FINAL

GROUP - IV
PAPER - 15

MANAGEMENT ACCOUNTING – ENTERPRISE PERFORMANCE MANAGEMENT

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STUDY NOTE - 1

Management Control Systems

This Study Note includes:

- Control Systems
- Management Control System
- Behavioural Implications of Control System

1.1 Control Systems

The term control is used in management parlance in a cybernetic sense, that is to say, as a self-regulating mechanism with the following sequence of actions:

1. Planning
2. Execution
3. Comparison of achievement with plan
4. Assessment of deviations, if any
5. Corrective action to bring back performance in conformity with the plan.

The basic elements of a central system are the following

1. A control object or variable to be controlled
2. A detector or scanning sub-system
3. A comparator/Assessor
4. An effecter or action taking subsystem

Control Object

A control object is the variable of the systems behavior chosen for monitoring and control. The choice of the control object is the most important consideration in studying and designing a control system. Variations in the status of control object i.e., its behavior become the stimuli which trigger the functioning of the control system. Without these variations the system has no reasons for existence.

Detector

The detector tracks the performance and can be visualised as a scanning system and it feeds on information. In fact the detector is another name for Management Information System(MIS).

Comparator/Assessor

The output of the scanning system constitutes the energizing input of the comparator. Its function is to compare deviation of the control object from the pre-determined standard or norm the deviation become input to the activating system.

Effecter

The effecter is a true decision maker. It evaluates alternative course of corrective action in the light of the significance of the deviations transmitted by the comparator. On the basis of this comparison, the systems output is classified as being in control. If out of control it initiates corrective action.

Communication Network

These are devices that transmit information between the detector and the assessor and between the assessor and the effecter.

Mr. Stafford Beer has given three principles governing control functions in cybernetic system.

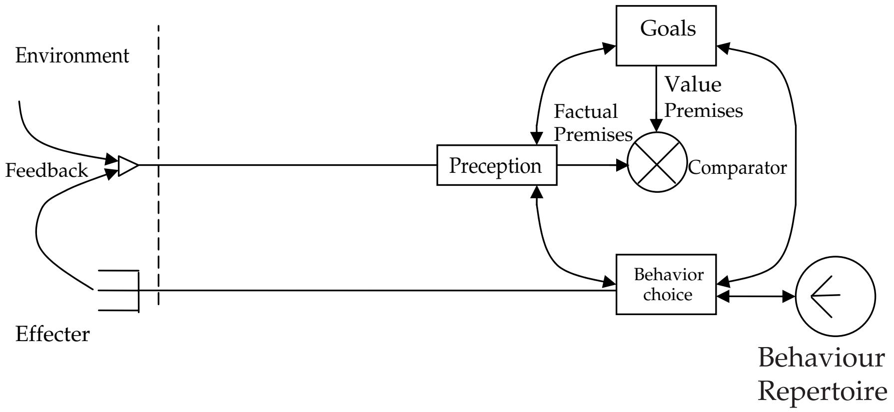
1. In implicit controllers there is *CONTINUOUS AND AUTOMATIC COMPARISON* of some behavioral characteristic of the system against a standard. Further there is *CONTINUOUS AND AUTOMATIC FEEDBACK* of corrective action.

2. In implicit controllers control is *SYNONYMOUS WITH COMMUNICATION.* Control is achieved as a result of transmission of information. Thus to be in control is to communicate. Control and communication are two sides of the same coin.

3. In implicit controllers, variables are brought back into control *IN THE ACT OF AND BY THE ACT* of going out of control.

Example:

The cybernetic paradigm of the control process can be diagrammatically represented as underThe term cybernetics is derived from the Greek word "Kybernetes" which means 'steersman'. A steersman is a person who directs a ship and corrects deviations from planned course of action as they occur.



A pressure cooker is a good example of self-regulatory control system. When the pressure in the cooking vessel rises above the set limit, the 'weight' lifts up to let out the extra pressure out of the **vents** on the top of the lid till the pressure stabilizes at the set limit. Thus in the pressure cooker control is automatic.

Organisations function by and through people. Hence, unlike mechanistic systems, control system in organization have to contend with behavior of diverse personalities and thus management control is not automatic. Further goal congruence requires the coordination of groups of people in the organization.

System

A system is a set of objects

together with their relationships between the objects

and between their attributes

related to each other

and to their environment.

'So as to form a whole'

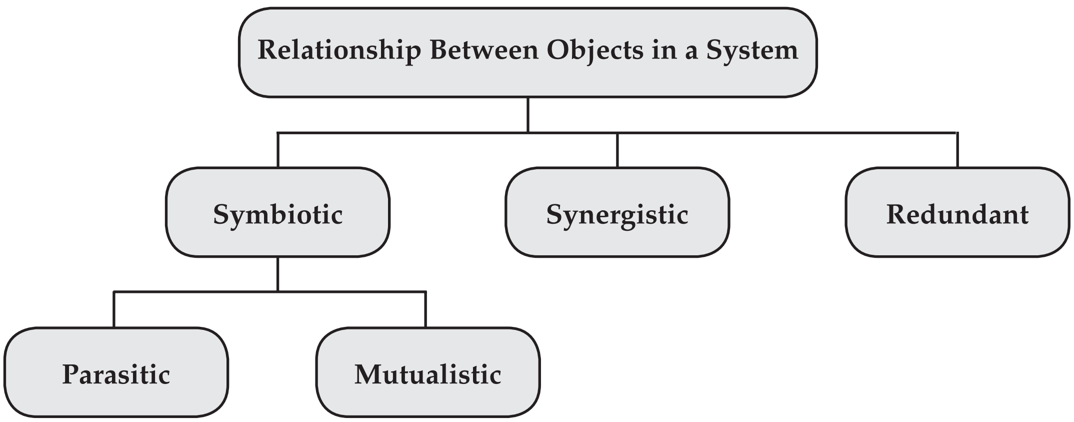
Schoderbek, Schoderbek, & Kefalas

Objects : Objects are elements of a system. There are three kinds of objects Inputs Processes & Outputs

Elements of a System

Relationships

Relationships are the bonds that link the objects together. They can be one of the three following categories.



Symbiotic Relationship is one in which the connected systems cannot function alone. The symbiotic relationship between a parasite and a plant is unipolar, to the extent that the parasite cannot live without the plant – parasitic symbiosis. However the Symbiosis Relationship between the production & sales sub-system is bipolar – no production, no sales – no sales, no production – Mutualistic Symbiosis.

Synergistic Relationship adds substantially to the systems performance Synergistic Relationship are those in which the cooperative action of semi-independent sub-systems taken together produces a total output greater than the sum of their outputs taken independently. A convenient expression of synergy is to say “2 + 2 = 5”

Redundant Relationships are those that duplicate other relationships. There are back-up relationships that increase system’s reliability but at greater expense.

Example: Stepney tyre in a car

Attributes

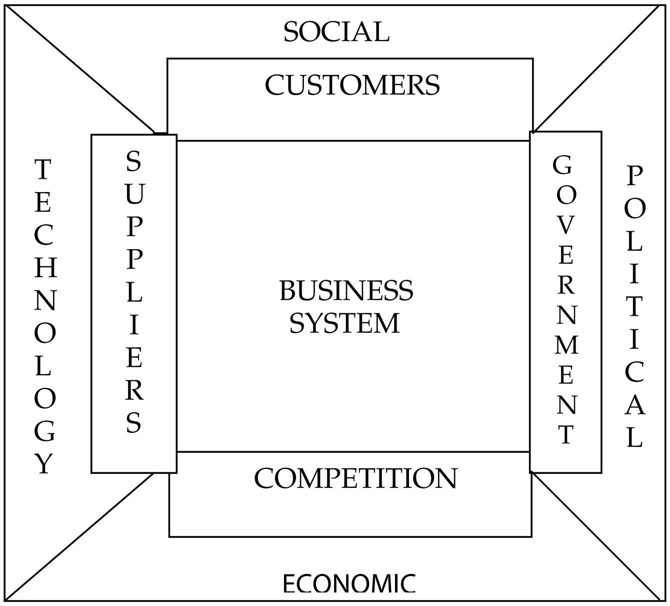
Attributes are properties of both Objects and Relationships. They are of 2 kinds

Defining characteristic – Eg. Load capacity of truck, speed, fuel, etc,.

Accompanying characteristic – Eg. The amount of pollution created by the engine of the truck

Environment: Each system has factors that are external to it, relevant to it and are uncontrollable. Such factors are called Environment.

Organization and its Environment



Whole

Whole is more than an aggregate of parts. The whole is an independent framework in which parts play a distinctive role.

The general systems theory is credited to L. Von. Bertalanffy.

The concepts of Control and Systems theory, applicable to biological and human systems have been applied with suitable modifications, to Management Science.

1.2 Management Control System (MCS)

Joseph Maciariello & Calvin Kirby have defined M.C.S. as follows

MCS is a set of inter-related communication structures that facilitates the processing of information for the purpose of assisting managers in coordinating the parts and attaining the purpose of an organization on a continuous basis.

They view "the entire organization as a control system. 'Control' is seen as a characteristic of a control system; it occurs when the organization is attaining its purpose. Purpose and attainment of purpose are central to the work of control system."

Thus Maciareillo and Kirby include both Control of strategy and Control of operations in the definition of M.C.S. A good management control framework, implemented properly, will enhance organizational adaptability, accelerate productivity and enhance competitiveness.

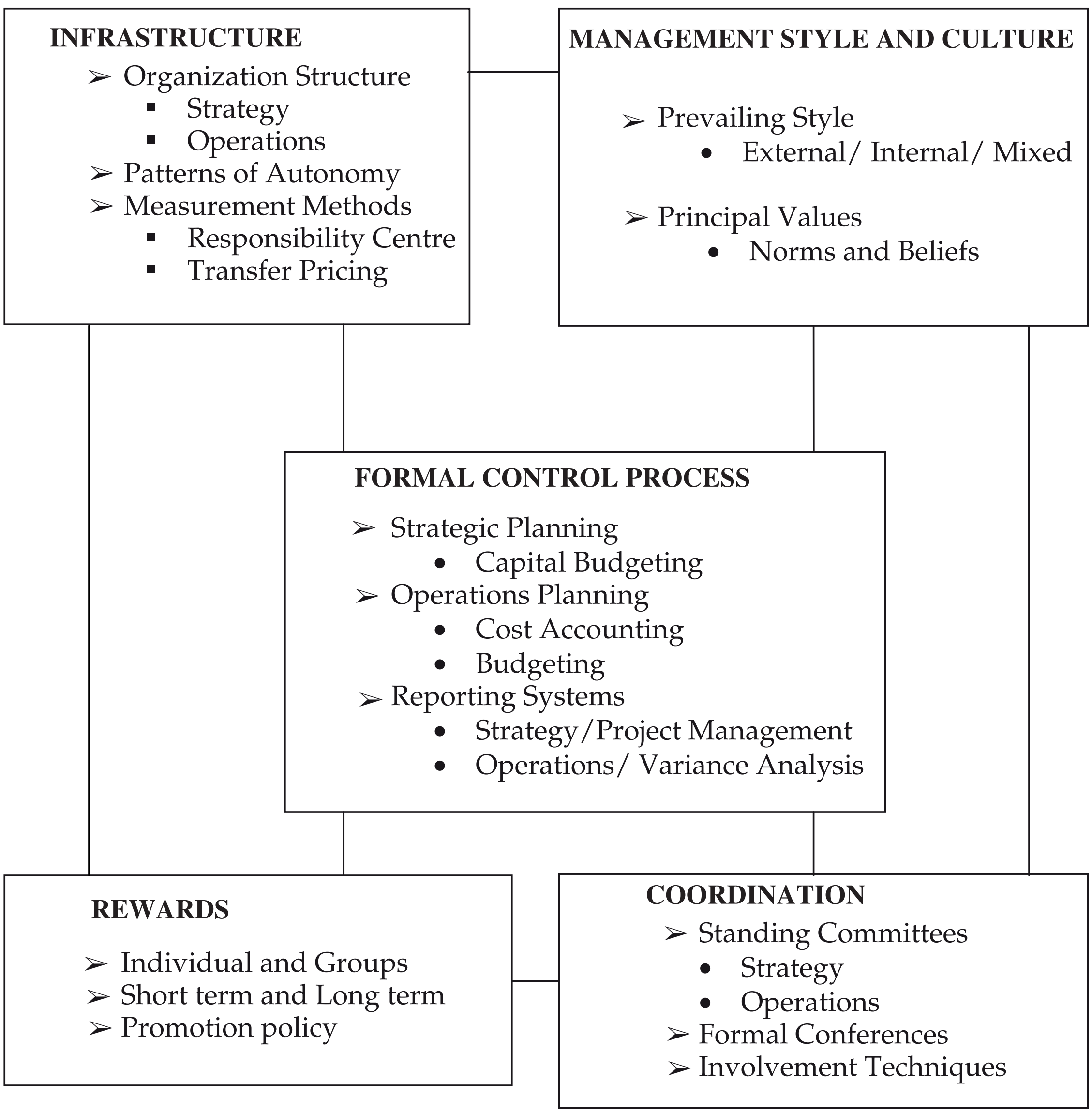
Purposes of MCS, according to them are

1. Coordination of parts of organization
2. Steering those parts to achieve organizational goals.
3. Bring along unity out of the diverse activities of an organization.

A control system consists of a set of formal and informal systems that are designed to assist management in steering the organization towards achievement of its goals. These two systems are distinct but closely inter-related, sometimes undistinguishable, sub divisions of control systems. They are considered adaptive, if the two systems are internally consistent, consistent with one another and designed to permit learning that is effectives in continuously meeting the competitively challenges in the environment.

The formal and informal systems along with the five components of each are explained further.

INFORMAL CONTROL SYSTEMS



Source: Joseph A. Maciareillo & Calvin J. Kirby – 'Management Control System' – Prentice Hall of India – Second Edition, 1997

FORMAL CONTROL SYSTEMS

INFRASTRUCTURE

- Personal Contacts
- Networks
- Expertise Oriented
- Minimal Structure
- Emergent Roles

MANAGEMENT STYLE AND CULTURE

- Prevailing Style
- External/ Internal/ Mixed
- Principle Values
- Norms and Beliefs

INFORMAL CONTROL PROCESS

- Search/alternative generations
- Ad hoc as needed
- Uncertainty coping
- Rationlisation/dialogue

INFORMAL REWARD

- Recognition
- Status Oriented
- Intrinsic
- Performance Oriented
- Stature Oriented
- Personal Contact

COORDINATION & INTEGRATION

- Based upon trust
- Simple / direct / Personal
- Telephone conversation
- Personal memos

Source: Joseph A. Maciareillo & Calvin J. Kirby – 'Management Control System' – Prentice Hall of India – Second Edition, 1997

1.2.1 Management Style & Culture

Management Style may be summarized as a continuum between highly autocratic or external style or Theory X Style and highly participative or internal style or Theory Y style.

In the external style there is

a) Centralisation of authority and decision making and lower levels of management have to strictly comply with the formal procedures laid.

b) The organization structure is pyramidal in nature

c) Detailed formal planning and control systems are formulated which are rigid in nature

d) There is strict supervision and guided tight control.

e) There is no freedom given and no empowerment at lower level.

f) Rewards and incentives are used effectively to motivate employee

This system does produce results, but it may demotivate employees who like to have more freedom in the works environment. Further it may thwart the innovative spirit. The intense competition amongst employee may even create a tense atmosphere in the organization which may not be conducive to long term growth.

However in case the employee are very subservient and not enterprising, this style may suit such organization.

The classic illustration of this external style was the one practiced by Harold Geneen of ITT in U.S. with a highly centralized tight central system. He personally made detailed evaluations of the performance of business units instead of monitoring the overall performance only, leaving the details to the unit managers.

Internal Style: The internal style is participative in nature and employees are given the freedom to offer suggestions, come out with innovations and take part in the decision making process. There is thus

a) Decentralization of authority i.e., bottom-up approach

b) The organization structure is flat

c) Rules and procedures are flexible

d) There is empowerment of employee which may encourage their creative spirit to blossom

e) The organization promotes commitment and self-control rather than thrusting a stifling control on employees

In this style of management there may be a tendency on the part of some employees, who are not self motivated, to be passengers, without making any positive contribution to the organization.

There is also the danger of each employee going his own way resulting in chaos, and to avoid such eventuality suitable coordinating mechanism must be in places. Moreover, the individual behavior must be goal-congruent with that of the organization.

John Chambers of CISCO practiced a participatory approach and encouraged his employees to lead, make good decision and take risks willingly.

Jack Welch the legendary CEO of General Electric was an autocratic leader in his early career, inviting the nickname of "Newtron Jack". From 1990s he transformed his style into one of involving people in decision-making and making use of the brain of every worker. His ambitions goal was to remove the "boss element" for G.E and to make it a boundary less organization.

Jeff Immelt who succeeded Jack Welch in 2001 is adored by everyone in G.E. for being a friendly likeable leader, with a proven track record.

In India, Infosys is a typical example of a company practicing a democratic approach in management.

Toyota is well-known for its philosophy of encouraging employees to come out with suggestions for improvement and rewarding them.

Mixed Style This is a composite of both the above styles, blending the advantages of each, without their drawbacks. Human nature being what it is, proper functioning of any organization requires suitable checks and balances. A control style based exclusively on intrinsic motivation seems to be naïve. A rigid authoritarian style, cast in a rule-bound framework, may be a noose round the organization

Murugappa group is a good example of this modified style of management. While the Board lays down the major policies and broad guidelines the professional divisional managers are given total freedom to attain the organizations goals.

Management Culture

Culture consists of shared values, beliefs and norms of organization which grew over time based upon the assumptions of what it takes to be successful. While management style is associated with individual managers, corporate culture is pervasive and is an organizational concept.

Culture facilitates cooperation & communication within the organization; however, if the beliefs are not consistent with the needs of business, dysfunctional consequences may follow.

A shared belief also ensures greater commitment of the employee to the organization.

BSNL's complacent culture in a monopolized environment had to undergo a radical shift to a market-oriented approach when the telecom sector was de-regulated.

Key themes or dominant values shape the organization culture

a)	A belief in the importance of people as individuals and in their ability to make a strong and effective contribution	Infosys Intel
b)	A belief in superior quality and service	I.B.M
c)	A belief in cleanliness & quality	M.T.R McDonald
d)	Belief in innovation	3M

Infrastructure It is necessary to design a proper control system infrastructure encompassing organization structure, responsibility centers, performance measures and rewards. A formal organization structure is a communication structure that is established to process information for the purpose of attaining the goals of the organization. An organization's ability to achieve and maintain control is directly proportional to it information processing and communication capability. The development in the information processing field have accelerated this capability.

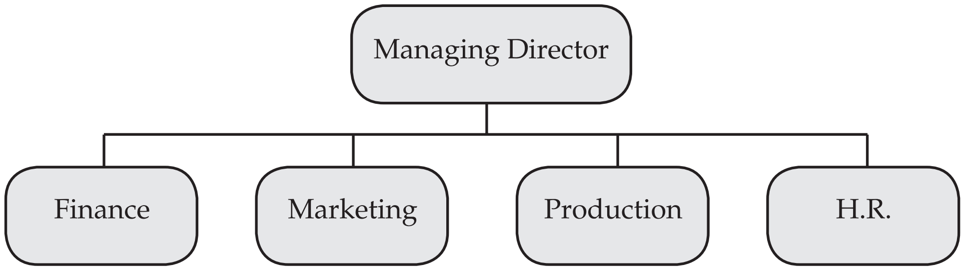
Organization Structure

A firms' strategy has a major influence on its structure. The type of structure in turn influences the design of the organization's management control system. Organization structure can be grouped into three general categories.

1. Functional Structure
2. Divisional Structure
3. Matrix Structure

Functional Structure

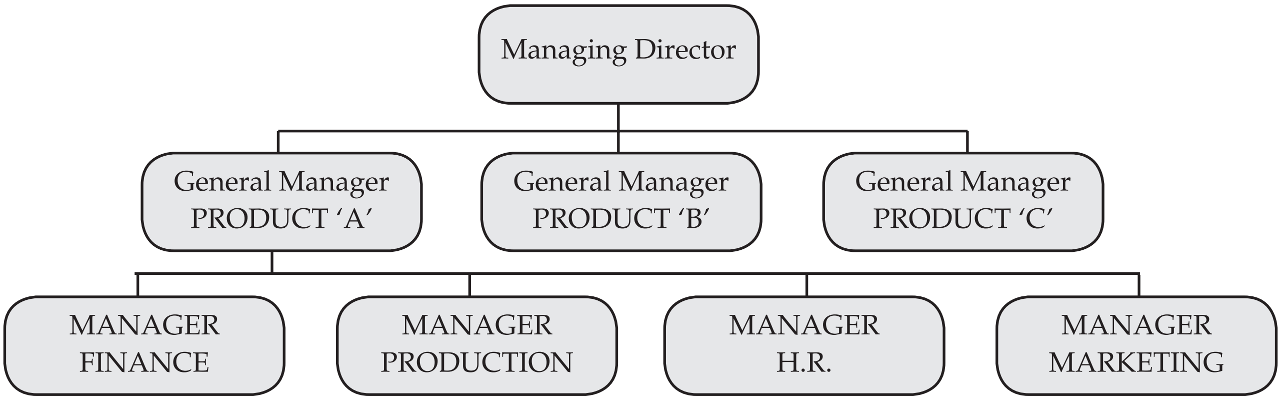
In this structure, each manager is responsible for a specified function as Finance or Marketing. The diagrammatic representation of this structure is as follows



This structure is based on the principle of division of labour and achieving excellence in each function. The drawback is the coordination problems that may arise to ensure optimization at the corporate level.

Divisional Structure

In this structure each of the decentralized division operates as a complete business unit in itself, like a semi-independent part of the company. The diagrammatic representation of this structure is as follows:



Similar Setup for products 'A' & 'C'

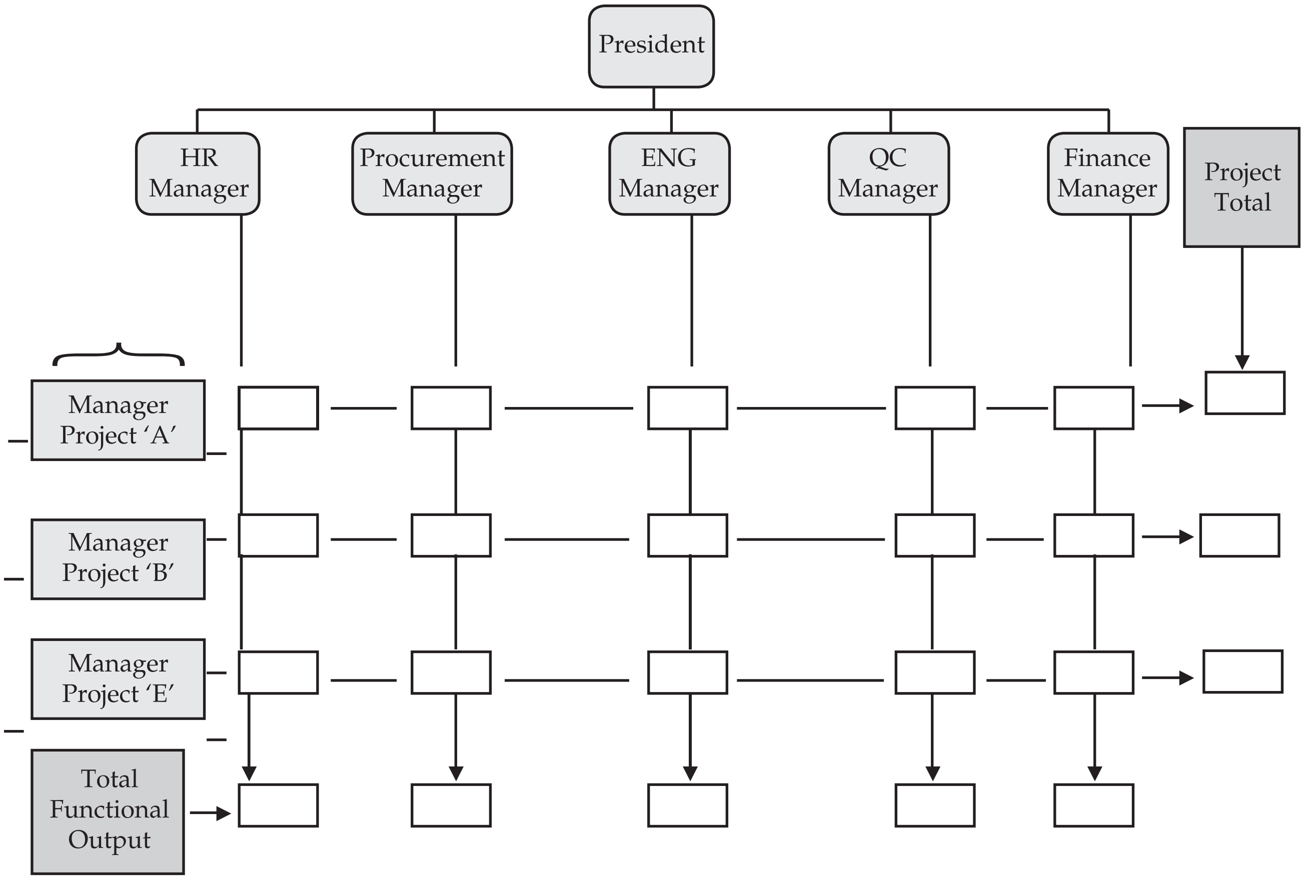
This structure helps the firms to be more market/customer-focused when the firm is engaged in unrelated product businesses. Full authority and accountability is given to the head of divisions as a separate profit and/or investment responsibility center. Structure produces greater managerial motivation to run their own business within broad company policies, thus acting as a good training ground for leadership.

Matrix Structure

Matrix Organisation Structure combines the coordination and control of the decentralized structure with the technical excellence economies of scale of the functional structures to reap the benefits of both. While managing complex programs as in large high-technology programs, complex products and services and multinational business, organization face several coordination problems. A matrix avoids such problems as the total responsibility for achieving the goals and objective of the program lies with Program Manager but must share resources from the various functional heads. The functional managers assigned to the projects are administratively reporting to the Project Manager but functionally to the Function Head.

The distinguishing feature of the matrix structure is thus the dual dimensions of management embodied in it.

The structure of a Matrix Organization is given below:



The outputs produced by the organization may be identified in the rows of the matrix while functional inputs utilized by each project may be identified in the columns of the matrix. The total outputs of the functions are found in the last column of the matrix.

Though the Project Manager assumes full responsibility for delivery of a product which meets performance specifications he does not have direct authority over the functional organization that actually performs the work. The functional personnel thus operate under the knowledge-based authority of the function and the resource-based authority of the Project Manager. This may create a friction in the course of the work but it is up to the Project Manager to use it as a creative friction to further the goals of the program.

b) The matrix organization structure is suitable for projects which are not large enough to warrant a fully decentralized set-up, with all functional managers under each project. Decentralization may result in loss of scale economics, by way of duplication of functional services for several projects. The matrix structure is suitable for projects of short duration.

c) (i) **Advantages**

1. Ensures better coordination and control of the decentralized structure along with achieving technical excellence and economies of scale of the functional organization.
2. Fosters creativity and multiple sources of diversity
3. Broader middle-management exposure to strategic issues of the business
4. Acts as a good training ground for future leaders.

(ii) **Disadvantages**

1. Dual accountability as explained above, which may create confusion
2. Necessitates tremendous horizontal and vertical coordination
3. Difference in orientation between Program and Functional personnel. The functional person may aim for high technical performance not warranted by project requirement
4. Diffuse responsibility As responsibility is distributed between program and functional personnel becomes difficult to administer system of accountability, leading to potential conflict
5. Program personnel may have a sense of insecurity as soon as a project is completed and this may lower their morale
6. The design of the reward structure for program and functional personnel is a ticklish issue which should be worked out in a fair and transparent manner to satisfy all.

The main consideration in design of organization structure are

- Functional Dimension
- Product Dimension
- Geographical Area Dimension

The basic problems in design of organization structure are

- Ensuring functional excellence
- Ensuring coordination
- Ensuring control
- Recognizing behavioural issues

The evolution of different structures associated with corporate stages of development are noted below:

Stage	Characteristics of the Firm	Typical Structure
I	Simple, Small business-offering one Product / Service to a small distinct local or regional market	Simple to functional
II	Single or closely related line of products but to a larger and sometimes more diverse markets (Geography, Channels or Customers)	Functional to Divisional
III	Expanded but related lines of products / services to diverse large markets	Divisional to Matrix
IV	Diverse, unrelated lines of products / services to large diverse markets	Divisional To S.B.U's

Controls for Differentiated Strategies

Robert Anthony & Vijay Govindarajan have given controls appropriate under different strategies which are reproduced below:

Different Corporate Strategies: Organisational Structure Implications

	Single Industry	*Related Diversified*	*Unrelated Diversified*
Organisational Structure	Functional	Business Units	Holding company
Industry familiarity of corporate management	High	⟶	Low
Functional background Of corporate management	Relevant Operating experience (mfg. mktg, R&D)	⟶	Mainly finance
Decision-making Authority	More Centralised	⟶	More Decentralized
Size of corporate Staff	High	⟶	Low
Reliance on internal promotions	High	⟶	Low
Use of lateral promotions	High	⟶	Low
Corporate culture	Strong	⟶	Weak

Different Corporate Strategies: Management Control Implications

	Single Industry	*Related Diversified*	*Unrelated Diversified*
Strategic Planning	Vertical-cum-horizontal	→	Vertical only
Budgeting: Relative control of business unit manager over budget formulation	Low	→	High
Importance attached to meeting the budget	Low	→	High
Transfer pricing: Importance of transfer pricing	High	→	Low
Sourcing flexibility	Constrained	→	Arm's-length market pricing
Incentive compensation: Bonus criteria	Financing and nonfinancial criteria	→	Primarily financial criteria
Bonus determination approach	Primarily Subjective	→	Primarily formula-based
Bonus basis	Based both on business unit and corporate performance	→	Based primarily on business unit performance

Source: Robert N Anthony & Vijay Govindarajan, Management Control Systems, Tata McGraw-Hill Publishing Co. Ltd. 12th Edition

1.2.2 Control Process

This covers the management accounting tools such as capital and operational budgets and reporting systems which are covered under other Study Material/s.

1.2.3 Coordination & Integration

To ensure that all the sub-units of an organization work in sync with each other it is imperative to have institutional mechanism for coordination. This is done through constitution of Committees for strategies & operational issues. There can be no substitute for face-to-face interaction amongst members of an organization. There could also be contacts with each other through e-mail & telephone.

1.2.4 Rewards

Rewards are a major motivational tool to secure the participation of individuals to achieve organizational goals. They are also an important source of communication and feedback. They communicate just what the firm values and just how valued an individual is to the firm. The feedback or rewards may be positive, seeking to reinforce and encourage certain behaviors or negative, seeking to alter behaviour to a more desirable pattern.

Reward system should blend the interest of individuals with that of the institution to ensure goal congruence. The system should be transparent and be perceived as fair.

An effective reward system requires

- Establishment of goals
- Performance measurements, financial and non-financial
- Rewards criteria

The rewards can be monetary or non-monetary.

Monetary rewards are salary, benefits and incentives. The incentives may be individual or group incentives. It could be short-term based on excellent performance in the current year or long-term through Equity Stock option plans. Such plans boost the morale of the employee and fosters a sense of belonging to the organization.

Apart from the foregoing factors, the reward system must be designed differently for the different levels of management. The compensation plan of Nucor Corporation, USA, serves as a good illustration.

Compensation

Nucor provided employees with a performance-related compensation system. All employees were covered under one of four compensation plans, each featuring incentives for meeting specific goals and targets.

1. **Production Incentive Plan**

   This covered most Nucor workers. Under this plan, employees directly involved in manufacturing were paid weekly bonuses based on actual output in relation to anticipated production tonnages produced. The bonuses were paid only for work that met quality standards and were pegged to work group, rather than individual output. (Each work group contained 25 to 40 workers.). Once the standard output was determined, it was not revised unless there was a significant change in the way a production process was performed due to a source other than the workers in the bonus group. Bonuses were tied to attendance and tardiness standards. If one worker's tardiness or attendance problems caused the group to miss its weekly output target, every member of the group was denied a bonus for that week. "This bonus system is very tough," said Iverson. "If you are late, even only five minutes, you lose your bonus for the day. If you are thirty minutes late or you are absent for sickness or anything else, you lose your bonus for the week. Now, we have four forgiveness days per year when you might need to close on a house or your wife is having a baby, but only four."

   Maintenance personnel were assigned to each shift, and they participated in the bonus along with other members operating on that shift; no bonus was paid if equipment was not operating. Production supervisors were also a part of the bonus group and received the same bonus as the employees they supervised. The weekly output by, and bonus for, each work group were displayed at the front entrance to the factory. While there were no upper caps the production incentive bonus, in general averaged 80 to 150 percent of the base wage.

   Iverson gave an example of how this plan worked: "In the steel mills, there are nine bonus groups: three in melting and casting, three in rolling, and three in finishing and shipping. Take melting and casting, for example. We start with a base of 12 tons of good billets per hour: Above that, the people in the group get a 4 percent bonus for every ton per hour. So if they have a week in which they run, say, 32 tons per hour – and that would be low – that's an 80 percent bonus. Take the regular pay, the overtime pay, everything, multiply it by an additional 80 percent – and we give them that check along with their regular check the next week.

2. Department Manager Incentive Plan

Nucor's department managers oversaw the production supervisors and, in turn, reported directly to the general manager of their plant. They earned an annual incentive bonus based on the performance of the entire plant to which they belonged. The target performance criterion here was return on asserts. Every plant operated as a stand-alone business unit. All the plants had the same performance target: a return of 25 percent or better on the assets employed within that plant. In recent years, bonuses averaged 82 percent of base salary.

3. Senior Officers Incentive Plan

The designation "senior officers" included all corporate executives and plant general managers Nucor senior officers did not have employment contracts, nor did they participate in any profit sharing, pension, or retirement plans, their base salaries were lower than those received by executives in comparable companies. Senior officers had only one incentive compensation system, based on Nucor's return on stockholder's equity above certain minimum earnings. A portion of pretax earnings was placed into a pool that was divided among the officers. If Nucor did well, the officer's bonuses, in the form of stock (about 60 percent) and cash (about 40 percent), could amount to several times their base salaries. If Nucor did poorly, an officer's compensation was only base salary and, therefore, significantly below the average pay for this level of responsibility.

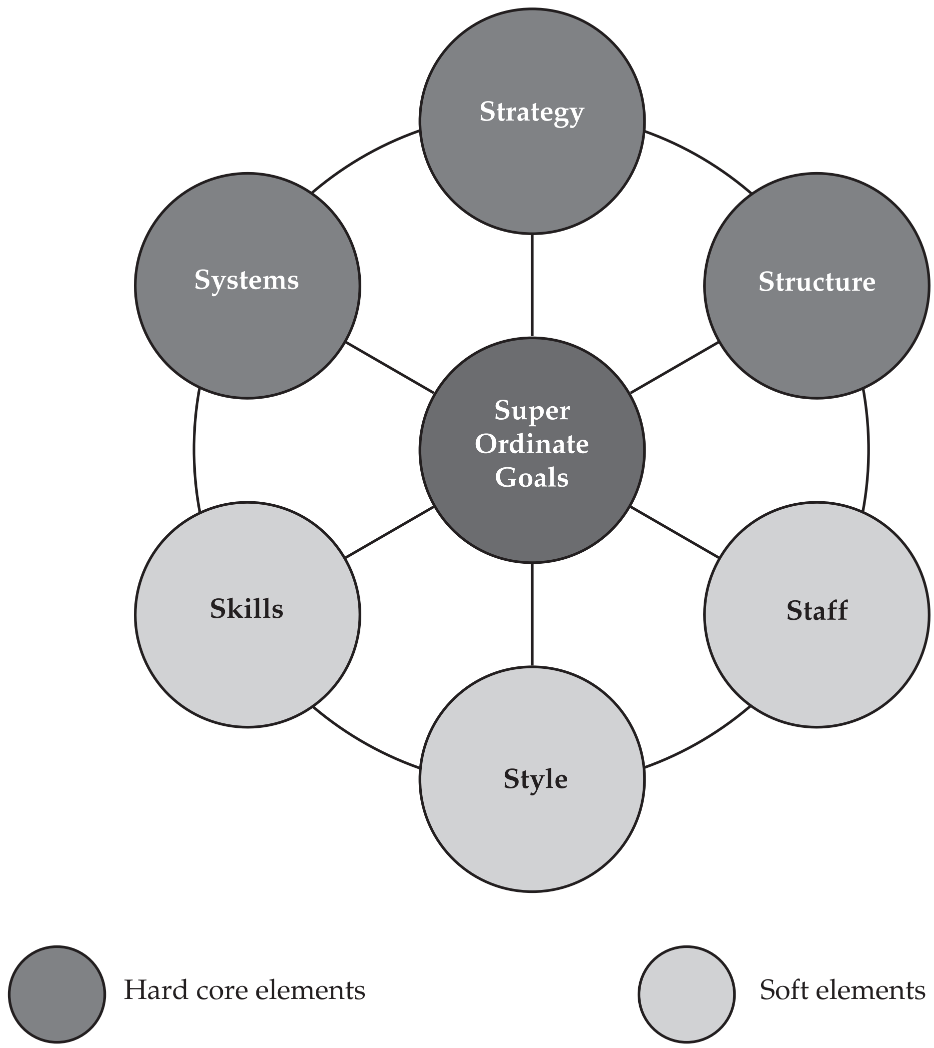
During a slack period in the 1980s, Iverson was named the Fortune 500 CEO with the lowest compensation. He saw this as an honor. "When I walked through a plant during that period of time when we had to cut back to a four-day work week, or even three-and-a-half days. I never heard an employee who complained," he said. "His pay may have been cut 25 percent, but he knew that his department head was cut even more and that the officers were cut, percentage wise, even more than that. I call it our 'share-the-pain' program…. I think in 1980 I earned $ 430,000. In 1982, I earned $ 108,000. Management should take the biggest drop in pay because they have the most responsibility.

Source: Robert N. Anthony & Vijay Govindarajan, Management Control Systems, Tata McGraw- Hill Publishing Co. Ltd, 12th edition- Pages: 24 & 25.

1.2.5 McKinsey's 7-S Framework

It would be interesting to note that the 7-S Framework given by McKinsey corresponds to the M.S.S.M Model of Maciareillo & Kirby.

7-S Framework



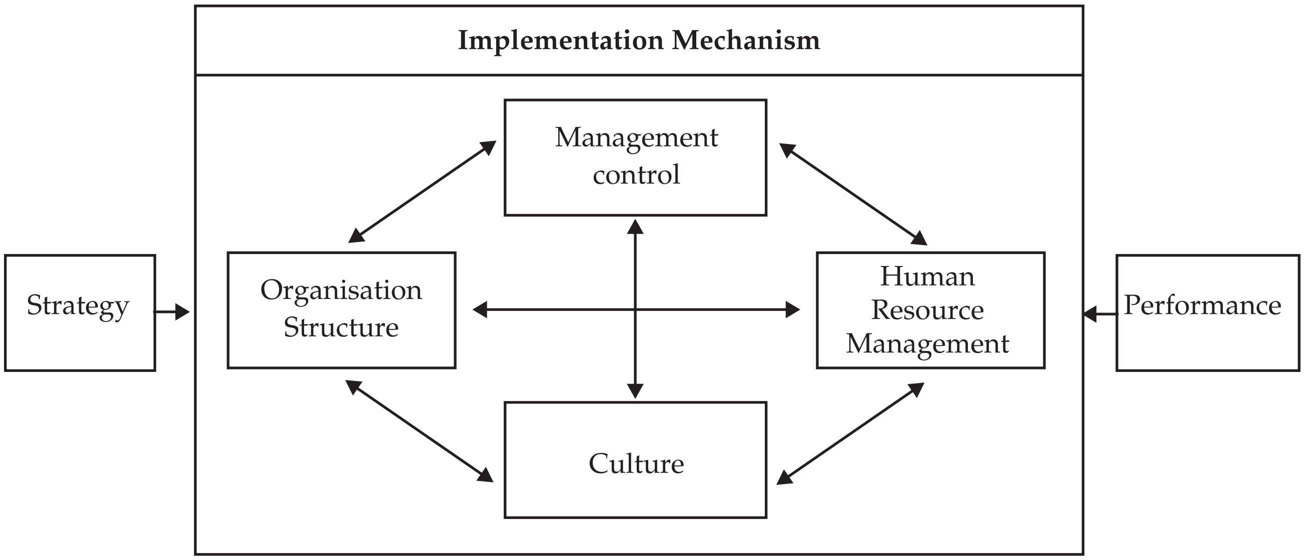
Strategy, Structure and System are the hard core elements corresponding to Infrastructure and Control Process.

Style / Staff / Skills are the soft elements corresponding to Managerial style, Coordination and Rewards. The super-ordinate goals represent the culture of the organization.

1.2.6 Robert Anthony & Vijay Govindarajan's view of Management Control:

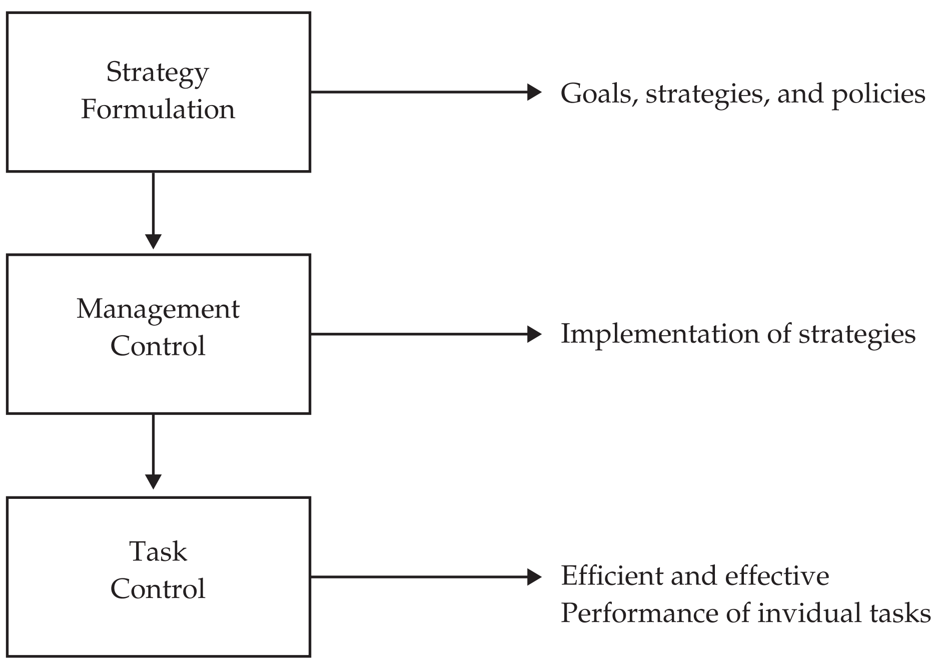
The learned authors have defined Management Control as "the process by which managers influence other members of the organization to implement the organization strategies."

Framework for Strategy Implementation



It will be observed that the elements given within the Implementation Mechanism box corresponds broadly to the elements in the M.S.S.M. model.

The authors have also outlined a three-tier planning and control framework as under



1.3 Behavioural Implications of Control System

Control system exerts considerable influence on the behavior of individual in an organization.
1.3.1 We have already seen the impact of managerial style on behavior – refer 1,2,1

1.3.2 We impact of control system on human behavior is best illustrated with the help of examining one type of control, say, budgetary control

The budget process affects behavior in three aspects

a) Formulation of budgets

The budgeting process may be top – down, determined wholly by top management. This may engender a feeling of budgets being thrust upon employees who perceive them as pressure devices; as a result their full enthusiasm may not be forthcoming in implementing it. In case the budget is formulated with a bottom-up approach, involving employees, commitment for meeting the budget can be assured.

b) Fixing targets

Sales production and other targets that are fixed should be challenging but attainable so as to bring out the best efforts of individuals. If targets are so high, as to be unattainable, it may be demotivate employees: in some cases it may also lead to manipulation of data to ensure conformity with budget. However such manipulations will have adverse effects in the long run. A common practice is far sales manager to dump stocks on their dealers at the year end to meet sales targets, perhaps giving unduly long credit.

c) Evaluation of performance

The evaluation of performance should be done in a constructive manner and not in vindictive style. While variances may be thrown up by the system, the causative factors may not be known readily. Hence it is necessary to analyze the reasons for variance and ensure proper accountability.

1.3.3 Budget as tool for coordination

Budget is not only a tool for planning in control but more importantly a means of ensuring coordination between the different departments of organizations. Thus if marketing demand is more than production capacity, ways for increasing production by working more shifts or sub-contracting may be explored. After looking at several scenarios the best option is chosen, reconciling the conflicting interest of all concerned and the entire organization operates on the same wavelength. Inter departmental conflicts are avoided.

1.3.4 Rewards

Rewards are powerful motivational tools. However if the reward is perceived to be unfair or not transparent, it may have a demoralizing effect.

The history of companies like Worldcom, Enron, Tyco etc have shown how CEO'S actuated by greed, manipulated and artificially boosted profits and share prices by resorting to dubious accounting practices to maximize their individual earnings, which ultimately led to the collapse of the companies.

1.3.5 Budgets may lead to waste

Waste may arise as managers adopt the view " we had better spend it or we will lose it. This is often coupled with ' empire building' in order to enhance the prestige of a department.

MCS

Distinction between Strategic Planning and Management Control

Characteristic	Strategic Planning	Management Control
Focus of plans	On one aspect at a time	On whole organization
Complexities	Many variables	Less complex
Degree of structure	Unstructured and irregular: each problem different	Rhythmic: prescribed procedures
Nature of information	Tailor-made for the problem; more external and predictive; less accurate	Integrated; more internal and historical; more accurate
Communication of information	Relatively simple	Relatively difficult
Purpose of estimates	Show expected results	Lead to desired results
Persons primarily involved	Staff and to management	Line and top management
Number of persons involved	Small	Large
Mental activity	Creative; analytical	Administrative: persuasive
Source discipline	Economics	Social psychology
Planning and control	Planning dominant, but some control	Emphasis on both planning and control
Time horizon	Tends to be long	Tends to be short
End result	Policies and precedents	Action within policies and precedents
Appraisal of the job done	Extremely difficult	Much less difficult

Distinctions between Management Control and Operational Control

Characteristic	Management Control	Operational Control
Focus of activity	Whole operation	Single task or transaction
Judgment	Relatively much; subjective decision	Relatively little; reliance on rules
Nature of structure	Psychological	Rational
Nature of information	Integrated; financial data throughout; approximations acceptable; future and historical	Tailor – made to the operation; often non – financial; precise; often in real time
Persons primarily involved	Management	Supervisors (or none)
Mental activity	Administrative; persuasive	Follow directions (or none)
Source discipline	Social psychology	Economics; physical sciences
Time horizon	Weeks, months years	Day to day
Type of costs	Discretionary	Engineered

STUDY NOTE - 2

Operations Management

This Study Note includes:

- Operation Strategy - Overview
- Strategies for Balancing Capacity and Demand
- Just-in-Time and Lean manufacturing
- Optimised Production Technology
- IT in Operation Management
  - MIS
  - Use of Intranet in Information Management
  - Manufacturing Resource Planning & Distribution Resource Planning
  - Enterprise Resource Planning
- Benchmarking and Bench Trending

2.1 Operations Strategy - Overview

2.1.1 Introduction

To look at what operations strategy is, we would break the word into the two separate forming words: operations and strategy. Both these words act as antitheses to the other. Where **operations** deals with the functions and procedures involved in the day-to-day processes of manufacturing goods and products, **strategy** deals with the direction and scope of an organisation over a long period on how they deliver to their clients. It turns out that the name itself holds information about the broad subject that tends to bind together routine process management, i.e., *operations managements* with a foresight of things forming up way ahead in the future.

2.1.2 Operations strategy

Companies and organisations making products and delivering, be it for profit or not for profit rely on a handful of processes to get their products manufactured properly and delivered on time. Each of the process acts as an operation for the company. To the company this is essential.

Understanding operations

Have you ever imagined a car without a gear or the steering wheel? Whilst, what remains of an utmost importance to you is to *drive* the locomotive from one location to another for whatever purpose you wish, but can only be made possible with each and every part of the car working together and attached.

Organisations behave in the same manner. The company has an ultimate goal of delivering goods to a client, but the processes of designing, manufacturing, analysing and then finally being delivered are the driving forces for the company's success. All these chunk of works **processes** that collectively define a bigger purpose, the **operations** for that particular organisation. The more effective these processes or operations would be, the more productive and profitable the business would be.

[Note: *Goods,* the ultimate by-product of a company, can be a *product* or a *service*. Take for instance, a car manufacturing company. For it, all operations would lead to the development and enhancement of a car, a product, something physical. But, to a therapist, the service he/she provides to their clients is the much needed result or required output. In this Study Note, the term 'goods' includes 'services' unless the context excludes such a meaning.]

Definition

According to Slack and Lewis, operations strategy holds the following definition:

Operations strategy is the total pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to the overall strategy, through the reconciliation of market requirements with operations resources.

Statement of McDonald's Operations Strategy

"To provide unmatched consistency in operations in support of high product quality. This must be accomplished with adequate speed, low cost, and process innovation to accommodate changes in consumer tastes."

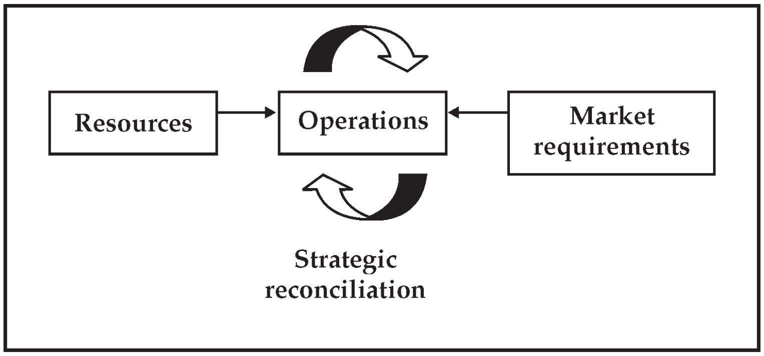
From the statement of McDonald's operations strategy, it is clear that both consistent and high-performance quality are considered order *winners*, while speed, cost, and innovation are considered order *qualifiers*.

2.1.3 Market requirements and operations strategy

Operations, of whatever kind, are influenced by two major factors, the resources for the operations and the market requirements.

Authors like Slack call the market perspective on the operation strategy as *'outside-in'* where the outside influence tends to tailor the overall strategy of the operations from within.

If one is tempted to tailor needs in the operations to match a certain market's requirements, they need to study the market first in order to match the company's marketing efforts. Such decisiveness is called market segmentation.



2.1.4 Components of the Operations Strategy

Structural Decision categories:	Capacity Facilities Vertical Integration Technology
Infrastructure Decision categories:	Workforce Organization Information/control systems
Capabilities:	Unique to each firm

Competitive priorities:	Cost
	Quality
	    High-performance design
	    Consistent quality
	Time
	    Fast delivery time
	    On-time delivery
	    Development speed
	Flexibility
	    Customization
	    Volume flexibility

2.1.5 Criteria for Evaluating an Operations Strategy

Consistency (internal and external)

Between the operations strategy and the overall business strategy

Between the operations strategy and the other functional strategies within the business

Among the decision categories that make up the operations strategy

Between the operations strategy and the business environment (resources available, competitive behaviour, governmental restraints, etc.)

Contribution (to competitive advantage)

Making trade-offs explicit, enabling operations to set priorities that enhance the competitive advantage

Directing attention to opportunities that complement the business strategy

Promoting clarity regarding the operations strategy throughout the business unit so its potential can be fully realized

Providing the operations capabilities that will be required by the business in the future

Sources:

http://en.wikibooks.org/wiki/Operations_Strategy/What_is_operations_strategy%3F/Operations_strategy#Defining_operations_strategy

Slack, N. and Lewis, M., Operations strategy, ISBN 0273637819, 2002, Prentice Hall: Harlow, Essex, p.3.

http://www2.bc.edu/~xueme/MD021/class%20notes/operations%20strategy.doc

2.2 Strategies for Balancing Capacity and Demand

2.2.1 Capacity Management Strategies

Capacity planning has seen an increased emphasis due to the financial benefits of the efficient use of capacity plans within material requirements planning systems and other information systems. Insufficient capacity can quickly lead to deteriorating delivery performance, unnecessarily increase work-in-process, and frustrate sales personnel and those in manufacturing. However, excess capacity can be costly and unnecessary. The inability to properly manage capacity can be a barrier to the achievement of maximum firm performance. In addition, capacity is an important factor in the organization's choice of technology.

Capacity is usually assumed to mean the maximum rate at which a transformation system produces or processes inputs. Sometimes, this rate may actually be "all at once"—as with the capacity of an airplane. A more usable definition of capacity would be the volume of output per elapsed time and the production capability of a facility.

Capacity planning is the process used to determine how much capacity is needed (and when) in order to manufacture greater product or begin production of a new product. A number of factors can affect capacity—number of workers, ability of workers, number of machines, waste, scrap, defects, errors, productivity, suppliers, government regulations, and preventive maintenance. Capacity planning is relevant in both the long term and the short term. However, there are different issues at stake for each.

2.2.2 Long-term Capacity Planning

Over the long term, capacity planning relates primarily to strategic issues involving the firm's major production facilities. In addition, long-term capacity issues are interrelated with location decisions.

Technology and transferability of the process to other products is also intertwined with long-term capacity planning. Long-term capacity planning may evolve when short-term changes in capacity are insufficient. For example, if the firm's addition of a third shift to its current two-shift plan still does not produce enough output, and subcontracting arrangements cannot be made, one feasible alternative is to add capital equipment and modify the layout of the plant (long-term actions). It may even be desirable to add additional plant space or to construct a new facility (long-term alternatives.)

2.2.3 Short-term Capacity Planning

In the short term, capacity planning concerns issues of scheduling, labor shifts, and balancing resource capacities. The goal of short-term capacity planning is to handle unexpected shifts in demand in an efficient economic manner. The time frame for short-term planning is frequently only a few days but may run as long as six months.

Alternatives for making short-term changes in capacity are fairly numerous and can even include the decision to not meet demand at all. The easiest and most commonly-used method to increase capacity in the short term is working overtime. This is a flexible and inexpensive alternative. While the firm has to pay one and one half times the normal labor rate, it foregoes the expense of hiring, training, and paying additional benefits. When not used abusively, most workers appreciate the opportunity to earn extra wages. If overtime does not provide enough short-term capacity, other resource-increasing alternatives are available. These include adding shifts, employing casual or part-time workers, the use of floating workers, leasing workers, and facilities subcontracting.

Firms may also increase capacity by improving the use of their resources. The most common alternatives in this category are worker cross training and overlapping or staggering shifts. Most manufacturing firms inventory some output ahead of demand so that any need for a capacity change is absorbed by the inventory buffer. From a technical perspective, firms may initiate a process design intended to increase productivity at work stations. Manufacturers can also shift demand to avoid capacity requirement fluctuation by backlogging, queuing demand, or lengthening the firm's lead times. Service firms accomplish the same results through scheduling appointments and reservations.

A more creative approach is to modify the output. Standardizing the output or offering complimentary services are examples. In services, one might allow customers to do some of the process work themselves (e.g., self-service gas stations and fast-food restaurants). Another alternative—reducing quality—is an undesirable yet viable tactic.

Finally, the firm may attempt to modify demand. Changing the price and promoting the product are common. Another alternative is to partition demand by initiating a yield or revenue management system. Utilities also report success in shifting demand by the use of "off-peak" pricing.

2.2.4 Capacity-planning Techniques

There are four procedures for capacity planning; capacity planning using overall factors (CPOF), capacity bills, resource profiles, and capacity requirements planning (CRP). The first three are rough-cut approaches (involving analysis to identify potential bottlenecks) that can be used with or without manufacturing resource planning (MRP) systems. CRP is used in conjunction with MRP systems.

CPOF: Capacity using overall factors is a simple, manual approach to capacity planning that is based on the master production schedule and production standards that convert required units of finished goods into historical loads on each work center.

Capacity Bills: Bills of capacity is a procedure based on the MPS. Instead of using historical ratios, however, it utilizes the bills of material and routing sheet (which shows the sequence or work centers required to manufacture the part, as well as the setup and run time). Capacity requirements can then be determined by multiplying the number of units required by the MPS by the time needed to produce each.

Resource Profiles: Resource profiles are the same as bills of capacity, except lead times are included so that workloads fall into the correct periods.

CRP: Capacity requirements planning is only applicable in firms using MRP or MRP II. CRP uses the information from one of the previous rough-cut methods, plus MRP outputs on existing inventories and lot sizing. The result is a tabular load report for each work center or a graphical load profile for helping plan-production requirements. This will indicate where capacity is inadequate or idle, allowing for imbalances to be corrected by shifts in personnel or equipment or the use of overtime or added shifts. *Finite capacity scheduling* is an extension of CRP that simulates job order stopping and starting to produce a detailed schedule that provides a set of start and finish dates for each operation at each work center.

A failure to understand the critical nature of managing capacity can lead to chaos and serious customer service problems. If there is a mismatch between available and required capacity, adjustments should be made. However, it should be noted that firms cannot have perfectly-balanced material and capacity plans that easily accommodate emergency order. If flexibility is the firm's competitive priority, excess capacity would be appropriate.

Aggregate Planning

Aggregate planning is the process of developing, analyzing, and maintaining a preliminary, approximate schedule of the overall operations of an organization. The aggregate plan generally contains targeted sales forecasts, production levels, inventory levels, and customer backlogs. This schedule is intended to satisfy the demand forecast at a minimum cost. Properly done, aggregate planning should minimize the effects of shortsighted, day-to-day scheduling, in which small amounts of material may be ordered one week, with an accompanying layoff of workers, followed by ordering larger amounts and rehiring workers the next week. This longer-term perspective on resource use can help minimize short-term requirements changes with a resulting cost savings.

In simple terms, aggregate planning is an attempt to balance capacity and demand in such a way that costs are minimized. The term "aggregate" is used because planning at this level includes all resources "in the aggregate;" for example, as a product line or family. Aggregate resources could be total number of workers, hours of machine time, or tons of raw materials. Aggregate units of output could include kilolitres, metres, tonnes of output, as well as aggregate units appearing in service industries such as hours of service delivered, number of patients seen, etc.

Aggregate planning does not distinguish among sizes, colors, features, and so forth. For example, with automobile manufacturing, aggregate planning would consider the total number of cars planned for not the individual models, colors, or options. When units of aggregation are difficult to determine (for example, when the variation in output is extreme) equivalent units are usually determined. These equivalent units could be based on value, cost, worker hours, or some similar measure.

Aggregate planning is considered to be intermediate-term (as opposed to long- or short-term) in nature. Hence, most aggregate plans cover a period of three to 18 months. Aggregate plans serve as a foundation for future short-range type planning, such as production scheduling, sequencing, and loading. The master production schedule (MPS) used in material requirements planning (MRP) has been described as the aggregate plan "disaggregated."

Steps taken to produce an aggregate plan begin with the determination of demand and the determination of current capacity. Capacity is expressed as total number of units per time period that can be produced (this requires that an average number of units be computed since the total may include a product mix utilizing distinctly different production times). Demand is expressed as total number of units needed. If the two are not in balance (equal), the firm must decide whether to increase or decrease capacity to meet demand or increase or decrease demand to meet capacity. In order to accomplish this, a number of options are available.

2.2.5 Demand stimulation: Options for situations in which demand needs to be increased in order to match capacity include:

1. **Pricing -** Varying (lower) pricing to increase demand in periods when demand is less than peak. For example, matinee prices for movie theaters, off-season rates for hotels, night time rates for mobile telephone service, and off-season pricing for items that experience seasonal demand.
2. **Promotion -** Advertising, direct marketing, bulk purchase discounts, bonus/free offers and other forms of promotion are used to shift demand.
3. **Back ordering -** By postponing delivery on current orders demand is shifted to period when capacity is not fully utilized. This is really just a form of smoothing demand. Service industries are able to smooth demand by taking reservations or by making appointments in an attempt to avoid walk-in customer. Some refer to this as "partitioning" demand.
4. **New demand creation -** A new, but complementary demand is created for a product or service. When restaurant customers have to wait, they are frequently diverted into a complementary (but not complimentary) service, the bar. Other examples include the addition of video arcades within movie theaters, and the expansion of services at convenience stores.

2.2.6. Adjusting Capacity

Options which can be used to increase or decrease capacity to match current demand include:

1. **Hire/lay off -** By hiring additional workers as needed or by laying off workers not currently required to meet demand, firms can maintain a balance between capacity and demand.
2. **Overtime -** By asking or requiring workers to work extra hours a day or an extra day per week, firms can create a temporary increase in capacity without the added expense of hiring additional worker.
3. **Part-time or casual labor -** By utilizing temporary workers or casual labor (workers who are considered permanent but only work when needed, on an on-call basis, and typically without the benefits given to full-time workers).
4. **Inventory -** Finished-goods inventory can be built up in periods of slack demand and then used to fill demand during periods of high demand. In this way no new workers have to be hired, no temporary or casual labor is needed, and no overtime is incurred.
5. **Subcontracting -** Frequently firms choose to allow another manufacturer or service provider to provide the product or service to the subcontracting firm's customer. By subcontracting work to an alternative source, additional capacity is temporarily obtained.

6. **Contract manufacturing:** Sub letting spare or idle manufacturing facilities to other firms needing extra facilities. This is the reverse of sub-contracting.
7. **Cross-training.** Cross-trained employees may be able to perform tasks in several operations, creating some flexibility when scheduling capacity.
8. **Other methods.** While varying workforce size and utilization, inventory buildup/backlogging, and subcontracting are well-known alternatives, there are other, more novel ways that find use in industry. Among these options are sharing employees with counter-cyclical companies and attempting to find interesting and meaningful projects for employees to do during slack times.

2.2.7 Aggregate Planning Strategies

There are two pure planning strategies available to the aggregate planner: a level strategy and a chase strategy. Firms may choose to utilize one of the pure strategies in isolation, or they may opt for a strategy that combines the two.

Level Strategy

A level strategy seeks to produce an aggregate plan that maintains a steady production rate and/or a steady employment level. In order to satisfy changes in customer demand, the firm must raise or lower inventory levels in anticipation of increased or decreased levels of forecast demand. The firm maintains a level workforce and a steady rate of output when demand is somewhat low. This allows the firm to establish higher inventory levels than are currently needed. As demand increases, the firm is able to continue a steady production rate/steady employment level, while allowing the inventory surplus to absorb the increased demand.

A second alternative would be to use a backlog or backorder. A backorder is simply a promise to deliver the product at a later date when it is more readily available, usually when capacity begins to catch up with diminishing demand. In essence, the backorder is a device for moving demand from one period to another, preferably one in which demand is lower, thereby smoothing demand requirements over time.

A level strategy allows a firm to maintain a constant level of output and still meet demand. This is desirable from an employee relations standpoint. Negative results of the level strategy would include the cost of excess inventory, subcontracting or overtime costs, and backorder costs, which typically are the cost of expediting orders and the loss of customer goodwill.

Chase Strategy

A chase strategy implies matching demand and capacity period by period. This could result in a considerable amount of hiring, firing or laying off of employees; insecure and unhappy employees; increased inventory carrying costs; problems with labor unions; and erratic utilization of plant and equipment. It also implies a great deal of flexibility on the firm’s part. The major advantage of a chase strategy is that it allows inventory to be held to the lowest level possible, and for some firms this is a considerable savings. Most firms embracing the just-in-time production concept utilize a chase strategy approach to aggregate planning.

Most firms find it advantageous to utilize a combination of the level and chase strategy. A combination strategy (sometimes called a hybrid or mixed strategy) can be found to better meet organizational goals and policies and achieve lower costs than either of the pure strategies used independently.

2.2.8 Techniques For Aggregate Planning

Techniques for aggregate planning range from informal trial-and-error approaches, which usually utilize simple tables or graphs, to more formalized and advanced mathematical techniques. (Production/ Operations Management) by William Stevenson contains an informal but useful trial-and-error process for aggregate planning presented in outline form.

This general procedure consists of the following steps:

1. Determine demand for each period.
2. Determine capacity for each period. This capacity should match demand, which means it may require the inclusion of overtime or subcontracting or both.
3. Identify company, departmental, or union policies that are pertinent. For example, maintaining a certain safety stock level, maintaining a reasonably stable workforce, backorder policies, overtime policies, inventory level policies, and other less explicit rules such as the nature of employment with the individual industry, the possibility of a bad image, and the loss of goodwill.
4. Determine unit costs for units produced. These costs typically include the basic production costs (fixed and variable costs as well as direct and indirect labor costs). Also included are the costs associated with making changes in capacity. Inventory holding costs must also be considered, as should storage, insurance, taxes, spoilage, and obsolescence costs. Finally, backorder costs must be computed. While difficult to measure, this generally includes expediting costs, loss of customer goodwill, and revenue loss from cancelled order.
5. Develop alternative plans and compute the cost for each.
6. If satisfactory plans emerge, select the one that best satisfies objectives. Frequently, this is the plan with the least cost. Otherwise, return to step 5.

An example of a completed informal aggregate plan can be seen in Figure 1. This plan is an example of a plan determined utilizing a level strategy. Notice that employment levels and output levels remain constant while inventory is allowed to build up in earlier periods only to be drawn back down in later periods as demand increases. Also, note that backorders are utilized in order to avoid overtime or subcontracting. The computed costs for the individual variables of the plan are as follows:

Output costs:

Regular time = Rs.5 per unit

Overtime = Rs.8 per unit

Subcontracted = Rs.12 per unit

Other costs:

Inventory carrying cost = Rs.3 per unit per period applied to average inventory

Backorders = Rs.10 per unit per period

Cost of aggregate plan utilizing a level strategy:

Output costs:

Regular time = Rs.5 × 1,500 = Rs.7,500

Overtime = Rs.8 × 0 = 0

Subcontracted = Rs.10 × 0 = 0

Other costs:

Inventory carrying cost = Rs.3 × 850 = Rs.2,400

Backorders = Rs.10 × 100 = Rs.1,000

Total cost = Rs.10,900

Period		1	2	3	4	5	6
Forecast		100	150	300	300	500	150
Output							
	Regular	250	250	250	250	250	250
	Overtime						
	Subcontract						
Forecast		150	100	-50	-50	-250	100
Inventory							
	Beginning	0	150	250	200	150	0
	Ending	150	250	200	150	0	100
	Average	75	200	225	175	75	50
Backlog	0	0	0	0	0	100	0

Cost of aggregate plan utilizing a level strategy :

Output:

Regular time	=	**Rs. 5**	**X**	**1500**	**= Rs.7500**
Overtime	=	**Rs. 8**	**X**	**0**	**= 0**
Subcontracted	=	**Rs. 10**	**X**	**0**	**= 0**
Inventory carrying cost	=	**Rs. 3**	**X**	**850**	**= 2550**
Backorders	=	**Rs. 10**	**X**	**100**	**= 1000**
Total Cost					**Rs.11050**

Figure 1

A second example, shown in Figure 2, presents the same scenario as in Figure 1 but demonstrates the use of a combination strategy (i.e., a combination of level and chase) to meet demand and seek to minimize costs. For this example, let's assume that company policy prevents us from utilizing backorders and limits our plan to no more than 50 units of overtime per period. Notice that the regular output level is constant, implying a level workforce, while overtime and subcontracting are used to meet demand on a period by period basis (chase strategy). One will notice that the cost of the combination plan is slightly lower than the cost of the level plan.

Output costs:

Regular time = Rs. 5 × 1,200 = Rs.6,000

Overtime = Rs.8 × 100 = Rs.800

Subcontracted = Rs.12 × 250 = Rs.2,500

Other costs:

Inventory carrying cost = Rs.3 × 325 = 975

Backorders = Rs.10 × 0 = 0

Total cost = Rs.10,275

Period		1	2	3	4	5	6
Forecast		100	150	300	300	500	150
Output							
	Regular	200	200	200	200	200	200
	Overtime					50	
	Subcontract					250	
Forecast		100	50	-100	-50	0	50
Inventory							
	Beginning	0	100	150	50	0	0
	Ending	100	150	50	0	0	50
	Average	50	125	100	25	0	25
Backlog	0	0	0	0	0	0	0

Cost of aggregate plan utilizing a level stragegy :

Output:

Regular time	=	**Rs. 5**	**X**	**1200**	=	**Rs.6000**
Overtime	=	Rs. **8**	**X**	**100**	=	**800**
Subcontracted	=	**Rs. 12**	**X**	**250**	=	**3000**
Inventory carrying cost	=	**Rs. 3**	**X**	**325**	=	**975**
Backorders	=	**Rs. 10**	**X**	**0**	=	**0**
Total Cost						**Rs.10775**

Figure 2

2.2.9 Mathematical Approaches to Aggregate Planning

The following are some of the better known mathematical techniques that can be used in more complex aggregate planning applications.

Linear Programming

Linear programming is an optimization technique that allows the user to find a maximum profit or revenue or a minimum cost based on the availability of limited resources and certain limitations known as constraints. A special type of linear programming known as the Transportation Model can be used to obtain aggregate plans that would allow balanced capacity and demand and the minimization of costs. However, few real-world aggregate planning decisions are compatible with the linear assumptions of linear programming. *Supply Chain Management: Strategy, Planning and Operation*, by Sunil Chopra and Peter Meindl, provides an excellent example of the use of linear programming in aggregate planning.

Mixed-integer Programming

For aggregate plans that are prepared on a product family basis, where the plan is essentially the summation of the plans for individual product lines, mixed-integer programming may prove to be useful.

Mixed-integer programming can provide a method for determining the number of units to be produced in each product family.

Linear Decision Rule

Linear decision rule is another optimizing technique. It seeks to minimize total production costs (labor, overtime, hiring/lay off, inventory carrying cost) using a set of cost-approximating functions (three of which are quadratic) to obtain a single quadratic equation. Then, by using calculus, two linear equations can be derived from the quadratic equation, one to be used to plan the output for each period and the other for planning the workforce for each period.

Management Coefficients Model

The management coefficients model, formulated by E.H. Bowman, is based on the suggestion that the production rate for any period would be set by this general decision rule:

$P_t = aW_{t-1} - bI_{t-1} + cF_{t+1} + K$, where
P_t = the production rate set for period t
W_{t-1} = the workforce in the previous period
I_{t-1} = the ending inventory for the previous period
F_{t+1} = the forecast of demand for the next period
a, b, c, and K are constants

It then uses regression analysis to estimate the values of a, b, c, and K. The end result is a decision rule based on past managerial behavior without any explicit cost functions, the assumption being that managers know what is important, even if they cannot readily state explicit costs. Essentially, this method supplements the application of experienced judgment.

Search Decision Rule

The search decision rule methodology overcomes some of the limitations of the linear cost assumptions of linear programming. The search decision rule allows the user to state cost data inputs in very general terms. It requires that a computer program be constructed that will unambiguously evaluate any production plan's cost. It then searches among alternative plans for the one with the minimum cost. However, unlike linear programming, there is no assurance of optimality.

Simulation

A number of simulation models can be used for aggregate planning. By developing an aggregate plan within the environment of a simulation model, it can be tested under a variety of conditions to find acceptable plans for consideration. These models can also be incorporated into a decision support system, which can aid in planning and evaluating alternative control policies. These models can integrate the multiple conflicting objectives inherent in manufacturing strategy by using different quantitative measures of productivity, customer service, and flexibility.

Functional Objective Search Approach

The functional objective search (FOS) system is a computerized aggregate planning system that incorporates a broad range of actual planning conditions. It is capable of realistic, low-cost operating schedules that provide options for attaining different planning goals. The system works by comparing the planning load with available capacity. After management has chosen its desired actions and associated planning objectives for specific load conditions, the system weights each planning goal to reflect the functional emphasis behind its achievement at a certain load condition. The computer then uses a computer search to output a plan that minimizes costs and meets delivery deadlines.

2.2.10 Aggregate Planning In Services

For manufacturing firms the luxury of building up inventories during periods of slack demand allows coverage of an anticipated time when demand will exceed capacity. Services cannot be stockpiled or inventoried so they do not have this option. Also, since services are considered "perishable," any capacity that goes unused is essentially wasted. An empty hotel room or an empty seat on a flight cannot be held and sold later, as can a manufactured item held in inventory.

Service capacity can also be very difficult to measure. When capacity is dictated somewhat by machine capability, reasonably accurate measures of capacity are not extremely difficult to develop. However, services generally have variable processing requirements that make it difficult to establish a suitable measure of capacity.

Historically, services are much more labor intensive than manufacturing, where labor averages 10 percent (or less) of total cost. This labor intensity can actually be an advantage because of the variety of service requirements an individual can handle. This can provide quite a degree of flexibility that can make aggregate planning easier for services than manufacturing.

2.2.11 What's New In Aggregate Planning

Rudy Hung, in his *Production and Inventory Management Journal* article entitled "Annualized Hours and Aggregate Planning," presents a new, useful idea for aggregate planning called Annualized Hours (AH). Under AH, employees are contracted to work for a certain number of hours (say 1,800 hours) per year, for a certain sum of money. Employees can be asked to put in more hours during busy periods and fewer hours in slow periods. Typically, employees receive equal monthly or weekly payments so that hourly workers in effect have gained salaried status. Overtime is paid only when employees have worked beyond their annual hour.

AH is also known as flexiyear, as it can be seen as an extension of flextime, in which employees can vary their work hours within limits. This concept is used almost exclusively in Europe, particularly in the United Kingdom. The Scandinavian pulp and paper industries pioneered AH in the mid-1970s. Around that time, some West German firms, particularly those in the retail industry, also used AH.

AH gives employers much flexibility. AH serves to cut labor costs by offering employees an annual sum less than their previous annual earnings with overtime. Even though their total earnings may fall, their average earnings per hour would remain the same or even rise. Effective earnings could rise even more so if the employer is unable to consume all contracted hour Employees have greater income security with no worries about layoffs. There is also increased morale because blue-collar workers are now salaried.

Another development affecting aggregate planning is postponement. This refers to delaying the "finish" of a product until the moment of sale. Firms that rely on the postponement strategy, such as PC-maker Dell Inc. or clothing franchise Benetton Group SpA, depend upon the availability of aggregate inventories of components that can be assembled to order shortly after, or even immediately, as an order is taken.

Further Reading:

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Cochran, Jeffery K., and Alberto Marquez Uribe. "A Set Covering Formulation for Agile Capacity Planning Within Supply Chains." International Journal of Production Economics 95, no. 2 (2005): 139–149.

Jonsson, Patrik, and Stig-Arne Mattsson. "Use and Applicability of Capacity Planning Methods." *Production and Inventory Management Journal* 43, no. 3-4 (2002): 89–95.

Meredith, Jack R., and Scott M. Shafer. *Operations Management for MBAs*. 2nd Edition. New York: John Wiley and Sons, Inc., 2002.

Vollmann, Thomas E., William L. Berry, D. Clay Whybark, and Robert F. Jacobs. *Manufacturing Planning and Control Systems*. Boston: McGraw-Hill, 2005.

AP

Chopra, Sunil and Peter Meindl. *Supply Chain Management: Strategy, Planning, and Operation*. Upper Saddle River, NJ: Pearson Prentice Hall, 2004.

Dejonckheere, J., S.M. Disney, M. Lambrecht, and D.R. Towill. "The Dynamics of Aggregate Planning." *Production Planning & Control* 14, no. 6, (2003): 497–516.

Finch, Byron J. *Operations Now*. Boston: McGraw-Hill Irwin, 2004.

Hung, Rudy. "Annualized Hours and Aggregate Planning." *Production and Inventory Management Journal* 38, no. 4 (1997).

Iyer, Ananth V., Vinayak Deshpande, and Zhengping Wu. "A Postponement Model for Demand Management." *Management Science* 49, no. 8, (2003): 983–1002.

Stevenson, William J. *Production Operations Management*. Boston: McGraw-Hill Irwin, 2004.

Source:

http://www.referenceforbusiness.com/management/Bun-Comp/Capacity-Planning.html

http://www.referenceforbusiness.com/management/A-Bud/Aggregate-Planning.html

2.3 Strategies for Balancing Capacity and Demand

2.3.1 Just in Time (JIT) and Lean Manufacturing

Associated with Japanese management techniques, just-in-time production (JIT) is a set of principles and practices based on the philosophy that firms should hold little or no inventory beyond that required for immediate production or distribution. That is, a manufacturer should receive raw materials or parts from its suppliers perhaps just hours before they will be used in production, and the firm's output should be shipped to its customers as soon after completion as possible—without holding onto a stock of either raw goods or finished products.

In practice, JIT has often been expressed as a holistic management system aimed at reducing waste, maximizing cost efficiency, and securing a competitive advantage. Thus, a number of additional conditions are considered necessary for the successful implementation of JIT. These include small lot sizes, short setup and changeover times, efficient and effective quality controls, and perhaps most of all, designing the whole production process to minimize backups and maximize the efficiency of human and machine labor.

Lean manufacturing encompasses a number of things. It essentially is a Westernized version of JIT and Japanese kaizen, or continuous improvement. Lean manufacturing is a process for measuring and reducing inventory and streamlining production. It is a means for changing the way a company measures plant performance. A knowledge-based system, lean manufacturing takes years of hard work, preparation, and support from upper management. Lean manufacturing is so named because it purports to use much less of certain resources (space, inventory, workers, etc.) than is used by normal mass-production systems to produce comparable output. The term came into widespread use with the 1990 publication of the book The Machine That Changed the World by James P. Womack, Daniel T. Jones, and Daniel Roos.

The APICS Dictionary defines lean manufacturing as a philosophy of production that emphasizes minimizing the amount of all resources (including time) used in various enterprise activities. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and customer relations. Lean producers employ teams of multiskilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in potentially enormous variety. In effect, they incorporate the advantages of both mass production (high volume, low unit cost) and craft production (variety and flexibility). Quality is higher than in normal mass production. Compensation and rewards are based on meeting the total cost equation rather than on labor, overhead, or individual quality measures.

Lean manufacturing and JIT (lean/JIT) share most of the same characteristics, goals, and philosophy. In fact, the terms are often used interchangeably.

2.3.2 History of Lean Manufacturing/JIT

Lean/JIT have roots in both Japan and the United States.

JAPAN

Since Japan is a physically small country with minimal resources and a large population, the Japanese have always been careful not to waste resources such as time, labor, and space. Waste is seen as abhorrent to the Japanese because they have so little space and so few natural resources. Hence, it has been necessary for the Japanese to maximize the yield from minimally available resources. Also, dense population has made it necessary for the Japanese people to maintain mutual respect in order to work and live together.

Under this *wa* (harmony) culture, everyone tries to maintain the best possible human relationship and is reluctant to be involved in any confrontations. Additionally, most Japanese firms have a rentai relationship, which entails maintaining a "joint responsibility" between management and workers. Under this relationship, management should treat all workers equally. In exchange, each worker respects management's leadership position and follows orders exactly without mistakes, cooperates with coworkers, and generates ideas and creativity to improve the firm's competitiveness. This type of culture reinforces the basic tenets of lean/JIT: waste minimization, continuous improvement, and respect for all workers.

This concept was originally developed in Japan in the mid-1970s by the Toyota Motor Corporation. In fact, many firms continue to refer to lean/JIT as the Toyota system. The concept emphasized the avoidance of waste of materials, space, and labor. Significant attention was paid to identifying and correcting potential problems that could lead to any form of waste. Operations were constantly being improved and fine-tuned so as to further eliminate waste and thereby increase productivity and yield. In addition, equal respect was paid to all workers, while minimizing the trappings of status. As a result, by using lean/JIT, Toyota was able to reduce the time needed to produce a car from fifteen days to one day.

United States

In 1924 Henry Ford's Highland Park plant, and later the River Rouge operation, mass-produced Model T parts just-in-time for assembly while assembly lines pulled work forward to the next assembly stations just-in-time. One hundred freight cars of material were unloaded daily, with materials flowing through fabrication, subassembly, final assembly, and back onto the freight cars. The production cycle was twenty-one days. At River Rouge the cycle was only four days, and that included processing ore into steel at the on-site steel mill.

Unfortunately, this "just-in-time" type manufacturing soon gave way to the large lot sizes and lengthy cycle times dictated by the economies of scale of mass production, mass markets, and standard designs with interchangeable parts. U.S. manufacturers held on to this paradigm until the early 1980s, when the development of the Toyota production system caused it to shift. U.S. manufacturers initially greeted lean/JIT with a great deal of ambivalence, thinking that the concept would never work in the United States due to its reliance on the cultural aspects of the Japanese work environment. However, this view changed when firms such as Hewlett-Packard and Harley-Davidson yielded significant benefits from its use.

2.3.3 Manufacturing

The idea behind lean/JIT is a concept called ideal production. Simply produce and deliver finished goods just in time to be sold, subassemblies just in time to go into subassemblies, and purchased materials just in time to be transformed into fabricated parts. The goal of lean/JIT is to find practical ways to create the effect of an automated industry that will come as close as possible to this concept of ideal production.

While the prevailing view of lean/JIT is that of an inventory control system, lean/JIT goes much further. It is an operational philosophy that incorporates an improved inventory control system in conjunction with other systems. These systems include:

- A setup improvement system
- A maintenance improvement system
- A quality improvement system
- A productivity improvement system

2.3.4 Inventory Control System

When larger quantities are ordered or produced, average inventory obviously is larger. This larger inventory results in increased inventory-carrying charges. If a reduction in carrying costs is desired, smaller quantities should be ordered and orders should be placed more often. However, the practice of ordering smaller quantities can have the side effect of increasing ordering costs. To balance these two costs, the concept of economic order quantity (EOQ) was developed. The EOQ formula derives the point, or order quantity, where inventory carrying costs and ordering or setup costs are the same. An order of this quantity will minimize the sum of the two costs.

However, the EOQ formula is flawed. While carrying costs and ordering/setup costs are obvious, other costs that can significantly affect lot size are not considered. The user of the formula often fails to consider quality, scrap, productivity, and worker motivation and responsibility. In addition, the EOQ formula user frequently fails to consider that even though setup costs are significant, they are not unalterable. American manufacturing managers traditionally considered setup costs as a necessary evil and made little or no effort to reduce them.

The lean/JIT philosophy suggests that a firm should eliminate any reliance upon the EOQ formula and seek the ideal production quantity of one. Of course, a lot size of one is not always feasible, but it is a goal used to focus attention on the concept of rapid adjustments and flexibility. Naturally, a reduction in inventory levels means an increase in setups or orders, so the responsibility rests with production to make every effort to reduce setup time and setup costs. It should be noted that this assumes setup time and cost are positively related. This is not always true because the cost to reduce setup time could be very high if retooling or equipment redesign were involved.

2.3.5 Setup Cost Reduction System

Toyota began a campaign to reduce setup times in 1971. Five years later, the time required to set up presses to form fenders and hoods had fallen from 1 hour to 12 minutes, while U.S. manufacturers needed 6 hours to perform the same task. Toyota continues to strive for a concept it calls “single setup,” which means less than 10 minutes for performing a setup. As the company continued to emphasize reduction of setup times, its operations became capable of “one-touch” setups, which take less than 1 minute.

Setup time can be divided into two phases: external time and internal time. External time includes activities that can take place while the machine is running, such as transporting dies between storage and the machines. These items are external to the run time and do not interrupt it. Internal time includes activities that can only be conducted when the machine is stopped, such as mounting and removing dies. These are items that will interrupt the run time. External time can be eliminated by ensuring that appropriate tools are ready before changeover begins. Internal time can be reduced by addressing the question, “How can operations be quickened?” Appropriate responses could include the use of locating pins and hand levers to replace bolts, the standardization of any remaining bolts, permanent installation of wrenches to adjusting nuts, and the use of an air driver instead of a ratchet.

Management sometimes tends to analyze the large, obvious costs such as direct labor, but then treat setup as an inherent cost that must be accepted. However, only by reducing setup time and costs can lot sizes be reduced toward the ideal lot size of one.

2.3.6 Preventive Maintenance System.

Most arguments against preventive maintenance (PM) suggest that PM programs are more expensive than programs that only repair broken equipment. The flaw in this line of thought arises from the unpredictable nature of equipment breakdown. This reaction mode of maintenance usually means that the maintenance personnel must temporarily patch the equipment and defer the substantive repair until time allows. Unfortunately, since the equipment already has suffered lost time due to the initial breakdown, the likelihood of finding repair time decreases. The result often is a circular process of "adjust and tinker," with an increased risk of unexplained defects in the output.

A proposed requirement for lean/JIT is that machinery be in top running condition at all times. When using small lot sizes, management can ill afford unexpected downtime in production flow. Equipment must be in condition to produce whatever is needed, whenever it is needed. Therefore, a little time should be scheduled each day to ensure that machinery is capable of producing top quality results. Preventive maintenance is necessary for continuous, long-term improvement in the quality of the production process.

2.3.7 Quality Improvement System

In order for companies to successfully produce goods while receiving only minimum deliveries, no room can be allowed for poor quality. This requires an overhaul in the thinking of management, which traditionally sought the so-called acceptable quality level (AQL). After receipt, delivered goods are randomly inspected to see how many defective parts there are within a predetermined sample size. If the number of defects exceeds a certain amount (the AQL), the entire batch is rejected. No such provision is made under lean/JIT; all parts must be good. The Japanese use the term zero defects to describe this philosophy.

Zero defects certainly cannot be obtained overnight, nor can it be expected from all of a firm's current suppliers. To facilitate the receipt of high quality goods, a firm must offer more than the usual short-term contract or purchase order to the lowest bidder. A firm also may have to eliminate or decrease the use of multiple sourcing, or purchasing the same part from several sources as a backup in case one source experiences quality or delivery problems. By issuing long-term contracts to a single source, the lean/JIT firm gives its supplier the confidence and incentive to spend time and money on ensuring near perfect quality and constantly improving the product. Frequently, this makes for a captive supplier who must maintain the required quality in order to survive. The lean/JIT firm should then work constantly and directly with the supplier to monitor quality and provide technical support.

The use of lean/JIT improves the quality of suppliers, as well as the lean/JIT firm's internal quality. When lot sizes are drastically reduced, defect discovery is naturally enhanced. If a worker produces a lot size of one and passes it to the next station, the quality of feedback will be immediate. In this way, defects are discovered quickly and their causes can be corrected immediately. Production of large lots with high defect rates is avoided.

U.S. manufacturers traditionally allowed lot sizes and inventory levels to remain high "just in case" a quality problem, an equipment problem, or a delivery problem should arise. This "just in case" inventory, commonly called buffer stock, allowed the firm to maintain its production flow while the problem was being corrected. When a quality problem emerged and inventory was ample, the search for the source of the problem was postponed until a more suitable time. This suitable time may have never occurred. When lot sizes are minimal, one worker's problem threatens to bring subsequent processes to a halt. This means that all production workers and management must collaborate to find an immediate solution. The benefits here are twofold. First, the firm avoids the production of large quantities of defective parts. Secondly, good managers will be able to use this as motivation for unity of purpose within the workforce.

2.3.8 Productivity Improvement System

Productivity can be defined as good output divided by required input. The productivity facet of lean/JIT been described as nothing sitting idle, which wastes time. If equipment is operated only for productive purposes, then energy waste is eliminated. If all inventory is converted into product, then material waste is eliminated. If errors are not allowed, then rework is eliminated.

A number of productivity improvements may result from lean/JIT implementation. Among these are lower inventory levels, lower scrap rates, reductions in rework costs, reduction inventory carrying costs, smaller floor space requirements, reduced material handling, simpler inventory accounting, and more positive inventory control. All of these lower the input component or increase the good output of the productivity ratio.

Reductions in idle inventories allow the firm to reduce internal lead times – from the purchase of raw materials to the shipping of finished goods – allowing quicker changes in product mix and production quantities. Furthermore, the firm's ability to forecast is enhanced because the forecast horizon is shortened.

2.3.9 Ten Steps To Lean/JIT Production

Steve L. Hunter lists ten steps to implement a Lean/JIT production system:

1. Reengineer the manufacturing system
2. Reduce setup
3. Integrate quality control
4. Integrate preventive maintenance
5. Level and balance the system
6. Integrate a pull system
7. Control inventory
8. Implement a vendor program
9. Utilize computer integrated manufacturing (CIM) benefits

While it was noted that inventory reduction is not the sole goal of lean/JIT implementation, it is a very obvious benefit. Less workspace is now needed due to the use of smaller lot sizes and reduced inventory levels. Much of this inventory was stored between and within work centers. By reducing inventory, firms have been able to actually move work centers closer together, freeing up space and reducing material handling distances. This results in a neater, more organized facility that provides for speedy identification of bottlenecks and fewer lost parts.

Additionally, this reduction in inventory and lot sizes promotes rapid feedback from downstream work centers when there is a quality problem. This feedback results in a reduction in scrap and rework, and ultimately a higher level of overall quality.

Reduced inventory and lot sizes also result in increased inventory turns. Inventory turn increases have been noted at Haworth (a twofold increase), Hewlett-Packard (a threefold increase), Richardson-Vicks Homecare Products (a threefold increase), IBM, Raleigh (a fourfold increase), and Harley-Davidson (a six fold increase).

The introduction of preventive maintenance and the use of smaller, more flexible machinery combine to yield increased equipment utilization. One major firm was able to change from three lines running three shifts to two lines running one shift with no change in output.

The lean/JIT producer combines the advantages of craft and mass production, while avoiding the high cost of the former and the rigidity of mass production. Lean/JIT producers set their sights explicitly on perfection: continually declining costs, zero defects, zero inventories, and endless product variety. Lean/JIT manufacturing is the new paradigm for manufacturing, replacing a mass-production system that has existed for more than 70 years.

Further Reading:

Cox, James F., III, and John H. Blackstone, Jr. APICS Dictionary. 9th ed. Falls Church, VA: American Production and Inventory Control Society, 1998.

Hunter, Steve L. "The 10 Steps to Lean Production." FDM 76, no. 5 (2004): 22–25.

Stevenson, William J. Operations Management. 8th ed. Boston: Irwin/McGraw-Hill, 2005.

Womack, James P., Daniel T. Jones, and Daniel Roos. The Machine That Changed the World: Based on the Massachusetts Institute of Technology 5-Million Dollar 5-Year Study on the Future of the Automobile. New York: Rawson Associates, 1990.

Womack, James P., and Daniel T. Jones. Lean Thinking: Banish Waste and Create Wealth in Your Corporation. New York: Simon & Schuster, 1996.

Source:

http://www.referenceforbusiness.com/management/Int-Loc/Lean-Manufacturing-and-Just-in-Time-Production.html

2.4 Strategy for Capacity and Demand Management:

Optimized Production Technology

2.4.1 Introduction

Optimized Production Technology originally known as "The Theory of Constraints" (TOC) is a management philosophy developed by Dr. Eliyahu Moshe Goldratt. According to Goldratt the strength of any chain, process, or system is dependent upon its weakest link. TOC is systemic and strives to identify constraints to system success and to effect the changes necessary to remove them. Dr. Goldratt and the TOC became widely known with the 1984 publication of Goldratt's novel *The Goal.*

2.4.2 History

In early 1979 Goldratt introduced a software-based manufacturing scheduling program known as Optimized Production Timetables (OPT), changed in 1982 to Optimized Production Technology. With the publication of *The Goal,* Goldratt used his Socratic teaching style to educate the world about managing bottlenecks (constraints) and his new ideas about performance.

