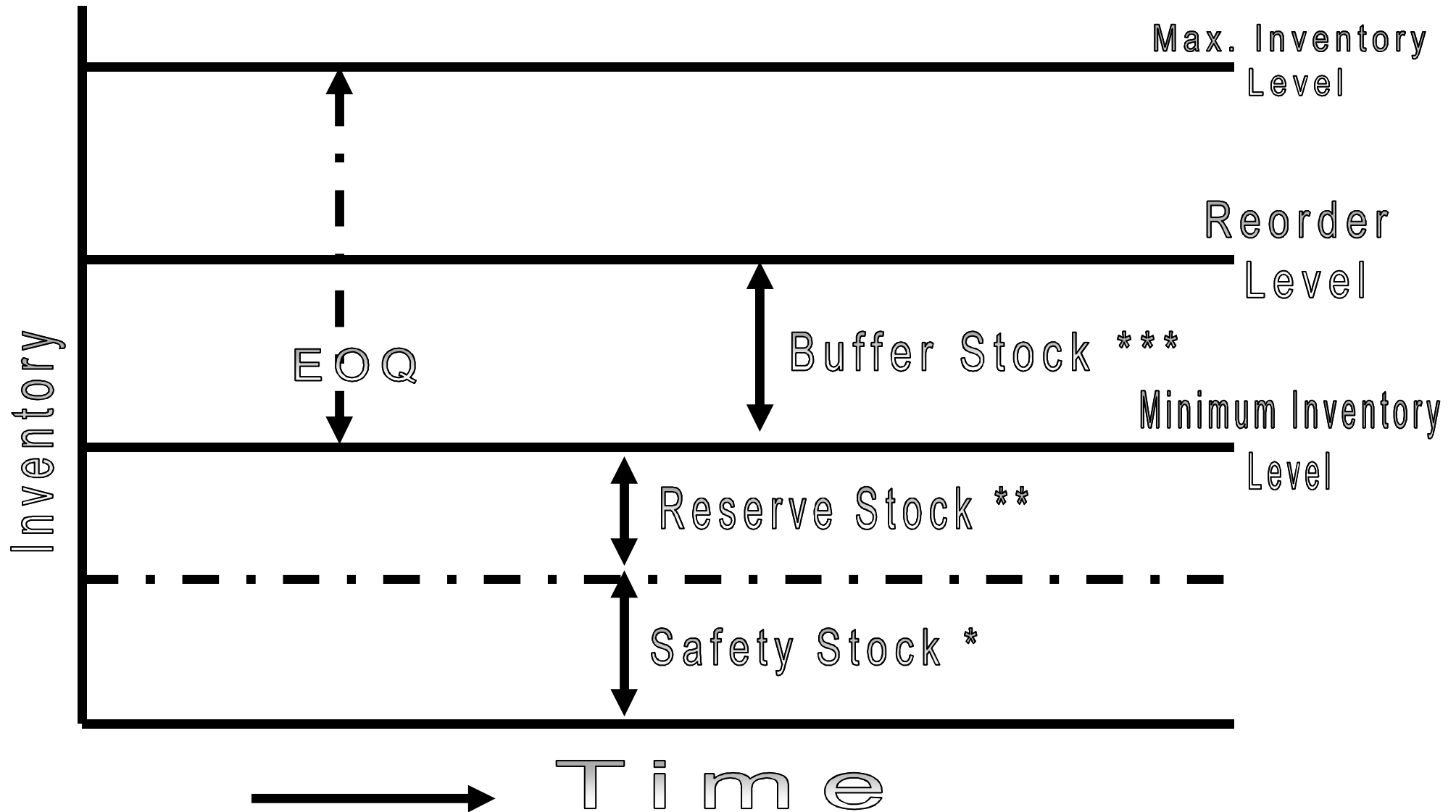
With Discounted Price

Total Cost = 35,92, 800 Plus 2, 85, 000

Including loss on obsolescence = Rs. 38,77,800

Extra cost with discounted offer = 38,77,800 – 36,36,000
= **Rs. 2,41,800**

Hence discount offer not to be accepted



- * Extension of lead time
- ** Excessive usage
- *** Consumption during lead time

Inventory Management

Q Determine Safety stock, reserve stock, & buffer stock for the data given below:

Normal Usage = 100 Per weeks

Lead Time = 4 – 6 weeks

Minimum Usage = 50 per week

Maximum Usage = 150 per week

Re-order Qty.
(Qty. of order ie. EOQ) = 600 nos.

Calculate :

- i) Re-order Level
- ii) Minimum Level
- iii) Maximum Level
- iv) Average Inventory Level

Ans.

$$\begin{aligned}\text{Buffer Stock} &= \text{Av. lead time} \times \text{Av. usage rate} \\ (\text{Consumption during lead time}) &= 5 \text{ weeks} \times 100 \text{ per week} \\ &= 500 \text{ ns.}\end{aligned}$$

Safety Stock

Usage at normal rate during extension of lead time
max. extension of lead time = $6 - 5 = 1$ week

Reserve Stock

It is to meet excess usage requirement during normal lead time

$$\begin{aligned}\text{Excess usage requirement} &= 150 - 100 \\ &= 50 \text{ per week}\end{aligned}$$

$$\text{Reserve Stock} = 50 \times 5 \text{ weeks} = 250 \text{ nos.}$$

Re-order Level

= Safety Stock + Reserve Stock + Buffer Stock

= SS + RS + BS

= 100 + 250 + 500 = 850 nos.

Minimum Inventory Level

= SS + RS

= 100 + 250 = 350 nos.

Maximum Inventory Level

= Minimum Level + Order Qty.

= 350 + 600 = 900 nos.

Average Inventory Level

Min. Level + Max. Level

$$= \frac{350 + 950}{2} = 650 \text{ nos}$$

Thanks