Goldratt used three additional novels to refine and develop the principles set forth in *The Goal. It's Not Luck,* a sequel to *The Goal,* addresses changing markets and introduces a number of methods of logical thinking that are used to make decisions, solve problems, and resolve conflict. *The Critical Chain* depicts a situation whereby TOC principles are effectively utilized in project management. *Necessary But Not Sufficient* contains Goldratt's most holistic expression of TOC and deals with the role of technology in organizations.

Goldratt also produced a number of nonliterary works that espouse his ideas.

2.4.3 Components of the Theory of Constraints

Theory of constraints consists of separate, but related processes and interrelated concepts, including the following: the performance measures and five focusing steps, logical thinking processes, and logistics.

Performance Measures

According to Goldratt there are three key performance measurements to evaluate:

- Throughput (T),
- Inventory (I), and
- Operating expense (O).

TOC emphasizes the use of these *three global operational measures* rather than local measures (e.g., efficiency and utilization). Goldratt places the greatest importance on increasing throughput.

Throughput is defined as the rate at which the system generates money through sales, not through production. *Goods are not considered an asset until sold. This contradicts the common accounting practice of listing inventory as an asset even if it may never be sold.* Goldratt has advocated a new accounting model as an alternative to traditional cost accounting procedures and measures.

Inventory is defined as the money invested in goods that the firm intends to sell or material that the firm intends to convert into salable items. The concept of value-added and overhead are not considered.

Operating expense includes all the money the firm spends converting inventory into throughput.

The objective of the firm, therefore, is to increase throughput and/or decrease inventory and operating expense in such a way as to increase profit, return on investment, and cash flow (more global measures). In *The Goal,* Alex explains to Jonah that his plant's use of a robot has resulted in a thirty six percent improvement in one area. Jonah then asks if Alex is now able to ship more products, and if he has fired any employees or reduced inventory as a result (in other words, whether increased throughput, reduced operating expense, or reduced inventory resulted). When the reply was no, Jonah questions how there can be any real improvement; and of course, there can't.

Increasing throughput and/or decreasing inventory or operating expense should lead to the accomplishment of the firm's goal: to make money now as well as in the future. Anything that prevents a firm from reaching this goal is labeled as a constraint.

Constraints may appear in the form of capacity, material, logistics, the market (demand), behavior, or even management policy. TOC thinking regards all progress toward the goal of making money as relating directly to management attention toward the constraint(s). The marginal value of time at a constraint resource is said to be equal to the throughput rate of the product processed at the constraint, while the marginal value of time at a nonconstraint resource is said to be negligible.

Five Focusing Steps

The five focusing steps are a tool Goldratt developed to help systems deal with constraints. These steps ensure improvement efforts remains on track towards system-level improvements. These are collectively the most important aspect of TOC. TOC's five focusing steps are:

Step 1: Identify the system's constraint(s).

Step 2: Decide how to exploit the system's constraint(s).

Step 3: Subordinate everything else to the decisions made in Step 2.

Step 4: Elevate the system's constraint(s)

Step 5: If a constraint is broken in Step 4, go back to Step 1, but do not allow inertia to cause a new constraint.

The orientation of TOC is toward the output of the entire system, rather than a look at a discrete unit or component. The five focusing steps assist with identifying the largest constraint that overshadows all of the others. These steps constitute an iterative process. As soon as one constraint is strengthened, the next weakest link becomes the priority constraint and should be addressed. Thus, a process of ongoing system improvement is applied to the business practice of the firm.

Logical Thinking Process

Goldratt introduced a staged logical thinking process to be used in conjunction with the five focusing steps. The thinking process assists with working through the change process by identifying the following:

- *what to change,*
- *what to change to, and*
- *how to effect the change.*

The thinking processes consist of logic tools used to identify problems, then develop and implement solutions. These tools include effect-cause-effect (ECE) diagramming and its components: negative branch reservations, the current reality tree, the future reality tree, the prerequisite tree, the transition tree, the evaporating cloud, the negative branch reservation, and the ECE audit process. These tools allow an organization to analyze and to verbalize cause and effect.

The following is a brief description of the thinking process. A current reality tree, a cause-effect diagram, is drawn in order to discover the problems. These problems are known as undesirable effects. The cause of an undesirable effect is known as a root cause. The first goal is to find the causes of these undesirable effects. Each statement in a current reality tree that is not a derivative of another must be a root cause. If you build a tree that is comprehensive enough, at least one root cause will lead to most of the undesirable effects. This particular root cause is labeled a core problem, the major improvement target. The fewer root causes responsible for the undesirable effects, the better. The solution to this core problem is apparently not readily available. If it were, then the problem would have already been solved. Some conflict, therefore, must exist that prevents an immediate solution. This conflict becomes evident upon the construction of an evaporating cloud.

An evaporating cloud is a conflict-resolution tool. The process begins with a statement of the desired objective, one that is the opposite of the core problem. Then, the prerequisites necessary to achieve the requirements are listed. Any conflicts and assumptions that exist between the prerequisites are verbalized. For example, if one objective is to increase profit, then the requirements may be to improve the product and to decrease expenses. Prerequisites for each, respectively, might be to increase expenditures on capital equipment and to decrease expenditures, two obviously conflicting elements. The best solution is to remove the conflict; a compromise is not desirable. The next move involves finding an injection, a breakthrough idea that will evaporate the cloud. The "evaporating" refers to the tool's ability to dissipate conflict and to create a win-win solution. Usually, the original injection is not sufficient to fully solve the problem, but additional needed injections become clear when building the future reality tree.

A future reality tree is another cause-effect diagram. The tree starts with the proposed solution to the core problem and delineates the injection(s) and the ensuing desirable effects. The future reality tree is a "what if." It provides the opportunity to evaluate and to improve a solution before it is implemented. It is noted that one should be careful not to allow the solution to cause new undesirable effects - a case of 'problem>solution>new problem'.

A prerequisite tree describes the implementation of the injection(s) and is composed of an obstacle and an intermediate objective. This diagram breaks the implementation tasks into smaller increments, noting expected obstacles and intermediate objectives whose accomplishments will overcome the obstacles. The intermediate objectives are sequenced, displaying the necessary order of accomplishment and determining which ones can be achieved in parallel. This tool is powerful in that it does not ignore the obstacles. It uses them, rather, as the main vehicle for this phase.

Finally, a transition tree or implementation plan is constructed. This element presents a detailed description of the gradually evolving change envisioned. This task forces one to carefully examine which actions are really needed and if they are sufficient to guarantee the required change.

The thinking-process tools are powerful resources when used effectively. They have found successful use in the logistics and medicine areas of the United States Air Force, in primary education, and in the service sector. James Cox and Michael Spencer, both college professors and "Jonahs," state in *The Constraints Management Handbook* that the thinking processes may be the most important management tools developed this century.

Logistics

Logistics in TOC include drum-buffer-rope scheduling, buffer management, and VAT analysis.

2.4.4 DRUM-BUFFER-ROPE

Drum-buffer-rope is a TOC production application and the name given to the method used to schedule the flow of materials in a TOC facility. Srikanth and Umble (1997), define each component as follows:

- **Drum** : The drum is the *constraint* and therefore sets the pace for the entire system. The drum must reconcile the customer requirements with the system's constraints. In simpler terms, the drum is the rate or pace of production set by the system's constraint.
- **Buffer** : A buffer includes time or materials that *support throughput* and/or due date performance. A buffer establishes some protection against uncertainty so that the system can maximize throughput. A time buffer is the additional planned lead time allowed, beyond the required setup and run times, for materials to reach a specified point in the product flow. Strategically placed, time buffers are designed to protect the system throughput from the internal disruptions that are inherent in any process. A stock buffer is defined as inventories of specific products that are held in finished, partially

finished, or raw material form, in order to fill customer orders in less than the normal lead-time. Stock buffers are designed to improve the responsiveness of the system to specific market conditions.

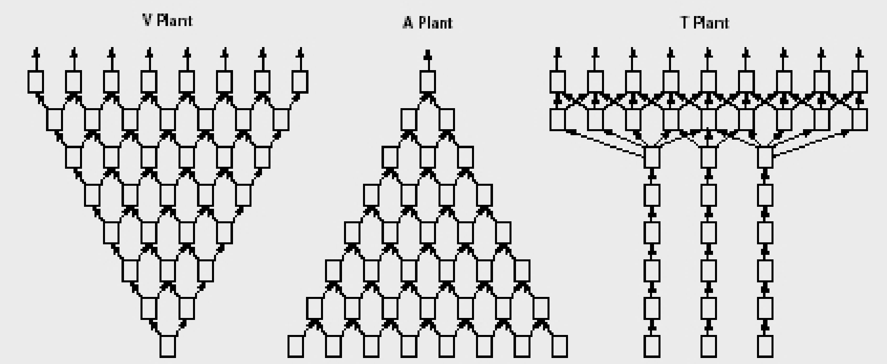
- **Rope** : The rope is a *schedule* for releasing raw materials to the floor. The rope is devised according to the drum and the buffer. The rope ensures that non-capacity constraint resources are subordinate to the constraint. Restated, the rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint.

2.4.5 Buffer Management

Buffer management provides the means by which the schedule is managed on the shop floor. Buffer management is a process in which all expediting in a shop is motivated by what is scheduled to be in the buffers (constraint, shipping, and assembly buffers). Buffers can be maintained at the constraint, convergent points, divergent points, and shipping points. By expediting this material into the buffers, the system helps to avoid idleness at the constraint and missed customer due dates. Also, the causes of items missing from the buffer are identified, and the frequency of occurrences is used to prioritize improvement activities.

2.4.6 VAT Analysis

VAT analysis determines the general flow of parts and products from raw materials to finished products. It conceptualizes an organization in terms of the interaction of its individual component parts, both products and processes. Three general categories of production structures result from this standpoint, each necessitating a unique approach to management planning and control. The logical structure is the sequence of operations through which each product must pass in order to manufacture and assemble a product or product family.



It is easy to see how each configuration got its name

A ***V*- logical structure** (many-to-one flow) starts with one or a few raw materials, and the product expands into a number of different products as it flows through its routings.

The shape of an ***A*- logical structure** (on-to-many flow) is dominated by converging points. Many raw materials are fabricated and assembled into a few finished projects.

A ***T*- logical structure** (many-to-many flow) consists of numerous similar finished products assembled from common assemblies and subassemblies.

The graph (above) shows the general appearance of each structure. Once the general parts flow is determined, the system control points (gating operations, convergent points, divergent points, constraints, and shipping points) can be identified and managed. This determination focuses management's attention on a few control points where buffers can be used to protect and to maximize throughput.

Five control points are used to manage the process:

(1) the constraint,

(2) the points of divergence (where a part or material is diverted to different routes in order to make different products),

(3) the points of convergence (where two or more parts are combined in subassembly),

(4) the gating operation (releases work into the shop), and

(5) the shipping operation.

The shape of the structure determines which control points are utilized to manage production. A *T* structure focuses attention on the constraint and the gating operation. The five-step focusing process is used to manage the constraint with a buffer placed before the constraint to absorb variations in the process. The output from the gating operation is tied to the constraint; that is, since the constraint controls the amount of throughput; the gating operation cannot process more than the constraint.

A *V* structure also uses a buffer to protect the constraint and the gating operation releases orders at the same rate as the constraint as seen in the *T* structure. However, an additional control point exists in the *V* structure, the divergent point. The divergent point is controlled by a schedule derived from the shipping schedule. This derivation prevents misallocation of material to a product not currently in demand.

The *A* structure also manages the constraint and gating operation in a fashion similar to the *T* structure. Any diverging points are scheduled in accordance with the shipping schedule. In addition, an assembly buffer is used to maintain the flow into the convergent points. An additional schedule based on the shipping schedule (similar to that used in the *V* structure) is used to keep capacity from being misallocated to the wrong order. By using VAT analysis, significant improvements in the production process can result.

Conclusion:

TOC in a word is "balance the flow, not the capacity"

Further Reading:

Cox, James F., and Michael S. Spencer. *The Constraints Management Handbook.* Boca Raton, FL: St. Lucie Press, 1998.

Dettmer, H. William. *Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement.* Milwaukee, WI: ASQC Quality Press, 1997.

Dugdale, David, and Colwyn Jones. "Accounting for Throughput: Techniques for Performance Measurement, Decisions and Control." *Management Accounting* 75, no. 11 (1997): 52–56.

Essays on the Theory of Constraints. Great Barrington, MA: The North River Press, 1990.

Gardiner, Stanley C., John H. Blackstone, and Lorraine R. Gardiner. "The Evolution of the Theory of Constraints." *Industrial Management* 36, no. 3 (1994): 13–16.

Goldratt Consulting Group. Available from http://www.goldrattconsulting.com.

Goldratt, Eliyahu M. *Critical Chain.* Great Barrington, MA: The North River Press, 1997.

——. *Haystack Syndrome: Sifting Information Out of the Data Ocean.* Croton-on-Hudson, NY: North River Press, 1990.

——. *It's Not Luck.* Croton-on-Hudson, NY: North River Press, 1994.

——. *Late Night Discussions on the Theory of Constraints.* Great Barrington, MA: The North River Press, 1992.

——. "What is the Theory of Constraints?" *APICS: The Performance Advantage,* June 1993, 18–20.

——. *What Is This Thing Called Theory of Constraints and How Should It Be Implemented?* Croton-on-Hudson, NY: North River Press, 1990.

Goldratt, Eliyahu M., Eli Schragenheim, and Carol A. Ptak. *Necessary But Not Sufficient: A Theory of Constraints Business Novel.* Great Barrington, MA: The North River Press, 2000.

Goldratt, Eliyahu M., and Jeff Cox. *The Goal: A Process of Ongoing Improvement.* 3rd ed. Great Barrington, MA: The North River Press, 2004

——. *The Goal: A Process of Ongoing Improvement.* 2nd ed. Croton-on-Hudson, NY: The North River Press, 1994.

——. *The Goal: Excellence in Manufacturing.* Croton-on-Hudson, NY: The North River Press, 1984.

Goldratt, Eliyahu M., and Robert E. Fox. *The Race.* Croton-on-Hudson, NY: The North River Press, 1986.

Kendall, Gerald I. *Securing the Future: Strategies for Exponential Growth Using the Theory of Constraints.* Boca Raton, FL: St. Lucie Press, 1998.

Mabin, Victoria, J., and Steven J. Balderstone. *The World of the Theory of Constraints: A Review of the International Literature.* Boca Raton, FL: St. Lucie Press, 2000.

McMullen, Thomas B., Jr. *Introduction to the Theory of Constraints (TOC) Management System.* Boca Raton, FL: St. Lucie Press, 1998.

Newbold, Robert C. *Project Management in the Fast Lane: Applying the Theory of Constraints.* Boca Raton, FL:

St. Lucie Press, 1998.

Noreen, Eric, Debra Smith, and James T. Mackey. *The Theory of Constraints and its Implications for Management Accounting*. Great Barrington, MA: The North River Press, 1995.

Rahman, Shams-ur. "Theory of Constraints: A Review of the Philosophy and Its Applications." *International Journal of Operations and Production Management* 18, no. 4 (1998): 336–355.

Scheinkopf, Lisa J. *Thinking for a Change: Putting the TOC Thinking Processes to Use.* Boca Raton, FL: St. Lucie Press, 1999.

Schragenheim, Eli, and H. William Dettmer. *Manufacturing at Warp Speed: Optimizing Supply Chain Financial Performance.* Boca Raton, FL: St. Lucie Press, 2001.

Smith, Debra. *The Measurement Nightmare: How the Theory of Constraints Can Resolve Conflicting Strategies, Policies, and Measures.* Boca Raton, FL: St. Lucie Press, 2000.

Srikanth, Mokshagundam L., and Harold E. Cavallaro, Jr. *Regaining Competitiveness: Putting 'The Goal' To Work.* New Haven, CT: The Spectrum Publishing Company, 1987.

Srikanth, Mokshagundam L., and Michael M. Umble. *Synchronous Management: Profit-Based Manufacturing for the 21st Century.* 2 vols. Guilford, CT: The Spectrum Publishing Company, 1997.

Stein, Robert R. *Reengineering the Manufacturing System: Applying the Theory of Constraints.* 2nd ed. New York: Marcel Dekker, Inc., 2003.

Woeppel, Mark J. *The Manufacturer's Guide to Implementing the Theory of Constraints.* Boca Raton, FL: St. Lucie Press, 2001.

Womack, David E., and Steve Flowers. "Improving System Performance: A Case Study in the Application of the Theory of Constraints." *Journal of Healthcare Management* 44, no. 5 (1999): 397–407.

Also visit the website: http://www.dbrmfg.co.nz/

Source:
http://www.referenceforbusiness.com/management/Str-Ti/Theory-of-Constraints.html

2.5 IT in Operations Management –

2.5.1 Management Information Systems

All businesses share one common asset, regardless of the type of business. It does not matter if they manufacture goods or provide services. It is a vital part of any business entity, whether a sole proprietorship or a multinational corporation. That common asset is information.

Information enables us to determine the need to create new products and services. Information tells us to move into new markets or to withdraw from other markets. Without information, the goods do not get made, the orders are not placed, the materials are not procured, the shipments are not delivered, the customers are not billed, and the business cannot survive.

But information has far lesser impact when presented as raw data. In order to maximize the value of information, it must be captured, analyzed, quantified, compiled, manipulated, made accessible, and shared. In order to accomplish those tasks, an information system (IS) must be designed, developed, administered, and maintained.

2.5.2 Information Systems

An information system is a computer system that provides management and other personnel within an organization with up-to-date information regarding the organization's performance; for example, current inventory and sales. It usually is linked to a computer network, which is created by joining different computers together in order to share data and resources. It is designed to capture, transmit, store, retrieve, manipulate, and or display information used in one or more business processes. These systems output information in a form that is useable at all levels of the organization: strategic, tactical, and operational.

Systems that are specifically geared toward serving general, predictable management functions are sometimes called management information systems (MIS). A good example of an MIS report is the information that goes into an annual report created for the stockholders of a corporation (a scheduled report). The administration of an information system is typically the province of the MIS or information technology (IT) department within an organization.

Some applications have infringed on the familiar MIS landscape. Enterprise resource planning (ERP) software and executive information systems (EIS) both provide packaged modules and programs that perform the same functions as traditional MIS, but with greater functionality, flexibility, and integration capabilities.

Mainframes

The original computerized information systems were based on mainframes. "Mainframe" is a term originally referring to the cabinet containing the central processor unit or "main frame" of a room-filling computer. After the emergence of smaller mini-computer designs in the early 1970s, the traditional large machines were described as "mainframe computers," or simply mainframes. The term carries the connotation of a machine designed for batch rather than interactive use, though possibly with an interactive time-sharing operating system retrofitted onto it.

It has been conventional wisdom in most of the business community since the late 1980s that the mainframe architectural tradition is essentially dead, having been swamped by huge advances in integrated circuit design technology and low-cost personal computing. Despite this, mainframe sales in the United States enjoyed somewhat of a resurgence in the 1990s, as prices came down and as large organizations found they needed high-power computing resources more than ever. Supporters claim that mainframes still house 90 percent of the data major businesses rely on for mission-critical applications, attributing this to their superior performance, reliability, scalability, and security compared to microprocessors.

The Internet.

The Internet has opened up further developments in information systems and the exchange of information via web-based e-mail, intranets, and extranets. These technologies allow for much faster data and information exchange and greater access for more users. Web-casting and videoconferencing allow for real-time information exchanges. Mobile computing technologies accessed by handheld devices, such as multi-functional mobile phones, personal digital assistants, and podcasting (via iPods), are offering further modes of communication.

2.5.3 Information System Design And Administration

The design of an information system is based on various factors. Cost is a major consideration, but there certainly are others to be taken into account, such as the number of users; the modularity of the system, or the ease with which new components can be integrated into the system, and the ease with which outdated or failed components can be replaced; the amount of information to be processed; the type of information to be processed; the computing power required to meet the varied needs of the organization; the anticipated functional life of the system and/or components; the ease of use for the people who will be using the system; and the requirements and compatibility of the applications that are to be run on the system.

There are different ways to construct an information system, based upon organizational requirements, both in the function aspect and the financial sense. Of course, the company needs to take into consideration that hardware that is purchased and assembled into a network will become outdated rather quickly. It is almost axiomatic that the technologies used in information systems steadily increase in power and versatility on a rapid time scale. Perhaps the trickiest part of designing an information system from a hardware standpoint is straddling the fine line between too much and not enough, while keeping an eye on the requirements that the future may impose.

Applying foresight when designing a system can bring substantial rewards in the future, when system components are easy to repair, replace, remove, or update without having to bring the whole information system to its knees. When an information system is rendered inaccessible or inoperative, the system is considered to be "down."

A primary function of the maintaining an information system is to minimize downtime, or hopefully, to eradicate downtime altogether. The costs created by a department, facility, organization, or workforce being idled by an inoperative system can become staggering in a short amount of time. The inconvenience to customers can cost the firm even more if sales are lost as a result, in addition to any added costs the customers might incur.

Another vital consideration regarding the design and creation of an information system is to determine which users have access to which information. The system should be configured to grant access to the different partitions of data and information by granting user-level permissions for access. A common method of administering system access rights is to create unique profiles for each user, with the appropriate user-level permissions that provide proper clearances.

Individual passwords can be used to delineate each user and their level of access rights, as well as identify the tasks performed by each user. Data regarding the performance of any user unit, whether individual, departmental, or organizational can also be collected, measured, and assessed through the user identification process.

The OSI seven-layer model attempts to provide a way of partitioning any computer network into independent modules from the lowest (physical/hardware) layer to the highest (application/program) layer. Many different specifications can exist at each of these layers.

A crucial aspect of administering information systems is maintaining communication between the IS staff, who have a technical perspective on situations, and the system users, who usually communicate their concerns or needs in more prosaic terminology. Getting the two sides to negotiate the language barriers can be difficult, but the burden of translation should fall upon the IS staff. A little patience and understanding can go a long way toward avoiding frustration on the part of both parties.

There is more to maintaining an information system than applying technical knowledge to hardware or software. IS professionals have to bridge the gap between technical issues and practicality for the users. The information system should also have a centralized body that functions to provide information, assistance, and services to the users of the system. These services will typically include telephone and electronic mail "help desk" type services for users, as well as direct contact between the users and IS personnel.

2.5.4 Information System Functions

Document and Record Management

Document and record management may well be the most crucial aspect of any information system. Some examples of types of information maintained in these systems would be accounting, financial, manufacturing, marketing, and human resources. An information system can serve as a library. When properly collected, organized, and indexed in accordance with the requirements of the organization, its stored data becomes accessible to those who need the information.

The location and retrieval of archived information can be a direct and logical process, if careful planning is employed during the design of the system. Creating an outline of how the information should be organized and indexed can be a very valuable tool during the design phase of a system. A critical feature of any information system should be the ability to not only access and retrieve data, but also to keep the archived information as current as possible.

Collaborative Tools

Collaborative tools can consist of software or hardware, and serve as a base for the sharing of data and information, both internally and externally. These tools allow the exchange of information between users, as well as the sharing of resources. As previously mentioned, real-time communication is also a possible function that can be enabled through the use of collaborative tools.

Data Mining

Data mining, or the process of analyzing empirical data, allows for the extrapolation of information. The extrapolated results are then used in forecasting and defining trends.

Query Tools

Query tools allow the users to find the information needed to perform any specific function. The inability to easily create and execute functional queries is a common weak link in many information systems. A significant cause of that inability, as noted earlier, can be the communication difficulties between a management information systems department and the system users.

Another critical issue toward ensuring successful navigation of the varied information levels and partitions is the compatibility factor between knowledge bases. For maximum effectiveness, the system administrator should ascertain that the varied collection, retrieval, and analysis levels of the system either operate on a common platform, or can export the data to a common platform. Although much the same as query tools in principle, intelligent agents allow the customization of the information flow through sorting and filtering to suit the individual needs of the users. The primary difference between query tools and intelligent agents is that query tools allow the sorting and filtering processes to be employed to the specifications of management and the system administrators, and intelligent agents allow the information flow to be defined in accord with the needs of the user.

Key Points

Managers should keep in mind the following advice in order to get the most out of an information system:

- Use the available hardware and software technologies to support the business. If the information system does not support quality and productivity, then it is misused.
- Use the available technologies to create and facilitate the flow of communication within your organization and, if feasible, outside of it as well. Collaboration and flexibility are the key advantages offered for all involved parties. Make the most of those advantages.
- Determine if any strategic advantages are to be gained by use of your information system, such as in the areas of order placement, shipment tracking, order fulfillment, market forecasting, just-in-time supply, or regular inventory. If you can gain any sort of advantage by virtue of the use of your information system, use it.
- Use the quantification opportunities presented by your information system to measure, analyze, and benchmark the performances of an individual, department, division, plant, or entire organization.

An information system is more than hardware or software. The most integral and important components of the system are the people who design it, maintain it, and use it. While the overall system must meet various needs in terms of power and performance, it must also be usable for the organization's personnel. If the operation of day-to-day tasks is too daunting for the workforce, then even the most humble of aspirations for the system will go unrealized.

A company will likely have a staff entrusted with the overall operation and maintenance of the system and that staff will be able to make the system perform in the manner expected of it. Pairing the information systems department with a training department can create a synergistic solution to the quandary of how to get non-technical staff to perform technical tasks. Oft times, the individuals staffing an information systems department will be as technical in their orientation as the operative staff is non-technical in theirs. This creates a language barrier between the two factions, but the communication level between them may be the most important exchange of information within the organization. Nomenclature out of context becomes little more than insular buzzwords.

If a company does not have a formal training department, the presence of staff members with a natural inclination to demonstrate and teach could mitigate a potentially disastrous situation. Management should find those employees who are most likely to adapt to the system and its operation. They should be taught how the system works and what it is supposed to do. Then they can share their knowledge with their fellow workers. There may not be a better way to bridge the natural chasm between the IS department and non-technical personnel. When the process of communicating information flows smoothly and can be used for enhancing and refining business operations, the organization and its customers will all profit.

Further Reading:

Caldelli, A., and M.L. Parmigiani. "Management Information System: A Tool for Corporate Sustainability." *Journal of Business Ethics* 55, no.2 (December 2004): 159–171.

Denton, D.K. "Focus on Data Context, Not Content." *Communications News* 40, no. 12 (December 2003): 50.

Lail, P.W. "Improving IT's Support of Business Strategy." *Pulp & Paper* 79, no.1 (January 2005): 23.

Lawrence, F.B., D.F. Jennings, and B.E. Reynolds. *ERP in Distribution.* Mason, OH: Thomson/South-Western, 2005.

Pawlowski, S. D. and D. Robey. "Bridging User Organizations: Knowledge Brokering and the Work of Information Technology Professionals." *MIS Quarterly* 28, no. 4 (December 2004): 645–672.

Zehir, C. and H. Keskin. "A Field Research on the Effects of MIS on Organizational Restructuring." *Journal of American Academy of Business* 3 (September 2003): 270–279.

Source:

http://www.referenceforbusiness.com/management/Log-Mar/Management-Information-Systems.html

2.6 IT in Operations Management –

Use of the Intranet In Information Management

2.6.1 Introduction

Information is a resource that is widely scattered in an organisation. Often it is fragmented, unreliable, not current and not readily accessible due to a variety of reasons. Organisational performance and productivity suffers often due to these lacunae. The development in the information and communication technology, especially the internet, has enabled organisations to attempt to overcome these deficiencies by the use of intranet.

An **intranet** is a private computer network that uses Internet protocols and network connectivity to securely share part of an organization's information or operations with its employees. Sometimes the term refers only to the most visible service, the internal website. The same concepts and technologies of the Internet such as clients and servers running on the Internet protocol suite are used to build an intranet. HTTP and other Internet protocols are commonly used as well, such as FTP. There is often an attempt to use Internet technologies to provide new interfaces with corporate "legacy" data and information systems.

Briefly, an **intranet** can be understood as "**a private version of an Internet,**" or as a version of the Internet confined to an organization. Through such devices and systems off-site employees can access company information, computing resources and internal communications.

Intranets (also called Enterprise portals) differ from "Extranets" in that the former are generally restricted to employees of the organization while extranets can generally be accessed by customers, suppliers, or other approved parties.

Increasingly, intranets are being used to deliver tools and applications, e.g., collaboration (to facilitate working in groups and teleconferencing) or sophisticated corporate directories, sales and CRM tools, project management etc., to advance productivity.

Intranets are also being used as culture change platforms. For example, large numbers of employees discussing key issues in an online forum could lead to new ideas.

Most commonly, intranets are owned by the communications, HR or CIO areas of large organizations, or some combination of the three.

Because of the scope and variety of content and the number of system interfaces, the intranets of many organisations are much more complex than their respective public websites. And intranets are growing rapidly. According to the Intranet design annual 2007 from Nielsen Norman Group the number of pages on participants' intranets averaged 200,000 over the years 2001 to 2003 and has grown to an average of 6 million pages over 2005–2007[3].

2.6.2 Intranet Portals Features

User profile

Role-based personalization can reference existing databases of user information and serve users information relevant to their job, department, and specific location. For multinational corporations, role-based personalization can also provide country-specific information, delivered in a user's preferred language. Intranet portals can target individual users with mission-critical applications they need, such as their own, personal employment benefits information.

Search

Intranets tie their search engine directly to their content, and substantially improve search performance by using a more-structured understanding of the content and proper metadata users need. They can study users' behaviour – analyzing which pages users visit and how they traverse the information space – to further understand users' needs. In domain-specific spaces, keyword indexing may also help, such as in a bank portal where users "speak banking slang," as one Credit Suisse portal manager puts it.

Single Tool

During the first ten years of their development, intranets were modeled after the Web: no central control, which produced a profusion of incompatible services. While this model has advantages during an experimental phase, it ultimately leads to wasted and duplicated efforts, and results in a substandard user experience.

Intranet portals replace this wild Web approach with a tool metaphor, where a company's content and services work together instead of undermining each other. Portals offer a single starting point, a single overview of each user's most important services, a single search, a single navigation scheme and information architecture, and a single set of consistent page design templates. All these things combine to make the intranet portal a more-promising corporate information infrastructure.

Applications like Lotus Notes/Domino and Microsoft's Share Point are used in building an intranet for an organisation.

2.6.3 Intranet Contents

Major parent categories (major sections or channels that represent virtually all the content on a corporate intranet) should be limited to 6 or 8 including sections for:

- About Us (Corporate profile, business structure, bios, directory, etc.)
- News (news stories, announcements, events, etc.)
- HR (human resource related information and tools)
- Products & Services (and/or Customer related information)
- Forms & Tools (an aggregate section of links or originals)
- Manuals & Policies (an aggregate section of links or originals)
- Other common parent categories (relevant to some organizations but not others include:

- Customer service
- Career / Learning
- Executive Corner
- Roles / Dashboards (sales, operations, administrative, etc.)
- Library / Reference

➲ Beware of catch-all sections such as "Resources" or "Information" that become dumping grounds for everything that doesn't fit in other sections rather than finding it a true home

➲ Navigational / usability elements such as Search, Site Map, Help, Contact Us, Feedback, etc. need not be in a parent category per se, but should be available in the main navigation banner and/or footer

➲ Card sorting exercises that allow users to determine content groupings and labels are extremely valuable for fixing navigation and usability problems

➲ Do not bury or overlook highly desirable but not necessarily mission-critical items that are usually very highly sought by employees including:

  o Cafeteria menus
  o Buy-and-sell / Classifieds
  o Job postings
  o Weather forecast
  o Office locations & maps

What do the Best Intranets contain

The Nielsen Norman Group report on the Intranet design annual 2008 reviews the designs and usability of best ten intranets. Excerpts follow:

These intranets represent big companies with large amounts of documents and mission-critical applications such as sales force support. But most of the lessons from these winning designs apply to smaller companies as well.

Bank of America

Bank of America's intranet users benefit from a powerful feature set that is specifically tailored for each of them. The redesigned intranet saved more than 10,000 hours for Bank of America associates in its first year of adoption. It has also become the primary source for information and tools that drive productivity and revenue gains.

Bankinter S.A.

It provides content and tools that people really need, and does so in an interface that is both uncomplicated and visually attractive.

Barnes & Noble

Barnes & Noble designers meld bold choices with a soft color palette to create a very useful intranet for booksellers and corporate users alike. In working to support the booksellers, designers created a community among these professionals by promoting store events, sharing best practices, and recognizing exceptional booksellers.

British Airways

Employee Self Service at British Airways is helping (and pleasing) BA employees with vast offerings of services and information online and at their disposal, at home or around the world, at any time. And the communication and cost *savings are pleasing the managers at the organization.*

Campbell Soup Company

Campbell's intranet team, armed with user research and ingenuity, was able to create a large-scale, customizable intranet that communicates and unifies the whole organization while still respecting all of the brands under the main umbrella.

Coldwell Banker Real Estate Corporation

Coldwell Banker designers took a practical approach to design, precisely adhering to what they know to be their users' needs. The applications and task-based navigation are very user-focused.

IKEA North America Services LLC

Many small touches add up to one major upbeat success in the IKEA US intranet - one that fosters collaboration and communication.

Ministry of Transport (New Zealand)

The New Zealand Ministry of Transport intranet makes it effortless to communicate research work and news across the organization.

New South Wales Department of Primary Industries

NSW DPI offers a wide range of services, and its intranet helps enormously in supporting the very diverse set of workers who deliver them. With an abundance of news, plus very elegantly designed forms, workers can effortlessly give and receive information

SAP AG

SAP designers took deliberate steps to ensure that employees will know where they're going and will get the specific information they need on the redesigned SAP Portal. Research, innovation, and risk-taking — plus an eye toward leading the user — make the SAP intranet one that employees can use to be productive and informed no matter what their organizational role.

Common Themes among the Winners

Consistent design and integrated IA are becoming standard on good intranets. This year's winners focused on productivity tools, employee self-service, access to knowledgeable people (as opposed to "knowledge management"), and better-presented company news.

Specific trends

- More Personalization Than Ever
- Reconciling Information Sources
- A Single Page as "One Stop Shop"
- Helping Employees to Help Themselves
- Supporting the Core Business
- Finding Subject matter Experts

2.6.4 Case Studies

2.6.4.1 Infosys, India

Infosys, a leading player in the IT field in India, offers an intranet product that comes with the following features.

Home page **–** with links to various parts of the web site and to other internet based applications and web sites.

About us **–** for holding information on your organisation and communicating your corporate message to all employees.

Telephone Book/Directory – a directory to all individuals and company offices

Policies & Procedures **–** for health and safety and customer management policies and all-important procedures. These are categorised so the right information is easy to find.

News – an easy and quick way of updating the whole organisation on important developments.

Events and Seminars **–** publicise key events that managers and employees should know about. ***Meet the team*** - light hearted introduction to key members of staff including a photo.

Marketing Campaigns – *key* information on current marketing campaigns to ensure everyone is ready to take advantage of the current initiatives

Press Releases – company press release central repository to keep the whole organization up to date

Job vacancies – advertise key employment opportunities throughout your organization.

Bright Ideas – e suggestion box. Allow people to contribute ideas to the organisation using a suggestion form which is submitted for review and publication.

Sports & Social and Classified – *allowing* users the ability to advertise social events and small sales on the intranet increases visibility to other information

2.6.4.2 Technologies, Netherlands

Founded in 1877 in the Netherlands, Océ is a printing and copying specialist offering a full range of products and services for the reproduction, distribution and management of documents.

Océ has been developing several initiatives to make its intranet work hard for the company.

One of the main business information tools available to staff globally via the intranet is a **competitors database.** This database provides all kinds of relevant competitor information including financial data and product announcements, and some of this information is sourced from Dialog's services.

The Information Management department has also been responsible for document management of **internally generated reports**, as Loonen says, "we're helping staff to get their knowledge onto paper". Together with two software companies in the Netherlands, the company has built a document management system that is capturing intellectual property and enabling it to be shared across the organisation via the intranet. The system assists staff in writing and standardising their reports. It then stores the reports electronically, enabling them to be easily searched, retrieved, distributed and printed.

The company is also looking into a **'yellow pages'** system, where staff would be asked to publish a profile of themselves - who they are, what they do, their responsibilities and areas of expertise. This would become a valuable pool of knowledge to draw on and would be made available via the intranet. "The question is, how do you convince people to input their information?" comments Loonen. "A yellow pages system would be invaluable when you consider that people tend to ask their colleagues for help, but in a rapidly growing company it is virtually impossible to have personal relationships with everyone."

One forthcoming enterprise-wide content application project is the implementation of Dialog's Monitor service on Océ's intranet Monitor is a key component of the Dialog Intranet Toolkit, which is based on a uniquely simple idea: to enable clients to custom build their own interfaces to the authoritative content from Dialog.

Working with Dialog, the Information Management department will set up highly **customised profiles** matching the information requirements of staff across the organisation. This can be done at the corporate-wide level, down to the specific requirements of departments, workgroups and individuals. Once defined, these custom-built profiles will then give staff the ability to retrieve and deliver relevant information direct via the intranet.

2.6.4.3 Advantages of intranets

1. **Workforce productivity** – Intranets can help users to locate and view information faster and use applications relevant to their roles and responsibilities. Users can access data held in any database the organization wants to make available, anytime and - subject to security provisions - from anywhere within the company workstations.
2. **Time** – With intranets, organizations can make more information available to employees on a "pull" basis (ie: employees can link to relevant information at a time which suits them) rather than being deluged indiscriminately by emails.
3. **Communication** – Intranets can serve as powerful tools for communication within an organization, vertically and horizontally. From a communications standpoint, intranets are useful to communicate strategic initiatives that have a global reach throughout the organization. The type of information that can easily be conveyed is the purpose of the initiative and what the initiative is aiming to achieve, who is driving the initiative, results achieved to date, and who to speak to for more information. By providing this information on the intranet, staff have the opportunity to keep up-to-date with the strategic focus of the organization.
4. **Knowledge Management** – Web publishing allows '***cumbersome***' corporate knowledge to be maintained and easily accessed throughout the company using hypermedia and Web technologies. Examples include: employee manuals, benefits documents, company policies, business standards, news feeds, and even training, can be accessed using common Internet standards (Acrobat files, Flash files, CGI applications). Because each business unit can update the online copy of a document, the most recent version is always available to employees using the intranet.
5. **Business operations and management** – Intranets are also being used as a platform for developing and deploying applications to support business operations and decisions across the internetworked enterprise.
6. **Cost-effective** – Users can view information and data via web-browser rather than maintaining physical documents such as procedure manuals, internal phone list and requisition forms.
7. **Promote common corporate culture** – Every user is viewing the same information within the Intranet.

8. **Enhance Collaboration –** With information easily accessible by all authorised users, teamwork is enabled.

Source:

http://en.wikipedia.org/wiki/Intranet

http://www.nngroup.com/reports/intranet/portals/

http://intranetblog.blogware.com/blog/Information Architecture

http://www.infosys.co.uk/website/infopool.nsf/HTML/F06E2FEC2D5CFBAA80256D2C005C1C87

http://www.dialog.com/products/casestudies/oce_tech.shtml

2.7 IT in Operations Management-

2.7.1 Manufacturing Resources Planning and Distribution Resources Planning

Manufacturing resource planning, also known as MRP II, is a method for the effective planning of a manufacturer's resources. MRP II is composed of several linked functions, such as business planning, sales and operations planning, capacity requirements planning, and all related support systems. The output from these MRP II functions can be integrated into financial reports, such as the business plan, purchase commitment report, shipping budget, and inventory projections. It has the capability of specifically addressing operational planning and financial planning, and has simulation capability that allows its users to conduct sensitivity analyses (answering "what if" questions).

The earliest form of manufacturing resource planning was known as material requirements planning (MRP). This system was vastly improved upon until it no longer resembled the original version. The newer version was so fundamentally different from MRP, that a new term seemed appropriate. Oliver Wight coined the acronym MRP II for manufacturing resource planning.

In order to best understand MRP II, one must have a basic understanding of MRP. So we will begin with a look at MRP and then expand into MRP II.

2.7.2 Material Requirements Planning

Material requirements planning (MRP) is a computer-based, time-phased system for planning and controlling the production and inventory function of a firm from the purchase of materials to the shipment of finished goods. All MRP systems are computer based since the detail involved and the inherent burden of computation make manual use prohibitive. MRP is time phased because it not only determines what and how much needs to be made or purchased, but also when.

Material requirements planning first appeared in the early 1970s and was popularized by a book of the same name by Joseph Orlicky. Its use was quickly heralded as the new manufacturing panacea, but enthusiasm slowed somewhat when firms began to realize the difficulty inherent in its implementation.

The MRP system is composed of three primary modules, all of which function as a form of input. These are the master production schedule, the bill-of-materials, and the inventory status file. Each module serves a unique purpose that is inter-related with the purpose of the other modules, and produces several forms of usable output.

2.7.3 Master Production Schedule

The master production schedule (MPS) is basically the production schedule for finished goods. This schedule is usually derived from current orders, plus any forecast requirements. The MPS is divided into units of time called "buckets." While any time frame may be utilized, usually days or weeks is appropriate. The MPS is also said to be the aggregate plan "disaggregated." In other words, the plan for goods to be produced in aggregate is broken down into its individual units or finished goods.

Bill-of-Materials (BOM)

The bill-of-materials is a file made up of bills-of-material (BOM). Each BOM is a hierarchical listing of the type and number of parts needed to produce one unit of finished goods. Other information, such as the routings (the route through the system that individual parts take on the way to becoming a finished good), alternate routings, or substitute materials may be also be contained with the BOM.

A tool known as a product structure tree is used to clarify the relationship among the parts making up each unit of finished goods. Figure 1 details how a product structure tree for a rolling cart might appear on a bill-of-material. This cart consists of a top that is pressed from a sheet of steel; a frame formed from four steel bars; and a leg assembly consisting of four legs, each with a caster attached. Each caster is made up of a wheel, a ball bearing, an axle, and a caster frame.

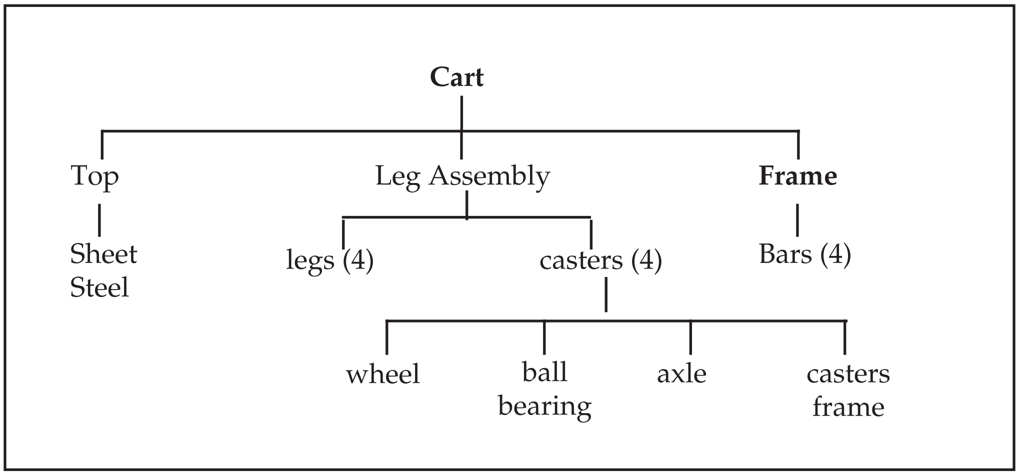


Figure 1

The bill-of-material can be used to determine the gross number of component parts needed to manufacturer a given number of finished goods. Since a gross number is determined, safety stock can be reduced because component parts may be shared by any number of finished goods (this is known as commonality).

The process of determining gross requirements of components is termed the "explosion" process, or "exploding" the bill-of-material. Assuming we need 100 rolling carts, we can use our example product structure tree to compute the gross requirements for each rolling cart component. We can easily see that in order to produce 100 rolling carts, we would need 100 tops, which would require 100 sheets of steel; 100 leg assemblies, which would require 400 legs and 400 casters (requiring 400 wheels, 400 ball bearings, 400 axles, and 400 caster frames); and 100 frames, which would require 400 bars.

Inventory Status File

The inventory status file, or inventory records file, contains a count of the on-hand balance of every part held in inventory. In addition, the inventory status file contains all pertinent information regarding open orders and the lead time (the time that elapses between placing an order and actually receiving it) for each item.

Open orders are purchase orders (orders for items purchased outside the firm) or shop orders (formal instructions to the plant floor to process a given number of parts by a given date) that have not been completely satisfied. In other words, they are items that have been ordered, but are yet to be received.

2.7.4 The MRP Process

The MRP logic starts at the MPS, where it learns the schedule for finished goods (how many and when). It takes this information to the BOM where it "explodes" the gross requirements for all component parts. The MRP package then takes its knowledge of the gross requirements for all components parts to the inventory status file, where the on-hand balances are listed. It then subtracts the on-hand balances and open orders from the gross requirements for components yielding the net requirements for each component.

Of course, we now know not only how many components are needed but when they are needed in order to complete the schedule for finished goods on time. By subtracting the lead time from the due date for each part, we now see when an order must be placed for each part so that it can be received in time to avoid a delay in the MPS. A manual version of MRP for a part with requirements of 100 in period 3 and 250 in period 6 and with a two-period lead time is shown in Figure 2.

Notice that in order for the firm to meet demand on time (the MPS), they must place an order for 25 in Period 1 and an order for 200 in Period 4. The reader should be aware that this is an overly simplified version of MRP, which does not include such relevant factors as lot sizing and safety stock.

	1	2	3	4	5	6
Gross Requirement			100			250
Scheduled Receipts (open order)			50		50	
On Hand (inventory balance)	25	25	25	0	0	50
Net Requriment			25			200
Planned Order Receipt			25			200
Planned Order Release	25			200		

Figure 2

2.7.5 Expanding into MRP II

With MRP generating the material and schedule requirements necessary for meeting the appropriate sales and inventory demands, more than the obvious manufacturing resources for supporting the MRP plan was found to be needed. Financial resources would have to be generated in varying amounts and timing. Also, the process would require varying degrees of marketing resource support. Production, marketing, and finance would be operating without complete knowledge or even regard for what the other functional areas of the firm were doing.

In the early 1980s MRP was expanded into a much broader approach. This new approach, manufacturing resource planning (MRP II), was an effort to expand the scope of production resource planning and to involve other functional areas of the firm in the planning process, most notably marketing and finance, but also engineering, personnel, and purchasing. Incorporation of other functional areas allows all areas of the firm to focus on a common set of goals. It also provides a means for generating a variety of reports to help managers in varying functions monitor the process and make necessary adjustments as the work progresses.

When finance knows which items will be purchased and when products will be delivered, it can accurately project the firm's cash flows. In addition, personnel can project hiring or layoff requirements, while marketing can keep track of up-to-the-minute changes in delivery times, lead times, and so on. Cost accounting information is gathered, engineering input is recorded, and distribution requirements planning is performed.

An MRP II system also has a simulation capability that enables its users to conduct sensitivity analyses or evaluate a variety of possible scenarios. The MRP II system can simulate a certain decision's impact throughout the organization, and predict its results in terms of customer orders, due dates, or other "what if" outcomes. Being able to answer these "what if" questions provides a firmer grasp of available options and their potential consequences.

As with MRP, MRP II requires a computer system for implementation because of its complexity and relatively large scale. Pursuit of MRP or MRP II in a clerical fashion would prove far too cumbersome to ever be useful.

In addition to its efficient performance of the data processing and file handling, a computer also allows the system to run remarkably quick, providing near-immediate results and reports when asked to simulate a decision.

2.7.6 Classes of Firms Using MRP and MRP II

MRP and MRP II users are classified by the degree to which they utilize the various aspects of these systems. Class D companies have MRP working in their data processing area, but utilize little more than the inventory status file and the master production schedule, both of which may be poorly used and mismanaged. Typically, these firms are not getting much return for the expense incurred by the system.

Class C firms use their MRP system as an inventory ordering technique but make little use of its scheduling capabilities.

Class B companies utilize the basic MRP system (MPS, BOM, and Inventory file) with the addition of capacity requirements planning and a shop floor control system. Class B users have not incorporated purchasing into the system and do not have a management team that uses the system to run the business, but rather see it as a production and inventory control system.

Class A firms are said use the system in a closed loop mode. Their system consists of the basic MRP system, plus capacity planning and control, shop floor control, and vendor scheduling systems. In addition, their management uses the system to run the business. The system provides the game plan for sales, finance, manufacturing, purchasing, and engineering. Management then can use the system's report capability to monitor accuracy in the BOM, the inventory status file, and routing, as well as monitor the attainment of the MPS and capacity plans.

Class A firms have also tied in the financial system and have developed the system's simulation capabilities to answer "what if" questions. Because everyone is using the same numbers (e.g., finance and production), management has to work with only one set of numbers to run the business.

2.7.7 Developments

With the advent of lean manufacturing and just-in-time (JIT), MRP and MRP II have fallen into disfavour with some firms, with some feeling that the systems are obsolete. However, research has found that in certain environments with advance demand information, MRP-type push strategies yield better performance in term of inventories and service levels than did JIT's kanban-based pull strategies.

A further extension of MRP and MRP II has been developed to improve resource planning by broadening the scope of planning to include more of the supply chain. The Gartner Group of Stamford, Connecticut, coined the term "enterprise resource planning" (ERP) for this system.

The authors of **Manufacturing Planning and Control for Supply Chain Management** note that MRP and ERP have become so entrenched in businesses that they no longer provide a source of competitive advantage. They feel that a sustaining competitive advantage will now require that manufacturing planning and control (MPC) systems to cross organizational boundaries and coordinate company units that have traditionally worked independently.

It is recommended that in the near future organizations will need to work in pairs or dyads. This means that pairs, or dyads, of firms will jointly develop new MPC systems that allow integrated operations. Organizations will learn as much as possible from each dyad and then leverage what they have learned into other dyads. They term this approach the "next frontier" for manufacturing planning and control systems.

2.7.8. Distribution Requirements Planning (DRP)

A supply channel is composed of three structures. At one end of the channel is the manufacturer. The manufacturer focuses on the development and production of products and originates the distribution process. The terminal point in the channel is the retailer who sells goods and services directly to the customer for their personal, non-business use. In between the two lies a process called distribution, which is more difficult to define. One involved in the distribution process is labeled a "distributor." The APICS Dictionary describes a distributor as "a business that does not manufacture its own products but purchases and resells these products. Such a business usually maintains a finished goods inventory." The proliferation of alternative distribution forms, such as warehouse clubs, catalog sales, marketing channel specialists, and mail order, have blurred functional distinctions and increased the difficulty of defining both the distribution process and the term distributor.

One ultimately could maintain that distributors include all enterprises that sell products to retailers and other merchants—and/or to industrial, institutional, and commercial users—but do not sell in significant amounts to the ultimate customer. According to this definition, most companies that are involved with the disbursement of raw materials and finished products belong, in one sense or another, to the distribution industry. By adopting this definition, distribution is expanded to cover nearly every form of materials management and physical distribution activity performed by channel constituents, except for the processes of manufacturing and retailing.

Distribution involves a number of activities centered around a physical flow of goods and information. At one time the term distribution applied only to the outbound side of supply chain management, but it now includes both inbound and outbound. Management of the inbound flow involves these elements:

- Material planning and control
- Purchasing

- Receiving
- Physical management of materials via warehousing and storage
- Materials handling

Management of the outbound flow involves these elements:

- Order processing
- Warehousing and storage
- Finished goods management
- Material handling and packaging
- Shipping
- Transportation

Distribution channels are formed to solve three critical distribution problems: functional performance, reduced complexity, and specialization.

The central focus of distribution is to increase the efficiency of time, place, and delivery utility. When demand and product availability are immediate, the producer can perform the exchange and delivery functions itself. However, as the number of producers grows and the geographical dispersion of the customer base expands, the need for both internal and external intermediaries who can facilitate the flow of products, services, and information via a distribution process increases.

Distribution management also can decrease overall channel complexity through sorting and assistance in routinization. Sorting is the group of activities associated with transforming products acquired from manufacturers into the assortments and quantities demanded in the marketplace. Reutilization refers to the policies and procedures providing common goals, channel arrangements, expectations, and mechanisms to facilitate efficient transactions. David F. Ross describes sorting as including four primary functions:

1. Sorting is the function of physically separating a heterogeneous group of items into homogeneous subgroups. This includes grading and grouping individual items into an inventory lot by quality or eliminating defects from the lot.
2. Accumulating is the function of combining homogeneous stocks of products into larger groups of supply.
3. Allocation is the function of breaking down large lots of products into smaller salable units.
4. Assorting is the function of mixing similar or functionally related items into assortments to meet customer demand. For example, putting items into kit form.

As the supply chain grows more complex, costs and inefficiencies multiply in the channel. In response, some channels add or contain partners that specialize in one or more of the elements of distribution, such as exchange or warehousing. Specialization then improves the channel by increasing the velocity of goods and value-added services and reducing costs associated with selling, transportation, carrying inventory, warehousing, order processing, and credit.

2.7.9. Role of the Distribution Function

There are a number of critical functions performed by the channel distributor. Ross describes these functions as:

1. **Product acquisition** – This means acquiring products in a finished or semi-finished state from either a manufacturer or through another distributor that is higher up in the supply channel. These functions can be performed by independent channel intermediaries or by the distribution facilities of manufacturing companies.

2. **Product movement** – This implies significant effort spent on product movement up or down the supply channel.

3. **Product transaction** – Distributors can be characterized as selling products in bulk quantities solely for the purpose of resale or business use. Downstream businesses will then sell these products to other distributors or retailers who will sell them directly to the end customer, or to manufacturers who will consume the material/components in their own production processes.

Following are the separate elements contained within the three critical functions of distribution:

- **Selling and promoting** – This function is very important to manufacturers. One strategy involves the use of distribution channels to carry out the responsibilities of product deployment. In addition to being marketing experts in their industry, distribution firms usually have direct-selling organizations and a detailed knowledge of their customers and their expectations. The manufacturer utilizing this distributor can then tap into these resources. Also, because of the scale of the distributing firm's operations and its specialized skill in channel management, it can significantly improve the time, place, and possession utilities by housing inventory closer to the market. These advantages mean that the manufacturer can reach many small, distant customers at a relatively low cost, thus allowing the manufacturer to focus its expenditures on product development and its core production processes.

- **Buying and building product assortments** – This is an extremely important function for retailers. Most retailers prefer to deal with few suppliers providing a wide assortment of products that fit their merchandizing strategy rather than many with limited product lines. This, of course, saves on purchasing, transportation, and merchandizing costs. Distribution firms have the ability to bring together related products from multiple manufacturers and assemble the right combination of these products in quantities that meet the retailer's requirements in a cost-efficient manner.

- **Bulk breaking** – This is one of the fundamental functions of distribution. Manufacturers normally produce large quantities of a limited number of products. However, retailers normally require smaller quantities of multiple products. When the distribution function handles this requirement it keeps the manufacturer from having to break bulk and repackage its product to fit individual requirements. Lean manufacturing and JIT techniques are continuously seeking ways to reduce lot sizes, so this function enhances that goal.

- **Value-added processing** – Postponement specifies that products should be kept at the highest possible level in the pipeline in large, generic quantities that can be customized into their final form as close as possible to the actual final sale. The distributor can facilitate this process by performing sorting, labeling, blending, kitting, packaging, and light final assembly at one or more points within the supply channel. This significantly reduces end-product obsolescence and minimizes the risk inherent with carrying finished goods inventory.

- **Transportation** – The movement of goods from the manufacturer to the retailer is a critical function of distribution. Delivery encompasses those activities that are necessary to ensure that the right product is available to the customer at the right time and right place. This frequently means that a structure of central, branch, and field warehouses, geographically situated in the appropriate locations, are needed to achieve optimum customer service. Transportation's goal is to ensure that goods are positioned properly in the channel in a quick, cost-effective, and consistent manner.

- **Warehousing** – Warehousing exists to provide access to sufficient stock in order to satisfy anticipated customer requirements, and to act as a buffer against supply and demand uncertainties. Since demand is often located far from the source (manufacturer), warehousing can provide a wide range of marketplaces that manufacturers, functioning independently, could not penetrate.
- **Marketing information** – The distribution channel also can provide information regarding product, marketplace issues, and competitors' activities in a relatively short time.

2.7.10. Need for Distribution Requirements Planning (DRP)

The need for more detailed distribution planning led to the emergence of distribution requirements planning (DRP) during the 1970s. DRP is a widely used and potentially powerful technique for helping outbound logistics systems manage and minimize inbound inventories. This concept extended the time-phase order point found in material requirements planning (MRP) logic to the management of channel inventory. By the 1980s DRP had become a standard approach for planning and controlling distribution logistics activities and had evolved into distribution resource planning. The concept now embraces all business functions in the supply channel, not just inventory and logistics, and is termed DRP II.

DRP is usually used with an MRP system, although most DRP models are more comprehensive than stand-alone MRP models and can schedule transportation. The underlying rationale for DRP is to more accurately fore-cast demand and then use that information to develop delivery schedules. This way, distribution firms can minimize inbound inventory by using MRP in conjunction with other schedules.

One of the key elements of DRP is the DRP table, which includes the following elements:

- Forecast demand for each stock-keeping unit (SKU)
- Current inventory level of the SKU
- Target safety stock
- Recommended replenishment quantity
- Replenishment lead time

The concept of DRP very closely mimics the logic of MRP. As with MRP, gross requirements consist of actual customer orders, forecasted demand, or some combination of both; scheduled receipts are the goods the distributor expects to receive from orders that already have been released, while goods that already are received and entered into inventory constitute the on-hand inventory balance. Subtracting scheduled receipts and on-hand inventory from gross requirements yields net requirements. Based upon the distributor's lot-sizing policy and receiving behavior, planned order receipts are generated. Firms may order only what they need for the next planning period or for a designated time period. Known as economic order quantity (EOQ), this involves a lot size based on a costing model. Alternatively, firms may be limited to multiples of a lot size simply because the supplying firm packages or palletizes their goods in standard quantities. Also, some distributors may require some time interval between the arrival of goods on their docks and the entry of the goods into the inventory system. For example, a firm may have a staging area where goods remain for an average time period while awaiting quality or quantity verification. Hence, planned order receipt may be during the planning period when the goods are needed, or they may need to be received earlier depending on time requirements. Order release is then determined by offsetting the planned order receipt by the supplier's lead time. Figure 1 is a representation of a DRP calculation (ignoring possible safety stock requirements).

Scheduled receipts	1200, period 3							
On-hand inventory balance	1000							
Lead time :	3 periods							
Order receipt :	period due							
Lot size	600 units per pallet							
Per iods	1	2	3	4	5	6	7	8
Gross Requirement	500	500	500	500	500	500	500	500
Scheduled Receipts			1200					
On Hand	500			200				
Net Requriments						300	200	100
Planned Order Receipt						600	600	600
Planned Order Release		600	600	600				

Figure 3: A DRP Calculation

Further Reading:

Krishnamurthy, Ananth, Rajan Suri, and Mary Vernon. "Re-Examining the Performance of MRP and Kanban Material Control Strategies for Multi-Product Flexible Manufacturing Systems." *International Journal of Flexible Manufacturing Systems* 16, no. 2 (2004): 123.

Orlicky, Joseph. *Material Requirements Planning*. New York, NY: McGraw-Hill, 1975.

Stevenson, William J. *Production Operations Management.* Boston, MA: Irwin/McGraw-Hill, 2004.

Vollmann, Thomas E., William L. Berry, D. Clay Whybark, and F. Robert Jacobs. *Manufacturing Planning and Control for Supply Chain Management.* Boston, MA: McGraw-Hill, 2005.

Wight, Oliver. *Manufacturing Resource Planning: MRP II.* Essex Junction, VT: Oliver Wight Ltd., 1984.

Zhou, Li, and Robert W. Grubbstrom. "Analysis of the Effect of Commonality in Multi-Level Inventory Systems Applying MRP Theory." *International Journal of Production Economics* 90, no. 2 (2004): 251.

Coyle, John J., Edward J. Bardi, and C. John Langley, Jr. The Management of Business Logistics: A Supply Chain Perspective. 7th ed. Mason, OH: South-Western/Thomson Learning, 2003.

Ross, David Frederick. Distribution Planning and Control: Managing in the Era of Supply Chain Management. 2nd ed. Boston: Kluwer Academic Publishers, 2004.

Source:

http://www.referenceforbusiness.com/management/Log-Mar/Manufacturing-Resources-Planning.html

http://www.referenceforbusiness.com/management/De-Ele/Distribution-and-Distribution-Requirements-Planning.html

2.8 IT in Operations Management -

2.8.1 Enterprise Resource Planning (ERP)

Enterprise resource planning (ERP) refers to a computer information system that integrates all the business activities and processes throughout an entire organization. ERP systems incorporate many of the features available in other types of manufacturing programs, such as project management, supplier management, product data management, and scheduling. The objective of ERP is to provide seamless, real-time information to all employees throughout the enterprise. Companies commonly use ERP systems to communicate the progress of orders and projects throughout the supply chain, and to track the costs and availability of value-added services.

ERP systems offer companies the potential to streamline operations, eliminate overlap and bottle-necks, and save money and resources. But ERP systems are very expensive and time-consuming to implement, and surveys have shown that not all companies achieve the desired benefits. According to the online business resource Darwin Executive Guides, it is "a tall order, building a single software program that serves the needs of people in finance as well as it does the people in human resources and the warehouse… To do ERP right, the ways you do business will need to change and the ways people do their jobs will need to change too. And that kind of change doesn't come without pain."

2.8.2 Evolution of ERP

ERP is a part of an evolutionary process that began with material requirements planning (MRP). MRP is a computer-based, time-phased system for planning and controlling the production and inventory function of a firm-from the purchase of materials to the shipment of finished goods. It begins with the aggregation of demand for finished goods from a number of sources (orders, forecasts, and safety stock). This results in a master production schedule (MPS) for finished goods. Using this MPS and a bill-of-material (a listing for all component parts that make up the finished goods), the MRP logic determines the gross requirements for all component parts and subassemblies. From an inventory status file, the MRP logic deducts the on-hand inventory balance and all open orders to yield the net requirements for all parts. Then all requirements are offset by their lead times to provide a date by which an order must be released in order to avoid delaying the production of finished goods.

From this MRP logic evolved manufacturing resource planning (MRP II). Before MRP II, many firms maintained a separate computer system within each functional department, which led to the overlap in storage of much of the firm's information in several different databases. In some cases, the firm did not even know how many different databases held certain information, making it difficult, if not impossible, to update it. This could also cause confusion throughout the firm if different units (such as engineering, production, sales, and accounting) held different values for the same variables. MRP II expands the role of MRP by linking together such functions as business planning, sales and operations planning, capacity requirements planning, and all related support functions. The output from these MRP II functions can be integrated into financial reports, such as the business plan, purchase-commitment report, shipping budget, and inventory projections. MRP II is capable of addressing operational planning in units or financial planning in dollars, and has a simulation capacity that allows its users to analyze the potential consequences of alternative decisions.

The next step in the evolutionary process was enterprise resource planning (ERP), a term coined by the Gartner Group of Stamford, Connecticut. ERP extends the concept of the shared database to all functions within the firm. By entering information only once at the source and making it available to all employees, ERP enables each function to interact with one centralized database and server. Not only does this eliminate the need for different departments within the firm to reenter the same information over and over again into separate computer systems, but it also eliminates the incompatibility that was created by past practice.

2.8.3 FEATURES OF ERP

ERP is a hybrid of many different types of software, incorporating many of the features available in other programs. ERP provides a way to keep track of materials, inventory, human resources, billing, and purchase orders. It is also useful for managing various types of orders, from mass-customized orders where daily or weekly shifts occur within the plant or multiple plants, to products that are made-to-stock, made-to-order, or assembled-to-order.

Higher-level ERPs employ design engineering and engineering change control modules. These modules facilitate the development of new product-engineering information and provide for modification of existing bills of material, allowing engineers to support working models of items and bills of material prior to their production releases.

It is important to understand that ERPs are not cheap to implement and operate, nor can they be implemented overnight. Owens-Corning spent more than $100 million over the course of two years installing one of the most popular ERP systems, SAP AG’s R/3 system. Microsoft spent $25 million over 10 months installing R/3. Chevron also spent $100 million on installation. Apparently, however, the benefits of ERP implementation and use can be enormous. Microsoft used it’s ERP system to replace 33 different financial tracking systems used in 26 of its subsidiaries, with an expected savings of $18 million annually. In the same respect, Chevron expected to recoup its $100 million investment within two years.

Owens-Corning’s aim was to offer buyers one-stop shopping for insulation, pipes, and roofing material. Use of the R/3 facilitated this goal by allowing sales representatives to quickly see what products were available at any plant or warehouse. Analog Devices use the R/3 to consolidate the products stored at its warehouse, thereby creating an international order-processing system that can calculate exchange rates automatically. ERP and supply chain management.

When ERP systems first appeared, they acted as the connection between front-office operations (e.g., sales and forecasting) and the day-to-day functions of manufacturing. As ERP technology has advanced, the systems have increasingly incorporated logistics and warehousing capabilities, further connecting them with the supply chain. Some ERP systems offer Internet functionality, which can provide real-time connectivity from suppliers to the end customer.

The result of ERP use is more than an automation of existing processes-it is a significantly new way of doing business that enables a firm to respond to market changes more rapidly and efficiently. This can apply to service firms as well as manufacturers. Many ERP packages also let the user track and cost service products in the same way they compute the cost of making, storing, and shipping physical products.

2.8.4 What does an ERP package contains

Here is a brief lst of what an ERP package can contain. The list is from a leading ERP player, Oracle.

Enterprise Applications

- Asset Lifecycle Management
- Customer Relationship Management

- Enterprise Resource Planning
- Financial Management
- Human Capital Management
- Project Management
- Procurement
- Product Lifecycle Management
- Supply Chain Management
- Supply Chain Planning
- Logistics & Transportation Management
- Order Management & Pricing
- Manufacturing

Further Reading:

"Enterprise Resource Planning." Darwin Executive Guides Available from http://guide.darwinmag.com/technology/enterprise/erp.

Hanson, J.J. "Successful ERP Implementations Go Far Beyond Software." San Diego Business Journal (5 July 2004).

Larson, Melissa. "Meet Customer Demands with New ERP Systems." Quality (February 1998): 80–81.

Millman, Gregory J. "What Did You Get from ERP and What Can You Get?" Financial Executive (May 2004).

O'Leary, Daniel F. ERP: Systems, Life Cycle, E-Commerce, and Risk. Cambridge University Press, 2000.

Olinger, Charles. "The Issues Behind ERP Acceptance and Implementation." APICS: The Performance Advantage (June 1998): 44–48.

Wallace, Thomas F., and Michael H. Kremzar. ERP: Making It Happen-The Implementer's Guide to Success with ERP. New York: John Wiley, 2001.

http://www.referenceforbusiness.com/management/Em-Exp/Enterprise-Resource-Planning.html

2.9 Benchmarking and Benchtrending

2.9.1 Introduction

Any performance standard viewed in isolation is of little value, it has to be compared in relation to similar objective standards to bring out its relative position and serve as a yardstick for measurement of progress. Thus, for example the turnover ratio of sales to capital employed can be studied over a period of time or as between different manufacturing plants of the same company to gauge the efficiency of asset utilization. While such insular evaluation have their utility, in a fiercely competitive environment, examination of one company's performance against a competing unit will afford meaningful insights into areas where the company is lagging behind. Such an understanding will trigger action for improvement, at least to close the gap, if not to better it, for the company to survive and progress. In fact such comparisons should be instituted against world class standards to attain excellence. In a market driven globalised economy, characterized by intense contest, this process has become an imperative necessity and has gained immense popularity as a distinct management concept under the style of "Benchmarking".

2.9.2 Definition:

The International Benchmarking Clearing House ("IBC") of American Productivity and Quality Center ("APQC") has given the following definition of Benchmarking.

"A systematic and continuous measurement process; a process of continuously comparing and measuring an organization's business processes against business leaders anywhere in the world, to gain information that will help the organization take action to improve its performance".

Benchmark: " A measure, "best – in – class" achievement; a reference or measurement standard for comparison, a performance level recognized as the standard of excellence for a specific business practice".

Rank Xerox, which pioneered this concept defines Benchmarking as "A continuous systematic process of evaluating companies recognized as industry leaders, to determine business and work processes that represent "best practice and established rational performance goals".

At IBM Benchmarking is "the continuous process of enlisting the best practice in the world for the process goals and objectives leading to world class levels of achievement".

2.9.3 Benchmarking Process:

Rank Xerox has given the following ten steps for Benchmarking:

Planning	1.	Identify benchmark outputs
	2.	Identify best competitors
	3.	Determine data collection method.
Analysis	4.	Determine current competitive "gap"
	5.	Project future performance level.
Integration	6.	Establish functional goals; communication of data / acceptance of analysis.
	7.	Develop functional action plan.
Action	8.	Implement specific actions
	9.	Monitor results / Report Progress
	10.	Recalibrate benchmarks.

A sound guiding principle will be, not just to focus on performance metric, but to identify the process enablers and improving by suitably adapting them to the specific situation.

2.9.4 Types of Benchmarking:

Different types of benchmarking are outlined below, though some of them seem to overlap.

A. Product Benchmarking (Reverse Engineering)

This is an age old practice of product oriented reverse engineering. Every organization buys its rival's products and tears them down to find out how the features and performances etc. compare with its products. This could be the starting point for improvement. When Ford Motor company redesigned the Tauras in 1992, it benchmarked 209 features on the car against 7 competitors. The company then worked to match / excel the higher standard set by any of its rival, in each of these features with its own product.

Japanese seemed to have excelled at this practice but to their credit it must be said that they just do not imitate, but ingeniously innovate.

B. Competitive Benchmarking

"A Measure of organizational performance compared against competing organization; studies the target specific product designs, process capabilities or administrative methods used by a company's direct competitors".

Competitive Benchmarking moved beyond product oriented comparisons to include comparisons of process with those of competitors. In this benchmarking, the process studied may include marketing, finance, human resource, R & D etc. A typical example would be the classical study the Rank Xerox performed with those of Canon and other photo copier manufacturers when it faced heightened competition from US and Japanese companies. By benchmarking Rank Xerox achieved significant performance improvements as given below:

Unit manufacturing cost reduced to half, comparable to 1980 product costs

Machine defects have improved by over 90%

Incoming parts acceptance has improved to 99.5%

Inventory methods of supply reduced by at least two thirds.

Engineering drawings per person year more than doubled

Marketing Productivity improved by one third.

Service labour cost reduced by 30%

Distribution productivity increased from 5% to 10%

Management Accountants are familiar with the technique of Inter Firm Comparison of financial performance of companies through ratios to draw meaningful inferences. For instance Hindalco's power cost is lowest in the world, due to the captive power plant set up by them long back. Other aluminium producers while endeavouring to move closer to this standard, must improve in other areas to have competitive parity.

C. Process Benchmarking

"The activity of measuring discrete performance and functionality against organizations through performance in excellent analogous business processes".

To gain leadership position it is essential to look at a paradigm-shifting jump to a new way of managing a process; for this you may have to go beyond your industry and look at the "best-in-breed" to bring about a fundamental change and not just an incremental improvement.

When Airlines wanted to improve their turn around times they compared the performance with the Pit Crew of Formula I races since it is well known that they are best in class in that operation. Hospitals in U.S. compare their patient management systems with the guest management practice in hotels. American Express credit card division compares its document handling process with that of a courier company. Citibank (India) instituted a benchmarking exercise in respect of HR practices and public relations with those of Hindustan Lever Ltd. Cadbury India benchmarks its distribution and logistics function not with Nestle but with Hindustan Lever Ltd. For supply chain management the best practice would be that of Mumbai Dubbawallas, which has now won universal acclaim.

Certain similar types of benchmarking are noted below:

Functional Benchmarking – "An application of process benchmarking that compares a particular business function at two or more organisations.

Generic Benchmarking – "An application of functional process benchmarking that compares a particular business function at two or more organisations, selected without regard to their industry.

D. Internal Benchmarking

"An application of process benchmarking performed, within an organisation by comparing the performance of similar business units or business processes".

Hewlett Packard through an extensive internal benchmarking exercise on the Best Scheduling Practice amongst its several product groups was able to cut its "time-to-market" by half. For a company like HP introduction of new products in time was a crucial performance metric. McKinsy study has shown that hi-tech products that came on budget, but six months behind schedule, sacrificed 33% of their potential profit over the first five years in the market. It might interest Management Accountants to know that the same study showed that on time project that were 50% over budget lost only 4% of the profits over the same period.

With 35 companies spanning seven different businesses, RPG Group is benchmarking the process and standards in each company against others in the group. Named the knowledge improvement process (KIP), benchmarking is a formal exercise to spread the best practice of one company horizontally across the group. Every company in the Group has been benchmarking itself against the others on 12 specific parameters; purchase management, value engineering, inventory management, energy saving, insurance optimization, demand forecasting receivables management, made or buy decision market research, pricing strategy, logistics management, and financing options.

E. Strategic Benchmarking

"The application of process benchmarking of the level of business strategy; a systematic process for evolving alternatives, implementing strategies, and improving performance by understanding and adapting successful strategy from external partners who participated in an on-going business alliance".

It will be seen that strategic benchmarking differs from operational benchmarking in its scope; it helps to develop a vision of the changed organisations; it will develop core competencies that will help sustained competitive advantage; targeting a specific shift in strategy such as entering new markets or develop new products, developing a new line of business or making an acquisition and creating an organisation that is more capable of learning how to respond in an uncertain future because it has increased its acceptance of change.

In mid 1980's When Jack Welch of General Electric wanted to position his company for the coming decade, he asked his Strategic Planning Group to study how successful companies positioned themselves for continuous improvement. The results of the study provided an operating definitions of a company that is World Class.

- It is one which knows it process better than its competitors knows their processes.
- Knows its industry competitors better than its competitors
- Knows its customers better than its competitors.
- Responds more rapidly to customer behavior than competitors do
- Competes for market share on a customer by customer basis.

The lessons learnt and successfully applied by G.E. resulted in its polevaulting itself as the premier world organisation.

GE applied benchmarking in the area of Strategy which clearly shows the contribution of macro level benchmarking for developing long range plans. When Hindustan Lever Ltd., planned to penetrate into rural areas, it benchmarked its rural market against a beedi manufacturer.

F. Global Benchmarking:

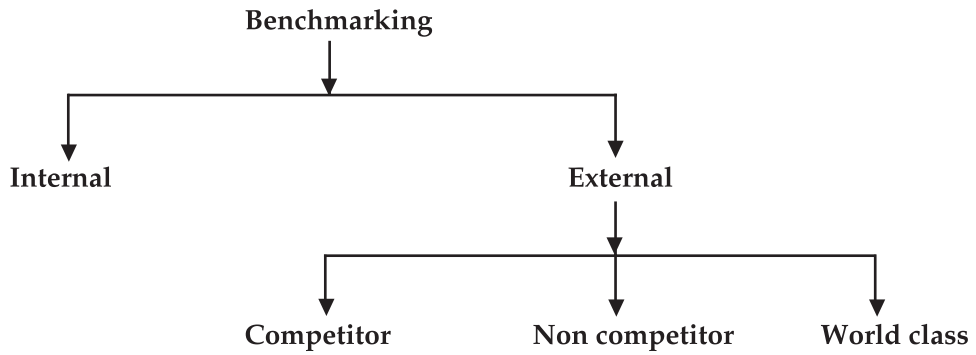
This is defined as "the extension of strategic benchmarking to include benchmarking partners on a global scale". A classic example of global benchmarking is given by Michael Hammer in his book "Re-engineering the corporation". He cites the example of Ford Company of US, which benchmarked its accounts payable function with that of Mazda in Japan and found to its astonishment that the entire function was managed by 5 persons as against 500 in Ford.

When Larsen & Toubro Ltd., the engineering and construction powerhouse wanted to enter the world market for projects, it deemed it fit to benchmark its project management skills with global rivals, Bechtel and Flour Daniel Corporation of US, assisted by McKinsy Co., Draughtsman were benchmarked for their CAD/CAM proficiency as well as their ability to handle bill of materials. Once gaps were identified, L & T used a combination of training and external recruitment to close them.

WAITRO (World Association of Industrial and Technological Research Organisation) in the year 1994 under took a global benchmarking exercise covering to R & D organisations from Asian, African, European and American subcontinents. The exercise focused on organisation processes and practices. The base idea was to deconstruct an organisation in terms of its various activities, which were termed as processes and from different R&D organisations information was collected on how these activities were carried out, which were termed as practices. As a R & D organisation is a knowledge generating organisation, any practice that facilitates this objective was considered a good practice and the ones which were deviating from the basic objective were considered as bad practice. In this way organizational processes and practices were analyzed and a set of practices for each of the processes were suggested as good / bad practices.

2.9.5 Benchmarking classification by nature of partnering organisations

This could be depicted as order



2.9.6 What to Benchmark?

Any process or activity, strategic or operational can be benchmarked. Its scope encompasses the entire gaunt of management. Xerox for instance has identified 67 business processes to a major business unit involved with sales, service and business operation under 10 broad groups. Xerox has identified 76 processes at a higher company-wide or enterprise level to cover the full spectrum of operations from product inception, design, engineering, manufacturing as well as customer delivery under 14 broad sub groups.

The choice of what to benchmark must naturally be guided by the critical success factor relevant to the business, that can be leveraged most for business improvement Prioritization is the vital first step in the whole exercise.

2.9.7 Sources for collecting information on Benchmarking

1. Management consulting organisation have set up data bases as mentioned below :

a. A.T. Kearney's Manufacturing Centre for Excellences.

b. Price Water houses Benchmarks Alliance

c. Arthur Andersons Global Best Practices Knowledge Base.

2. American Productivity and Quality Centre's, International Benchmarking Clearing House.
3. Industry Associations
4. Govt. Publications
5. Business Magazines
6. Market survey findings etc.

2.9.8 Does Benchmarking tantamount to Industrial Espionage

Benchmarking, it must be categorically stated is by no means synonymous with industrial espionage. The initiation of benchmarking study pre-supposes voluntary and willing co-operation between the benchmarking parties to open up their books on a reciprocal basis. It is implicitly understood that no information of proprietary or confidential nature will be parted and the sharing of information and experience is in total conformity with ethical conduct. In short, the benchmarking exercise should result in a win – win situation.

The APQC – IBC has drawn up a benchmarking code of conduct which sets forth the protocol of benchmarking – a set of conventions prescribing correct etiquette and procedures to be used in conducting benchmarking studies.

2.9.9 BENCHTRENDING

While the benefits of benchmarking are quite impressive, it results in the benchmarking partner to be forever in a catch up situation. The better partner will not stand still but will be booking continuously for ways to improve his own performance. To leapfrog it becomes imperative for an organisation to continuously do a P.E.S.T Scan – monitor the developments in the political, economic social and technological fronts and identify future gaps that may be created by significant market changes, customer preferences, innovation threats new entrants and other environmental variables critical to the long term success of the firm. Such trend studies are known as "bench trending" which is similar to benchmarking, but with a structural dimension.

There are two types of bench trending- Strategic Bench Trending is used to set direction for a business unit and Operations or Process Bench Trending which is used to identify technological trends and steps initiated to bridge the gaps in current performance levels.

The Steps in strategies bench trending are as follows:

1. Firstly the market is defined by determining its size, customer preferences, competitors and relative business position of the company within the market.
2. The industry direction, technology shifts, geopolitical changes, customer changes and potential threats from outside sources are assessed.
3. The strongest current and potential competitors are then determined by evaluating the trends in industry.
4. Data on performance of competitors is gathered and the current and future performance of the unit is compared with that of its competitor.
5. A performance baseline for the business units, is then established and the relative performance of current and projected competition is estimated.
6. A set of initiatives which form the basis of an improvement plan are identified to maintain strengths while reducing projected gaps.

For instance Indian Auto companies must plan to design their products to meet Euro III standards which will become the order of the day. Even a company like Microsoft was late in spotting the emergence of the internet, though it woke up in time to change gear and adapt to the requirements of the new technology. Pharma companies in US must take note of the changing demographic profile to develop medicines to meet the needs of ageing population.

To sum up, to effectively compete in the global market, companies should be adept at the techniques if not only benchmarking but more importantly, bench trending too.

Sources:

- Strategic Benchmarking – Gregory H. Watson
- Definitions are as given by Mr. Watson in the Glossary of Benchmarking Terms
- Management Control System by Joseph Maciariello & Calvin Kirby
- Organisation of R & D – An evaluation of best practices by Pradosh Nath & N. Mrinalini.
- Business Today – July 1996.

STUDY NOTE - 3

Cost Planning and Analysis for Competitive Advantage

This Study Note includes:

- Concept of Quality Function Deployment
- Value Analysis
- Target Costing
- Product Mix
- Life Cycle Costing
- Contribution Approach
- Break Even Analysis
- Learning Curve
- Strategic Cost Management
- Supply Chain Management

3.1 Quality Function Deployment

3.1.1 Introduction

Quality must be designed into the product, not inspected into it. Quality can be defined as meeting customer needs and pr-oviding superior value. This focus on satisfying the customer's needs places an emphasis on techniques such as Quality Function Deployment to help understand those needs and plan a product to provide superior value.

Quality Function Deployment (QFD) is a structured approach to defining customer needs or requirements and translating them into specific plans to produce products to meet those needs. The "voice of the customer" is the term to describe these stated and unstated customer needs or requirements. The voice of the customer is captured in a variety of ways: direct discussion or interviews, surveys, focus groups, customer specifications, observation, warranty data, field reports, etc. This understanding of the customer needs is then summarized in a product planning matrix or "house of quality". These matrices are used to translate higher level "what's" or needs into lower level "how's" - product requirements or technical characteristics to satisfy these needs.

While the Quality Function Deployment matrices are a good communication tool at each step in the process, the matrices are the means and not the end. The real value is in the process of communicating and decision-making with QFD. QFD is oriented toward involving a team of people representing the various functional departments that have involvement in product development: Marketing, Design Engineering, Quality Assurance, Manufacturing/ Manufacturing Engineering, Test Engineering, Finance, Product Support, etc.

The active involvement of these departments can lead to balanced consideration of the requirements or "what's" at each stage of this translation process and provide a mechanism to communicate hidden knowledge - knowledge that is known by one individual or department but may not otherwise be communicated through the organization. The structure of this methodology helps development personnel understand essential requirements, internal capabilities, and constraints and design the product so that everything is in place to achieve the desired outcome - a satisfied customer. Quality Function Deployment helps development personnel maintain a correct focus on true requirements and minimizes misinterpreting customer needs. As a result, QFD is an effective communications and a quality planning tool.

Capturing the Voice of the Customer

It is important to remember that there is no one monolithic voice of the customer. Customer voices are diverse. In consumer markets, there are a variety of different needs. Even within one buying unit, there are multiple customer voices (e.g., children versus parents). This applies to industrial and government markets as well. There are even multiple customer voices within a single organization: the voice of the procuring organization, the voice of the user, and the voice of the supporting or maintenance organization. These diverse voices must be considered, reconciled and balanced to develop a truly successful product. One technique to accomplish this is to use multiple columns for different priority ratings associated with each customer voice in the product planning matrix.

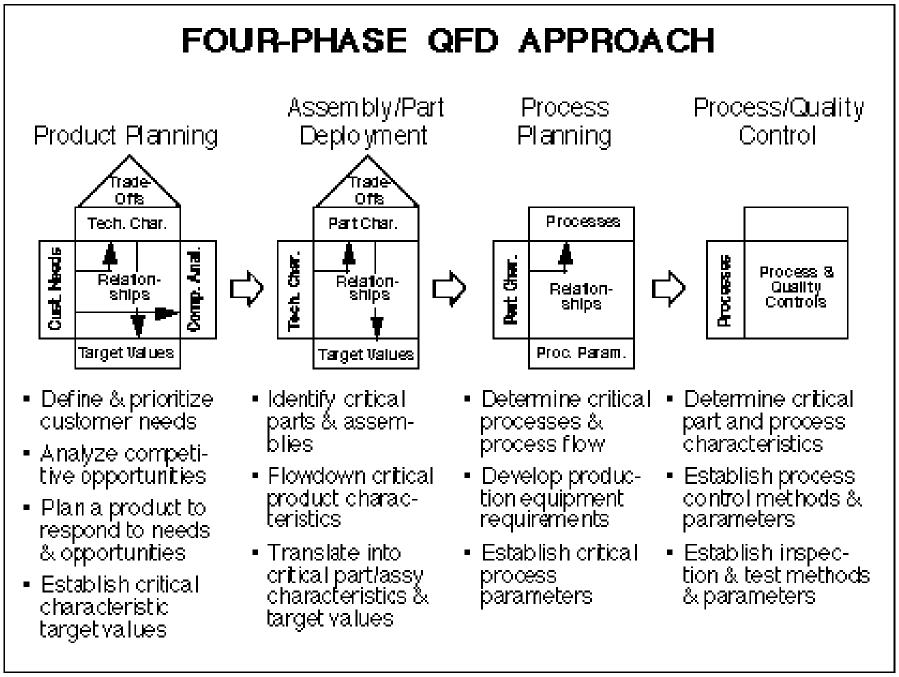
Quality Function Deployment requires that the basic customer needs are identified. Frequently, customers will try to express their needs in terms of "how" the need can be satisfied and not in terms of "what" the need is. This limits consideration of development alternatives. Development and marketing personnel should ask "why" until they truly understand what the root need is. Breakdown general requirements into more specific requirements by probing what is needed.

Once customer needs are gathered, they then have to be organized. The mass of interview notes, requirements documents, market research, and customer data needs to be distilled into a handful of statements that express key customer needs. Affinity diagramming is a useful tool to assist with this effort. Brief statements which capture key customer requirements are transcribed onto cards. A data dictionary which describes these statements of need are prepared to avoid any misinterpretation. These cards are organized into logical groupings or related needs. This will make it easier to identify any redundancy and serves as a basis for organizing the customer needs for the first QFD matrix.

In addition to "stated" or "spoken" customer needs, "unstated" or "unspoken" needs or opportunities should be identified. Needs that are assumed by customers and, therefore not verbalized, can be identified through preparation of a function tree. These needs normally are not included in the QFD matrix, unless it is important to maintain focus on one or more of these needs. Excitement opportunities (new capabilities or unspoken needs that will cause customer excitement) are identified through the voice of the engineer, marketing, or customer support representative. These can also be identified by observing customers use or maintain products and recognizing opportunities for improvement.

QFD Methodology Flow

The basic Quality Function Deployment methodology involves four basic phases that occur over the course of the product development process. During each phase one or more matrices are prepared to help plan and

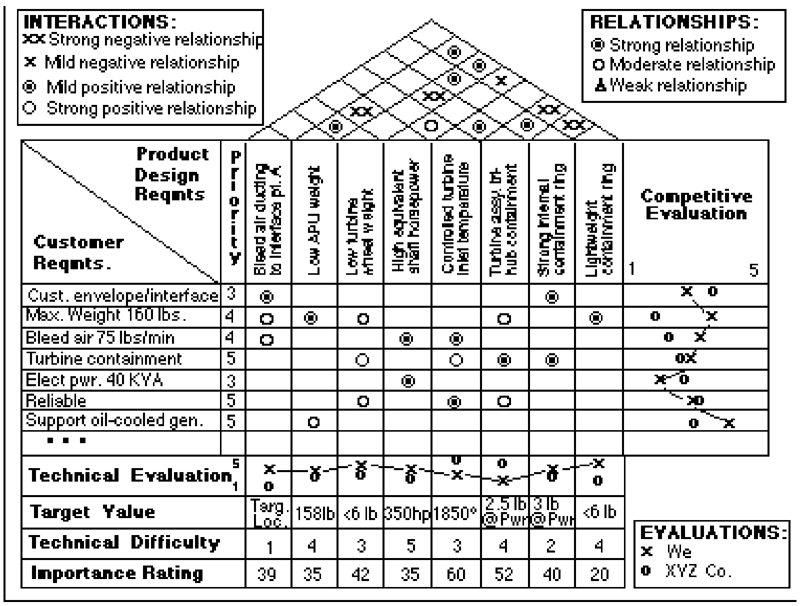


communicate critical product and process planning and design information. This QFD methodology flow is represented below.

Product Planning Using QFD

Once customer needs are identified, preparation of the product planning matrix or "house of quality" can begin. The sequence of preparing the product planning matrix is as follows:

1. Customer needs or requirements are stated on the left side of the matrix as shown below. These are organized by category based on the affinity diagrams. Insure the customer needs or requirements reflect the desired market segment(s). Address the unspoken needs (assumed and excitement capabilities). If the number of needs or requirements exceeds twenty to thirty items, decompose the matrix into smaller modules or subsystems to reduce the number of requirements in a matrix. For each need or requirement, state the customer priorities using a 1 to 5 rating. Use ranking techniques and paired comparisons to develop priorities.



2. Evaluate prior generation products against competitive products. Use surveys, customer meetings or focus groups/clinics to obtain feedback. Include competitor's customers to get a balanced perspective. Identify price points and market segments for products under evaluation. Identify warranty, service, reliability, and customer complaint problems to identify areas of improvement. Based on this, develop a product strategy. Consider the current strengths and weaknesses relative to the competition? How do these strengths and weaknesses compare to the customer priorities? Where does the gap need to be closed and how can this be done - copying the competition or using a new approach or technology? Identify opportunities for breakthrough's to exceed competitor's capabilities, areas for improvement to equal competitors capabilities, and areas where no improvement will be made. This strategy is important to focus development efforts where they will have the greatest payoff.

3. Establish product requirements or technical characteristics to respond to customer requirements and organize into related categories. Characteristics should be meaningful, measurable, and global. Characteristics should be stated in a way to avoid implying a particular technical solution so as not to constrain designers.

4. Develop relationships between customer requirements and product requirements or technical characteristics. Use symbols for strong, medium and weak relationships. Be sparing with the strong relationship symbol. Have all customer needs or requirement been addressed? Are there product requirements or technical characteristics stated that don't relate to customer needs?

5. Develop a technical evaluation of prior generation products and competitive products. Get access to competitive products to perform product or technical benchmarking. Perform this evaluation based on the defined product requirements or technical characteristics. Obtain other relevant data such as warranty or service repair occurrences and costs and consider this data in the technical evaluation.
6. Develop preliminary target values for product requirements or technical characteristics.
7. Determine potential positive and negative interactions between product requirements or technical characteristics using symbols for strong or medium, positive or negative relationships. Too many positive interactions suggest potential redundancy in "the critical few" product requirements or technical characteristics. Focus on negative interactions - consider product concepts or technology to overcome these potential tradeoff's or consider the tradeoff's in establishing target values.
8. Calculate importance ratings. Assign a weighting factor to relationship symbols (9-3-1, 4-2-1, or 5-3-1). Multiply the customer importance rating by the weighting factor in each box of the matrix and add the resulting products in each column.
9. Develop a difficulty rating (1 to 5 point scale, five being very difficult and risky) for each product requirement or technical characteristic. Consider technology maturity, personnel technical qualifications, business risk, manufacturing capability, supplier/subcontractor capability, cost, and schedule. Avoid too many difficult/high risk items as this will likely delay development and exceed budgets. Assess whether the difficult items can be accomplished within the project budget and schedule.
10. Analyze the matrix and finalize the product development strategy and product plans. Determine required actions and areas of focus. Finalize target values. Are target values properly set to reflect appropriate tradeoff's? Do target values need to be adjusted considering the difficulty rating? Are they realistic with respect to the price points, available technology, and the difficulty rating? Are they reasonable with respect to the importance ratings? Determine items for further QFD deployment. To maintain focus on "the critical few", less significant items may be ignored with the subsequent QFD matrices. Maintain the product planning matrix as customer requirements or conditions change.

One of the guidelines for successful QFD matrices is to keep the amount of information in each matrix at a manageable level. With a more complex product, if one hundred potential needs or requirements were identified, and these were translated into an equal or even greater number of product requirements or technical characteristics, there would be more than 10,000 potential relationships to plan and manage. This becomes an impossible number to comprehend and manage. It is suggested that an individual matrix not address more than twenty or thirty items on each dimension of the matrix. Therefore, a larger, more complex product should have its customers needs decomposed into hierarchical levels.

To summarize the initial process, a product plan is developed based on initial market research or requirements definition. If necessary, feasibility studies or research and development are undertaken to determine the feasibility of the product concept. Product requirements or technical characteristics are defined through the matrix, a business justification is prepared and approved, and product design then commences.

Concept Selection and Product Design

Once product planning is complete, a more complete specification may be prepared. The product requirements or technical characteristics and the product specification serve as the basis for developing product concepts. Product benchmarking, brainstorming, and research and development are sources for new product concepts. Once concepts are developed, they are analyzed and evaluated. Cost studies and trade studies are performed. The concept selection matrix can be used to help with this evaluation process.

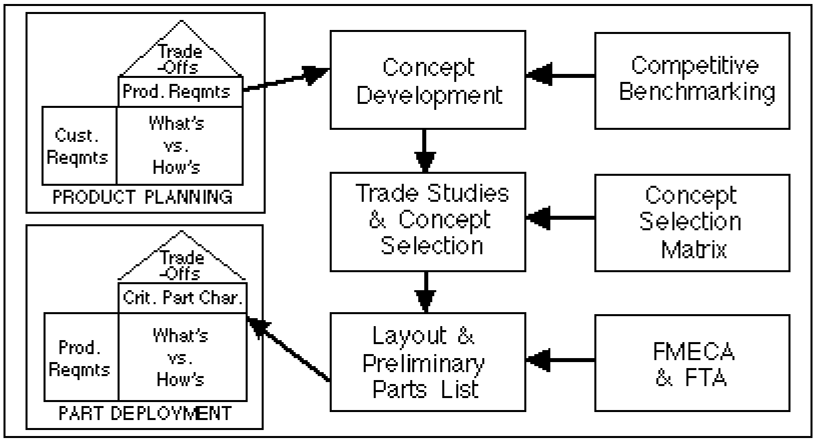
The concept selection matrix shown below lists the product requirements or technical characteristics down the left side of the matrix.

Criteria	Importance Rating	Concept A	Concept B	Concept C
Low APU Weight	4	◉ 20	○ 12	○ 12
Low turbine wheel weight	4	◉ 20	○ 12	◉ 20
Controlled turbine inlet temperature	6	○ 18	◉ 30	△ 6
Acceptable turbine assembly life	5	○ 15	◉ 25	○ 15
Turbine assy tri-hub containment	5	◉ 25	◉ 25	○ 15
High equivalent shaft horsepower	4	△ 4	◉ 20	◉ 20
Strong internal containment ring	4	○ 12	◉ 20	○ 12
Total		114	144	100

These serve as evaluation criteria. The importance rating and target values (not shown) are also carried forward and normalized from the product planning matrix. Product concepts are listed across the top. The various product concepts are evaluated on how well they satisfy each criteria in the left column using the QFD symbols for strong, moderate or weak. If the product concept does not satisfy the criteria, the column is left blank. The symbol weights (5-3-1) are multiplied by the importance rating for each criteria. These weighted factors are then added for each column. The preferred concept will have the highest total. This concept selection technique is also a design synthesis technique. For each blank or weak symbol in the preferred concept's column, other concept approaches with strong or moderate symbols for that criteria are reviewed to see if a new approach can be synthesized by borrowing part of another concept approach to improve on the preferred approach.

Based on this and other evaluation steps, a product concept is selected. The product concept is represented with block diagrams or a design layout. Critical subsystems, modules or parts are identified from the layout. Criticality is determined in terms of effect on performance, reliability, and quality. Techniques such as fault tree analysis or failure modes and effects analysis (FMEA) can be used to determine criticality from a reliability or quality perspective.

The subsystem, assembly, or part deployment matrix is then prepared. The process leading up to the preparation of the deployment matrix is depicted below.



The product requirements or technical characteristics defined in the product planning matrix become the "what's" that are listed down the left side of the deployment matrix along with priorities (based on the product planning matrix importance ratings) and target values. The deployment matrix is prepared in a manner very similar to the product planning matrix. These product requirements or technical characteristics are translated into critical subsystem, assembly or part characteristics. This translation considers criticality of the subsystem, assembly or parts as well as their characteristics from a performance perspective to complement consideration of criticality from a quality and reliability perspective. Relationships are established between product requirements or technical characteristics and the critical subsystem, assembly or part characteristics. Importance ratings are calculated and target values for each critical subsystem, assembly or part characteristic are established. An example of a part/assembly deployment matrix is shown:

Product Design Requirements	Priority	Critical Part Char. / Targ. Value	Turbine wheel					Combustor			
			Balanced	Surface finish	Backface geometry	Grain refinement	Airfoil geo. & thickness	Material	Liner pattern factor	Nozzle throat area	...
Low APU Weight	4	158 lb					◉	○			
Low turbine wheel weight	5	48 lb			○	◉	○				
Controlled turbine inlet temperature	6	1850° max				○			◉	◉	
Acceptable turbine assembly life	3	3,000 hrs	⊜		⊜	⊜	⊜	⊜	⊜		
Turbine assy tri-hub containment	4	25 lb @ PW		◉	◉	◉		○		○	
High equivalent shaft horsepower	4	350 hp		◉		○				◉	
Importance Rating			15	40	35	90	50	39			

◉ Strong relationship
○ Mild relationship

Process Design

Quality Function Deployment continues this translation and planning into the process design phase. A concept selection matrix can be used to evaluate different manufacturing process approaches and select the preferred approach. Based on this, the process planning matrix shown below is prepared.

Critical Process Steps \ Critical Part Characteristics	Turbine wheel: Balanced	Turbine wheel: Surface finish	Turbine wheel: Backface geometry	Turbine wheel: Grain refinement	Turbine wheel: Airfoil geo. & thickness	Rating	Part Control Parameters
Priority	2	4	4	9	5		
Mold preparation	○	⊗			⊗	51	- surface finish - Airfoil geometry
Hot isostatic pressure casting	○	⊗		⊗	⊗	96	- surface finish - inclusions, cracks, porosity - Blade tip fill
Mass center balancing	◉					10	- Machine centers
Turbine tip OD & shroud line contour machining		○				12	- Outer diameter - Profile geometry - surface finish
Low stress grind - backface	○	⊗	◉			46	- Backface geometry - surface finish

Other Data:

- Equipment
- Location
- Tooling

Again, the "how's" from the higher level matrix (in this case the critical subsystem, assembly or part characteristics) become the "what's" which are used to plan the process for fabricating and assembling the product. Important processes and tooling requirements can be identified to focus efforts to control, improve and upgrade processes and equipment. At this stage, communication between Engineering and Manufacturing is emphasized and tradeoff's can be made as appropriate to achieve mutual goals based on the customer needs.

In addition to planning manufacturing processes, more detailed planning related to process control, quality control, set-up, equipment maintenance and testing can be supported by additional matrices. The following provides an example of a process/quality control matrix.

Critical Process Steps	Process Control Parameters	Control Points	Control Method	Sample Size & Freq.	Check Method
Hot isostatic presurre casting	Mat'l temp. Mold temp. Remelt %	Mat'l prop. Heat treat FPI	Cert.	100%	N/A
Mass center balancing	Balance mach. calibration Speed	Detailed balance	Cert.	100%	N/A
Turbine tip OD & shroud line contour machining	Set-up Speeds & feeds Tool wear	Dim. insp. Surface finish	X bar & R chart	4 pieces/ lot	Elect. gage Check fixture Visual
Low stress grind - backface	Speeds & feeds Diamond dressed wheel	Dim. insp. Surface finish	N/A	100%	CMM Visual
Florescent penetrant insp. & proof spin	Speed	Cracks Inclusions O.D.	N/A	100%	Visual Spin test

The process steps developed in the process planning matrix are used as the basis for planning and defining specific process and quality control steps in this matrix.

The result of this planning and decision-making is that Manufacturing focuses on the critical processes, dimensions and characteristics that will have a significant effect on producing a product that meets customers needs. There is a clear trail from customer needs to the design and manufacturing decisions to satisfy those customer needs. Disagreements over what is important at each stage of the development process should be minimized, and there will be greater focus on "the critical few" items that affect the success of the product.

Quality Function Deployment (QFD) Process

Quality Function Deployment begins with product planning; continues with product design and process design; and finishes with process control, quality control, testing, equipment maintenance, and training. As a result, this process requires multiple functional disciplines to adequately address this range of activities. QFD is synergistic with multi-function product development teams. It can provide a structured process for these teams to begin communicating, making decisions and planning the product. It is a useful methodology, along with product development teams, to support a concurrent engineering or integrated product development approach .

Quality Function Deployment, by its very structure and planning approach, requires that more time be spent up-front in the development process making sure that the team determines, understands and agrees with what needs to be done before plunging into design activities. As a result, less time will be spent downstream because of differences of opinion over design issues or redesign because the product was not on target. It leads to consensus decisions, greater commitment to the development effort, better coordination, and reduced time over the course of the development effort.

QFD requires discipline. It is not necessarily easy to get started with. The following is a list of recommendations to facilitate initially using QFD.

- Obtain management commitment to use QFD.
- Establish clear objectives and scope of QFD use. Avoid first using it on a large, complex project if possible. Will it be used for the overall product or applied to a subsystem, module, assembly or critical part? Will the complete QFD methodology be used or will only the product planning matrix be completed?
- Establish multi-functional team. Get an adequate time commitment from team members.
- Obtain QFD training with practical hands-on exercises to learn the methodology and use a facilitator to guide the initial efforts.
- Schedule regular meetings to maintain focus and avoid the crush of the development schedule overshadowing effective planning and decision-making.
- Avoid gathering perfect data. Many times significant customer insights and data exist within the organization, but they are in the form of hidden knowledge - not communicated to people with the need for this information. On the other hand, it may be necessary to spend additional time gathering the voice of the customer before beginning QFD. Avoid technical arrogance and the belief that company personnel know more than the customer.

Quality Function Deployment is an extremely useful methodology to facilitate communication, planning, and decision-making within a product development team. It is not a paperwork exercise or additional documentation that must be completed in order to proceed to the next development milestone. It not only brings the new product closer to the intended target, but reduces development cycle time and cost in the process.

Source : www.npd-solutions.com/qfd.html

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3.2 Value Analysis

3.2.1 Introduction

The term "value" has four different meanings

Cost Value – the summation of material labour overheads and all other elements of cost required to produce an item or provide a service

Use Value – the properties and qualities which accomplish a use, work or service compared to a base. The use value is equal to the value of the functions performed.

Esteem Value – the properties, features or attractiveness which create a desire to possess the article but are not necessarily required so far as functional performance is concerned

Exchange Value – the properties or qualities which will remain attractive enough to other people to permit market resale in the future

Value Matrix		
Product	Use Value	Esteem Value
Brief Case	Hold things	Improve image
Color cement	Protect surface	Provide aesthetics
Wrist Watch	Show time	Enhance prestige

The Value Equation

Value = (Performance + Capability)/Cost = Function/Cost

Value is not a matter of minimizing cost. In some cases the value of a product can be increased by increasing its function (performance or capability) and cost as long as the added function increases more than its added cost. The concept of functional worth can be important. Functional worth is the lowest cost to provide a given function. However, there are less tangible "selling" functions involved in a product to make it of value to a customer.

Detailed explanation of Value Analysis technique is given in 3.2.2.

3.2.2 History Value Analysis

Lawrence Miles conceived of Value Analysis (VA) in the 1945 based on the application of function analysis to the component parts of a product. Component cost reduction was an effective and popular way to improve "value" when direct labor and material cost determined the success of a product. The value analysis technique supported cost reduction activities by relating the cost of components to their function contributions.

Value analysis defines a "basic function" as anything that makes the product work or sell. A function that is defined as "basic" cannot change. Secondary functions, also called "supporting functions", described the manner in which the basic function(s) were implemented. Secondary functions could be modified or eliminated to reduce product cost.

As VA progressed to larger and more complex products and systems, emphasis shifted to "upstream" product development activities where VA can be more effectively applied to a product before it reaches the production phase. However, as products have become more complex and sophisticated, the technique needed to be adapted to the "systems" approach that is involved in many products today. As a result, value analysis evolved into the "Function Analysis System Technique" (FAST) which is discussed later.

The Value Analysis Method

In all problem-solving techniques, we are trying to change a condition by means of a solution that is unique and relevant. If we describe in detail what we are trying to accomplish, we tend to describe a solution and miss the opportunity to engage in divergent thinking about other alternatives. When trying to describe problems that affect us, we become locked in to a course of action without realizing it, because of our own bias. Conversely, the more abstractly we can define the function of what we are trying to accomplish, the more opportunities we will have for divergent thinking.

This high level of abstraction can be achieved by describing what is to be accomplished with a verb and a noun. In this discipline, the verb answers the question, "What is to be done?" or, "What is it to do?" The verb defines the required action. The noun answers the question, "What is it being done to?" The noun tells what is acted upon. Identifying the function by a verb-noun is not as simple a matter as it appears.

Identifying the function in the broadest possible terms provides the greatest potential for divergent thinking because it gives the greatest freedom for creatively developing alternatives. A function should be identified as to what is to be accomplished by a solution and not how it is to be accomplished. How the function is identified determines the scope, or range of solutions that can be considered.

Those functions designated as "basic" represent the operative function of the item or product and must be maintained and protected. Determining the basic function of single components can be relatively simple. By definition then, functions designated as "basic" will not change, but the way those functions are implemented is open to innovative speculation.

As important as the basic function is to the success of any product, the cost to perform that function is inversely proportional to its importance. This is not an absolute rule, but rather an observation of the consumer products market. Few people purchase consumer products based on performance or the lowest cost of basic functions alone. When purchasing a product it is assumed that the basic function is operative. The customer's attention is then directed to those visible secondary support functions, or product features, which determine the worth of the product. From a product design point of view, products that are perceived to have high value first address the basic function's performance and stress the achievement of all of the performance attributes. Once the basic functions are satisfied, the designer's then address the secondary functions necessary to attract customers. Secondary functions are incorporated in the product as features to support and enhance the basic function and help sell the product. The elimination of secondary functions that are not very important to the customer will reduce product cost and increase value without detracting from the worth of the product.

The cost contribution of the basic function does not, by itself, establish the value of the product. Few products are sold on the basis of their basic function alone. If this were so, the market for "no name" brands would be more popular than it is today. Although the cost contribution of the basic function is relatively small, its loss will cause the loss of the market value of the product.

One objective of value analysis or function analysis, to improve value by reducing the cost-function relationship of a product, is achieved by eliminating or combining as many secondary functions as possible.

Value Analysis Process

The first step in the value analysis process is to define the problem and its scope. Once this is done, the functions of the product and its items are derived. These functions are classified into “basic” and “secondary” functions. A Cost Function Matrix or Value Analysis Matrix is prepared to identify the cost of providing each function by associating the function with a mechanism or component part of a product. Product functions with a high cost-function ratio are identified as opportunities for further investigation and improvement. Improvement opportunities are then brainstormed, analyzed, and selected.

The objective of the Function Cost Matrix approach is to draw the attention of the analysts away from the cost of components and focus their attention on the cost contribution of the functions. The Function Cost Matrix displays the components of the product, and the cost of those components, along the left vertical side of the graph. The top horizontal legend contains the functions performed by those components. Each component is then examined to determine how many functions that component performs, and the cost contributions of those functions.

Detailed cost estimates become more important following function analysis, when evaluating value improvement proposals. The total cost and percent contribution of the functions of the item under study will guide the team, or analyst, in selecting which functions to select for value improvement analysis.

A variation of the Function-Cost Matrix is the Value Analysis Matrix. This matrix was derived from the Quality Function Deployment (QFD) methodology. It is more powerful in two ways. First, it associates functions back to customer needs or requirements. In doing this, it carries forward an importance rating to associate with these functions based on the original customer needs or requirements. Functions are then related to mechanisms, the same as with the Function-Cost Matrix. Mechanisms are related to functions as either strongly, moderately or weakly supporting the given function. This relationship is noted with the standard QFD relationship symbols. The associated weighting factor is multiplied by customer or function importance and each columns value is added.

These totals are normalized to calculate each mechanism’s relative weight in satisfying the designated functions. This is where the second difference with the Function-Cost Matrix arises. This mechanism weight can then be used as the basis to allocate the overall item or product cost. The mechanism target costs can be compared with the actual or estimated costs to see where costs are out of line with the value of that mechanism as derived from customer requirements and function analysis.

Function Analysis System Technique

Function Analysis System Technique is an evolution of the value analysis process created by Charles Bytheway. FAST permits people with different technical backgrounds to effectively communicate and resolve issues that require multi-disciplined considerations. FAST builds upon VA by linking the simply expressed, verb-noun functions to describe complex systems.

FAST is not an end product or result, but rather a beginning. It describes the item or system under study and causes the team to think through the functions that the item or system performs, forming the basis for a wide variety of subsequent approaches and analysis techniques. FAST contributes significantly to perhaps the most important phase of value engineering: function analysis. FAST is a creative stimulus to explore innovative avenues for performing functions.

The FAST diagram or model is an excellent communications vehicle. Using the verb-noun rules in function analysis creates a common language, crossing all disciplines and technologies. It allows multi-disciplined team members to contribute equally and communicate with one another while addressing the problem objectively without bias or preconceived conclusions. With FAST, there are no right or wrong model or result. The problem should be structured until the product development team members are satisfied that the real problem is identified. After agreeing on the problem statement, the single most important output of the multi-disciplined team engaged in developing a FAST model is consensus. Since the team has been charged with the responsibility of resolving the assigned problem, it is their interpretation of the FAST model that reflects the problem statement that's important. The team members must discuss and reconfigure the FAST model until consensus is reached and all participating team members are satisfied that their concerns are expressed in the model. Once consensus has been achieved, the FAST model is complete and the team can move on to the next creative phase.

FAST differs from value analysis in the use of intuitive logic to determine and test function dependencies and the graphical display of the system in a function dependency diagram or model. Another major difference is in analyzing a system as a complete unit, rather than analyzing the components of a system. When studying systems it becomes apparent that functions do not operate in a random or independent fashion. A system exists because functions form dependency links with other functions, just as components form a dependency link with other components to make the system work. The importance of the FAST approach is that it graphically displays function dependencies and creates a process to study function links while exploring options to develop improved systems.

There are normally two types of FAST diagrams, the technical FAST diagram and the customer FAST diagram. A technical FAST diagram is used to understand the technical aspects of a specific portion of a total product. A customer FAST diagram focuses on the aspects of a product that the customer cares about and does not delve into the technicalities, mechanics or physics of the product. A customer FAST diagram is usually applied to a total product.

Creating a Fast Model

The FAST model has a horizontal directional orientation described as the HOW-WHY dimension. This dimension is described in this manner because HOW and WHY questions are asked to structure the logic of the system's functions. Starting with a function, we ask HOW that function is performed to develop a more specific approach. This line of questioning and thinking is read from left to right. To abstract the problem to a higher level, we ask WHY is that function performed. This line of logic is read from right to left.

There is essential logic associated with the FAST HOW-WHY directional orientation. First, when undertaking any task it is best to start with the goals of the task, then explore methods to achieve the goals. When addressing any function on the FAST model with the question WHY, the function to its left expresses the goal of that function. The question HOW, is answered by the function on the right, and is a method to perform that function being addressed. A systems diagram starts at the beginning of the system and ends with its goal. A FAST model, reading from left to right, starts with the goal, and ends at the beginning of the "system" that will achieve that goal.

Second, changing a function on the HOW-WHY path affects all of the functions to the right of that function. This is a domino effect that only goes one way, from left to right. Starting with any place on the FAST model, if a function is changed the goals are still valid (functions to the left), but the method to accomplish that function, and all other functions on the right, are affected.

Finally, building the model in the HOW direction, or function justification, will focus the team's attention on each function element of the model. Whereas, reversing the FAST model and building it in its system orientation will cause the team to leap over individual functions and focus on the system, leaving function "gaps" in the system. A good rule to remember in constructing a FAST Model is to build in the HOW direction and test the logic in the WHY direction.

The vertical orientation of the FAST model is described as the WHEN direction. This is not part of the intuitive logic process, but it supplements intuitive thinking. WHEN is not a time orientation, but indicates cause and effect.

Scope lines represent the boundaries of the study and are shown as two vertical lines on the FAST model. The scope lines bound the "scope of the study", or that aspect of the problem with which the study team is concerned. The left scope line determines the basic function(s) of the study. The basic functions will always be the first function(s) to the immediate right of the left scope line. The right scope line identifies the beginning of the study and separates the input function(s) from the scope of the study.

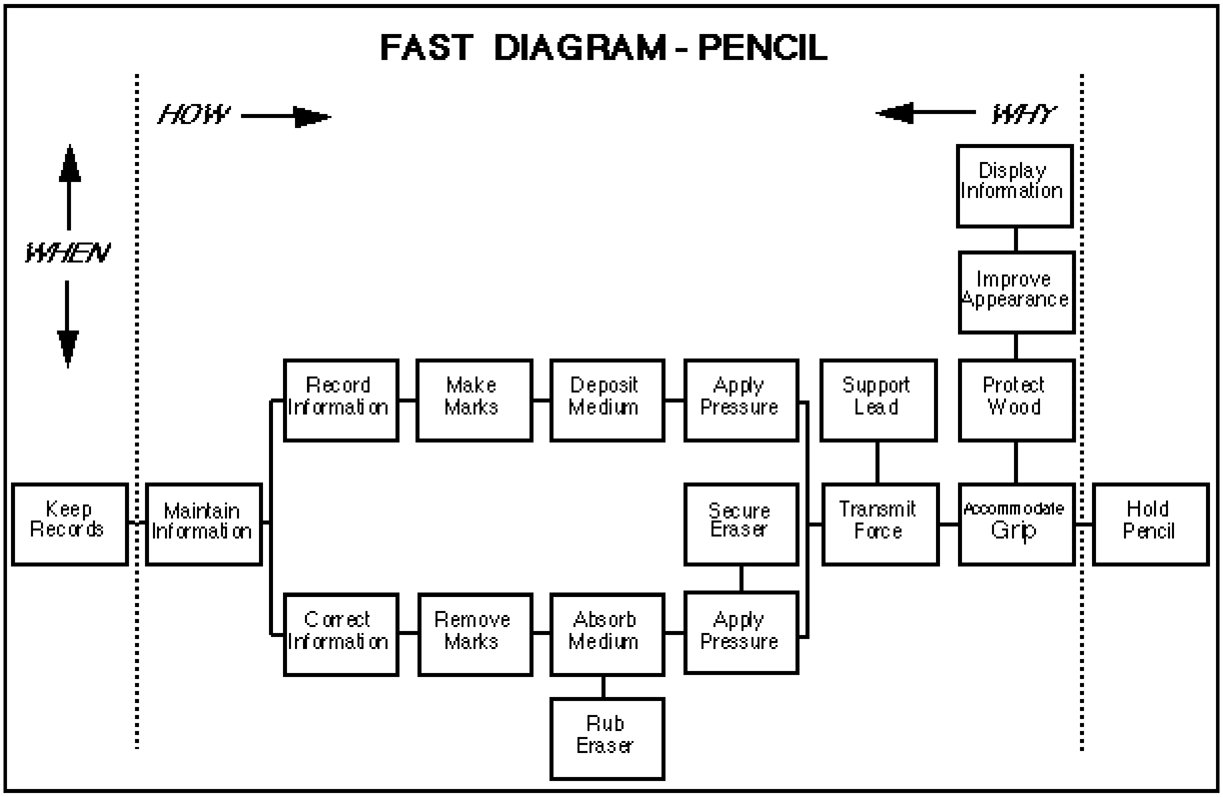
The objective or goal of the study is called the "Highest Order Function", located to the left of the basic function(s) and outside of the left scope line. Any function to the left of another function is a "higher order function". Functions to the right and outside of the right scope line represent the input side that "turn on" or initiate the subject under study and are known as lowest order functions. Any function to the right of another function is a "lower order" function and represents a method selected to carry out the function being addressed.

Those function(s) to the immediate right of the left scope line represent the purpose or mission of the product or process under study and are called Basic Function(s). Once determined, the basic function will not change. If the basic function fails, the product or process will lose its market value.

All functions to the right of the basic function(s) portray the conceptual approach selected to satisfy the basic function. The concept describes the method being considered, or elected, to achieve the basic function(s). The concept can represent either the current conditions (as is) or proposed approach (to be). As a general rule, it is best to create a "to be" rather than an "as is" FAST Model, even if the assignment is to improve an existing product. This approach will give the product development team members an opportunity to compare the "ideal" to the "current" and help resolve how to implement the differences. Working from an "as is" model will restrict the team's attention to incremental improvement opportunities. An "as is" model is useful for tracing the symptoms of a problem to its root cause, and exploring ways to resolve the problem, because of the dependent relationship of functions that form the FAST model.

Any function on the HOW-WHY logic path is a logic path function. If the functions along the WHY direction lead into the basic function(s), than they are located on the major logic path. If the WHY path does not lead directly to the basic function, it is a minor logic path. Changing a function on the major logic path will alter or destroy the way the basic function is performed. Changing a function on a minor logic path will disturb an independent (supporting) function that enhances the basic function. Supporting functions are usually secondary and exist to achieve the performance levels specified in the objectives or specifications of the basic functions or because a particular approach was chosen to implement the basic function(s).

Independent functions describe an enhancement or control of a function located on the logic path. They do not depend on another function or method selected to perform that function. Independent functions are located above the logic path function(s), and are considered secondary, with respect to the scope, nature, level of the problem, and its logic path. An example of a FAST Diagram for a pencil is shown below.



Adapted from an example developed by J. Jerry Kaufman

The next step in the process is to dimension the FAST model or to associate information to its functions. FAST dimensions include, but are not limited to: responsibility, budgets, allocated target costs, estimated costs, actual costs, subsystem groupings, placing inspection and test points, manufacturing processes, positioning design reviews, and others. There are many ways to dimension a FAST model. The two popular ways are called Clustering Functions and the Sensitivity Matrix.

Clustering functions involves drawing boundaries with dotted lines around groups of functions to configure sub-systems. Clustering functions is a good way to illustrate cost reduction targets and assign design-to-cost targets to new design concepts. For cost reduction, a team would develop an "as is" product FAST model, cluster the functions into subsystems, allocate product cost by clustered functions, and assign target costs. During the process of creating the model, customer sensitivity functions can be identified as well as opportunities for significant cost improvements in design and production.

Following the completion of the model, the subsystems can be divided among product development teams assigned to achieve the target cost reductions. The teams can then select cost sensitive sub-systems and expand them by moving that segment of the model to a lower level of abstraction. This exposes the detail components of that assembly and their function/cost contributions.

Integrating QFD with Fast

A powerful analysis method is created when FAST is used in conjunction with QFD. QFD enables the uses of the Value Analysis Matrix. An example of a value analysis matrix for the pencil example is shown below.

Customer Requirements/ Functions	Importance	Mechanisms				
		Lead	Eraser	Body	Paint	Band
Make Marks	30	⊙ 150				
Remove Marks	20		⊙ 100			
Prevent Smudges	15	o 45		o 45		
Support Lead	5			⊙ 25		
Improve Appearance	10			o 30	o 30	Δ 10
Accomodate Grip	20			⊙ 100	Δ 20	
Column weight	555	195	100	200	50	10
Mech. weight	1.0	.351	.180	.360	.090	.018
Mech. target cost	2.80	.98	.51	1.01	.25	.05
Mech. actual cost	2.92	1.20	.43	.94	.10	.25

⊙ Strong correlation weight factor = 5

o Moderate correlation weight factor = 3

Δ Weak correlation weight factor = 1

The steps for using these two methodologies are as follows:

1. Capture customer requirements and perform QFD product planning with the product planning matrix. Translate customer needs into directly into verb-noun functions or use a second matrix to translate technical characteristics into verb-noun functions.

2. Prepare a FAST diagram and develop the product concept in conjunction with the QFD concept selection matrix. Review the verb-noun functions in the QFD matrix and assure that they are included in the FAST diagram. Revise verb-noun function descriptions if necessary to assure consistency between the QFD matrix and the FAST diagram.

3. Dimension the system in the FAST diagram into subsystems/assemblies/parts. These are generically referred to as mechanisms.

4. Develop value analysis matrix at system level. The "what's" or system requirements/function in the value analysis matrix are derived from either a customer (vs. technical) FAST diagram or by selecting those function statements that correspond to the customer needs or technical characteristics in the product planning matrix. The importance rating is derived from the product planning matrix as well.

5. Complete the value analysis matrix by relating the mechanisms to the customer requirements/ functions and calculate the associated weight. Summarize the column weights and normalize to

create mechanism weights. Allocate the target cost based on the mechanism weights. This represents the value to the customer based on the customer importance. Compare with either estimated costs based on the product concept or actual costs if available.

6. Identify high cost to value mechanisms / subsystems by comparing the mechanism target costs to the mechanism estimated/actual costs

A product or system such as an automobile contains a great many components and would result in an extremely complex FAST model. The complexity of the process is not governed by the number of components in a product, but the level of abstraction selected to perform the analysis. With an automobile, a high level of abstraction could contain the major subsystems as the components under study, such as: the power train, chassis, electrical system, passenger compartment, etc. The result of the FAST model and supporting cost analysis might then focus the team's attention on the power train for further analysis. Moving to a lower level of abstraction, the power train could then be divided into its components (engine, transmission, drive shaft, etc.) for a more detailed analysis.

In other words, the concept of decomposition is applied to a FAST model. The initial FAST model will stay at a high level of abstraction. Starting at a higher level of abstraction allows for uncluttered macro analysis of the overall problem until those key functions can be found, isolated, and the key issues identified. If a function is identified for further study, we note that with a "^" below the function box. A supporting FAST diagram is then created for that subsystem function. This process of decomposition or moving to lower levels of abstraction could be carried down several levels if appropriate.

Once high cost to value mechanisms are identified in the initial system value analysis matrix, the next step is to focus more attention on those mechanisms and associated functions. Dimensioning groups the functions together into those associated with a particular subsystem, assembly or part. The FAST diagram can be expanded into a lower level of abstraction in the area under investigation. The steps involved are as follows:

1. Use QFD to translate higher-level customer needs to subsystem technical characteristics.
2. Create FAST diagram at lower level of abstraction for targeted mechanism/subsystem.
3. Prepare a FAST diagram and develop the product concept in conjunction with the QFD concept selection matrix
4. Dimension the system in the FAST diagram into assemblies/parts or identify the assemblies/parts needed to perform the given function.
5. Develop value analysis matrix at a lower level of abstraction for the targeted subsystem. The "what's" or system requirements/function in the value analysis matrix are derived from either a customer (vs. technical) FAST diagram or by selecting those function statements that correspond to the customer needs or technical characteristics in the subsystem planning matrix.
6. Complete the value analysis matrix and identify high cost to value mechanisms by comparing the mechanism target costs to the mechanism estimated/actual costs.

Value Improvement Process

Performing value analysis or producing the FAST model and analyzing functions with the value analysis matrix are only the first steps in the process. The real work begins with brainstorming, developing and analyzing potential improvements in the product. These subsequent steps are supported by:

- The QFD Concept Selection Matrix is a powerful tool to evaluate various concept and design alternatives based on a set of weighted criteria that ultimately tie back to customer needs.
- Benchmarking competitors and other similar products helps to see new ways functions can be performed and breaks down some of the not-invented-here paradigms.
- Product cost and life cycle cost models support the estimating of cost for the Function-Cost and Value Analysis Matrices and aid in the evaluation of various product concepts.
- Technology evaluation is leads us to new ways that basic functions can be performed in a better or less costly way. Concept development should involve people with a knowledge of new technology development and an open mind to identify how this technology might relate to product functions that need to be performed. Methods such as the theory of inventive problem solving or TRIZ are useful in this regard.
- Design for Manufacturability/Assembly principles provide guidance on how to better design components and assemblies that are more manufacturability and, as a result, are lower in cost.

Value Analysis or Function Analysis provide the methods to identify the problem and to begin to define the functions that need to be performed. As we proceed in developing a FAST model, implicit in this process is developing a concept of operation for the product which is represented by all of the lower order functions in a FAST diagram.

Concept alternatives will be developed through brainstorming, benchmarking other products performing similar functions, and surveying and applying new technology. Since multiple concepts need to be evaluated, we want to use a higher level of abstraction for the FAST model to provide us with the greatest flexibility and a minimum level of effort. Trade studies and technical analysis will be performed to evaluate various product concepts. A concept selection matrix is a good tool to summarize a variety of different data and support making a decision about the preferred concept.

All of these steps may be iterative as a preferred concept evolves and gets more fully developed. In addition, there should be a thorough evaluation of whether all functions are needed or if there is a different way of accomplishing a function as the concept is developed to a lower level of abstraction. When a Function Cost or Value Analysis Matrix is prepared, functions that are out of balance with their worth are identified, further challenging the team to explore different approaches.

Summary

Value analysis and its more robust cousin, Function Analysis System Technique, are important analysis tools. These methodologies lead to improved product designs and lower costs by:

- Providing a method of communication within a product development team and achieving team consensus
- Facilitating flexibility in thinking and exploring multiple concepts
- Focusing on essential functions to fulfill product requirements
- Identifying high cost functions to explore improvements

Source:

VALUE ANALYSIS AND FUNCTION ANALYSIS SYSTEM TECHNIQUE

Adapted by Kenneth Crow, DRM Associates

3.3. Target Costing

3.3.1 Introduction

Today's economy is market driven and the consumer is sovereign. He/she has become more discerning, demanding quality products of myriad variety and that too at competitive prices. Customer focus has become imperative for survival.

These developments have forced a rethinking on conventional cost management approaches and led to the evolution of target cost management. It is a philosophy in which product development is based on what the customer wants and is willing to pay for and not what it costs to produce. Hence start with the market determined price; then deduct the desired profit margin; and work back the target cost. Peter Drucker calls this "price-led costing."

Target Cost = Target Price – Target Profit

And not

Cost + Profit = Selling Price

3.3.2 History of Target Cost

Akio Morita is credited with pioneering this cost approach when he led the development of Walkman as a portable, pocketable and affordable musical gadget. Rattan Tata's development of Nano is a recent illustration of an affordable price of Rupees One Lakh being fixed initially and the engineers working to achieve this goal.

Number of industries in the auto sector, consumer electronics, aircraft and engineering have profited by applying target costing.

3.3.3 Definition of Target Cost Management

"Target Cost Management is a management technology using scientific principles and technologies to establish a cost target, breakdown the cost target and improve cost. It adopts these technologies through the development and design phases in order to achieve product specification cost within the cost targets that are included in life cycle cost; development, design, manufacturing, distribution, sales, usage and disposal costs".

Vide contemporary Cost Management by Masayasu Tanaka, Takeo Yoshikawa, John Innes and Falconer Mitchell.

Here is a simpler definition:

"Target Costing is a structured approach for determining the cost at which a product with a specific functionality and quality must be produced to generate the desired level of profitability." Business Today

3.3.4 Steps in development of target cost

1. Ascertainment of customer requirements
2. Product planning
3. Concept design
4. Basic design
5. Detailed design
6. Manufacturing preparation

3.3.4.1 Customer Requirements

- Gather market information about the perceptions of the customer regarding product characteristics and also his expectations about price, quality, product performance, technology etc.
- Data can be obtained through market research, customer survey, sales force feedback, comparison with competitors for existing product etc.

3.3.4.2 Product Planning

Net product planning is summarized in a document which defines and clarifies the design requirements. Usually it contains.

- Outline of the mission and concept of the product.
- Primary performance specifications and design schedule, manufacturing and marketing activities for the products.
- Cost target, selling price, sales volume and profitability study of the product.

3.3.4.3 Concept Design

At this stage we formulate the basic concept, normal selling price and attainable cost target of the new product on the basis of design requirements. Usually it consists of the following items:

- Formulation of main function areas.
- Assignment of cost target to the top level function areas.
- Designing the basic concept of the product under the assigned cost target.
- Ascertaining whether or not the basic concept of the product is designed to fit the cost target by using rough cost estimation.
- Profitability study of the product.

3.3.4.4 Basic Design

The focus of this stage is to construct a general drawing of the product based on the cost target. It is composed of the following items.

- Assignment of the cost target to the top and middle function areas or main components.
- Framing a general drawing under the cost target.
- Ascertaining whether or not the general drawing of the product is designed to fit the cost target by making use of the rough cost estimation.

3.3.4.5 Detailed Design

At this stage we draw up the manufacturing specification of the product on the basis of the framework of the general drawing and the cost target described in the earlier stage. Usually it is composed of the following items.

- Drawing up details of manufacturing specifications under the cost target.
- Ascertaining whether or not the manufacturing specifications of the product are designed to fit the cost target by using detailed cost estimation.

3.3.4.6 Manufacturing Preparation

At this stage the manufacturing system is designed including production method, tools and processes of the product under the cost target. The detailed target cost structure is determined.

3.3.5 Features of Target Cost Management

- Cost planning is done in the design and development stage itself where the impact will be significant, since normally 80% of costs are committed before production starts.
- Cross-functional team fosters fruitful teamwork.
- External information built into the system along with internal information.
- Cost awareness created throughout the organization.
- It is not just a cost accounting technique but a strategic cost management philosophy that focuses on the core of the operations of an organization.

3.3.6 Target Cost Enablers

Two powerful tools for achieving target cost are

- o Quality function deployment
- o Functional Analysis

For details about these techniques refer Para 3.1 and 3.2

3.3.7 Cost Table

According to Tanaka, "cost table includes data summarized to estimate costs quickly and easily with a certain degree of accuracy for cost estimation purpose such as pricing decisions for product specification and decisions for production methods and means". In short, it is a cost data base which is used for cost estimation and cost prediction, to reckon cost of using alternate materials, tools etc.

- Cost table facilitates ready answers to 'what if' questions while evolving the target cost.
- A variety of cost tables are used such as design tables, such contracting cost table, production cost table etc. cost tables based on functions have also been developed.

Cost tables are built either adopting.

a) Bottom-up approach, or

b) Top-down approach

Bottom-up approach:

In this approach costs are built more or less on conventional lines as direct material, conversion cost, management costs etc. But making suitable corrections for futurity of costs and proposed capacity levels etc. Thus for e.g. while calculating machine hour rate for say, numerically controlled lathe, automatic lathe, etc, replacement cost is adopted instead of historical cost.

Top-down approach:

In this approach costs are built in two ways:

On a global basis identifying the key or critical factor influencing cost. For instance the cost of a conveyor belt can be estimated as a function of its length, the cost of a motor cycle as a function of its engine capacity etc. This estimate is no doubt, approximate but is a useful guide at the basic design stage.

By detailed mathematical equation. The cost of a conveyor belt has been expressed in the form of equation give below (by the authors referred earlier)

$C = 760 - 16L + 214H + 46N$, where,

C = Cost in Yen, N = Number of curves in the conveyor belt,

H = Horse power in kw, L = Length of belt in meters.

3.3.8 Methodology of working out target cost

A. Subtraction Method

- Establish selling price
- Decide profit margin
- Target cost is worked back by deduction of profit from selling price
- Cardinal merit is external orientation

B. Addition Method

The target cost is worked forward from design, production etc, based on internal factors and capabilities. this can be based on costs of similar product or on design properties as seen above. However, due corrections have to be made to past costs for items like abnormal costs, inflation, new features etc. In Japan, it has been found that cost of a new product will be about 70% of the current product cost. In respect of similar products this 'rough and ready' estimate can be taken as a useful starting point for critical examination of costs.

C. Integrated Method

This method aims at a reconciliation of the two methods to arrive at target cost.

3.3.9 Target Cost for Producer and Target Cost for Consumer

We have so far looked at Target Cost for producer covering different aspects as

Target Cost for design

Target Cost for production

Target Cost for selling and distribution

There is another significations dimension Target Cost t.c. which can be depicted as under:

Target Cost for Consumer →
- Target Cost for operating product
- Target Cost for maintaining product
- Target Cost for disposal of product

An organization must consider not only pre-production and manufacturing costs but also post-manufacturing and post-sales costs incurred by customers. The cost to the user of an equipment/product goes by the name of user quality costs. These broadly can be categorized as under:

1. Cost of repairs
2. Cost of effectiveness loss e.g. extra defects in process shutdown
3. Cost of maintaining extra capacity because of expected failures
4. Cost of damages caused by a failed item e.g. injury to personnel
5. Lost income
6. Extra operating and maintenance cost compared to competing products: Lower functional output per cycle of operation.

Benefits of User Quality Costs

1. When making purchase decisions for equipment one should not merely look at initial acquisition cost but also take into account operational cost over the life span of the equipment.
2. Use quality costs will help the manufacturer to justify the higher price for his products over that of the competitor.
3. User quality costs also help the manufacturer to fix warranty period for his products.

   Statistical studies will help a company to assess mean time between failures (MTBF) and determine target cost at the customer's end.

Total target cost

Total target cost is thus the sum of Target Cost for producer + Target Cost for consumer.

In other words this can be stated as target life cycle cost.

3.3.10 Standard cost vs Target cost

	Standard cost	Target cost
Objective	Control of operation costs	Reinvent the product with a strategic thrust
Time dimension	Short-term Reactive--export facto	Medium to long-term proactive--ex-ante
Focus	Internal	External
Waste	Within allowed limits	Zero-defect approach
Behavioural impact	Variance analysis sets the stage for excuse hunting and friction	Promotes creative cohesive teamwork
Orientation	Conformance to standards	Kaizen (Continuous improvements)

3.4 Product Mix

3.4.1 In a multi-product company, the contribution made by each product to the total profit varies significantly. It is also observed that the company's ability to maximize its profits, by focusing only on the profitable products is constrained by the capacity of the market to absorb such products. Further, the not-so-profitable products may be easy to produce and ensure full capacity utilization of the plant. Though desirable from a production angle, it may not bring about maximum corporate profit.

The task of the CMA thus becomes one of reconciling the apparently conflicting objectives and work out a product mix that will optimize corporate profits.

3.4.2 This is illustrated by taking the case of Aluminium Foil Industry, which produces products catering to a several industries as given below:

a) Pharma - Blister, Pharma Foil

b) Cigarette - Cigarette foil, Board laminate

c) Telecom - Cable wrap

d) Confectionery - Triple laminate, Confectionery foil

e) Beverages - Tea packet

etc.

The thickness of cable wrap is 200 microns while that of triple laminate is 9 microns. The input foil is obtained in thickness of 600 microns and by passing through the rolling mill the thickness is reduced to the required size. Thus thinner gauge foils take longer production time than thicker ones. Thus if the plant were to produce only cable wrap the production can go up to 570 MT; however, if triple laminate only is to be produced, the production quantity would be only 270 MT.

3.4.3 The contribution (selling price minus variable cost) of the products is given below:

		Rs. lakhs/MT
Board Laminate	-	2.25
Triple Laminate	-	1.95
Label Foil	-	1.40
Contraceptive Foil	-	1.35
Blister	-	1.30
Cigarette/Tea Packet	-	0.90
Pharma Foil	-	0.75
Barefoil	-	0.65
Confectionery Foil	-	0.45
Tagger	-	0.30
Cable wrap	-	0.15

Cable wrap is least profitable; however, in view of market limitation in respect of other products, production of cable wrap is undertaken to ensure that plant is not kept partly idle.

3.4.4 You are given 3 alternative product mix patterns. As we move from product mix 1 to product mix 3, with progressive reduction in the quantity of cable wrap from 110 to 100 to 80, the total contribution goes up from Rs. 193.75 to 207.15 to 230.75 lakhs. The quantity of other products is increased in keeping with the requirements of the market. It is also not advisable to drop cable wrap completely as this would mean loss of an additional contribution of Rs.12 lakhs, partly idle capacity and being totally out of this market segment.

PRODUCT MIX - I			
PRODUCT GROUP	QUANTITY (MT.)	VALUE CONTRIBUTION	% CONTRIBUTION
BLISTER	40	52.00	43.33
PHARMA	60	45.00	33.33
TRIPLE/MULTI LAMINATE	5	9.75	45.88
BARE FOLI	35	22.75	37.14
CIGARETTE	12	10.80	32.14
TEA PACKET	15	13.50	28.57
BOARD LAMINATE	5	11.25	30.00
CABLE WRAP	110	16.50	10.71
CONTRACEPTIVE	2	2.70	27.00
LABLE FOIL	4	5.60	35.00
TAGGER	10	3.00	21.43
CONFECTIONERY	2	0.90	20.00
TOTAL	300	193.75	29.61

PRODUCT MIX - II			
PRODUCT GROUP	QUANTITY (MT.)	VALUE CONTRIBUTION	% CONTRIBUTION
BLISTER	45	58.50	43.33
PHARMA	55	41.25	33.33
TRIPLE/MULTI LAMINATE	7	13.65	45.88
BARE FOLI	40	26.00	37.14
CIGARETTE	15	13.50	32.14
TEA PACKET	12	10.80	28.57
BOARD LAMINATE	6	13.50	30.00
CABLE WRAP	100	15.00	10.71
CONTRACEPTIVE	3	4.05	27.00
LABLE FOIL	5	7.00	35.00
TAGGER	10	3.00	21.43
CONFECTIONERY	2	0.90	20.00
TOTAL	300	207.15	30.61

PRODUCT MIX - III			
PRODUCT GROUP	QUANTITY (MT.)	VALUE CONTRIBUTION	% CONTRIBUTION
BLISTER	50	65.00	43.33
PHARMA	70	52.50	33.33
TRIPLE/MULTI LAMINATE	10	19.50	45.88
BARE FOLI	14	26.00	37.14
CIGARETTE	15	13.50	32.14
TEA PACKET	12	10.80	28.57
BOARD LAMINATE	8	42.00	30.00
CABLE WRAP	80	12.00	10.71
CONTRACEPTIVE	3	4.05	27.00
LABLE FOIL	5	7.00	35.00
TAGGER	5	1.50	21.43
CONFECTIONERY	2	0.90	20.00
TOTAL	300	230.75S	32.12

Note : Contribution is in terms of Rs. lakhs

% contribution – this is the contribution margin of each product.

3.5 Life Cycle Costing

3.5.1 What is Life Cycle Costing?

Life Cycle Costing (LCC) also called Whole Life Costing is a technique to establish the total cost of ownership. It is a structured approach that addresses all the elements of this cost and can be used to produce a spend profile of the product or service over its anticipated life-span. The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options. The accuracy of LCC analysis diminishes as it projects further into the future, so it is most valuable as a comparative tool when long term assumptions apply to all the options and consequently have the same impact.

3.5.2 Why is it important?

The visible costs of any purchase represent only a small proportion of the total cost of ownership. In many departments, the responsibility for acquisition cost and subsequent support funding are held by different areas and, consequently, there is little or no incentive to apply the principles of LCC to purchasing policy. Therefore, the application of LCC does have a management implication because purchasing units are unlikely to apply the rig ours of LCC analysis unless they see the benefit resulting from their efforts.

There are 4 major benefits of LCC analysis:

- evaluation of competing options in purchasing;
- improved awareness of total costs;
- more accurate forecasting of cost profiles; and
- performance trade-off against cost.

Option Evaluation – LCC techniques allow evaluation of competing proposals on the basis of through life costs. LCC analysis is relevant to most service contracts and equipment purchasing decisions.

Improved Awareness – Application of LCC techniques provides management with an improved awareness of the factors that drive cost and the resources required by the purchase. It is important that the cost drivers are identified so that most management effort is applied to the most cost effective areas of the purchase. Additionally, awareness of the cost drivers will also highlight areas in existing items which would benefit from management involvement.

Improved Forecasting – The application of LCC techniques allows the full cost associated with a procurement to be estimated more accurately. It leads to improved decision making at all levels, for example major investment decisions, or the establishment of cost effective support policies. Additionally, LCC analysis allows more accurate forecasting of future expenditure to be applied to long-term costings assessments.

Performance Trade-off Against Cost – In purchasing decisions cost is not the only factor to be considered when assessing the options . There are other factors such as the overall fit against the requirement and the quality of the goods and the levels of service to be provided. LCC analysis allows for a cost trade-off to be made against the varying attributes of the purchasing options.

3.6 Who is involved ?

The investment decision maker (typically the management board) is accountable for any decisions relating to the cost of a project or programme.

Principles

The cost of ownership of an asset or service is incurred throughout its whole life and does not all occur at the point of acquisition. The gives an example of a spend profile showing how the costs vary with time. In some instances the disposal cost will be negative because the item will have a resale value whilst for other procurements the disposal, termination or replacement cost is extremely high and must be taken into account at the planning stage.

- Acquisition costs are those incurred between the decision to proceed with the procurement and the entry of the goods or services to operational use
- Operational costs are those incurred during the operational life of the asset or service
- End life costs are those associated with the disposal, termination or replacement of the asset or service. In the case of assets, disposal cost can be negative because the asset has a resale value.

A purchasing decision normally commits the user to over 95 per cent of the through-life costs. There is very little scope to change the cost of ownership after the item has been delivered.

The principles of LCC can be applied to both complex and simple projects though a more developed approach would be taken for say a large project than a straightforward equipment purchase.

The Process

LCC involves identifying the individual costs relating to the procurement of the product or service. These can be either "one-off" or "recurring" costs. It is important to appreciate the difference between these cost groupings because one-off costs are sunk once the acquisition is made whereas recurring costs are time dependent and continue to be incurred throughout the life of the product or service. Furthermore, recurring costs can increase with time for example through increased maintenance costs as equipment ages. The types of costs incurred will vary according to the goods or services being acquired, some examples are given below.

Examples of one-off costs include:

- procurement;
- implementation and acceptance;
- initial training;
- documentation;
- facilities;
- transition from incumbent supplier(s);
- changes to business processes.
- withdrawal from service and disposal

Examples of recurring costs include:

- retraining;
- operating costs;
- service charges;
- contract and supplier management costs;
- changing volumes;
- cost of changes;
- downtime/non-availability;
- maintenance and repair; and
- transportation and handling.

3.7 The Methodology of LCC

LCC is based on the premise that to arrive at meaningful purchasing decisions full account must be taken of each available option. All significant expenditure of resources which is likely to arise as a result of any decision must be addressed. Explicit consideration must be given to all relevant costs for each of the options from initial consideration through to disposal.

The degree sophistication of LCC will vary according to the complexity of the goods or services to be procured. The cost of collecting necessary data can be considerable, and where the same items are procured frequently a cost database can be developed.

The following fundamental concepts are common to all applications of LCC:

- cost breakdown structure;
- cost estimating;
- discounting; and
- inflation.

3.8 Cost Breakdown Structure (CBS)

CBS is central to LCC analysis. It will vary in complexity depending on the purchasing decision. Its aim is to identify all the relevant cost elements and it must have well defined boundaries to avoid omission or duplication. Whatever the complexity any CBS should have the following basic characteristics:

- it must include all cost elements that are relevant to the option under consideration including internal costs;
- each cost element must be well defined so that all involved have a clear understanding of what is to be included in that element;
- each cost element should be identifiable with a significant level of activity or major item of equipment or software;

- the cost breakdown should be structured in such a way as to allow analysis of specific areas. For example, the purchaser might need to compare spares costs for each option; these costs should therefore be identified within the structure;
- the CBS should be compatible, through cross indexing, with the management accounting procedures used in collecting costs. This will allow costs to be fed directly to the LCC analysis;
- for programmes with subcontractors, these costs should have separate cost categories to allow close control and monitoring; and
- the CBS should be designed to allow different levels of data within various cost categories. For example, the analyst may wish to examine in considerable detail the operator manpower cost whilst only roughly estimating the maintenance manpower contribution. The CBS should be sufficiently flexible to allow cost allocation both horizontally and vertically.

3.9 Cost Estimating

Having produced a CBS, it is necessary to calculate the costs of each category. These are determined by one of the following methods:

- known factors or rates: are inputs to the LCC analysis which have a known accuracy. For example, if the Unit Production Cost and quantity are known, then the Procurement Cost can be calculated. Equally, if costs of different grades of staff and the numbers employed delivering the service are known, the staff cost of service delivery can be calculated;
- cost estimating relationships (CERs): are derived from historical or empirical data. For example, if experience had shown that for similar items the cost of Initial Spares was 20 per cent of the UPC, this could be used as a CER for the new purchase. CERs can become very complex but, in general, the simpler the relationship the more effective the CER. The results produced by CERs must be treated with caution as incorrect relationships can lead to large LCC errors. Sources can include experience of similar procurements in-house and in other organisations. Care should be taken with historical data, particularly in rapidly changing industries such as IT where can soon become out of date; and.
- expert opinion: although open to debate, it is often the only method available when real data is unobtainable. When expert opinion is used in an LCC analysis it should include the assumptions and rationale that support the opinion.

3.10 Discounting

Discounting is a technique used to compare costs and benefits that occur in different time periods. It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later. This is known as 'time preference'. .

When comparing two or more options, a common base is necessary to ensure fair evaluation. As the present is the most suitable time reference, all future costs must be adjusted to their present value. Discounting refers to the application of a selected discount rate such that each future cost is adjusted to present time, i.e. the time when the decision is made. Discounting reduces the impact of downstream savings and as such acts as a disincentive to improving the reliability of the product.

3.11 Inflation

It is important not to confuse discounting and inflation: the Discount Rate is not the inflation rate but is the investment "premium" over and above inflation. Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking LCC analysis.

However, if the analysis is estimating the costs of two very different commodities with differing inflation rates, for example oil price and man-hour rates, then inflation would have to be considered. However, one should be extremely careful to avoid double counting of the effects of inflation. For example, a vendor's proposal may already include a provision for inflation and, unless this is noted, there is a strong possibility that an additional estimate for inflation might be included.

3.12 Other Issues

Risk Assessment

Cost estimates are made up of the base estimate (the estimated cost without any risk allowance built in) and a risk allowance (the estimated consequential cost if the key risks materialise). The risk allowance should be steadily reduced over time as the risks or their consequences are minimised through good risk management.

3.13 Sensitivity

The sensitivity of cost estimates to factors such as changes in volumes, usage etc need to be considered

3.14 Optimism bias

Optimism bias is the demonstrated systematic tendency to be over-optimistic about key project parameters. In can arise in relation to:

- Capital costs;
- Works duration;
- Operating costs; and
- Under delivery of benefits.

Optimism bias needs to be assessed with care, because experience has shown that undue optimism about benefits that can be achieved in relation to risk will have a significant impact on costs. A recommended approach is to consider best and worst case scenarios, where optimism and pessimism can be balanced out. The probability of these scenarios actually happening is assessed and the expected expenditure adjusted accordingly.

3.15 Contribution Approach

3.15.1 Contribution Approach is "a method of preparing income statements that separates variable costs from fixed cost in order to emphasize the importance of cost behavior patterns for purposes of planning and control".

Variable Cost: "Cost that is uniform per unit but fluctuates in total in direct proportion to changes in the related total activity or volume".

Variable Cost is a way of studying the behavior of cost in relation to variation in volume of production. Typical examples would be raw material and direct labour. Further it must be noted that variable cost covers not only manufacturing variable cost but also all other cost which vary with volume such as sales commission related to sales quantity and freight charges.

Variable cost is also known as Direct Cost or Marginal Cost.

Fixed Cost "Cost that remain unchanged in total for a given time period, despite wide fluctuations in activity".

Note that the so-called fixed cost could vary with time; when the term fixed cost is used it means for that given period cost remain constant. Examples are rent, property tax, interest on term loan etc.

Semi-Variable Cost "This cost has both fixed and variable elements. Its total fluctuates as x changes within the relevant range, but not in direct proportion. Its behavior conforms with the basic formula $y = a + bx$.

A typical example would be electricity charges which is levied as a two part tariff, with fixed charge for maximum demand and a variable charge based on the actual units consumed.

3.15.2 Ratios or Relationships under Contribution Concept

Contribution	=	Sales – Variable Cost
Variable Cost	=	Prime Cost + Variable Overhead (Factory, Office, Sales & Distribution)
Profit	=	Contribution – Fixed Cost
Sales – Variable Cost	=	Contribution
Sales – Variable Cost	=	Fixed Cost + Profit

3.15.3 Illustration : Let us take a simple hypothetical example of a company having three products A, B, C.

S.No.	Products	A	B	C	Total
1	Sales	5,000	3,000	2,000`	10,000
2	Variable Cost	3,000	2,000	1,500	6500
3	Contribution (1-2)	2,000	1,000	500	3,500
4	Fixed Cost	-	-	-	3,000
5	Profit (3-4)				500
6.	Profit / Volume Ratio	40%	33.33%	25%	35%

Under absorption costing method, assuming that the fixed cost are distributed according to sales value the profit will be as under:

Contribution	2,000	1,000	500	3,500
Fixed Cost	1,500	900	600	3,000
Profit / Loss	500	100	(100)	500

It will be seen that product C is making loss and therefore may have to dropped. However, this product contributes Rs.500 towards recovery of the fixed cost, an aspect which is highlighted under the contribution approach. Hence it will not be prudent to drop product C.

3.15.4 Profit/Volume Ratio – PV Ratio

Profit/Volume Ratio is the Ratio of Contribution to Sales. The PV Ratio for the above example is shown below:

S.No.	Product	Calculation	Profit / Volume Ratio
1	(A)	2,000/5,000 x 100	40%
2	(B)	1,000/3,000 x 100	33.33%
3	(C)	500/2,000 x 100	25%
4	Total of 3 Products	3,500/10,000 x 100	35%

From the above calculations it will be seen that product A is more profitable than the other products.

3.15.5 Merits of Contribution Approach

3.15.6 Aids Decision Making – The major utility of this technique lies in the assistance it gives to the management in vital decision making, particularly in dealing with problems which require short term decision, where fixed costs do not count. The inclusion of fixed cost in decision making is defective for the following reasons.

a) The impact of some items of fixed cost, supervision and inspection expenses on various products is not uniform. The adoption of a single rate to all products may result in cost distortion.

b) The selection of a suitable base and the correct level of activity for working out the fixed overhead rate presents considerable difficulties. Different conclusions may be arrived at with the use of different basis.

The basic consideration in all decision making problems is that contribution is a reliable index of profitability. When alternative courses of action are available, the most suitable course will be the one which yields the highest contribution, provided there are no limiting factors (this issue is considered later).

3.15.7 Cost Control – This technique is essentially a tool for cost analysis and cost presentation. It enables the presentation of data in a particular manner useful to various levels of management for the purpose of controlling costs. Variable cost can be controlled at lower levels but fixed overhead may be controlled only by the top management. The contribution facilitates evaluation of performance because the results are not distorted by subjective allocation of the non-controllable cost.

3.15.8 Profit Planning – Profit Planning is a planning of future operations to attain maximum profit or to maintain a specified level of profit. The contribution ratio indicates the relative profitability of different sectors of the business whenever there is a change in sales price, variable cost or product mix. Due to the merging of fixed variable cost absorption cost fail to bring out correctly the effect of any such change on the profits of the concern.

3.15.9 Evaluation of Performance – The various business segment of a concern such as a department, a product or a product line, a market or sales division or territory have different revenue earning potentialities. The performance of each such sector can be brought out by means of contribution analysis.

3.15.10 Contribution per Limiting Factor – Very often various limiting factors exist in any business which may arise from factors such as limited availability of power or raw material or manpower etc. In such a situation it will be better to calculate contribution for limited factors instead of the usual calculation of product-wise contribution. This is illustrated with the help the following example.

	Per Unit	
	Product A	Product B
Sales	Rs.100	Rs.120
Consumption of material	2 Kg	3 Kg
Material Cost	Rs. 10	Rs. 15
Direct Wages Cost	Rs. 15	Rs. 10
Machine Hours Used	3	2
Overhead Expenses		
- Fixed	Rs. 5	Rs. 10
- Variable	Rs. 15	Rs. 20

Direct wages per hour is Rs.5/-. Comment on the profitability of each product (both use the same raw material) when:

i) Total Sales potential in units is limited

ii) Raw material is in short supply

iii) Production capacity (in terms of machine hours) is the limiting factor.

Assuming raw material as the key factor, availability of which is 10,000 kg and maximum sales potential of each product being 3,500 units, find the product mix which will yield the maximum profit.

Solution

	Per Unit	
	Product A	Product B
Sales	Rs. 100	Rs. 120
Material	---------	---------
Direct Wages	Rs. 10	Rs. 15
Direct Expenses	Rs. 15	Rs. 10
Variable overheads	Rs. 5	Rs. 6
Total variable cost	Rs. 15	Rs. 20
	Rs. 45	Rs. 51
Marginal contribution per unit	Rs. 55	Rs. 69
Marginal contribution per kg. of material	Kg. 27.5	23.00
Marginal contribution per machine hour	18.3	34.5

When the limiting factor is :

Sales : Ranking is – B A

Raw Material : Ranking is – A B

Production Capacity : Ranking is – B A

When raw material is scarce and limited to 10,000 kg and maximum production limit is 3,500 units of each, the raw material allotment will be

Product A - 7,000 kgs for 3500 units

Product B - 3,000 kgs for 1000 units

3.16 Break – Even Analysis

3.16.1 Break Even Analysis is a study of the interrelationships of costs and volume and its impact on profit. This is also called as cost-volume-profit or C.V P. analysis. The break even point is only incidental in these studies. The breakeven point is that point of activity where total sales and total costs are equal; that is, at that point there is neither profit nor loss.

B.E. Analysis may be made with the help of Break Even Chart. All charts are visual aids and the B.E.Chart conveys in telling manner, the relationship of cost, volume and profit.

3.16.2 B.E.Chart A simple breakeven chart is prepared with the following data

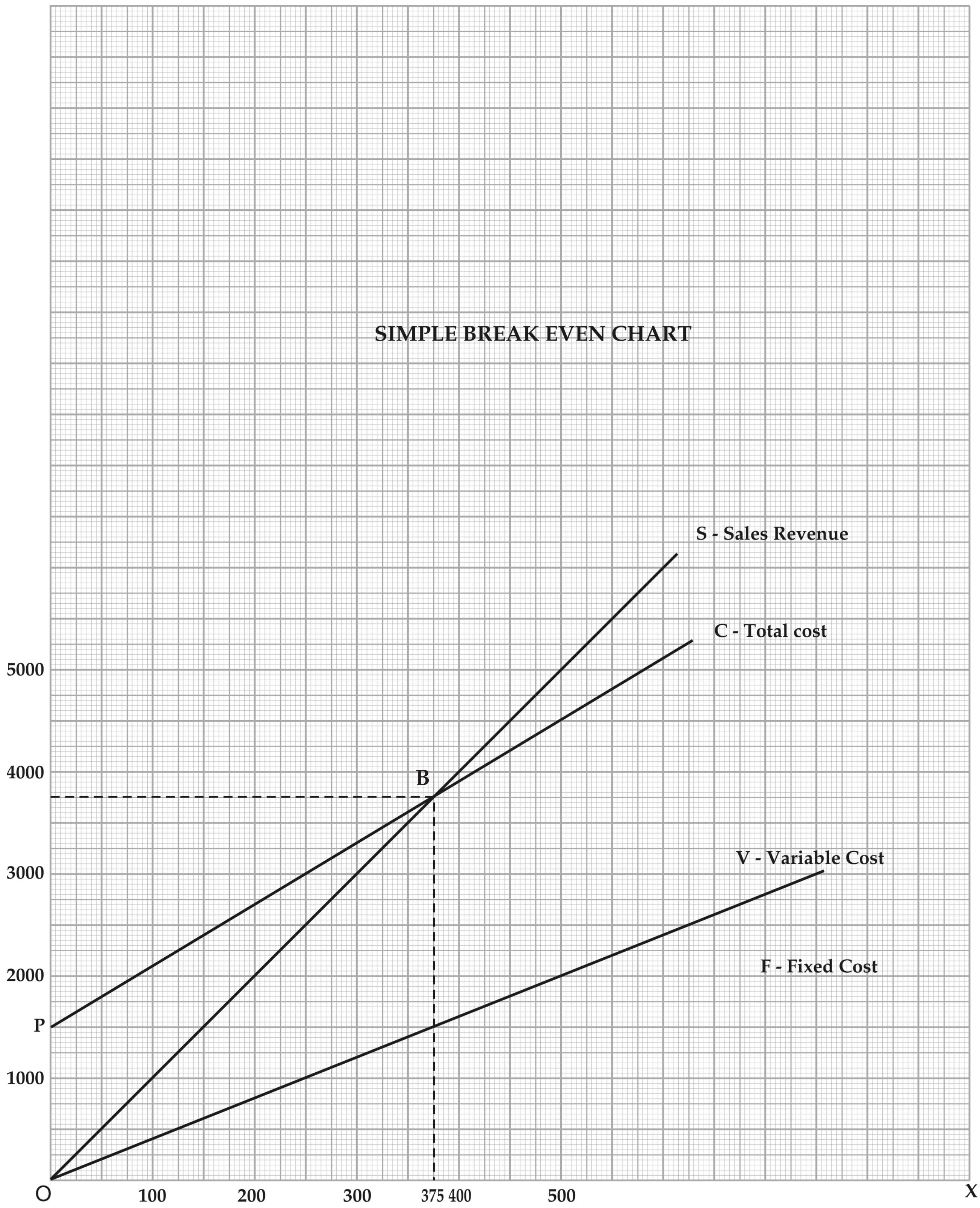
PRODUCT A

Unit selling price	Rs.10.00
Unit Variable Cost	Rs.06.00
Sales Quantity	500 units
Fixed cost	Rs.1500.00

Sales Qty.	**100**	**200**	**300**	**400**	**500**
	Rs.	**Rs.**	**Rs.**	**Rs.**	**Rs.**
Sales Value	1000	2000	3000	4000	5000
Variable cost	600	1200	1800	2400	3000
Fixed cost	1500	1500	1500	1500	1500
Total cost	2100	2700	3300	3900	4500
Profit /(Loss)	(1100)	(700)	(300)	100	500

Sales Quantity is shown along the X-axis and revenue and cost along the Y-axis.

Line OS	-	Sales Revenue
Line PC	-	Total Cost
Line OV	-	Variable Cost
Line PF	-	Fixed Cost


SIMPLE BREAK EVEN CHART
S - Sales Revenue
C - Total cost
B
V - Variable Cost
F - Fixed Cost
5000
4000
3000
2000
P
1000
O
100
200
300
375 400
500
X

The breakeven point is the point of intersection of OS and PC. At this point the sales quantity is 375 units and sales value Rs.3750/-.

The area OBP is the loss area while SBC is the profit zone. The angle SBC is called the angle of incidence

3.16.3 Mathematical Calculation of B.E.P.

Contribution = Sales – Variable Cost

Profit / Volume Ratio = $\frac{\text{Contribution}}{\text{Sales}} \times 100$

Break Even Sales **V**alue = $\frac{\text{Fixed Cost}}{\text{P/V Ratio}}$

Break Even Sales Quantity = $\frac{\text{Fixed Cost .}}{\text{Unit Contribution}}$

Unit contribution = Rs.10/- - 6 = Rs.4/-

P/V Ratio = 4 / 10= 40%

B.E. Sales Value = Rs.1500/- / 40% = Rs.3750/-

B.E. Sales Quantity = Rs.1500/- / Rs.4/- = 375 units

With the help of the above formulae we can easily calculate the impact of changes in price or cost. Thus if selling price were to go up by Rs.1/-, the contribution per unit will be Rs.5/- and the B.E.Quantity will come down to 300 and B.E.Value will come down to Rs.3000/-. Similarly the impact of changes in volume can be easily ascertained.

Thus it will be seen that B.E.P. Shifts

i) If there is increase or decrease in prices

ii) If there is increase or decrease in variable costs

iii) If there is increase or decrease in fixed costs.

3.16.4 Multi-product Break Even Chart

The construction of a multi-product B.E.Chart is illustrated by taking the following data.

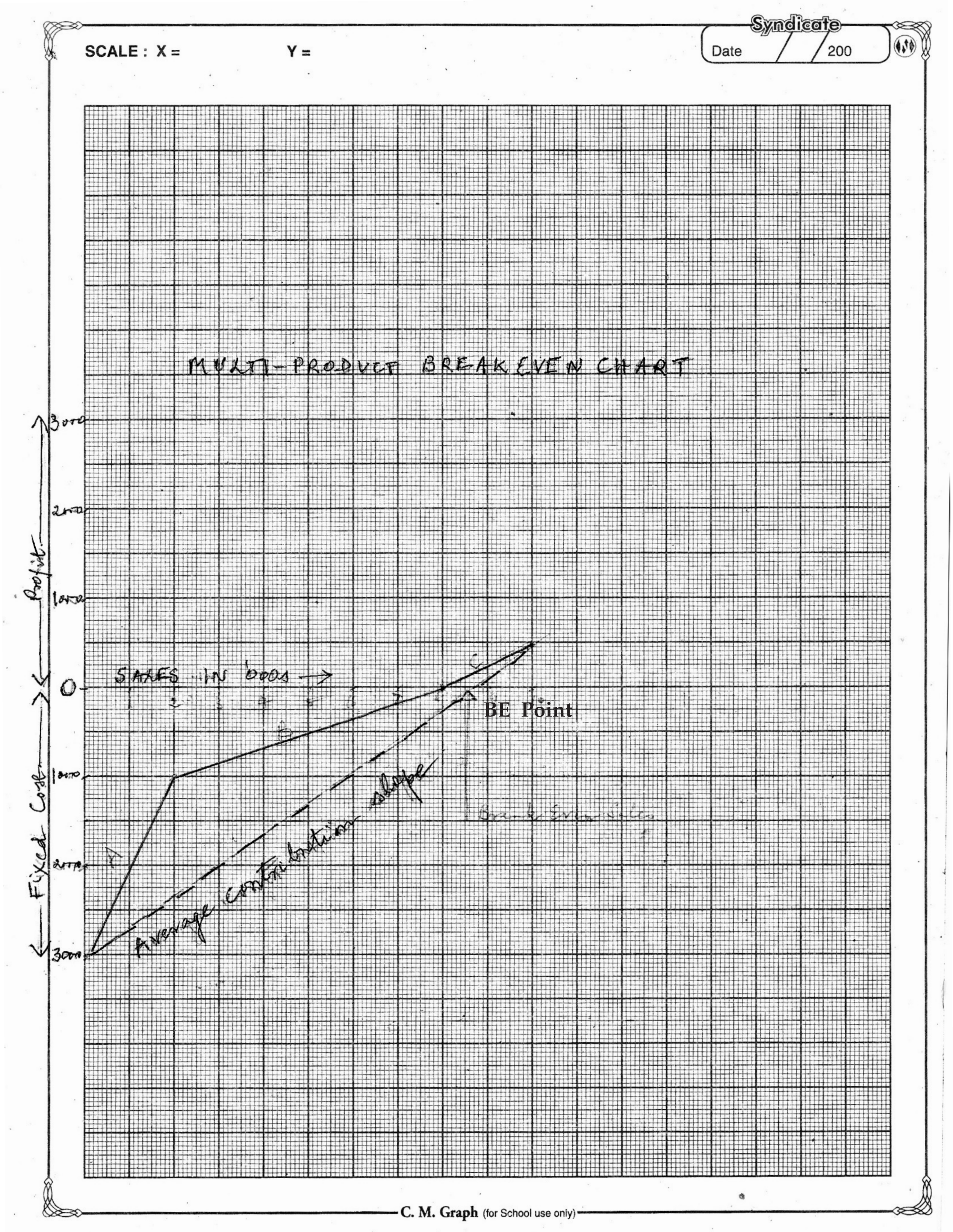
Product	Sales	Cum sales	Var.Costs	Cum. Var.Costs	Fixed Costs	Net profit / Loss
A	5000	5000	3000	3000	3000	-1000
B	3000	8000	2000	5000	3000	0
C	2000	10000	1500	6500	3000	500

Over all Break Even Sales = $\frac{\text{F – C}}{\text{P/V Ratio}} = \frac{3000}{35\%}$ = Rs. 8571

P/V Ratio – A – 40%, B – 33.33%, C – 25%

Method of drawing the chart

1. Indicate sales value along the horizontal axis
2. Keeping the sales line as base depict the fixed cost, on the vertical axis below.
3. The vertical axis line above the sales line will denote profit.
4. Select the product with the highest P/V Ratio
5. Start from the Fixed Cost point and extend the line upto the Profit/Loss point.
6. The line for the second product starts where the first line ends
7. Repeat this process for the third product
8. Connect the fixed cost point to the point reached by the last product. This line is the average contribution slope.
9. The point at which the slope intersects the horizontal sales line is the Break Even Sales Value for the profit mix.


Syndicate
SCALE : X = Y =
Date / / 200
MULTI-PRODUCT BREAK EVEN CHART
3000
2000
1000
0
1000
2000
3000
Profit
Fixed Cost
SALES IN '000s →
BE Point
Average contribution slope
C. M. Graph (for School use only)

3.16.5 Margin of Safety

Margin of safety (MS) is the actual sales minus the sales at Break Even Point.

$$M/S\% = \frac{\text{Actual Sales} - \text{Sales at break Even}}{\text{Actual Sales}} \times 100$$

In the example given

$$M/S\% = \frac{500 - 375}{500} = 25\%$$

A high margin of safety shows that the Break Even Point is much below the actual sales so that even if there is a fall in sales there will be profit. A low margin of safety, conversely indicates that even a small drop in sales may result in loss.

Margin of safety can be calculated by the formula.

$$M/S = S - \frac{F}{P/V}$$

Also M/S X P/V Ratio = Profit

3.16.6 Advantages

1. Break Even Analysis presents Cost-Volume-Profit relationship in a meaningful way and aids profit planning.
2. It is a useful tool for making managerial decisions

3.16.7. Limitation

1. The BE Chart is static because it is a picture of relationships that prevail under only one set of assumptions. If conditions change a different set of C-V-P relationships is likely to appear. The fluid nature of these relationships must be kept in mind when making use of this tool.

Conclusion:

In the words of Charles Horngren, "the chart is useful as a frame of reference for analysis, as a vehicle for expressing overall performance and as a planning device."

3.17 Learning Curve

3.17.1 The **learning curve effect** and the closely related **experience curve effect** express the relationship between experience and. As individuals and/or organizations get more experienced at a task, they usually become more efficient at it. Both concepts originate in the adage, "practice makes perfect",.

The term "learning curve" was introduced by the 19th-century German psychologist in the context of the efficiency of memorizing vs. the number of repetitions.

Later the term acquired a broader meaning. The learning curve effect states that the more times a task has been performed, the less time will be required on each subsequent iteration. This relationship was probably first quantified in at in the, where it was determined that every time total production doubled, the required labour time decreased by 10 to 15 percent. Subsequent empirical studies from other industries have yielded different values ranging from only a couple of percent up to 30 percent, but in most cases it is a constant percentage: It did not vary at different scales of operation. Learning curve theory states that as the quantity of items produced doubles, costs decrease at a predictable rate.

For example, assuming a cost reduction rate of 20%, which equivalent to an 80% (i.e. 100 – percentage of reduction) learning rate, and 8 hours as the time taken for the first unit, the average time per unit for 2 units will be (0.8) x 8 = 6.40 hours, i.e. a total of 12.80 hours for both. Thus the second unit takes 4.80 (12.80 – 8) hours to produce and the incremental cost improvement is 4.80/8 – 60%. Similarly the average for 4 units will be (.8) x 6.40 = 5.12 hours each or a total of 20.48 hours. Thus the third and fourth units will take together, 20.48 – 12.80 – 7.68 hours, and so on for 8,16,32, etc. units, as will be seen in the table given below:

Batch No	Cumulative Production (units)	Average cum. hrs required per unit (80% Learning Rate)	Cum. Total Hrs. to perform task
1	*2*	*3*	*4*
1	1	8.00	8.00
2	2	6.40	12.80
3	4	5.12	20.48
4	8	4.10	32.80
5	16	3.28	52.48
6	32	2.62	83.84
7	64	2.10	134.40

Expressed mathematically, the formula for learning curve effect is,

$Y = aX^b = \log Y = \log a + b \log X$
where,
Y = average number of labour hours required for X units,
a = number of labour hours required for the first units,
X = cumulative number of units produced, and
b = LEARNING INDEX or learning curve constant. This is equal to log 1/log 2, where 1 is the learning rate. (For Learning rate of 80%, b = log 0.8/log 2 – (-) 0.3219.

If data are available, the formula stated above may be used to determine the learning rate or given the learning rate and other data required to fit with the formula, values of the variables, Y, X, or a, may be calculated. For example, if a pair of the values of Y and X is given, the number of hours required for the first unit (or batch) and the learning rate can be determined. Assuming the values of Y and X for batches 4 and 5 in the table, we have :

log 4.10 = log a + b log 8 .. (i)

log 3.28 = log a + b log 16 .. (ii)

Solving equations, (i) and (ii) for log a and b, we get :

Log a = 0.9035, or a – 8.00 (This agrees with the figure in table), and

B – (-)0.3219, or Learning rate – 0.8

To take another illustration : given the learning rate and the number of hours per unit for the first batch, the average cumulative hours required per unit for a subsequent batch, (say, batch 6), may be calculated as follows :-

$Y = aX^b = 8 \times 32 = 0.3219$

or log Y = log 8 + (-.3219) log 32

or Y – 2.62 hours

The process of learning cannot go on indefinitely but has to end when a certain efficiency level is reached at a given production volume. In practice, to begin with in the first stage, there is a progressive increase in production rate till the maximum expected rate is reached. In the second stage, the maximum rate is maintained and in the third stage, which may be called the reverse learning, the production rate starts falling.

3.17.2 The Experience Curve

The experience curve effect is broader in scope than the learning curve effect encompassing far more than just labor time. It states that the more often a task is performed the lower will be the cost of doing it. The task can be the production of any good or service. Each time cumulative volume doubles, value added costs (including administration, marketing, distribution, and manufacturing) fall by a constant and predictable percentage.

Examples

NASA quotes the following experience curves:

- Aerospace 85%
- Shipbuilding 80-85%
- Complex machine tools for new models 75-85%
- Repetitive electronics manufacturing 90-95%
- Repetitive machining or punch-press operations 90-95%
- Repetitive electrical operations 75-85%
- Repetitive welding operations 90%
- Raw materials 93-96%
- Purchased Parts 85-88%

There are a number of reasons why the experience curve and learning curve apply in most situations. They include:

- **Labour efficiency** – Workers become physically more dexterous. They become mentally more confident and spend less time hesitating, learning, experimenting, or making mistakes. Over time they learn short-cuts and improvements. This applies to all employees and managers, not just those directly involved in production.
- **Standardization, specialization, and methods improvements** – As processes, parts, and products become more standardized, efficiency tends to increase. When employees specialize in a limited set of tasks, they gain more experience with these tasks and operate at a faster rate.
- **Technology-Driven Learning** – Automated production technology and information technology can introduce efficiencies as they are implemented and people learn how to use them efficiently and effectively.
- **Better use of equipment** – as total production has increased, manufacturing equipment will have been more fully exploited, lowering fully accounted unit costs. In addition, purchase of more productive equipment can be justifiable.
- **Changes in the resource mix** – As a company acquires experience, it can alter its mix of inputs and thereby become more efficient.
- **Product redesign** – As the manufacturers and consumers have more experience with the product, they can usually find improvements. This filters through to the manufacturing process. A good example of this is Cadillac's testing of various "bells and whistles" specialty accessories. The ones that did not break became mass produced in other General Motors products; the ones that didn't stand the test of user "beatings" were discontinued, saving the car company money. As General Motors produced more cars, they learned how to best produce products that work for the least money.
- **Value chain effects** – Experience curve effects are not limited to the company. Suppliers and distributors will also ride down the learning curve, making the whole value chain more efficient.
- **Network-building and use-cost reductions** – As a product enters more widespread use, the consumer uses it more efficiently because they're familiar with it. One fax machine in the world can do nothing, but if everyone has one, they build an increasingly efficient network of communications. Another example is email accounts; the more there are, the more efficient the network is, the lower everyone's cost per utility of using it.
- **Shared experience effects** – Experience curve effects are reinforced when two or more products share a common activity or resource. Any efficiency learned from one product can be applied to the other products.

3.17.3 Application of Learning Curve – Learning curve may be applied to direct labor, materials and spoilage and defective work.

(i) Direct Labor: Director labor is the general application area of the learning curve since it is only people who are capable of learning. Learning presupposes a certain degrees of inexperience in the performance of an activity and as such, the learning curve is mainly applicable to new activities and new labour force, whether employed on new or old activities.

(ii) **Materials –** Materials respond to learning only in an indirect way under specific circumstances. The learning curve is applicable mainly to sub-contract or fabrication order placed outside or components purchased from suppliers. The cost of the sub-contract or the components purchased would normally contain an element of labour and the purchaser will expect that at least a part of the benefit of learning should be passed on to him in the form of reduced price for the repeat orders for the sub-contract or components.

(iii) Spoilage and defective work : This is also an area for learning because with the acquirement of more skill and efficiency, losses on account of spoilage and defective production would decline.

On the other hand, the concept of learning curve may not be gainfully applicable in the following cases:-

(i) Where machine work predominates and the operation time is limited by the speed and feed of the machine.

(ii) In old established industries where no substantial change takes place.

(iii) In industries which do not received repeat orders.

(iv) In small units where the quantity of production is small and costs are low.

3.17.4 Uses of the learning Curve – The learning curve theory has gained significant importance as a technique for cost prediction and cost control. Some of the uses to which the learning rate may be put to are as follows:-

(i) Developing bid prices for contracts

(ii) **Work Scheduling –** The learning curve concept assists the management in work scheduling and production control in three ways :

(a) It predicts man-hours and the workforce required for meeting the production plan so that timely action may be taken to procure the required workforce.

(b) It indicates the time required for production so that schedule deliveries can be maintained.

(c) It enables production control to take advantage of reducing the time per unit of production by increasing the product lot sizes.

(iii) **Planning Inventory –** The learning curve indicates how with increased efficiency of the worker, the pace of production increases consequent to which more materials are required and work-in-progress and finished goods stocks grow rapidly in size. Awareness of the growth rate enables the management to plan the inventories properly.

(iv) **Planning working capital –** When unit prices are based on average cumulative cost per unit, the cost of the first few units produced will be higher than the cost on which the bid price was based. As a result, the profit level may not be high enough to provide sufficient working capital. In such a situation, the learning curve will indicate the quantum of the shortage of working capital so that suitable action may be taken on time to meet the shortfall.

(v) **Make or buy decision –** The learning curve is usedful in make or buy decision-making. While purchasing from outside on long term basis, it is to be seen whether the supplier has already reached the maximum efficiency in which case no learning curve will apply and no reduction in price in future can be expected. In another situation where instead of purchasing, internal production is speeded up, new inexperienced workers may have to be employed resulting in high costs now but gradual lower costs may be expected when the improvement process operates.

Illustration No. 1

(a) The usual learning curve model is $Y = ax^b$ where

Y is the average time per unit for x units.

a is the time for first unit

x is the cumulative number of units

b is the learning coefficient and is

equal to $\dfrac{\log 0.8}{\log 2} = -0.322$ of a learning rate of 80%

Given that a = 10 hours and learning rate 80%, you are required to Calculate:

(i) The average time for 20 units.

(ii) The total time for 30 units.

(iii) The time for units 31 to 40.

Given that log 2 = 0.301, Antilog of 0.5811 = 3.812

log 3 = 0.4771,Antilog of 0.5244 = 3.345.

log 4 = 0.6021,Antilog of 0.4841 = 3.049.

(b) Enumerate the uses of Learning Curve.

Solution:

a) $Y = AX^b$

$Y = 10(20)^{-0.322}$

Taking log on both sides

$\log y = \log 10 + \log 20^{(-0.322)}$

$\log y = \log 10 - (0.322) \log 20$

$= 1 - (0.322) \log 20$

$= 1- (0.322) \times (1.3010)$

$= 1-0.41892 = 0.5811$

$\log y = 0.5811$

Y = Anti log (0.5811) = 3.812 hrs (average time)

b) $\log y = \log 10 + \log 30^{(-0.322)}$

$\log y = 1-(0.322) \times (1.4771)$

$= 1 - (0.4756) = 0.5244$

Y = anti log (0.5244) = 3.345 hrs (average time)

Total time = 3.345 x 30 = 100.35 hrs

c) $\log y = \log 10 + \log 40^{(-0.322)}$

$= 1-(0.322) \times (1.6021)$

$\log y = 0.4841$

Y = anti log (0.4841) = 3.049hrs

Total time = 40 x 3.049 = 121.96hrs

Time from 31 to 40 units = 121.96 – (100.35) = 21.61hrs

Illustration No. 2

The learning curve as a management accounting has now become or going to become an accepted tool in industry, for its applications are almost unlimited. When it is used correctly, it can lead to increase business and higher profits; when used without proper knowledge, it can lead to lost business and bankruptcy. State precisely:

(i) Your understanding of the learning curve:

(ii) The theory of learning curve;

(iii) The areas where learning curves may assist in management accounting; and

(iv) Illustrate the use of learning curves for calculating the expected average units cost of making.

(a) 4 machines (b) 8 machines

Using the data below:

Data:

Direct Labour need to make first machine	= 1000 hrs.
Learning curve	= 90%
Direct Labour cost	= Rs.15/- per hour.
Direct materials cost	= Rs.1,50,000
Fixed cost for either size orders	= Rs.60,000.

Solution

Statement showing computation of cost of making 4 machines&8 machines:

No. of machines	Average time	Labour cost	Material	Fixed cost	Total
1	1000	15000	150000	60000	225000
2	900	13500	150000	30000	193500
4	810	12150	150000	15000	177150
8	729	10935	150000	7500	168435

Average cost of making 4 machines Rs.1,77,150

Average cost of making 8 machines Rs.1,68,435

EXERCISE PROBLEM

Problem No.1

Ƶ Plc experience difficulty in its budgeting process because it finds it necessary to qualify the learning effect as new products are introduced.

Substantial product changes occur and result in the need for retraining.

An order for 30 units of a new product has been received by Ƶ Plc So far, 14 have been completed; the first unit required 40 direct labour hours and a total of 240 direct labour has been recorded for the 14 units. The production manager expects an 80% learning effect for this type of work.

The company use standard absorption costing. The direct costs attributed to the centre in which the unit is manufactured and its direct materials costs are as follows:

	Rs.
Direct material	30.00 per unit.
Direct Labour	6.00 per hour.
Variable overhead	0.50 per direct labour hour.
Fixed overhead	6,000 per four-week operating period.

There are ten direct employees working a five-day week, eight hours per day. Personal and other downtime allowances account for 25% of total available time.

The company usually quotes a four-week delivery period for orders.

You are required to:

(i) Determine whether the assumption of an 80% learning effect is a reasonable one in this case, by using the standard formula $y = ax^b$

Where Y = the cumulative average direct labour time per unit (productivity)

a = the average labour time per unit for the first batch.

x = the cumulative number of batches produced.

b = the index of learning.

(ii) Calculate the number of direct labour hours likely to be required for an expected second order of 20 units.

(iii) Use the cost data given to produce an estimated product cost for the initial order, examine the problems which may be created for budgeting by the presence of the learning effect.

Ans:

(i) 80% learning ratio is effective.

(ii) 166.1 hours

(iii) Total Cost = Rs. 5,516

3.18 Strategic Cost Management

3.18.1 Three Key Themes

The emergence of SCM results from a blending of three underlying themes, each taken from the strategic management literature:

1. Value chain analysis
2. Strategic positioning analysis
3. Cost driver analysis

Each of these three themes is developed and illustrated in the following chapters. Each represents a stream of research and analysis in which cost information is cast in a light very different from that in which it is viewed in conventional management accounting. This chapter first represents an overview of each of these themes.

3.18.2 The Value Chain Concept

The first theme that underlies the work in strategic cost management concerns the focus of cost management efforts. Stated in question form: How do we organize our thinking about cost management?

In the SCM framework, managing costs effectively requires a broad focus, external to the firm. Porter (1985a) has called this focus the value chain. The value chain for any firm in any business is the linked set of value-creating activities all the way from basic raw material sources for component suppliers through to the ultimate end-use product delivered into the final consumers' hands. This focus is external to the firm, seeing each firm in the context of the overall chain of value-creating activities of which it is only a part, from basic raw material components to end-use consumers.

In contrast, management accounting today often adopts a focus that is largely internal to the firm—its purchases, its processes, its functions, its products, and its customers. Another way of saying this is that management accounting takes a value-added perspective, starting with payments to suppliers (purchases), and stopping with charges to customers (sales). The key theme is to maximize the difference (the value added) between purchases and sales.

But the value chain concept is fundamentally different from the value-added concept. From a strategic perspective, the value-added concept has two big problems; it start too late and it stops too soon. Starting cost analysis with purchases misses all the opportunities for exploiting linkages with the firm's suppliers. Such opportunities can be dramatically important to a firm. Consider the following examples case.

A few years ago, one of the major U.S. automobile companies began to implement Just in Time (JIT) management concepts in its assembly plants (Houliham. 1987). Manufacturing costs represented 30% of sales for the auto firm. It was believed that applying JIT concepts could eliminate 20% of these costs because assembly costs in Japanese auto plants were known to be more than 20% below those in U.S. plants. As the firm began to manage its factories differently to eliminate waste and the need for inventory buffers, its assembly costs began to drop noticeably. But, at the same time, the firm experienced dramatic problems with its major suppliers. They began to demand price increases that more than offset the assembly plant costs savings. The auto firm's first response was to chide its suppliers that they, too, needed to embrace JIT concepts for their own operations.

A value chain perspective revealed a much different picture of the overall situation. Of the auto company's sales, 50% was purchases from parts suppliers; of this amount, 37% was purchases by the parts suppliers and 63% was suppliers' value added. Thus, suppliers were adding more manufacturing value to the auto than the assembly plants (63% x 50% - 31.5%, versus 30%). As the auto company reduced its need for buffer stocks, it placed major new strains on the manufacturing responsiveness of its suppliers. The suppliers' manufacturing costs went up more than the assembly plants' costs went down.

The reason, once identified, was very simple. The assembly plants experienced huge and uncertain variability in their production schedules. One week ahead of actual production, the master schedule was more than 25% wrong 95% of the time. When the inventory buffers are stripped away from a highly unpredictable production process, the manufacturing activities of the suppliers become a nightmare. For every dollar of manufacturing cost the assembly plants saved by moving toward JIT management concepts, the suppliers' plants spent much more than one dollar extra because of schedule instability.

Because of its narrow value-added perspective, the auto company had overlooked the impact of its changes on its suppliers' costs. Management had ignored the idea that JIT involves a partnership with suppliers. Management did not realize that a major element in the success of JIT for a Japanese auto assembly plant is schedule stability for its supplier firms. In fact, whereas the U.S. plants regularly missed schedules only one week ahead by 25% or more, the Japanese plants varied 1% or less from schedules planned four weeks in advance (Jones & Udvare, 1986).1 The failure to adopt a value chain perspective doomed this major effect by a leading U.S. firm. The lack of awareness of supply chain cost analysis concepts on the part of this company's management accountants proved to be a very costly oversight. Should those management accountants have been exposed to value chain concepts somewhere in their accounting education?

In addition to starting too late, value-added analysis has another major flaw; is stops too soon. Stopping cost analysis at sales misses all the opportunities for exploiting linkages with the firm's customers. Customer linkages can be just as important as supplier linkages.

Exploiting customer linkages is the key idea behind the concept of life cycle costing. Life cycle costing deals explicitly with the relationship between what a customer pays for a product and the total cost the customer incurs over the life cycle of using the product. Forbis and Mehta (1981) describe how a life cycle costing perspective on the customer linkage in the value chain can lead to increased profitability. Explicit attention to post purchase costs by the customer can lead to more effective market segmentation and product positioning. Or, designing a product to reduce post purchase costs of the customer can be a major weapon in capturing competitive advantage. In many ways, the lower life cycle cost of imported Japanese autos helps to explain their success in the U.S. market.

Just as many cost management problems are misunderstood because of failure to see the impact on the overall value chain, many cost management opportunities are missed in the same way. Consider one further example.

In 1992, the U.S. suppliers of paper to envelope converters suffered a loss in profit because they were caught unaware by a significant shift in the value chain of the envelope converter. The shift from sheet-fed to roll-fed envelope finishing machines dramatically changes the raw material specifications for envelope paper. With sheet-fed machines, the envelope company buys large rolls of paper (forty to sixty inches wide) that are first cut into sheets, then cut into blanks in die-cutting machines, and finally fed by hand into the folding and gluing machines. With roll-fed machines, the envelope company buys very narrow rolls of paper (five to eleven inches wide) that are converted directly into envelopes in one combined operation. Roll-fed machines are much more expensive to buy but much less expensive to operate. For large orders, they represent substantial overall savings for the envelope converter. Roll-fed machines were only introduced in the United States about 1980, but they now produce more than 60% of all domestic envelopes.

The paper manufacturers do not want to complicate that primary manufacturing process by producing rolls that are only five to eleven inches wide directly on the paper machines. Instead, they use secondary machines called rewinder-slitters to convert the large rolls of paper from the paper machines into the narrower rolls the converters want. Thus, the transition from selling wide rolls to selling narrow rolls added an additional processing step for the paper manufacturers. The business issue here is how the change in the customers' value chain should be reflected in paper prices. Now that manufacturing costs along the value chain have changed (in response to changed customer requirements), how should prices change?

In the paper industry, where management accounting does not include value chain analysis or life cycle costing, rewinder-slitter costs are seen as just a small part of mill overhead, which is assigned to all paper production on a per-ton basis. For a large, modern paper mill, rewinder-slitter cost is no more than 1% or 2% of total cost. The impact on total average cost per ton in less than $10. Also, very little of this cost caries with incremental production because the mill always keeps excess capacity in such a small department. It is common sense to make sure that $300 million paper machines are never slowed down by a bottleneck at a $2 million rewinder-slitter.

The industry norm is to charge $11 per ton extra if the customer wants the rolls slit to the narrow widths (less than eleven inches). The savings to the envelope converter from roll-fed machines for exceed this extra charge. Unfortunately, the full cost to the paper mill of providing the incremental rewinding-slitting service also far exceeds this extra charge. It can cost more than $100 per ton to have an outside subcontractor slit rolls to narrow widths. An external value chain perspective extra costs to the paper mill and set a price differential somewhere in between. An internal mill costing perspective, however, sees no cost issues at all. The lack of a value chain perspective contributed to the lack of concern about product costing issues. The eleven dollar surcharge looked like pure extra contribution to profit. The result is an uneconomic price, the impact of which is buried in a mill management accounting system that ignores value chain issues. Should the management accountants in the paper companies have been exposed to value chain concepts somewhere in their management accounting education?

3.18.3 The Strategic Positioning Concept

The second major theme underlying the work in strategic cost management concerns the perceived uses of management accounting information, stated, again, in question form: What role does cost management play in the firm?

The theme of SCM can be stated very succinctly. In SCM, the role of cost analysis differs in important ways depending on how the firm is choosing to compete. Following Porter's (1980) delineation of basic strategic choices, a business can compete either by having lower costs (cost leadership) or by offering superior products (product differentiation). That these two approaches demand very different conceptual frameworks has been widely accepted in the strategy literature.2 and, although strategic positioning does not involve simple either/or choices in practice, the implications for strategic management have been frequently amplified.1 but the implications of strategic positioning for management accounting are not as well explored. Since differentiation and cost leadership involve different managerial mindsets, they also involve different cost analysis perspectives. As one example of how strategic positioning can significantly influence the role of cost analysis, consider the decision to invest in more carefully engineered product costs. For a firm following a cost leadership strategy in a mature, commodity business, carefully attention to engineered target costs is likely to be a very important ongoing management tool. But for a firm following a product differentiation strategy in a market-drive, rapidly growing, fast-changing business, carefully engineered manufacturing costs may well be much less important.

Large chemical company uses cost variances extensively for some products and not at all for others of R&D productivity is much more important to a pharmaceuticals company like Merch than is manufacturing cost control. On the other hand, a system for better monitoring R & D costs would not gain much attention in a company like International Paper, but they have many accountants whose jobs involves tracking manufacturing cost on a monthly basis. Although cost information is important in all companies in one form or another, different strategies demand different cost perspectives.

Expanding upon the work by Gupta and Govindarajan (1984b) and Govindarajan (1986a), exhibit 2-1 summarizes some illustrative differences in control system or cost management emphases depending on the primary strategic thrust of the firm.

Govindarajan's widely cited work provides empirical evidence of major differences in cost management and control system design depending on the strategic being followed.

It is interesting to compare the SCM perspective on the role of cost.

EXHIBIT 2-1

Differences in Cost Management Caused by Differences in Strategy

	Primary Strategic Emphasis	
	Product Differentiation	Cost Leadership
Role of engineered product cost in assessing performance	Not very important	Very import
Importance of such concepts as Flexible budgeting for manufacturing cost control	Moderate to low	High to very high
Perceived importance of meeting budgets	Moderate to low	High to very high
Importance of marketing cost Analysis	Critical to success	Often not done on
Importance of product cost as an Input to pricing decisions	Low	High
Importance of competitor cost Analysis	Low	High

Information with the perspective that is more prevalent in management accounting today. Often, the theme in management accounting texts today is the same that it has been for thirty years. That theme was first articulated by Simon et al. (1954), who coined three phrases to capture the essence of management accounting: "Score keeping",problem solving", and "attention directing". Although these specific words are not always preserved, these three objectives frequently still come through in today's textbook as clearly as they did when the Controllers Institute (now the Financial Executives Institute) commissioned a team of faculty from Carnegie Tech (now Carnegie Mellon) to study the elements of effective controllership. It is interesting and somewhat ironic the Carnegie Tech and the Controllers Institute have long since been modernized, but not this 1954 tripartite delineation of the roles of managerial accounting.

The point is not to deprecate this longstanding common starting point, but rather to emphasize how much our conception of what we do starts with our consensus about why we do it. Each of the three well-known roles involves a set of concepts and techniques that are implicitly assumed to apply to all firms-albeit in varying degrees. For example, standard cost variances are a key tool for attention-directing and contribution margin analysis is a key tool for problem solving.

Because the three roles are not seen as varying across firms depending on strategic context, the relevance of the related costs analysis tools also is not seen to vary, across the firms. If agreement could be reached that why we do management accounting differs in important ways depending on the basic strategic thrust of the firm, it would be a much easier transition to see that how we do management accounting should also reflect the basic strategic thrust.

Even if management accounting in most companies today is still heavily involved with conventional tasks, it is important to realize that this focus need not be true in the future. Management accounting can adapt to the real business needs of the firm, if those needs are articulated.

3.18.4 The Cost Driver concept

In SCM it is acknowledged that cost is caused, or driven, by many factors that are interrelated in complex ways. Understanding means understanding the complex interplay of the set of cost drivers at work in any given situation. At this level of generality, the idea is almost tautological. It is hardly contentious or counterintuitive until one contrasts it with the prevailing theme in traditional management accounting today. In management accounting, cost is a function, primarily, of only one cost drive, output volume. Cost concepts related to output volume permeate the thinking and the writing about cost: fixed versus variable cost, average cost versus marginal cost, cost-volume-profit analysis, break even analysis, flexible budgets, and contribution margin, to name a few. In SCM, output volume as such is seen to capture very little of the richness of cost behavior. Management accounting, in this regard, tends to draw upon the simple models of basic microeconomics. SCM, on the other hand, tends to draw upon the richer models of the economics of industrial organization (Scherer, 1980).

One other strategic cost driver, cumulative experience, has also received some attention among management accountants over the years as a determinant of unit costs. 5 Reference to the learning curve also appear in many managerial accounting Text. 6 However, rather than seeing experience as one of many cost drivers, the accounting literature sees it more narrowly as an explanation of how the relationship between cost and output volume changes over time as cumulative output increases for one particular product of process. That is, even in the learning curve literature in accounting, output volume is still the preeminent cost driver. Experience is seen as a phenomenon that can help explain the changing relationship between output volume and costs over time.

If output volume is a poor way to explain cost behavior, what is a better way? Porter (1985a) presents one attempt to create a comprehensive list of cost drivers, but his attempt is more important than his particular list. In the strategic management is more important than this particular list. In the strategic management literature, better lists exist (Riley, 1987). Following Riley, the following list of cost drivers is broken into two categories. The first category comprises "structural" cost drivers, drawing upon the industrial organization literature (Scherer, 1980). From this perspective there are at least five strategic choices by the firm regarding its underlying economic structure that drive cost position for any given product group:

1. Scale: How big an investment to make in manufacturing, in R&D, and in marketing resources.
2. Scope: Degree of vertical integration. Horizontal integration is more related to scale.
3. Experience: How many times in the past the firm has already done what it is doing again.
4. Technology: What process technologies are used at each step of the firm's value chain.
5. Complexity: How wide a line or products of services to offer to customers.

Each structural driver involves choices by the firm that drive product cost. Given certain assumptions, the cost calculus of each structural driver can be specified. 7 Of the structural drivers, scale, scope, and experience have received a large amount of attention from economists and strategists over the years. Of these three, only experience has drawn much interest from management accountants, as noted previously. Technology choice is such a thorny topic area that it is not surprising that management accountants have pretty much ignored it. At the level of explicit analysis, so have most other people as well. Perhaps the most explicit work that deals with cost analysis for technology choices is in industrial economics. Gold et al. (1970) and Oster (1982) represent excellent examples of innovations in the steel industry.

Complexity, as a structural variable, has received the most attention among accountants recently. Some examples of the potential importance of complexity as a cost determinant are in the work on activity based costing by Kaplan (1987), Cooper (1986), or Shank and Goindarajan (1988d). We consider this work as a useful strategic analysis tool, but not as the primary tool.

The second category of cost drivers, executional drivers (Riley, 1987), are those determinants of a firm's cost position that hinge on its ability to execute successfully. Whereas structural cost drivers are not monotonically scaled with performance, executional drivers are. That it for each of the structural drivers, more is not always better. There are diseconomies of scale, or scope, as well as economics. A more complex line. Too much experience can be as bad as too little in a dynamic environment. For example, Texas Instruments emphasized the learning curve and became the world's lowest-cost producer of microchips that were no longer state of the art. Technological leadership versus followership is a legitimate choice for most firms.

In contrast, for each of the executional drivers, more is always better. The list of basic executional drivers includes at least the following:

Work force involvement (participation) – the concept of work force commitment to continual improvement.(refer Kaizen in Chapter 6)

Total quality management (beliefs and achievement regarding product and process quality).(Refer Chapter 6—Quality Management)

Capacity utilization (given the scale choices on plant construction).

Plant layout efficiency. (How efficient, against current norms, is the layout)

Product configuration. (Is the design or formulation effective?) (Refer Target Costing)

Exploiting linkages with suppliers and/or customers, per the firm's value chain.

While it may not always be true that a higher level of these executional factors improves cost position, examples of diseconomies are much less frequent.

Operationalizing each of these drivers also involves specific cost analysis issues, as illustrated later. Many strategy consultants maintain that the strategic cost analysis field is moving very quickly toward executional drivers because the insights from analysis based on structural drivers are too often old fashioned. It is somewhat ironic that the cost drivers concept is moving from one revolution to a second one before the accounting world has caught up with the first one.

As of this writing there is no clear agreement on the list of fundamental cost derivers. For examples, two different lists are proposed in one single publication (Booz, Allen, & Hamilton, 1987). However, those who see cost behavior in strategic terms are clear that output volume alone does not typically catch enough of the richness. How unit cost changes as output volume changes in the short run in seen to be a less interesting question than how cost position is influenced by the firm's comparative position on the various drivers that are relevant in its competitive situation.

Whatever cost drivers are on the list, the key ideas are as follows:

- For strategic analysis, volume is usually not the most useful way to explain cost behavior.
- In a strategic sense, it is more useful to explain cost position in terms of the structural choices and executional skills that shape the firm's competitive position.
- Not all the strategic drivers are equally important all the time, but some (more than one) of them are very probably very important in every case.
- For each cost driver there is a particular cost analysis frame work that is critical to understanding the positioning of a firm. Being a well-trained cost analysis requires knowledge of these various frameworks. ..

Source: Reproduced partially from the Selected Reading Material given by ICWAI for the Programme on "Cost Contol & Cost Effectiveness" Feb, 2006.

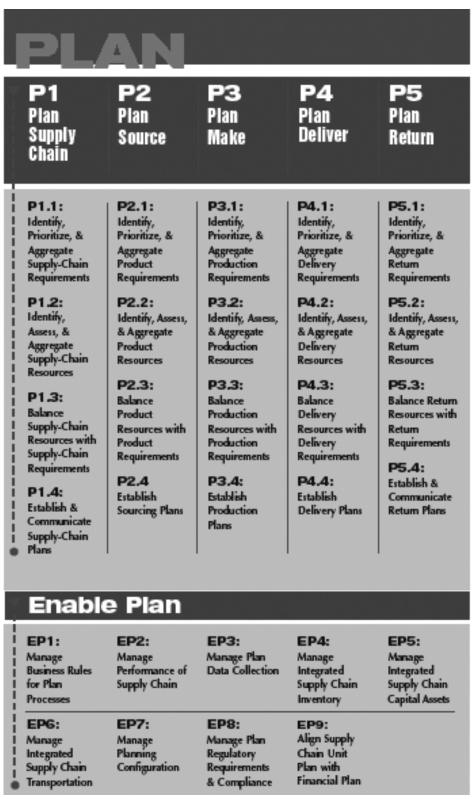
3.19 Supply Chain Management

3.19.1 Supply Chain Management encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies. More recently, the loosely coupled, self-organizing network of businesses that cooperates to provide product and service offerings has been called the *extended enterprise*

The concept of the supply chain, with its emphasis on linkages among all of the value-adding activities in the chain, did not emerge until the early 1990s. Since then, supply chain—and supply chain management—have become pervasive terms in the business and academic vernacular. So pervasive, in fact, that they have virtually displaced the predecessor term, "business logistics," in the business literature. One might even argue that the supply chain's emergence is

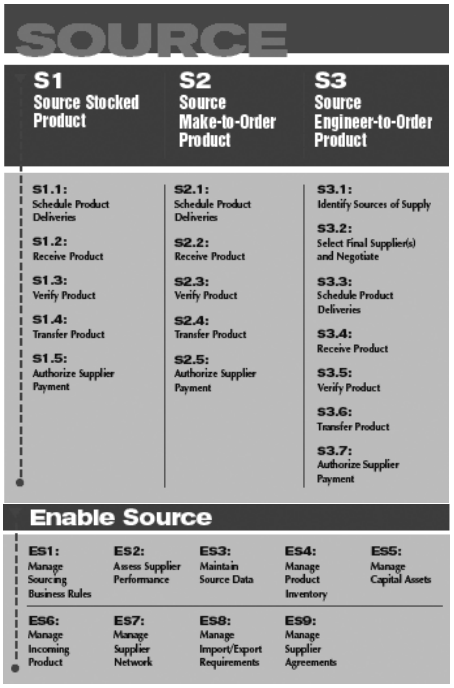
perhaps the most significant development in business management since the early 1980s when U.S. firms began adopting the just-in-time concept. Why the overwhelming attention being paid to supply chain management? The short answer is that savvy business executives are discovering that effective management of the supply chain can help boost a firm's performance.

In particular, they recognize that supply chain management can provide a distinctive and sustainable competitive advantage and improved profitability. They understand that a well-managed supply chain can help them succeed on the four dimensions of competitiveness—cost, quality, response time, and flexibility.



3.19.2. Five Basic Components of SCM.

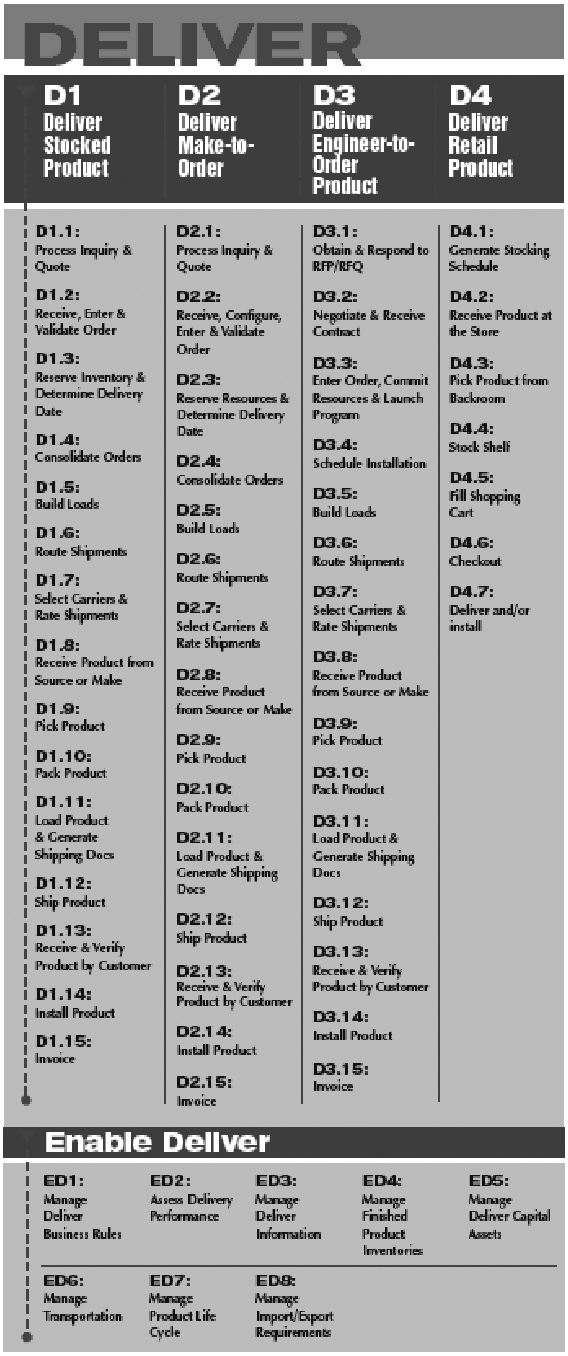
1. **Plan** – This is the strategic portion of SCM. You need a strategy for managing all the resources that go toward meeting customer demand for your product or service. A big piece of planning is developing a set of metrics to monitor the supply chain so that it is efficient, costs less and delivers high quality and value to customers.

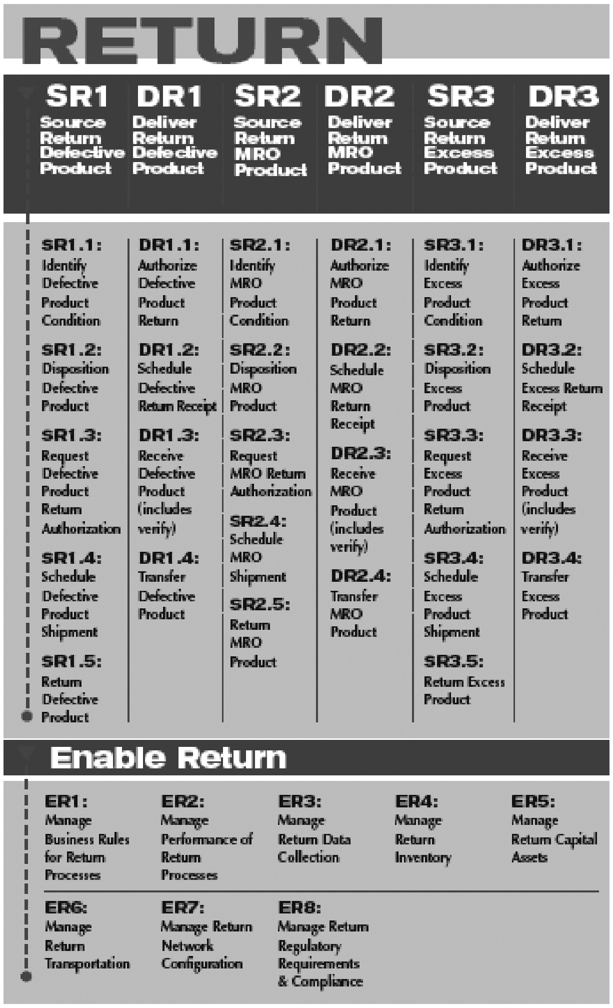


2. **Source –** Choose the suppliers that will deliver the goods and services you need to create your product. Develop a set of pricing, delivery and payment processes with suppliers and create metrics for monitoring and improving the relationships. And put together processes for managing the inventory of goods and services you receive from suppliers, including receiving shipments, verifying them, transferring them to your manufacturing facilities and authorizing supplier payments.

3. **Make** – This is the manufacturing step. Schedule the activities necessary for production, testing, packaging and preparation for delivery. As the most metric-intensive portion of the supply chain, measure quality levels, production output and worker productivity.

4. **Deliver –** This is the part that many insiders refer to as logistics. Coordinate the receipt of orders from customers, develop a network of warehouses, pick carriers to get products to customers and set up an invoicing system to receive payments.





5. **Return –** The problem part of the supply chain. Create a network for receiving defective and excess products back from customers and supporting customers who have problems with delivered products.

3.19.3 Supply Chain Metrics

Supply chain metrics are the calculations by which an implementing organization can measure how successful they are in achieving their desired positioning within the competitive market space.

- Perfect Order Fulfillment
- Order Fulfillment Cycle Time
- Upside Supply Chain Flexibility
- Upside Supply Chain Adaptability
- Downside Supply Chain Adaptability
- Supply Chain Management Cost
- Cost of Goods Sold
- Cash-to-Cash Cycle Time
- Return on Supply Chain Fixed Assets
- Return on Working Capital

3.19.4 Supply Chain Collaboration

Let's look at consumer packaged goods for an example of collaboration. If there are two companies that have made supply chain a household word, they are Wal-Mart and Procter & Gamble. Before these two companies started collaborating back in the '80s, retailers shared very little information with manufacturers. But then the two giants built a software system that hooked P&G up to Wal-Mart's distribution centers. When P&G's products run low at the distribution centers, the system sends an automatic alert to P&G to ship more products. In some cases, the system goes all the way to the individual Wal-Mart store. It lets P&G monitor the shelves through real-time satellite link-ups that send messages to the factory whenever a P&G item swoops past a scanner at the register.

With this kind of minute-to-minute information, P&G knows when to make, ship and display more products at the Wal-Mart stores. No need to keep products piled up in warehouses awaiting Wal-Mart's call. Invoicing and payments happen automatically too. The system saves P&G so much in time, reduced inventory and lower order-processing costs that it can afford to give Wal-Mart "low, everyday prices" without putting itself out of business.

3.19.5 Extended Supply Chain

The extended supply chain is a clever way of describing everyone who contributes to a product. So if you make text books, then your extended supply chain would include the factories where the books are printed and bound, but also the company that sells you the paper, the mill where that supplier buys their stock, and so on. It is important to keep track of what is happening in your extended supply chain because with a supplier or a supplier's supplier could end up having an impact on you (as the old saying goes, a chain is only a strong as its weakest link). For example, a fire in a paper mill might cause the text book manufacturer's paper supplier to run out of inventory. If the text book company knows what is happening in its extended supply chain it can find another paper vendor.

3.19.6 Impact of Globalization on the Supply Chain

Just in time manufacturing isn't the only way companies have used their supply chains to reduce cost. Manufacturing in developing countries is substantially cheaper than in the U.S. because of the low cost of labor. For example, the median wage at a Chinese manufacturing plant is 1,000 Yuan, or about $120, per month, according to a 2005 survey by The MPI Group. But foreign manufacturing brings with it another set of challenges. It isn't as easy to set up real-time data sharing with a factory in, say, China as it is with a factory you own in the United States. And the sheer distance that overseas goods need to travel – not to mention the number of vessels they need to travel on – in order to reach the U.S. increases the chance that they will get delayed. The bottom line is that foreign manufacturing brings back a lot of the uncertainty that supply chain systems were designed to eliminate. The good news is that technology capable of tracking shipments throughout the world is getting better. The bad news is that a lot of this technology is still pretty expensive, that some of the places you would want to deploy it don't have the necessary infrastructure in place, and well, there isn't a piece of technology out there that can make up for the whim of a Chinese Customs official. Furthermore, labor costs in some places are so low that IT automation and monitoring projects may add more to costs—in terms of software, hardware and still-precious (and unreliable) bandwidth—than they save in productivity. Hence, some low-tech or commodity products may not be worth monitoring at all until they hit a ship in a foreign port.

In the meantime, the best bet is to use whatever systems you can to gain as much visibility into the global supply chain as possible. It may be impossible to replicate the just in time model on a global scale, but by applying whatever technology you can, and by choosing the supply chain partners who have the capability to share data with you, you can get many of the benefits of just in time while paying low foreign prices.

3.19.7 Trends in Supply Chain Management Today

For manufacturers, supply chain management continues to evolve at a very rapid rate. The most important overall development is the movement away from "interfacing" with customers and suppliers and toward "integrating" with customers and suppliers. This represents a fundamental shift in the way manufacturers transact business. The very foundation on which companies managed demand and supply business relationships is rapidly disappearing in favor of more effective supply chain management methods. Of course, good product, quality, and price will always be important, but the added requirements to respond rapidly to customer requests and deliver flawlessly in meeting commitments has had profound effects on how manufacturers perceive and manage their entire supply chains.

3.19.8 Lean Supply Chain Management

Effectively integrating both information and material flows into the demand and supply process is what lean supply chain management is all about. In most companies, two major and very interdependent issues must be simultaneously addressed. The first deals with delivering customer-acceptable quality, in very short lead times, at a customer acceptable cost, while keeping inventories throughout the supply chain at a minimum. The second issue, which leads to be less understood and accepted, is the need for high quality, relevant, and timely information that is provided where and when needed. For many customers and manufacturers, business processes and support systems do not measure up to the task of quickly providing planning and execution information from customers to the manufacturer and onto suppliers so that the customer's objectives are consistently met. The fact is that most information supplied is excessive, often late, and frequently inaccurate.

Regardless of the industry and customer base, more effectively managing the supply chain is a prerequisite for future success. Supply chain performance improvement must be high on any CEO's priority list. But before meaningful action plans can be implemented, an assessment must made of the circumstances and develop a strategy that is appropriately aimed at what your customers want, need, and value.

The Ten Principles of Lean Supply Chains

1. Organize and synchronize around logical and complete processes rather than functions.
2. Create a continuous flow of the right material throughout the supply chain.
3. Move to making product to customer demand rather than finished goods.
4. Eliminate non-value added steps throughout the supply chain.
5. Reduce order-to-delivery lead times to quicker than customer requirements.
6. Mistake-proof processes to do it right the first time and every time.
7. Create on optimal high velocity flow of high quality, relevant and necessary information throughout the supply chain.
8. Store material at the point of use.

9. Make your customers and suppliers your real partners.
10. Develop a team-based organization, provide the necessary support and empower them to make decision that affect their work.

As always, the challenge for top management is setting the right priorities, allocating appropriate resources, and, of course, achieving the required results. Complicating the challenge is the enormous penalty for not keeping pace. It can result in driving your customers into the open arms of your more aggressive competitors. The impact of lost customers on revenue and profit is compounded by the costs a company incurs to recapture or replace lost customers.

3.19.9 Emerging Technologies That Will Affect the Supply Chain

The most notable is Radio Frequency Identification, or RFID. RFID tags are essentially barcodes on steroids. Whereas barcodes only identify the product, RFID tags can tell what the product is, where it has been, when it expires, whatever information someone wishes to program it with. RFID technology is going to generate mountains of data about the location of pallets, cases, cartons, totes and individual products in the supply chain. It's going to produce oceans of information about when and where merchandise is manufactured, picked, packed and shipped. It's going to create rivers of numbers telling retailers about the expiration dates of their perishable items—numbers that will have to be stored, transmitted in real-time and shared with warehouse management, inventory management, financial and other enterprise systems. In other words, it is going to have a really big impact.

Another benefit of RFIDs is that, unlike barcodes, RFID tags can be read automatically by electronic readers. Imagine a truck carrying a container full of widgets entering a shipping terminal in China. If the container is equipped with an RFID tag, and the terminal has an RFID sensor network, that container's whereabouts can be automatically sent to Widget Co. without the truck ever slowing down. It has the potential to add a substantial amount of visibility into the extended supply chain.

Right now the two biggest hurdles to widespread RFID adoption are the cost of building the infrastructure and the lack of agreed-upon industry standards.

For a number of case studies refer

http://www.glscs.com/archives/index.htm?adcode=0

Source:

http://www.cio.com/article/40940/ABC_An_Introduction_to_Supply_Chain_Management/1

http://www.supply-chain.org/galleries/public-gallery/SupplyChainFinanceLink-Article.pdf

http://www.supply-chain.org/galleries/public-gallery/SupplyChainFinanceLink-Article.pdf

http://www.supply-chain.org/galleries/publicgallary/SCOR_Quck_Reference_Guide_10.23.pdf

3.20 Marginal Costing

Illustration No.1

Accelerate Co. Ltd., manufactures and sells four types of products under the brand names of A, B, C & D. The sales mix in value comprises 33 1/3%, 41 2/3%, 16 2/3% and 8 1/3% of products A,B,C and D respectively. The total budgeted sales (100% are Rs.60,000 p.m.). Operating Costs are:

Variable Costs:

Product A 60% of selling Price

Product B 68% of selling Price

Product C 80% of selling Price

Product D 40% of selling Price

Fixed Costs: Rs.14,700 p.m.

(a) Calculate the break-even-point for the products on overall basis and

(b) Also calculate break-even-point, if the sales mix is changed as follows the total sales per month remaining the same.

(Mix: - A - 25% : B - 40% : C - 30%: D - 5%)

Solution:

(a) Statement showing computation of break even point on overall basis: (Rs.)

	A	B	C	D	TOTAL
a) Sales	20000	25000	10000	5000	60000
b) Variable cost	12000	17000	8000	2000	39000
c) Contribution	8000	8000	2000	3000	21000
d) Fixed cost					14700
e) Profit					6300
f) P/V ratio	40%	32%	20%	60%	35%
g) Break even sales				14700/35% =	42000

(b) Statement showing computation of break even point if the sales mix is changed:

	A	B	C	D	TOTAL
Sales	15000	24000	18000	3000	60000
Variable cost	9000	16320	14400	1200	40920
Contribution	6000	7680	3600	1800	19080
Fixed cost					14700
P/V ratio	40%	32%	20%	60%	(19080/60000) x 100 = 31.8%
Break even sales					14700/31.8% = 46266

Illustration No. 2

A Co. currently operating at 80% capacity has the following; profitability particulars:

	Rs.	Rs
Sales		12,80,000
Costs:		
Direct Materials	4,00,000	
Direct labour	1,60,000	
Variable Overheads	80,000	
Fixed Overheads	5,20,000	11,60,000
Profit		1,20,000

An export order has been received that would utilise half the capacity of the factory. The order has either to be taken in full and executed at 10% below the normal domestic prices, or rejected totally. The alternatives available to the management are given below:

a) Reject order and Continue with the domestic sales only, as at present;

b) Accept; order, split capacity equally between overseas and domestic sales and turn away excess domestic demand;

c) Increase capacity so as to accept the export order and maintain the present domestic sales by:

   i) buying an equipment that will increase capacity by 10% and fixed cost by Rs. 40,000 and

   ii) Work overtime a time and a half to meet balance of required capacity.

Prepare comparative statements of profitability and suggest the best

Solution:

Statement showing computation of comparative profit of different alternatives:

	80% capacity	100% capacity	130% capacity
Sales	1280000	800000 + 720000	1280000 + 720000
Variable cost:			
Material	400000	500000	650000
Direct labour	160000	200000	260000
Variable OHs	80000	100000	130000
Overtime premium			20000
	640000	800000	1060000
Contribution	640000	720000	940000
Fixed cost	(520000)	(520000)	(560000)
Profit	120000	200000	380000

From the above computations we find that the profit is more at alternative III i.e., accepting the foreign order fully & maintaining the present domestic sales.

Illustration No. 3

A practicing Cost and Management Accountant now spends Rs.0.90 per K.m on taxi fares for his client's work. He is considering to other alternatives the purchase of a new small car or an old bigger car.

Item	New Small Car	Old Bigger Car
Purchase price	35,000	20,000
Sale price after 5 years	19,000	12,000
Repairs and servicing per annum	1,000	1,200
Taxes and insurance p.a.	1,700	700
Petrol consumption per liter(k.m.)	10	7
Petrol price per liter	3.5	3.5

He estimates that he does 10,000 K.m annually. Which of the three alternatives will be cheaper? If his practice expands he has to do 19,000 Km p.a will be cost of the two cars break even and why? Ignore interest and Income-tax.

Solution:

Statement showing computation of break even point for three alternatives:

	Taxi	New smaller car	Old bigger car
Fixed Cost:			
Depreciation		16000/5 = 3200	8000/5 = 1600
Repairs		1000	1200
Taxes		1700	700
		5900	3500
Variable cost per KM	0.9	0.35	0.5
TOTAL COST PER 10000 KMS	9000	3500 + 5900 = 9400	5000 + 3500 = 8500
Cost per 19000 KMS	17100	12550	13000

(a) At 10000 KMS old bigger car is cheaper than the other two alternatives.

(b) At 19000 KMS it is better and cheaper to purchase the new smaller car.

Indifference point = (difference in fixed cost / difference in variable cost per unit)

= (2400/0.15) = 16000kms

Illustration No. 4

Study Horse Ltd., a cycle manufacturing company, has drawn up a programme for the manufacture of a new product for the purpose of fuller utilisation of its capacity. The scheme envisages the manufacture of baby tricycle fitted with a bell. The company estimates the sales of tricycles at 10,000 during the first year and expects that from the second year onwards the sales estimates will stabilise at 20,000 tricycles. Since the company has no provision for the manufacture of the small bells is initially proposed to be met by way of purchase from the market, at Rs. 8 each.

However, if the company desires to manufacture the bell in its factory by installation of new equipment, it has two alternative proposals as under:

	Installation of Super - X Machine	Installation of Janta Machine
Initial cost of machine	Rs. 3,00,000	Rs. 2,00,000
Life	10 years	10 years
Fixed overheads other than depreciation on machines (per annum)	Rs. 54,000	Rs. 28,000
Variable expenses per bell	Rs. 4.00	Rs. 5.00

Depreciation on machine should be charged on straight line basis.

Required:

i) For each of the two levels of output namely, 10,000 and 20,000 bells state with suitable workings whether the company should purchase the bells from market or install new equipment for manufacture of bells. If your decision is in favour of the installation of new equipment, which of the two new machines should be installed?

ii) What would be your decision in case the forecast of requirement from the second year onwards is estimated at 40,000 bells instead of 20,000 bells.

iii) At what volume of bells will the installation of the two machines break-even.

Solution:

(i) and (ii)

Statement showing comparative costs at the 3 levels of output at the 3 alternatives

Particulars	Market	10,000 SPX	Janta	Market	20,000 SPX	Janta	Market	40,000 SPX	Janta
Fixed Cost:									
Depreciation	-	30,000	20,000	-	30,000	20,000	-	30,000	20,000
FOH other than dep.	-	54,000	28,000	-	54,000	28,000	-	54,000	28,000
	-	84,000	48,000	-	84,000	48,000	-	84,000	48,000
Variable Cost	80,000	40,000	50,000	1,60,000	80,000	1,00,000	3,20,000	1,60,000	2,00,000
Total Cost	80,000	1,24,000	98,000	1,60,000	1,64,000	1,48,000	3,20,000	2,44,000	2,48,000

From the above computations it is evident that,

At level of out put 10,000 – buying from market
20,000 – Installation of Janta
40,000 – Installation of Super – X are beneficial.

iii) Volume of bells at which the two machines will break even = $\frac{\textit{Difference in FC}}{\textit{Difference in VC per unit}}$

$$\frac{84{,}000 - 48{,}000}{5 - 4} = 36{,}000$$

Illustration No. 5

Something More Ltd. is considering adding to its product line. After a lot of deliberations between the sales and production personnel, it is decided that products P, Q and R would be the most desirable additions to be company's product range on account of the technical competency, marketing potential and production flexibility as regards these products. In fact P, Q and R can all be made on the same kind of plant as that already in use and therefore as regards production, all products can be readily interchanged. However, it is considered necessary to build further plant facilities to cater for additional production. In this connection the following data are relevant:

Products (Per Unit)	P	Q	R
Direct Materials	Rs 100	120	90
Direct Labour	50	70	90
Variable Overheads	50	130	100
Selling Price	350	420	370
Demand in units per cost period (on the basis of the above selling price)	200	125	750
Machine Hours required per units of production	15	5	3

It is felt that initially extra plant facilities can be built to operate at the following five different levels of activity, viz., 1,800; 2,300; 2,800; 3,300 and 3,800 machine hours per cost period. The fixed overhead costs for a cost period relevant to these five different levels of activity are estimated at Rs. 15,000; Rs.20,000; Rs. 26,000; Rs.33,000 and 39,000 respectively.

You are required to advise, with supporting figures, the product or products to be manufactured and in what quantities at each of the five contemplated levels of activity in order to maximize the profits at each level and also indicate the level of activity and would seem most desirable to be pursued for such maximization of profits.

Solution:

Statement showing contribution per machine hour and determination of priority for profitability:

Selling Price	-	350		420		370
Variable Cost:						
Direct Material	100		120		90	
Direct Labour	50		70		90	
Variable Overheads	50	200	130	320	100	280
Contribution Per unit		150		100		90
Contribution per machine hour		10		20		30
		III		II		I

Statement Showing optimum mix and profit of the 5 levels and determination of capacity to be pursued for maximization of profit:

Level of Activity	P			Q			R					
	Hours	Units	Cont.	Hours	Units	Cont.	Hours	Units	Cont.	Total Cont.	Fixed Cost	Profit
1800	-	-	-	-	-	-	1800	600	54000	54000	15000	39000
2300	-	-	-	50	10	1000	2250	750	67500	68500	20000	48500
2800	-	-	-	550	110	11000	2250	750	67500	78500	26000	52500
3300	425	28.33	4250	625	125	12500	2250	750	67500	84250	33000	51250
3800	925	61.67	9250	625	125	12500	2250	750	67500	89250	39000	50250

From the above computation it is evident that 2800 hour capacity level of activity is to be pursued to maximize profit.

Illustration No. 6

Bathing Care Ltd. manufactures and sells soaps under the brand name — Elite, Lovely, Fresh and Janata. The Janata soap is very popular as it is of good quality and at the same time reasonably priced. The company produces and sells per annum on an average 50,000 cakes of Elite, 1,00,000 cakes of Lovely, 75,000 cakes of fresh and 2,00,000 cakes of Janata at a unit selling price of Rs.3.50, Rs.3.00, Rs.2.50 and Rs.1.5 respectively.

At this level of production and sales the unit cost of a cake of each brand of soap is as follows:

				(Expressed in Paise)
	Elite	Lovely	Fresh	Janata
Direct Material	50	40	35	45
Direct Labour	20	20	15	10
Production Expenses:				
Variable	10	10	5	5
Fixed	20	25	20	20
Administrative Expenses:				
Fixed	30	40	25	30
Variable	15	5	10	5
Selling & Distribution Expenses:				
Fixed	80	60	45	10
Variable	45	20	25	5
Total Cost	270	220	180	130

The Co. has lot of unutilised capacity and there is ample scope for improving production and sales volumes. Bathing Care Ltd. has built a name for its products in the market and with proper sales effort it should be possible to sell whatever is produced by the co., the production manager sees no problems. The sales manager put up a bold scheme for almost quartrupling the present profits of the company.

1. An exclusive advertising campaign has to be undertaken to produce and sell Janata Soaps and it is estimated at Rs.4,85,000.

2. At the same time the selling price of Janata Soap should be reduced to Rs. 1/- by adopting this sales strategy the sales manager is confident that he is able to double the present sales volume of Janata Soap and with each 1 lack increase of Janata Soap he would be able to push 30,000 cakes of Elite, 70,000 of lovely, 50,000 of fresh in the market. You are required to find out the profit at present and profit if the sales managers scheme is implemented.

Solution:

Statement showing computation of profit at the current Mix:

	Elite	Levels	Fresh	Janata	Total
I) SP	3.50	3.00	2.50	1.50	
II) VC:					
DM	0.50	0.40	0.35	0.45	
DL	0.20	0.20	0.15	0.10	
Prod. Exp.	0.10	0.10	0.50	0.50	
AOH	0.15	0.05	0.10	0.05	
SOH	0.45	0.20	0.25	0.05	
	1.40	0.95	0.90	0.70	
III) Contribution (I - II)	2.10	2.05	1.60	0.80	
IV) Total Contribution (III x No. Units Sold)	1,05,000	2,05,000	1,20,000	1,60,000	5,90,000
V) F.C:					
Prod. Exp.	0.20	0.25	0.20	0.20	
Adv. Exp.	0.30	0.40	0.25	0.30	
S & D Exp.	0.80	0.60	0.45	0.10	
	1.30	1.25	0.90	0.60	
VI) Total F.C (V x No. of Units Sold)	65,000	1,25,000	67,500	1,20,000	3,77,500
VII) Profit (IV - VI)	40,000	80,000	52,500	40,000	2,12,500

Statement showing computation of profit by adopting sales manager's scheme:

	Elite	Levels	Fresh	Janata	Total
No. of Units	1,10,000	2,40,000	1,75,000	4,00,000	
Contribution per unit	2.10	2.05	1.60	(0.8 – 0.5) 0.30	
Total Contribution	2,31,000	4,92,000	2,80,000	1,20,000	11,23,000
F C					8,62,500
Profit					2,60,500

Illustration No. 7

Evenkeel Ltd. manufactures and sells as single product X whose price is Rs.40 per unit and the variable cost is Rs.16 per unit.

(a) If the fixed costs for this year are Rs.4,80,000 and the annual sales are at 60% margin of safety, calculate the rate of net return on sales, assuming an income tax level of 40%.

(b) For the next year, it is proposed to add another product line Y whose selling price would be Rs.50 per unit and the variable cost Rs.10 per unit. The total fixed costs are estimated at Rs.6,66,600. The sales mix of X:Y would be 7:3. At what level of sales next year, would Evenkeel Ltd. break even ? Give separately for both X and Y the break even sales in rupees and quantities.

Solution:

a) Statement showing computation of profit on X:

SP = 40

VC = 16

C = 24

P/V Ratio = $\frac{C}{S}$ x 100 = $\frac{24}{40}$ x 100 = 60%

BES = $\frac{FC}{PV\ Ratio}$ = $\frac{4{,}80{,}000}{60\%}$ = Rs. 8,00,000

Let x be the total sales

0.6x = x – 8,00,000

=> x = 20,00,000

=> No. of units = $\frac{x}{40}$ = 50,000

i)	Sales (50,000 x 40)	=	20,00,000
ii)	Variable Cost	=	8,00,000
iii)	Contribution	=	12,00,000
iv)	Fixed Cost	=	4,80,000
v)	Profit	=	7,20,000
vi)	Tax (7,20,000 x 40%)	=	2,88,000
vii)	Net Profit	=	4,32,000

b) Let the break – even units of products X & Y be 7a & 3a respectively.

In order to break even the contribution must be equal to FC

- (7a x 24) + (3a x 40) = 6,66,000
- a = 2314.58

BES of X = 7a = 16,202.08 x SP = 648080

Y = 3a = 6943.75 x SP = 347200

Illustration No. 8

The profit for the year of Push On Ltd. work out to 12.5% of the capital employed and the relevant figures are as under:

	Rs
Sales	5,00,000
Direct Material	2,50,000
Direct labour	1,00,000
Variable overheads	40,000
Capital employed	4,00,000

The new sales manager who has joined the company recently estimates for the next year a profit of about 23% on the capital employed provided the volume of sales is increased by 10% and simultaneously there is an increase in Selling Price of 4% and an overall cost reduction in all the elements of cost by 2%.

Find out by computing in detail the cost and profit for next year, whether the proposal of sales manager can be adopted.

b) Details about the single product marketed by a company are as under

Per Unit	Rs
Selling Price	100
Direct Material	60
Direct Labour	10
Variable Overheads	10

No. of units sold in the year 5.035. Pursuant to an agreement reached with the Employee's union, there would be next year a 10% increase in wages across the board for all those directly engaged in production.

Work out:

i) How many more units have to be sold next year to maintain the same quantum of profit?

ii) Or else, by what percentage the Selling Price has to be raised to maintain the same P/V ratio.

Solution:

a) Computation of Fixed Cost:

Sales		5,00,000
(-) Profit	4,00,000 x 12.5%	50,000
Total Cost		4,50,000
(-) VC: DM	2,50,000	
DL	1,00,000	
VOH	40,000	3,90,000
Fixed Cost		60,000

Statement showing computation of profit obtained on adopting the Sales Manager's proposal:

i)	Sales	$4,00,000 \times \frac{110}{100} \times \frac{104}{100}$	5,72,000
ii)	Variable Cost	$3,90,000 \times \frac{110}{100} \times \frac{98}{100}$	4,20,420
iii)	Contribution		1,51,480
iv)	Fixed Cost	60,000 x 98%	58,800
v)	Profit		92,780

% of profit on Capital Employed = $\frac{92,780}{4,00,000} \times 100 = 23.195 > 23$,

$\therefore$ Proposal may be accepted

b) Current year details:

Sales	5035 x 100	5,03,500
Variable Cost	80 x 5035	4,02,800
Contribution		1,00,700
P/V Ratio	$\frac{C}{S} \times 100 = \frac{20}{100} \times 100 =$	20%

Details of next year:

SP		100
VC: DM	60	
DL – 10 x 110%	11	
VOH	10	81
C		19

i) No. of units to maintain same profit = $\frac{\text{Desired Contribution}}{\text{Contribution per unit}} = \frac{1,00,000}{19} = 5,300$

ii) Let S be the new SP

P/V Ratio = $\frac{S - V}{S} \times 100$

- $0.2 = \frac{S - 81}{S}$
- S = 101.25

$\therefore$ SP has to be increased by 1.25%.

Illustration No. 9

The management accountant of X Ltd. has prepared the following estimates of working results for the year ending 31st Dec, 2007 for the purpose of preparing the budget for the year ending 31st Dec, 2008.

	Year ending 31-12-2007
Direct material	Rs. 16 per unit
Direct wages	Rs. 40 per unit
Variable	Rs. 12 per unit
Selling price	Rs.125 per unit
Fixed expenses	Rs.6,75,000 per annum
Sales	Rs.25,00,000 per annum

During the year 2007, it is expected that the material prices and variable over heads will go up by 10% and 5% respectively. As a result of reorganisation of production methods the overall direct labour efficiency will increase by 12% but the rate will go up by 5%. The fixed overheads are also expected to increase by Rs.1,25,000.

The technical director states that the same level of output as obtained in 2007 should be maintained in 2008 also and efforts should be made to maintain the same level of profit by suitably increasing the selling price.

The marketing director states that the market will not absorb any increase in the selling price. On the other hand he proposes that publicity involving advertisement expenses in these proportions will increase the quantity of sales as under

Advertisement Expenses (Rs.)	80,000	1,94,000	3,20,000	4,60,000
Additional units of sales	2,000	4,000	6,000	8,000

Required:

i) Present an income statement for the year 2007

ii) Find the revised price and the percentage of increase in the price for 2008 if the technical directors views are accepted.

iii) Evaluate the four alternative proposals put forth by the marketing director, determine the best output level to be budgeted and prepare the overall income statement for 2008 at the level of output.

Solution:

Statement showing computation of profit for the year 2007:

i)	SP		125
ii)	Variable Cost		68
iii)	Contribution		57
iv)	Total Contribution	$25,00,000 \times \frac{57}{125}$	11,40,000
v)	Fixed Expenses		6,75,000
vi)	Profit		4,65,000

ii) Technical Director's proposal:

VC:			
R M	$16 \times \frac{110}{100}$		17.6
Wages	$40 \times \frac{105}{100} \times \frac{100}{112}$		37.5
Variable OH	$12 \times \frac{105}{100}$		12.6
Total VC			67.7
FC		6,75,000	
(+) Addnl.		1,25,000	8,00,000
Total Cost			21,54,000
Profit			4,65,000
Sales			26,19,000

$$SP = \frac{26,19,000}{20,000} = \text{Rs. } 130.95$$

$$\% \text{ in SP} = \frac{5.95}{125} \times 100 = 4.76\%$$

iii) Marketing Director's view:

Additional Sales	2,000	4,000	6,000	8,000
Cost per unit	57.3	57..3	57.3	57.3
Add: C	1,14,600	2,29,200	3,43,800	4,58,400
Add: FC	80,000	1,94,000	3,20,000	4,60,000
P / (L)	34,600	35,200	23,800	(16,000)

Statement showing computation of profit at optimum level forecasted by the marketing director:

i)	No. of units		24,000
ii)	C per unit		57.3
iii)	Total C		13,75,200
iv)	FC	(8,00,000 + 1,98,000)	9,94,000
v)	Profit		3,81,200

Illustration No.10

S.U Ltd. produces three products namely A, B and C. The budgeted production, costs and selling prices for the next year are as under:

Direct materials (Rs./unit)	24	16	12
Direct wages:			
Dept. Rate/Hour:			
1. Rs 4 Hrs/ unit	3	5	25
2. Rs 2 Hrs/unit	3	8	6
Budgeted Production (units)	10,000	12,000	20,000
Max. possible sales (units)	12,000	16,000	24,000
Selling price (Rs./unit)	75	105	60

Variable overheads:

Dept.1 Recovered at 100% of direct wages.

Dept.2 Recovered at 50% of direct wages.

Fixed overheads Rs.5,00,000 per annum.

A direct labour hour in Dept1 is in short supply and the budgeted volume of output envisages full utilisation of the available direct labour hours. In Dept 2, the co. has committed to engage the workers to the extent of the direct labour hours required for the budgeted volume of production. Should a change in the product mix be desired, the co. can engage additional direct labour hours required in dept 2 at normal rates; but any portion of the direct labour hours of dept 2 rendered surplus by reasons of a change in the present product mix have to be paid by the co. as idle wages in view of the commitment already made.

Required:

i) Present a statement showing the budgeted profitability.

ii) Set optimal product mix and work out the optimum profit after taking into consideration the idle time wages, if any, payable in dept 2.

If the co. desires to subcontract the surplus direct labour hours, if any, in dept 2, what minimum charges should be quoted per direct labour hour.

Solution:

i) Statement showing computation of budgeted profit and contribution per labour hour in dept. 1: (Rs.)

	A	B	C	Total
SP	75	105	60	
VC:				
DM	24	16	12	
DW: Dept 1	12	16	12	
Dept 2	6	16	12	
VOH	15	23	16	
	57	70	50	
Contribution	18	35	10	
Cont. Per lab hour	6	5	4	
In Dept. I				
	I	II	III	
Budged units	10,000	12,000	20,000	8,00,000
Total contribution	1,80,000	4,20,000	2,00,000	5,00,000
Profit				3,00,000

ii) Statement showing optimum mix and profit at that mix:

No. of Units	A	B	C	Total
No. of Units	12,000	16,000	9,600	
C P.U	18	25	10	
Total	2,16,000	4,00,000	96,000	7,12,000
FC				5,00,000
Profit				2,12,000
(-) Cost of idle wages in dept 2			24,400 x 2	48,800
Profit after idle wages				1,63,200

Working Notes:

No. of hours in dept 1 = (10,000 x 3) + (12,000 x 5) + (20,000 x 2.5) = 1,40,000

No. of hours in dept 2 = (10,000 x 3) + (12,000 x 8) + (20,000 x 6) = 2,46,000

	Dept I	Dept II
Available Hours	1,40,000	2,46,000
(-) utilized for A	36,000	36,000
	1,04,000	2,10,000
(-) for B	80,000	1,28,000
	24,000	82,000
No. of Units of C = $\frac{24,000}{2-5}$ = 9,600	24,000	9600 x 6 = 57,600
	-	24,400

iii) Hire charges = Labour Cost + Var. O.H

= 2 + 2 x 50% = Rs. 3

Illustration No. 11

V Ltd. produces two products P and Q. The draft budget for the next month is as under:

Budgeted production and sale (units)	40,000	80,000
Selling price Rs./unit	25	50
Total costs Rs./unit	20	40
Machine hours/unit	2	1
Max. sale potential (units)	60,000	1,00,000

The fixed expenses are estimated at Rs.9,60,000 per month. The Co. absorbs fixed overheads on the basis of machine hours which are fully utilised by the budgeted production and cannot be further increased.

When the budget was discussed, the managing director states that the product mix should be altered to yield optimum profit.

The Marketing Director suggests that he could introduce a new product C each unit of which take 1.5 machine hours. However a processing vat involving a capital outlay of Rs.2,00,000 is to be installed for processing product C. The additional fixed overheads relating to the processing vat was estimated at Rs.60,000 per month. The variable costs are product C was estimated at Rs.21 per unit.

Required:

i) Calculate the profit as per draft budget for the next month.

ii) Revise the product mix based on data given P and Q to yield optimum profit.

iii) The company decides to discontinue either product P on Q whichever is giving lower profit and proposes to substitute product C instead. Fix the selling price of C in such a way to yield 15% return on additional capital employed besides maintaining the same overall profit as envisaged in (ii) above.

Solution:

Computation of profit as per draft budget:

	P	Q	Total (Rs.)
SP	25	50	
Total Cost	20	40	
Profit	5	10	
Budgeted Units	40,000	80,000	
Profit (Budgeted Units x Profit Per Unit)	2,00,000	8,00,000	10,00,000
Total Cost	8,00,000	3,20,000	11,20,000
(-) FC			9,60,000
VC			1,60,000
FC P u	12	6	
VC P u	8	34	
Contribution Per Unit	17	16	
Contribution Per machine hour	8.5	16	
Ranking	II	I	

Statement showing optimum mix and relevant profit:

	P	Q	Total
No. of units	30,000	1,00,000	
Contribution Per Unit	17	16	
Total Contribution	5,10,000	16,00,000	21,10,000
FC			9,60,000
Profit			11,50,000

Working Notes:

Available hours = (40,000 x 2) + (80,000 x 1) =	1,60,000
(-) Utilised for Q	1,00,000
	60,000

No. of units of P = $\frac{60,000}{2}$ = 30,000 *units*

Computation of SP of product C:

Out of products P & Q, P is less profitable and hence can be replaced by C.

Variable Cost	21
FC	60,000
Machine hours released =	60,000

No. of units of C = $\frac{60,000}{15}$ = 40,000

In order to get the profit as above, the contribution to be recovered is as follows:

Total Contribution	21,00,000
(+) Fixed Cost (Additional)	60,000
(+) Return on capital employed	30,000
	22,00,000
(-) Recovered from Q	16,00,000
	6,00,000

Contribution per unit = $\frac{60,000}{40,000}$ = 15

(+) VC	21
SP	36

Illustration No. 12

Household Equipments Ltd. is producing kitchen equipment from five components three of which are made using general purpose machines and two by manual labour. The data for the manufacture of the equipment is as follows:

Components	A	B	C	D	E	Total
Machines hours reqd. per unit	10	14	12	-	-	36
Labour hours reqd. per unit	-	-	-	2	1	3
Variable cost per unit (in Rs.)	32	54	58	12	4	160
Fixed cost per unit (apportioned)	48	102	116	24	36	316
Total component cost	80	156	174	36	30	476
Assembly cost/unit (all variable)						Rs.40
Selling price/unit						Rs.600

The marketing department of the company anticipates 50% increase in demand during the next period. General purpose machinery used to manufacture. A,B and C is already working to the maximum capacity of 4752 hours and there is no possibility of increasing this capacity during the next period. But labour is available for making components D and E and also for assembly according to demand. The management is considering the purchase of one of the components A,B or C from the market to meet the increase in demand. These components are available in the market at the following prices:

Components A: Rs.80
Components B: Rs.160
Components C: Rs.125

Required:

a) Profit made by the company from current operations.
b) If the company buys any one of the components A,B or C, what is the extent of additional capacity that can be created?
c) Assuming 50% increase in demand during the next period, which component should the company buy from the market?
d) The increase in profit, if any, if the component suggested in c) is purchased from the market.

Solution:

a) Statement showing profit at current operations:

SP		600
Less:- Variable Cost	(160 + 40)	200
Contribution		400
No. of units	$\frac{4752}{36}$	132
Total Contribution		52,800
Fixed Cost		41,712
Profit		11,088

b)

	A	B	C
Buying cost	80	160	125
Variable Cost	32	54	58
Extra buying Cost	48	106	67
Excess buying cost per hour	4.8	7.571	5.583

It is better to buy component A from the market because excess buying cost per machine hour is less.

Computation of additional capacity created if components are bought from outside:

<u>If A is bought</u>:

No. of units that can be manufactured	$\frac{4752}{26}$	182.76 units
Increase in capacity	$\frac{182.86 - 132}{132} \times 100$	38.46 %

<u>If B is bought</u>:

No. of units	$\frac{4752}{22}$	216
Increase in capacity	$\frac{216 - 132}{132} \times 100$	63.64%

<u>If C is bought</u>:

No. of units	$\frac{4752}{24}$	198
Increase in capacity	$\frac{198 - 132}{132} \times 100$	50%

c) A is cheaper to buy. But the increase in capacity will not be sufficient to meet the expected demand for next year. Therefore, we shall try to buy the next cheaper component. i.e., C and by buying it the increase in capacity will be exactly equal to the demand for our product during the next year. hence, component 'C' should be bought from the market.

d) Statement showing computation of profit by buying C from outside:

I) No. of Units	$\frac{4752}{24}$	198
II) Selling Price		600
III) Variable Cost	(200 – 58 + 125)	267
IV) Contribution		333
V) Total Contribution		65,934
VI) Fixed Cost		41,712
VII) Profit		24,222
Less: Existing Profit		11,088
Increase in profit		13,134

Illustration No. 13

As a part of its rural upliftment programme, the Government has put under cultivation a farm of 96 hectors to grow tomatoes of four varieties: Royal Red, Golden Yellow, Juicy Crimson and Sunny Scarlet of the total 68 hectors are suitable for all four varieties, but the remaining 28 hectors are suitable for growing only Golden Yellow and Juicy Crimson. Labour is available for all kinds of farm work and there is no constraint.

The market requirement is that all four varieties of tomato must be produced with a minimum of 1,000 boxes of any one variety.

The farmers engaged have decided that the area devoted to any crop should be in terms of complete hectors and not in fractions of a hector. The other limitation is that not more than 22,750 boxes of any one variety should be produced. The following data are relevant.

Annual Yield	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet
Boxes per hector	350	100	70	180
Costs	Rs.	Rs.	Rs.	Rs.
Direct:				
Material per hector	476	216	196	312
Labour:				
Growing per hector	896	608	371	528
Harvesting and packing per box	3.60	3.28	4.40	5.20
Transport per box	5.20	5.20	4.00	9.60
Market price per box	15.38	15.87	18.38	22.27

Fixed overheads per annum

Growing	Rs. 11,200
Harvesting	7,400
Transport	7,200
General Administration	10,200

Find out: (i) within the given constraints, the area to be cultivated with each variety of tomatoes, if the largest total profit has to be achieved.

(ii) The amount of such profit in rupees.

A nationalised bank has come forward to help in the improvement programme of the 28 hectors in which only Golden Yellow and Juicy Crimson will grew, with a loan of Rs. 5,000 at a very nominal interest of 6% per annum. When this improvement is carried out, there will be a saving of Rs. 1.25 per box in the harvesting cost of Golden Yellow and the 28 hectors will become suitable for growing Royal Red in addition to the existing Golden Yellow and Juicy Crimson varieties. Assuming that other constraints continue, find the maximum total profit that would be achieved when the improvement programme is carried out.

Solution:

Statement showing contribution per hectare and determination of priority for profitability

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet
i) Sales realised per hectare	**5383**	**1587**	**1288.6**	**4008.6**
ii) Variable cost:				
a. direct material	476	216	196	312
b. growing cost per hectare	896	608	371	528
c. harvesting and packing	1260	328	308	936
d. transport	1820	520	280	1728
	4452	**1672**	**1055**	**3504**
iii) Contribution per hectare	**931**	**-85**	**233.6**	**504.6**
iv) Priority	1	4	3	2

Statement showing optimum product mix under the given conditions and computation of profit at that mix

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet	Total
Minimum boxes to be produced	1,000.00	1,000.00	1,000.00	1,000.00	
Area required for this minimum	3.00	10.00	14.00	6.00	33.00
Remaining land Apportioned on the basis of given data according to priority	59.00		4.00		63.00
i) No. of hectares	62.00	10.00	18.00	6.00	96.00
ii) Contribution per hectare	931.00	(85.00)	131.60	504.60	
iii) Total contribution	57,722.00	(850.00)	2,368.80	3,027.60	62,268.40
iv) Fixed cost					36,000.00
v) Profit					26,268.40

Statement showing optimum mix after the improvement programme and computation of profit

	Royal Red	Golden Yellow	Juicy Crimson	Sunny Scarlet	Total
Area required for this minimum	3.00	10.00	14.00	6.00	33.00
Remaining land Apportioned on the basis of given data according to priority	62.00			1.00	63.00
i) No. of hectares	65.00	10.00	14.00	7.00	96.00
ii) Contribution per hectare	931.00	(85.00)	131.60	504.60	
iii) Total contribution	60,515.00	400.00	2,368.80	3,532.20	66,289.60
iv) Fixed cost					36,300.00
v) Profit					29,989.60

Illustration No. 14

Nice and Warm, Ltd. manufactures and markets hot plates. During the first five years of operations, the company has experienced a gradual increase in sales volume, and the current annual growth in sales of 5% is expected to continue in the foreseeable future. The plant is now producing at its full capacity of one lakh hot plates.

At the monthly Management Advisory committee meting, amongst other things, the plan of action for next year was discussed.

Managing Director proposed two alternatives. First, operations could be continued at full capacity and with the existing facilities, an output of one lakh hot plates at a selling price of Rs. 100 per plate per unit could be maintained. Secondly, production and sales could be increased by 5% to take advantage of the rate of expansion in demand for the product. But this could increase cost, as to achieve the output, the company will have to resort to weekend and over time workings. However, a policy of steady growth was preferable to maintaining status quo.

In view of the company’s competitors having a substantial share of the market, the Works Director was of the view that it was not enough for the company to maintain merely the present share of the total market. A large share of the total market should be obtained. For that, the company should increase production by 10% through a modest expansion of the plant capacity. In order to sell the output of 1,10,000 units the selling price could be reduced to Rs. 95 per unit.

Thinking on the same lines, the Marketing Director put forth a more radical proposal. The strategy should be to seize the competitive leadership in the market with regard to both price and volume. With this end in view, he suggested that the company should straightaway embark on an expensive modernisation programme, which will initially increase volume by 20%. The entire output of 1,20,000 hot plates could be easily sold at a price of Rs. 90 per unit.

At this juncture, the Managing Director expressed concern about the probable behavior of the company’s competitors. They might also expand in order to produce more and sell at lower prices. Suppose this happened, he wanted also the financial effects of the proposals of the Works Director and Marketing Director, if in these proposals, the expected increase in sales were to be only half of that predicted.

As a Cost Accountant of the company, you are required to critically evaluate the six alternative along with your recommendations and circulate the same to the Directors. In this connection, you have gathered the following details:

i) If next year's production was maintained at the current year's level, variable cost would remain at Rs. 50 per unit. Fixed cost would remain unchanged at Rs. 30 lakhs.

ii) The week-end and overtime working would increase with the variable and fixed costs. Variable cost would rise to Rs. 55 per unit while fixed cost would increase to Rs. 30,25,000

iii) In the proposal of the Works Director, the ratio of variable costs to sales would continue to be 50%. Fixed costs would rise to Rs. 32,25,000.

iv) In the proposal of Marketing Director, as a result of increased production, efficiency and some savings from purchase of materials, it is estimated that the ratio of variable cost of sales would decrease to 48% and the fixed costs would increase by Rs. 5,16,000.

Your answer should contain:

a) A tabular statement of comparative figures pertaining to total turnover, total contribution, Percentage of Profit to Sales and Breakeven units as regard to each of the six proposals.

b) Comments on the relative risk involved.

c) Consideration of the short-term and long-term implications of the Managing Director's proposals.

d) Comment on the price elasticity of demand for the company's products and your suggestions on the pricing policy and cost structure

e) Comment on financial implications of the expansion scheme.

Solution:

a) Statement showing contribution, profit at six alternatives

		Managing Director		Works Director		Marketing Director	
		I	II	I	II	I	II
i)	No. of units	100,000.00	105,000.00	110,000.00	105,000.00	120,000.00	110,000.00
ii)	Selling price per unit	100.00	100.00	95.00	95.00	90.00	90.00
iii)	Sales turnover (Rs. Lakhs)	100.00	105.00	104.50	99.75	108.00	99.00
iv)	Variable cost per unit	50.00	55.00	47.50	47.50	43.20	43.20
v)	Contribution per unit (ii-iv)	50.00	45.00	47.50	47.50	46.80	46.80
vi)	Total contribution (Rs. Lakhs)	50.00	47.25	52.25	49.88	56.16	51.48
vii)	Fixed cost (Rs. Lakhs)	30.00	30.25	32.25	32.25	3,516.00	35.16
viii)	Profit (Rs. Lakhs) (vi-vii)	20.00	17.00	20.00	17.63	21.00	16.32
ix	% of profit on sales	20.00	16.19	19.14	17.67	19.44	16.48
x)	Break even units (vii/v)	60,000.00	67,222.00	67,895.00	67,895.00	75,128.00	75,128.00
xi)	Margin of safety units	40,000.00	37,778.00	42,105.00	37,105.00	44,872.00	34,872.00
xii)	P.V ratio	0.50	0.45	0.50	0.50	0.52	0.52

b) Managing directors first proposal seems to be more favorable from the risk point of view because it has low break even and high margin of safety coupled with higher percentage of profit to sales.

c) From the short run point of view, Managing director's second proposal, i.e steady growth of 5% a year would be better, even by resorting to weekend over time working. However, from the long term view point, the above proposal is not advisable because when they have steady growth, they can go for expansion of business rather than resorting to overtime working. If it I not possible to go for expansion, a steady status quo is the best solution.

d) It was given that, annual growth of sales of 5% is expected to continue in foreseenable future. It is not clear, why the second proposal of the works director and marketing director should suggest, reduction in price for 5% and 10% respectively.

   It seems no serious study has been made on the price elasticity of demand of the product. If there is demand for the product and increased production, they may reduce the price by adapting discriminate price policy

e) If the company desires to expand the production, it is necessary to find out the sources of financing of expansion scheme by relative profitability of different funds.

Illustration No. 15

Domestic political trouble in the country of an overseas supplier is causing concern in your company because it is not known when further supplies of raw material 'x' will be received. The current stock held of this particular raw material is 17,000 kilograms, which costs Rs. 1,36,000. Based on raw material `x', your company makes five different products and the expected demand for each of these, for the next three months, it given below together with other relevant information:

Product code	Kilogram of raw material 'x' per unit of finished product	Direct labour hours per unit of finished product	Selling price per unit	Expected demand over three month
	Kg.	Hours	Rs.	units
701	0.7	1.0	26	8,000
702	0.5	0.8	28	7,200
821	1.4	1.5	34	9,000
822	1.3	1.1	38	12,000
937	1.5	1.4	40	10,000

The direct wages rate per hour is Rs. 5 and production overhead is based on direct wages cost - The variable overhead absorption rate being 40% and the fixed overhead absorption rate being 60% variable selling costs, including sales commission, are 15% of selling price.

Budget fixed selling and administration costs are Rs. 300,000 per annum. Assume that the fixed production overhead incurred will equal the absorbed figure.

You are required to:

a) Show what quantity of the raw material on hand ought to be allocated to which products in order to maximize profits for the forthcoming three months.

b) Present a brief statement showing contribution and profit for the forthcoming three months, if your suggestion in (a) is adopted;

c) Comment briefly on the analysis you used to aid the decision making process in (a) and give three other examples of business problems where this type of analysis can be useful.

Statement showing computation of contribution per koilogram of material and determination of priority for profitability

Solution:

Statement showing computation of contribution per koilogram of material and determination of priority for profitability

	Product Code	701	702	821	822	937
i)	Selling price	**26.00**	**28.00**	**34.00**	**38.00**	**40.00**
ii)	Variable cost					
	a. Direct material	5.60	4.00	11.20	10.40	12.00
	b. Labour	5.00	4.00	7.50	5.50	7.00
	c. Production overheads	2.00	1.60	3.00	2.20	2.80
	d. Selling expenses	3.90	4.20	5.10	5.70	6.00
		16.50	**13.80**	**26.80**	**23.80**	**27.80**
iii)	Contribution	**9.50**	**14.20**	**7.20**	**14.20**	**12.20**
iv)	Contribution per kilogram of material	**13.57**	**28.40**	**5.14**	**10.90**	**8.13**
v)	Ranking	II	I	V	III	IV

Statement showing optimum mix under given conditions and computation of profit at that mix

Product Code	701	702	821	822	937	Total
No. of units	8,000.00	7,200.00		6,000.00		
Contribution per Unit	9.50	14.20		14.20		
Total contribution	76,000.00	102,340.00		85,200.00		263,440.00
Fixed cost						136,080.00
Profit						127,360.00

<u>Working notes</u>

Computation of material apportion on the basis of priority

Available material	17,000.00
Less : used for 702 (7200 x 0.5)	3,600.00
	13,400.00
701 (8000 x 0.7)	5,600.00
	7,800.00

Therefore no. of units of 822 to be produced from remaining material (7800/1.3) = 6000 Units

Fixed cost

Selling and Adm. Overheads [(300000/12)x3]	75,000.00
Factory Overheads [(8000x5x60%)+(7200x4x60%)+(6000x5.5x60%)]	61,080.00
	136,080.00

Illustration No. 16

Z Ltd., makes a range of five products to which the following standards apply:

	Rs. Per Unit				
	A	B	C	D	E
Sales price	50	60	70	80	90
Direct materials	9	10	17	12	21
Direct Wages	16	20	24	28	32
Variable production overheads	8	10	12	14	16
Variable selling and distribution overheads	5	6	7	8	
Fixed overheads	4	5	6	7	8
	42	51	66	69	86

The direct labour wage rate is Rs.4 per hour. Fixed overheads have been allocation the basis of direct labour hours. The company has commitments to produce a minimum of 400 units of each product per month direct hours cannot exceed 13,000 per month due to restriction of space. The Board is now considering an offer of a new three-year contract to produce an additional 400 units of product B per month at a selling price of Rs.58 per unit. The contract would involve an outlay of Rs.1,00,000 on the lease of additional factory premises and purchase of new plant and equipment. There would be residual value at the end of the contract. Variable production costs would be in accordance with existing standards, variable selling and distribution costs would be one-half of the existing rate and cash outflows on fixed costs would be Rs.20,000 per annum. There would be no change to existing production arrangements. An outside supplier has offered to supply 400 units of product B per month at a price of Rs.48 per unit. If purchased externally cash flows on additional fixed costs will be Rs. 25,000 per annum.

Required:

(a) Give recommendations, supported by calculations, to show how direct labour hours in the existing factory should be utilised in order to maximize profits.

(b) Show the budgeted trading results on the basis of your recommendations in (a).

(c) Give calculations to show whether or not the proposed contract for product B should be accepted and, if so, whether it should be purchased externally or manufactures in the new premises. The company's cost of capital is 10% (the present value of an annuity of Rs.1 for three years at 10% is Rs.2.49). Ignore taxation and inflation.

Solution:

A. Statement showing contribution per labour hour and determination of priority for profitability

	A	B	C	D	E
i) Selling price	**50.00**	**60.00**	**70.00**	**80.00**	**90.00**
ii) Variable cost					
a. Direct material	9.00	10.00	17.00	12.00	21.00
b. labour	16.00	20.00	24.00	28.00	32.00
c. Variable overheads	8.00	10.00	12.00	14.00	16.00
d. Variable selling & dis. Overheads	5.00	6.00	7.00	8.00	9.00
	38.00	**46.00**	**60.00**	**62.00**	**78.00**
iii) Contribution	**12.00**	**14.00**	**10.00**	**18.00**	**12.00**
iv) Contribution per labour hour	**3.00**	**2.80**	**1.66**	**2.57**	**1.50**
v) Ranking	I	II	IV	III	V

B. Statement showing optimum mix under given conditions and computation of profit at that mix.

	A	B	C	D	E	Total
Minimum no. of units	4,800.00	4,800.00	4,800.00	4,800.00	4,800.00	
Units in remain hours (w/n)	3,000.00					
No. of units	7,800.00	4,800.00	4,800.00	4,800.00	4,800.00	
Contribution per Unit	12.00	14.00	10.00	18.00	12.00	
Total contribution	93,600.00	67,200.00	48,000.00	86,400.00	57,600.00	352,800.00
Fixed cost (156000 hoursx1)						156,000.00
Profit						196,800.00

Working notes:

Available hours	156,000.00
Hours utilised for minimum {(4+5+6+7+8)x4800}	144,000.00
Remaining hours	12,000.00
Therefore units of a to be produced (12000/4)	3000 units

C.

Option I	
Selling price offered	58.00
Less ; Variable cost (46-(6/2))	43.00
Contribution	15.00
No. of units	4,800.00
Total contribution	72,000.00
Less ;: Fixed cost	20,000.00
Profit	52,000.00

Present value of profit for three years contract

Inflow (52000x2.49)	129,480.00
Less : Outflow	100,000.00
Net present value	29,480.00

Option II		
Contract value (4800x48)	230,400.00	
Add : Fixed cost	25,000.00	
	255,400.00	
Present value for three years	(255400x2.49)	(635,946.00)
Present value of inflows	(4800x58x2.49)	693,216.00
Net present value		57,270.00

It is better to accept the order for product-B and to supply them by sub-contracting the order.

Illustration No. 17

The management accountant of X ltd., has prepared the following estimates of working results for the year ending 31st December,2007 for the purpose of preparing the budgets for the year ending 31st December,2008.

	Year ending 31/12/2007		
Direct material	Rs./unit	16.00	
Direct wages	"	40.00	
Variable overheads	"	12.00	
Selling price	"	125.00	
Fixed expenses	Rs.	6,75,000	p.a.
Sales	Rs.	25,00,000	p.a.

During the year 2008, it is expected that the material prices and variable overheads will go up by 10% and 5% respectively. As a result of re-organisation of production methods the overall direct labour efficiency will increase by 12% but the wage rate will go up by 5%. The fixed overheads are also expected to increase by Rs.1,25,000.

The Technical Director states that the same level of output as obtained in 2007 should be maintained in 2008 also and efforts should be made to maintain the same level of profit by suitably increasing the selling price.

The Marketing Director states that the market will not absorb any increase in the selling price. On the other hand he proposes that publicity involving advertisement expenses in the proportions will increase the quantity of sales as under:

Advertisement expenses (Rs.)	80,000	1,94,000	3,20,000	4,60,000
Additional units of sales	2,000	4,000	6,000	8,000

Required:

(i) Present an income statement for the year 2007.

(ii) Find the revised price and the percentage of increase in the price for 2008 if the Technical Directors' views are accepted.

(iii) Evaluate the four alternative proposals put forth by the Marketing Director, determine the best output level to be budgeted and prepare an overall income statement for 2008 at that level of output.

Solution:

I. Statement of profit at budget

i) Selling price	**125.00**
ii) Variable cost	
a. Direct material	16.00
b. Direct wages	40.00
c. Variable overheads	12.00
	68.00
iii) Contribution (i-ii)	**57.00**
iv) No. of units (25,00,000/125)	**20,000.00**
v) Total contribution	**1,140,000.00**
vi) Less: Fixed cost	**675,000.00**
vii) Profit (v-vi)	**465,000.00**

II. Computation of selling price, if the Technical Director is views are implemented.

Variable cost		
Direct material	(16x110%)	17.60
Direct wages	[(40x105%)x(100/112)]	37.50
Variable overheads	(12x105%)	12.60
		67.70

In order to get the same profit contribution to be recovered is as follows:

Existing fixed overheads	675,000.00
Add :Expected increase	125,000.00
	800,000.00
Add : Desired Profit	465,000.00
	1,265,000.00

Therefore Contribution per unit (1265000/20000)	63.25
Required selling price = variable cost + contribution =67.7+63.25	130.95
% Increase in profit =[{(130.95-125)/125}x100]	4.76%

III. Computation of additional profit at four alternatives proposed by Marketing Director.

Units	2000	4000	6000	8000
a. Contribution per unit (125-67.7)	57.30	57.30	57.30	57.30
b. Total contribution	114,600.00	229,200.00	343,800.00	458,400.00
c. Additional fixed cost	80,000.00	194,000.00	320,000.00	460,000.00
d. Profit/(loss)	34,600.00	35,200.00	23,800.00	(1,600.00)

Statement showing overall income for the year 1987

a. No. of units	24,000.00
b. Contribution per unit	57.30
c. Total contribution	1,375,200.00
d. Fixed cost (800000+194000)	994,000.00
e. Profit	381,200.00

Illustration No. 18

Allplay Ltd., are specialists in the manufacture of dolls for children. They manufacture and market four types of dolls patented the names, Dolly, Molly, Jolly, Polly and a doll dress sewing kit. They require your assistance as a Cost Accountant for determining the appropriate sales and product-mix of their products for the coming year. From the production standards established market forecasts and pricing policies, you get the following data:

Doll's name	Estimated demand for next year	Standard material cost per unit	Standard labour cost per unit.	Estimated net price per unit.
	Unit	Rs.	Rs.	Rs.
Dolly	50,000	1.40	0.80	5.20
Molly	42,000	0.70	0.50	2.40
Jolly	35,000	2.70	1.40	8.50
Polly	40,000	1.00	1.00	4.00
Sewing kit	3,25,000	0.60	0.40	3.00

(i) To promote sales of the sewing kit, there is a 15% discount offered in the established price of a kit, purchased at the same time along with a doll and it is expected that all the customers will avail this benefit.

(ii) The labour rate of Rs.2.00 per hour is expected to continue without change in the next year. The plant has an effective capacity of 1,30,000 labour hours on a single shift basis. Present equipment can produce all of the products. Overtime worked is paid at double the normal rate.

(iii) Next year's fixed cost is estimated at Rs.30,000 in the factory, Rs.20,000 in administration and Rs. 50,250 in selling and distribution.

(iv) Variable costs will be equivalent to 50% of standard Direct Labour cost.

(v) The company has a very small inventory of its products that can be ignored.

(a) You are required to draw a conservative estimate for the next year of the total contribution that would be made by each product line and the net income that would earned by the company.

(b) The company is at present having some industrial relations problem and if this continues in the next year, it would not then be possible to arrange for overtime work. Anticipating that eventuality, you are required to suggest a product-mix that would absolutely minimize the drop in the income already envisaged.

With that product-mix, work out product-wise contribution and the new net income that would be earned as a result.

	Dolly	Molly	Jolly	Polly	Sewing kit		Total
					Discount	No Discount	
Selling price	**5.20**	**2.40**	**8.50**	**4.00**	**2.55**	**3.00**	
Variable cost							
a. Direct material	1.40	0.70	2.70	1.00	0.60	0.60	
b. Direct wages	0.80	0.50	1.40	1.00	0.40	0.40	
c. Variable overheads	0.40	0.25	0.70	0.50	0.20	0.20	
	2.60	**1.45**	**4.80**	**2.50**	**1.20**	**1.20**	
Contribution	**2.60**	**0.95**	**3.70**	**1.50**	**1.35**	**1.80**	
Hours per unit	0.40	0.25	0.70	0.50	0.20	0.20	
Contribution per hour	**6.50**	**3.80**	**5.29**	**3.00**	**6.75**	**9.00**	
No. of units	50,000.00	42,000.00	35,000.00	40,000.00	167,000.00	158,000.00	
Total contribution	**130,000.00**	**39,900.00**	**129,500.00**	**60,000.00**	**225,450.00**	**284,400.00**	**869,250.00**
Fixed cost							100,250.00
Profit before considering overtime							**769,000.00**
Less : Overtime premium (w/n)							20,000.00
Profit at conservative estimate							**749,000.00**

Solution:

Statement showing computation of contribution per hour, determination of priority and profit at conservative estimate

Computation of over time premium

Available hours		130,000.00
Less : Utilised for		
Dolly	(50000x.4)	20,000.00
Molly	(42000x0.25)	10,500.00
Jolly	(35000x.7)	24,500.00
Polly	(40000x.5)	20,000.00
Sewing kit (discount)	(167000x.2)	33,400.00
Sewing kit (no discount)	(158000x0.2)	31,600.00
		10,000.00

Therefore overtime premium (10000x2) = Rs.20000

Computation of profit when no over time is available

	Dolly	Molly	Jolly	Polly	Sewing kit		Total
					Discount	No Discount	
a. No. of units	50,000.00	42,000.00	35,000.00	20,000.00	147,000.00	178,000.00	
b. Contribution per unit	2.60	0.95	3.70	1.50	1.35	1.80	
c. Total contribution	130,000.00	39,900.00	129,500.00	30,000.00	198,450.00	320,400.00	848,250.00
d. Fixed cost							100,250.00
e. Profit							748,000.00

Illustration No. 19

The operating results of B.N. Ltd., for the year 2007 were as under:

Sales mix: Product	Sales Mix %	P/V Ratio%
A	40	20
B	10	6
C	30	12
D	20	10

Total sales value of all the products was Rs.80 lacs. Total fixed overheads amounted to Rs. 10 lacs. Raw material contents of each product represented 50% of the respective variable cost. The forecast for the year 1982 is as under:

(i) The raw material costs will go up by 10%

(ii) The company has been able to obtain export quota of raw material of the value of Rs. 35 lacs.

(iii) The maximum sale potential of any of the above four products is 40% of the 2007 sale value.

(iv) The Company expects to secure an increase of 5% in the selling prices of all the products uniformly.

Required:

a) Prepare a statement showing the profitability of 2007.

b) Set a Product mix to maximise profit in 2008.

c) Prepare a statement showing the profitability of 2008.

Solution:

Statement showing profit for 2007, computation of contribution per rupee of material and determination of priority for profitability

	A	B	C	D	Total
Sales	3,200,000.00	800,000.00	2,400,000.00	1,600,000.00	8,000,000.00
Contribution	640,000.00	48,000.00	288,000.00	160,000.00	1,136,000.00
Fixed cost					1,000,000.00
Profit					136,000.00

Variable cost	2,560,000.00	752,000.00	2,112,000.00	1,440,000.00
Raw material cost	1,280,000.00	376,000.00	1,056,000.00	720,000.00
Contribution per rupee	0.50	0.13	0.27	0.22
Ranking	I	IV	II	III

Statement showing optimum mix under given conditions and computation of profit at that mix

	A	B	C	Total
i) Sales	**3,360,000.00**	**3,360,000.00**	**1,152,242.00**	**7,872,242.00**
	(80x40%x105%)	(80x40%x10)	(w/n)	
ii) Variable cost				
a. Raw material	1,408,000.00	1,548,800.00	543,200.00	
	[32x(12.8/32)x110%]			
b. Other variable cost	1,280,000.00	1,408,000.00	493,818.00	
	2,688,000.00	**2,956,800.00**	**1,037,018.00**	**6,681,818.00**
iii) Contribution	672,000.00	404,000.00	115,224.00	1,190,424.00
iv) iv) Fixed cost				1,000,000.00
v) v) Profit				**190,424.00**

<u>Working notes</u>

Available material	3,500,000.00
Less : utilised for	
A {(33.6)x(12.8x1.1)/(3.2 x1.05)]	1,408,000.00
C {(33.6)x(10.56x1.1)\(24x1.05)}	1,548,800.00
	543,200.00

Sales of D to be produced

Let X be sales

[(X x 7.2x1.1)/16x1.05] =543200

X = Rs. 1,152,242

Illustration No. 20

A small-scale manufacturing unit has employed skilled persons for doing pressing and welding operations on various products. The welders produce two different products, W_1 and w_2. The press operators also produce two products, P_1 and P_2. Due to specific skill requirements, the press operators can't do welding job and vice-versa. The labour hours and cost data in respect of the above 4 products are as under.

	W_1	W_2	P_1	P_2
Hours per unit	4	4	5	2
Price per unit (Rs.)	50	50	80	65
Direct Material per unit (Rs.)	18	22	35	45
Direct Labour Rate per hour	Rs. 4	4	4	4
Variable Overheads per unit	Rs. 2	2	3	3

The unit incurs Rs.50,000 per annum on fixed costs for producing the above products. The available labour hours for welding are 20,000 and for pressing 16,000.

The unit has also observed that the market can absorb minimum 2,000 units of W_1 2,500 units of W_2 1,800 units of P_1 and 2,200 units of P_2. The demand keeps on fluctuating. The manager of the shop has, therefore suggested that the workers should be trained to do either of welding or pressing job so that any excess demand can be fulfilled. It is estimated that this decision will increase the burden of fixed costs by Rs.5,000 p.a.

Required:

(a) Present the figures of optimum product mix assuming that the minimum marketable quantity is produced before the workers are trained and after they are trained.

(b) Prepare profitability statement for optimum product mix under both the above conditions and recommend whether it is advisable to train employees.

Solution:

Statement showing computation per hour and determination of priority

	W1	W2	P1	P2
i) Selling price	**50.00**	**50.00**	**80.00**	**65.00**
ii) Variable cost				
a. direct material	18.00	22.00	35.00	45.00
b. direct wages	16.00	16.00	20.00	8.00
c. variable overheads	2.00	2.00	3.00	3.00
	36.00	**40.00**	**58.00**	**56.00**
iii) Contribution	**14.00**	**10.00**	**22.00**	**9.00**
iv) Contribution per hour	**3.50**	**2.50**	**4.40**	**4.50**
v) Priority	III	IV	II	I

Statement showing calculation of profit before workers are trained

	W1	W2	P1	P2	Total
Minimum units	2,000	2,500	1,800	2,200	
Units in remaining time	500			1,300	
i) Total units	2,500	2,500	1,800	3,500	
ii) Contribution per unit	14.00	10.00	22.00	9.00	
iii) Total contribution	35,000	25,000	39,600	31,500	131,100
iv) Fixed cost					50,000
v) Profit					81,100

Working notes:

	W1 hours	P2 hours
Available hours	20,000	16,000
Less : used for minimum	18,000	13,400
	2,000	2,600
units	500 (2000/4)	1,300 (2600/2)

Statement showing calculation of Profit after Conversion

	W1	W2	P1	P2	Total
Minimum units	2,000	2,500	1,800	2,200	
Units in remaining time				2,300	
i) Total units	2,000	2,500	1,800	4,500	
ii) Contribution per unit	14.00	10.00	22.00	9.00	
iii) Total contribution (Rs.)	28,000	25,000	39,600	42,500	133,100
iv) Fixed cost (Rs.)					55,000
v) Profit (Rs.)					78,100

From the above, it is not advisable to versatile the machines.

Illustration No. 21

PH Ltd., has a productive capacity of 2,00,000 units of product BXE per annum. The company estimated its normal capacity utilisation at 90% for 2009-10. The variable costs are Rs.22 per unit and the fixed factory overheads were budgeted at Rs.7,20,000 per annum. The variable selling overheads amounted to Rs.6 per unit and the fixed selling expenses were budgeted at Rs.5,04,000. The operating data for 2009-10 are as under:

Production	1,60,000 units
Sales @ Rs.40 per unit	1,50,000 units
Opening stock of finished goods	10,000 units

The cost analysis revealed an excess spending of variable factory overheads to the extent of Rs.80,000. There are no variances in respect of other items of cost.

Required:

(i) Determine the budgeted break even point for 2009-10

(ii) What increase in price would have been necessary to achieve the budgeted profit?

(iii) Present statements of profitability for 2009-10 using:

(a) Marginal costing basis.

(b) Absorption costing basis.

Solution:

Fixed cost = Fixed overheads + selling expenses = 720000+504000 = 1224000

i	Selling price	40.00
ii	Variable cost	28.00
iii	Contribution	12.00

Break even at budget= (1224000/12) = 102000 units

Contribution at budget = [(200000 x 90%)x12] 2160000

Contribution per unit (2160000/150000)	14.40
Add : Variable cost	28.00
	42.40
Standard variable production cost	22.00
Add: Standard fixed cost (720000/200000x90%)	4.00
	26.00

Profit under Absorption Costing (Rs.)

Standard Variable cost	(160000 x 22)			3,520,000.00
Add : Variance				80,000.00
				3,600,000.00
Add : Fixed production cost absorbed	(160000 x 4)		680,000.00	
Add : Under recovery	(720000 - 680000)		40,000.00	720,000.00
		160,000.00		4,320,000.00
Add : Opening stock		10,000.00		260,000.00
				4,580,000.00
Less : Closing stock		20,000.00	(43.2x2/1.6)	540,000.00
				4,040,000.00
Add : Selling & Dist. Cost				
Variable	(150000 x 6)		900,000.00	
Fixed			504,000.00	1,404,000.00
Total cost				5,444,000.00
Profit (b/f)				556,000.00
Sales	(150000 x 40)			6,000,000.00

Profit under Marginal Costing Rs.

i) Sales				6,000,000.00
ii) Variable cost				
Production			3,600,000.00	
Add : Opening	(10000 x 22)		220,000.00	
			3,820,000.00	
Less : Closing	(20000 x 36/10)		450,000.00	3,370,000.00
Selling & distribution				900,000.00
Total Variable Cost				4,270,000.00
iii) Contribution (i) – (ii)				1,730,000.00
iv) Fixed cost				1,224,000.00
v) Profit (iii) – (iv)				506,000.00

EXERCISE PROBLEMS

Problem No. 1

An umbrella manufacturer marks an average net profit of Rs.2.50 per piece on a selling price of Rs.14.30 by producing and selling 6,000 pieces or 60% of the capacity. His cost of sales is

	Rs
Direct material	3.50
Direct wages	1.25
Works overheads (50% fixed)	6.25
Sales overheads (25% variable)	0.80

During the current year, he intend to produce the same number but anticipates that fixed charges will go up by 10% which direct labour rate and material will increase by 8% and 6% respectively but he has no option of increasing the selling price. Under this situation, he obtains an offer for furthur 20% of the capacity. What minimum price you recommend for acceptance to ensure the manufacturer an overall profit of Rs.16,730.

Ans: S.P. Rs.11.30

Problem No. 2

Y Company has just been incorporated and planed to produce a product that will sell for Rs. 10 per unit. Preliminary market surveys show that demand will be around 10,000 units per year.

The company has the choice of buying one of the two machines 'A' would have fixed costs of Rs.30,000 per year and would yield a profit of Rs.Rs.30,000 per year on the sale of 10,000 units.

Variable costs behave linearly for both machines. Machine B would have F.C. of Rs. 18,000 p.a. and would yield a profit of Rs.22,000 p.a. on the sale of 10,000 units.

Required to:

a) Break-even sales for each machine

b) Sales level where both machines are equally profitable

c) Range of sales where one machine is more profitable than the other.

Ans : (a) 50,000 : 40,000

(b) 6,000

(c) Sales above 6,000 units 'A' profitable, below 'B' profitable.

Problem No. 3

A farmer owns an orchard which has an area of 300 acres on which he grows apples, apricots, Cherrie and plums. Of the total area, 200 acres of land are suitable for growing apricots and cherries and in the remaining acres of land any of the four fruits can be grown.

The marketing policy requires that in each season all the four types of fruits must be produced and the quantity of any one of the four fruits should not be less than 12,000 boxes.

It is essential that the area devoted to any one should be in terms of complete acres and not in fractions of an acre. There are no physical or marketing limitations and there is an adequate supply of all types of labour

The details regarding the selling price, production and cost are given below:

	Apples	Apricots	Cherries	Plums
Selling price per box Rs	10	10	20	30
Acreage at each present devoted to each line	120	70	80	30
Seasons yield in boxes per acre	500	150	100	200
Weight per box kg	30	30	40	0
Costs (Rs.):				
Direct: Material per acre	180	70	60	100
Labour:				
Growing per acre	200	150	100	130
Harvesting & Picking per box	1	1	2	3
Transport per box	2	2	1	3

Fixed overhead incurred each season:

	Rs	Basis of apportionment to produce
Cultivation and growing	27,840	Direct labour cost incurred
Harvesting	20,900	Direct labour cost incurred
Administration	42,250	No. of boxes produced
Transport	5,110	Weight produced
Land revenue	9,000	No. of acres cultivated

Using above information, you are required to:

(a) Calculate profit and loss per box of each type of fruit that the farmer will obtain from operating the orchard on the present basis.

(b) Advise the farmer on the area to be allocated to each item in order to earn the maximum total profit.

Ans: a) 5.34; 3.57; 13.47; 20.34; b) 24; 80; 120; 76.

Problem No. 4

Taurus Ltd. produces three products A, B and C from the same manufacturing facilities. The cost and other details of the three products are as follows:

	A	B	C
Selling price per unit (Rs.)	200	160	100
Variable cost per unit (Rs.)	120	120	40
Fixed expenses/month (Rs.)	2,76,000		
Maximum production per month (units)	5,000	8,000	6,000
Total hours available for the month	200		
Maximum demand per month (units)	2,000	4,000	2,400

The processing hour cannot be increased beyond 200 hrs per month.

You are required to:

(a) Compute the most profitable product-mix.

(b) Compute the overall break-even sales of the co., for the month based in the mix calculated in (a) above.

Ans: A - 2,000; B - 2,400; C - 1,600; (b) BEP - Rs.6,72,000

Problem No. 5

A review, made by the top management of Sweet and Struggle Ltd. which makes only one product, of the result of two first quarters of the year revealed the following:-

Sales in units	10,000
Loss	Rs.10,000
Fixed Cost (for the year Rs.1,20,000)	30,000
Variable cost per unit	Rs. 8

The finance Manager who feels perturbed suggests that the company should at least break-even in the second quarter with a drive for increased sales. Towards this the company should introduce a better packing which will increase the cost by Rs.0.50 per unit.

The Sales Manager has an alternate proposal. For the second quarter additional sales promotion expenses can be increased to the extent of Rs.5,000 and a profit of Rs.5,000 can be aimed at the for the period with increased sales.

The production Manager feels otherwise. To improve the demand the selling price per unit has to be reduced by 3%. As a result the sales volume can be increased to attain a profit level of Rs.4,000 for the quarter

The Managing Director asks for as a cost Accountant to evaluate these three proposals and calculate the additional sales required in each case and help him to make a decision.

Ans: Additional Sales Volume - 10,000 units.

Problem No. 6

S.G Ltd produces four products in its factory. The volume of production and sales achieved is considerably lower than normal and so there has been substantial under recovery of overheads. The sales and cost particulars are as under:

					(Rs. In lakhs)
		Products			
	A	B	C	D	Total
Sales	160	200	80	40	480
Costs:					
Direct Material	24	32	16	3	75
Direct Wages	40	48	32	8	128
Factory Overheads	48	64	40	8	160
Selling & Admn. (15% Sales)	24	30	12	6	72
Total	136	174	100	25	435
Profit / Loss	24	26	(20)	15	45
Under recovery of overheads					24
Profit before tax					21

40% of factory overheads are variable at normal volume and the selling and administration overheads are variable to the extent of 5% of sales. 20% of sales of product C are done in connection with Product A in as much as the discontinuance of Product C will bring down the sale of Product A by 10%. Alternatively, the sale of product C can be reduced to 20% of the present level to maintain the sales of product A.

The view of the loss reported for Product C the management has for consideration three proposals, viz;

a) Discontinue product C. In that event the co. can save a sum of Rs.8 lakhs p.a. in fixed expenses.

b) Maintain the sales of product C to the extent of 20% of the present sales as sales as service to product A. In that event the reduction of fixed expenses will be Rs.3 lakhs p.a.

c) Discontinue product C totally and increase the sales of product D for which demand is available to the extent of another Rs.40 lakhs. This can be done without any change in fixed expenses.

Draft a report to the management bringing out the financial implications of the aforesaid three proposals as compared with the annual operating results generating a profit before tax of Rs.21 lakhs. Suggest a source of action to be followed by the S.G Ltd.

Ans: a) 12.808 lakhs

b) 16.32 lakhs

c) 28.124 lakhs

Hence Proposal C may be adopted

Problem No. 7

T.T.D Ltd., manufacturing a single product has normal working capacity of 8,000 units per annum. The sales manager has projected a sale of 10,000 units for the year 2009-10 at a price of Rs.250 per unit.

The operating budget for 2009-10 as under:

	Rs. in lakhs	Rs. in lakhs
Sales: 8,000 units @ Rs.250 each		20.00
Cost of production		
Raw material	12.00	
Direct wages	3.00	
Works overhead (50% Fixed)	1.40	
Admn. overhead (all fixed)	0.60	
Selling & Distribution OH (80% fixed)	1.00	18.00
		2.00

In order to increase production to meet the sales demand, two proposals have been put forward as under:

1) Subcontracting the production of 2,000 units at Rs.225 per unit.

2) Installing additional machine which will entail the following expenses :

a) Cost of machine Rs.2,00,000; Life 20 years.

b) Recruitment of 10 workers including direct workers to operate the machine at a wage rate of Rs.500 each per month. Add 25% towards fringe benefits. (None of the existing workers will be utilised for this purpose).

c) Interest on capital required for the purchase of machine 15% p.a.

The following additional fixed expenses will be required in respect of both alternatives.

Administration expenses - Rs.10,000 per year.

Selling & Distribution expenses - Rs.20,000 per year.

You are required to prepare

(1) A statement showing respective profitability of the two methods of increasing the production.

(2) Comment upon the choice of one of the two proposals.

Ans: Profit under present position - Rs.2 lakhs ;

Under Sub-contracting - Rs.2.2 lakhs;

Under increased facilities - Rs.2.325 lakhs

Problem No. 8

SV Ltd engaged in the manufacture of four products has prepared the following budget for 2008-09.

Production Units	20,000	5,000	25,000	15,000
Selling price Rs/unit	21.75	36.75	44.25	64.00
Direct Materials Rs/unit	6.00	13.50	10.50	24.00
Direct Wages Rs/Unit	7.50	10.00	18.00	24.00
Variable Overheads Rs./unit	5.00	6.00	6.50	2.25
Fixed Overheads Rs.p.a.	75,000	25,000	2,25,000	1,80,000

When the budget was discussed, it was proposed that the production should be increased by 10,000 units for which capacity existed in 2008-09.

It was also decided that for the next year i.e. 2009-10, the production capacity should be further increased by 25,000 units over and above the increase of 10,000 units envisaged as above for 2008-09. The additional production capacity of 25,000 units should be used for the manufacture of product ‘B’ for which new production facilities were to be created at an annual fixed overhead cost of Rs.35,000. The direct material costs of all the four products were expected to increase by 10% in 2009-10 while the other costs and selling prices would remain the same.

Required: -

(a) Find the profit of 2008-09 on the assumption that the existing capacity of 10,000 units is utilised to maximize the profit.

(b) Prepare a statement of profit for 2009-10.

(c) Assuming that the increase in the output of product ‘B’ may not fully materialise in the year 2009-10, find the number of units of product B to be sold in 2009-10 to earn the same overall profit as in 2008-09.

Ans: a) Rs. 1,40,000

b) Rs. 1,80,000

c) Additional Units 18,333.33

Problem No. 9

(a) A firm produces 5 different products from a single raw material. Raw material is available in abundance at Rs.6 per kg. The labour rate is Rs.8 per hour for all products. The plant capacity is 21,000 labour hours for the budget period. Production facilities can produce the products. The factory overhead rate is Rs.8 per hour, comprising Rs.5.60 per hour fixed overhead and Rs.2.40 per hour as variable overhead. The selling commission is 10% of the product price. Given the following information, you are to suggest a suitable sales mix which will maximise the company's profits. Determine the profits that will be earned at the selected sales mix.

Product	Market Demands (Units)	Selling Price	Labour Hours Per Unit	Raw Material Required Per Unit (in gms)
A	4,000	32.00	1.00	700
B	3,600	30.00	0.80	500
C	4,500	48.00	1.50	1,500
D	6,000	36.00	1.10	1,300
E	5,000	44.00	1.40	1,500

(b) Assume, in above situation, 3,500 hours of over time working is possible. It will result in additional fixed overheads of Rs.20,000; a doubling of labour rates and a 50% increase in variable overheads. Do your recommend to overtime working?

Ans: a) Rs. 1,67, 130

b) Loss Rs. 12,125/-

c) Overtime not recommended.

Problem No. 10

Akshara combines manufactures 3 components X, Y and Z which are made up from 3 parts A, B and C in the following proportions:

X	1A and 1B
Y	2A, 2B and 1C
Z	3A, 1B and 2C

These parts are made on the premises. Further information as follows:

	A	B	C
Selling price	Rs 6	Rs 14	Rs 24
Direct materials	2	2	5
Time cost	2	9	12

Time cost which covers the cost of direct labour and overheads is valued at Rs.6 per hour. All parts can be sold individually at the above selling prices, but the market demand, which it is hoped, will be satisfied from the expansion will be for the components. The furthur expansion would provide an additional 58,000 hours and the additional market demand for the components would be 5,000 units each. Additional fixed expenses related to the expansion are expected to be Rs.15,000.

Prepare a statement showing how the additional capacity available should be used to generate maximum additional profit.

Ans: Rs. 1,76,500/-

Problem No. 11

AB Ltd. manufactures three products. The standard selling prices and costs have been estimated for 2009-10 as follows:

	Per Unit		
	X	Y	Z
Selling Price	Rs 28	Rs 60	Rs 125
Direct materials	8	15	20
Direct wages	10	20	50
Variable overheads	5	10	25

Direct wages are paid at the rate of Rs.2 per hour in each case. Fixed overheads are budgeted at Rs.25,000 for the coming year.

In short run, the company cannot increase its direct labour strength and as a result, only 35,000 direct labour hours will be available in the coming year. The company has commitments to produce 500 units of each product.

It has been suggested that after meeting the minimum requirements for X, Y and Z, the balance of available direct labour hours should be used to produce the product Z.

You are required to:

(a) to prepare an income statement showing the expected results if the proposal is adopted

(b) comment on the statement you have produced in (a) and prepare an income statement for any alternative policy which you consider would be more profitable.

(c) Basing your calculations on your suggestion in (b), show the company's BEP in terms of units and sales value.

(d) Show the sales value which is required to produce an after tax return of 10% on capital employed of Rs.1,00,000 assuming tax rate of 50%.

Ans: a) Profit Rs. 18,000/-

b) Profit Rs. 22,500/-

c) Break Even Units of each product 500 units; Break Even Sales Rs. 1,06,500/-

d) Sales Rs. 1,86,500/-

Problem No. 12

Domestic political trouble in the country of an overseas supplier is causing concern in your company because it is not known when further supplies of raw material 'x' will be received. The current stock held of this particular raw material is 17,000 kilograms, which costs Rs. 1,36,000. Based on raw material `x', your company makes five different products and the expected demand for each of these, for the next three months, it given below together with other relevant information:

Product code	Kilogram of raw material 'x' per unit of finished product	Direct labour hours per unit of finished product	Selling price per unit	Expected demand over three month
	Kg.	Hours	Rs.	units
701	0.7	1.0	26	8,000
702	0.5	0.8	28	7,200
821	1.4	1.5	34	9,000
822	1.3	1.1	38	12,000
937	1.5	1.4	40	10,000

The direct wages rate per hour is Rs. 5 and production overhead is based on direct wages cost - The variable overhead absorption rate being 40% and the fixed overhead absorption rate being 60% variable selling costs, including sales commission, are 15% of selling price.

Budget fixed selling and administration costs are Rs. 300,000 per annum. Assume that the fixed production overhead incurred will equal the absorbed figure.

You are required to:

d) Show what quantity of the raw material on hand ought to be allocated to which products in order to maximize profits for the forthcoming three months.

e) Present a brief statement showing contribution and profit for the forthcoming three months, if your suggestion in (a) is adopted;

f) Comment briefly on the analysis you used to aid the decision making process in (a) and give three other examples of business problems where this type of analysis can be useful.

Ans: Rs. 1,27,360/-

Problem No. 13

A company produces four products A,B,C, and D which marketed in cartons. Of the total of 20 machines installed, 8 are suitable for manufacturing all the four products and the remaining 12 machines are not suitable for the manufacture of products A and D.

Each machine is in production for 300 days per year and each is used on a given product in terms of full days and not in fractions of days. The company however has not problem in obtaining adequate supplies of labour and raw materials.

The marketing policy is that all four products should be sold and the minimum annual production should be 3000 cartons for each product. Fixed costs budgeted amount to Rs.50 lacs. production cost and price data are as under:-

	A	B	C	D
Production/day/machine (cartons)	14	4	3	6
Selling price/carton	Rs.810	790	845	1290
Cost: Process I				
Direct Materials/day.				
Machine	Rs.140	52	45	84
Direct Labour/day/Machine	224	148	90	132
Process II				
Direct Material/Carton	Rs. 30	30	30	30
Direct Labour/Carton	Rs.240	216	300	360
Variable Overheads/Carton	Rs.390	390	300	720

With a view to meeting the increasing demand for products A and D, the company is contemplating to convert such number of machines as may necessary out of the 12 machines which at present are unsuitable to produce products A and D into all purpose machines. The cost of conversion of these machines is Rs.2,10,000 per machines. The expenditure is to be amortized over a period of three years. The company expects 12.5% return on this expenditure.

Market research indicates that the company's sales products A and D can be increased to 37,500 cartons and 5,400 cartons respectively.

Required:

(a) Calculate the optimum profit of the company if the existing machines were worked on most profitable basis before conversion.

(b) Recommend the maximum number of machines to be converted into all purpose machines giving supporting calculations.

(c) Calculate for the first year the optimum profit of the company after conversion of the required number of machines into all-purpose machines.

Ans: a) Profit Rs. 4,94,660/-

b) 4 machines

c) Rs. 12,06,810/-

Problem No. 14

A firm has two machines, namely, machine 'P' and machine 'Q'. Machine 'P' can be used for the production of either product 'A' or product 'B' or both. Machine 'Q' can be used for the production of either product 'X' or product 'Y' or both. In order to maintain customer relations a minimum quantity of 1500 units each of 'A' and 'B' and 1200 units each of 'X' and 'Y' should be produced by the firm.

The production and cost data for 2009 are as under:

Machine hours available P-4500 hours

Q-5100 hours

	PRODUCTS			
	A	B	X	Y
Machine used	P	P	Q	Q
Machine hours required per unit of out put	1.0	1.25	1.25	0.8
Selling price per unit	Rs.200	Rs.250	Rs.300	Rs.256
Direct material per unit	80	100	100	80
Direct labour per machine hour	90	80	100	125
Variable overhead per machine hour	12	12	20	20

Fixed overheads are Rs. 4 lacs per annum. An additional expenditure involving a fixed overhead of Rs.25,000 per annum will convert the machine P and Q into a versatile centre such that any four of the products can be manufactured on these two machines. The rate of output on these machines and direct wage rate will, however, remain the same. Required:

(i) Set an optimal product mix subject to minimum market commitments both before and after the conversion of the machines into a versatile centre.

(ii) Evaluate the profitability under the two sets or product mixes.

(iii) Advise the management whether the conversion of machine should be undertaken or not.

Ans: i) Profit Rs. 41,000

ii) & iii) Rs. 68,875/-

Problem No. 15

Novelties Ltd. seeks your advice on production mix in respect of the three products Super, Bright and Fine. You have the following information:

	Data for Standard Costs per Unit:			
	Super	Bright	Fine	
Direct Materials	Rs.320	Rs. 240	Rs.160	
Variable overhead	16	40	24	
Direct Labour:				
Department:	Rate per Hour	Hours	Hours	Hours
A	Rs.8.00	6	10	5
B	16.00	6	15	11
From current budget, you have further details as below:				
	Super	Bright	Fine	
Annual production (No.s)	5,000	6,000	10,000	
Selling price per unit (Rs.)	624	800	480	
Fixed Overhead: Rs.16,00,000				
Sales department's estimate of maximum possible sales in the coming year (No.s)	6,000	8,000	12,000	

You are also to note that there is a constraint on supply of labour in Department A and its manpower cannot be increased beyond its present level.
Suggest the best production and sales mix from the standpoint of maximum profitability. Prepare statements setting out the profits resulting from the budgeted production and the best alternative suggested by you.

Ans: Budgeted Profit Rs. 11,20,000/-

Optimum mix profit Rs. 12,48,000/-

Problem No. 16

ABC Ltd. manufactures only one product which are identical in every respect.

The following information relates to April and May 2009:

i) Budgeted costs and selling prices:

	April	May
Variable manufacturing cost per unit	Rs. 2.00	Rs.2.20
Total fixed manufacturing cost		
(based on budgeted sales of	25,000 units	
per month)	40,000	44,000
Total fixed marketing cost (based on		
budgeted sales of 25,000 units per month)	14,000	15,400
Selling price per unit	5.00	5.50
(ii) Actual production and sales achieved:	units	units
Production	24,000	24,000
Sales	21,000	26,500

(iii) There was no stock of finished goods at the beginning of April 2009. There was no wastage or loss of finished goods during either April or May 2009.

(iv) Actual costs incurred corresponded to those budgeted for each month.

Required:

Calculate the relative effects on the monthly operating profits of applying the following methods:

(i) Absorption costing and

(ii) Marginal costing.

Ans: i) Profit under Absorption Costing

April Rs. 13,800/-

May Rs. 24,730/-

ii) Under Marginal Costing

April Rs.9,000/-

May Rs. 28,650/-

3.21 Decision Making

Illustration No. 1

(a) A machine which originally cost Rs.12,000 has an estimated life of 10 years and it depreciated at the rate of Rs.1,200 per year. It has been unused for some time, however, as expected production orders did not materialise.

A special order has now been received which would require the use of the machine for two months.

The current net realisable value of the machine is Rs.8,000. If it is used for the job, its value is expected to fall to Rs.7,500. The net book value of the machine is Rs.8,400. Routine maintenance of the machine currently costs Rs.40 per month. With use, the cost of maintenance and repairs would increase to Rs.60 per month.

What would be the relevant cost of using the machine for the order so that it can be charged as the minimum price for the order?

(b) X Ltd. has been approached by a customer who would like a special job to be done for him and is willing to pay Rs.22,000 for it. The job would require the following materials:

Materials	Total units required	Units already in stock	Book Value of units in stock Rs./unit	Realisable Value Rs./unit	Replacement Cost Rs./unit
A	1,000	0	—	—	6
B	1,000	600	2	2.5	5
C	1,000	700	3	2.5	4
D	200	200	4	6	9

(i) Material B is used regularly by X Ltd. and if stocks were required for this job, they would need to be replaced to meet other production demand.

(ii) Materials C and D are in stock as the result of previous excess purchase and they have a restricted use. No other use could be found for material C but material D could used in another job as substitute for 300 units of material which currently cost Rs.5 per unit (of which the company has no units in stock at the moment.)

What are the relevant costs of material, in deciding whether or not to accept the contract? Assume all other expenses on this contract to be specially incurred besides the relevant cost of material is Rs.550.

Solution:

Decision making

a) Computation of relevant cost of using the machine for the order

Fall in sale value, if used	(8000-7500)	500.00
Incremental maintenance cost	[(60-40)x2]	40.00
		540.00

b) Computation of relevant cost of the job

A	(1000x6)	6,000.00
B	(1000x5)	5,000.00
C	[(700x2.5)+(300x4)]	2,950.00
D	(300x5)	1,500.00
		15,450.00
Add : other expenses		550.00
		1,6000.00

As the revenue from the order, which is more than the relevant cost of Rs.16000 the order should be accepted

Illustration No. 2

Reel and Roll Ltd. manufactures a range of films extensively used in the cinema industry. The films once manufactured are packed in a circular container and stored in specially constructed crates lined with 'Protecto'. These crates are manufactured and maintained by a special department within the company and the department costs last year are as under :

Direct materials (Including 'Protecto')		Rs.1,40,000
Direct Labour		1,00,000
		2,40,000
Overheads:		
Department manager	16,000	
Depreciation of machine	30,000	
Maintenance of machine	7,200	
Rent(portion of warehouse)	9,000	
Other miscellaneous costs	31,500	
		93,700
		3,33,700
Administration overhead (20% of direct costs)		48,000
		3,81,700

Pack Knack Associates have approached the Reel and Roll Ltd., offering to make all the crates required on a four year contract for Rs.2,50,000 per annum and/or to maintain them for further Rs.50,000 per annum.

The following data are relevant:

(i) The machine used in the department costs Rs. 2,40,000 four years ago and will last for four more years. It could be currently sold for Rs. 50,000.

(ii) A stock of 'protecto' was acquired last year for Rs.2,00,000 and one-fifth was used last year and included in the material cost. It originally cost Rs. 1,000 per tone but the replacement cost is Rs.1,200 per tone; and it could be currently sold for Rs.800 per tone.

(iii) The department has acquired warehouse space for Rs.18,000 per annum. It uses only one-half of the space; the rest is idle.

(iv) If the department were closed, the Manager will be transferred to another department and the terminal benefits be met will amount to Rs. 15,000 per annum. In that event, Pack Knack Associates will undertake to manufacture and maintain the crates.

If the Reel and Roll Ltd., continued to maintain the crates, but left their manufacture to Pack Knack Associates.

(i) The machine will not be required.

(ii) The manager will remain in the department.

(iii) The warehouse space requirements will not be reduced.

(iv) Only 10% of all materials will be used.

(v) Only one worker will be dispensed with and taking the terminal benefit to be met into account, the saving will be Rs. 5,000 per annum.

(vi) The miscellaneous costs will be reduced by 80%.

If Reel and Roll Ltd., continue manufacture the crates but left their maintenance to Pack Knak Associates;

(i) The machine will be reduced.

(ii) The manager will remain in the department.

(iii) The warehouse space will be required.

(iv) 90% of all the materials will be required.

(v) The labour force will continue.

(vi) The miscellaneous costs will be reduced by 20%

Assuming that for the four-year period, there is no significant change envisaged in the pattern of other costs, you are required to evaluate the alternative courses of action with supporting figures of cash flows over the four-year period and advise accordingly.

Solution:

Statement showing evaluation of alternatives (Rs.)

	Manufacture & Maintenance	Only Manufacture	Only Maintenance
i) Outflows	**1,200,000**	**1,000,000**	**200,000**
ii) Inflows			
Direct material	100,000	90,000	10,000
direct labour	85,000	5,000	
Maintenance of machinery	7,200	7,200	
Rent	18,000		
Miscellaneous cost	31,500	252,000	6,300
Annually	241,700	127,400	16,300
Four yearly savings	966,800	509,600	65,200
Sale value of machine	50,000	50,000	
Sale of protecto	128,000	115,200	12,800
	1,144,800	**674,800**	**78,000**
iii) Net gain/(loss)	(55200)	(325200)	(122000)

In all the three alternatives, outflows are more than inflows and therefore it is advisable not to close the operations of manufacture and maintenance.

Illustration No. 3

The Officers' Recreation Club of a large public sector undertaking has a cinema theater for the exclusive use of themselves and their families. It is a bit difficult to get good motion pictures for show and so pictures are booked as and when available.

The theater has been showing the picture 'Blood Bath' for the past two weeks. This picture, which is strictly for adults only has been a great hit and the manager of the theater is convinced that the attendance will continue to be above normal for another two weeks, if the show of 'Blood Bath' is extended. However, another popular movie, eagerly looked forward to by both adults and children alike, 'Appu on the Airbus' is booked for next two weeks. Even if 'Blood Bath' is extended the theater has to pay the regular rental on 'Appu on the Airbus' as well.

Normal attendance at theater is 2,000 patrons per week, approximately one fourth of whom are children under the age of 12. Attendance of 'Blood Bath' has been 50% greater than the normal total. The manager believes that this would taper off during the second two weeks, 25% below that of the first two weeks, during the third week and 33 1/3 % below that of the first two weeks, during the fourth week. Attendance for 'Appu on the Airbus' would be expected to be normal throughout its run regardless of the duration.

All runs at the theater are shown at a regular price of Rs.2 for adults and Rs.1.20 for children fewer than 12. The rental charge for 'Blood Bath' is Rs.900 for one week or Rs.1,500 for two weeks. For 'Appu on the Airbus' it is Rs. 750 for one week or Rs. 1,200 for two weeks. All other operating costs are fixed - Rs.4,200 per week, except for the cost of potato wafers and cakes, which average 60% of their selling price, sales of potato wafers and cakes regularly average Rs.1.20 per patron, regardless of age.

The Manager can arrange to show 'Blood Bath' for one week and 'Appu on the Airbus' for the following week or he can extend the show of 'Blood Bath' for two weeks or else he can show 'Appu on the Airbus' for two weeks as originally booked.

Show by computation, the most profitable course of action he has to pursue.

Solution:

Statement showing evaluation of alternatives

		Blood Bath	Blood Bath & Appu on the Airbus	Appu on the Airbus
No. of spectators				
Adults:				
Third week	3,000 x 75%	2,250.00	2,250.00	1,500.00
fourth week	3,000 x 2/3	2,000.00	1,500.00	1,500.00
Total Adults		**4,250.00**	**3,750.00**	**3,000.00**
Children:				
Third week		—	—	500.00
Fourth week		—	500.00	500.00
Total Children		—	**500.00**	**1,000.00**
Total spectators: (Adult + Children)		**4,250.00**	**4,250.00**	**4,000.00**
Revenue:				
Sale of tickets		8,500.00	8,100.00	7,200.00
				(3,000 x 2 + 1000 x 1.2)
Add : Contribution from snacks		2,040.00	2,040.00	1,920.00
		10,540.00	**10,140.00**	**9,120.00**
Less : Incremental cost		1,500.00	900.00	–
		9,040.00	**9,240.00**	**9,120.00**

It is found that the net revenue is more at the option of running blood bath and Appu on the Air bus a week each, it must be chosen.

Illustration No.4

A review, made by the top management of Sweat and Struggle Ltd. which makes only one product, of the result of the first quarter of the year revealed the following:

Sales in units	10,000
Loss	Rs. 10,000
Fixed cost (for the year Rs.1,20,000)	30,000
Variable cost per unit	8.00

The Finance Manager who feels perturbed suggests that the company should at least break-even in the second quarter with a drive for increased sales. Towards this, the company should introduce better packing which will increase the cost by Rs.0.50 per unit.

The Sales Manager has an alternative proposal. For the second quarter additional sales promotion expenses a can be increased to the extent of Rs.5,000 and a profit of Rs. 5,000 can be aimed at during the period with increased sales.

The Production Manager feels otherwise. To improve the demand, the selling price per unit has to be reduced by 3%. As a result the sales volume can be increased to attain a profit level of Rs. 4,000 for the quarter.

The Manager Director asks you as a Cost Accountant to evaluate the three proposals and calculate the additional sales volume that would be required in each case, in order to help him to take a decision.

Solution:

Calculation of Selling Price

Variable cost	(8x10,000)	80,000
Add : Fixed cost		30,000
Total cost		1,10,000
Profit		(10,000)
Sales		1,00,000
Selling price	(100000/10000)	Rs. 10

Statement showing evaluation of alternatives and the number of units required to attain the targets of respective managers

		Finance Manager	Sales Manager	Production Manager
i)	Selling price (Rs.)	10.00	10.00	9.70
ii)	Variable cost (Rs.)	8.50	8.00	8.00
iii)	Contribution per unit (Rs.)	1.50	2.00	1.70
iv)	Fixed cost (Rs.)	30,000	35,000	30,000
v)	Target (Units)	B.E.P	Profit of Rs.5000	Profit of Rs.4000
		(30000/1.5)	(40000/2)	(34000/1.7)
		20,000	20,000	20,000
Additional units required		10,000	10,000	10,000

Illustration No. 5

A Company manufacturing agricultural tractors has a capacity to produce 6,000 tractors annually. The capital employed in the project as on date is Rs.20 crores. With increasing cost of production and reducing margins, the company is fast narrowing its margin of safety. The return on capital employed fell from 10% in the previous year to 6% in the current year. i.e., the current year profit is 1.20 crores. The company wants to maintain the original cut-off rate of 12% and various possibilities have been examined for this purpose.

The company is at present manufacturing and marketing 6,000 tractors annually though there is imbalance in the plant. The company has the following major production departments wit percentage capacity utilisation for the present production: -

Production Department	Capacity utilised
Machine shop	75%
Assembly shop	100%
Heat treatment shop	75%
Induction hardening	50%

The company operates a single shift of 8 hrs per day on an average for 300 days in a year. For technical reasons the plant will have to operate on single shift basis only.

The two alternatives which have emerged after a detailed study are:

(a) To hire out the surplus capacity in the production shop for which constant demand exists. The following income and expenditure projections are drawn out:

	Hire Charge per hour	Incremental Cost per hour
Machine shop	Rs.10,000	Rs.2,000
Heat treatment shop	7,500	1,500
Induction hardening	5,000	1,000

(b) To increase the installed capacity to 8,000 tractors by spending Rs.2 crores on additional machinery for the assembly shop. The incremental revenue form the additional sales will be Rs. 5,000 per tractor. The cost of additional finance will be 12% being the cost of existing capital employed, In addition, tax benefits on an average will work out to 1% of additional investment.

You are required:

(i) To work out the profitability, i.e., average rate of return of the two alternatives; and

(ii) To comment on the advisability of maintaining an imbalance plant from a long-term point of view.

Solution:

Computation of hire charges and return on capital employed

Machine shop	[2400 x 25% x (10000 - 2000)]	4,800,000
Heat treatment	[2400 x 25% x (7500 - 1500)]	3,600,000
Induction hardening	[2400 x 50% (4000)]	4,800,000
		13,200,000
Present profit		12,000,000
Total profit		25,200,000
Return on investment	[(25200000/20000000) x 100]	12.6%

Computation of profit under alternative 2

Profit from sale of tractors	(5000 x 2000)	10,000,000
Hire charges		3,200,000
Tax benefit (1% on 2 crores)		200,000
		13,400,000
Add : Existing profit		12,000,000
		254,00,000
Return on Investment (ROI)	[(25400000/220000000) x 100]	11.55%

Working notes

Computation of surplus capacity in the production shop

Machine shop	{[(300 x 8) x 75%] x 100/75}	2,400
		(no extra capacity)
Heat treatment	{[(300 x 8) x 75%] x 100/75}	2,400
		(no extra capacity)
Induction	{[(300 x 8) x 50% x (8000/6000)]	1,600
Extra capacity in induction	(1600 x 50%)	800 hours
Therefore hire charges	(800 x 4000)	3,200,000

As the required cut off rate is 12%, it is better to hire out the balance capacity instead of increasing capacity

Illustration No.6

A Modern Packing Corporation specialises in the manufacture of one-liter plastic bottles. The firm's customers include dairy processors, fruit juice manufactures and manufactures of edible oils. The bottles are produced by a process called blow moulding. A machine heats plastic to the melting point. A bubble of molten plastic is formed inside a mould, and a jet of hot air is forced into the bubble. This blows the plastic into the shape of the mould. The machine releases the moulded bottle, an employee trims off any flashing (excess plastic around the edge), and the bottle is complete.

The Firm has four moulding machines, each capable of producing 100 bottles per hour. The firm estimates that the variable cost of producting a plastic bottle is 20 paise. The bottles are sold for 50 paise each.

Management has been approached by a local toy company that would like the firm to produce a moulded plastic toy for them. The toy company is willing to pay Rs. 3.00 per unit for the toy. The variable cost of manufacture the toy will be Rs.2.40. In addition, Modern Packing Corporation would have to incur a cost of Rs.20,000 to construct the needed mould exclusively for this order. Because the toy uses more plastic and is of a more intricate shape than a bottle, a moulding machine con produce only 40 units per hour. The customer wants 1,00,000 units. Assume that Modern Packing Corporation has the total capacity of 10,000 machine hours available during the period in which the toy company wants the delivery of toys. The firm's fixed costs, excluding the costs to construct the toy mould, during the same period will be Rs.2,00,000.

Required:

(a) If the management predicts that the demand for its bottles will require the use of 7,500 machine hours or less during the period, should the special order be accepted? Give the reasons.

(b) If the management predicted that the demand for its bottles would be higher than its ability to produce bottles, should the order be accepted? Why?

(c) The management has located a firm that has just entered the moulded plastic business. The firm has considerable excess capacity and more efficient moulding machines and is willing to subcontract the toy job, or any portion of it for Rs. 2.80 per unit. It will construct its own toy mould. Determine Modern Packing Corporation's minimum expected excess machine hour capacity needed to justify producing any portion of the order itself rather than subcontracting it entirely.

(d) The management predicated that it would have 1,600 hours of excess machine hour capacity available during the period. Consequently, it accepted the toy order and subcontracted 36,000 units to the other plastic company. In fact demand for bottles turned out to be 9,00,000 units for the period. The firm was able to produce only 8,40,000 units because it had to produce the toys. What was the cost of the prediction error failure to predict demand correctly?

Solution:

Contribution from M bottle per hour	[100(0.5-.2)]	Rs.30
Contribution from toy per hour	[40(3-2.4)]	Rs.24

a) When the demand for the bottles is 7500or less hours, it is better to accept, toy order because it gives additional profit of Rs.40000

b) When the capacity for bottles is more than 7500 hours, the toy order should not be accepted because the contribution of bottle Rs.30, is more than the contribution per hour of toy Rs.24

c) The level at which it is necessary tom sub contract the toy order is

   [20000/(2.8 – 2.4)] = 50000 units

d) Computation of cost of prediction error

(i) Statement showing computation of profit if 36000 toys are given for sub contract

		Bottles	Toy Manufacture	Toy Sub contract	Total
i.	No. of units	840,000	64,000	36,000	
ii.	Contribution per unit	0.30	0.60	0.20	
iii.	Total contribution	252,000	38,400	7,200	297,600
iv.	Fixed cost	200,000	20,000		220,000
v.	Profit	52,000	18,400	7,200	77,600

ii) Computation of profit at actual position

		Bottles	Toys	Total
i.	No. of units	900,000	100,000	
ii.	Contribution per unit	0.30	0.20	
iii.	Total contribution	270,000	20,000	290,000
iv.	Fixed cost	200,000		200,000
v.	Profit	70,000	20,000	90,000
Therefore cost of prediction error			(90000 - 77600)	Rs.12400

Illustration No.7

Tiptop Textiles manufactures a wide range of fashion fabrics. The company is considering whether to add a further product that 'Superb' to the range. A market research survey recently undertaken at a cost of Rs.50,000 suggests that demand of the 'Superb' will last for only one year, during which 50,000 units could be sold at Rs.18 per unit. Production and sale of 'Superb' would take place evenly throughout the year. The following information is available regarding the cost of manufacturing 'Superb'.

Raw Materials: Each 'Superb' would require 3 types of raw materials Posh, Flash and Splash. Quantities required, current stock levels and cost of each raw material are shown below. Posh s used regularly by the company and stocks are replaced as they are used. The current stock of Flash is the result of over buying for an earlier contract. The material is not used regularly by Tiptop Textiles and any stock that was not used to manufacture 'Superb' would be sold. The Company does not carry a stock of splash and the units required would be specially purchased.

Raw	Quantity regd. per unit of superb (Meters)	Current stock (meters)	Costs per metre of raw material		
			Original Cost	Current replacement cost	Current resale cost
			Rs.	Rs.	Rs.
Posh	1.00	1,00,000	2.10	2.50	1.80
Flash	2.00	60,000	3.30	2.80	1.10
Splash	0.50	0	5.50	5.00	5.00

Labour; Production of each 'Superb' would require a quarter of an hour of skilled labour and two hours of unskilled labour and Rs.2 per hour for unskilled labour. In addition, one foreman would be required to devote all his working time for one year in supervision of the production of superb. He s currently paid an annual salary of Rs.15,000. Tiptop Textiles is currently finding it very difficult to get skilled labour.

The skilled workers needed to manufacture 'Superb' would be transferred form another job on which they are earning a contribution surplus of Rs.1.50 per labour hour, comprising sales revenue of Rs.10.00 less skilled labour wages of Rs.3.00 and other variable costs of Rs.5.50. It should not be possible to employ additional skilled labour during the coming year. If 'Superb' are not manufactured, the company expects to have available 2,00,000 surplus unskilled labour hours during the coming year. Because the company intends to expand in the future, it has decided not to terminate the services of any unskilled worker in the foreseeable future. The foreman is due to retire immediately on an annual pension payable by the company of Rs.6,000. He has been prevailed upon to stay on for a further year and to differ his pension for one year in return for his annual salary.

Machinery: Two Machines would be required to manufacture 'Superb' MT 4 and MT 7. Details of each machine are as under:

		Start of the year Rs.	End of the year Rs.
MT 4			
	Replacement cost	80,000	65,000
	Resale Value	60,000	47,000
MT 7			
	Replacement cost	13,000	9,000
	Resale Value	11,000	8,000

Straight-line depreciation has been charges on each machine for each year of its life. Tiptop Textiles owns a number of MT 4 machines, which are used regularly or various products. Each MT 4 is replaced as soon it reaches the end of its useful life. MT 7 machines are no longer used and the one which would be used for 'Superb' is the only one the company now has. If it were not used to produce 'Superb' it would be sold immediately.

Overheads: A predetermined rate of recovery for overheads is in operation and the fixed overheads are recovered fully from the regular production at Rs.3.50 per labour hour. Variable overhead costs for Superb are estimated at Rs. 1.20 per unit produced.

For decision-making, incremental costs based on relevant costs and opportunity costs are usually computed.

You are required to compute such a cost sheet for 'Superb' with all details of material, labour overhead etc., substantiating the figures with necessary explanations.

Solution:

For each of the element the relevant cost will be as follows for preparing cost sheet

i) Market survey cost is a sunk cost and not relevant for decision making

ii) Raw materials

   a) Raw material 'posh', is used regularly and stocks are replenished and hence current replacement cost is relevant i.e.(5000 x 1 x 2.5) = 125,000.00

b) Current stock of 'flash' is a result of over buying and will not be used for other than 'superb' and hence relevant cost is net releasable value

Material required (50000 x 2) = 100000 units

(60000x1.1)	66,000.00	
(40000x2.8)	112000	178,000.00

c) Material 'splash' has no stock and has to be bought and relevant cost is hence not relevant in decision making

(50000 x 0.5 x 5) = 125,000.00

iii) Labour:

a) Due to unskilled labour , no work has been suffered and so no extra cost and hence not relevant in decision making

b) Skilled labour is scarce therefore not only the cost, but also the contribution forgone, being opportunity cost, should be considered for decision making

(50000 x 0.25 x 4.5) = 56,250.00

c) Effective cost of pension (15000 – 6000) = 9,000.00

iv) Machinery:

a) MT-4 are regularly used and therefore the difference between replacement cost at the start and at the end of the year is relevant (80000-65000) = 15,000.00

b) MT-7 is not used regularly and the difference between resale value at the start and at the end of the year should be taken (11000-8000) = 3,000.00

v) Variable overheads are relevant (50000x1.2) = 60,000.00

vi) Fixed overheads are not relevant because it is recorded fully at regular production

Cost sheet of 50000 units of "Superb"

Raw material:		
Posh	125,000.00	
Flash	178,000.00	
Splash	125,000.00	428,000.00
Labour:		
Skilled	56,250.00	
Pension	9,000.00	65,250.00
Machinery:		
MT-4	15,000.00	
MT-7	3,000.00	18,000.00
Variable overheads		60,000.00
		571,250.00
Profit (b/f)		328,750.00
Sales (50000x18)		**900,000.00**

Illustration No.8

Forward and Foundry Ltd. is feeling the effects of a general recession in the industry. Its budget for the coming half year is based on an output of only 500 tones of casting a months which is less than half of its capacity. The prices of casting vary with the composition of the metal and the shape of the mould, but they average Rs. 175 a tone. The following details are from the Monthly Production Cost Budget at 500 tone levels:

	Core making	Melting and Pouring	Moulding	Cleaning and Grinding
Labour	Rs.10,000	Rs. 16,000	Rs. 6,000	Rs.4,500
Variable overhead	3,000	1,000	1,000	1,000
Fixed overhead	5,000	9,000	2,000	1,000
	18,000	26,000	9,000	6,500
Labour and O.H. rate per direct labour hour	9.00	6.50	6.00	5.2

Operation at this level has brought the company to the brink of break-even. It is feared that if the lack of work continues, the company may have to lay off some of the most highly skilled workers whom it would be difficult to get back when the volume picks up later on. No wonder, the workers Manager at this Juncture, welcome an order for 90,000 casting, each weighing about 40 lbs., to be delivered on a regular schedule during the next six months. As the immediate concern of the Works Manager is to keep his work force occupied, he does not want to lose the order and is ready to recommended a quotation on a non-profit and no-loss basis.

Materials required would cost Re. 1 per casting after deducting scrap credits. The direct labour hour per casting required for each department would be:

Core Making	0.09
Melting and pouring	0.15
Moulding	0.06
Cleaning and grinding	0.06

Variable overheads would bear a normal relationship to labour cost in the melting and pouring department and in the moulding department. In core making, cleaning and grinding however, the extra labour requirements would not be accompanied by proportionate increases in variable overhead. Variable overhead would increase by Rs.1.20 for every additional labour hour in core making and by 30 paise for every additional labour hour in cleaning and grinding. Standard wage rates are in operation in each department and no labour variances are anticipated.

To handle an order as large as this, certain increases in factory overheads would be necessary amounting to Rs. 1,000 a month for all departments put together. Production for this order would be spread evenly over the six months period.

You are required to:

(a) Prepare a revised monthly labour and overhead cost budget, reflecting the addition of this order.

(b) Determine the lowest price which quotation can be given for 90,000 castings without incurring a loss.

Solution:

Computation of labour and overhead rate

	Core Making	Melting & Pouring	Moulding	Cleaning & Grinding
Labour & overheads	18,000.00	26,000.00	9,000.00	6,500.00
Labour & overheads per hour	9.00	6.50	6.00	5.20
No. of hours	2,000.00	4,000.00	1,500.00	1,250.00
Variable overhead per hour	1.50	0.25	0.67	0.80
Labour rate per hour	5.00	4.00	4.00	3.60
Hours required for new order	1,350.00	2,250.00	900.00	900.00
Labour cost required for order	6,750.00	9,000.00	3,600.00	3,240.00
Variable overhead cost for order	1,620.00	563.00	600.00	270.00

Revised monthly labour and overheads cost budget reflecting the additions of the order

	Core Making	Melting & Pouring	Moulding	Cleaning & Grinding	Total
Labour	10,000.00	16,000.00	6,000.00	4,500.00	
Labour for the order	6,750.00	9,000.00	3,600.00	3,240.00	
	16,750.00	**25,000.00**	**9,600.00**	**7,740.00**	
Variable overheads	3,000.00	1,000.00	1,000.00	1,000.00	
Variable overheads for the order	1,620.00	563.00	600.00	270.00	
	4,620.00	**1,563.00**	**1,600.00**	**1,270.00**	
Fixed cost	**5,000.00**	**9,000.00**	**2,000.00**	**1,000.00**	
Total	**26,370.00**	**35,563.00**	**13,200.00**	**10,010.00**	85,143.00
Add : additional fixed cost					1,000.00
				Total:	86,143.00

Computation of Total Price for the Order		
Material	(15000x1)	15,000.00
Labour & Overheads	(86143-59500)	26,643.00
		41,643.00
Total price for the order	(41643x6)	**Rs. 249858**

Illustration No.9

A small scale manufacture produces an article at the operated capacity of 10,000 units while the normal capacity of his plant is 14,000 units. Working at a profit margin of 20% on sales realization, he has formulated his Budget as under:

	10,000	14,000
Sales Realization	Rs. 2,00,000	Rs.2,80,000
Variable overheads	50,000	70,000
Semi-variable overheads	20,000	22,000
Fixed Overheads	40,000	40,000

He gets an order for a quantity equivalent to 20% of the operated capacity and even this additional production, profit margin is desired at the same percentage on Sales realization as for production to operated capacity.

Assuming prime cost is constant per unit of production, what should be the minimum price to realise this objective.

Solution:

Computation of Prime Cost

Sales		200,000.00
Less : Profit (20% on Sales)		40,000.00
Total cost		160,000.00
Less : Overheads		
Variable	50,000.00	
Semi variable	20,000.00	
Fixed	40,000.00	110,000.00
Prime cost		50,000.00

Computation of Differential Cost at two levels of output

Output (Units)	10000	12000	Differential Cost
Prime cost (Rs.)	50,000.00	60,000.00	10,000.00
Variable overheads (Rs.)	50,000.00	60,000.00	10,000.00
Semi variable overheads (Rs.)	20,000.00	21,000.00	1,000.00
			21,000.00

Computation of minimum selling price at desired margin

Total cost	(21000/2000)	10.50
Add : Profit	(20% on sales = 25% on cost)	2.63
Required Selling Price		13.13

Illustration No.10

A theatre with some surplus accommodation proposes to extend its catering facilities to provide light meals to its patrons.

The Management Board is prepared to make initial funds available to cover capital costs. It requires that these be repaid over a period of five years at a rate of interest of 14% and discount factors at this interest rate are indicated below.

Year	0	1	2	3	4	5
Discounting factor	1	0.88	0.77	0.67	0.59	0.52

The capital costs are estimated at Rs.60,000 for equipment that will have a life of five years and no residual value . Running costs of staff, etc., will be Rs. 20,000 in the first year. increasing by Rs.2,000 in each subsequent year. The board proposes to charge Rs. 5,000 per annum for lighting, heating and other property expenses and wants a nominal Rs. 2,500 per annum to cover any unforeseen contingencies. Apart from this, the Board is not looking for any profit, as such from the extension of these facilities because it believes that this will enable more theatre seats to be sold. It is proposed that costs should be recovered by setting prices for the food at double the direct costs.

It is note expected that the full sales level will be reached until year 3. The proportions of the level estimated to be reached in years 1 and 2 are 35% and 65% respectively.

Calculate the sales that need to be achieved in each of the five years to meet the Board's targets. Ignore taxation and inflation.

Solution:

Statement showing Calculation of Present Value of Outflows

	1	2	3	4	5	Total
Running cost	20,000.00	20,000.00	24,000.00	26,000.00	28,000.00	
Lighting, heating & other property expenses	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	
Cost of contingencies	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	
	27,500.00	29,500.00	31,500.00	33,500.00	35,500.00	
Present value factor	0.88	0.77	0.67	0.59	0.52	
Present values	24,200.00	22,715.00	21,105.00	19,765.00	18,460.00	106,245.00
Initial investment						60,000.00
						166,245.00

In order to recover outflows in five years, income must be equal to the present value of inflows over the five years

Year	Capacity	Discount factor	Present value
1	0.35	0.88	0.31
2	0.65	0.77	0.50
3	1.00	0.67	0.67
4	1.00	0.59	0.59
5	1.00	0.52	0.52
			2.59

Average out flow	(166245 ÷ 2.59)	64,187.00
Sales required for the year	(64187x2)	128,374.00
Sales in the first year	(128375x35%)	44,931.00
Sales in the second year	(128375x65%)	83,444.00
Sales in the third year		128,375.00
Sales in the fourth year		128,375.00
Sales in the fifth year		128,375.00

Illustration No.11

A Local Government Authority owns and operates a leisure centre with numerous sporting facilities, residential accommodation, a cafeteria and a sports shop. The summer season lasts for 20 weeks including a peak period of 6 weeks corresponding to the school holidays. The following budgets have been prepared for the next summer season:

Accommodation:

60 single rooms let on a daily basis.

35 double rooms let on a daily basis at 160% of the single room rate.

Room rate:

Fixed costs Rs.29,900.

Variable costs Rs. 4 per single room per day and Rs.6.40 per double room per day

Sports centre:

Residential guests each pay Rs. 2 per day and casual visitors Rs. 3 per day for the use of facilities.

Fixed costs Rs.15,500.

Sports Shop:

Estimated contribution Re.1 per person per day.

Fixed costs RS. 8,250.

Cafeteria:

Estimated contribution Rs. 1.50 per person per day.

Fixed costs Rs.12,750.

During the summer season the centre is open 7 day a week and the

Following activity levels are anticipated.

Double rooms fully booked for the whole season.

Single rooms fully booked for the peak period but at only 80% of

Capacity during the rest of the season.

30 casual visitors per day on average.

You are required to:

(a) Calculate the charges for single and double rooms assuming that the authority wishes to make a Rs. 10,000 profit on accommodation.

(b) Calculate the anticipated total profit for the leisure centre as a whole for the season.

(c) Advise the authority whether an offer of Rs.2,50,000 form a private leisure company to operate the centre for five years is worth while, assuming that the authority uses a 10% cost of capital and operations continue as outlined above.

Solution:

Computation of usage of room days		
Single room		
(60 x 7 x 6)	2,520.00	
(60 x 7 x 14 x 80%)	4,704.00	
		7,224.00
Double room (35 x 7 x 20)		4,900.00
i) Total sale value of accommodation		
Variable cost		
Single room (7224 x 4)	28,896.00	
Double room (4900 x 4)	31,360.00	60,256.00
Fixed cost		29,900.00
Required Profit		10,000.00
		100,156.00

Let 'S' be the room rent of single room and 1.6'S' is the rent of double room Therefore

7224S + 4900(1.6S) = 100516

7224S + 7840S = 100516 = S = 6.65

Double room rent = (6.65 x 1.6) = 10.64

ii) Statement showing computation of total profit to leisure centre

a. Accommodation			10,000.00
b. Sports centre:			
Total	[(7224x2)+(4900x2x2)+(30x7x20x3)]	46,648.00	
Less : Fixed Cost		15,550.00	31,148.00
c. Sports centre:			
Contribution	[(7224x1)+(4900x2x1)+(30x7x20x1)]	21,224.00	
Less : Fixed Cost		8,250.00	12,974.00
d. Cafeteria			
Contribution	[(7224x1.5)+(4900x2x1.5)+(30x7x20x1.5)]	31,836.00	
Less : Fixed Cost		12,750.00	19,086.00
			73,208.00

iii) Present values

Present value compound factor @ 10% for 5 years	3.79
P.V. of profit for 5 years (73208x3.7906)	277,500.00

As the present value of profit for 5 years is Rs. 277500, which is more than the lease rent of Rs. 250000, it is not worthwhile to give leisure centre for lease.

Illustration No.12

N Ltd. supports the concept of tero technology or life cycle costing for new investment decisions covering its engineering activities. The financial side of this philosophy is now well established and its principles extended to all other areas of decision making.

The company is to replace a number of its machines and the Production Manager is torn between the Exe Machine, a more expensive machine with a life of 12 years, and the Wye machine with an estimated life of 6 years. If the Wye machine is chosen it is likely that it would be replaced at the end of 6 years by another Wye machine. The patter of maintenance and running costs differs between the two types of machine and relevant data are shown below :

	Exe	Wye
Purchase price	Rs.19,000	Rs. 13,000
Trade-in value/brakeup/scrap	3,000	3,000
Annual repair costs	2,000	2,600
Overhaul costs	(at year 8) 4,000	(at year 4) 2,000

Estimated financing costs averaged over machine life

10% p.a -Exe

10% p.a. -Wye

You are required to:

(a) Recommend, with supporting figures, which machine to purchase, stating any assumptions made.

(b) Describe life cycle costing and give the benefits that are likely to accrue from its use. Support your answer with examples of changes in practice that could occur from adopting this philosophy.

Solution:

Computation of present value of outflows and equivalent annual

		Exe machine		WYE machine
Initial cost		19,000.00		13,000.00
Less : Scrap at the end of the life	(3000x0.32)	960.00	(3000x.56)	1,680.00
		18,040.00		11,320.00
Present value of total annual cost	(2000x6.81)	13,620.00	(2600x4.36)	11,336.00
Overhaul cost	(4000x.47)	1,880.00	(2000x.68)	1,360.00
Total cost		33,540.00		24,016.00
Capital recovery factor	(1/6.81)	0.15	(1/4.36)	0.23
Equivalent Annual Cost [Toal Cost x Cap. Recovery factor]		4,925.00		5,508.00

As the equivalent annual cost is less for Exe machine, it is better to purchase the same.

EXERCISE PROBLEMS

Problem No. 1

Chakra Ltd. manufactures Mixer Grinders. The manufacture involves an assembly of various parts which are proceeds in the machine shop and purchased components. The on/off switch is presently being purchased form a vendor at Rs. 4.50 each, annual requirement being 20,000 pieces.

The production manager has put up a proposal two months back to make the switch in the machine shop. He had suggested that the company would make profit and save taxes on bought out switch. The costing department was asked to make an estimate of making the item which showed that the cost of making was Rs. 4.73. The purchase department continuing buying the item on the basis of the cost estimate given to them. Recently, the Vendor has sent a letter requesting the purchase department to grant increase in price of 10% minimum per switch as the input costs had gone up. The costing department was once again requested to estimate cost of making the switch.

The costing department re-estimated the costs using current prices and observed that the cost of making has gone up to Rs. 5.33. Purchase department again decided to continued buying as it was cheaper to buy than make. The cost estimate prepared by the costing department were as under:

	Annual costs	
	Previous (Rs.)	Current (Rs.)
Direct Materials	40,000	48,000
Direct Labour Rs.2 per hour	20,000	22,000
Overheads at Rs.3 per hour	30,000	31,500
Total cost at current price	90,000	1,01,500
Add: expected increase 5%	4,500	5,075
Expected manufacturing cost	94,500	1,06.575
Cost per price	4.73	5.33

Twenty-five per cent of the overheads are fixed.

Required: Do you agree with the decision of buying considering the relevant costs? If the cost of making or buying is more or less same, what factors other than cost will influence making decision?

Problem No. 2

A Company manufacturing a highly successful line of cosmetics intends to diversify the product line to achieve fuller utilization of its plant capacity. As a result of considerable research made the company has been able to develop a new product called 'EMO'.

EMO is packed in tubes of 50 grams capacity and is sold to the wholesalers in cartons of 24 tubes at Rs. 240 per carton. Since the company uses its spare capacity for the manufacturer of EMO, no additional fixed expenses will be incurred. However, the cost account has allocated a share of Rs. 4,50,000 per month as fixed expenses to be absorbed by EMO as a fair share of the company's present fixed costs to the new production for costing purposes.

The company estimated the production and sale of EMO at 3,00,000 tubes per month and on this basis the following cost estimates have been developed.

	Rs. per carton
Direct Materials	108
Direct Wages	72
All overheads	54
Total costs	234

After a detailed market survey the company is confident that the production and sales of EMO can be increased to 3,50,000 empty tubes and the cost of empty tubes, purchased from outside will result in a saving of 20% in material and 10% in direct wages and variable overhead costs of EMO. The price at which the outside firm is willing to supply the empty tubes is Rs. 1.35 per empty tube. If the company desires to manufacture empty tubes in excess of 3,00,000 tubes, new machine involving an additional fixed overheads Rs. 30,000 per month will have to be installed. Required.

(i) State by showing your working whether company should make or buy the empty tubes at each of the three volumes of production of EMO namely 3,00,000; 3,50,000 and 4,50,000 tubes.

(ii) At what volume of sales will it be economical for the company to install the additional equipment for the manufacture of empty tubes?

(iii) Evaluate the profitability on the sale of EMO at each, of the aforesaid three levels of output based on your decision and showing the cost of empty tubes as a separate element of cost.

Ans:

Make at 3 lakhs level. Buy above that level.

Problem No. 3

Z Ltd. manufactures a range of products which it sells through manufacture's agents to whom it pays commission of 20% of the selling price of the products. Its budgeted profits and loss statement for 2009 is as follows:

Sales Rs.		22,50,000
Production costs:		
Prime costs and variable overhead Rs.	7,87,500	
Fixed Overhead	3,62,500	
		11,50,000
		11,00,000
Selling costs:		
Commission to manufacturer's agents	4,50,000	
Sales office expenses (fixed)	20,000	
		4,70,000
		6,30,000
Administration costs (fixed)		3,00,000
Profit		3,30,000

Subsequent to the preparation of the above budgeted profit and loss statement, the company is faced with a demand from its agents for an increase in their commission to 22% of selling price. As a result, the company is considering whether it might achieve more favorable results if it were to discontinue the use of manufacturer's agent and, instead employ its own sales force. The costs that this could involve are budgeted as follows:

Sales manager (salary and expenses)	Rs. 75,000
Salesmen's expenses (including traveling costs)	20,000
Sales office costs (additional to present costs)	50,000
Interest and depreciation on sales department cars	35,000

In addition to the above, it will be necessary to hire four salesmen at a salary of Rs.40,000 per annum each plus commission of 5% on sales plus car allowance of Re.1 per Kilometer to over all costs except interested and depreciation.

On the assumption that the company decided to employ its own sales force on the above terms are you are required to ascertain:

(a) What is the maximum average kilometer per annum that salesmen could travel if the company is to achieve the same budgeted profit as it would have obtained by retaining the manufacturer's agents and granting them the increased commission they had requested. Assume that sales in each case would be as budgeted.

(b) At what level of sales would the original budgeted profit be achieved if each salesmen were to travel on average of 14,000 kilometers per annum. Assume that all other assumptions inherent in the budgets were maintained.

(c) What is the maximum level of commission on sales that the company could afford to pay if it wished to achieve a 16% increase in its original budgeted profit and expected a 16% increase in sales (at budgeted selling prices) and average of 16,000 kilometers per annum to be traveled by each salesmen.

Ans: a) 10,625 kms

b) Sales required Rs. 23,47,500/-

c) Commission allowable 8.7%.

Problem No. 4

Navyug Enterprises is considering the introduction of a new product. Generally, the Company's products have a life of about five years, after which they are usually dropped form the range of products the company sells.

The new product envisages the purchase of new machinery costing Rs.4,00,000 including freight and installation charges. The useful life of the equipment is five years with an estimated average value of Rs.1,57,500 at the end of that time. The machine will be depreciated for tax purpose by the reducing balance method at a rate of 15% on the book value.

The new product will be produced in a factory which is already owned by the company. The company built the factory some years age at Rs.1,50,000. The book value on the written down value basis is zero.

Today the factory has a resale value of Rs.3,50,000 which should remain fairly stable over the next five years. The factory is currently being rented to another company under a lease agreement, which has five years to run, and which provides for annual rental of Rs.5,000. Under the lease agreement if the lessor wishes to cancel the lease, can do so by paying the lessee compensation equal to one year's rental payment. This amount is not deductible for income tax purposes.

Additions to current asset will require Rs.22,500 at the commencement of the proposal which, it is assumed, is fully recoverable at the end of year 5. The company will have to spend Rs. 50,000 in year towards market research.

The net cash inflows from operations before depreciation and income tax are:

Year	Rs.
1	2,00,000
2	2,50,000
3	3,25,000
4	3,00,000
5	1,50,000

It may be assumed that all cash flows are received or paid at the end of each year and that income tax and paid in the year in which the inflow occurred.

The company's tax rate may be assumed to be 50% and the company's required return after tax is 10%

Required: Evaluate the proposal.

Ans: Product can be launched.

Problem No.5

A Company proposes to install a machine for the manufacture of a component which at present is being purchased at Rs.24 each. There are two alternatives, namely

(a) Installation of an automatic machine and

(b) Installation of a semi-automatic machine.

The details of the two machines are as under:

	Automatic machine	Semi-Automatic machine
Initial cost of machine (Rs.)	9,00,000	6,00,000
Life	10 years	10 years
Fixed overheads other than depreciation on machines (per annum) (Rs.)	1,62,000	84,000
Component (Rs.)	12	15

The company charges depreciation on straight-line method. Scrap value of the machine at the end of life is nil.

The demand for the components at present is 20,000 units per annum. This demand is expected to increase to 40,000 units.

Required:

(a) For each of the two volumes of output namely 20,000 and 40,000 units, state with supporting calculations whether the components should be purchased or manufactured by installation of machine. If your decision is in favor of installation of machine, which model will you advise?

(b) At what volume of output should the company change over form purchase of components to manufacture by installation of (i) semi-automatic machine and (ii) automatic machine?

(c) At what volume of manufacture of the components will the company switch over from installation of the type machine to the other?

Problem No. 6

Shri Kiran manufactures lighters. He sells his product at Rs.20 each, and makes profit of Rs.5 on each lighter.

He worked 50 per cent of his machinery capacity at 50,000 lighters. The cost of each lighter is as

Direct material	Rs. 6
Wages	2
Workers overhead	5 (50 per cent fixed)
Sales expenses	2 (25 per cent variable)

His anticipation for the next year is that the cost will be go up as under:

Fixed cost	10%
Direct wages	20%
Material	5%

There will not be any change in selling price. There is an additional order for 20,000 lighters in the next year.

What is the lowest rate he can quote so that he can earn the same profit as the current year?

Ans: Selling Price Rs. 14.45

Problem No.7

A manufacturing company currently operating at 80% capacity has received an export order from Middle East, which will utilise 40% of the capacity of the factory. The order has to be either taken in full and executed at 10% below the current domestic prices or rejected totally.

The current sales and cost data are given below.

Sales	Rs.16.00 lakhs.
Direct Material	Rs. 5.80 lakhs.
Direct Labour	Rs. 2.40 lakhs.
Variable Overheads	Rs. 0.60 lakhs.
Fixed Overheads	Rs. 5.20 lakhs.

The following alternatives are available to the management:

a. Continue with domestic sales and reject the export order.

b. Accept the export order and allow the domestic market to starve to the extent of excess of demand.

c. Increase capacity so as to accept the export order and maintain the domestic demand by

(i) Purchasing additional plant and increasing 10% capacity and there by increasing fixed overheads by Rs.65,000 and

(ii) Working overtime at one and half time the normal rate to meet balance of the required capacity.

(iii) You are required to evaluate each of the above alternatives and suggest the best one.

Ans: Profits Rupees lakhs 2: 3 & 4.

Problem No.8

AB Ltd manufactures a picnic table which has three components, X,Y,Z one of each being required for each table. The company is working to its full machine capacity of 28,000 hours per period and the machinery used is capable of making all the components.

The tables are made in batches of 20 and data relating to current production are:

			Per batch of 20	
Components	Machine Hours	Variable Costs Rs.	Fixed Costs Rs.	Total Costs Rs.
X	6	15	6	21
Y	10	18	7	25
Z	12	18	13	36
	28			
Assembly		32	13	45
		83	44	127
		Profit		23
		Selling price		150

Over the next budget period the machine capacity cannot be increased although the assembly capacity can be increases as required. The budget for the next period is being prepared. Because sales are buy and purchase of one of the components is being considered and the following quotation has been received:

	Batches of 20
Component	Price
X	Rs.22
Y	28
Z	32

The company has decided that only one component will be bought outside in any one period. The sales director thinks that he could sell at least 50% more tables than at present and probably 75% more provided that the production capacity was available.

You are required to:

(a) Recommend which component should be bought outside if production is increased by 50% and how many components should be bought;

(b) Recommend which component should be bought outside if production is increased by 75% and how many components should be bought.

3.22 Decisions of Transfer Pricing and use of Costs in Pricing

Illustration No. 1

PH Ltd. manufactures and sells two products, namely BXE and DXE. The company's investment in fixed assets is Rs.2 lakh. The working capital investment is equivalent to three months' cost of sales of both the products. The fixed capital has been financed by term loan lending institutions at an interest of 11% p.a. Half of the working capital is financed through bank borrowing carrying interest at the rate of 19.4%, the other half of the working capital being generated through internal resources.

The operating data anticipated for 2009-10 is as under:

	Product BXE	Product DXE
Production per annum (in units)	5,000	10,000
Direct Material/unit:		
Material A (Price Rs.4 per kg)	1 Kg	0.75 Kg
Material B (Price Rs.2 per kg)	1 Kg	1 Kg
Direct labour hours	5	3

Direct wage rate Rs.2 per hour. Factory overheads are recovered at 50% of direct wages. Administrative overheads are recovered at 40% of factory cost. Selling and distribution expenses are Rs.2 and Rs.3 per unit respectively of BXE and DXE. The company expects to earn an after tax profit of 12% on capital employed. The income tax rate is 50%.

Required:

(i) Prepare a cost sheet showing the element wise cost, total cost profit and selling price per unit of both the products.

(ii) Prepare a statement showing the net profit of the company after taxes for the 2009-10.

Solution:

(a) Cost sheet

	BXE		DXE		TOTAL
	UNITS	TOTALS	UNITS	TOTAL	
Direct material	6	30000	5	50000	80000
Direct wages	10	50000	6	60000	110000
Prime cost	16	80000	11	110000	190000
Factory OHs	5	25000	3	30000	55000
Factory cost	21	105000	14	140000	245000
Office OHs	8.40	42000	5.60	56000	98000
Cost of production	29.40	147000	19.60	196000	343000
Selling & dist. OHs	2.00	10000	3.00	30000	40000
Cost of sales	31.40	157000	22.60	226000	383000
Profit as % on					
Fixed capital		21818		26182	48000
Working capital		9420		13560	22980
Sales/S.P	37.6476	188238	26.5742	265742	453980

Working notes

Return after tax	[{383000 x 0.25} + 200000] 12%	35490
∴Sales	383000 + 35490 x (1/50%)	453980

(b) Statement showing net profit:

Sales		453980
(-) cost of sales		(383000)
Gross profit		70980
(-) interest	{22000 + (95750/2) 19.4%}	(31288)
profit before tax		39692
(-) tax @ 50%		(19846)
Profit after tax		19846

Illustration No. 2

Megatron Ltd. has entered into a collaboration agreement with Kozuki of Japan for import of TV Kit in completely knocked down (CKD) condition. The terms of agreement are as under:

(a) Megatron will import 40% items by value (interms of FOB price of complete T.V. set) and balance 60% will be locally manufactured / purchased.

(b) For all non-standard items which are to be produced locally, Kozuki will provide drawings.

(c) Megatron will pay a lump sum of Rs.30 lakh for supply of technical know-how and drawing.

(d) Megatron will also pay a royalty at 10% of selling price fixed by it for sale in the local market less landed cost of imported Kit, less cost of standard items purchased locally.

(e) Megatron will send a six monthly return to Kozuki showing No. sets sold, sale value, standard components costs, landed cost of CKD, etc.

Considering the above terms and additional information given below, calculate the selling price that should be fixed for local sale so as to get 20% profit on selling price (Round off the answer to nearest rupee).

(a) Agreement expires on production of 3 lakhs sets.

(b) FOB price quoted is 1,20,000 yen.

(c) Insurance and freight Rs. 200 per CKD.

(d) Customs Duty at 140% of CIF price. However, effective rate of duty is only 40% as per Government notification.

(e) Estimated cost of 60% items to be manufactured/procured locally, will be 1.5 items as compared to cost of manufacture by Kzuki. The quoted price by Kzuki contains 20% margin on cost.

(f) The ratio of standard and non-standard parts is 2:3 (interms of rupee value).

(g) Assembling and other overhead costs will be Rs.1000 per set.

(h) Exchange rate is Rs.5 per 100 yen.

Solution:

Computation of landed cost of CKD kit:

		Yen
FOB price		120000
FOB price in rupees	(120000/20)	6000
FOB price of import content	6000 x 40%	2400
(+) freight & insurance		200
CIF value		2600
(+) customs duty@40%		1040
Landed cost of imported CKD kit		3640

Cost estimate of locally manufactured items:

FOB price of local purchase	6000 x 60%	3600
(-) Profit	3600 x (1/6)	600
		3000
Cost of in business manufacture:	3000 x 1.50	4500
Cost of standard part	{4500 x (2/5)}	1800
Non- standard part	{4500 x (3/5)}	2700

Computation of cost & selling price:

Landed cost of imported CKD kit		3640
Cost of indigenous manufacture		4500
Assembling and other OHs costs		1000
Cost of technical know – how	(3000000/300000)	10
		9150
(+) Royalty		685
		9835
(+) Return	{9835 x (1/4)}	2459
Selling price		**12294**

<u>Working notes:</u>

Let X be the selling price

$\Rightarrow$ 9150 + (X – 3640 – 1800) 10% + X (1/5) = X

$\Rightarrow$ X = Rs. 12294/-

Illustration No. 3

P.H. Ltd. has two manufacturing departments organised into separate profit centres known as the Basic unit and Processing unit. The Basic unit has a production capacity of 4,000 tonnes per month of Chemvax but at present its sales are limited Rs. 2,000 tonnes to outside market and 1,200 tonnes to the Processing unit.

The transfer price for the year 2008 was agreed at Rs. 400 per tonne. This price has been fixed in line with the external wholesale trade price on 1st January 2008. However due to heavy competition the Basic unit has been forced to reduce the wholesale trade price to Rs. 360 per tonne with effect from 1st June, 2008.

This price however was not made applicable to the sales made to the Processing unit of the company. The Processing unit applied for revision of the price as applicable to the outside market buyers as from 1st June 2008 but the same was turned down by the basic unit.

The Processing unit refines Chemvax and packs the output Known as Colour-X in drums of 50kgs each. The selling price of colour-X is Rs. 40 per drum. The Processing unit has a potential of selling a further quantity of 16,000 drums of colour-X provided the overall price is reduced to Rs.32 per drum. In that event it can buy the additional 800 tonnes of Chemvex from the basic unit whose capacity can be fully utilised. The outside market will not however absorb more than the present quantity of 2,000 tonnes.

The cost data relevant to the operations are:

	Basic Unit	Processing Unit
	Rs.	Rs.
Raw Materials/tonne	70	Transfer price
Variable Cost/tonne	140	170
Fixed Costs/month	Rs.3,00,000	1,20,000

You are Required :

(i) Prepare statement showing the estimated profitability for June 2008 for each uint and the company as a whole on the following bases:

(a) At 80% and 100% capacity utilisation of the Basic unit at the market price and transfer price to the Processing unit of Rs.400 per tonne.

(b) At 80% capacity utilisation of the basic unit at the market price of Rs.360 per tonne and the transfer price to the Processing unit of Rs. 400 per tonne.

(c) At 100% capacity utilisation of the Basic unit at the market price and transfer price to the Processing unit of Rs.360 per tonne.

(ii) Comment on the effect of the company's transfer pricing policy on the profitability of the Processing Unit.

Solution:

(a) Statement showing computation of profit at 80% capacity when transfer price is Rs.400/- ton:

	Basic unit	Processing unit	Total
i) No. of units	3200	(1200x1000)/50	24000
ii) Contribution per unit	{400-(140 + 70)} = 190	{40 – (570/20)}	11.50
iii) Total contribution	608000	276000	884000
iv) Fixed cost	300000	120000	420000
v) Profit	308000	156000	464000

At 100% capacity:

	Basic unit	Processing unit	Total
i) No. of units	4000	40000	
ii) Contribution per unit	190	3.50	
iii) Total contribution	760000	140000	900000
iv) Fixed cost	300000	120000	420000
v) Profit	460000	20000	480000

b) Computation of profit:

		Basic unit		Processing unit	Total
		Out side sale	Internal transfer		
i)	No of units	2000	1200	24000	
ii)	Contribution per unit	150	190	11.50	
iii)	Total contribution	300000	228000		
			528000	276000	804000
iv)	Fixed cost		300000	120000	420000
v)	Profit		228000	156000	384000

c) Computation of profit:

	Basic unit	Processing unit	Total
No of units	4000	40000	
Contribution per unit	150	5.50	
Total contribution	600000	220000	820000
Fixed cost	300000	120000	420000
Profit	300000	100000	400000

Overall profit is more at 100% capacity of basic unit with a transfer price of Rs400/- per ton being the market price if individual interests are not considered this may adopted. However, from the view point of the processing unit, it will not be interested to buy more than 1200tonnes from the basic unit, because its profit gets reduced when it takes additional units. Therefore, the present policy of the management is not at all attractive to the processing unit.

Illustration No. 4

Division A is a profit centre which produces three products X, Y and Z. Each product has an external market.

	X	Y	Z
External market price per unit	Rs.48	Rs.46	Rs.40
Variable cost of production in division A	Rs.33	Rs.24	Rs.28
Labour hours required per unit in division A	3	4	2

Product Y can be transferred to Division B, but the maximum quantity that might be required for transfer is 300 units of Y.

	X	Y	Z
The maximum external sales are :	800 units	500 units	300 units

Instead of receiving transfers of Product Y from Division A, Division B could buy similar product in the open market at a slightly cheaper price of Rs.45 per unit.

What should the transfer price be for each unit for 300 units of Y, if the total labour hours available in Division A are?

(a) 3800 hours

(b) 5600 hours.

Solution:

Computation of contribution per labour hour from external sales:

	X	Y	Z
Market price	48	46	40
Variable cost	33	24	28
Contribution	15	22	12
Labour hours required	3	4	2
Contribution per labour hour	5	5.50	6
Priority	III	II	I

Computation of transfer price when

(a) The capacity is 3800 hours:

Hours required for	Z = 300 x 2 =	600
	Y = 500 x 4=	2000
		2600
	X = 800 x 3	2400
		5000

The existing capacity is not sufficient to produce the units to meet the external sales. In order to transfer 300 units of Y, 1200 hours are required in which division A will give up the production of X to this extent.

Variable cost of Y	24
(+) contribution lost by giving up production of X to the extent of 1200 hours = 1200 x 5 = 6000	
∴Opportunity cost per unit = (6000/300)	20
Required transfer price	**44**

(b) If the capacity is 5600 hours:

Variable cost	24
Contribution cost of giving up X to the extent of 600hours = 600 x 5 = 3000	
Opportunity Cost Per unit = (3000/300)	10
Required Transfer price	**34**

Illustration No. 5

SV Ltd. manufactures a product which is obtained basically from a series of mixing operations. The finished product is packaged in the company made glass bottles and packed in attractive cartons.

The company is organised into two independent divisions viz. one for the manufacture of the end product and the other for the manufacture of glass bottles. The Product manufacturing division can buy all the bottle requirements from the bottle manufacturing division.

The General Manager of the bottle manufacturing division has obtained the following quotations from the outside manufacturers for the empty bottles.

Volume empty bottles	Total cost (Rs.)
8,00,000	14,00,000
12,00,000	20,00,000

A cost analysis of the bottle manufacturing division for the manufacture of empty bottles reveals the following production costs:

Volume empty bottles	Total purchase value (Rs.)
8,00,000	Rs. 10,40,000
12,00,000	14,40,000

The production cost and sales value of the end product marketed by the product manufacturing division are as under.

Volume (Bottle of end product)	Total cost of end product*	Sales Value (Packed in bottles)
8,00,000	Rs.64,80,000	Rs. 91,20,000
12,00,000	Rs.96,80,000	Rs.1,27,80,000

There has been considerable discussion at the corporate level as to the use of proper price for transfer of empty bottles from the bottle manufacturing division to product manufacturing division. This interest is heightened because a significant portion of the Divisional General Manager's salary is in incentive bonus based on profit centre results.

As the corporate management accountant responsible for defining the proper transfer prices for the supply of empty bottles by the bottle manufacturing division to the product manufacturing division, you are required to show for the two levels of volume of 8,00,000 and 12,00,000 bottles, the profitability by using (i) market price and (ii) shared profit relative to the cost involved basis for the determination of transfer prices. The profitability position should be furnished separately for the two divisions and the company as a whole under each method. Discuss also the effect of these methods on the profitability of the two divisions.

* (Excluding cost of empty bottles)

Solution:

Statement showing Computation of transfer price on the basis of profit shared on cost basis:

	Output (800000)	Output (1200000)
Sales	9120000	12780000
Costs:		
Product manufacturing division	6480000	9680000
Bottle manufacturing division	1040000	1440000
	7520000	11120000
Profit	1600000	1660000
Share of bottle manufacturing division	221276	214964
Product manufacturing division	1378724	1445036
Transfer price	1261276	1654964
Transfer price per bottle	1.5777	1.379

Profitability on the basis of market price:

		Output (800000)	Output (1200000)
Bottle manufacturing division			
Sale value		1400000	2000000
(-)cost		1040000	1440000
Profit		360000	560000
Product manufacturing division			
Sale value		9120000	12780000
(-)cost of product	6480000		
Cost of bottle	1400000		
Profit		7880000	11680000
		1240000	1100000
Total profit		1600000	1660000
Transfer price		1.75	1.67

Illustration No. 6

A Company with two manufacturing divisions is organised on profit centre basis. Division 'A' is the only source for the supply of a component that is used in Division B in the manufacture of a product KLIM. One such part is used each unit of the product KLIM. As the demand for the product is not steady. Division B can obtain orders for increased quantities only by spending more on sales promotion and by reducing the selling prices. The Manager of Division B has accordingly prepared the following forecast of sales quantities and selling prices.

Sales units per day	Average Selling price per unit of KLIM
1,000	Rs.5.25
2,000	3.98
3,000	3.30
4,000	2.78
5,000	2.40
6,000	2.01

The manufacturing cost of KLIM in Division B is Rs.3,750 first 1,000 units and Rs.750 per 1,000 units in excess of 1,000 units.

Division A incurs a total cost of Rs.1,500 per day for an output to 1,000 components and the total costs will increase by Rs.900 per day for every additional 1,000 components manufactured. The Manager of Division A states that the operating results of his Division will be optimised if the transfer price of the component is set at Rs.1.20 per unit and he has accordingly set the aforesaid transfer price for his supplies of the component to Division A

You are required:

(a) Prepare a schedule showing the profitability at each level of output for Division A and Division B.

(b) Find the profitability of the company as a whole at the output level which

(i) Division A's net profit is maximum.

(ii) Division B's net profit is maximum.

(c) If the Company is not organised on profit centre basis, what level of output will be chosen to yield the maximum profit.

Solution:

i. Statement showing profit of division A:

Sale per day(units)	Sale value	Cost	Profit/(loss)
1000	1200	1500	(300)
2000	2400	2400	-
3000	3600	3300	300
4000	4800	4200	600
5000	6000	5100	900
6000	7200	6000	1200

Profit of division B:

No of units	Sales	Transfer price	Other manufacturing cost	Total cost	Profit/(loss)
1000	5250	1200	3750	4950	300
2000	7960	2400	4500	6900	1060
3000	9900	3600	5250	8850	1050
4000	11120	4800	6000	10800	320
5000	12000	6000	6750	12750	(750)
6000	12060	7200	7500	14700	(2640)

ii. Profitability of the company at the output level where division A's net profit is maximum :

Profit of division A at 6000units	1200
Profit of division B at 6000units	(2640)
Profit /(loss)	(1440)
Division B's net profit is maximum:	
Profit of division A at 2000 units	-
Profit of division B at 2000units	1060
	1060

iii. When the company is not organized on profit centre basis

Profit at different levels of output

Units	Division A	Division B	Total
1000	(300)	300	-----
2000	-----	1060	1060
3000	300	1050	1350
4000	600	320	920
5000	900	(750)	150
6000	1200	(2640)	(1440)

Best output level is 3000 units

Illustration No. 7

Transferor Ltd. has two processes Preparing and Finishing. The normal output per week is 7,500 units (Completed) at a capacity of 75%

Transferee Ltd. had production problems in preparing and requires 2,000 units per week of prepared material for their finishing processes.

The existing cost structure of one prepared unit of Transferor Ltd. at existing capacity

Material	Rs.2.00 (variable 100%)
Labour	Rs.2.00 (Variable 50%)
Overhead	Rs.4.00 (variable 25%)

The sale price of a completed unit of Transferor Ltd is Rs.16 with a profit of Rs.4 per unit.

Construct the effect on the profits Transferor Ltd., for six months (25 weeks) of supplying units to Transferee Ltd. with the following alternative transfer prices per unit:

(i) Marginal Cost

(ii) Marginal Cost + 25%

(iii) Marginal Cost + 15% Return on capital(assume capital employed Rs.20 lakhs)

(iv) Existing Cost

(v) Existing Cost + a portion profit on the basis of (preparing cost / Total Cost) x Unit Profit

(vi) At an agreed market price of Rs.8.50 Assume no increase in fixed cost.

Solution:

Transferred units	25 x 2000	50000
Existing profit	7500 x 25 x 4	750000

Effect on profit if Transfer price is

i. Marginal cost

Material	2.00
Labour	1.00
OHs	1.00
	4.00

At this transfer price there is no effect on profit of transferor Ltd.

ii. Profit 50000

iii. Profit per unit = 4 + {(2000000 x 15% x 0.5)/50000} = 7

Under this method profit of transferor ltd is increases by 150000 i.e., 50000 x (7-4)

Profit increases by 50000 x (8-4) = 200000

Transfer price:

{8 + (8/12)4}	= 10.67
(-) profit	= 4.00
	6.67

Profit increases by 50000 x 6.67 = Rs. 333500/-

vi. Transfer price = 8.50

Profit increase by 4.5 x 50000 = 225000

Illustration No. 8

A manufacture has three products A, B, C, current sales; cost and selling price details and processing time requirements are as follows:

	Product A	Product B	Product C
Annual sales (units)	6000	6000	750
Selling Price (Rs.)	20	31	39
Unit Cost (Rs.)	18	24	30
Processing time required per unit (hour)	1	1	2

The firm is working at full capacity (13,500 processing hours per year.) Fixed manufacturing overheads are absorbed into unit costs by a charge of 200% of variable costs. This procedure fully absorbs the fixed manufacturing overhead.

Assuming that:

(i) Processing time can be switched from one product line to another.

(ii) The demand at current selling price is:

Product A	Product B	Product C
11,000	8,000	2,000

(iii) The selling prices are not be altered, you are required to calculate the best production programme for the next operating period and to indicate the increase in net profit that this should yield. In addition identify the shadow price of processing hour.

Solution:

Computation of contribution per labour hour & priority:

	A	B	C
i) Selling price	20	31	39
ii) Variable cost(1/3rd of total cost)	6	8	10
iii) Contribution per unit	14	23	29
iv) Contribution per hour	14	23	14.5
v) Ranking	III	I	II

Computation of current profit:

	A	B	C	TOTAL
i) No of units	6000	6000	750	
ii) Contribution per unit	14	23	29	
iii) Total contribution	84000	138000	21750	243750
iv) Fixed cost	72000	96000	15000	183000
v) Profit				60750

Statement showing optimum mix & profit at that mix:

	A	B	C	Total
i) No of units	1500	8000	2000	
ii) Contribution per unit	14	23	29	
iii) Total contribution	21000	184000	58000	263000
iv) Fixed cost				183000
v) Profit				80000

Working notes:

Hours available	13500
(-) used for B = 8000 x 1	8000
	5500
(-) used for C = 2000 x 2	4000
Used for A	1500

Increase in profit = 80000 – 60750 = 19250

Shadow price of processing hour:

The shadow price is the opportunity cost of one unit of resource for the decision maker. In the present case every extra processing hour will increase contribution by Rs. 14/-

There fore the shadow price of processing hour is Rs. 14.

EXERCISE PROBLEMS

Problem No. 1

Your company fixes the inter-divisional transfer prices for its products on the basis of cost, plus a return on investment in the division. The Budget for Division A for 2009-10 appears as under:

Fixed Assets	5,00,000
Current assets	3,00,000
Debtors	2,00,000
Annual Fixed Cost of the Division	8,00,000
Variable Cost per unit of Product	10
Budgeted Volume	4,00,000 units per year
Desired ROI	28%

Determine the transfer Price for Division A.

Ans:

Variable Cost		10.00
Fixed Cost per unit	8,00,000 ÷ 4,00,000	2.00
required Return	$\frac{10,00,000 \times 28\%}{4,00,000}$	0.70
Total cost or Transfer price		**12.70**

Problem No. 2

You have just taken up the position as the first full-time accountant for a jobbing engineering company. Previously the accounting work had been undertaken by the company's auditors who had produced the following summarised profit and loss statement for the financial year which ended on 31st March of this year:

	Rs.	Rs.	Rs.
Sales			24,00,000
Direct material		10,00,000	
Direct labour-Grinding Dept.	2,00,000		
Direct labour-Finishing Dept.	2,60,000		
		4,60,000	
Production overhead-Grinding	1,75,000		
Production overhead-Finishing	2,08,000		
		3,83,000	
Administration costs		1,18,500	
Selling costs		1,92,000	
			21,53,500
Net profit			2,46,500

The sales manager is currently negotiating a price for an inquiry for a job which has been allotted number '878' and he has been given the following information by his staff:

Preferred price to obtain a return of 16-2/3% on selling price	Rs.22,656
Lowest acceptable	Rs.18,880

These prices have been based on the following estimated costs for proposed job '878':

Direct material		9,000
Direct labour-Grinding Dept. 400 hours @ Rs. 5 =	2,000	
Direct labour-Finishing Dept. 300 hours @ Rs. 6 =	1,800	
		3,800
		12,800
Add 47.5% to cover all other costs		6,080
Total cost		18,880

The sales manager seeks your advice about the validity of the method he is using to quote for job '878'.

The company is currently busy with a fairly full order book but the Confederation of British Industry has forecast that a recession is imminent for the engineering industry.

You are required: as the accountant.

(a) To criticise the method adopted for estimating the costs which are used as the basis for quoting prices for jobs;

(b) To suggest a better method of estimating job costs and to calculate a revised job cost and price based on the information available.

Ans:

(a) The predominant mistake in the estimating price for the job is use of application of blanket or general over head rate for absorbing all types of costs.

(b) It is general practice to recover production overheads on the basis of direct labour and that too by applying departmental over head rates wherever possible. Similarly, Administration overheads are to be recovered on the basis of factory cost, Selling and Distribution over heads are recovered on the basis of cost of production.

Problem No. 3

S.V.Ltd budgets to make 1,00,000 units of product P. The variable cost per unit is Rs.10. Fixed costs are Rs.6,00,000.

The finance Director suggested that the cost-plus approach should be used with a profit mark-up of 25%.

However, the Marketing Director disagreed and has supplied the following information:

Price per unit	Demand
(Rs.)	(Unit)
18	84,000
20	76,000
22	70,000
24	64,000
26	54,000

As Management Accountant of the Company analyse the above proposals and comment.

Ans:

At the SP of Rs. 24/unit, the profit is maximum and hence that price must be fixed for the product.

Problem No. 4

Look Ahead Ltd. wants to fix proper selling prices for their products 'A' and 'B' which they are newly introducing in the market. Both these products will be manufactured in Department D, which is considered as a Profit Centre.

The estimated data are as under: -

	A	B
Annual Production (unit)	1,00,000	2,00,000
	Rs.	Rs.
Direct Materials per unit	15.00	14.00
Direct Labour per unit	9.00	6.00
(Direct Labour Hour Rate = Rs.3)		

The proportion of overheads other than interest, chargeable to the two products are as under :

Factory overheads (50% fixed) 100% of Direct Wages. Administration overheads (100% fixed) 10% of factory costs. Selling and Distribution overheads (50% variable) Rs. 3 and Rs. 4 respectively per unit of products A and B.

The fixed capital investment in the Department is Rs.50 lakhs. The working capital requirement is equivalent to 6 months stock of cost of sales of both the product. For this project a term loan amounting to Rs.40 lakhs has been obtained from Financial Institutions on a interest rate of 14% per annum. 50% of the working capital needs are met by bank borrowing carrying interest at 18% per annum. The Department is expected to give a return of 20% on capital employed.

You are required to:

(a) Fix the selling price of products A and B such that the contribution per direct labour hour is the same for both the products.

(b) Prepare a statement showing in details the overall profit that would be made by the Department.

Ans:

a) Selling Price as per Finance Director Rs. 20 (10 + 6 + 4)

b) Marketing Director was correct in his approach because the profit at selling of Rs. 24 is more and there fore that price should be fixed for the product.

Problem No. 5

Look Ahead Ltd. wants to fix proper selling prices for their products 'A' and 'B' which they are newly introducing in the market. Both these products will be manufactured in Department D, which is considered as a Profit Centre.

The estimated data are as under: -

	A	B
Annual Production (unit)	1,00,000	2,00,000
	Rs.	Rs.
Direct Materials per unit	15.00	14.00
Direct Labour per unit	9.00	6.00
(Direct Labour Hour Rate = Rs.3)		

The proportion of overheads other than interest, chargeable to the two products are as under :

Factory overheads (50% fixed) 100% of Direct Wages. Administration overheads (100% fixed) 10% of factory costs. Selling and Distribution overheads (50% variable) Rs. 3 and Rs. 4 respectively per unit of products A and B.

The fixed capital investment in the Department is Rs.50 lakhs. The working capital requirement is equivalent to 6 months stock of cost of sales of both the product. For this project a term loan amounting to Rs.40 lakhs has been obtained from Financial Institutions on a interest rate of 14% per annum. 50% of the working capital needs are met by bank borrowing carrying interest at 18% per annum. The Department is expected to give a return of 20% on capital employed.

You are required to:

Fix the selling price of products A and B such that the contribution per direct labour hour is the same for both the products.

Prepare a statement showing in details the overall profit that would be made by the Department.

Ans:

a) Selling Price for A = Rs. 49.26, B = Rs. 37.84

b) Profit = Rs. 10,14,730

Problem No. 6

L Ltd. and M Ltd. are subsidiaries of the same group of companies.

L ltd produces a branded product sold in drums (10,000 in number) at a price of Rs.20 per drum.

Its direct products cost per drum are:

-Raw material from M Ltd. AT a transfer price of Rs.9 for 25 liters.

-Other products and services from outside the group : At a cost of Rs.3.

L Ltd's fixed costs are Rs.40,000 per month. These costs include process labour whose costs will not alter until L Ltd's output reaches twice its present level.

A market research study has indicate that L Ltd's market could increase by 80% in volume if it were to reduce its price by 20%.

M Ltd produces a fairly basic product which can be converted into a wide range of end products. It sells one third of its output to L Ltd and the remainder to customers outside the group.

M Ltd production capacity is 1,000 kiloliters per month, but competition is keen and it budgets to sell no more than 750 kiloliters per month for the year 31st December 1990.

Its variable costs are Rs.200 per kiloliter and its fixed costs are Rs.60,000 per month.

The current policy of the group is to market prices, where known, as the transfer price between its subsidiaries. This is the basis of the transfer price between M Ltd and L Ltd.

You are required:

(a) To calculate the monthly profit position for each of L Ltd and M Ltd if sales of L Ltd are :

  (i) At their present level and

  (ii) At the higher potential level indicated by the market research, subject to a cut in price of 20%.

(b) To explain why the use of market price as the transfer price produces difficulties under the conditions outlined in (a) (ii) above

(c) To recommend, with supporting calculations, what transfer price you would propose.

Ans:

a) (i) M Ltd. Profit Rs. 60,000, L Ltd. Rs. 40,000

  (ii) M Ltd. Profit Rs. 92,000, L Ltd. Rs. 32,000

b) Usually, the market price is most satisfactory basis for intercompany transfer pricing system as it avoids an extensive arbitration system.

c) Recommended transfer price is **Rs. 6.80 per drum** for additional production.

Problem No. 7

A group has two companies:

K Ltd. which is operating at just above 50% capacity, and

L Ltd. which is operating at full capacity (7,000 production hours).

L Ltd. produces two products, X and Y, using the same labour for each product. For the next year its budgeted capacity involves a commitment to the sale of 3,000 kgs of Y, the remainder of its capacity being used on X.

Direct costs of these two products are:

	X	Y
	Rs.per kg	Rs.per kg
Direct materials	18	14
Direct wages	15 (1 production hour)	10 (2/3 production hour)

The company's overhead is Rs.1,26,000 per annum relating to X and Y in proportion to their direct wages. At full capacity Rs.70,000 of this overhead is variable. L Ltd prices its products with a 60% mark up on its total costs.

For the coming year, K Ltd. wishes to buy from L Ltd. 2,000 kgs of product X which it proposes to adopt and sell as product Z for Rs.100 per kg. The direct costs of adaptation are Rs.15 per kg. K Ltd's total fixed costs will not change, but variable overhead of Rs.2 per kg will be incurred.

You are required to recommend: as group management accountant:

(a) At what range of transfer prices, if at all 2,000 kgs of product X should be sold to K Ltd.

(b) What other points should be borne in mind when making any recommendations about transfer prices in the above circumstances?

Ans:

a) Transfer price is market price which avoids extensive arbitration and it also gives buyers and sellers equitable basis for price fixation. Transfer price may range from Rs. 78.40 to 81.60.

b) Cost savings and interdivisional profits etc.

3.23 Decisions Relating to Joint and By-Products

Illustration No. 1

A manufacturing unit imports Raw Material and processes it to produce three different products viz. Bright, Light and White. The raw material has F.O.B. value of Rs.5 per kg. freight and insurance are charged at 10% F.O.B. price. Customs duty at 120% of C.I.F. is levied at the time of import. Auxiliary duty at 20% is also charged on C.I.F. price. Countervailing duty is charged on C.I.F. plus duty at 10%. The landed cost includes 5% for clearing charges.

Bright and Light are joint products while white emerges as a by-product. The value of by-product after deducting 30% (10% being notional profit and 20% for selling expenses) from sale value is credited to process account. The unit consumed 4,000 kgs raw materials during a year. The relevant data is as under:

	Bright	Light	White
Production and sale Kg.	1,400	1,600	1,000
Selling price Rs. per kg.	30	26	12
Further processing cost Rs.	1,500	1,000	—

Assuming additional processing cost other than material at Rs.15,800 for all products (include Rs.800 for White), prepare a statement showing:

Credit to process A/c for by-product sale;

Allocation of joint costs on relative sale value basis; and

Profit on each product.

Solution:

i. Calculation of amount to be credited to main product from sale of by product:

Sale value of white 1000 x 12	12000
(-) Profit @ 10%	1200
Total cost	10800
(-) 20% of 12000 towards selling expenses	2400
Total manufacturing cost	8400
(-) Separation expenses	800
Sale value at split off	7600

There-fore amount to be credited to the process account is Rs.7600.

ii. Computation of joint cost

		Rs.
Material	4000 x 5	20000
Freight and insurance	20000 x 10%	2000
CIF value		22000
(+) Customs duty @ 120% (+) Auxiliary duty @ 20% i.e.,	22000 x 140%	30800
		52800
(+) Countervailing duty (CVD)	52800 x 10%	5280
		58080
(+) Clearing charges	(58080 x 5%)	2904
Landed cost of material		60984
(+) Joint process cost		15000
		75984
(-) Sale value of By-product		7600
Joint cost		68384

Statement showing apportionment of joint expenses:

	Bright	Light	Total
Sale value	42000	41600	83600
Joint cost	34356	34028	68384

iii. Statement showing computation of profit:

	Bright	**Light**	**White**	**Total**
Sales	42000	41600	12000	95600
(-) costs				
Joint costs	34356	34028	7600	75984
Further costs	1500	1000	800	3300
Selling expenses	----	-----	2400	2400
Total costs	35856	35028	10800	81684
Profit	6144	6572	1200	13916

Illustration No. 2

A chemical factory produces four products from a single raw material. The cost of raw material for a year is Rs.67,000 and the initial processing costs amounted to Rs.1,28,200. All the four products viz. A, B, C and D are produced simultaneously at a single split off point. Product C is sold immediately without any further processing. A,B and D are processed further.

The output, sales and further processing costs are:

Product	Output in units	Sales Rs.	Further Processing Cost Rs.
A	4,00,000	1,92,000	40,000
B	89,725	58,000	32,000
C	5,000	8,000	—-
D	9,000	60,000	1,000

If these products were sold out at the split off point the prices attained per unit would be A=Rs.0.32; B=Rs.0.40; C=Rs.1.60; D=Rs.5.00

Using the concepts of relevancy of costs and differential costs, advise your management whether further processing should be undertaken or not.

Solution:

Statement showing computation of profit before further processing :

	A	B	C	D	Total
No of units	400000	89725	5000	9000	
Selling price	0.32	0.40	1.60	5.00	
Sales (NRV)	128000	35890	8000	45000	216890
Joint cost	115199	32301	7200	40501	195200
Profit/ (Loss)	12801	3589	800	4499	21690

Statement showing profit after further processing:

	A	B	C	D	Total
Final sales	192000	58000	8000	60000	318000
Further processing costs	40000	32000	---	1000	73000
Sale value at split off	152000	26000	8000	59000	245000
Joint cost	121104	20715	6374	47007	195200
Profit/(loss)	30896	5285	1626	11993	49800

Statement showing computation of additional (cost) / profit:

	A	B	C	D	Total
Final sales	4192000	58000	8000	60000	318000
Sale value of split off	128000	35890	8000	45000	216890
Additional sales	64000	22110	---	15000	101110
Further costs	40000	32000	---	1000	73000
Additional profit / (loss)	24000	(9890)	---	14000	28110

From the above computations, it is advisable to further process products A & D as there is additional profit and not to further process products B & C as there is no additional profit.

Illustration No. 3

The Management Team of Exe Ltd. is considering the possibility of undertaking a single production process which jointly produces four products in standard proportions. The output from each 10kg.batch of raw material input into the process together with net realisable value per kg. of output immediately after the split-off point is:

Material	Output per 10kg.	Input Net realisable value per kg. of output
A	4 kg.	Rs.8
B	3	4
C	2	10
D	1	2

The cost of processing each 10 kg. input batch are Rs.12 and cost of the raw material input is Rs.4 per kg.

For each of the four materials jointly produced there is the possibility of further processing before sale. The further processing will entail both manful operation and mechanical processing as well as incurring some costs directly attributable to each product. Details of resources used in, and costs incurred by, the further processing as well as the final price per kg. are:

Material	Machine hours	Labour hours	Other direct costs	Sales price
A	2	1	Rs.4	Rs.17
B	6	1	2	13
C	4	5	3	36
D	2	2	2	9

"Other direct costs" are variable costs but exclude the cost of labour, also a variable cost at Rs.3 per labour hour. A part from "other direct cots" and labour costs, all other costs of this further processing are fixed and are expected to amount to Rs.3,40,000 per annum.

Exe Ltd. has the opportunity to process 1,00,000 kg. of the basic raw material per year and machine capacity is capable of fully processing this amount.

The Managing Director feels that all products which are subjected to further processing must be treated as joint products and all products sold immediately after the split-off point without further processing are to be treated as by products of the original process. The net costs of the joint process are allocated to the joint products in proportion to the contribution of each product line, after considering the marginal costs after the split-off point and sales revenues.

However, the Managing Director is uncertain whether the Rs.3,40,000 fixed production cots of further processing should be allocated to products in accordance with machine or labour hours.

Required:

(a) Specify which of the jointly produced materials should be subject to further processing if the joint process is carried out.

(b) Produce a product profitability report for the joint products, utilizing the Managing Director's approach to the determination of joint and

(c) Byproducts for each of the methods of allocating fixed production over head, he has mentioned. You may assume all production will be sold.

Solution:

a) Statement showing profitability after further processing:

	A	B	C	D
Selling price	17	13	36	8
Variable cost:				
Labour	3	3	15	6
Others	4	2	3	2
	7	5	18	8
Contribution	10	8	18	1
NRV	8	4	10	2
Gain /(loss)	2	4	8	(1)

Products A, B & C should be subject to further processing and hence treated as joint products and product D as by product.

b) Working note

Joint cost	Amount
Material 100000 x 4	400000
Processing cost 100000 x (12/10)	120000
	520000
(-) Sale value of by product [100000 x (2/10)	20000
Joint cost	500000

Ratio of apportionment of joint cost

Labour hour Contribution	Amount	Ratio
A (40000 x 10)	400000	10
B (30000 x 8)	240000	6
C (20000 x 18)	360000	9
Machine hour		
A 40000 x 2	80000	FOH / Machine hour =
B (30000 x 6)	180000	340000 / 340000 = 1
C (20000 x 4)	80000	
	340000	

Profit when fixed costs are distributed on machine hour basis

	A	B	C	Total
No of units	40000	30000	20000	
Sales	680000	3900000	720000	1790000
Joint cost	200000	120000	180000	500000
Labour	120000	90000	300000	510000
Other direct costs	160000	60000	60000	280000
Fixed cost	80000	180000	80000	340000
	560000	450000	620000	1630000
Profit / (loss)	120000	(60000)	100000	160000

Profit when fixed costs are distributed on the basis of labour hours

	A	B	C	Total
Sales	680000	390000	720000	1790000
Variable cost	480000	270000	540000	1290000
Contribution	200000	120000	180000	500000
Fixed cost	80000	60000	200000	340000
Profit /(loss)	120000	60000	(20000)	160000

Working notes:

Labour hours

A	40000 x 1	40000
B	30000 x 1	30000
C	20000 x 5	100000
		170000

Fixed cost per labour hour (340000 / 170000) = 2

Illustration No.4

A chemical factory processes raw material R and produces three similar products P1,P2 and P3 out of a joint process. The joint cost of processing 5,000 kg of R are as under:

Labour Cost	Rs.6,000
Overhead cost	2,000
Total	8,000

The raw material R is purchased at Rs.2.40 per kg. This rate is after a trade discount of 20% on list price. Normal loss is estimated at 10% of input weight. The scrap generated from processing R is recovered to the extent of 25% by weight and sold as such in the market at Rs.4 per kg. The products P1,P2,P3 can be sold at Rs.5.00, Rs.6.00 and Rs.6.50 per kg respectively without any further processing.

However, products P1 and P2 can also be further jointly processed at an additional cost of Rs.2 per kg of, input to get product J1. The further processing cost of J1 will be Rs1 per kg of output weight.

Similarly, products P2 and P3 can be jointly processed to get a product J2 at an additional cost of Rs.5 per kg of Input. The further processing cost of J2 will be Rs.2 per kg of output weight. The normal loss of processing J1 out of P1 and P2 will be 5% of input weight. No processing loss is expected on processing J2. The selling prices of J1 and J2 including the input composition is given below:

Input	Output	
	J1	J2
P1	40%	
P2	60%	50%
P3		50%
Price per kg	Rs.10.00	12.00

The output weights of P1, P2 and P3 will be in the proportion of 3:4:2.

Required to:

(a) Show profitability of processing P1, P2 and P2 from 5,000kg. of R assuming the sale of split-off point.

(b) Profitability after both J1 and J2 are further processed and marketed using P2 in the ratio of 3:2 for J1 and J2 respectively.

(c) Recommend the processing decision among the alternatives i.e. to use whole output of P2 for processing J1 or J2 to yield maximum profit and the amount of such maximum profit.

Solution:

a) Statement showing profitability of $P_{1,}$ P_2 and P_3 at spilt off:

	P_1	P_2	P_3	Total
No. of units	1500	2000	1000	
Selling price	5	6	6.50	
Sales	7500	12000	6500	26000
Joint cost	5625	9000	4875	19500
Profit	1875	3000	1625	6500

JOINT COST:

Raw Material	2.4 x 5000	12000
Labour and O.H	6000+2000	8000
(-) scrap realised	125 Kg x 4	500
		19500

b) Computation of profit from J_1, J_2:

"J_1"

Units of P_2 Required	2000 x (3/5)	1200
Joint cost	2000 ----- 9000 1200 ------?	5400
Units of P_1 Required	60 ------ 1200 40 --------?	800
Joint cost	1500 ----- 5625 800 --------?	3000
Units of J_1	1200 **+** 800	2000
Joint cost of J_1	5400 + 3000	8400
Joint Processing cost	2000 x 2	4000
Total cost		12400
Units	(2000 – 100)	1900
Further processing cost	1900 x 1	1900
TOTAL COST		14300
Profit		4700
Sales	1900 x 10	19000

"J_2"

		Units	amount
P_2	(2000 – 1200) X 9000/(2000)	800	3600
P_3	1000 ---- 4875 800 ------?	800	3900
		1600	7500
(+)joint processing cost	1600 x 5		8000
(+)further processing cost	1600 x 2		3200
Total cost			18700
Profit			500
Sales	1600 x 12		19200

Profit from the remaining units of P_1	(1500 – 800) = 700 units	
	1500 --- 1875	
	700 -----?	875
Units of P_3	(1000 - 800) = 200 units	
	1000 ----- 1625	
	200 -------?	325
Total profit = 4700 + 500 + 875 + 325		**6400**

(c) Profit per unit of P_2 from J_1= 4700/1200 = 3.916

Profit per unit of P_2 from J_2 = 500 / 800 = 0.625

As the profit per unit of P_2 is more when it is used in J_1 the entire P_2 should be used in J_1.

Profit from J_1:

	Units	Amount
Units of P_2 required	2000	9000
units of P_1 (40/60) x 2000	1333	5000
	3333	14000
(+)joint processing cost(3333 x 2)	----	6666
(-) weight loss (3333 x 5%)	166	---
(+)further processing cost	-----	3167
	3167	23833
Profit (9671-1625-209)	------	7837
Sales	**3167**	**31670**
Profit from the remaining units of P_1 (1500 -1333) x(1875/1500)		209
P_3 Profit		1625
Total profit		9671

Illustration No. 5

Progressive Process Industries manufactures two products P and Q . Under present operations , raw materials are processed in Department A and the two products are separated at the end of this process. For every unit of P, two units of Q are obtained. P is then finished in Dept. B and Q in Dept.C. Actual operating data for 2008-09 are as under: -

	Dept. A	Dept. B	Dept. C	Total
Units produced				
P	40,000	40,000		40,000
Q	80,000		80,000	80,000
Cost incurred (Rs)				
Raw Material	1,20,000			1,20,000
Direct Labour	70,000	50,000	60,000	1,80,000
Variable Overheads	40,000	20,000	20,000	80,000
Avoidable fixed overheads	20,000	10,000	10,000	40,000
Common fixed overheads allocated on basis of floor space	50,000	25,000	25,000	1,00,000

At present P is sold for Rs.6.25 and Q for Rs.4 per unit. Both products are also readily marketable at the completion of processing in Department A-p for Rs.4.50 per unit and Q for Rs.2.75 per unit. Department B and /or Department C could be closed down completely if P and/or Q, respectively were sold at the split-off point.

(a) Under an absorption Costing System, what would be the average unit cost of P and Q during 2008-09?

(b) From the point of view of short-run profits maximization, when should each product be sold during 2008-09 after final completion or at the split-off point?

Solution:

a. Statement showing computation of unit cost price:

	P	Q	TOTAL
Sales at spilt off	180000	220000	400000
Joint cost	135000	165000	300000
Separate cost	105000	115000	220000
Total cost	240000	280000	520000
Cost per unit	6	3.50	

b. Profit at spilt off point (before further processing):

	P	Q	TOTAL
Sales at spilt off	180000	220000	400000
Joint cost	135000	165000	300000
Profit	45000	55000	100000
(-)Common FOHs			(50000)
			50000

Incremental profit:

	P	Q	TOTAL
Incremental sales	70000	100000	170000
(-)Separate costs	80000	90000	170000
Profit/(loss)	(10000)	10000	----------

From the above it is better to sell P at spilt off and Q after further processing.

Profit statement if product Q is further processed.

	P	Q	TOTAL
Sales	180000	320000	500000
Joint cost	135000	165000	300000
Separate cost	-------	115000	115000
Profit	45000	40000	85000
(-)Fixed cost of Dept B			25000
Actual profit			60000

EXERCISE PROBLEMS

Problem No. 1

Chem Co. Ltd. produces two products 'J' and 'K' in Department 'A' from a basic raw material. The input output ratio of Department A is 100:90. Product 'J' which becomes the input of Department 'B' can be further processed in Department 'B' to make one of the most popular industrial product 'N'. The input-output ratio of Department 'B' is 100:95. Alternatively product 'J' can also be sold at the split off stage.

The selling prices are

Product	Rs./Kg.
J	29.40
K	26.00
N	31.50

The departmental expenses, production data in selling expenses envisaged in the budget for 1986 are as under:

(a) Departmental expenses:

	A Rs. lacs	B Rs. lacs
Raw Materials Rs.16 per kg.		
Direct Materials	10.00	3.00
Direct Wages	15.00	5.00
Variable Overheads	20.00	7.00
Fixed Overheads	25.00	10.00

(b) Production data:

Product	kg.
N	4,75,000
K	8,50,000

(c) Selling expenses:

Product	Rs.
J	1,00,000
K	2,00,000
N	2,00,000

You are required to:

(i) Prepare a statement showing the apportionment of joint costs between products 'J' and 'K'.

(ii) Advise whether the company should process 'J' further into product 'N' or not. Show workings.

(iii) Present a statement of profitability based on your decision.

Problem No. 2

Fine Chemicals Ltd. produces A, B, C from a common mixing process. The products are made in batches and from an input of 1,100kg of material the standard output is:

A	400 kg.
B	300
C	200
By-product	100

Waste has no value.

The common costs per batch for the mixing process are:

Direct Material (1,100kg)	Rs.440
Direct labour (100 hrs)	300
Variable overhead	200

Fixed overheads in the mixing department are budgeted at Rs.26,000 per month. The normal production is 100 batches per month.

The products are all capable of further processing and the company has idle space available. Additional capital equipment would be required at a cost of Rs.1,20,000 to be depreciated over a 10 year period on a straight line basis with no residual value. Rent, rates and other fixed costs of further processing are budgeted to Rs.15,000 per month.

	A per kg.	B per kg.	C per kg.
Direct Materials	Rs.1.00	Rs.0.50	Rs.0.80
Direct labour	1.50	3.00	2.25
Variable overhead	1.00	2.00	1.50

Direct wages are Rs.3 per hour and variable overhead is calculated at Rs.2 per hour. The sales value of products before and after further processing are:

	A split-off point per kg	**After further processing per kg**
A	Rs. 1.25	Rs.5.35
B	1.50	7.15
C	2.00	7.55
By-product	0.50	0.50

Only 25,000 direct labour hours will be available for further processing during the coming year.

Required:

(a) A statement showing the budgeted monthly results if further processing is not undertaken.

(b) Assuming that at the end of financial year 20% of the output for one month from the mixing department was in stock, show the valuations, which two alternative methods of valuation would give.

(c) Give calculations and recommendations on the most profitable use of direct labour hour in further processing.

Ans: a)

	Rs
Profit A	2,000
Profit B	9,000
Profit C	16,000
By Product	(7,000)
Total Profit	20,000

b) i) Value of Stock when the joint costs are distributed on the basis of output

		Rs
Value of Stock	A	9,600
	B	7,200
	C	4,800
By Product		1,000*

* Limited to NRV

ii) Value of Stock if Joint costs are distributed in the ratio of sales

		Rs
Value of Stock	A	8,752
	B	7,714
	C	6,857
By Product		857

c) Further process should not be carried out for any product since there is a loss of Rs. 1,58,667.

Problem No. 3

A company's plant process 6,00,000 kg. of raw material in a month to produce two products viz. Allex and Ballex. The cost of raw materials is Rs.3.00 per kg. The process costs per month are:

Direct Materials	Rs.90,000
Direct wages	Rs. 1,20,000
Variable overheads	Rs. 1,00,000
Fixed overheads	Rs. 1,00,000

The loss in process is 5% of input and the output ratio of Allex and Ballex which emerge simultaneously is 1:2. The selling prices of the two products at the point of split-off are: Allex Rs.3 per kg. and Ballex Rs.5 per kg.

A proposal is available to process Allex further by mixing it with other purchased materials. The entire current output of the factory can be so processed further to obtain a new product SA. The price per kg. of SA is Rs.3.75 and each kg. of output of SA will require one kg. of input of Allex. The cost of processing of Allex into SA including other materials is Rs.1,85,000 per month.

Alternatively, another proposal available is to introduce a new material for the manufacture of Allex and Ballex. The new raw material will bring down the process loss to 4% and change the output mix of Allex and Ballex to 2:3. The company's capacity to process the new raw material is also 6,00,000 kg. p.m. The cost of new raw material is Rs.2.90 per kg. All other costs will remain the same.

Required:

i) Present a statement showing the monthly profitability based on the existing manufacturing operations.

ii) Evaluate the two proposals independently and present statements showing the respective monthly profitability.

Ans:

i) Profit Allex Rs. 60,000

Ballex Rs. 2,00,000

ii) Proposal One

Profit = Rs. 2,17,500 (2,00,000 + 17,500)x

Proposal Two

Profit = Rs. 2,69,200 (76,914 + 1,92,286)

Proposal Two is to be adopted. Because it gives maximum profit than the other.

STUDY NOTE - 4

Treatment of Uncertainty in Decision Making

This Study Note includes:

- Concept of Risk Management
- Sensitivity Analysis
- Probabilistic Model
- Expected Value
- Decision Tree Analysis

4.1 Risk Management

4.1.1 Introduction

Risk management is a systematic process of identifying and assessing company risks and taking actions to protect a company against them. Some risk managers define risk as the possibility that a future occurrence may cause harm or losses, while noting that risk also may provide possible opportunities. By taking risks, companies sometimes can achieve considerable gains. However, companies need risk management to analyze possible risks in order to balance potential gains against potential losses and avoid expensive mistakes. Risk management is best used as a preventive measure rather than as a reactive measure. Companies benefit most from considering their risks when they are performing well and when markets are growing in order to sustain growth and profitability.

The task of the risk manager is to predict, and enact measures to control or prevent, losses within a company. The risk-management process involves identifying exposures to potential losses, measuring these exposures, and deciding how to protect the company from harm given the nature of the risks and the company's goals and resources. While companies face a host of different risks, some are more important than others. Risk managers determine their importance and ability to be affected while identifying and measuring exposures. For example, the risk of flooding in Arizona would have low priority relative to other risks a company located there might face. Risk managers consider different methods for controlling or preventing risks and then select the best method given the company's goals and resources. After the method is selected and implemented, the method must be monitored to ensure that it produces the intended results.

4.1.2 The Evolution of Risk Management

The field of risk management emerged in the mid-1970s, evolving from the older field of insurance management. The term *Risk Management* was adopted because the new field has a much wider focus than simply insurance management. Risk management includes activities and responsibilities out-side of the general insurance domain, although insurance is an important part of it and insurance agents often serve as risk managers. Insurance management focused on protecting companies from natural disasters and basic kinds of exposures, such as fire, theft, and employee injuries, whereas risk management focuses on these kinds of risks as well as other kinds of costly losses, including those stemming from product liability, employment practices, environmental degradation, accounting compliance, offshore outsourcing, currency fluctuations, and electronic commerce. In the 1980s and 1990s, risk management grew into vital part of company planning and strategy and risk management became integrated with more and more company functions as the field evolved. As the role of risk management has increased to encompass large-scale, organization-wide programs, the field has become known as enterprise risk management.

4.1.3 Types of Risk Managers and Types of Risk

Company managers have three general options when it comes to choosing a risk manager:

1. Insurance agents who provide risk assessment services and insurance advice and solutions to their clients;
2. Salaried employees who manage risk for their company (often chief financial officers or treasurers); and

3. Independent consultants who provide risk-management services for a fee.

   Because risk management has become a significant part of insurance brokering, many insurance agents work for fees instead of for commissions. To choose the best type of risk manager for their companies, managers should consider the company's goals, size, and resources.

   Managers also should be aware of the types of risks they face. Common types of risks include automobile accidents, employee injuries, fire, flood, and tornadoes, although more complicated types such as liability and environmental degradation also exist. Furthermore, companies face a number of risks that stem primarily from the nature of doing business. In *Beyond Value at Risk*, Kevin Dowd sums up these different types of risks companies face by placing them in five general categories:

1. Business risks, or those associated with an organization's particular market or industry;
2. Market risks, or those associated with changes in market conditions, such as fluctuations in prices, interest rates, and exchange rates;
3. Credit risks, or those associated with the potential for not receiving payments owed by debtors;
4. Operational risks, or those associated with internal system failures because of mechanical problems (e.g., machines malfunctioning) or human errors (e.g., poor allocation of resources); and
5. Legal risks, or those associated with the possibility of other parties not meeting their contractual obligations.

In addition, environmental risks constitute a significant and growing area of risk management, since reports indicate the number and intensity of natural disasters are increasing. For example, the periodical *Risk Management* reported that there were about five times as many natural disasters in the 1990s as in the 1960s. The year 2004 was one of the worst in history, with three major hurricanes hitting the state of Florida and a tsunami causing death and devastation in the Pacific Rim. Some observers blame the rising number of natural disasters on global warming, which they believe will cause greater floods, droughts, and storms in the future.

Furthermore, any given risk can lead to a variety of losses in different areas. For example, if a fire occurs, a company could lose its physical property such as buildings, equipment, and materials. In this situation, a company also could lose revenues, in that it could no longer produce goods or provide services. Furthermore, a company could lose human resources in such a disaster. Even if employees are not killed or injured, a company would still suffer losses because employers must cover benefits employees draw when they miss work.

4.1.4 Assessing Risks Associated with Doing Business

One way managers can assess the risks of doing business is by using the risk calculator developed by Robert Simons, a professor at the Harvard Business School. Although the risk calculator is not a precise tool, it does indicate areas where risks and potential losses exist, such as the rate of expansion and the level of internal competition. Using the risk calculator, managers can determine if their company has a safe or dangerous amount of risk. The risk calculator measures three kinds of internal pressures: risk stemming from growth, corporate culture, and information management. Rapid growth, for example, could be a risk and lead to losses, because if a company grows too quickly, it may not have enough time to train new employees adequately. Hence, unchecked growth could lead to lost sales and diminished quality.

Managers can assess the increased risk associated with growth by determining if sales goals are set by top management without input from employees. If a company sets sales goals in this manner, then it has a high level of risk in that the goals may be too difficult for employees to meet. In cases where employees feel extreme pressure in trying to achieve goals, they may take unnecessary risks. Similarly, companies that rely heavily on performance-based pay also tend to have higher levels of risk.

To assess risk arising from corporate culture, managers should determine what percentage of sales comes from new products or services developed by risk-taking employees. If the percentage is high, then the amount of risk is also high, because such a company depends significantly on new products and the related risks. In addition, a corporate culture that allows or encourages employees to work independently to develop new products increases company risk, as does a high rate of new product or service failures.

Finally, managers can determine business risks resulting from information management by determining if they and their subordinates spend a lot of time gathering information that should already be available. Another way of assessing these risks is by managers considering whether they look at performance data frequently and whether they notice if reports are missing or late.

4.1.5 Risk Management Methods

Risk managers rely on a variety of methods to help companies avoid and mitigate risks in an effort to position them for gains. The four primary methods include exposure or risk avoidance, loss prevention, loss reduction, and risk financing. A simple method of risk management is exposure avoidance, which refers to avoiding products, services, or business activities with the potential for losses, such as manufacturing cigarettes. Loss prevention attempts to root out the potential for losses by implementing such things as employee training and safety programs designed to eradicate risks. Loss reduction seeks to minimize the effects of risks through response systems that neutralize the effects of a disaster or mishap.

The final option risk managers have is to finance risks, paying for them either by retaining or transferring their costs. Companies work with risk managers insofar as possible to avoid risk retention. However, if no other method is available to manage a particular risk, a company must be prepared to cover the losses – that is, to retain the losses. The deductible of an insurance policy is an example of a retained loss. Companies also may retain losses by creating special funds to cover any losses.

Risk transferring takes place when a company shares its risk with another party, such as an insurance provider, by getting insurance policies that cover various kinds of risk that can be insured. In fact, insurance constitutes the leading method of risk management. Insurance policies usually cover (a) property risks such as fire and natural disasters, (b) liability risks such as employer's liability and workers' compensation, and (c) transportation risks covering air, land, and sea travel as well as transported goods and transportation liability. Managers of large corporations may decide to manage their risks by acquiring an insurance company to cover part or all of their risks, as many have done. Such insurance companies are called captive insurers.

Risk managers also distinguish between preloss and postloss risk financing. Preloss risk financing includes financing obtained in preparation for potential losses, such as insurance policies. With insurance policies, companies pay premiums before incurring losses. On the other hand, postloss financing refers to obtaining funds after losses are incurred (i.e., when companies obtain financing in response to losses). Obtaining a loan and issuing stocks are methods of postloss financing.

During the implementation phase, company managers work with risk managers to determine the company goals and the best methods for risk management. Generally, companies implement a combination of methods to control and prevent risks effectively, since these methods are not mutually exclusive, but complementary. After risk management methods have been implemented, risk managers must examine the risk management program to ensure that it continues to be adequate and effective.

4.1.6 Emerging areas of Risk Management

In the 1990s, new areas of risk management began to emerge that provide managers with more options to protect their companies against new kinds of exposures. According to the Risk and Insurance Management Society (RIMS), the main trade organization for the risk management profession, among the emerging areas for risk management were operations management, environmental risks, and ethics.

As forecast by RIMS, risk managers of corporations started focusing more on verifying their companies' compliance with federal environmental regulations in the 1990s. According to *Risk Management*, risk managers began to assess environmental risk such as those arising from pollution, waste management, and environmental liability to help make their companies more profitable and competitive. Furthermore, tighter environmental regulations also goaded businesses to have risk managers check their compliance with environmental policies to prevent possible penalties for noncompliance.

Companies also have the option of obtaining new kinds of insurance policies to control risks, which managers and risk managers can take into consideration when determining the best methods for covering potential risks. These nontraditional insurance policies provide coverage of financial risks associated with corporate profits and currency fluctuation. Hence, these policies in effect guarantee a minimum level of profits, even when a company experiences unforeseen losses from circumstances it cannot control (e.g., natural disasters or economic downturns). Moreover, these nontraditional policies ensure profits for companies doing business in international markets, and hence they help prevent losses from fluctuations in a currency's value.

Risk managers can also help alleviate losses resulting from mergers. Stemming from the wave of mergers in the 1990s, risk managers became a more integral part of company merger and acquisition teams. Both parties in these transactions rely on risk management services to determine and control or prevent risks. On the buying side, risk managers examine a selling company's expenditures, loss history, insurance policies, and other areas that indicate a company's potential risks. Risk managers also suggest methods for preventing or controlling the risks they find.

Finally, risk managers have been called upon to help businesses manage the risks associated with increased reliance on the Internet. The importance of online business activities in maintaining relationships with customers and suppliers, communicating with employees, and advertising products and services has offered companies many advantages, but also exposed them to new security risks and liability issues. Business managers need to be aware of the various risks involved in electronic communication and commerce and include Internet security among their risk management activities.

4.1.7 Enterprise Risk Management

As the field of risk management expanded to include managing financial, environmental, and technological risks, the role of risk managers grew to encompass an organization-wide approach known as enterprise risk management (ERM). This approach seeks to implement risk awareness and prevention programs throughout a company, thus creating a corporate culture able to handle the risks associated with a rapidly changing business environment. Practitioners of ERM incorporate risk management into the basic goals and values of the company and support those values with action. They conduct risk analyses, devise specific strategies to reduce risk, develop monitoring systems to warn about potential risks, and perform regular reviews of the program.

In the United States, the Sarbanes-Oxley Act of 2002 provided the impetus for a number of large firms to implement enterprise risk management. Passed in the wake of scandals involving accounting compliance and corporate governance, the act required public companies to enact a host of new financial controls. In addition, it placed new, personal responsibility on boards of directors to certify that they are aware of current and future risks and have effective programs in place to mitigate them. "Fueled by new exchange rules, regulatory initiatives around the globe, and a bevy or reports that link good corporate governance with effective risk management, attention is turning to ERM," Lawrence Richter Quinn noted in *Financial Executive*. "[Some executives believe that it] will save companies from any number of current and future ills while providing significant competitive advantages along the way."

In late 2004 the London-based Treadway Commission's Committee of Sponsoring Organizations (COSO) issued *Enterprise Risk Management-Integrated Framework*, which provided a set of "best practice" standards for companies to use in implementing ERM programs. The COSO framework expanded on the work companies were required to do under Sarbanes-Oxley and provided guidelines for creating an organization-wide focus on risk management. According to Financial Executive, between one-third and one-half of Fortune 500 companies had launched or were considering launching ERM initiatives by the end of 2004.

Definition and Scope

Enterprise risk management deals with risks and opportunities affecting value creation or preservation, defined as follows:

Enterprise risk management is a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives.

The underlying premise of enterprise risk management is that every entity exists to provide value for its stakeholders. All entities face uncertainty, and the challenge for management is to determine how much uncertainty to accept as it strives to grow stakeholder value. Uncertainty presents both risk and opportunity, with the potential to erode or enhance value. Enterprise risk management enables management to effectively deal with uncertainty and associated risk and opportunity, enhancing the capacity to build value.

Value is maximized when management sets strategy and objectives to strike an optimal balance between growth and return goals and related risks, and efficiently and effectively deploys resources in pursuit of the entity's objectives.

Enterprise risk management encompasses:

- ***Aligning risk appetite and strategy*** **–** Management considers the entity's risk appetite in evaluating strategic alternatives, setting related objectives, and developing mechanisms to manage related risks.
- ***Enhancing risk response decisions*** **–** Enterprise risk management provides the rigor to identify and select among alternative risk responses – risk avoidance, reduction, sharing, and acceptance.
- ***Reducing operational surprises and losses*** **–** Entities gain enhanced capability to identify potential events and establish responses, reducing surprises and associated costs or losses.

- ***Identifying and managing multiple and cross-enterprise risks* –** Every enterprise faces a myriad of risks affecting different parts of the organization, and enterprise risk management facilitates effective response to the interrelated impacts, and integrated responses to multiple risks.
- ***Seizing opportunities* –** By considering a full range of potential events, management is positioned to identify and proactively realize opportunities.
- ***Improving deployment of capital* –** Obtaining robust risk information allows management to effectively assess overall capital needs and enhance capital allocation. These capabilities inherent in enterprise risk management help management achieve the entity's performance and profitability targets and prevent loss of resources. Enterprise risk management helps ensure effective reporting and compliance with laws and regulations, and helps avoid damage to the entity's reputation and associated consequences. In sum, enterprise risk management helps an entity get to where it wants to go and avoid pitfalls and surprises along the way.

4.1.8 Business Continuity Planning

Organizations are faced with a variety of threats and vulnerabilities, and these continue to evolve. Business disruptions can include natural disasters such as floods, fires, hurricanes, and power outages. Since 9/11, the threat of man-made disasters such as terrorist attacks has taken on a sense of urgency as well. The increasing density of our population further exacerbates the threats posed by both natural and manmade disasters. Although business continuity planning and disaster recovery planning are now generally recognized as vital, creating and maintaining a sound plan is quite complex.

Business continuity planning addresses the prospect that a disaster might interrupt an organization's business operations. Whether an organization is for-profit, non-profit, or governmental, the need to mitigate disaster risks has become especially salient. Firms should evaluate their degree of exposure to disaster, both externally (e.g., floods, fires, hurricanes) and internally (e.g., HVAC failure, sabotage).

A business impact analysis helps management to understand the criticality of different business functions, recovery time required, and the need for various resources. The question of which corporate functions receive top priority should be addressed. In selecting a strategy to protect the organization, cost-benefit comparisons are made with regard to the effects of doing without various services and functions (e.g., call centers, production locations, proprietary data) at specific points in time, and developing plans for optimum recovery periods for each service and function.

Thus, a business continuity plan includes the procedures and information about resources to help an organization recover from a disruption in its business operations. In the financial markets, major industry players have responded to the 9/11 terrorist attacks by attempting to deal with future risks, especially risks regarding trading operations. But because most networks rely on the open Internet, viruses or other service attacks remain potential threats.

A central office failure brought about by a fire or power outage can also affect trading operations. Redundancy (including back-up sites and additional staff and technologies) is recommended, albeit expensive. An additional risk is that an entire network (such as AT&T) might go down. Jay Pultz, research vice-president at disaster and business continuity consultancy firm Gartner, Inc., is concerned that failures will increase because the companies that provide the networks are collapsing their infrastructure to a single backbone, as opposed to separate backbones for the Internet, phone, data, etc.

Business continuity and disaster recovery planning can demand a great deal of resources. For example, Voca (the United Kingdom direct debits clearing house) spends about 35 percent of its IT budget on these plans. But the alternative may be worse. Losses can mount quickly when firms cannot access data.

According to a study by Gartner, Inc., the average cost of computer-network downtime is $42,000 an hour. Technology-dependent firms such as online brokerages may incur costs of $1 million or more an hour. To ensure seamless service in case of disaster, Voca runs its business from a back-up site for up to five weeks a year. Off-site backups appear to be a favourite method for protecting data for 58 percent of solution providers, according to recent CRN poll data.

The Confederation of British Industry and security firm Qinetiq report that, even after overhauling business continuity plans, 60 percent of British companies are concerned about their preparation for disaster. Almost 70 percent of respondents to Information Week Research's Outlook 2005 survey ranked business continuity planning or disaster preparedness as a high priority. Still, according to analyst David Hill of Mesabi Group, most companies have neglected some operational needs, such as recovering data after a virus attack. Moreover, many business continuity plans are never even tested, and according to Peter Gerr of the Enterprise Strategy Group, one out of every five recovery efforts fails.

But forward-thinking enterprises are recognizing both external and internal signals for the need to formulate contingency plans. Externally, business continuity plans may be driven by regulation, as in the banking industry. Internal risk exposure, however, is a critical driver as well. A case in point is Madrid-based Banco Santander International, the largest commercial bank in South America and the tenth largest bank in the world. If operations stopped and trades or payments failed, the bank could be liable for compensation.

To maintain protection of business-critical customer data at its private banking center in Miami, Banco Santander chose a solution from VERITAS Software Corp. based on its compatibility with the bank's infrastructure. Data could then be replicated between Miami and New York sites over the IP network. During the rash of hurricanes that hit Florida in 2004, every time a major warning was issued and facilities evacuated, primary operations were transferred to New York until the threat passed. The system is viewed as an insurance policy for the bank.

Oddly enough, smaller businesses have been found to lead many midsize businesses in implementing true disaster-recovery solutions. Small businesses often rely on value added resellers (VARs) for their solutions, and larger firms use internal IT departments. Midsize firms, however, are too complex to be relocated quickly, yet lack the internal staff to restore business processes rapidly, increasing opportunities for VARs to offer business continuity services to this market.

4.1.9. Applications to Supply Chain Management

Outsourcing has become a standard practice among many organizations as a way to add flexibility to the supply chain. Often a particular task can be done more efficiently and/or effectively by an outside vendor. The advantage for the focal firm is that it can focus on its core competence, or at least those functions it does well, and outsource other functions so as to gain efficiency. Thus, rather than integrating all functions within the firm boundaries, the trend toward outsourcing and a variety of cooperative relationships continues. Ironically, the gains in efficiency and flexibility may often be outweighed by risks of being dependent on sole suppliers.

In a Bank Technology News article titled "Business Continuity Planning Must Extend to Vendors," John Hoge argues that client-vendor relationships are symbiotic and should lead to greater efficiency and productivity in a variety of industries. In banking, technology vendors are critical for the bank's basic business processes. But if the vendor's systems go down, the bank's systems can go down as well.

The implication is that vendors are increasingly compelled to include business continuity and disaster recovery as key aspects of their activities. Some vendors have adopted business impact analysis to tailor a recovery plan to meet the recovery requirements of specific units. An interesting twist regarding the benefits of "leaner" supply chains is the increased need for contingency plans in case of disruptions.

The "dark side" of supply chain management is discussed in a white paper appearing in a March 2005 issue of *Supply Chain Management Review*. The authors explore the notion of supply continuity planning, which is a comprehensive approach to managing supply risk. They state that by employing their supply continuity planning model, organizations can guard against a major supply disruption that could potentially delay orders and result in loss of customers.

Whereas companies previously relied on inventory buffers (safety stock, lead times, excess capacity) to protect them, today's competitive environment makes these buffers less attractive. A consequence is that today's lean supply chains are increasingly fragile, or more sensitive to shocks and disruptions.

The authors make a strong case for how devastating disruptions can be by citing several events, including a fire at a factory supplying valves to Toyota, resulting in estimated costs of $195 million; an earthquake in Taiwan, hampering the supply of computer chips and computer demand during the holiday season; a lightning strike at a radio-frequency chip plant in Albuquerque, NM, resulting in a fire, production delays, and the eventual withdrawal of Ericsson from mobile phone manufacturing-because the plant was its sole supplier; and the 9/11 terrorist attacks, resulting in loss of life and loss of information databases.

Based on case studies of four organizations that proactively manage inbound supply risk, the authors present a framework describing detailed efforts focused on four major activities: creating system awareness of supply risk, preventing the occurrence of supply disruptions, remediating supply interruptions, and managing knowledge.

Being Prepared

In a 2005 *Canadian Business* article titled "Always Be Prepared," an expert in enterprise risk presents a series of questions that managers should ask about the firm's state of readiness to continue business after a disruption. For example, does the business even have a plan? Is the plan tailor-made or "off the rack?" Are critical functions the basis of the plan? The maintenance of knowledge management, regular testing of the plan, and supplier preparedness are other important issues.

Being prepared for disaster is increasingly essential. The good news for those new to business continuity planning and disaster recovery planning is that information on how to prepare is proliferating. Business continuity and disaster recovery planning software explore the potential impacts of disaster, and underlying risks; constructing a plan; maintenance, testing, and auditing to ensure that the plan remains appropriate to the needs of the organization; and support infrastructure and services.

4.1.10 Succession Planning

Succession planning is a critical part of the human resources planning process. Human resources planning (HRP) is the process of having the right number of employees in the right positions in the organization at the time that they are needed. HRP involves forecasting, or predicting, the organization's needs for labor and supply of labor and then taking steps to move people into positions in which they are needed.

Succession planning is the systematic process of defining future management requirements and identifying candidates who best meet those requirements. Succession planning involves using the supply of labor within the organization for future staffing needs. With succession planning, the skills and abilities of current employees are assessed to see which future positions they may take within the organization when other employees leave their positions. Succession planning is typically used in higher-level organizational positions, such as executive-level positions. For instance, if a company predicts that its Chief Executive Officer will retire in the near future, the organization may begin looking months or even years in advance to determine which current employee might be capable of taking over the position of the CEO.

Succession planning is aimed at promoting individuals within the organization and thus makes use of internal selection. Internal selection, as opposed to hiring employees from outside the organization, has a number of benefits and drawbacks. With internal selection, the organization is aware of current employees' skills and abilities, and therefore is often better able to predict future performance than when hiring from the outside. Because of access to annual performance appraisals and the opinions of the employee's current managers, the company can have a fairly accurate assessment of the employee's work capabilities. Additionally, the organization has trained and socialized the employee for a period of time already, so the employee is likely to be better prepared for a position within the organization than someone who does not have that organizational experience. Finally, internal selection is often motivating to others in the organization—opportunities for advancement may encourage employees to perform at a high level.

Despite its many advantages, internal selection can also have some drawbacks. While the opportunities for advancement may be motivating to employees who believe that they can move up within the organization at a future date, those employees who feel that they have been passed over for promotion or are at a career plateau are likely to become discouraged and may choose to leave the organization. Having an employee who has been trained and socialized by the organization may limit the availability of skills, innovation, or creativity that may be found when new employees are brought in from the outside. Finally, internal selection still leaves a position at a lower level that must be staffed from the outside, which may not reduce recruitment and selection costs.

Many companies organize their management training and development efforts around succession planning. However, not all organizations take a formal approach to it, and instead do so very informally, using the opinions of managers as the basis for promotion, with little consideration of the actual requirements of future positions. Informal succession planning is likely to result in managers who are promoted due to criteria that are unrelated to performance, such as networking within and outside of the organization. Organizations would be better served by promoting managers who were able to successfully engage in human resource management activities and communicate with employees. Poor succession planning, such as just described, can have negative organizational consequences. Research indicates that poor preparation for advancement into managerial positions leaves almost one-third of new executives unable to meet company expectations for job performance. This may have negative repercussions for the newly promoted manager, the other employees, and the company's bottom line.

Steps in Succession Planning

There are several steps in effective succession planning: human resources planning, assessing needs, developing managers, and developing replacement charts and identifying career paths.

Human Resources Planning

Engaging in human resources planning by forecasting the organization's needs for employees at upper levels is the first step in succession planning. Some staffing needs can be anticipated, such as a known upcoming retirement or transfer. However, staffing needs are often less predictable—organizational members may leave for other companies, retire unexpectedly, or even die, resulting in a need to hire from outside or promote from within. The organization should do its best to have staff available to move up in the organization even when unexpected circumstances arise. Thus, accurate and timely forecasting is critical.

Assessing Needs and Developing Replacement Charts

The second major step for succession planning is to define and measure individual qualifications needed for each targeted position. Such qualifications should be based on information from a recent job analysis. Once these qualifications are defined, employees must be evaluated on these qualifications to identify those with a high potential for promotion. This may involve assessing both the abilities and the career interests of employees. If a lower-level manager has excellent abilities but little interest in advancement within the organization, then development efforts aimed at promotion will be a poor investment.

To determine the level of abilities of employees within the organization, many of the same selection tools that are used for assessing external candidates can be used, such as general mental ability tests, personality tests, and assessment centers. However, when selecting internally, the company has an advantage in that it has much more data on internal candidates, such as records of an employee's career progress, experience, past performance, and self-reported interests regarding future career steps.

Developing Managers

The third step of succession planning, which is actually ongoing throughout the process, is the development of the managers who are identified as having promotion potential. In order to prepare these lower-level managers for higher positions, they need to engage in development activities to improve their skills. Some of these activities may include:

- **Job rotation through key executive positions –** By working in different executive positions throughout the organization, the manager gains insight into the overall strategic workings of the company. Additionally, the performance of this manager at the executive level can be assessed before further promotions are awarded.
- **Overseas assignments –** Many multinational companies now include an overseas assignment as a way for managers to both learn more about the company and to test their potential for advancement within the company. Managers who are successful at leading an overseas branch of the company are assumed to be prepared to take an executive position in the home country.
- **Education –** Formal courses may improve managers' abilities to understand the financial and operational aspects of business management. Many companies will pay for managers to pursue degrees such as Masters in Business Administration (MBAs), which are expected to provide managers with knowledge that they could not otherwise gain from the company's own training and development programs.
- **Performance-related training and development for current and future roles –** Specific training and development provided by the company may be required for managers to excel in their current positions and to give them skills that they need in higher-level positions.

Developing Replacement Charts and Identifying Career Paths.

In the final step of succession planning, the organization identifies a career path for each high-potential candidate—those who have the interest and ability to move upward in the organization. A career path is the typical set of positions that an employee might hold in the course of his or her career. In succession planning, it is a road map of positions and experiences designed to prepare the individual for an upper-level management position. Along with career paths, the organization should develop replacement charts, which indicate the availability of candidates and their readiness to step into the various management positions. These charts are depicted as organizational charts in which possible candidates to replacement others are listed in rank order for each management position. These rank orders are based on the candidates' potential scores, which are derived on the basis of their past performance, experience, and other relevant qualifications. The charts indicate who is currently ready for promotion and who needs further grooming to be prepared for an upper-level position.

Problems with Succession Planning

Succession planning is typically useful to the organization in its human resource planning, and when done properly, can be beneficial to organizational performance. However, there are potential problems associated with the use of succession planning: the crowned prince syndrome, the talent drain, and difficulties associated with managing large amounts of human resources information.

Crowned prince syndrome

The first potential problem in succession planning is the crowned prince syndrome, which occurs when upper management only considers for advancement, those employees who have become visible to them. In other words, rather than looking at a wider array of individual employees and their capabilities, upper management focuses only on one person—the "crowned prince." This person is often one who has been involved in high-profile projects, has a powerful and prominent mentor, or has networked well with organizational leaders. There are often employees throughout the organization who are capable of and interested in promotion who may be overlooked because of the more visible and obvious "crowned prince," who is likely to be promoted even if these other employees are available. Not only are performance problems a potential outcome of this syndrome, but also the motivation of current employees may suffer if they feel that their high performance has been overlooked. This may result in turnover of high quality employees who have been overlooked for promotion.

Talent drain

The talent drain is the second potential problem that may occur in succession planning. Because upper management must identify only a small group of managers to receive training and development for promotion, those managers who are not assigned to development activities may feel overlooked and therefore leave the organization. This turnover may reduce the number of talented managers that the organization has at the lower and middle levels of the hierarchy. Exacerbating this problem is that these talented managers may work for a competing firm or start their own business, thus creating increased competition for their former company.

Managing Human Resource Information

The final problem that can occur in succession planning is the concern with managing large amounts of human resources information. Because succession planning requires retention of a great deal of information, it is typically best to store and manage it on a computer. Attempting to maintain such records by hand may prove daunting. Even on the computer, identifying and evaluating many years' worth of information about employees' performance and experiences may be difficult. Add to that the challenges of comparing distinct records of performance to judge promotion capability, and this information overload is likely to increase the difficulty of successful succession planning.

Succession planning, which is identifying and preparing managers for future promotions within the organization is one element of successful human resource planning. Unfortunately, many organizations do a poor job of succession planning. Even when it is done properly, succession planning has some potential problems that can harm employee motivation and the company's bottom line. Effective succession planning, however, is likely to improve overall firm performance and to reward and motivate employees within the organization.

Further Reading:

Braunstein, Adam. "Strategies for Risk Management." CIO (24 February 2005). Available from *http://www2.cio.com/analyst/report2268.html.*

D'Arcangelo, James R. "Beyond Sarbanes-Oxley: Section 404 Exercises Can Provide the Starting Point for a Comprehensive ERM Program." *Internal Auditor* (October 2004).

Dowd, Kevin. Beyond Value at Risk. New York: Wiley: 1998.

Lam, James. *Enterprise Risk Management: From Incentives to Controls*. Hoboken, NJ: John Wiley, 2003.

Mills, Evan. "The Coming Storm: Global Warming and Risk Management." *Risk Management* (May 1998): 20.

Quinn, Lawrence Richter. "ERM: Embracing a Total Risk Model." Financial Executive (January-February 2005).

Risk and Insurance Management Society, Inc. "(RIMS) Website." Available from http://.

Simons, Robert. "How Risky Is Your Company?" Harvard Business Review (May 1999): 85.

Telegro, Dean Jeffery. "A Growing Role: Environmental Risk Management in 1998." Risk Management (March 1998): 19.

White, Larry. "Management Accountants and Enterprise Risk Management." *Strategic Finance* (November 2004).

Barnes, James C. *A Guide to Business Continuity Planning*. New York, NY: Wiley, 2001.

"The Business Continuity Planning & Disaster Recovery Planning Directory." Disaster Recovery World. Available from *http://www.disasterrecoveryworld.com*.

Garvey, Martin J. "From Good to Great (Maybe)." *Information-Week*, 3 January 2005, 45.

Gerson, Vicki. "Better Safe Than Sorry." *Bank Systems & Technology* 42, no. 1 (2005): 41.

Hanna, Greg. "How to Take a Computer Disaster in Stride."*Strategic Finance* 86, no. 7 (2005): 48–52.

Hofmann, Mark A. "Y2K Spurred Continuity Plan That Was Put to Test by 9/11."*Business Insurance* 39, no. 16 (2005): 71.

Hoge, John. "Business Continuity Planning Must Extend to Vendors."*Bank Technology News* 18, no. 2 (2005): 47.

Hood, Sarah B. "Always Be Prepared." Canadian Business 78, no. 6 (2005): 61–63.

Huber, Nick. "Business Continuity Plans Eat 35% of Clearing House's Core IT Spend." *Computer Weekly*, 8 February 2005, 5.

Roberts, John, and Frank J. Ohlhorst. "Disaster Planning Promises Big Channel Profits." *CRN* 1130 (2005): 22.

Sisk, Michael. "Business Continuity: Still Not Entirely Ready For Disaster. "*Bank Technology News* 17, no. 12 (2004): 41.

Zsidisin, George, A., Gary L. Ragatz, and Steven A. Melnyk. "The Dark Side of Supply Chain Management." *Supply Chain Management Review* 9, no. 2 (March 2005): 46–52.

Dessler, Gary. *Human Resource Management*. 8th edition. Upper Saddle River, NJ: Prentice Hall, 2000.

Goldstein, Irwin L, and J. Kevin Ford. *Training in Organizations*: *Needs Assessment, Evaluation, and Development*. 4th edition. Belmont, CA: Wadsworth/Thomson Learning, 2002.

Gomez-Mejia, Luis R., David B. Balkin, and Robert L. Cardy. *Managing Human Resources*. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2004.

Noe, Raymond A. *Employee Training and Development*. Boston, MA: Irwin/McGraw-Hill, 1999.

Noe, Raymond A., John R. Hollenbeck, Barry Gerhart, and Patrick M. Wright. *Human Resource Management*: *Gaining a Competitive Advantage*. 5th edition. Boston, MA: McGraw-Hill/Irwin, 2006.

Source:

http://www.coso.org/Publications/ERM/COSO_ERM_ExecutiveSummary.pdf

http://www.referenceforbusiness.com/management/Pr-Sa/Risk-Management.html

http://www.referenceforbusiness.com/management/Bun-Comp/Business-Continuity-Planning.html

http://www.referenceforbusiness.com/management/Str-Ti/Succession-Planning.html

4.2 Sensitivity Analysis

4.2.1 Investment Appraisal

An investment proposal is evaluated by calculating the cash flow during the life of the project working out the I.R.R. and checking whether it is above the company's criterion rate. The cash flow is subject to assumptions regarding

Sale Price

Sales Volume

Raw Material Cost

Power Cost

Other indirect factory cost

Selling distribution and administration costs

All quantitative and financial figures are best estimates made with the experience of the executives and study of macro-economic and industry-specific factors. In actual practice while executing the project all factors are subject to variation.

Hence a prudent management would also like to ascertain the impact of changes in the final profitability.

One practical method often adopted is to make three estimates under the most optimistic, most pessimistic and normal scenarios. The project is subjected to see whether it can withstand adverse circumstances such as steep, drop in sales price, significant increase in raw material cost etc.

The limitation of this approach is that it relies heavily on the management's view of optimism or pessimism and is thus subjective and intuitive not amenable to objective validation.

4.2.2 Sensitivity Analysis

A more objective method is to ascertain the impact on final profitability by taking specific changes in each critical factor. Thus if the company is to operate in a highly competitive market, with many rivals, sales volume and price will be critical imports, and hence one would like to assess how sensitive the project is to changes in sales volume and price. A calculation may be done assuming 10% drop in selling price and visualizing the final impact.

In material intensive industry, fluctuation in raw material costs or its free availability may be key factors.

In the S.A. method one factor is taken at a time keeping all others constant, to ascertain the outcome in case of variation in the input factor. The question to be posed is does a small change in input factor produce a disproportionately large change in the final output.

4.2.3 Case Example

The following case example illustrates some of the significant aspects of the application of sensitivity analysis applied to a capital investment decision. The table below shows the discounted cash flow rate of return for manufacturing project based on original estimates or base-case assumptions. The effects of 10 percent changes in various estimates used to compute the discounted cash flow rate of return are also shown. It can be seen that 10 percent errors in certain estimates (sales prices and raw materials costs, for example) are much more significant that errors in other estimates in terms of their effect on the discounted cash flow rate of return.

Sensitivity Analysis of a Manufacturing project

			Discounted Cash Flow Rates of Project	
Likely maximum Error in Given Estimate	*Base-Case*	*Base-Case Revised*	*Increase (Decrease)*	*Percentage Change*
10% decrease in estimated sales prices	12.0%	4.7%	(7.3) %	60.8%
10% decrease in estimated sales volume	12.0%	10.1%	(1.9) %	15.8%
10% increase in estimated raw material cost	12.0%	7.4%	(4.6) %	38.3%
10% increase in estimated processing cost	12.0%	11.6%	(0.4) %	3.3%
10% increase in estimated overhead / maintenance cost	12.0%	11.4%	(0.6) %	5.0%
10% increase in capital investment	12.0%	11.2%	(0.8) %	6.7%

Let us assume further that the management of the company in question has established a cutoff rate of return of 8 percent for all manufacturing projects. The base-case discounted cash flow rate of return for this proposal is 12 percent, well above the cutoff rate. If the base-case estimates are used to compute the discounted cash flow rate of return, the project will probably be accepted.

However, a 10 percent decrease in sales prices or a 10 percent increase in raw material cost will cause the discounted cash flow rate of return to decline below the cutoff rate of 8 percent. Therefore, an investment decision based on the discounted cash flow rate of return in this case is sufficiently sensitive to errors in estimates of sales prices and raw materials costs to justify further investigation of the accuracy of such estimates before accepting the proposal in question. Errors of 10 percent in the remaining four estimates do not cause the discounted cash flow rate of return to decline to or below the cutoff point. Therefore, further investigation of the accuracy of these estimates is not required.

If there are no formal cutoff points in effects, the percentage changes that occur in the discounted cash flow rate of return when various estimates are altered by a fixed percentage can be used as a gauge of the significance of such errors. In the case cited, a 10 percent decrease in estimated sales prices causes a 60.8 percent decrease in the discounted cash flow rate of return to decline 38.3 percent. A 10 percent decrease in sales volume causes the discounted cash flow rate of return to decline by 15.8 percent, Errors of 10 percent in processing cost, overhead/maintenance cost, and capital investment cause the discounted cash flow rate to decline by 7 percent or less.

These results indicate that a decision to invest in this project (on the basis of the discounted cash flow rate of return) is very sensitive to errors in estimates of sales prices and of raw materials costs and moderately sensitive to errors in estimates of processing cost, overhead / maintenance costs, and capital investment. Assuming that management cannot investigate the accuracy of all estimates more thoroughly, it would seem advisable to concentrate on the most significant estimates (i.e., sales prices, raw material costs, and possibly sales volume).

Some would argue that much of the same information as that shown here can be obtained using conventional breakeven analysis. However, the use of a discounted measure of return within the sensitivity analysis framework offers several important advantages. First, it permits cash flows to be related to invested capital; this cannot be done easily with breakeven analysis, and the productivity of capital may be impossible to portray in a meaningful manner. Second, it gives consideration to the time value of money while breakeven analysis does not. Finally, breakeven analysis is based on the assumption that the variables being considered are linearly related. In actual practice this may not be true. The sensitivity analysis approach does not require a strictly linear relationship among the variables being considered.

4.2.4 Limitation

There are some problems associated with sensitivity analysis in a business context.

a) Variables are often interdependent, which makes examining them each individually unrealistic e.g. changing one factor such as sales volume, will most likely affect other factors such as selling price.

b) often the assumption upon which the analysis is based are made using past data/experience which may not hold in the future.

c) Assigning a maximum and minimum or optimistic and pessimistic value is open to subjective interpretation and risk preferences of the decision maker. For instance one person's optimistic forecast may be more conservative than that of another person performing a different part of the analysis. This sort of subjectivity can adversely affect the accuracy and overall objectivity of the analysis.

d) S.A. is neither a risk-measuring nor a risk reducing technique. It does not produce any clearer decision rule.

4.2.5 Advantages

a) The S.A. method gives greater visibility to the weak spots in an investment.

b) The information will help management to more critically investigate such factors to validate the assumptions. It does forewarn the actions to be taken to mitigate or eliminate the drawbacks in the investment proposal.

c) Thus S.A. aids management in proper decision making.

4.3 Probabilistic Models

4.3.1. Introduction

Management Accountants have to look ahead to formulate business plans. This is largely based on their 'gut' or intuitive judgement. Through the use of probability, they can make explicit their judgements, which will facilitate better decision making.

4.3.2. One way of doing this is to make a three-way forecast, pessimistic, optimistic and most likely. Another way is to say that there is 50% chance that sales will be 1,00,000 units, 30% chance that it will be 80,000 and 20% chance that it will touch 1,10,000 units. Using the theory of probability it is easy to arrive at a better estimate of what the target sales should be. This is illustrated with the help of a problem.

4.3.3. The Profit Budget of XYZ Company is given below.

Profit Budget for year ending 31st March XXXX

Sales 1,00,000 units @ Rs.10/-

Sales 1,00,000 units @ Rs.10/-		Rs. 10,00,000.00
Variable costs: Manufacturing Marketing	 Rs.5/- per unit) 5,00,000 Rs.0.50 per unit 50,000	 5,50,000.00
Contribution:		4,50,000.00
Fixed costs Manufacturing Marketing Administrative	 2,00,000 50,000 1,00,000	 3,50,000.00
Profit Before Tax		1,00,000.00
Tax (assumed at 50%)		50,000.00
Profit after Tax		50,000.00

In the table below, a three-way forecast is given.

PROFIT BUDGET

Description	Pessimistic Rs.	Most likely Rs.	Optimistic Rs.
Sales	8,00,000	10,00,000	11,00,000.00
Variable Costs:			
Manufacturing	4,08,000	5,00,000	5,28,000.00
Marketing	40,000	50,000	55,000.00
Contribution	3,52,000	4,50,000	5,17,000.00
Fixed Costs:			
Manufacturing	2,00,000	2,00,000	2,00,000.00
Marketing	50,000	50,000	50,000.00
Administration	1,00,000	1,00,000	1,00,000.00
Profit Before Tax	2,000	1,00,000	1,67,000.00
Tax (assumed 50%)	1,000	50,000	83,500.00
Profit after Tax	1,000	50,000	83,500.00

Note: Manufacturing variable cost is

Rs.5.10 per unit at volume of 80,000 units

Rs.5.00 per unit at volume of 1,00,000 units

Rs.4.80 per unit at volume of 1,10,000 units

4.3.4. The marketing manager has given the sales forecast as follows.

Probability 0.2 - 80,000 units

Probability 0.5 - 1,00,000 units

Probability 0.2 - 1,10,000 units

The production manager has indicated the variable manufacturing cost to be as follows:

Probability 0.2 - Rs.5.10 per unit

Probability 0.6 - Rs.5.00 per units

Probability 0.2 - Rs.4.80 per units

The Management Accountant is to work out the profit Budget taking the above factors into account. All other costs are as given earlier. The Probabilistic Profit Budget is shown below.

PROBABILISTIC BUDGET

Volume	Variable Cost per unit	P.A.T.	Joint probability (J.P.)	P.A.T. X J.P.
80,000				
P = 0.3	5.10 (P=0.2)	1000	0.06	60
	5.00 (P=0.6)	5000	0.18	900
	4.80 (P=0.2)	13000	0.06	780
1,00,000				
P = 0.5	5.10 (P=0.2)	45,000	0.10	4500
	5.00 (P=0.6)	50,000	0.30	1500
	4.80 (P=0.2)	60,000	0.10	6000
1,10,000				
P = 0.2	5.10 (P=0.2)	67,000	0.04	2680
	5.00 (P=0.6)	72,500	0.12	8700
	4.80 (P=0.2)	83,500	0.04	3340
1.00			1.00	28460

Note : 1 Joint Probabilities are calculated by multiplying the probabilities on the path moving toward each outcome.

2. As there are 3 estimates of volume and 3 estimates of variable cost we get 9 profit combinations, with Joint Probabilities.

Thus it can be observed that a realistic profit estimate will be Rs.28,460/- and not Rs.50,000/-

4.4 Expected Value

4.4.1. Decisions are classified as those made under certainty and those made under uncertainty. Certainty exists when there is absolutely no doubt about which event will occur. Hence there is a single outcome for each possible action. When an event is certain, the probability of the event is 1.0.

4.4.2. Decisions under uncertainty are not always obvious. There are often numerous possible actions, each of which may offer certain outcomes. The distinction among various degrees of uncertainty centers on how probabilities are assigned. The probabilities may be assigned with a high degree of confidence. That is, the decision-maker may know the probability of occurrence of each of the events such as the probability of drawing a particular card from a well-shuffled deck is 1/52. In a business, the probability of defective units may be assigned with a great degree of confidence based on production experience with thousands of units.

4.4.3. If the decision-maker has no basis in past experience or in mathematical proofs for assigning probabilities of occurrence of various events, he may resort to subjective assignment of probabilities. For example, the probability of the success or failure of a new product may have to be assessed without the help of any related experience. The assignment is subjective because no two individuals assessing a situation will necessarily assign the same probabilities. Executives may be virtually certain about the range of possible events or outcomes, but they may differ about the likelihood of various probabilities within that range, depending upon their personal risk profile.

4.4.4. The concept of uncertainty can be illustrated by considering two investment proposals on new projects. The manager believes that the following discrete probability distribution describes the relative likelihood of cash flows for the one year, which is the life of the project.

Proposal A		**Proposal B**	
Probability	**Cash Flow Rs.**	**Probability**	**Cash Flow Rs.**
0.10	3000	0.10	2000
0.20	3500	0.25	3000
0.40	4000	0.30	4000
0.20	4500	0.25	5000
0.10	5000	0.10	6000

The expected value for each probability distribution is calculated as under

A = (0.10 X 3000) + (0.20 X 3500) + (0.40 X 4000) + (0.20 X 4500) + (0.10 X 5000) = Rs.4000.00

B = (0.10 X 2000) + (0.25 X 3000) + (0.30 X 4000) + (0.25 X 5000) + (0.10 X 6000) = Rs.4000.00

It is observed that the expected value is same for both the proposals. However if one of them is higher, that will be the choice.

4.4.5. The equal expected values in the two proposals, leaves the decision-maker in a dilemma. To solve this, we calculate the standard derivation (S.D.), which will throw light on the relative riskiness of the two proposals. The S.D. is the square root of the mean of the squared deviations from the expected value.

(Sigma) $\sigma = \sqrt{\,}^{n}\Sigma_{x}$=1 (x-ev)2 X Px

or A σ = {0.1(3000-4000)2 + 0.20 (3500-4000)2 + 0.40 (4000-4000)2 + 0.20 (4500-4000)2 + 0.10 (5000 – 4000)2 } = (3,00,000)1/2 = Rs.548.00

For B σ = {0.1 (2000-4000) + 0.25 (3000-4000) + 0.30 (4000-4000) + 0.25 (5000-6000) + 0.1 (6000 – 4000)} = (1,3,00,000)1/2 = Rs.1140.00

Since S.D. for A is Rs.548/- and for B it is Rs.1140/-, B is the riskier of the two proposals.

4.5 Coefficient of Variation (CV)

A relative measure of dispersión is the coefficient of variation which is the Standard deviation divided by expected value. The

CV for A = 548/4000 = 0.14

CV for B = 1140/4000 = 0.29.

Thus B has a greater degree of risk

4.5.1 By explicitly recognising uncertainity and by using probability calculations, the Management Accountant will portray the underlying phenomena, in a more realistic manner, instead of portraying the data as if they came from a world of certainty.

Source: Charles T. Horngren – Cost Accounting

4.6 Decision Tree Analysis

4.6.1 Decision Trees are excellent tools for helping you to choose between several courses of action. They provide a highly effective structure within which you can lay out options and investigate the possible outcomes of choosing those options. They also help you to form a balanced picture of the risks and rewards associated with each possible course of action.

4.6.2 How to use tool

You start a Decision Tree with a decision that you need to make. Draw a small square to represent this towards the left of a large piece of paper.

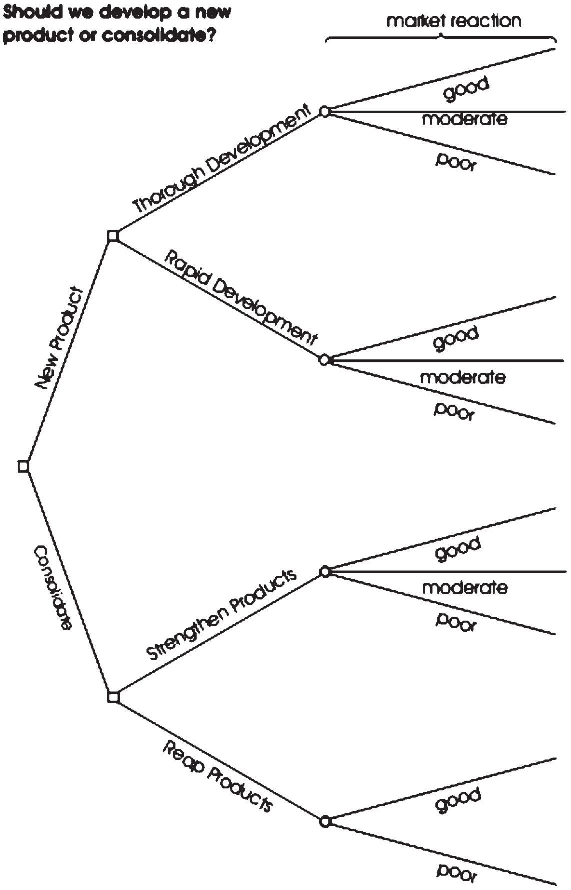
From this box draw out lines towards the right for each possible solution, and write that solution along the line. Keep the lines apart as far as possible so that you can expand your thoughts.

At the end of each line, consider the results. If the result of taking that decision is uncertain, draw a small circle. If the result is another decision that you need to make, draw another square. Squares represent decisions, and circles represent uncertain outcomes. Write the decision or factor above the square or circle. If you have completed the solution at the end of the line, just leave it blank.

Starting from the new decision squares on your diagram, draw out lines representing the options that you could select. From the circles draw lines representing possible outcomes. Again make a brief note on the line saying what it means. Keep on doing this until you have drawn out as many of the possible outcomes and decisions as you can see leading on from the original decisions.

An example of the sort of thing you will end up with is shown in Figure 1:

Figure 1
Example Decision Tree: Should we develop a new product or consolidate?



Once you have done this, review your tree diagram. Challenge each square and circle to see if there are any solutions or outcomes you have not considered. If there are, draw them in. If necessary, redraft your tree if parts of it are too congested or untidy. You should now have a good understanding of the range of possible outcomes of your decisions.

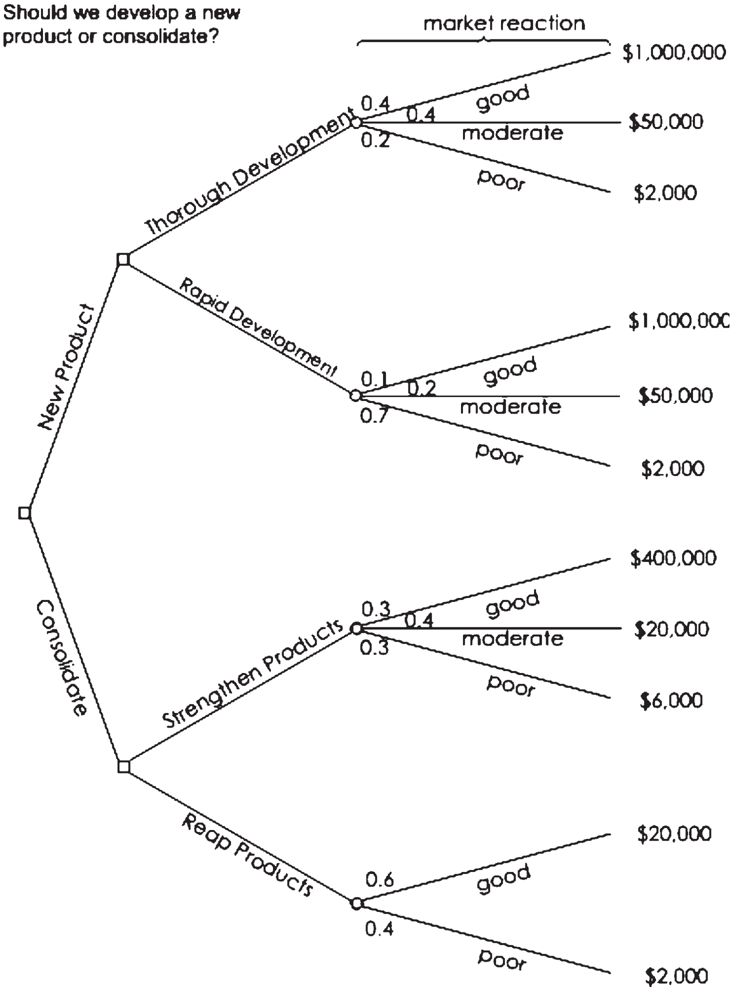
4.6.3 Evaluating Your Decision Tree

Now you are ready to evaluate the decision tree. This is where you can work out which option has the greatest worth to you. Start by assigning a cash value or score to each possible outcome. Estimate how much you think it would be worth to you if that outcome came about.

Next look at each circle (representing an uncertainty point) and estimate the probability of each outcome. If you use percentages, the total must come to 100% at each circle. If you use fractions, these must add up to 1. If you have data on past events you may be able to make rigorous estimates of the probabilities. Otherwise write down your best guess.

This will give you a tree like the one shown in Figure 2:

Figure 2
Example Decision Tree: Should we develop a new product or consolidate?



4.6.4 Calculating Tree Values

Once you have worked out the value of the outcomes, and have assessed the probability of the outcomes of uncertainty, it is time to start calculating the values that will help you make your decision.

Start on the right hand side of the decision tree, and work back towards the left. As you complete a set of calculations on a node (decision square or uncertainty circle), all you need to do is to record the result. You can ignore all the calculations that lead to that result from then on.

Calculating The Value of Uncertain Outcome Nodes

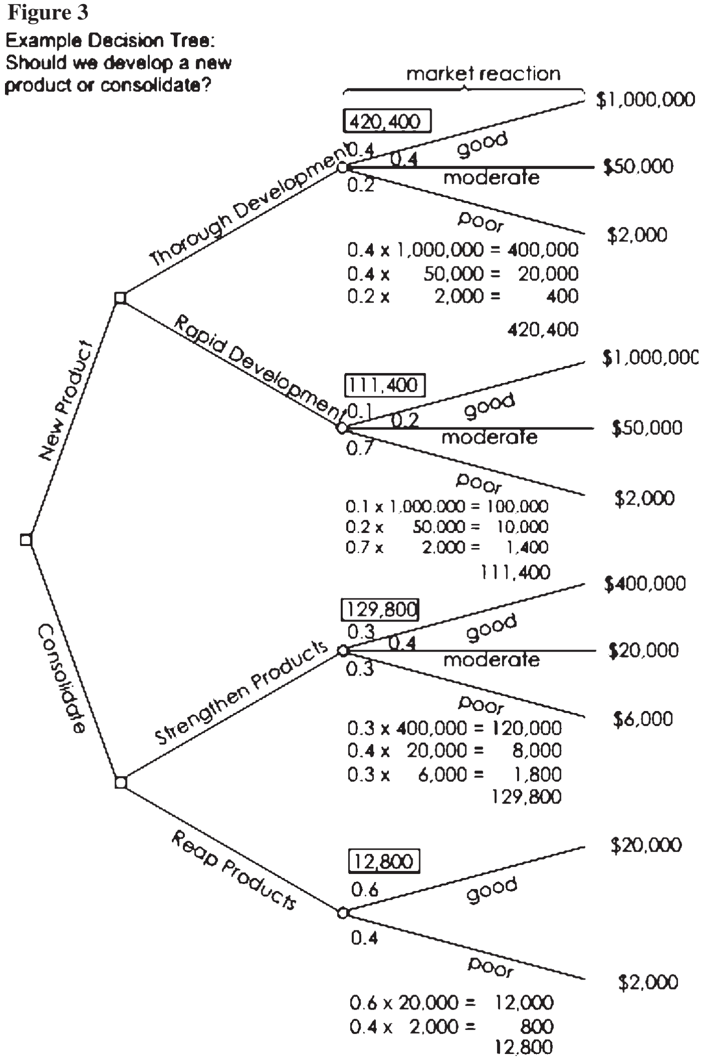
Where you are calculating the value of uncertain outcomes (circles on the diagram), do this by multiplying the value of the outcomes by their probability. The total for that node of the tree is the total of these values.

In the example in Figure 2, the value for 'new product, thorough development' is:

0.4 (probability good outcome) x $1,000,000 (value) =	$400,000
0.4 (probability moderate outcome) x £25,000 (value) =	$20,000
0.2 (probability poor outcome) x £1,000 (value) =	$400
+	**$420,400**

Figure 3 shows the calculation of uncertain outcome nodes:

Figure 3



Note that the values calculated for each node are shown in the boxes.

Calculating The Value of Decision Nodes

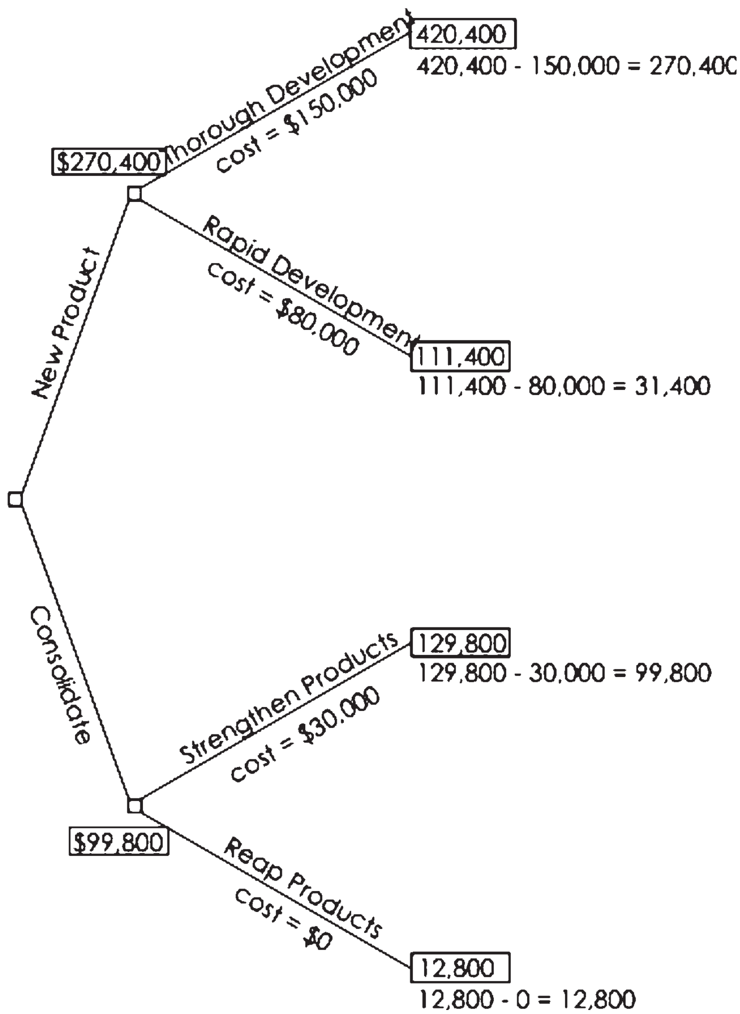
When you are evaluating a decision node, write down the cost of each option along each decision line. Then subtract the cost from the outcome value that you have already calculated. This will give you a value that represents the benefit of that decision.

Note that amounts already spent do not count for this analysis - these are 'sunk costs' and (despite emotional counter-arguments) should not be factored into the decision.

When you have calculated these decision benefits, choose the option that has the largest benefit, and take that as the decision made. This is the value of that decision node.

Figure 4 shows this calculation of decision nodes in our example:

Figure 4:
Example Decision Tree:
Should we develop a new product or consolidate?



In this example, the benefit we previously calculated for 'new product, thorough development' was $420,400. We estimate the future cost of this approach as $150,000. This gives a net benefit of $270,400.

The net benefit of 'new product, rapid development' was $31,400. On this branch we therefore choose the most valuable option, 'new product, thorough development', and allocate this value to the decision node.

Result

By applying this technique we can see that the best option is to develop a new product. It is worth much more to us to take our time and get the product right, than to rush the product to market. It is better just to improve our existing products than to botch a new product, even though it costs us less.

4.6.5 Key points

Decision trees provide an effective method of Decision Making because they:

- Clearly lay out the problem in a graphic visual manner, so that all options can be challenged.
- Allow us to analyze fully the possible consequences of a decision.
- Provide a framework to quantify the values of outcomes and the probabilities of achieving them.
- Help us to make the best decisions on the basis of existing information and best guesses.
- Demerit: The decision tree can become more complicated by the inclusion of more and more alternatives. It is complicated even further if the alternatives are interdependent.

As with all Decision Making methods, decision tree analysis should be used in conjunction with common sense - decision trees are just one important part of your Decision Making tool kit.

Source: www.mindtools.com

4.7 Mathematical/Statistical Applications to Managerial Problems

Illustration No. 1 A dealer of perishable product earns a Profit of Rs. 3 per kg. if he can sell within two days, but incurs a loss of Rs.2 per kg. if fails to do so. The estimated demand for the product and the relative probabilities are as given below:

Estimated Demand	Probability
0 kg	5%
1 kg	20%
2 Kg	40%
3 kg	25%
4 kg	10%

In order to maximize his profit, what should be the quantity of stock that he should hold?

Solution:

Statement showing expected profit at different levels of stock:

Stock level	Expected profit			Expected loss			Net expected profit/(loss)
	Profit	P	Exp profit	Loss	P	Exp loss	
0	--	--	---	--	--	--	----
1	3	0.95	2.85	2	0.05	0.1	2.75
				4	0.05	0.2	
2	6	0.75	4.5	2	0.2	0.4	3.9
						0.6	
						0.3	
				6	0.05	0.8	
3	9	0.35	3.15	4	0.2	0.8	1.25
				2	0.4	1.9	
				8	0.05	0.4	
				6	0.2	1.2	
				4	0.4	1.6	
4	12	0.1	1.2	4	0.25	0.5	(2.5)
				2		3.7	

Expected level of stock to hold is 2 units because expected profit is more.

Illustration No. 2

TTD Ltd. is now considering the purchase of a new machine for Rs.350. The Directors feel quite confident that they can sell the goods produced by the machine so as to yield a yearly cash surplus of Rs.100. There is, however, some uncertainty as to the machine's working life. A recently published Trade Association survey shows that members of the association have among them owned 250 of these machines and have found the lives of the machine to vary as follows:

Number of years of machine life	Numbers of machines having given life
3	20
4	50
5	100
6	70
7	10
	Σ=250

Assuming a discount rate of 10%, the net present value for each different machine life is as follows :

Machine life	Net Present Value
3	(101)
4	(33)
5	29
6	86
7	137

As a Management Accountant, You are asked to advise whether the company should purchase a new machine or not.

Solution:

Life of machine	NPV	Probability	Expected NPV
3	(101)	0.08	(8.08)
4	(33)	0.2	(6.6)
5	29	0.4	11.6
5	86	0.28	24.08
7	137	0.04	5.48
			26.48

As there is the expected NPV of TTD ltd should go ahead with purchase of new machine.

Illustration No. 3

Dry Twigs and Fresh Blossoms Ltd. is always discarding old lines and introducing new lines of products and is at present considering three alternative promotional plans for ushering in new products. Various combinations of prices, development expenditures and promotional outlays are involved in these plans. High, medium and low forecasts of revenues under each plan have been formulated; and their respective probabilities of occurrence have been estimated. These budgeted revenues and probabilities along with other relevant data are summarised as under:

			Rs. in lakhs
	Plan I	**Plan II**	**Plan III**
Budgeted Revenue with probability			
High	30(.3)	24(.2)	50(.2)
Medium	20(.3)	20(.7)	25(.5)
Low	5(.4)	15(.1)	0(.3)
Variable cost as % of Revenue	60%	75%	70%
Initial Investment	25	20	24
Life in years	8	8	8

The company's Cost of Capital is 12%; the income tax rate is 40%. Investments in promotional programmes will be amortised by the straight-line method. The company will have net taxable income in each year, regardless of the success or failure of the new products. The present value of an annuity of Rs. 1/- at 12% for 8 years is 4.9676.

a) Substantiating with figures makes a detailed analysis and find out which of the promotional plans is expected to be the most profitable.

b) In the event the worst happened, which of the plans would result in the maximising profit.

Solution:

(a) Statement showing Present Values & Profitability Index:

	Plan I	Plan II	Plan III
Expected probability	17.000	20.300	22.50
Contribution (PBT @40%)	6.800	5.075	6.75
(-)tax@40%	2.720	2.030	2.70
PAT@60%	4.080	3.045	4.05
(+)tax savings(25/8)x0.4	1.250	1.000	1.20
Total inflows	5.330	4.045	5.24
Present value of inflows(4.9676)	26.477	20.094	26.08
(-)outlays	25.000	20.000	24.00
NPV	1.477	0.094	2.08
Profitability Index (inflows/outflows)	1.039	1.005	1.087

Plan III is better one.

(b) If worst happens:

	Plan I	Plan II	Plan III
Sales	500000	1500000	----
Contribution	200000	375000	----
PAT	120000	225000	----
(+)Tax Advantage	125000	100000	120000
Inflows	245000	325000	120000
Present value of inflow(4.9676)	1217062	1614470	596112
(-) outlays	2500000	2000000	2400000
(NPV)	1282938	385530	1804000

If worst happens plan I is better.

Illustration No. 4

(a) A company has estimate the following demand level of its product :

Sales Volume units	Probability
10,000	0.10
12,000	0.15
14,000	0.25
16,000	0.30
18,000	0.20

It has assumed that the sales price will be Rs.6 per unit. Marginal cost Rs.3.50 per unit and fixed cost Rs.34,000

What is the probability that

(i) The company will be break-even in the period?

(ii) The company will make a profit of at least Rs.10,000.

(b) Frusted Ltd., observes that its sales for the past few years and its profits have been around the following figures:

Sales	Rs.15,00,000
Marginal cost	5,00,000
Contribution	10,00,000
Fixed cost	8,00,000
Profit	2,00,000

In preparing the budget for the next year there is uncertainty about several important points :

(i) It has submitted offer for two contracts, each to an overseas customer;

	Sales Value
Contract A	Rs.8,00,000
Contract B	3,00,000

For each of these orders, variable costs (including selling and shipping costs) would be 40% of sales value. Total fixed costs would be unaffected by the order. The company hopes to win both orders but thinks it more likely that it will win Contract A but not Contract N.

* Expected sales x contribution per unit.

(ii) A new product is due to be introduced next year. Expected sales are Rs.30,000 per month with variable costs 50% of sales and fixed costs of Rs.5,000 per month. The most likely date for introduction of the new product is middle of next year but could be introduced at the end of fourth month or as late at the end of nine month.

(iii) Although it is expected on balance that sale price and costs will not go up there is a reasonable possibility that variable costs on the current product range will go up by 10%.

Prepare a pessimistic and an optimistic budget of the company for the next year.

Solution:

(a)

i. Break even point = 34000/2.5 = 13600

Probability is 0.75 for break even

ii. Required sales to earn desired profit = (10000 + 34000)/2.5 = 17600

Probability is 0.2 to make a profit of Rs.10000/-

(b) Statement showing computation of expected profit at both situations:

	Pessimistic	Optimistic
I. Sales	1500	1500
(-)Variable Cost	(550)	(500)
Contribution	950	1000
II. Contract:		
Sales	-	800
(-)Variable Cost	-	(320)
Contribution	-	480
III. New product:	(3 months)	(8 months)
Sales	90	240
(-) Variable Cost	(45)	(120)
Total contribution	995	1600
Fixed cost	815	840
Profit	180	760

Illustration No. 5

DB Ltd. operates a conventional stock control system based on re-order levels and Economic Ordering Quantities. The various control levels were set originally based on estimates which did not allow for any uncertainty and this has caused difficulties because, in practice, lead times, demands and other factors do vary.

As part of a review of the system, a typical stock item, Part No. X206, has been studied in detail as fellows:

Data for Part No. X206	
Lead times.	Probability
15 working days	0.2
20 working days	0.5
25 working days	0.3
Demand per working day	Probability
5,000 units	0.5
7,000 units	0.5

Note: It can be assumed that the demands would apply for the whole of the appropriate lead time.

DB Ltd. works for 240 days per year and it costs Re. 0.15 p.a. to carry a unit of X 206 in stock. The re-order level for this part is currently 1,50,000 units and the re-order cost is Rs. 1,000.

You are required:

a) To calculate the level of buffer stock implicit in a re-order level of 1,50,000 units.

b) To calculate to probability of a stock-out

c) To calculate the expected annual stock-outs in units;

d) To calculate the stock out cost per unit at which it would be worth while raising the re-order level to 1,75,000 units;

Solution:

a) Buffer stock level

Expected value = lead time x total demand in lead time x joint probability

15 x 5000 x 0.2 x 0.5 =	7500
15 x 7000 x 0.2 x 0.5 =	10500
20 x 5000 x 0.5 x 0.5 =	25000
20 x 7000 x 0.5 x 0.5 =	35000
25 x 5000 x 0.3 x 0.5 =	18750
25 x 7000 x 0.3 x 0.5 =	26250
	123000

Expected value of demand in lead time = 123000

Buffer stock = 150000-123000 = 27000 units

b) Stock out(shortage) = p>150000 = 0.15 joint probability at 17500 units

c) $EOQ = \frac{\sqrt{2 \times 6000 \times 240 \times 1000}}{0.15} = 138564$ units

Demand per working day = (5000 x 0.5) + (7000 x 0.5) = 6000 units

Orders per annum = (6000 x 240) / 138564 =10.39 (on an average)

Expected stock out per annum = (175000-150000) x 0.15 x 10.39 = 38962 units

d) At 150000 reorder level, stock out is 38962 units

At 175000 reorder level, stock out is nil

Additional cost is 25000 x 0.15 = Rs.3750

Additional cost per unit = 3750/38962 = Rs.0.96 (or) 96paise

EXERCISE PROBLEMS

Problem No. 1

An Engineering Company has been offered a one year contract to supply a motor car component XY at a fixed price of Rs.8 per unit. Its normal capacity for this type of component is 25,000 units a year. The estimated costs to manufacture are shown below. These costs are considered to be firm except for the direct material price.

Cost Data:

Variable Costs per unit:	Rs.
Direct Wages	1.50
Direct Material	2.25
Direct Expenses	0.65

Semi-Variable Costs per annum:

	Output level		
	80%	100%	120%
Indirect Wages	Rs. 15,400	Rs.16,000	Rs.23,100
Indirect Materials	8,600	9,000	9,900
Indirect Expenses	2,000	2,500	3,000

Fixed Costs per annum:	Rs.
Supervisory Salaries	10,000
Depreciation	4,000
Other Overheads	16,000

You are required to:

a) Calculate the cost and profit per unit and total annual profit assuming that the customer's orders in the year total:

i) 20,000 components or

ii) 25,000 components or

iii) 30,000 components, and that direct material is Rs.2.25 per unit.

b) Calculate the estimated profit for the year if it is assumed that the probability of the total order is:

0.3 for 20,000 components;

0.6 for 25,000 components;

0.1 for 30,000 components;

and that for direct material is:

0.5 for Rs.2.25 per unit;

0.3 for Rs.2.50 per unit;

0.2 for Rs.2.75 per unit;

Ans:

a)

	20,000 components	25,000 components	30,000 components
Profit per unit	0.8	1.3	1.4
Cost per unit	7.2	6.7	6.6

b) Profit = Rs. 25,000

Problem No. 2

S & V Company is preparing budget for 2009 Data relating to sales, prices and costs are as follows:

Sales Price Rs. 20 per unit

Variable Cost Rs. 12 per unit

Fixed Costs Rs. 2,00,000 per year

Sales forecasts have been prepared, which disclose the following.

Quantity	Probability	Quantity	Probability
15,000	10%	35,000	30%
20,000	10%	40,000	10%
25,000	10%	45,000	10%
30,000	20%		

Required:

a) What is the break-even quantity?

b) How many units must be sold to i) earn a profit of Rs.60,000 ii) incur a loss of Rs.50,000.

c) Based on the sales forecast, what is the probability that the firm can break even?

d) What are the probabilities of achieving sales volume involved in part (b)

Ans:

a) Break Even Quantity = 25,000 units

b) i) 32,500 units

ii) 18,750 units

c) Probability = 80%

Units = 25,000 x 80% = 20,000

d) i) 50% ii) 10%

Problem No. 3

Better Budgets Ltd. are preparing their budget for 2009. In the preparation of the budget they would like to take no chances, but would like to envisage all sorts of possibilities and incorporate them in the Budget. Their considered estimates are as under:

a) If the worst possible happens, sales will be 8,000 units at a price of Rs.19 per unit the material cost will be Rs.9 per unit, direct labour Rs.2 per unit, and the variable overhead will be Rs.1.50 per unit. The fixed cost will be Rs.60,000 per annum.

b) If the best possible happens, sales will be 15,000 units at a price of Rs.20 per unit. The material cost will be Rs.7 per unit, direct labour Rs.3 per unit and the variable overhead will be Re.1 per unit. The fixed cost will be Rs.48,000 per annum.

c) It is most likely, however, that the sales will be 2,000 units above the worst possible level at a price of Rs.20 per unit. The material cost will be Rs.8 per unit, direct labour Rs.3 per unit and the variable overhead will be Re.1 per unit. The fixed cost will be Rs.50,000 per annum.

d) There is a 20% probability that the worst will happen, a 10% probability that the best will happen and a 70% probability that the most likely outcome will occur.

What will be the expected value of Profit as per the Budget for 2009 ?

Ans: Expected profit = Rs. 28,100

Problem No. 4

X Ltd. has to decide between rentals of two types of machine manufacturing the same product. Machine A, an inexpensive economy model, rents for Rs.1,000 per month, but the variable production cost is Rs.0.25 per unit. Machine B rents for Rs.3,000 per month, but the variable production cost is only Rs.0.10 per unit. Monthly demand varies between 10,000 and 19,000 according to the following probabilities:

Demand	**Probability**
10,000	0.12
12,000	0.17
15,000	0.41
17,000	0.24
19,000	0.06

Make a comparison of the two machines. Which machine X Ltd. should rent? If the demand is definitely known to be 10,000 units, would the decision reverse?

Ans:

Machine B is better to take on rent.

Indifference point = 13,333 units

4.8 Quantitative Techniques used in Business Decisions

(a) Linear Programming

EXERCISE PROBLEMS

Problem No. 1

A firm manufacturers and sells two products Alpha and Beta. Each unit of Alpha requires 1 hour of machining and 2 hours of skilled labour, whereas each unit of Rate uses 2 hours of machining and 1 hour of labour. For the coming month the machine capacity is limited to 720 machine hours and the skilled labour is limited to 780 hours. Not more than 320 units of Alpha can be sold in the market during a month.

(i) Develop a suitable model that will enable determination of the optimal product mix.

(ii) Determine the optimal product-mix and the maximum contribution. Unit contribution from Alpha is Rs.6 and from Beta is Rs.4.

(iii) What will be the incremental contribution per unit of the machine hour, per unit of labour, per unit of Alpha saleable?

Problem No. 2

A Chemical Company produces two compounds A and B. The following table gives the units of ingredients C and D per kg of compounds A and B as well as minimum requirements of C and D and costs/kg of A and B. Using the simplex method, find the quantities of A and B which would give a supply of C and D at a minimum cost.

		Table Compound		Minimum requirement
		A	B	
Ingredient	C	1	2	80
	D	3	1	75
Cost per kg.		4	6	

Problem No. 3

A pension fund manager is considering investing in two shares A and B. It is estimated that:

(i) Share A will earn a dividend of 12% per annum and share B 4% per annum.

(ii) Growth in the market value in one year of share A will be 10 paise per Re.1 invested and in B 40 paise per Re.1 invested.

He requires investing the minimum total sum which will give:

Dividend income of at least Rs.600 per annum and growth in one year of at least Rs.1,000 on the initial investment.

You are required to:

(i) State the mathematical formulation of the problem

(ii) Compute the minimum sum to be invested to meet the manager's objective by using the simplex method.

Problem No. 4

A company possesses two manufacturing plants each of which can produce three products X, Y and Z from a common raw material. However, the proportions in which the products are produced are different in each plant and so are the plant's operating costs per hour. Data on production per hour costs are given below, together with current orders in hand for each product.

	Product			Operating cost/ hour in Rs.
	X	**Y**	**Z**	
Plant A	2	4	3	9
Plant B	4	3	2	10
Orders on hand	50	24	60	

You are required to use the simplex method to find the number of production hours needed to fulfill the orders on hand at minimum cost.

Interpret the main features of the final solution.

Problem No. 5

A Company produces the products P, Q and R from three raw materials A, B and C. One unit of product P requires 2 units of A and 3 units of B. A unit of product Q requires 2 units of B and 5 units of C and one unit of product R requires 3 units of A, 2 unit of B and 4 units of C. The Company has 8 units of material A, 10 units of B and 15 units of C available to it. Profits/unit of products P, Q and R are Rs.3, Rs.5 and Rs.4 respectively.

(a) Formulate the problem mathematically,

(b) How many units of each product should be produced to maximize profit?

(c) Write the Dual problem.

Problem No. 6

A Factory manufactures 3 products which are processed through 3 different production stages. The time required to manufacture one unit of each of the three products and the daily capacity of the stages are given in the following table:

State	Time/unit in minutes			
	Product 1	**Product 2**	**Product 3**	**Stage capacity (minutes)**
1	1	2	1	430
2	3	-	2	460
3	1	4	-	420
Profit/unit	Rs.3	Rs.2	Rs.5	

(i) Set the data in a simplex table.

(ii) Find the table for optimum solution

(iii) State from the table - maximum profit, production pattern, and surplus capacity of any stage.

(iv) What is the meaning of the shadow price? Where is it shown in this table? Explain it in respect of resource of stages having shadow price.

(v) How many units of other resources will be required so as to completely utilise the surplus resource?

Problem No. 7

The products P, Q and R are being produced in a plant having profit margin as Rs.3, Rs.5 and Rs.4 respectively. The raw materials A, B and C are of scarce supply and the availability is limited to 8, 15 and 10 units respectively. Specific consumption is indicated in the table below:

	P	Q	R
A	2	3	-
B	3	2	4
C	-	2	5

(a) Write down the problem mathematically for maximization of profit margin.

(b) Solve the problem by Simplex Method for obtaining optimum production pattern.

(c) What are the opportunity costs of each of the raw material?

Problem No. 8

Formulate Linear programming model for the following problem and solve the problem using simplex method.

A company sells two types of fertilizers, one is liquid and the other is dry. The liquid fertilizer contains 2 units of chemical A and 4 units of chemical B per jar and the dry fertilizer contains 3 units of each of the chemicals A and B per carton. The liquid fertilizer sells for Rs.3 per jar and the dry fertilizer sells for Rs.4 per certain. A farmer requires at least 90 units of chemical A and at least 120 units of the chemical B for his farm. How many of each type of fertilizers should the farmer purchase to minimize the cost while meeting his requirements?

Problem No. 9

An Investor has Rs. 15 lakhs for investment in four alternatives. Table below gives data on price per share, average growth rate in the price, the annual dividend and the associated risk. Return per share is defined as the difference in current price and price a year later plus the dividend for the year. The following constraints have to be must:

i) At most Rs. 4,00,000 may be invested in share1.

ii) At least 100 shares of each stock must be bought.

iii) At least 15% of the investment made should be in shares 3 and 4 combines;

iv) The total weighted risk should not exceed 0.08, where total weighted risk = (Σ investment in share j x risk in j)/total investment;

v) Dividend for the year should be at least Rs. 20,000.

The objective is to maximize the earnings at the end of the first year from both dividends and growth. Formulate a linear program. Model that will determine the optimal no. of shares to be invested in each script.

Share No.	1	2	3	4
Current price per share	90	120	200	180
Expected annual growth rate	0.10	0.08	0.12	0.15
Expected annual dividend per share (Rs.)	5.00	7.50	4.00	3.00
Expected risk	0.07	0.05	0.10	0.08

Problem No. 10

A Bank is in the process of formulating its loan policy. Involving a maximum of Rs.600 Million. Table below gives the relevant types of loans. Bad debts are not recoverable and produce no interest receive. To meet competition from other Banks the following policy guidelines have been set. At least 40% of the funds must be allocated to the agricultural and commercial loans. Funds allocated to housing must be at least 50% of all loans given to personal, car, Housing. The overall bad debts on all loans may not exceed 0.06.

Formulate a linear program Model to determine optimal loan allocations.

Type of loan	Interest rate %	Bad debts (Probability)
Personal	17	0.10
Car	14	0.07
Housing	11	0.05
Agricultural	10	0.08
Commercial	13	0.06

(b) Assignment

Illustration No. 1

Six men are available for different jobs. From past records the time in hours taken by different persons for different jobs are given below.

		Jobs					
		1	2	3	4	5	6
Men	1	2	9	2	7	9	1
	2	6	8	7	6	14	1
	3	4	6	5	3	8	1
	4	4	2	7	3	10	1
	5	5	3	9	5	12	1
	6	9	8	12	13	9	1

Find out an allocation of men to different jobs which will lead to minimum operation time.

Solution:

2	9	2	7	9	1
6	8	7	6	14	1
4	6	5	3	8	1
4	2	7	3	10	1
5	3	9	5	12	1
9	8	12	13	9	1

Row Operation

1	8	1	6	8	0
5	7	6	5	13	0
3	5	4	2	7	0
3	1	6	2	9	0
4	2	8	4	11	0
8	7	11	12	8	0

Colomn Operation

$\boxed{0}$	7	0	4	1	0
4	6	5	3	6	$\boxed{0}$
2	4	3	$\boxed{0}$	0	0
2	$\boxed{0}$	5	0	2	0
3	1	7	2	4	0
7	6	10	10	1	0

Improved

$\boxed{0}$	7	0	4	1	1
3	5	4	2	5	$\boxed{0}$
2	4	3	$\boxed{0}$	0	1
2	0	5	0	2	1
2	$\boxed{0}$	6	1	3	0
6	5	9	9	$\boxed{0}$	0

Improved Matrix

0	9	$\boxed{0}$	6	3	1
1	5	2	2	5	$\boxed{0}$
$\boxed{0}$	4	1	0	0	1
0	$\boxed{0}$	3	0	2	1
0	0	4	1	3	0
4	5	7	9	$\boxed{0}$	0

Assignment

0	9	$\boxed{0}$	6	3	3
1	5	2	2	5	$\boxed{0}$
$\boxed{0}$	4	1	0	0	1
0	0	3	$\boxed{0}$	2	1
0	$\boxed{0}$	4	1	3	0
4	5	7	9	$\boxed{0}$	0

Optimal Assignment, then is

1	→	3	-	2
2	→	6	-	1
3	→	1	-	4
4	→	4	-	3
5	→	2	-	3
6	→	5	-	9
				22

Illustration No. 2

A captain of a cricket team has to allot five middle batting positions to five batsmen. The average runs scored by each batsman at these positions are as follows:

		Batting Position				
		III	IV	V	VI	VII
Batsmen	A	40	40	35	25	50
	B	42	30	16	25	27
	C	50	48	40	60	50
	D	20	19	20	18	25
	E	58	60	59	55	53

Make the assignment so that the expected total average runs scored by these batsmen are maximum.

Solution:

	III	IV	V	VI	VII
A	40	40	35	25	50
B	42	30	16	25	27
C	50	48	40	60	50
D	20	19	20	18	25
E	58	60	59	55	53

Loss Matrix

20	20	25	35	10
18	30	44	35	33
10	12	20	0	10
40	41	40	42	35
2	0	1	5	7

Row Operation

M_3

10	10	15	25	0
0	12	26	17	15
10	12	20	0	10
5	6	5	7	0
2	0	1	5	7

Column Operation

10	10	14	25	$\boxed{0}$
$\boxed{0}$	12	25	17	15
10	12	19	$\boxed{0}$	10
5	6	4	7	0
2	$\boxed{0}$	0	5	7

Improved Matrix

10	6	10	25	$\boxed{0}$
$\boxed{0}$	8	21	17	15
10	8	15	$\boxed{0}$	10
5	2	$\boxed{0}$	7	0
6	$\boxed{0}$	0	9	11

Maximum Profit

A	→	VII	–	50
B	→	III	–	42
C	→	VI	–	60
D	→	V	–	20
E	→	IV	–	60
				232

Illustration No.3

Average time taken by an operator on a specific machine is tabulated below. The management is considering replacing one of the old machines by a new one and the estimated time for operation by each operator on the new machine is also indicated.

	Machines						
Operation	M_1	M_2	M_3	M_4	M_5	M_6	New
01	2	3	2	1	4	5	6
02	4	4	6	3	2	5	1
03	6	10	8	4	7	6	1
04	8	7	6	5	3	9	4
05	7	3	4	5	4	3	12
06	5	5	6	7	8	1	6

(a) Find out an allocation of operators to the old machines to achieve a minimum operation time.

(b) Reset the problem with the new machine and find out the allocation of the operators to each machine and comment on whether it is advantageous to replace an old machine to achieve a reduction in operating time only.

(c) How will the operators be reallocated to the machines after replacement?

Solution:

Operation	M_1	M_2	M_3	M_4	M_5	M_6	New
01	2	3	2	1	4	5	6
02	4	4	6	3	2	5	1
03	6	10	8	4	7	6	1
04	8	7	6	5	3	9	4
05	7	3	4	5	4	3	12
06	5	5	6	7	8	1	6

a)

2	3	2	1	4	5
4	4	6	3	2	5
6	10	8	4	7	6
8	7	6	5	3	9
7	3	4	5	4	3
5	5	6	7	8	1

Row Operation

1	2	1	0	3	4
2	2	4	1	0	3
2	6	4	0	3	2
5	4	3	2	0	6
4	0	1	2	1	0
4	4	5	6	7	0

Column Operation

$\boxed{0}$	2	0	0	3	4
1	2	3	1	$\boxed{0}$	3
1	6	3	$\boxed{0}$	3	2
4	4	2	2	0	6
3	$\boxed{0}$	0	2	1	0
3	4	4	6	7	$\boxed{0}$

Improved matrix

0	2	$\boxed{0}$	1	4	5
$\boxed{0}$	1	2	1	0	3
0	5	2	$\boxed{0}$	3	2
3	3	1	2	$\boxed{0}$	6
3	$\boxed{0}$	0	3	2	1
2	3	3	6	7	$\boxed{0}$

01	→	M_3	-	2
02	→	M_1	-	4
03	→	M_4	-	4
04	→	M_5	-	3
05	→	M_2	-	3
06	→	M_6	-	1
				17

b & c)

2	3	2	1	4	5	6
4	4	6	3	2	5	1
6	10	8	4	7	6	1
8	7	6	5	3	9	4
7	3	4	5	4	3	12
5	5	6	7	8	1	6
0	0	0	0	0	0	0

Improved matrix

1	2	1	$\boxed{0}$	3	4	5
2	2	4	1	0	3	$\boxed{0}$
2	6	4	0	3	2	0
5	4	3	2	$\boxed{0}$	6	1
4	$\boxed{0}$	1	2	1	0	9
4	4	5	6	7	$\boxed{0}$	5
$\boxed{0}$	0	0	0	0	0	0

Improved matrix

0	1	0	$\boxed{0}$	3	4	5
2	2	4	2	1	4	$\boxed{0}$
4	8	6	3	6	5	0
4	3	2	2	$\boxed{0}$	6	1
4	$\boxed{0}$	1	3	2	1	10
3	3	4	6	7	$\boxed{0}$	5
$\boxed{0}$	0	0	1	1	1	1

01	→	M_1	–	2
02	→	M_4	–	3
03	→	New	–	1
04	→	M_5	–	3
05	→	M_2	–	3
06	→	M_6	–	1
07	→	M_3	–	0
				13

0	2	0	$\boxed{0}$	4	5	6
1	2	3	1	1	4	$\boxed{0}$
3	8	5	2	6	5	0
3	3	1	1	$\boxed{0}$	6	1
3	$\boxed{0}$	0	2	2	1	10
2	3	3	5	7	$\boxed{0}$	5
$\boxed{0}$	1	0	1	2	2	2

$\boxed{0}$	2	0	0	5	6	7
0	1	2	$\boxed{0}$	1	4	0
2	7	4	1	6	5	$\boxed{0}$
2	2	0	0	$\boxed{0}$	6	1
3	$\boxed{0}$	0	2	3	2	11
1	2	2	4	7	$\boxed{0}$	5
0	1	$\boxed{0}$	1	3	3	3

Illustration No. 4

Six salesmen are to be allocated to six sales regions so that the cost of allocation of the job will be minimum. Each salesman is capable of doing the job at different cost in each region. The cost matrix is given below:

		Region					
		I	II	III	IV	V	VI
Salesmen	A	15	35	0	25	10	45
	B	40	5	45	20	15	20
	C	25	60	10	65	25	10
	D	25	20	35	10	25	60
	E	30	70	40	5	40	50
	F	10	25	30	40	50	15

(Figures are in Rupees)

(a) Find the allocation to give minimum cost what is the cost?

(b) Now suppose the above table gives earning of each salesman at each region. How can you find an allocation so that the earning will be maximum? Determine the solution with optimum earning.

(c) There are restrictions for commercial reasons that A cannot be posted to region V and E cannot be posted to region II. Write down the cost matrix suitably after imposing the restrictions.

<u>Solution</u>

15	35	0	25	10	45
40	5	45	20	15	20
25	60	10	65	25	10
25	20	35	10	25	60
30	70	40	5	40	50
10	25	30	40	50	15

<u>Row Operation</u>

15	35	0	25	10	45
35	0	40	15	10	15
15	50	0	55	15	0
15	10	25	0	15	50
25	65	35	0	35	45
0	15	20	30	40	5

<u>Column Operation</u>

15	35	$\boxed{0}$	25	10	45
35	$\boxed{0}$	40	15	0	15
15	50	0	55	5	$\boxed{0}$
15	10	25	$\boxed{0}$	5	50
25	65	35	0	25	45
$\boxed{0}$	50	20	30	30	5

<u>Improved Matrix</u>

20	35	$\boxed{0}$	30	0	45
40	$\boxed{0}$	40	20	0	15
20	50	0	60	5	$\boxed{0}$
15	5	20	0	$\boxed{0}$	45
25	60	30	$\boxed{0}$	20	40
$\boxed{0}$	10	15	30	30	0

A	→	III	-	0
B	→	II	-	5
C	→	VI	-	10
D	→	V	-	25
E	→	IV	-	5
F	→	I	-	10
				55

b)

Loss Matrix

55	35	70	45	60	25
30	65	25	50	55	50
45	10	60	5	45	60
45	50	35	60	45	10
40	0	30	65	30	20
60	45	40	30	20	55

Row Operation

30	10	45	20	35	0
5	40	0	25	30	25
40	5	55	0	40	55
35	40	25	50	35	0
40	0	30	65	30	20
40	25	20	10	0	35

Column Operation

25	10	45	20	35	$\boxed{0}$
$\boxed{0}$	40	0	25	30	25
35	5	55	$\boxed{0}$	40	55
30	40	25	50	35	0
35	$\boxed{0}$	30	65	30	20
35	25	20	10	$\boxed{0}$	35

Improved Matrix

5	10	25	20	35	$\boxed{0}$
$\boxed{0}$	60	0	15	50	45
15	5	35	$\boxed{0}$	40	55
10	40	5	50	35	0
15	$\boxed{0}$	10	65	30	20
15	25	$\boxed{0}$	10	0	35

$\boxed{0}$	10	20	20	30	0
0	65	$\boxed{0}$	50	50	50
10	5	30	$\boxed{0}$	35	55
5	40	0	50	30	$\boxed{0}$
10	$\boxed{0}$	5	65	25	20
15	30	0	15	$\boxed{0}$	40

A	→	I	–	15
B	→	III	–	45
C	→	IV	–	65
D	→	VI	–	60
E	→	II	–	70
F	→	I	–	50
				305

c) The cost matrix after imposing the given restriction is

Region

		I	II	III	IV	V	VI
	A	15	35	0	25	0	45
	B	40	5	45	20	15	10
Sales man	C	25	60	10	65	25	10
	D	25	20	35	10	25	60
	E	30	0	40	5	40	50
	F	10	25	30	40	50	15

Illustration No. 5

A company has four zones open and four salesmen available for assignment. The zones are not equally rich in their sales potentials. It is estimated that a typical salesman operating in each zone would bring in the following annual sales:

Zone: A: 1,26,000: Zone B:1,05,000; Zone C: 84,000; Zone D: 63,000.

The four salesmen are also considered to differ in ability. It is estimated that working under the same condition their yearly sales would be proportionately as follows:

Salesman P:7; Salesman Q: 5; Salesman R:5; Salesman S:4. If the criterion is maximum expected total sales, the intuitive answer is to assign the best salesman to the richest zone, the next best to the second richest zone and so on. Verify this by the method of assignment.

Solution

Zone:

Sales Man	A	B	C	D
P	42	35	28	21
Q	30	25	20	15
R	30	25	20	15
S	24	20	16	12

Loss Matrix

0	7	14	21
12	17	22	27
12	17	22	27
18	22	26	30

Row Operation

0	7	14	21
0	5	10	15
0	5	10	15
0	4	8	12

Column Operation

$\boxed{0}$	3	6	9
0	1	2	3
0	1	2	3
0	$\boxed{0}$	0	0

$\boxed{0}$	2	5	8
0	$\boxed{0}$	1	2
0	0	1	2
1	0	$\boxed{0}$	0

$\boxed{0}$	2	4	7
0	$\boxed{0}$	0	1
0	0	$\boxed{0}$	1
2	1	0	$\boxed{0}$

P	→	A	-	42
Q	→	B	-	25
R	→	C	-	20
S	→	D	-	12
				99

EXERCISE PROBLEMS

Problem No. 1

Four jobs can be processed on four different machines, one job on one machine. Resulting profits vary with assignments. They are given below:

		Machines			
Jobs	I	42	35	28	21
	II	30	25	20	15
	III	30	25	20	15
	IV	24	20	16	12

Find the optimum assignment of jobs to machines and the corresponding profit.

Ans: Maximum Profit Rs. 232

Problem No. 2

A salesman has to visit five cities A,B,C,D and E. The inter-city distances are tabulated below. Note the distance between two cities need not be same both ways.

From / To	A	B	C	D	E
A	-	12	24	25	15
B	6	--	16	18	7
C	10	11	--	18	12
D	14	17	22	--	16
E	12	13	23	25	--

Note further that the distances are in km.

Required:

If the salesman starts from city A and has to come back to city A, which route would you advise him to take that total distance traveled by him is minimised?

Ans: Optimum Distance 76 Kms. (A-B-E-D-C-A)

Problem No. 3

A company has four zones open and four salesmen available for assignment. The zones are not equally rich in their sales potentials. It is estimated that a typical salesman operating in each zone would bring in the following annual sales:

Zone: A: 1,26,000: Zone B:1,05,000; Zone C: 84,000; Zone D: 63,000.

The four salesmen are also considered to differ in ability. It is estimated that working under the same condition their yearly sales would be proportionately as follows:

Salesman P:7; Salesman Q: 5; Salesman R:5; Salesman S:4. If the criterion is maximum expected total sales, the intuitive answer is to assign the best salesman to the richest zone, the next best to the second richest zone and so on. Verify this by the method of assignment.

Ans: Rs. 99,000

(c) Transportation

Illustration No. 1

A manufacturer has distribution centres X, Y, and Z. These centres have 40,20 and 40 units of his product. His retail outlets at A, B, C, D and E require 25,10,20,30 and 15 units respectively. The transport cost in (Rupees/Unit) between each centre and each outlet is given in the following table:

Distribution Centre	Retail outlets				
	A	B	C	D	E
X	55	30	40	50	40
Y	35	30	100	45	60
Z	40	60	95	35	30

We have to find out the optimum distribution cost.

Solution:

	A	B	C	D	E		
X	55 5	30 10	40 20	50 5	40	40/20/10/5/0	10/10*/10/5/5
Y	35 20	30	100	45	60	20/0	5/5/10/10
Z	40	60	95	35 25	30 15	40/25/0	5/5/5/5/5
	25 5 0	10 0	20 0	30 5 0	15 0		
	5 5 5 5 15	0 0	55*	10 10 10 10 15*	10 10 10*		

There are m + n - 1 allocations. Hence Optimality test can be performed

						Ui
	55 5	30 10	40 20	50 5	40 -10	**0**
	35 20	30 20	100 80	45 15	60 30	**-20**
	40 0	60 45	95 70	35 +25	30 -15	**-15**
Vj	**55**	**30**	**40**	**50**	**50**	

						Ui
	55 / 5	30 / 10	40 / 20	50 / 5	40 / +5	**0**
	35 / 20	30 / 20	100 / 80	45 / 20	60 / 40	**-20**
	40 / -5	60 / 40	95 / 65	35 / 30	30 / 10	**-10**
Vj	**55**	**30**	**40**	**45**	**50**	

						Ui	
	55 / 5	30 / 10	40 / 20	50 / 5	40 / 10	**0**	**Since Δij is ≥ 0**
	35 / 20	30 / 15	100 / 75	45 / 15	60 / 35	**-15**	**The solution is optimum**
	40 / 5	60 / 40	95 / 65	35 / 30	30 / 5	**-10**	
Vj	**55**	**30**	**40**	**45**	**50**		

		Qty.		**Minimum cost**
X ⟶	B ——	10 x 30	=	300
⟶	C ——	20 x 40	=	800
⟶	E ——	10 x 40	=	400
Y ⟶	A ——	20 x 35	=	700
Z ⟶	A ——	5 x 40	=	200
⟶	D ——	30 x 35	=	1050
⟶	E ——	5 x 30	=	150
		100		3600

Illustration No. 2

The cost conscious company requires for the next month 300, 260 and 180 tonnes of stone chips for its three constructions C1,C2 and C3 respectively. Stone chips are produced by the company at three mineral fields taken on short lease by the company. All the available boulders must be crushed into chips. Any excess chips over the demands at sites C1, C2 and C3 will be sold ex-fields.

The fields are M1, M2 and M3 which will yield 250,320 and 280 tones of stone chips respectively.

Transportation costs from mineral fields to construction sites vary according to distances, which are given below in monetary unit (MU).

	To	C1	C2	C3
From	M1	8	7	6
	M2	5	4	9
	M3	7	5	5

(i) Determine the optimal economic transportation plan for the company and the overall transportation cost in MU.

(ii) What are the quantities to be sold from M1, M2 and M3 respectively?

Solution:

	C_1	C_2	C_3	Dummy		
M_1	8	7	6 / 140	0 / 110	250/140	6*/1/1/1
M_2	5 / 300	4 / 20	9	0	320/20/0	4/1/5*
M_3	40	60 / 240	95 / 40	35	280/40/0	5/0/0/0
	300/0	260/240/0	180/0	110/0	850	——
	2/*2	1/1/1/*2	1/1/1/1	0		

Hence There are m + n – 1 allocations.

Hence Optimality test is to be performed.

					Ui
	8 / 1	7 / 1	6 / 140	0 / 110	**0**
	5 / 300	4 / 20	9 / 5	0 / 2	**-2**
	7 / 1	5 / 240	5 / 40	35 / 1	**-1**
Vj	**7**	**6**	**6**	**0**	

SinceΔij is ≥ 0Solution is optimum.

		Qty.		Minimum cost
M_1 →	C_3 —	140 x 6	=	840
→	C_4 —	110 x 0	=	0
M_2 →	C_1 —	300 x 5	=	1500
→	C_2 —	20 x 4	=	80
M_3 →	C_2 —	240 x 5	=	1200
→	C_3 —	40 x 5	=	200
		850		3820

Illustration No. 3

Ladies Fashion Shop wishes to purchase the following quantity of summer dresses:

Dress size	I	II	III	IV
Quantity	100	200	450	150

Three manufacturers are willing to supply dresses.

The quantities given below are the maximum that they are able to supply of any given combination of orders for dresses:

Manufacturers	A	B	C
Total quantity	150	450	250

The shop expects the profit per dress to vary with the manufacturer as given below:

Size

	I	II	III	IV
A	£2.5	£4.0	£5.0	£2.0
B	£3.0	£3.5	£5.5	£1.5
C	£2.0	£4.5	£4.5	£2.5

Required:

(a) Use the transportation technique to solve the problem of how the orders should be placed with the manufacturers by the fashion shop is order to maximise profit.

(b) Explain how you know there is no further improvement possible.

Solution:

Profit Matrix

	I	**II**	**III**	**IV**	
A	25	4	5	2	**150**
B	3	3.5	5.5	1.5	**450**
C	2	4.5	4.5	2.5	**250**
D	0	0	0	0	**50**
	100	**200**	**450**	**150**	

Profit Matrix is concerted into Loss Matrix.

	I	II	III	IV		
A	3 100	1.5	.5	3.5	**150/50/0**	**1/1.5/.5***
B	2.5	2	0 450	4	**450/0 2***	
C	3.5	1 200	1	3 50	**250/50/0**	**0/2*/.5**
D	5.5	5.5	5.5	5.5 50	**50/0**	**0/0/0**
	100/0	200/0	450/0	150/100/0		
	.5/.5/.5	.5/.5	1	.5/.5/.5		

There are 1 less than m + n – 1 allocations.

Hence E is introduced in least cost unallocated cell.

					Ui
	3 100	1.5 0	.5 E	3.5 50	**0**
	2.5 0	2 1	0 450	4 1	**-.5**
	3.5 5	1 200	1 1	3 50	**-.5**
	5.5 .5	5.5 2	5.5 3	5.5 50	**2**
Vj	**3**	**1.5**	**.5**	**3.5**	

Since Δij is ≥ 0, the solution is optimum

		Qty.		Minimum cost
A ⟶	I	—— 100 x 2.5	=	250
⟶	IV	—— 50 x 2	=	100
B ⟶	III	—— 450 x 5.5	=	2475
C ⟶	II	—— 200 x 4.5	=	900
C ⟶	IV	—— 50 x 2.5	=	125
Dummy	IV	—— 50 x 0	=	
		900		3850

Illustration No. 4

departmental store wishes to purchase the following quantities of Sprees:

Types of sprees	A	B	C	D	E
Quantity	150	100	75	250	200

Tenders are submitted by 4 different manufacturers who undertake to supply not more than the quantities mentioned below (all types of sprees combined):

Manufacturer	W	X	Y	Z
Total quantity	300	250	150	200

The store estimates that its profit/spree will vary with the manufacturer as shown in the following matrix.

	Sprees				
Manufacturers	A	B	C	D	E
W	275	350	425	225	150
X	300	325	450	175	100
Y	250	350	475	200	125
Z	325	275	400	250	175

How should the orders be placed?

Solution:

Profit matrix

	A	**B**	**C**	**D**	**E**	**F**	
W	275	350	425	225	150	0	**300**
X	300	325	450	175	100	0	**250**
Y	250	350	475	200	125	0	**150**
Z	325	275	400	250	175	0	**200**
	150	**100**	**75**	**250**	**200**	**125**	

Loss Matrix

200	125 25	50	250 50	325 200	475 25	300/275/225/25
175	150	25	300	375	475 100	250/100/0 25/25/125/75/5
225	125 75	0 75	275	350	475	150/75/0 125* 100*
150	200	75	225 200	300	475	200/0

75/50/50/75/75/75*

150	150	75	250	200	125
0	25	0	50	0	100
	0		0		0
25	0	25	25	25	0
25	0		25	25	0
25	25		25	25	0
25			25	25	0
			25	25	0
			50	50	0

m + n – 1 allocation s are there, optimality test can be performed.

200 25	125 25	50 50	250 50	325 200	475 25	**0**
175 150	150 25	25 25	300 50	375 50	475 100	**0**
225 50	125 75	0 75	275 25	350 25	475 0	**0**
150 0	200 100	75 100	225 200	300 0	475 25	**-25**
175	**125**	**0**	**250**	**325**	**475**	

		Qty.		Minimum cost
W ⟶	B	25 x 350	=	8750
	D	50 x 225	=	11250
	E	200 x 150	=	30000
	F	25 x 0	=	0
X ⟶	A	150 x 300	=	45000
	F	100 x 0	=	0
Y ⟶	B	75 x 350		26250
	C	75 x 475		35625
Z ⟶	D	200 x 250		50000
Max. Profit				2,06,875

Illustration No. 5

The products of three plants F1,F2 and F3 are to be transported to 5 warehouses W1,W2,W3,W4 and W5. The capacities of plants, demand of warehouses and the cost of transportation from one plant to various warehouses are indicated in the following table:

	W1	W2	W3	W4	W5	Plant Capacity
F1	74	56	54	62	68	400
F2	58	64	62	58	54	500
F3	66	70	52	60	60	600
Warehouse Demand	200	280	240	360	320	1500/1400

(a) Find out a distribution plan of products from plants to the warehouses at a minimum cost. What is the minimum cost?

(b) Is there any surplus capacity of the plants? If so, in which plant should we associate that surplus capacity?

(c) Is there any alternate solution for the optimum solution achieved in

Solution:

74	56 280	54	62 20	68	0 100	400/300/20/0 54/2/6/6/6/6
58 200	64	62	58	54 300	0	500/300/0 *54/4/4/4/4
66	70	52 240	60 340	60 20	0	600/360/340/0 52/8/0/0/0/6
200 0	280 0	240 0	360 340 0	320 20 0	100 0	
8 8 8 8*	8 8 8*	2 2	2 2 2 2 2 2	6 6 6 6 6* 8*	0	

Alternative Solution:

							u_i
F_1	74 / 8	56 / 280	54 / 0	62 / 20	68 / 6	0 / 100	0
F_2	58 / 200	64 / 16	62 / 18	58 / 4	54 / 300	0 / 8	-8
F_3	66 / 2	70 / 16	52 / 240	60 / 340	60 / 20	0 / 2	-2
Vj	66	56	54	62	62		0

Since m + n – 1 allocations, optimality can be performed.

Since Δij is ≥ 0, the solution is optimal.

		Qty.		Minimum cost
$F_1 \longrightarrow$	W_2	—— 280 x 56	=	15680
	W_4	—— 20 x 62	=	1240
	Dummy	100 x 0	=	0
$F_2 \longrightarrow$	W_1	—— 200 x 58	=	11600
	W_5	—— 300 x 54	=	16200
$F_3 \longrightarrow$	W_3	—— 240 x 52	=	12480
	W_4	—— 340 x 60	=	20450
	W_5	—— 20 x 60	=	1200
	Max. Profit	1500		78800

Alternative Solution:

74	56 / 280	54	62 / 20	68 / 6	0 / 100
58 / 200	64	62	58	54 / 300	0
66	70 / 16	52 / 220	60 / 360	60 / 20	0

		Qty.		Minimum cost
$F_1 \longrightarrow$	W_2	—— 280 x 56	=	15680
	W_4	—— 20 x 54	=	1080
	Dummy	100 x 0	=	0
$F_2 \longrightarrow$	W_1	—— 200 x 58	=	11600
	W_5	—— 300 x 54	=	16200
$F_3 \longrightarrow$	W_3	—— 220 x 52	=	11440
	W_4	—— 360 x 60	=	21600
	W_5	—— 20 x 60	=	1200
	Max. Profit	1500		78800

Illustration No. 6

A Company has 4 factories F_1, F_2, F_3 and F_4, manufacturing the same product. Production and raw material costs differ from factory to factory and are given in the table below in the first two rows. The transportation costs from the factories to the sales depots S_1, S_2 and S_3 are also given. The last two columns in the table below give the sales price and total requirements at each depot and the production capacity of each factory is given in the last row.

	F_1	F_2	F_3	F_4	Sales Price/Unit (Rs)	Requirement
Production Cost/Unit (Rs.)	15	18	14	13		
Raw Materials Cost/Unit (Rs.)	10	9	12	9		
Transportation Cost/Unit (Rs.)						
S_1	3	9	5	4	34	80
S_2	1	7	4	5	32	120
S_3	5	8	3	6	31	150
Production capacity	10	150	50	100		

Determine the optimal solution and the associated profit by using the Vogel's Approximation Method (VAM)

Solution:

Loss Matrix

2	10	5	0 80	8	80/0	2/0/0/0
2 10	10 90	6	3 20	8	120/110/90/0	1/1/3*/2
7	12 60	6 50	5	8 15	150/90/40/0	1/1/1/2*
10/0	150/60/0	50/0	100/20/0	40/0		
0/5*	0/2/2/2	1/0/0/0	3*/2/2/0	0/0/0		

						Ui
	2 3	10 3	5 4	0 80	8 5	-3
	2 10	10 90	6 2	3 20	8 2	0
	7 3	12 60	6 50	5 0	8 40	2
Vj	2	10	4	3	6	

		Qty.		Minimum cost
$S_1 \longrightarrow$	F_4 —	80 x 8	=	640
S_2	F_1	10 x 6	=	60
	F_2	90 x (-2)	=	(-) 180
	F_4	20 x 5	=	100
S_2	F_2	60 x -4	=	(-) 240
	F_3	50 x 2	=	100
	Dumy	60 x 2		0
		350		480

Illustration No. 7

The Bombay Transport Company has trucks available at four different sites in the following numbers:

Site A	**5 Trucks**
Site B	**10 Trucks**
Site C	**7 Trucks**
Site D	**3 Trucks**

Customers – W, X and Y require trucks as shown below.

Customer W	**5 Trucks**
Customer X	**8 Trucks**
Customer Y	**10 Trucks**

Variable Costs of getting trucks to the Customers are given below:

From A to W	**Rs. 7, to X**	**Rs. 3, to Y**	**Rs. 6**
From B to W	**Rs. 4, to X**	**Rs. 6 to Y**	**Rs. 8**
From C to W	**Rs. 5, to X**	**Rs. 8 to Y**	**Rs. 4**
From D to W	**Rs. 8 to X**	**Rs. 4 to Y**	**Rs. 3**

Solve the above transportation problem.

Solution:

$\boxed{7}$	$\boxed{3}$ 5	$\boxed{6}$	$\boxed{0}$	5/0	3	3*	-	-	-
$\boxed{4}$ 5	$\boxed{6}$ 3	$\boxed{8}$	$\boxed{0}$ 2	10/8/3/0	4*	2	2*	2	2
$\boxed{5}$	$\boxed{8}$	$\boxed{4}$ 7	$\boxed{0}$	7/0	4	1	1	4	-
$\boxed{8}$	$\boxed{4}$	$\boxed{3}$ 3	$\boxed{0}$	3/0	3	1	1	1	1
5/0	8/3/0	10/3/0	2/0						
1	1	1	0						
1	1	1	-						
1	2	1							
-	2	1	-						
-	2	5	-						

					Ui
	7 6	3 5	6 5	0 3	**-3**
	4 5	6 3	8 4	0 2	**0**
	5 1	8 2	4 7	0	**0**
	8 5	4 -1	3 3	0 1	**-1**
Vj	**4**	**6**	**4**	**0**	

	W	**X**	**Y**	**Z**	*Ui*
A	7 6	3 5	6 4	0 3	**-3**
B	4 5	6 3	8 3	0 2	**0**
C	5 2	8 3	4 7	0 1	**-1**
D	8 6	4	3 3	0 1	**-2**
Vj	**4**	**6**	**5**	**0**	

Allocation

A ⟶	X ⟶	5 x 3	=	15
B ⟶	W ⟶	5 x 4	=	20
	X ⟶	3 x 6	=	18
	Z ⟶	2 x 0	=	0
C ⟶	Y ⟶	7 x 4	=	28
D ⟶	Y ⟶	3 x 3	=	9
		25		90

EXERCISE PROBLEMS

Problem No.1

The products of two plants A and B are to be transported to 3 warehouses W1, W2 and W3. The cost of transportation of each unit from plants to the warehouses are indicated below:

	Warehouses			
Plants	(W1)	(W2)	(W3)	Capacities
A	25	17	25	30
B	15	10	18	500
Demand	300	300	500	800/1100

Find the optimum distribution and the optimum cost.

Ans: Optimum cost: Rs. 13,200

Problem No. 2

Priyanshu enterprise has three factories at locations A, B and C which supply three warehouses located at D,E and F. Monthly factory capacities are 10,80 and 15 units respectively. Monthly warehouse requirements are 75,20 and 50 units respectively. Unit shipping costs (in Rs.) are given in the following table:

	To	D	E	F
From	**A**	**5**	**1**	**7**
	B	**6**	**4**	**6**
	C	**3**	**2**	**5**

The penalty costs for not satisfying demand at the warehouses D,E and F are Rs.5, Rs.3 and Rs.2 per unit respectively. Determine the optimum distribution for Priyanshu, using any of the known algorithms.

Ans: Rs. 595/-

Problem No.3

A company has 3 plants located at different places but producing an identical product. The cost of production, distribution cost of each plant to the 3 different warehouses, the sale price at each warehouse and the individual capacities for both the plant and warehouse are given below:

Plants	F1	F2	F3		
Raw material	15	18	14		
Other expenses	10	9	12		
Distribution cost to warehouse				Sales Price in (Rs.)	Warehouse Capacity (No)
W1	3	9	5	34	80
W2	1	7	4	32	110
W3	5	8	3	31	150
Capacity of Plant (No.)	150	100	130		

(a) Establish a suitable table giving net profit/loss for a unit produced at different plants and distributed at different locations.

(b) Introduce a suitable dummy warehouse / plant so as to match the capacities of plants and warehouses.

(c) Find distribution pattern so as to maximise profit / minimise loss.

(d) Interpret zero value of square evaluation of an empty cell and find alternative solutions.

Ans: Profit Rs. 1,000/-

Problem No.4

A company manufacturing television sets has four plants with a capacity of 125, 250, 175 and 100 units respectively. The company supplies T.V. sets to its four show rooms which have demand of 100,400,90 and 60 units respectively. Due to the differences in the raw material cost and the transportation cost, the profit per unit (in Rs.) differ which are given in the following table:

		Showroom			
		I	II	III	IV
	I	90	100	120	110
Plants	II	100	105	130	117
	III	111	109	110	120
	IV	130	125	108	113

By using Vogel's approximation method, plan the production programme so as to maximise the profit. Also determine the maximum total profit.

Ans: Maximum profit Rs. 73,795/-

Problem No.5

A firm manufacturing single product has three plants at locations X,Y and Z. The three plants have produced 60, 35 and 40 Units respectively during this week. The firm has made commitments to sell 22, 45, 20, 18 and 30 Units of the product to customers A, B, C, D and E respectively. The net per unit cost of transporting from the three plants to the five customers is given in the table below.

		Customers				
		A	**B**	**C**	**D**	**E**
Plant	**X**	**4**	**1**	**3**	**4**	**4**
Location	**Y**	**2**	**3**	**2**	**2**	**3**
	Z	**3**	**5**	**2**	**4**	**4**

Use Vogel's approximation method to determine the cost shifting the product from plant locations to the customers. Does your solution provide a least cost transportation schedule?

Ans: least cost Rs. 290/-

Problem No.6

A manufacturing company has three plants at locations X,Y and Z which supply to the distributors located at A, B, C, D and E. Monthly capacities are 80, 50 and 90 units respectively. Monthly requirements of distributors are 40,40,50,40 and 80 units respectively. Unit transportation costs are given below in Rupees.

	To	A	B	C	D	E
From	X	5	8	6	6	3
	Y	4	7	7	6	6
	Z	8	4	6	6	3

Determine an optimum distribution for the company in order to minimise the total transportation cost.

Ans: Minimum Cost Rs. 920/-

Problem No.7

The products of two plants A and B are to be transported to three warehouses W1, W2, and W3. The cost of transportation of each unit from plants to the warehouses along with the normal capacities of plants and warehouses are indicated below:

Plants	Warehouses			Capacity
	W1	W2	W3	
A	25	17	25	300
B	15	10	18	500
Demand	300	300	500	800/1100

(a) Solve the problem for minimum cost of transportation. Are there any alternative solutions? If any, explain the methodology of solving.

(b) Overtime can be used in each plant to raise the capacity by 50% of the normal but corresponding cost of transshipment will also increase by 10 and 15 for plants A and B respectively.

Again solve the problem for minimum cost of transportation.

Ans: a) Minimum Cost Rs. 13,200

b) Minimum Cost Rs. 33,700

Problem No.8

Anand Batteries have plants at X, Y and Z. Its products 'Torch Batteries' is sent in trucks to the warehouses situated at A, B, C and D for final delivery. The shipment, production runs and storage capacities are given on the basis of truckloads/week. The costing for transportation is also on the basis of truckloads.

The plants have their working capacities and the warehouses are of different sizes depending on market demand. The following tables show:

(i) The capacity details of the plants and the warehouses, and (ii) the transportation cost/truckload

Table-1:

Warehouse	Capacity Truckloads	Factory	Production Truckloads
A	16	X	48
B	20	Y	32
C	40	Z	40
D	44	-	—
Total	120		120

Table 2: Transportation cost per truckload in units of Rs.100

	A	B	C	D
X	6	11	3.5	6
Y	2	6	5	4
Z	1.5	11	4.5	3

You are required to workout as to how the supplies from the plant be allocated to the warehouses to minimise total transportation cost. Determine the minimum total transportation cost.

Transport cost matrix

Warehouses	A	B	C	D	Capacity/Production
Factory X	6	11	3.5	6	48
Y	2	6	5	4	32
Z	1.5	11	4.5	3	40
Demand	16	20	40	44	120

Ans: Minimum Cost Rs. 44,000

(d) Simulation

In the earlier chapters, we have absent analyse the characteristics of a given system. Such models are useful for determining optimal solutions. Especially the techniques of LPP, Transportation, and assignment are used for such optimization. However, all the business situations can not be solved with the above techniques only. There may be some complex situations, where numbers of assumptions are also necessary. It may be quite often possible to simulate the given system and study the behavior.

To simulate means to imitate. In general, simulation involves developing a model of real phenomenon and then performing experiments on the model evolved. It is to be noted that it is a descriptive and not optimizing technique. In simulation, a given system is copied and the variables and constants associated with it are manipulated in that artificial environment to examine the behavior of the system. For ex: aerodynamic testing, scaled down models of airplanes and placing term in worked tunnels etc.

Thus, a businessman also in a complex situation a given system is taken and simulates for obtaining the required results.

It consists of four phases:

1) Definition of the problem and statement of objectives.

2) Construction of an appropriate model

3) Experimentation with the model constructed.

4) Evaluation of the results of simulation.

Illustration No. 1

State the major two reasons for using simulation to solve a problem

A confectioner sells confectionery items. Past data of demand per week in hundred kilograms with frequency is given below:

Demand/Week	0	5	10	15	20	25
Frequency	2	11	8	21	5	3

Using the following sequence of random numbers, generate the demand for the next 10 weeks. Also find out the average demand per week

Random numbers	35	52	13	90	23	73	34	57
	35	83	94	56	67	66	60	

Solution:

Random No. Range Table for demand				
Demand per week	Frequency	Probability	Cumulative Probability	Range
0	2	.04	.04	0-3
5	11	.22	.26	4-25
10	8	.16	.42	26-41
15	21	.42	.84	42-83
20	5	.10	.94	84-93
25	3	.06	1.00	94-99
	$\sum f = 50$	**1.00**		

Simulated Values for next 10 weeks		
Weeks	R. Nos.	Demand
1	35	10
2	52	15
3	13	5
4	90	20
5	23	5
6	73	15
7	34	10
8	57	15
9	35	10
10	83	15
		120

Average weekly demand = $\frac{120}{10}$ =12

Illustration No. 2

The manager of a book store has to decide the number of copies of a particular tax law book to order. A book costs Rs. 60 and is sold for Rs. 80. Since some of the tax laws change year after year, any copies unsold while the edition is current must be sold for Rs. 30. From past records, the distribution of demand for this book has been obtained as follows:

Demand (No of copies)	15	16	17	18	19	20	21	22
Proportion	0.05	0.08	0.20	0.45	0.10	0.07	0.03	0.02

Using the following sequence of random numbers, generate the demand for 20 time periods(years). Calculate the average profit obtainable under each of the courses of action open to the manager. What is the optimal policy?

14	02	93	99	18	71	37	30	12	10
88	13	00	57	69	32	18	08	92	73

Solution:

Random No. Range Table			
Demand	**Probability**	**Cumulative Probability**	**Random Range**
15	.05	.05	0-4
16	.08	.13	5-12
17	.20	.33	13-32
18	.45	.78	33-77
19	.10	.88	78-87
20	.07	.95	88-94
21	.03	.98	95-97
22	.02	1.00	98-99
	1.00		

Calculation of Demand and Profit for next 20 years					
Year	**Random Numbers**	**Expected demand**	**No. of books unsold if stock is**		
			16	**17**	**18**
1	14	17	-	-	1
2	02	15	1	2	3
3	93	20	-	-	-
4	99	22	-	-	-
5	18	17	-	-	1
6	71	18	-	-	-
7	37	18	-	-	-
8	30	17	-	-	1
9	12	16	-	1	2
10	10	16	-	1	2
11	88	20	-	-	-
12	13	17	-	-	1

Calculation of Demand and Profit for next 20 years					
Year	**Random Numbers**	**Expected demand**	**No. of books unsold if stock is**		
			16	**17**	**18**
13	00	15	1	2	3
14	57	18	-	-	-
15	69	18	-	-	-
16	32	17	-	-	1
17	18	17	-	-	1
18	08	16	-	1	2
19	92	20	-	-	-
20	73	18	-	-	-
Total			2	7	18

Statement Showing Computation of Profit			
No. of Books order	**No. of Books sold**	**Profit**	**Average Profit**
15	15 x 20 = 300	6000	300
16	16 x 20 – 2 = 318	6300 (318 x 20) – 2 x 30	315
17	(17 x 20) – 7 = 333	6450 (333 x 20) -7 x 30	322.5
18	(18 x 20) – 18	6300 (342 x 20) – 18 x 30	315

Since profit is more at 17 books order, it is the best quantity and ordering is more optimum.

Illustration No. 3

A Small retailer has studied the weekly receipts and payments over the past 200 weeks and has developed the following set of information:

Weekly Receipts	Probability	Weekly Payments	Probability
(Rs)		(Rs)	
3000	0.20	4000	0.30
5000	0.30	6000	0.40
7000	0.40	8000	0.20
12000	0.10	10000	0.10

Using the following set of random numbers, simulate the weekly pattern of receipts and payments for the 12 weeks of the next quarter, assuming further that the beginning bank balance is Rs 8000. What is the estimated balance at the end of the 12 weekly period? What is the highest weekly balance during the quarter? What is the average weekly balance for the quarter?

Random Numbers

For Receipts	03	91	38	55	17	46	32	43	69	72	24	22
For payments	61	96	30	32	03	88	48	28	88	18	71	99

According to the given information, the random number interval is assigned to both the receipts and the payments.

Solution:

Range of Random Numbers							
Receipt	Probability	Cumulative probability	Range	Payments	Probability	Cumulative probability	Range
3000	0.20	0.20	0-19	4000	0.30	0.30	0-29
5000	0.30	0.50	20-49	6000	0.40	0.70	30-69
7000	0.40	0.90	50-89	8000	0.20	0.90	70-89
12000	0.10	1.00	90-99	10000	0.10	1.00	90-99

Simulation of Data for a period of 12 weeks					
Week	Random No. for receipt	Expected Receipt	Random No. for payment	Expected Payment	Week end Balance
Opening Balance					8000
1	03	3000	61	6000	5000 (8000 + 3000 – 6000)
2	91	12000	96	10000	7000
3	38	5000	30	6000	6000
4	55	7000	32	6000	7000
5	17	3000	03	4000	6000
6	46	5000	88	8000	3000
7	32	5000	48	6000	2000
8	43	5000	28	4000	3000
9	69	7000	88	8000	2000
10	72	7000	18	4000	5000
11	24	5000	71	8000	2000
12	22	5000	99	10000	(3000)

Estimated balance at the end of 12th week = (3,000)

Highest balance = 7,000

Average balance during the quarter = 45,000/12 = 3,750

Illustration No. 4

Patients arriving at a village dispensary are treated by a doctor on a first-come-first-served basis. The inter-arrival time of the patients is known to be uniformly distributed between 0 and 80 minutes, while their service time is known to be uniformly distributed between 15 and 40 minutes. It is desired to simulate the system and determine the average time a patient has to be in the queue for getting service and the proportion of time the doctor would be idle.

Carry out the simulation using the following sequences of random numbers. The numbers have been selected between 00 and 80 to estimate inter-arrival times and between 15 and 40 to estimate the service times required by the patients.

Series 1	07	21	12	80	08	03	32	65	43	74
Series 2	23	37	16	28	30	18	25	34	19	21

Solution:

Simulation of data at a village dispensary							
No. of patients	**Inter arrival time Random No. (minutes)**	**Entry time in to queue (hrs)**	**Service Time Random No. (minutes)**	**Service Start time (hrs)**	**End time (hrs)**	**Waiting time of patient (minutes)**	**Idle time of doctor (minutes)**
1	07	8.07	23	8.07	8.30	-	07
2	21	8.28	37	8.30	9.07	2	-
3	12	8.40	16	9.07	9.23	27	-
4	80	10.00	28	10.00	10.28	-	37
5	08	10.08	30	10.28	10.58	20	-
6	03	10.11	18	10.58	11.16	47	-
7	32	10.43	25	11.16	11.41	33	-
8	65	11.48	34	11.48	12.22	-	07
9	43	12.31	19	12.31	12.50	-	09
10	74	01.45	21	01.45	02.06	-	55
Total (in minutes)						**129**	**115**

Average waiting time of patient = 129/10 = 12.9 minutes

Average waiting time of doctor = 115/10 = 11.5 minutes

It has been assumed that starting time be 8.00 A.M.

Illustration No. 5

An automobile production line turns out about 100 cars a day, but deviations occur owing to many causes. The production is more accurately described by the probability distribution given below

Production/Day	Prob.	Production/Day	Prob.
95	0.03	101	0.15
96	0.05	102	0.10
97	0.07	103	0.07
98	0.10	104	0.05
99	0.15	105	0.03
100	0.20		
		Total	1.00

Finished cars are transported across the bay, at the end of each day, by ferry. If the ferry has space for only 101 cars, what will be the average number of cars waiting to be shipped, and what will be the average number of empty space on the boat?

Solution:

Simulation of data of an Automobile Production line			
Production/day	**Probability**	**Cumulative Probability**	**Random No. Range**
95	0.03	0.03	0-2
96	0.05	0.08	3-7
97	0.07	0.15	8-14
98	0.10	0.25	15-24
99	0.15	0.40	25-39
100	0.20	0.60	40-59
101	0.15	0.75	60-74
102	0.10	0.85	75-84
103	0.07	0.92	85-91
104	0.05	0.97	92-96
105	0.03	1.00	97-99
	1.00		

Stimulated data				
Day	**Random No.**	**Production**	**No.of cars waiting to be shipped**	**No. of empty space on the boat**
1	20	98	-	3
2	63	101	-	-
3	46	100	-	1
4	16	98	-	3
5	45	100	-	1
6	41	100	-	1
7	44	100	-	1
8	66	101	-	-
9	87	103	2	-
10	26	99	-	2
11	78	102	1	-
12	40	100	-	1
13	29	99	-	2
14	92	104	3	-
15	21	98	-	3
Total			6	18

Average no. of cars waiting to be shipped = 6/15 = 0.40

Average no. of empty space on the boat = 18/15 = 1.2

Illustration No. 6

A book store wishes to carry 'Ramayana' in stock. Demand is probabilistic and replenishment of stock takes 2 days (i.e. if an order is placed on March 1, it will be delivered at the end of the day on March 3). The probabilities of demand are given below

Demand (daily)	0	1	2	3	4
Probability	0.05	0.10	0.30	0.45	0.10

Each time an order is placed, the store incurs an ordering cost of Rs. 10 per order. The store also incurs a carrying cost of Rs. 0.50 per book per day. The inventory carrying cost in calculated on the basis of stock at the end of each day.

The manager of the bookstore wishes to compare two options for his inventory decision.

Order 5 books when the inventory at the beginning of the day plus order outstanding is less than 8 books.

Order 8 books when the inventory at the beginning of the day plus order outstanding is less than 8.

Currently (beginning 1st day) the store has a stock of 8 books plus 6 books ordered two days ago and expected to arrive next day.

Using Monte-Carlo Simulation for 10 cycles, recommend, which option the manager, should choose.

The two digit random numbers are given below:

89	34	70	63	61	81	39	16	13	73

Solution:

Demand	Probability	Cumulative Probability	Range
0	0.05	0.05	0-4
1	0.10	0.15	5-14
2	0.30	0.45	15-44
3	0.45	0.90	45-89
4	0.10	1.00	90-99

Option - A

Day	R No.	Demand	Option	Stock order	Closing Stock	Order Placed
1	89	3	8	-	5	-
2	34	2	5	6	9	-
3	70	3	9	-	6	0
4	63	3	6	-	3	5
5	61	3	3	0	0	-
6	81	3	0	5	2	5
7	39	2	2	-	0	5
8	16	2	0	5	3	-
9	13	1	3	5	7	-
10	73	3	7	-	4	5
					39+5=44	

Ordering cost 4 x 10	40
Ordering cost 0.5 x 44	22
Total Cost	62

Option B

Day	R No.	Demand	Option	Orders received	Closing Stock	No. of Orders
1	89	3	8	-	5	-
2	34	2	5	6	9	-
3	70	3	9	-	6	-
4	63	3	6	-	3	8
5	61	3	3	-	0	-
6	81	3	0	8	5	-
7	39	2	5	-	3	8
8	16	2	3	-	1	-
9	13	1	1	8	8	-
10	73	3	8	-	5	-
					45	

Ordering cost 2 x 10	20
Ordering cost 0.5 x 45	22.5
Total Cost	42.5

Option 'B' is better because it has low Inventory costs.

Illustration No. 7

After observing heavy congestion of customers over a period of time in a petrol station, Mr. Petro has decided to set up a petrol pump facility on his own in a nearby site. He has compiled statistics relating to the potential customer arrival pattern an service pattern as given below. He has also decided to evaluate the operations by using the simulation technique.

Arrivals		Services	
Inter-arrival time (minutes)	Probability	Inter-arrival time (minutes)	Probability
2	0.22	4	0.28
4	0.30	6	0.40
6	0.24	8	0.22
8	0.14	10	0.10
10	0.10		

Assume:

i) The clock starts at 8:00 hours

ii) Only one pump is set up.

iii) The following12 Random Numbers are to be used to depict the customer arrival pattern:

78, 26, 94, 08, 46, 63, 18, 35, 59, 12, 97 and 82.

iv) The following 12 Random Numbers are to be used to depict the service pattern:

44, 21, 73, 96, 63, 35, 57, 31, 84, 24, 05, 37

You are required to find out the

i) Probability of the pump being idle, and

ii) Average time spent by a customer waiting in queue.

Solution:

	Inter-arrival time				Service time		
	Probability	**Cumulative probability**	**Range**		**Probability**	**Cumulative probability**	**Range**
2	.22	.22	00-21	4	.28	.28	00-27
4	.30	.52	22-51	6	.40	.68	28-67
6	.24	.76	52-75	8	.22	.90	68-89
8	.14	.90	76-89	10	.10	1.00	90-99

Sl. No.	Random No. for inter arrival	Inter arrival time	Entry time in queue	Service start time	Random no for service.	Service time	Service end time	Waiting time of customer	Idle time
1	78	8	8.08	8.08	44	6	8.14	-	8
2	26	4	8.12	8.14	21	4	8.18	2	-
3	94	10	8.22	8.22	73	8	8.30	-	4
4	08	2	8.24	8.30	96	10	8.40	6	-
5	46	4	8.28	8.40	63	6	8.46	12	-
6	63	6	8.34	8.46	35	6	8.52	12	-
7	18	2	8.36	8.52	57	6	8.58	16	-
8	35	4	8.40	8.58	31	6	9.04	18	-
9	59	6	8.46	9.04	84	8	9.12	18	-
10	12	2	8.48	9.12	24	4	9.16	34	-
11	97	10	8.58	9.16	05	4	9.20	18	-
12	82	8	9.06	9.20	37	6	9.26	14	-
Total Validity Time								**140**	**12**

Average waiting time spent by the customer = 140/12 = 11.67 minutes

Probability of idle time of petrol station = 12/86 = 0.1395

EXERCISE PROBLEMS

Problem No. 1

A bakery keeps stock of a popular brand of cakes. Previous experience shows the daily demand pattern for the item with associated probabilities, as given:

Daily demand (Nos.)	0	10	20	30	40	50
Probability	0.01	0.20	0.15	0.50	0.12	0.02

Use the following sequence of random numbers to simulate the demand for next 10 days. Also find out the average demand per day

Random Numbers: 25, 39, 65, 76, 12, 05, 73, 89, 19, 49

Ans:

Average Demand per day = 24 Nos.

Problem No. 2

The Tit-Fit Scientific Laboratories is engaged in producing different types of high class equipment for use in science laboratories. The company has two different assembly lines to produce its most popular product 'Pressure'. The processing time for each of the assembly lines is regarded as a random variable and is described by the following distributions.

Process Time (minutes)	Assembly A1	Assembly A2
10	0.10	0.20
11	0.15	0.40
12	0.40	0.20
13	0.25	0.15
14	0.10	0.05

Using the following random numbers, generate data on the process times for 15 units of the item and compute the expected process time for the product. For the purpose, read the numbers vertically taking the first two digits for the processing time on assembly A1 and the last two digits for processing time on assembly A2.

4134	8343	3602	7505	7428
7476	1183	9445	0089	3424
4943	1915	5415	0880	9309

In the first stage, we assign random number intervals to the processing times on each of the assemblies.

Ans:

Expected process time for the product = 23.27 minutes (12 .20 + 11.07)

Problem No. 3

A plant has a large number of similar machines. The machines breakdown randomly and the breakdowns are independent of each other. Once a machine breaks down, it has to be taken out of production till the time it is repaired. On the basis of the past data, the following distributions have been constructed.

No. of Break downs per hour	Probability	No. of Hours Required for repair per break down	Probability
0	0.900	1	0.100
1	0.085	2	0.240
2	0.012	3	0.450
3	0.003	4	0.165
		5	0.040
		6	0.005

Each hour that a machine remains idle due to being, or waiting to be repaired, it costs the plant Rs 80 per hour by way of lost production. If a repairman is paid at Rs. 8 per hour, how many repairmen should be hired by the company to service the machine breakdowns? For the purpose, simulate the system for a 50 hour period and use the following random numbers, reading row-wise starting with the NW corner.

For breakdowns

100	375	084	990	128	660	310	852	635	737
985	118	834	886	995	654	801	743	699	098
914	803	441	125	636	611	154	945	424	235
044	005	359	598	460	321	692	195	451	948
980	331	809	797	186	740	541	116	483	690

For Repair times

765	648	196	093	801	340	455	020	053	035
672	121	099	195	981	783	389	421	125	623

Ans:

Two repair men should be hired which gives lower cost.

Problem No. 4

A businessman is considering taking over a certain new business. Based on past information and his own knowledge of the business, he works out the probability distribution of the monthly costs and sales revenues, as given here:

Cost (in Rs.)	Probability	Sales Revenue (Rs.)	Probability
17000	0.10	19000	0.10
18000	0.10	20000	0.10
19000	0.40	21000	0.20
20000	0.20	22000	0.40
21000	0.20	23000	0.15
		24000	0.05

Use the following sequences of random numbers to be used for estimating costs and revenues. Obtain the probability distribution of the monthly net revenue.

Sequence 1	82	84	28	82	36	92	73	91	63	29
	27	26	92	63	83	02	10	39	10	10
Sequence 2	39	72	38	29	71	83	19	72	92	59
	49	39	72	94	04	92	72	18	09	00

b. Repeat the analysis in (a) by using the following random number streams:

Sequence 1	20	63	46	16	45	41	44	66	87	26
	78	40	29	92	21	36	57	03	28	08
Sequence 2	23	57	99	84	51	29	41	11	66	30
	41	80	62	74	64	26	41	40	97	15

(e) Life Cycle Costing & Replacement

Illustration 1 – In Organic Chemicals Ltd. is about to replace its old boiler equipment, either by a coal-fired system or by an oil-fired system. Finance costs 15% a year, and other estimated costs are as follows :

(Rs. '000)

	Coal	Oil
Initial cost of boiler	70	100
Annual operating costs	60 p.a.	45 p.a.

If the company expected the new boiler system to last at least fifteen years, which system should be chosen?

Solution:

On the basis of initial cost only, the company would choose coal. But coal's lifetime costs are much higher than oils as we can see when we include the discounted annual operating costs of each system :

(Rs. '000)

	Coal	Oil
Initial cost of boiler	70	100
Annual operating costs *	351	263
Total life cycle costs	421	363

Annual costs × 5.847 [Annuity at 15%]

On this basis, oil is clearly much cheaper than coal. Unless there are other overriding considerations favouring coal, oil fired Boiler should be chosen.

If the decision seemed closer, it might be useful to try sensitivity analysis. How much would fuel costs need to change to alter the decision? What difference would it make if the life were much shorter (or much longer) than fifteen years? What if the discount rate were significantly different from 15% a year?

Illustration 2 – A company is considering a cost saving project. This involves purchasing a machine costing Rs. 7,000, which will result in annual savings on wage costs of Rs. 1,000 and on material costs of Rs. 400.

The cost of capital of the company, is 15%.

The following forecasts are made of the rates of inflation each year for the next 5 years :

Wages costs	10%
Material costs	5%
General prices	6%

Evaluate the project, assuming that the machine has a life of 5 years and no scrap value.

Calculation of net present value

Year Rs.	Labour cost saving Saving (Rs.)	Material cost (Rs.)	Total savings @ 15%	DCF Rs.	Present values
1	$1000\times(1.1) = 1{,}100$	$400 \times (1.05) = 420$	1,520	0.870	1.322
2	$1000\times(1.1)^2 = 1{,}210$	$400 \times (1.05)^2 = 441$	1,651	0.756	1.255
3	$1000\times(1.1)^3 = 1{,}331$	$400 \times (1.05)^3 = 463$	1,794	0.658	1.184
4	$1000\times(1.1)^4 = 1{,}464$	$400 \times (1.05)^4 = 486$	1,950	0.572	1.112
5	$1000\times(1.1)^5 = 1{,}610$	$400 \times (1.05)^5 = 510$	1,120	0.497	1.060
Present value of total savings					5,933
Less : Initial cash outflow					7,000
Net Present Value (Negative)					(–) 1,067

Analysis : Since the present value of cost of project exceeds the cost of savings from it and hence it is not suggested to purchase the machine.

EXERCISE PROBLEMS

Problem No. 1

A machine owner finds from his past experience that cost per year of maintenance of a machine whose purchase price is Rs.6,000/- are as given below:

Year:	1	2	3	4	5	6	7	8
Maintenance Cost (Rs.):	1,000	1,200	1,400	1,800	2,300	2,800	3,400	4,000
Resale price (Rs.):	3,000	1,500	750	375	200	200	200	200

At what age is replacement due?

Problem No.2

The data on the operating costs per year and resale prices of equipment A whose purchase price is Rs.10,000 are given here:

Year:	1	2	3	4	5	6	7
Operating Cost (Rs.):	1500	1900	2300	2900	3600	4500	5500
Resale Value (Rs.):	5000	2500	1250	600	400	400	400

a) What is the optimum period for replacement?

b) When equipment A is 2 years old, equipment B, which is a new model for the same usage, is available. The optimum period for replacement is 4 years with an average cost of Rs.3600. Should we change equipment A with that of B? If so, when?

Problem No.3

A firm has a machine whose purchase price is Rs.20,000. Its maintenance cost and resale price at the end of different years are as given here:

Year:	1	2	3	4	5	6
Maintenance Cost:	1500	1700	2000	2500	3500	5500
Resale Price:	17000	15300	14000	12000	8000	3000

a) Obtain the economic life of the machine and the minimum average cost.

b) The firm has obtained a contract to supply the goods produced by the machine, for a period of 5 years from now. After this time period, the firm does not intend to use the machine. If the firm has a machine of this type that is one year old, what the machine. If the firm has a machine of this type that is one year old, what replacement policy should it adopt if it intends to replace the machine not more than replacement policy should it adopt if it intends to replace the machine not more than once?

Problem No.4

A large computer installation contains 2,000 components of identical nature which are subject to failure as per probability distribution that follows:

Month End:	1	2	3	4	5
% Failure to date:	10	25	50	80	100

Components which fail have to be replaced for efficient functioning of the system. If they are replaced as and when failures occur, the cost of replacement per unit is Rs.3. Alternatively, if all components are replaced in one lot at periodical intervals and individually replace only such failures as occur between group replacement, the cost of component replaced is Re 1.

a) Assess which policy of replacement would be economical.

b) If group replacement is economical at current costs, then assess at what cost of individual replacement would group replacement be uneconomical.

c) How high can the cost per unit in-group replacement be to make a preference for individual replacement policy?

Problem No.5

An electro-mechanical equipment has a purchase price of Rs.7,000. Its running costs per year and resale values are given here:

Year:	1	2	3	4	5	6	7	8
Running Costs (Rs.)	2,000	2,100	2,300	2,600	3,000	3,500	4,100	4,600
Resale Value (Rs.)	4,000	3,000	2,200	1,600	1,400	700	700	700

At which year is the replacement due?

Problem No.6

Goodlite Company has installed 200 electric bulbs of a certain brand. The company follows the policy of replacing the bulbs as and when they fail. Each replacement costs Rs. 2. The probability distribution of the life of the bulbs is as given here:

Life of Bulb (Weeks):	1	2	3	4	5
% of Bulbs	0.10	0.30	0.45	0.10	0.05

Determine the cost/week of the replacement policy in the long run.

STUDY NOTE - 5

Enterprise Performance Measurement System

This Study Note includes

- Balanced Scorecard

5.1 Balanced Scorecard

5.1.1 Definition

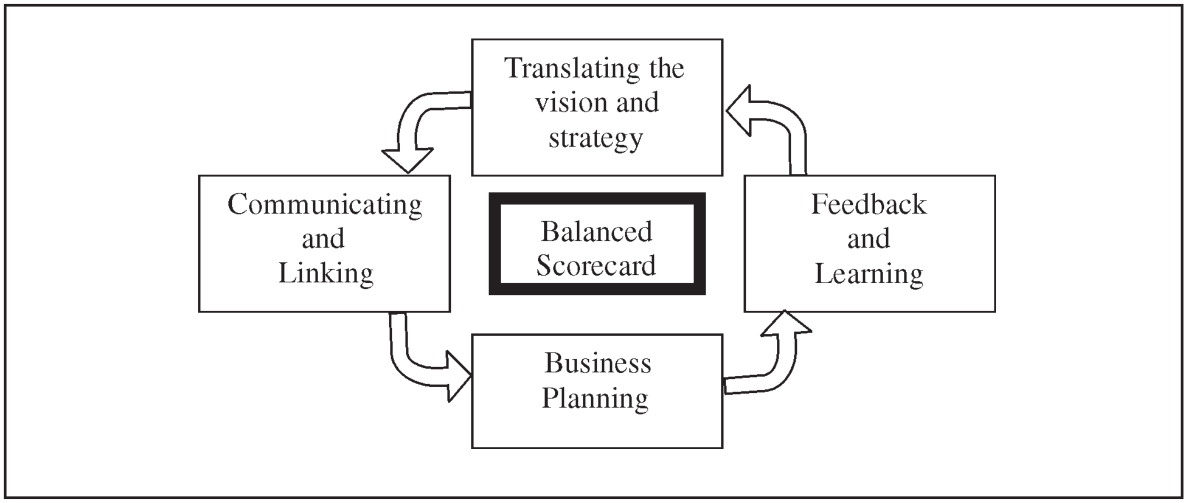
Balanced Scorecard (BSC) is a new approach to Strategic Management which was developed by Robert Kaplan and David Norton. It is a performance management and strategy deployment methodology that helps executives translate an organization's mission statement and overall business strategy into specific, quantifiable goals and monitors the organization's performance in terms of these goals. The BSC also aligns budgets to strategy and helps in developing an enterprise performance management system.

Kaplan and Norton describe the innovation of the balanced scorecard as follows:

"The balanced scorecard retains traditional financial measures. But financial measures tell the story of past events, an adequate story for industrial age companies for which investments in long-term capabilities and customer relationships were not critical for success. These financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology, and innovation."

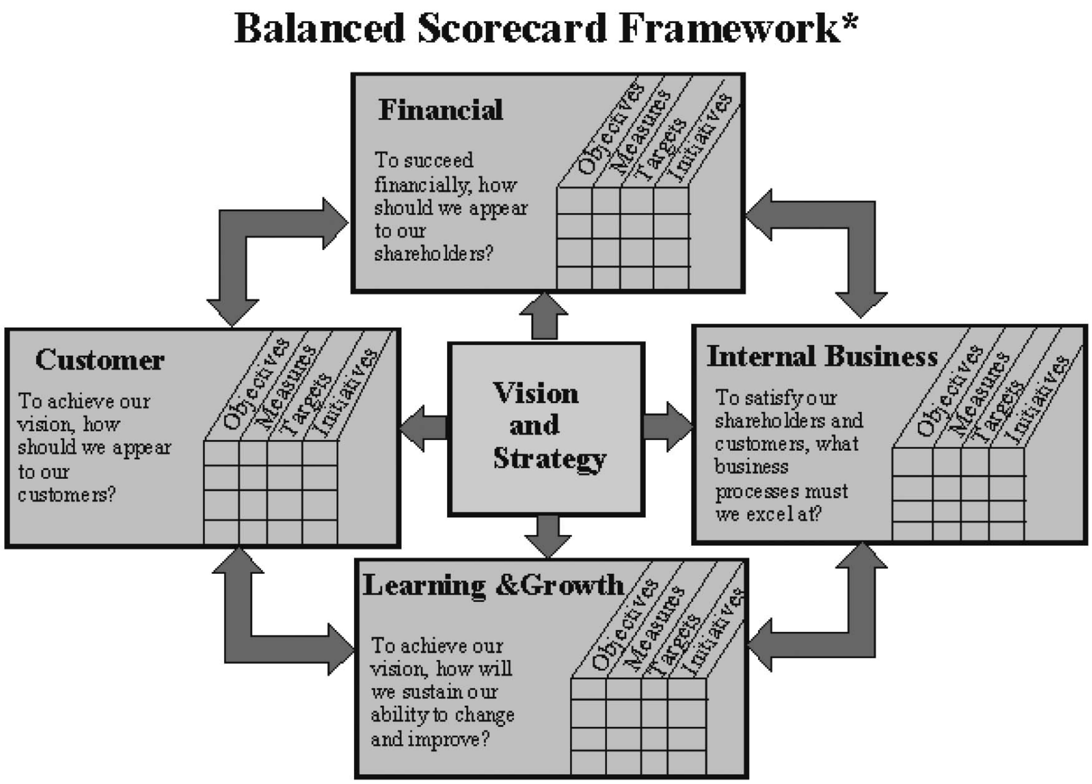
Indeed BSC is a way "to translate strategy into action", as depicted in the figure below:

Strategic Management System



5.1.2 Four Perspectives

The BSC suggests that we take a holistic view of the organization and look at it from four perspectives and develop metrics to collect data and analyze it relative to each of these perspectives



* Adapted Kaplan & Norton 1996. The Balanced Scorecard. Harvard Business School Press : 9. Original from HBR Jan/Feb 1996,p.76.

The Customer Perspective

Recent management philosophy has shown an increasing realization of the importance of customer focus and customer satisfaction in any business. These are leading indicators. If customers are not satisfied, they will eventually find other suppliers that will meet their needs. Poor performance from this perspective is thus a leading indicator of future decline, even though the current financial picture may look good.

In developing metrics for satisfaction, customers should be analyzed in terms of kinds of customers and the kinds of processes for which we are providing a product or service to those customer groups.

The Business Process Perspective

This perspective refers to internal business processes. Metrics based on this perspective allow the managers to know how well the business is running, and whether its products and services conform to customer requirements (the mission). These metrics have to be carefully designed by those who know these processes most intimately; with our unique missions these are not something that can be developed by outside consultants.

In addition to the strategic management process, two kinds of business processes may be identified:

a) mission-oriented processes, and

b) support processes.

Mission-oriented processes are the special functions and many unique problems are encountered in these processes. The support processes are more repetitive in nature and hence easier to measure and benchmark using generic metrics.

The learning and growth perspective

This perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. In a knowledge-worker organization, people – the only repository of knowledge – are the main resource. In the current climate of rapid technological change, it is becoming necessary for knowledge workers to be in a continuous learning mode. Metrics can be put in place to guide managers in focusing training funds where they can help the most. In any case, learning and growth constitute the essential foundation for success of any knowledge-worker organization.

The emerging realization is that “learning” is more than “training”; It also includes things like mentors and tutors within the organization, as well as that ease of communication among workers that allows them to readily get help on a problem when it is needed. It also includes technological tools like the Intranet.

The financial perspective

This does not disregard the traditional need for financial data. Timely and accurate funding data will always be a priority, and managers will do whatever necessary to provide it. In fact, often there is more than enough handling and processing of financial data. With the implementation of a corporate database, it is hoped that more of the processing can be centralized and automated. But the point is that the current emphasis on financials leads to the “unbalanced” situation with regard to other perspectives.

5.1.3 Performance Measures

A list of suggested measures that drive performance under each of the four perspectives, as given by Robert Kaplan & David Norton is noted below:

Financial Perspective	
Goals	Measures
Survive	Cash flow
Succeed	Quarterly sales growth and operating income by division
Prosper	Increase market share and ROE

Customer Perspective	
Goals	Measures
New Product	Percent of sales from new Products Percent of sales from Proprietary products
Responsive supply	On-time delivery
Preferred accounts	Share of key
Supplier	purchases Ranking by key accounts
Customer Partnership	Time with customers

Internal Business Perspective	
Goals	Measures
Technology	Manufacturing geometry
Capability	Vs competition
Manufacturing	Cycle time
Excellence	Unit cost
	Yield
Design	Silicon efficiency
Productivity	Engineering efficiency
New product introduction	Actual introduction schedule Vs. Plan

Internal Business Perspective	
Goals	Measures
Technology Leadership	Time to develop next generation
Manufacturing Learning	Process time to maturity
Product focus	Percent of products that equal 80% sales
Time to Market	New product Introduction Vs. Competition

5.1.4 Characteristics of Measures

a) The measures can be classified as "Lead Indicators" and "Lag Indicators". A lead indicator such as time spent with customers on product development cycle that drive performance are known as lead indicators. A lag indicator is an outcome measures and tells only what has happened in the past.

b) The BSC includes both financial and non-financial parameters. In fact the non-financial parameters are dominant because it is these measures that are a guide to the actual performance.

c) Both internal and external information is built into the system and thus influences that are operating in the environment are brought into the organization.

d) The cause and effect relationship is clearly brought about through the balanced scorecard as given below:

Balanced Scorecard Perspectives

Satisfied and loyal Customers lead to Increased revenues.	Financial Results
Improved processes Lead to improved products And services for customers.	Customer Satisfaction
Skilled, creative employees question the status quo and work to improve business Process	Business processes.
Learning and Growth of employees is the foundation for innovation and creativity.	Learning and growth

e) **Key Metrics:** You can't improve what you can't measure. So metrics must be developed based on the priorities of the strategic plan, which provides the key business drivers and criteria for metrics managers most desire to watch. Processes are then designed to collect information relevant to these metrics and reduce it to numerical form for storage, display, and analysis. Decision makers examine the outcomes of various measured processes and strategies and track the results to guide the company and provide feedback.

So the value of metrics is in their ability to provide a factual basis for defining.

- Strategic feedback to show the present status of the organization from many perspectives for decision makers.
- Diagnostic feedback into various processes to guide improvements on a continuous basis.
- Trends in performance over time as the metrics are tracked.
- Feedback around the measurement methods themselves, and which metrics should be tracked.
- Quantitative inputs to forecasting methods and models for decision support systems.

The Key Performance Indicators in the balanced scorecard serve as a dashboard or control panel to facilitate the safe and smooth navigation of an organization through a turbulent environment.

5.1.5 Application in Private Sector

BSC has been very successfully applied in a number of private sector companies throughout the world. In India, Tata Motors was the first company to win the BSC Hall of Fame award.

BSC adoption rate is 45% in corporate India which compares favourably with 44% in US as per an IIM, Ahmedabad research study.

Case Study in BSC:

The application of BSC in Air Deccan is given below:

Air Deccan is a low cost airline which has been able to compete with Full Service Airlines (FSA) by adopting the following cost saving measures.

1. **Food Cost**: Food is not provided on board since domestic flights are of a short duration.
2. **Extra Seats**: Since no food is provided, no space is required for storing meals, which could be utilized for providing extra seats. Further the size of the seats were slightly reduced. Hence it was possible to provide 180 seats as against 140 seats in FSA.
3. **Turnaround Time Management**: Turnaround time is reduced to 20 minutes only since the time for loading and unloading of meals is saved along with cleaning time, thereby giving more flying hours.
4. **Sale of Tickets**: This is done through websites and call centers, eliminating travel agents. With the booking number, passengers get the boarding pass at the airport and the printing charge of tickets is saved.
5. **Repair and Maintenance Cost**: The Company has a single type of aircraft in its fleet and hence inventory of spares is optimized. This function is also outsourced to economize on cost.
6. **Pricing Strategy**: Apart from low fares, the Company offered various incentive packages to passengers like frequent flier scheme etc.

   Source: The above data was taken from an article titled Cost Management in the Competitive Environment: A Case Study of Air Deccan written by Dr. Mukesh Chauhan which appeared in the Management Accountant, September 2007, Vol.42 No.9.

   From the above data a Strategy Map and Balanced Scorecard have been drawn as an illustration – vide figures 1 and 2.

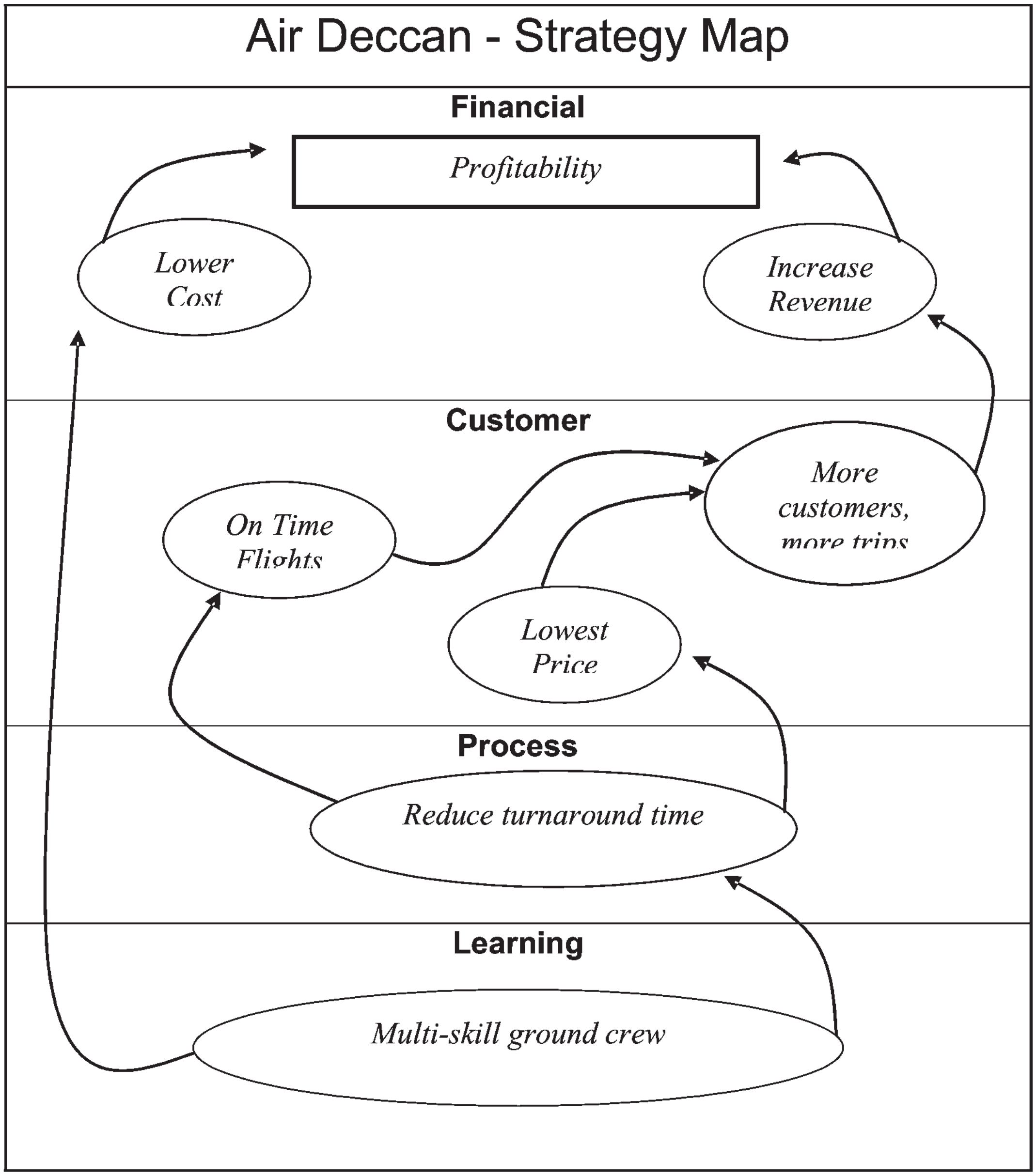


Fig. 1. Strategy Map

AIR DECCAN Scorecard

Customer

GOAL	PERFORMANCE METRIC
1. Lowest Price	1. Benchmarked Price
2. On-Time Flights	2. On-Time Arrival Rating
ACTION PLAN	**TARGET**
1. Special Fares and Customer Loyalty Programs	1. #1 in the market segment
2. Rewards for On-Time Performance	2. 98% On-Time Arrivals

Internal Processes

GOAL	PERFORMANCE METRIC
Maximize air time	Ground Turnaround Time
ACTION PLAN	**TARGET**
Cycle Time Optimization Program	25 minutes

Financial

GOAL	PERFORMANCE METRIC
1. Higher Revenue	1. Revenue Per Passenger Kilometer (RPKM)
2. Lower Cost	2. Fleet Lease Cost
ACTION PLAN	**TARGET**
1. Route Optimization	1. 15% increase in Y-o-Y RPKM
2. Fewer planes in the fleet	2. 5% reduction Y-0-Y in Fleet Lease cost

Learning

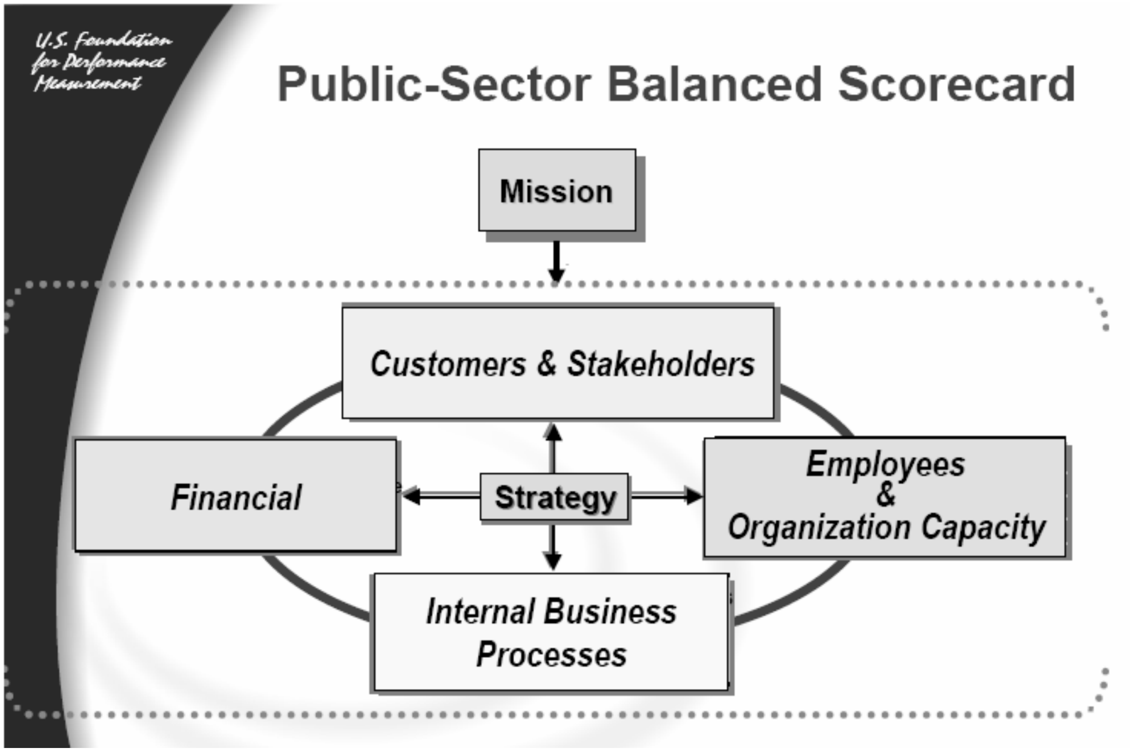
GOAL	PERFORMANCE METRIC
Employee skill enrichment	Ground crew training in cross-skills
ACTION PLAN	**TARGET**
Outsource training to expert agency	200 employees per year

Fig. 2. Balanced Scorecard

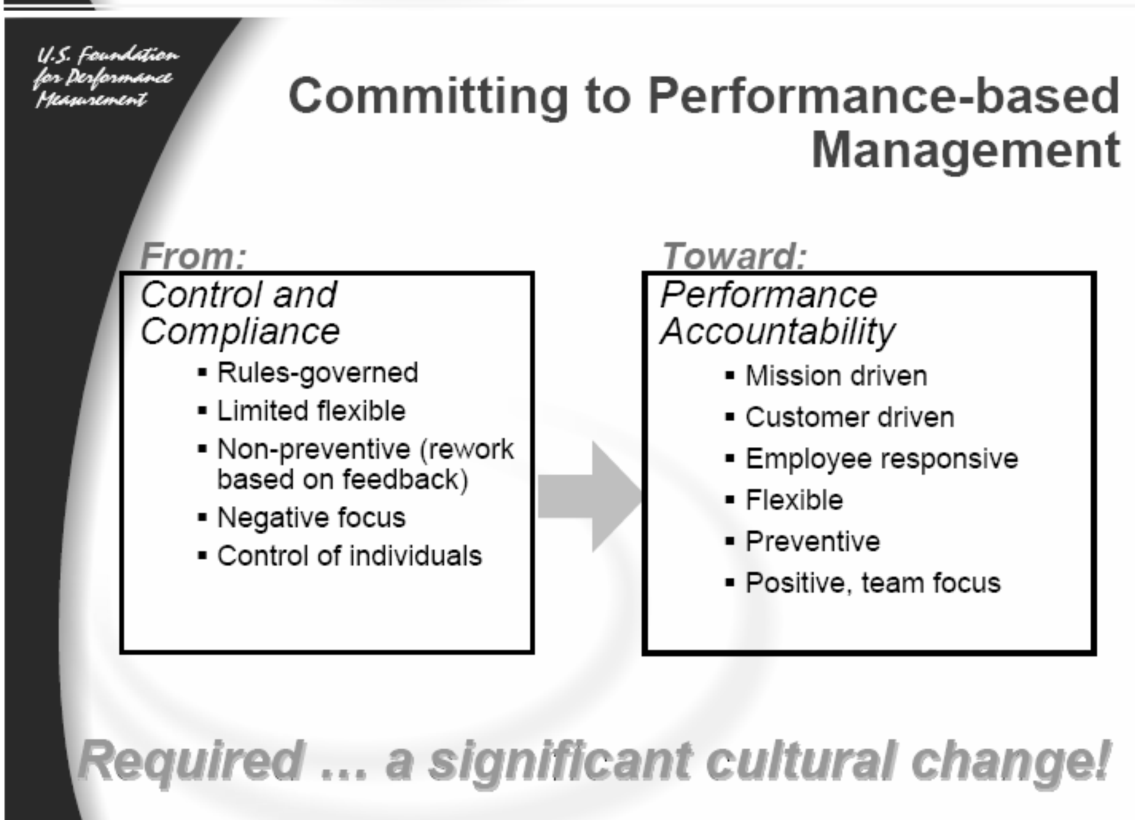
5.1.6 Application in Government Sector

The application in Government Sector (known as public sector in US) as given by Howard Rohm, Vice-President, The Balanced Scorecard Institute and Director, US Foundation for Performance Management is reproduced below:

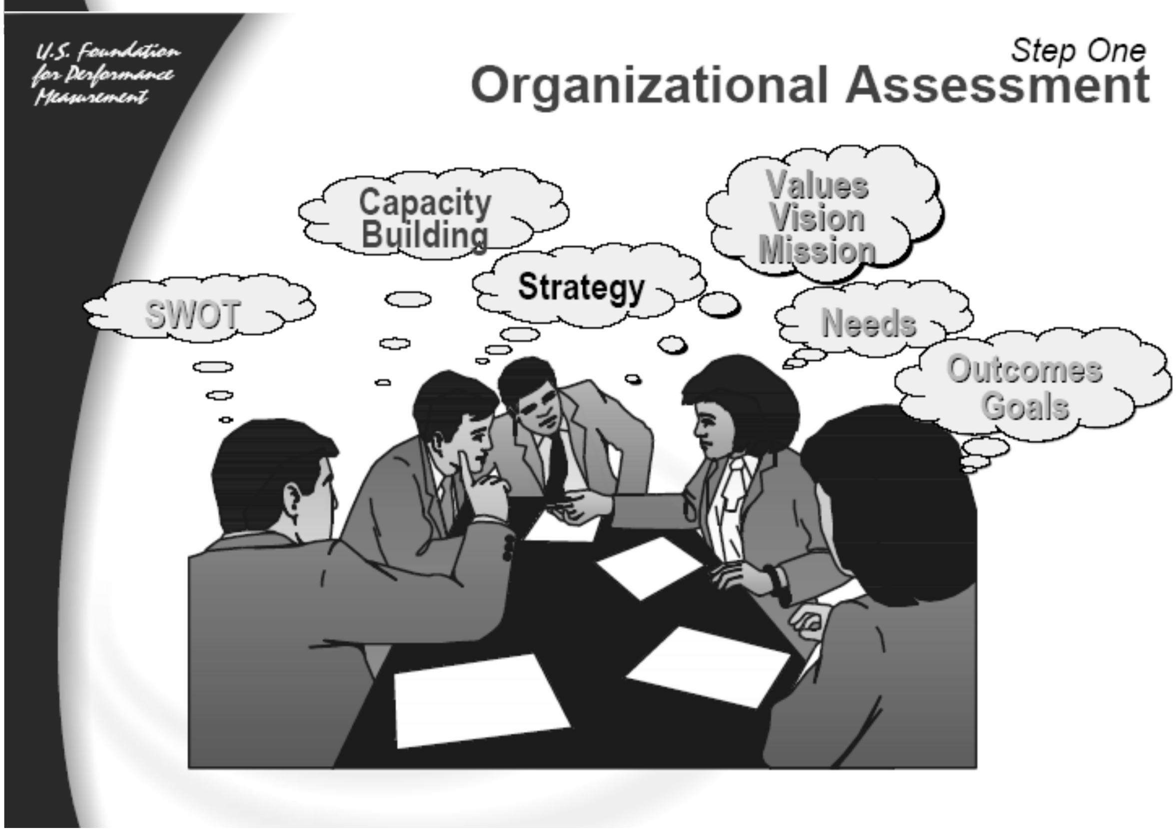
Source: www.balancedscorecard.org

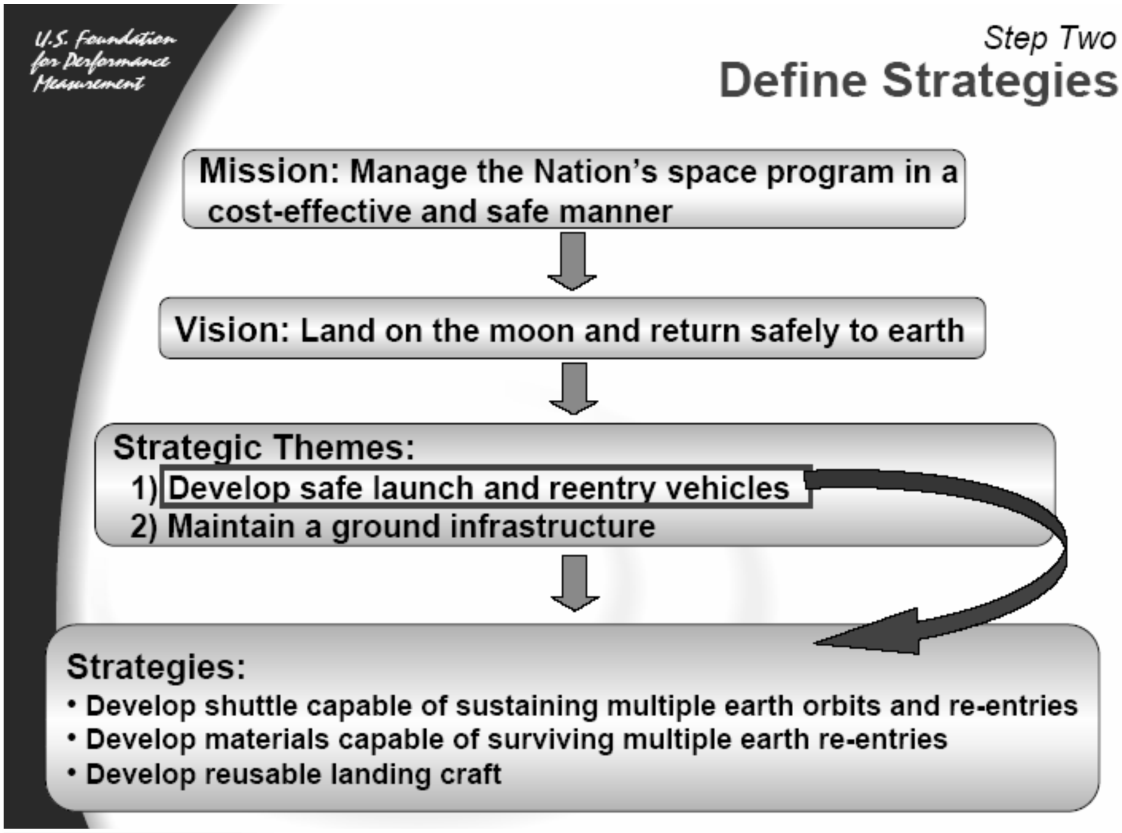


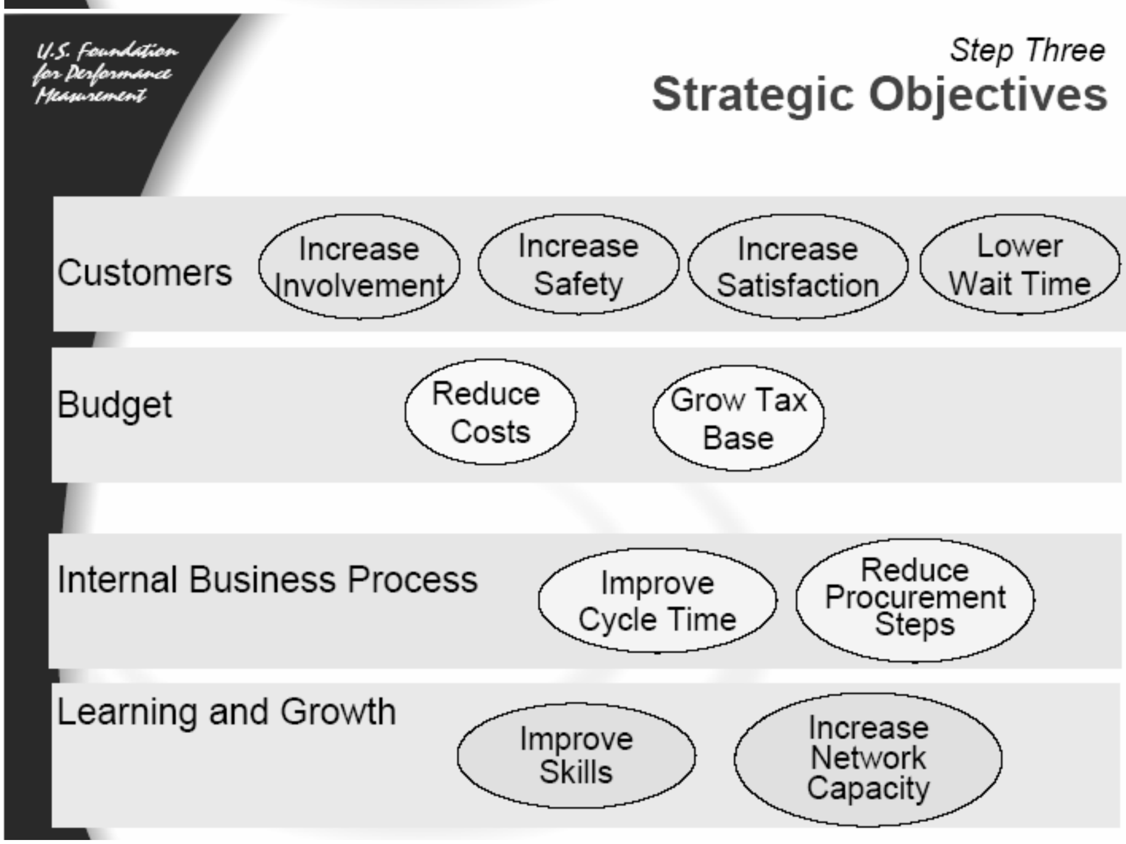

U.S. Foundation for Performance Measurement
Balanced Scorecard Logic
Customers
Mission
Vision
Core Values
Goals
Perspectives
STRATEGY
Focus Areas
Strategic Map
Objectives
Measures
Targets
Initiatives

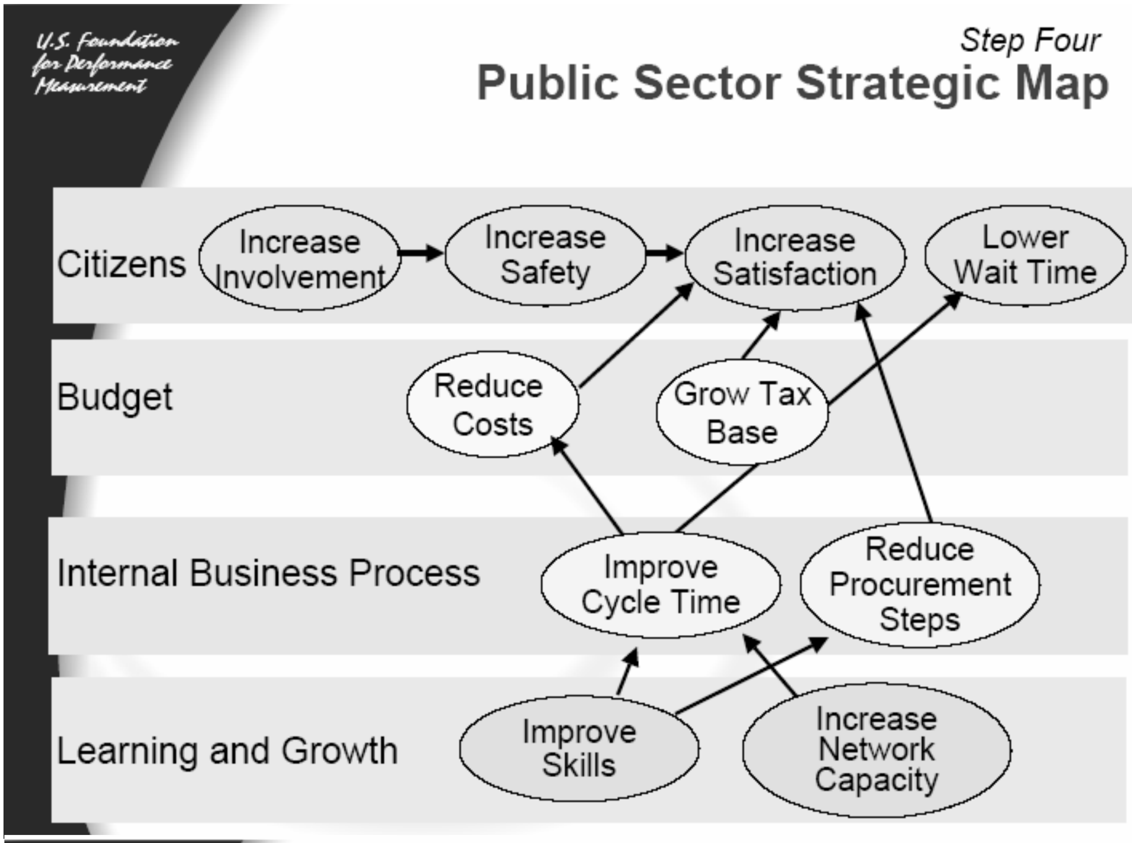

U.S. Foundation for Performance Measurement
Committing to Performance-based Management
From:
Control and Compliance
Rules-governed
Limited flexible
Non-preventive (rework based on feedback)
Negative focus
Control of individuals
Toward:
Performance Accountability
Mission driven
Customer driven
Employee responsive
Flexible
Preventive
Positive, team focus
Required … a significant cultural change!

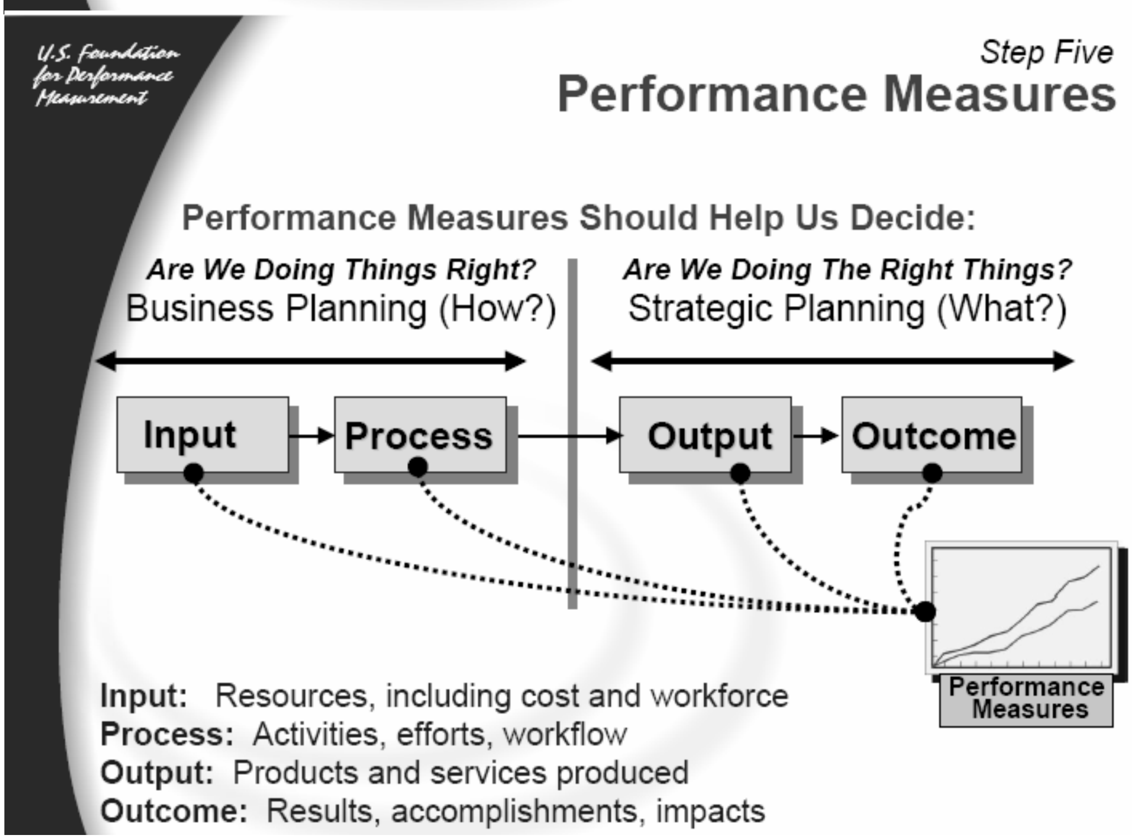

U.S. Foundation for Performance Measurement
Balanced Scorecard Methodology: Nine Steps To Success
Assessment
Evaluation
Cascade
Automation
Initiatives
Performance Measures
Strategic Map
Objectives
Strategy
Financial
Internal Processes
Learning & Growth
Customers
Mission Strategy

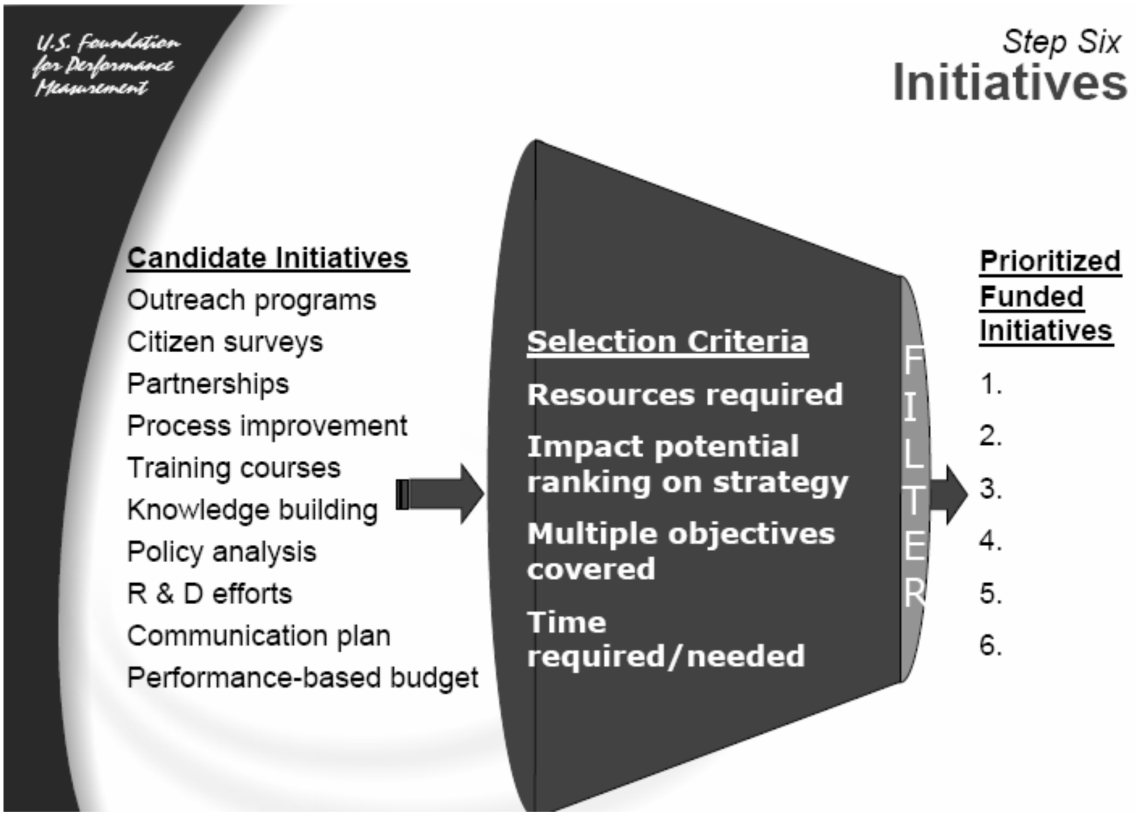

U.S. Foundation for Performance Measurement
Step One
Organizational Assessment
Capacity Building
Values Vision Mission
Strategy
SWOT
Needs
Outcomes Goals

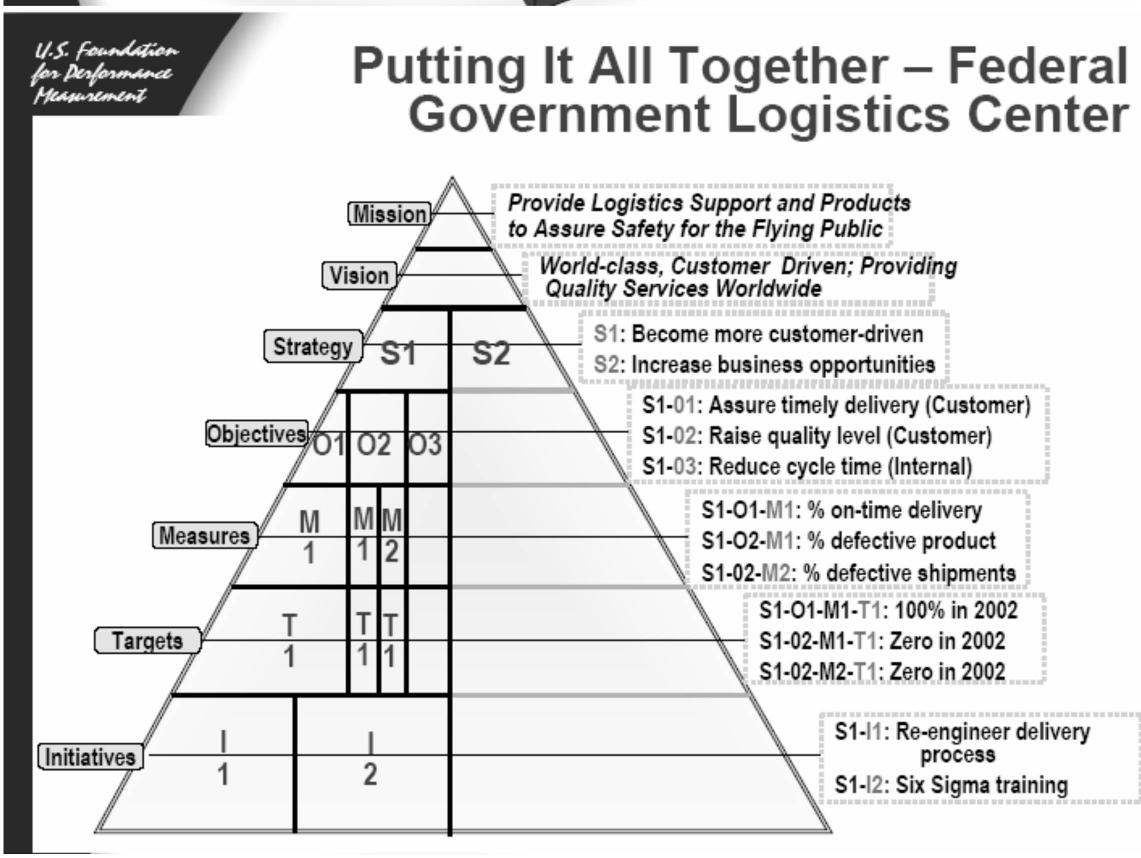

U.S. Foundation for Performance Measurement
Step Two
Define Strategies
Mission: Manage the Nation's space program in a cost-effective and safe manner
Vision: Land on the moon and return safely to earth
Strategic Themes:
1) Develop safe launch and reentry vehicles
2) Maintain a ground infrastructure
Strategies:
• Develop shuttle capable of sustaining multiple earth orbits and re-entries
• Develop materials capable of surviving multiple earth re-entries
• Develop reusable landing craft

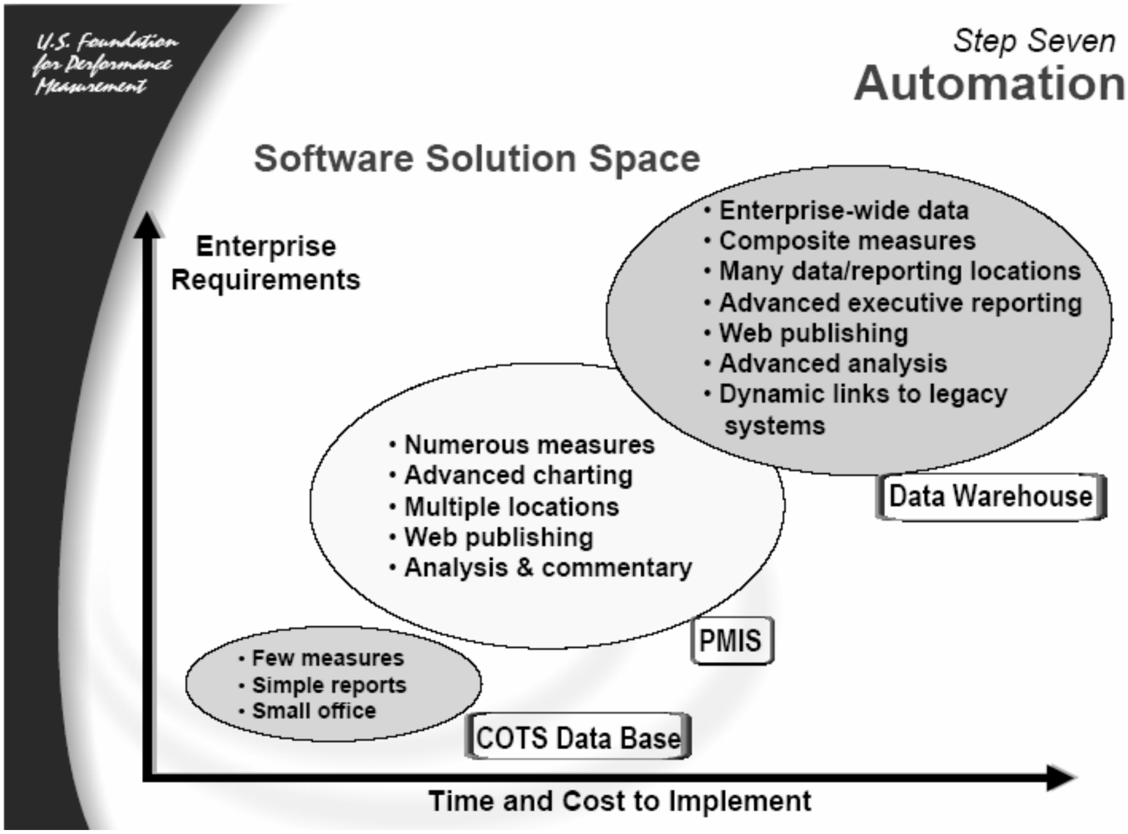

U.S. Foundation for Performance Measurement
Step Three
Strategic Objectives
Customers
Increase Involvement
Increase Safety
Increase Satisfaction
Lower Wait Time
Budget
Reduce Costs
Grow Tax Base
Internal Business Process
Improve Cycle Time
Reduce Procurement Steps
Learning and Growth
Improve Skills
Increase Network Capacity

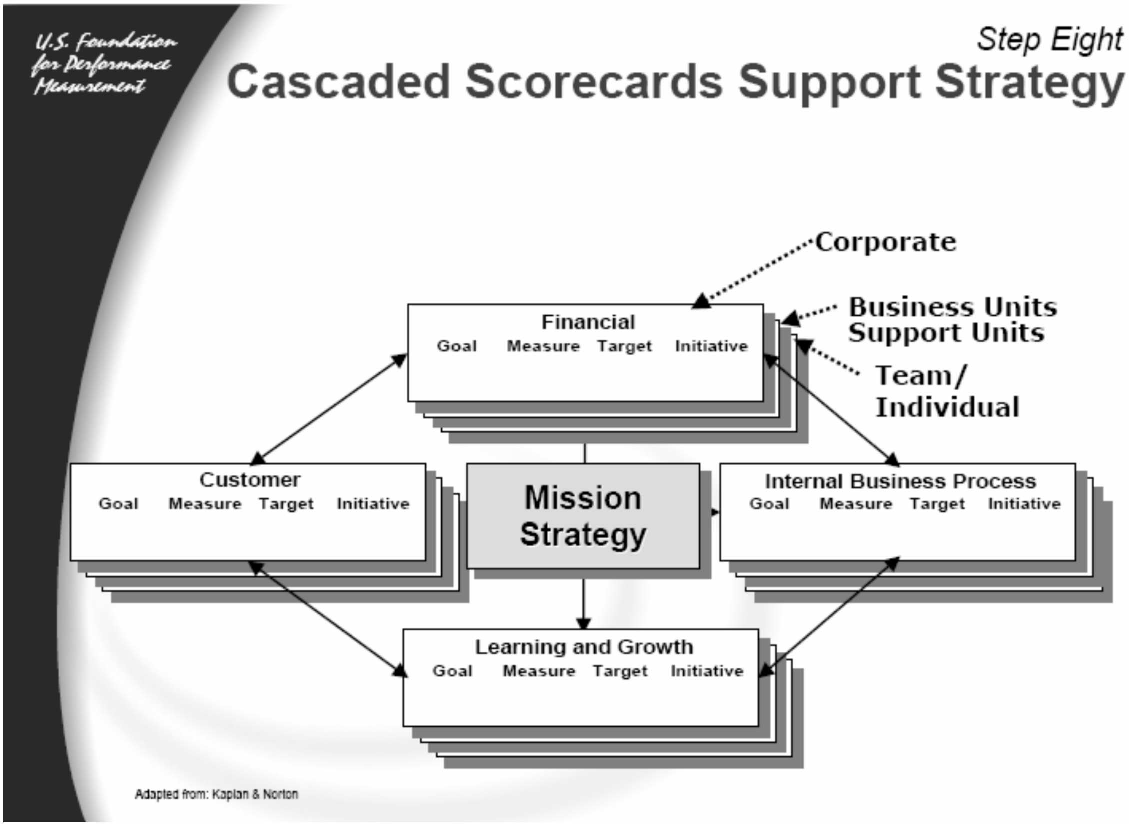

U.S. Foundation for Performance Measurement
Step Four
Public Sector Strategic Map
Citizens
Increase Involvement
Increase Safety
Increase Satisfaction
Lower Wait Time
Budget
Reduce Costs
Grow Tax Base
Internal Business Process
Improve Cycle Time
Reduce Procurement Steps
Learning and Growth
Improve Skills
Increase Network Capacity

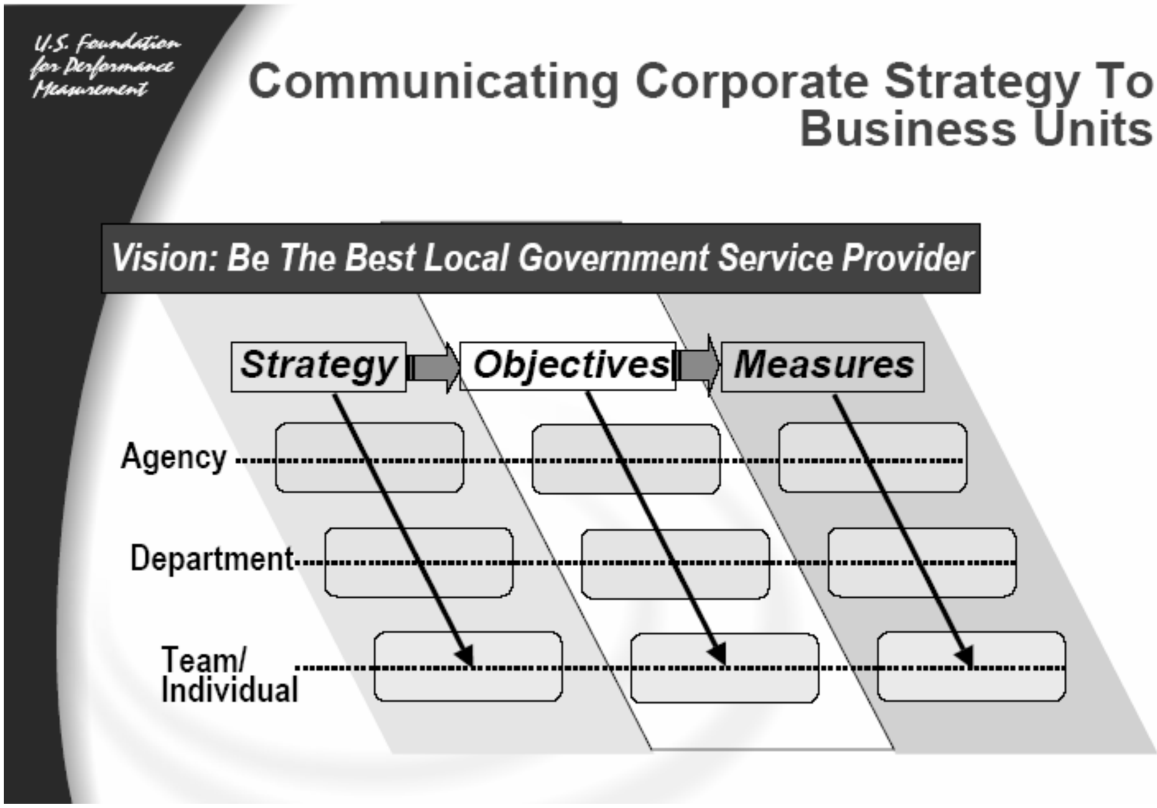

U.S. Foundation for Performance Measurement
Step Five
Performance Measures
Performance Measures Should Help Us Decide:
Are We Doing Things Right?
Business Planning (How?)
Are We Doing The Right Things?
Strategic Planning (What?)
Input
Process
Output
Outcome
Performance Measures
Input: Resources, including cost and workforce
Process: Activities, efforts, workflow
Output: Products and services produced
Outcome: Results, accomplishments, impacts

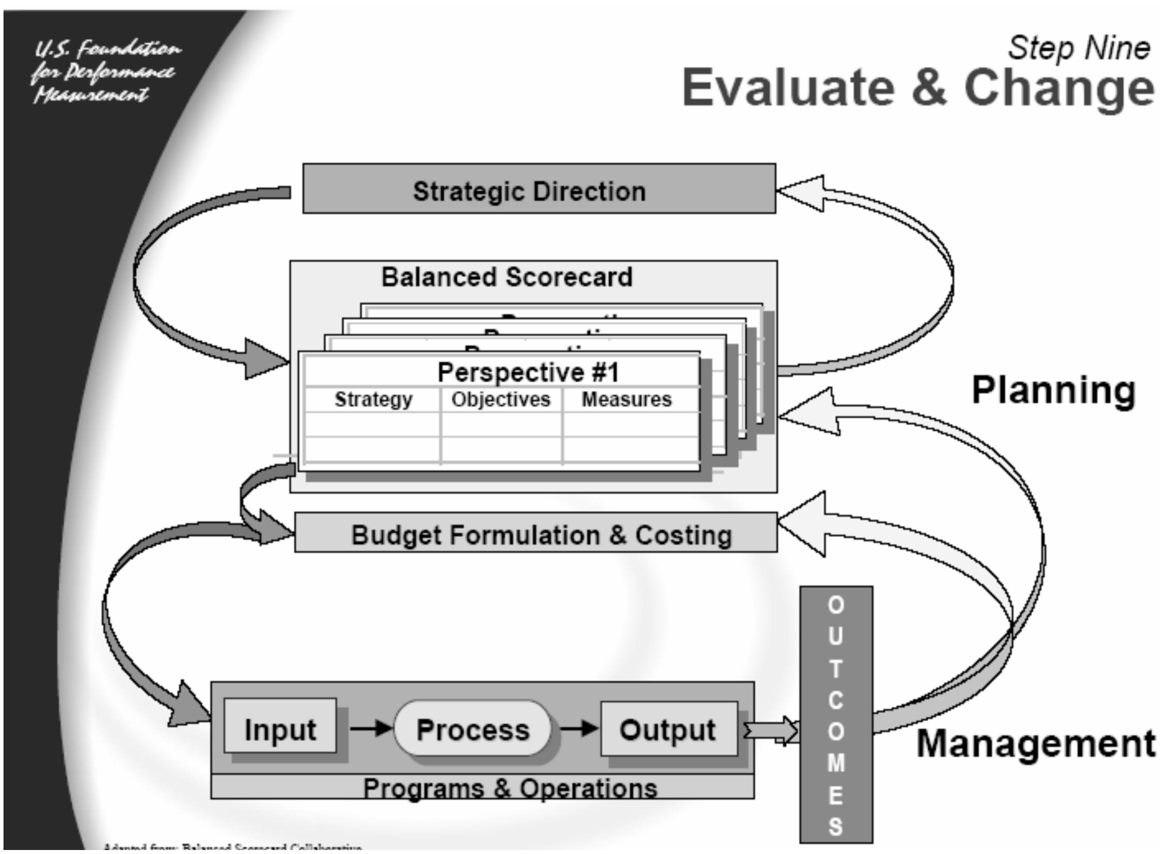

U.S. Foundation for Performance Measurement
Step Six
Initiatives
Candidate Initiatives
Outreach programs
Citizen surveys
Partnerships
Process improvement
Training courses
Knowledge building
Policy analysis
R & D efforts
Communication plan
Performance-based budget
Selection Criteria
Resources required
Impact potential ranking on strategy
Multiple objectives covered
Time required/needed
FILTER
Prioritized Funded Initiatives
1.
2.
3.
4.
5.
6.


U.S. Foundation for Performance Measurement
Putting It All Together – Federal Government Logistics Center
Mission
Provide Logistics Support and Products to Assure Safety for the Flying Public
Vision
World-class, Customer Driven; Providing Quality Services Worldwide
Strategy
S1
S2
S1: Become more customer-driven
S2: Increase business opportunities
Objectives
O1 O2 O3
S1-01: Assure timely delivery (Customer)
S1-02: Raise quality level (Customer)
S1-03: Reduce cycle time (Internal)
Measures
M 1
M 1
M 2
S1-O1-M1: % on-time delivery
S1-O2-M1: % defective product
S1-02-M2: % defective shipments
Targets
T 1
T 1
T 1
S1-O1-M1-T1: 100% in 2002
S1-02-M1-T1: Zero in 2002
S1-02-M2-T1: Zero in 2002
Initiatives
I 1
I 2
S1-I1: Re-engineer delivery process
S1-I2: Six Sigma training

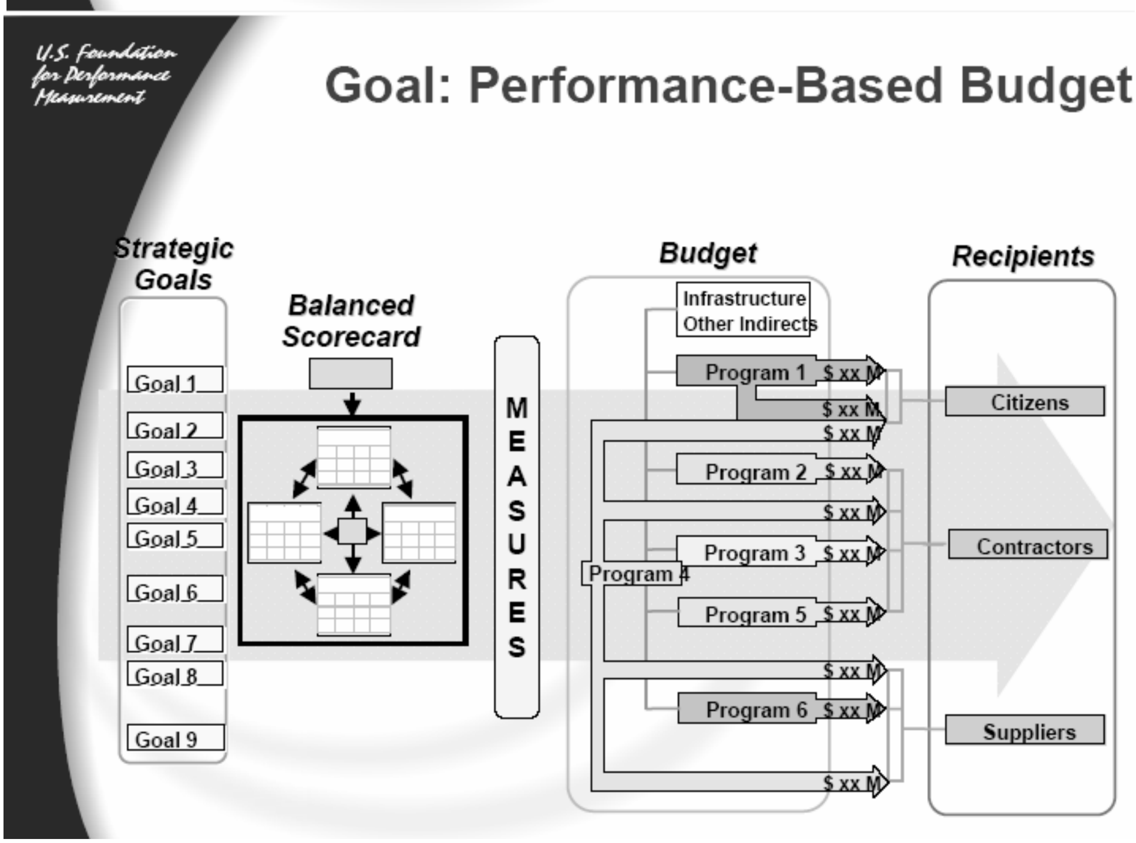

U.S. Foundation for Performance Measurement
Step Seven
Automation
Software Solution Space
Enterprise Requirements
• Enterprise-wide data
• Composite measures
• Many data/reporting locations
• Advanced executive reporting
• Web publishing
• Advanced analysis
• Dynamic links to legacy systems
Data Warehouse
• Numerous measures
• Advanced charting
• Multiple locations
• Web publishing
• Analysis & commentary
PMIS
• Few measures
• Simple reports
• Small office
COTS Data Base
Time and Cost to Implement


U.S. Foundation for Performance Measurement
Step Eight
Cascaded Scorecards Support Strategy
Corporate
Business Units
Support Units
Team/ Individual
Financial
Goal Measure Target Initiative
Customer
Goal Measure Target Initiative
Mission Strategy
Internal Business Process
Goal Measure Target Initiative
Learning and Growth
Goal Measure Target Initiative
Adapted from: Kaplan & Norton


U.S. Foundation for Performance Measurement
Communicating Corporate Strategy To Business Units
Vision: Be The Best Local Government Service Provider
Strategy
Objectives
Measures
Agency
Department
Team/ Individual


U.S. Foundation for Performance Measurement
Step Nine
Evaluate & Change
Strategic Direction
Balanced Scorecard
Perspective #1
Strategy
Objectives
Measures
Planning
Budget Formulation & Costing
OUTCOMES
Input
Process
Output
Programs & Operations
Management


U.S. Foundation for Performance Measurement
The BSC Is The Strategic "Front-End" Of Managing-For-Results
Corporate BSC
Strategic Planning
Department BSC
Program/Service Area Planning
Evaluation
Results
Accountability
Performance Measures
Measure Performance
Budget


U.S. Foundation for Performance Measurement
Goal: Performance-Based Budget
Strategic Goals
Goal 1
Goal 2
Goal 3
Goal 4
Goal 5
Goal 6
Goal 7
Goal 8
Goal 9
Balanced Scorecard
MEASURES
Budget
Infrastructure Other Indirects
Program 1
Program 2
Program 3
Program 4
Program 5
Program 6
$ xx M
Recipients
Citizens
Contractors
Suppliers

U.S. Foundation for Performance Measurement

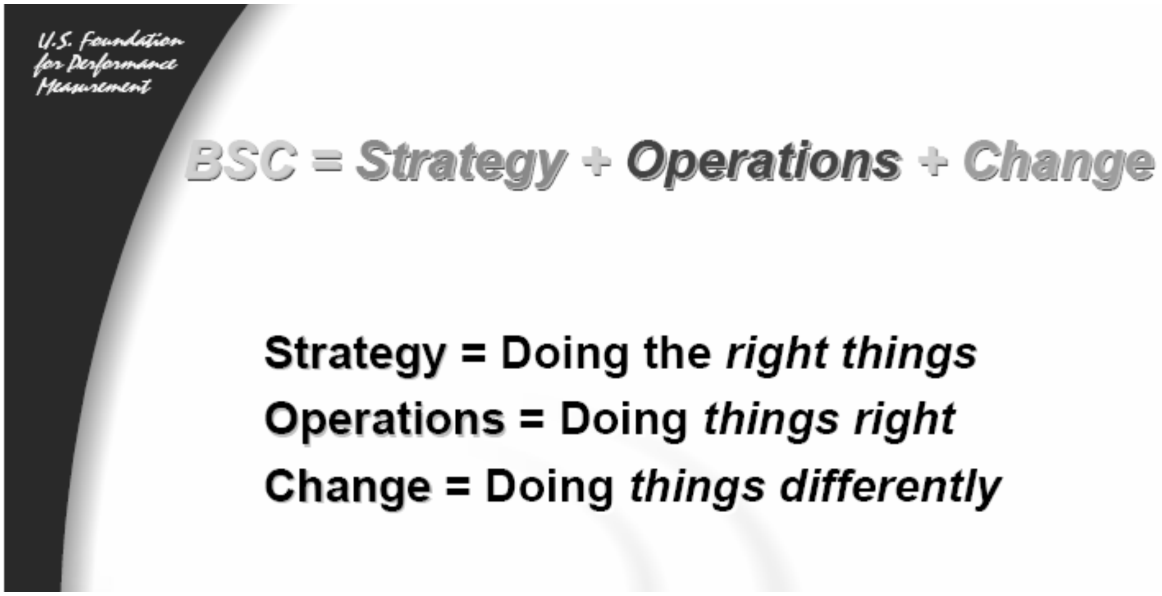
The Balanced Scorecard Is (Is Not)

IS:	***IS NOT:***
• *A strategic performance management system for the whole organization* • *A communications tool to make strategy clear to everyone* • *A way to balance financial and non-financial views of organization performance* • *A journey* • *A system for increasing accountability* • *A commitment to change* • *A way of aligning organization vision with human and capital resources, and with day-to-day operations*	• *A performance measurement tool to control individual productivity* • *A "flavor of the month" performance measurement system* • *About placing your existing performance measures into four categories* • *A project* • *Easy* • *The status quo* • *A TQM initiative*

U.S. Foundation for Performance Measurement

Performance Management System Challenges

- Fear of measurement and new systems
- Lack of common definitions and terms
- Inconsistent or weak buy-in, and lack of understanding
- Visions and strategies that are poorly defined and understood, not actionable, and not linked to individual actions
- Treating budgeting as separate from strategy development
- Measures that are set independently of the performance framework, or measures with no ownership
- No performance targets, or targets that are set too high or too low
- Little or no strategic feedback
- Lack of meaningful employee involvement



5.1.7 Other Areas of Application

The BSC is equally applicable to the services providers (belonging to both private and public sectors) and to the Not-for-Profit Organizations (again, in both NGOs and state funded) For example, several hospitals in Canada and US and have started using the BSC to drive performance and achieve objectives.

5.1.8 Shortcomings of the Balanced Scorecard

a) Community and Environmental Issues are missing. Today these are critical issues.

b) Competitors have not been included. Companies need to monitor the environment to track competitor activity and technological developments.

These criticisms mainly stem from the fact that the balanced scorecard is not a multiple stakeholder frame work. Any performance measurement frame work needs to reflect the needs of all the important stakeholders.

Conclusion: These criticisms however, do not detract from the inherent merit of the balanced scorecard which helps to clarify, consolidate and gain consensus around the strategy of the organization. It is also a very powerful tool for strategy implementation. The points missed out may be added as additional perspectives to the original four.

5.2 Variance Analysis and Standard Costing

Illustration No. 1

S.V.Ltd. Manufacturers by mixing three raw materials. For every batch of 100Kg. of BXE, 125 Kg. of raw Materials are used. In April, 2009, 60 batches were prepared to produce an output of 5,600 Kg. of BXE. The standard and actual particulars for April, 2009 are as under:-

RAW MATERIAL	MIX %	PRICE PER kg	MIX %	PRICE PER kg	QUANTITY OF RAW MATERIALS PURCHASED Kg
A	50	20	60	21	5,000
B	30	10	20	8	2,000
C	20	5	20	6	1,200

Calculate all variances.

Solution:

	Standard data			Actual data		
	Q	P	V	Q	P	V
A	3750	20	75000	4500	21	94500
B	2250	10	22500	1500	8	12000
C	1500	5	7500	1500	6	9000
	60 x 125=7500		105000	7500		115500
(-)Standard loss	60 x 25=1500			1900		
	6000		105000	5600		115500

	SQSP	RSQSP	AQSP	AQAP
A	3500 x 20		4500 x 20	
B	2100 x 10		1500 x 10	
C	1400 x 5		1500 x 5	
A	70000		90000	
B	21000		15000	
C	7000		75000	
Total	98000	105000	112500	115500

SQ FOR A=5600/6000 x 3750, B=5600/6000x2250, C=5600/6000 x 1500

- Material yield variance =2500(A)
- Material mix variance= 7500(A)
- Material yield variance=7000(A)
- material cost variance=17500(A)

Illustration No.2

A brass foundry making castings which are transferred to the machine shop of the company at standards in regard to material stocks which are kept at standard price are as follows:-

Standard Mixture 70% Copper : 30% Zinc

Standard Price Copper Rs.2,400 per ton

Zinc Rs. 650 per ton

Standard loss in melting 5% of input

Figures in respect of a costing period are as follows:

Commencing stocks	Copper	100 tons	
	Zinc	60 tons	
Finishing stocks	Copper	110 tons	
	Zinc	50 tons	
Purchases	Copper	300 tons	Cost Rs.7,32,500
	Zinc	100 tons	Cost Rs.62,500
Metal melted	400 tons		
Casting produced	375 tons		

Present figures showing: Material Price, Mixture and yield Variance.

Solution:

	Copper		Zinc	
	Q	V	Q	V
Opening stock	100	240000	60	39000
(+)Purchases	300	732500	100	62500
	400	972500	160	101500
(-)Closing stock	110	264000	50	32500
	290	708500	110	69000

	Q	P	V	Q	P	V
Copper	280	2400	672000	290		708500
Zinc	120	650	78000	110		69020
	400		750000	400		777500
(-)Standard loss @ 5%	20			25		
	380		750000	375		777500

	SQSP	RSQSP	AQSP	AQAP
Copper	276.315x2400		29x2400	
Zinc	118.42x650		110x650	
Copper	663157		696000	
Zinc	76975		71500	
Total	740132	750000	767500	777500

- Material yield variance= 9868(A)
- Material price variance=10000(A)
- Material mix variance=17500(A)

Illustration No.3

A company manufacturing a special type of fencing tile 12″X 8″ X ½″ used

a system of standard costing. The standard mix of the compound used for making the tiles is :-

1,200 kg. of material A @ Rs.0.30 per kg.

500 kg. of Material B @ Rs.0.60 per kg.

800 kg. of Material C @ Rs.0.70 per kg.

The compound should produce 12,000 square feet of tiles of 1/2″ thickness. During a period in which 1,00,000 tiles of the standard size were produced, the material usage was:-

Kg		Rs
7,000	Material A @ Rs.0.32 per kg.	2,240
3,000	Material B @ Rs.0.65 per kg.	1,950
5,000	Material C @ Rs.0.75 per kg.	3,750
15,000		7,940

Present the cost figures for the period showing Material price, Mixture, Sub-usage Variance.

Solution:

Area of tile =12x8/12x12=2/3 sq ft

No of tiles that can be laid in 12000 sq ft is 12000/(2/3) = 18000

	Standard data			Actual data		
	Q	**P**	**V**	**Q**	**P**	**V**
A	6666.67	0.3	2000	7000		2240
B	2777.77	0.6	16666.67	3000		1950
C	4444.44	0.7	3111.11	5000		3750
	13888.89		6778	15000		7940

Q for A = 18000/100000 x 1200 = 6666.67

Q for B = 18000/100000500 = 2777.77

Q for C = 18000/100000 x 800 = 4444.44

	SQSP	RSQSP	AQSP	AQAP
A		7200 x 0.3	7000 x 0.3	
B		3000 x 0.6	3000 x 0.6	
C		4800 x 0.7	5000 x 0.7	
A		2160	2100	
B		1800	1800	
C		3360	3500	
	6778	7320	7400	7920

RSQ for A= (15000/13888.89) x 666667

- Material sub usage variance=542(A)
- Material mix variance= 80(A)
- Material usage variance=622(A)
- Material price variance =540(A)
- Material cost variance=1162(A)

Illustration No.4

The Standard labour complement and the actual labour complement engaged in a week for a job are as under:

		Skilled Workers	Semi-Skilled Workers	Unskilled Workers
a)	Standard No. of workers in the gang	32	12	6
b)	Standard wage rate per hour Rs.	3	2	1
c)	Actual No. of workers employed in the gang during the week	28	18	4
d)	Actual wage rate per hour	Rs.4	3	2

During the 40 hour working week the gang produced 1,800 standard labour hours of work. CALCULATE:

(1) Labour efficiency variance (2) Mix variance (3) Rate of wages variance (4) Labour cost variance

Solution:

	Standard data			**Actual data**		
	H	**R**	**V**	**H**	**R**	**V**
Skilled	1280	3	3840	1120	4	4480
semi skilled	480	2	960	720	3	2160
Unskilled	240	1	240	160	2	320
	2000		5040	2000		6960

	SRSH	**SRRSH**	**SRAH**	**ARAH**
Skilled	3 x 1152		3 x 1120	
Semi skilled	2 x 432		2 x 720	
Unskilled	1 x 216		1 x 160	
	4536	5040	4960	6960

SH for skilled workers = (1800/2000) x 1280 = 1152

SRSH = Standard cost of standard labour = 4536

SRRSH= Revised standard cost of labour = 5040

SRAH = Standard cost of actual labour = 4960

ARAH =Actual cost labour = 6960

- Labour sub efficiency variance = 504(A)
- Labour mix variance = 80(F)
- Labour efficiency variance = 424(A)
- Labour rate variance = 200(A)
- Labour cost variance = 2424(A)

Illustration No.5

Item	Budget	Actual
No.of working days	20	22
Output per man hour	1.0 Units	0.9 Units
Overhead cost	Rs.1,60,000	1,68,000
Man-hours per day	8,000	8,400

CALCULATE OVERHEAD VARIANCES.

Solution:

(1)	(2)	(3)	(4)	(5)
SRSH	SRAH	SRRBH	SRBH	ARAH
1 x 266320	1 x 184800	1 x 176000		
166320	184800	176000	160000	168000

- SR = budgeted FOH/budgeted hours = 160000/160000 = 1
- RBH = (22/20) x 160000 = 176000
- AH = 22 x 8400 = 184800
- AQ = 184800 x 0.9 = 166320
- SH = 166320/1 = 166320

FOH efficiency variance = 18480(A)

FOH capacity variance = 8800(F)

FOH calendar variance = 16000(F)

FOH volume variance = 6320(F)

FOH budget variance = 8000(A)

FOH cost variance = 1680(A)

Illustration No.6

In a company operating on a standard costing system for a given four week period budgeted for sales of 10,000 units. at Rs.50 per unit, actualsales were 9,000 units at Rs.51.25 per unit. Costs relating to that period were as follows:

	STANDARDS	ACTUALS
Materials	Rs.2,50,000	2,57,400
Wages	75,000	70,875
Fixed Overhead	20,000	18,810
Variable Overhead	10,000	9,250
Semi-variable overhead	2,700	2,430
Standard hours 50,000		
Actual hours 40,500		

1) The Standard material content of each unit is estimated at 25 kg. at Rs.1 per kg. actual figures were 26 kg. at Rs.1.10 per kg.
2) Semi-variable Overhead consists of $5/9$ ths fixed expenses and $4/9$ ths variable.
3) The Standard wages per unit are 5 hours at Rs.1.50 per Unit actual wages were 4.5 hours at Rs.1.75.
4) There were no opening stocks and the whole production for the period was sold.
5) The four week period was normal period.

YOU ARE REQUIRED:-

a) To compute the variances in Sales, Materials, Labour and Over heads due to all possible causes; and
b) with the help of such a computation draw a statement reconciling the actual profit for the period with the standard profits.

Solution:

Working notes:

	Budget	Actual
Fixed overhead	20000	18810
Share in semi variable OHs	1500	1350
	21500	20160
Variable OHs	10000	9250
Share in semi variable OHs(4/9)	1200	1080
	11200	10330

Variances:

⇒ Sales

(1)	(2)	(3)
AQAP	AQSP	SQSP
51.25 x 9000	50 x 9000	50 x 10000
461250	450000	500000

a) AQAP = Actual value of sales = 461250
b) SQSP = Actual sales at standard prices = 450000
c) SQSP = Standard value of sales = 500000

i. Sales Volume variance = (2) – (3) = 50000(A)

ii. Sales Price variance = (1) – (2) = 11250(F)

iii. Sales Value variance = (1) – (3) 38750(A)

⇒ Material

(1)	(2)	(3)
SQSP	AQSP	AQAP
1 x 225000	1 x 234000	1.1 x 234000
225000	234000	257400

AQ = 9000 x 26 = 234000

SQ = 9000 x 25 = 225000

1) Standard cost of standard material = 225000

2) Standard cost of actual material = 234000

3) Actual cost of material = 257400

(a) Material Usage variance = (1) – (2) = 9000(A)

(b) Material Price variance = (2) – (3) =23400(A)

(c) Material Cost variance = (1) – (3) = 32400(A)

⇒ Labour

(1)	(2)	(3)
SRSH	SRAH	ARAH
1.5 x 45000	1.5 x 40500	1.75 x 40500
67500	60750	70875

SH = 9000 x 5 = 45000

1) SRSH = Standard cost of standard labour = 67500

2) SRAH = Standard cost of actual labour = 60750

3) ARAH = Actual cost of labour = 70875

(a) Labour Efficiency variance = (1) – (2) = 6750(F)

(b) Labour Rate variance = (2) – (3) = 10125(A)

(c) Labour Cost variance = (1) – (3) = 3375(A)

⇒ Variable OHs

(1)	(2)	(3)
SRSH	SRAH	ARAH
0.224 x 45000	0.224 x 40500	10330
10080	9072	10330

SR = 11200/50000 = 0.224

1) SRSH = Standard cost of standard variable OHs = 10080

2) SRAH = Standard cost of actual variable OHs = 9072

3) ARAH = Actual cost of variable OHs = 10330

   (a) Variable OHs efficiency variance = (1) – (2) = 1008(F)

   (b) Variable OHs budget variance =(2) – (3) = 1258(A)

   (c) Variable OH cost variance = (1) - (3) = 250(A)

⇒ Fixed OHs

(1)	(2)	(3)	(3)
SRSH	SRAH	SRBH	ARAH
0.43 x 45000	0.43 x 40500	0.43 x 50000	
19350	17415	21500	20160

SR = 21500/50000 = 0.43

1) SRSH = Standard cost of standard fixed OHs = 19350

2) SRAH = Standard cost of actual fixed OHs = 17415

3) SRBH = Budgeted fixed OHs = 20160

4) ARAH = Actual fixed OHs = 20160

   (a) Fixed OHs efficiency variance = (1) – (2) = 1935(F)

   (b) Fixed OHs capacity variance = (2) –(3) = 4085(A)

   (c) Fixed OHs volume variance = (1) – (3) = 2150(A)

   (d) Fixed OHs budget variance = (3) – (4) = 1340(F)

   (e) Fixed OH cost variance = (1) – (4) = 810(A)

Statement showing Reconciliation of Actual & Standard profits:

Budgeted sales		500000
(+)sales price variance	11250	
(-) sales volume variance	(50000)	(38750)
Actual sales		461250
(-) standard cost of sales		
Material {250000 x (9/10)}	225000	
Wages {75000 x (9/10)}	67500	
Fixed OHs {21500 x (9/10)}	19350	
Variable OHs {11200 x (9/10)}	10080	321930
Standard profit		139320

Add favorable variances		
labour efficiency variance	6750	
Variable OH efficiency	1008	
Fixed OH efficiency	1935	
Fixed OH budget	1340	11033
		150353
Less adverse variances		
material usage variance	9000	
Material price variance	23400	
Labour rate variance	10125	
Variable OH budget	1258	
Fixed OH capacity variance	4085	47868
Actual profit		102485

Illustration No.7

One kilogram of product 'K' requires two chemicals A and B.The following were the details of product 'K' for the month of June, 2008:-

a) Standard mix Chemical 'A' 50% and Chemical 'B' 50%

b) Standard price per kilogram of Chemical 'A' Rs.12 and Chemical 'B' Rs.15

c) Actual input of Chemical 'B' 70 kilograms.

d) Actual price per kilogram of Chemical 'A' Rs.15

e) Standard normal loss 10% of total input.

f) Materials Cost variance total Rs.650 adverse.

g) Materials Yield variance total Rs.135 adverse.

You are required to calculate:

1. Materials mix variance total
2. Materials usage Variance total
3. Materials price variance total
4. Actual loss of actual input
5. Actual input of chemical 'A'
6. Actual price per kilogram of Chemical 'B'

Solution:

Let, actual output of chemical A be a kgs

Actual price per Kg of chemical B be Rs b

Standard input be 100Kgs

Actual output be 90Kgs

	Standard			Actual		
	Q	**P**	**V**	**Q**	**P**	**V**
A	50	12	600	a	15	15a
B	<u>50</u>	15	<u>750</u>	<u>70</u>	b	<u>70b</u>
	100		1350	70 + a		15a + 70b
(-) normal loss	<u>10</u>	--	--	<u>a – 20</u>	--	--
	90		1350	90		15a + 70b

	(1)	(2)	(3)	(4)
	SQSP	**RSQSP**	**AQSP**	**AQAP**
A		12 x (70+a/100) x 50	12 x a	
B		15 x (70+a/100)/50	15 x 70	
	1350	945 + 13.5a	1050 + 12a	15a + 70b

Given material cost variance = (1) – (4) = -650

= 15a + 70b = 2000

Material yield variance = (1) – (2) = -135

$\Rightarrow$ a = 40

$\Rightarrow$ b = 20

1) SQSP = 1350
2) RSQSP = 945 + (13.5 x 40) = 1485
3) AQSP = 1050 + (12 x 40) = 1530
4) AQAP = (15 x 40) + (70 x 20) = 2000
   - (a) Material mix variance = 45(A)
   - (b) Material usage variance = 180(A)
   - (c) Material price variance = 470(A)
   - (d) Actual loss of actual input = 20
   - (e) Actual input of chemical A = 40Kgs
   - (f) Actual price per Kgs of chemical B = 20

Illustration No.8

Compute the missing data indicated by the Question marks from the following.

	Product 'R'	**Product 'S'**
Sales quantity		
Std.(units)	?	400
Actual (Units)	500	?
Price (Unit)		
Standard	Rs.12	Rs.15
Actual	Rs.15	Rs.20
Sales price variance	?	?
Sales volume variance	Rs. 1,200 F	?
Sales value variance	?	?

Sales mix variance for both the products together was Rs.450 F,'F' denotes Favourable.

Solution:

Let the standard units of product R be r

Actual units of product S be s

	Standard			Actual		
	Q	**P**	**V**	**Q**	**P**	**V**
R	R	12	12r	500	15	7500
S	400	15	6000	s	20	20s
	400 + r		6000 + 12r	500 + s		7500 + 20s

Given sales volume variance for R = 1200(F)

⇒AQSP – SQSP = 1200

r = 400

Sales mix variance = AQSP - RSQSP = 450(F)

	AQSP	**RSQSP**
R	12 x 500	12 x {(500+s)/(400+r)} x 400
S	15 x s	12 x {(500+s)/(400+r)} x 400
	6000 + 15s	6750 + 13.5s

Then s = 800

→ Standard units of product R, r = 400

→ Actual units of product S, s =800

→ Sales price variance for R = AQ(AP - SP) = 1500(F)

S = 4000(F)

→ Sales volume variance for S = SP(AQ – SQ) = 6000(F)

→ Sales value variance for R = AQAP – SQSP = 2700(F)

For S = 10000(F)

Illustration No. 9

The assistant management accountant of your company has been preparing the profit and loss account for the week ended 31st October. Unfortunately, he had a traffic accident and is now in a hospital, so as senior cost analyst you have been asked to complete this statement. The uncompleted statement and relevant data are shown below.

Week ended 31st October

			Rs.	Rs.
Sales				50,000
Standard Cost:				
Direct materials				
Direct wages				
Overhead			—	—
Standard profit				
Variances	Fav./(adv.)	Fav./(adv.)		
	Rs.	Rs.		
Direct materials: Price	(400)			
Usage	(300)			
Total:		700		
Direct Labour:				
Rate				
Efficiency				
Total		—		
Overhead expenditure				
Volume				
Total	—			
Total variance			—	
Actual Profit			—	

Standard Data

The standard price of direct material used is Rs.600 per tone. From each tone of material it is expected that 2,400 units will be produced. A forty hour week is operated. Standard labour rate per hour is Rs.4. There are 60employees working as direct labour.

The standard performance is that each employee should produce one unit of product in 3 minutes. There are 4 working weeks in October. The budgeted fixed overhead for October is Rs.76,800.

Actual data

Materials used during the week were 20 tones at Rs.620 per tone. During the week 4 employees were paid of Rs.4.2 p.h and 6 were paid Rs.3.8 p.h and Remaining were paid at Standard Rate Overheads incurred was Rs. 18000.

You are required to complete the P & L Statement for the week ended 31stOct.

Solution:

Actual cost of material 620 x 20		Rs 12400/-
(-) direct material: price variance	400	
Usage variance	<u>300</u>	<u>(700)</u>
		<u>11700</u>

For Rs 600/- production = 2400 units

For Rs 11700/- production = (2400/600) x 11700 = 46800 units

Labour variances

(1)	(2)	(3)
SRSH	SRAH	ARAH
4 X 2340	4 x (40 x 60)	[(4 x 4.20) + (6 x 3.80) + (50 x 4)] 40
9360	9600	9584

Labour rate variance (2) – (3): 16(F)

Labour efficiency variance: (1) – (2): 240(A)

Overhead variances:

(1)	(2)	(3)	(4)
SRSH	SRAH	SRBH	ARAH
8 x 2340	8 x 2400		
18720	19200	19200	18000

OHs expenditure variance: (3) – (4): 1200(F)

OHs volume variance: (1) – (3): 480(A)

P&L statement for the week ended 31st October:

		<u>**Rs**</u>	<u>**Rs**</u>
Sales			**50000**
<u>Standard cost</u> direct material direct wages overheads		 11700 9360 <u>18720</u>	 <u>39780</u>
<u>Standard profit</u>			10220
Variances	F/(A)	F/(A)	
direct material: price usage total	 (400) (300)	 (700)	

		Rs	Rs
Sales			**50000**
Direct labour:			
rate	16		
efficiency	(240)		
Total		(224)	
Overheads:			
Expenditure	1200		
Volume	(480)		
Total		720	
Total variance			(204)
Actual profit			10016

Illustration No.10

Standard Cost card of a product is as under:

Direct Materials:	Rs.
A. 2Kg. @Rs.3 per kg.	6.00
B. 1Kg. @Rs.4 Per Kg.	4.00
Direct wages 5 Hours @ Rs.4 per hour	20.00
Variable overheads 5 hours @Re.1 per hour	5.00
Fixed overheads 5 hours @Rs.2 per hour	10.00
Total:	45.00
Standard profit	5.00
Standard selling price	50.00

Budgeted out put are 8,000 units per month. In April 2009, the company produced 6,000 units.

The actual sales value was Rs.3,05,000. Direct material consumed was Material A 14,850Kg valued at Rs.43,065 and material B 7,260 kg valued at Rs.29750. The total direct labour hours worked was 32,000 and the wages paid there fore amounted to Rs.1,27,500. The direct labour hours actually booked on production was 31,800. Overheads recorded were: Fixed Rs.80,600 and variable Rs.30,000. Closing work in progress 600 units in respect of which materials A and B were fully issued and labour and overheads were 50%complete.

Analyse the variance and present an operating statement showing the reconciliation between budgeted and actual profit for the month in the following format:

Operating Statement	Rs.
Budgeted Profit	
Sales Variances	
	Price
	Volume
	Total
Cost Variances	
	Direct Material
	Price
	Yield
	Mix
Direct Wages	
	Rate
	Efficiency
	Idle time
Variable overheads	
	Expenses
	Efficiency
Fixed Overheads	
	Expenses
	Efficiency
	Idle time
	Capacity
Total cost variance	
Actual Profit.	

Solution:

Sales margin or profit variances:

(1)	(2)	(3)
AQAR	AQSR	SQSR
6000 x (50.83 – 45)	6000 x 5	8000 x 5
35000	30000	40000

a) Profit variance due to selling price = (1) – (2) = 5000(A)

b) Profit variance due to sales volume = (2) – (3) = 10000(A)

c) Profit value variance = (1) – (3) = 5000(A)

Material variances:

	Standard			Actual		
	Q	P	V	Q	P	V
A	13200	3	39600	14850		43065
B	6600	4	26400	7260		29750
	19800		66000	22110		72815

	SQSP	RSQSP	AQSP	AQAP
A		14740 x 3	14850 x 3	
B		7370 x 4	7260 x 4	
	66000	73700	73590	72815
(6000/6600) x	60000	67000	66900	66195

a) Material yield variance:(1) – (2) = 7000(A)

b) Material mix variance : (2) – (3) = 100(F)

c) Material price variance : (3) –(4) = 705(F)

Labour variances:

	(1)	(2)	(3)
	SRSH	SRAH	ARAH
	4 x 31500	4 x 32000	
	126000	128000	127500
(6000/6300) x	120000	121905	121429

a) Labour idle time variance : 200 x 4 = 800 (A)

b) Labour rate variance: (2) – (3) = 476(F)

c) Labour efficiency variance: 1905 – 800 = 1105 (A)

Variable overheads variances:

	(1)	(2)	(3)
	SRSH	SRAH	ARAH
	1 x 31500	1 x 31800	
	31500	31800	30000
(6000/6300) x	30000	30286	28571

a) VOH efficiency variance: (1) – (2) = 286 (A)

b) VOH budget variance : (2) – (3) = 1715(F)

Fixed overhead variance:

	(1)	(2)	(3)	(4)
	SRSH	SRAH	SRBH	ARAH
	2 x 31500	2 x 32000		
	63000	64000	80000	80600
(6000/6300) x	60000	60952	80000	76762

a) FOH idle capacity variance:200 x 2 = 400(A)

b) FOH efficiency variance :952 – 400 = 552 (A)

c) FOH capacity variance = 19048 (A)

d) FOH budget variance: 3238(F)

Operating statement showing reconstruction of budgeted and actual profit:

Budgeted profit		40000
Sales margin variance due to: Price Volume	 5000(F) 10000(A)	 (5000) 35000
Cost variances		
Direct material variances: Price Mix Yield	 705(F) 100(F) 7000(A)	 (6195)
Direct wages variances: Rate Efficiency Idle time	 476(F) 1105(A) 800(A)	 (1429)
Variable OHs variances: Expenditure Efficiency	 1715(F) 286(A)	 1429
Fixed OHs variances: Efficiency Expenditure Idle time Capacity	 552(A) 3238(F) 400(A) 19048(A)	 (16762)
Actual profit		12043

Illustration No.11

The summarised results of a company for the two years ended 31st December 2008 and 2007 are given below: -

	1988	1987
	Rs.lacs	Rs.lacs
Sales	770	600
Direct Materials	324	300
Direct Wages	137	120
Variable Overheads	69	60
Fixed Overheads	150	80
Profit	90	40

As a result of re-organisation of production methods and extensive advertisement campaign use, the company was able to secure an increase in the selling prices by 10% during the year 2008 as compared to the previous year.

In the year 2007,the company consumed 1,20,000 Kgs. of raw materials and used 24,00,000 hours of direct labour. In the year 2008, the corresponding figures were 1,35,000kgs. of raw materials and 26,00,000 hours of direct labour.

You are required to: -

Use information given for the year 2007 as the base year information to analyse the results of the year 2008 and to show in a form suitable to the management the amount each factor has contributed by way of price, usage and volume to the change in profit in 2008.

Solution:

- Sales price variance = 770 – {770 x (100/110)} = 70(F)
- Sales volume variance = {770 x (100/110)} - 600 = 100(F)
- % increase in volume = (100/600) x 100 = 16.66667%
- Sales cost variance = 770 – 600 = 170170(F)
- Material cost variance = 300 – 324 = 24 (F)
- Material volume variance = 300 x (1/6) = 50(A)
- Material price = (30000000)/120000 = Rs 250/-
- Material expected to be used = (120000/600) x 700 = 140000 Kgs
- Material usage variance = 5000 x 250 = 12.5 (F)
- Material price variance = 50 – 24 – 12.5 = 13.5 (F)
- Labour cost variance = 17 (A)
- Labour volume variance = 120/6 = 20(A)

- Labour rate = (12000000)/(2400000) = Rs. 5/-
- Labour hours expected to be used = (2400000/600) x 700 = 2800000
- Labour efficiency variance = 2 x 5 = 10 (F)
- Labour rate variance = 20 – 17 -10 = 7 (A)
- VOH cost variance = 9(A)
- VOH volume variance = 60/6 = 10(A)
- VOH efficiency variance = 200000 x 2.5 = 5 (F)
- VOH expenditure variance = 10 – 9 – 5 = 4(A)
- FOH cost variance = 70(A)

Profit Reconciliation Statement:

		Rs in lakhs
Profit for 2007		40
(+)sales variance:		
Price	70	
Volume	100	
Material variance:		
Usage	12.50	
Price	13.50	
Labour variance-efficiency	10	
VOH efficiency variance	5	211
		251
(-) Material volume variance	50	
Labour variance:		
Volume	20	
Rate	7	
VOH variances:		
Volume	10	
Expenditure	4	
FOH cost variance	70	161
Profit for 2008		90

Illustration No.12

A company using a detailed system of standard costing finds that the cost of investigation of variances is Rs.20,000. If After investigation an out of control situation is discovered, the cost of correction is Rs.30,000. If no investigation is made, the present value of extra cost involved is Rs.1,50,000. The probability of the process being in control is 0.82 and the probability of the process being out of control is 0.18. You are required to advise.

(i) Whether investigation of the variances should be undertaken or not;

(ii) The probability at which it is desirable to institute investigation into variances.

Solution:

i. Cost of investigation = 20000 + 0.18 x (30000) = 25400

Cost of investigation is not conducted = 150000 x 0.18 = 27000

Hence, it is worthwhile to undertake the investigation.

ii. Let X be the probability of process being in – control where it is desirable to institute investigation into variances.

→ 20000 + 30000(1 - X) = 150000(1 - X)

→ X = 83.33%

Therefore, if the probability of the process being in – control is 83.33% of less it is better to investigate into variances, or else it is not necessary.

Illustration No.13

The following data have been obtained from the records of a machine shop for an average month:

	Budget
No.of working days	25
Working hours per day	8
No.of direct workers	16
Efficiency	One standard hour per clock hour
Down time	20%
Fixed	Rs.15,360
Variable	20,480

The actual data for the month of April 2009 are as under:

Overheads: Fixed	16,500
Variable	14,500
Net operator hours worked	1,920
Standard hours produced	2,112

There was a special holiday in April 2009. Required to present reports to Departmental Manager:

i) Showing the three cost ratios you have chosen: ii) Setting out the analysis of variances.

Solution:

i)

- Efficiency ratio = (SH/AH) x 100 = (2112/1920) x 100 = 110%

- Activity ratio = (SH/BH) x 100 = (2112/2560) x 100= 82.5%
- Capacity utilization ratio = (actual hours/budgeted hours) x 100
  = (1920/2560) x 100 = 75%
- Capacity usage ratio = (budgeted hours/maximum possible hours) x 100
  = (2560/3200) x 100 = 80%
- Idle capacity ratio = 100% - 80% = 20%
- Calendar ratio = (actual days/budgeted days) x 100
  = (24/25) x 100 = 96%

ii. Variances:

Variable OHs:

(1)	(2)	(3)
SRSH	SRAH	ARAH
8 x 2112	8 x 1920	
16896	15360	14500

- VOH efficiency variance = 1536(F)
- VOH budget variance = 860(F)
- VOH cost variance = 2396(F)

Fixed OHs:

(1)	(2)	(3)	(4)	(5)
SRSH	SRAH	SRRBH	SRBH	ARAH
6 x 2112	6 x 1920	6 x 2457.6		
12672	11520	14746	15360	16500

FOH efficiency variance = 1152(F)

FOH capacity variance = 3226(A)

FOH calendar variance = 614(A)

FOH volume variance = 2688(A)

FOH budget variance = 1140(A)

FOH cost variance = 3828(A)

EXERCISE PROBLEMS

Problem No. 1

The standard mix of product M5 is as follows: -

Kgs	MATERIAL	PRICE PER Kg
50	A	5.00
20	B	4.00
30	C	10.00

The standard loss in production is 10% of input. There is no scrap value. Actual Production for a month was 7,240 Kgs. of M5 from 80 mixes. Actual purchases and consumption of material during the month were:-

Kgs	MATERIAL	PRICE PER Kg
4,160	A	5.50
1,680	B	3.75
2,560	C	9.50

Calculate variances.

Ans: Cost Variance Rs.2,820 (A) :M.P.V. 380 (A): M.Y.V. 2,240 (A)

: M.M.V. 200 (A) : M.V.V. 2,440 (A)

Problem No.2

Calculate variances from the following:

STANDARD				ACTUAL			
INPUT	MATERIAL	RS./KG	TOTAL	INPUT	RS.KG		TOTAL
400	A	@ 50	20,000	420	@ 45		18,900
200	B	@20	4,000	240	@ 25		6,000
100	C	@15	1,500	90	@ 15		1,350
700			25,500	750			26,250
	LABOUR HOURS				LABOUR HOURS		
	100 @ Rs. 2 Per hour	200			120 Hrs. @ Rs.2.50	300	
	200 Women @ Rs. 1.50	300	500		240 Women @ Rs. 1.60	384	684
25	Normal Loss			75	Actual Loss		
675			26,500	675			26,034

Ans: M.C.V. 750 (A) : M.P.V. 900 (F) : M.M.V. 171.43 (F):

H.Y.V. 1,021.43 (A) : L.C.V. 194(A)

L.M.V. 450/7 (A) : L.Y.V. 35.71 (A) .L.R.V. 84 (A)

Problem No.3

The standard cost sheet per unit for the product produced by Modern Manufactures is worked out on this basis.

Direct materials 1.3 tons @ Rs.4 per ton

Direct labour 2.9 hours @ 2.3 per hour

Factory overhead 2.9 hours @ Rs.2 per hour

Normal capacity is 2,00,000 direct labour hours per month.

The factory overhead rate is arrived at on the basis of a fixed overhead of Rs.1,00,000 per month and a variable overhead of Rs.1.50 per direct labour hour.

In the month May,50,000 units of the product was started and completed. An investigation of the raw material inventory account reveals that 78,000 tons of raw material were transferred into and used by the factory during May.These goods cost Rs.4.20 per ton. 1,50,000 hours of direct labour were spent during May at cost of Rs.2.50 per hour. Factory overhead for the month amounted to Rs.3,40,000 of which 1,02,000 was fixed.

Compute and identify all variances under Material, Labour and Overhead as favourable or adverse. Also identify one or more departments in the Co. who might be held responsible for each variance.

Ans: M.C.V 67,600 (A) : M.P.V 15,000 (A) : M.U.V. 52,000 (A)

V.O.C 20,500 (A) : V.E.V 13,000 (A) : V.E.V. 7,500 (A)

F.O.V.29,500 (A) : F.B.V. 2,000 (F) : F.V.V. 17,500 (A)

IDENTIFICATION DEPARTMENTS

Nature of the Variance	Name of the Department responsible
1. Material price	Purchase
2. Material Usage	Production
3. Labour Rate	Personnel
4. Labour Efficiency	Production
5. Overheads: Rate Increase	Administration
Other Variances	Production

Problem No.4

Budgeted and actual sales for the month of December, 2008 of two products A and B of M/s. XY Ltd. were as follows:

PRODUCT	BUDGETED UNITS	SALES PRICE/ UNIT	ACTUAL UNITS	SALES PRICE / UNIT
A	6,000	5	5,000	5.00
			1,500	4.75
B	10,000	2	7,500	2.00
			1,750	8.50

Budgeted costs for Products A and B were Rs.4.00 and Rs. 1.50 unit respectively. Work out from the above data the following variances.

Sales Volume Variance, Sales Value Variance, Sales Price Variance, Sales Sub Volume Variance , Sales Mix Variance

Ans: Sales Volume Variance 1000 (F)

Sales Value Variance 450 (F)

Sales Price Variance 550 (A)

Sales Sub Volume Variance 781 (A)

Sales Mix Variance 1781 (F)

Problem No.5

	(Rs. In lakhs)	
	31-3-2008	31-3-2009
Sales	120	129.6
Prime cost of sales	80	91.1
Variable Overheads	20	24.0
Fixed expenses	15	18.5
PROFIT	5	(4.0)

During 2008-09, average prices increased over these of the previous years

(1) 20% in case of sales (2) 15% in case of prime cost (3) 10% in case of Overheads.

Prepare a profit variance statement from the above data.

Problem No.6

ABC Ltd; adopts a standard costing system. The standard output for a period is 20,000 units and the standard cost and profit per unit is as under:

Direct Material (3 units @ Rs.1.50)	4.50
Direct Labour (3 Hrs. @ Re.1.00)	3.00
Direct Expenses	0.50
Factory Overheads : Variable	0.25
Fixed	0.30
Administration Overheads	0.30
TOTAL COST	8.85
PROFIT	1.15
SELLING PRICE (FIXED BY GOVERNMENT)	10.00

The actual production and sales for a period was 14,400 units. There has been no price revision by the Government during the period.

The following are the variances worked out at the end of the period.

Direct Material		Favourable	Adverse
	Price		4,250
	Usage	1,050	
Direct labour			
	Rate		4,000
	Efficiency	3,200	
Factory Overheads			
	Variable – Expenditure	400	
	Fixed – Expenditure	400	
	Fixed – Volume		1,600
Administration Overheads			
	Expenditure		400
	Volume		1,600

You are required to:

a. Ascertain the details of actual costs and prepare a Profit and Loss Statement for the period showing the actual Profit/Loss. Show working clearly.

b. Reconcile the actual Profit with standard profit.

Ans: Actual Profit - Rs.9,600.

Problem No.7

You have been appointed as Management Accountant of S.M. Ltd. Given below is the Company's operating profit and loss Statement for the month of April, 2009.

	Standard and Variances	Actual
	Rs.	Rs.
Budgeted Sales:	90,000	
Variances due to Volume of Orders	5,000	
Selling prices	2,000	97,000
Budgeted profit	19,000	
Profit Variance due to Sales Volume	1,200	
Selling price	2,000	22,200
Production cost Variances:		
Materials		
Price	750	
Usage	(300)	450
Labour		
Rate	(1,250)	
Efficiency	(500)	(1,750)
Overheads Expenditure: Fixed	500	
Variable	(1,250)	
Efficiency	1,000	
Capacity	500	750
Operating Profit		21,650

The costing department provides you with the following information about sales and cost for the month of May,2009.

		Budgeted Sales		Actual Sales	
Product	**Standard Cost per unit**	**Number of Units**	**Sales Value Rs**	**Number of Units**	**Sales Value Rs**
A	31	1,250	50,000	1,400	54,000
B	25	1,000	30,000	950	27,500
C	15	750	15,000	900	17,500

Materials:	**Rs**
Standard cost of materials actually used	26,150
Standard cost of materials allowed	26,650
Actual cost of materials used	27,150
Labour:	
Standard labour cost per hour	Re. 0.90
Actual clocked hours	22,000
Actual labour cost	Rs. 21,300
Budgeted hours	20,000
Standard hours produced	22,500

Overheads:

Budgeted rates of overheads recovery per direct labour hour:

Variable Re. 1.00 Fixed Re. 0.50

Actual Overhead Costs.

Variable Rs.21,500 Fixed Rs.12,000

Prepare an operating profit and loss statement for May, 2009 in the same form as for April, 2009.

Ans: Operating Profit = Rs. 17,050

Problem No.8

The budgeted output of a single Product manufacturing company for 2009-10 was 5,000 units. The financial results in respect of the actual output of 4,800 units achieved during the year were as under:-

	Rs
Direct Material	29,700
Direct wages	44,700
Variable Overheads	72,750
Fixed Overheads	39,000
Profit	36,600
Sales	2,22,750

The standard direct wage rate is Rs.4.50 per hour and the standard variable overhead rate is Rs.7.50 per hour.

The cost accounts recorded the following variances for the year.

Variances	Favourable	Adverse
	Rs	Rs
Material Price	-	300
Material Usage	-	600
Wage Rate	750	-
Labour Efficiency	-	2,250
Variable Overhead Expense	3,000	-
Variable Overhead Efficiency	-	3,750
Fixed Overhead Efficiency	-	1,500
Selling Price	6,750	-

Required:

(i) Prepare a statement showing the original budget.

(ii) Prepare the standard product cost sheet per unit.

(iii) Prepare a statement showing the reconciliation of originally budgeted profit and the actual profit.

Ans: Profit at Original Budget Rs. 37,500

Standard Cost per unit Rs. 37.50

Actual Profit Rs. 36,600, Budgeted Profit Rs. 37,500

Problem No.9

You are appointed cost Accountant of Zed Ltd. Given below is the company's operating report for April 2009.

Standard and Actual Variance

	Rs.	**Rs.**
Sales-Budgeted	18,000	
Variances due to:		
Volume of orders	1,000	
Selling Price	400	19,400
Profit budgeted	3,800	
Variance due to:		
Sales volume	240	
Sales price	400	4,400
Production Cost Variances:		
Labour – Rate	(250)	
- Efficiency	(100)	

Standard and Actual Variance

	Rs.	Rs.
Material-Price	150	
-Usage	(60)	
Overhead Expenditure- Fixed	100	
- Variable	(250)	
- Efficiency	200	
- Capacity	100	
		150
Operating Profit		4,330

Your assistant provides the following information about sales and costs for May 2009:

Sales	Budgeted Units	Sales Value Rs.	Actual Units	Sales value Rs.
Product A	250	10,000	280	10,800
Product B	200	6,000	190	5,500
Product C	150	3,000	180	3,500
		19,000		19,800

Product	Standard Selling Price per unit	Standard Product Cost per unit
A	Rs.40	Rs.31
B	30	25
C	20	15

Labour:	
Standard labour cost per hour	Rs.0.90
Budgeted hours	4,000
Actual clocked hours	4,400
Standard hours produced	4,500
Actual labour cost	4,260
Materials:	
Standard cost of material actually used	5,230
Standard cost of material allowed	5,330
Actual cost of material used	5,430
Overheads:	
Budgeted rates of overhead recovery per labour hour:	
Fixed	0.50
Variable	1.00
	1.50
Actual overhead costs: Fixed	2,000
Variable	4,300
	6,300

Required:

Prepare the operating Statement for May 2009 in the same form as April 2009.

Ans: Budgeted Profit Rs. 30,600

Actual Profit Rs. 6,100

Problem No.10

The profitability of a company for two years ended 31st March after eliminating the effects of inflation is as under:

	Years ended 31st March	
	2008	**2009**
	Rs. in lacs	**Rs. in lacs**
Sales	1,200	1,540
Direct Materials	600	648
Direct wages and variable overhead	360	412
Fixed overheads	160	300
Profit	80	180

Consequent upon the reorganisation of production methods and improvement in quality the company has been able to secure an increase in the selling prices by 10% during the year ended 31st March 2009.

The position of consumption of materials and utilisation of direct labour hours during the two years is as under:

	2008	2009
Direct Materials(Tones)	4,80,000	5,40,000
Direct Labour Hours	72,00,000	80,00,000

Required:

(i) Keeping the year ended 31st March, 2008 as the base year, analyse the result of the year ended 31st March, 2009 to show the amount which each factor has contributed to the change in the profit.

(ii) Find the break-even sales for both the years.

(iii) Calculate the percentage increase in selling price that would have been further necessary over the sales value for the year ended 31st March 2008 to earn a margin of safety of 40%

Ans: Rs. Lakhs

SPV 140 (F); SVV 200 (F); MVV 100 (A); MUV 25 (F); MPV 27 (F);

Wages & VOH VV 60 (A); Wages & VOH Eff. V 20 (F); Wages & VOH RV 12 (A);

FOH Cost V 140 (A).

STUDY NOTE - 6

Quality Management

- Concept and relevance of Quality Concept to Cost Management.
- Total Quality Management
- Quality Tools
- Contemporary Developments in Quality Management
- External Quality Standard
- Global Awards for Best Practices and Business performance

6 Quality Management

6.1 Introduction

6.1.1 Relevance of Quality Concept to Cost Management

Nothing would drive home the relevance of quality in cost management than the major instances of defective products in the recent past.

a) Nokia branded BL-5C Battery : 100 incidents of over- heating of the battery were reported worldwide which could result in short circuit while charging, causing the battery to dislodge. Nokia deemed it fit to recall all such batteries and issued a product advisory offering to replace the batteries free of cost. 46 million batteries were estimated to be replaced and the cost to Matsushita which manufactured the batteries was dollars 172 million.

b) In 2006 Sony was hit by hefty cost for the recall of 9.6 million PC batteries that could overheat and catchfire.

c) In May 2001 Ford had to recall 1.3 million tyres at a cost of $ 2.1 billion, marking the end of its 100 year relationship with US tyre maker Firestone.

d) In December 2000 Ford recall 876,413 Explorers and Mercury Mountaineers to replace faulty parts on the suspension system.

The magnitude of monitory losses, not to speak of the dent to the company's image will highlight the importance of ensuring total quality in products; nothing short of a eternal vigilance is an imperative need.

Quality thus is Cost and Quality Control and Cost Control are in fact the obverse and reverse of the same coin. The emphasis should be on prevention of errors and failures through Quality Planning. Investments in Quality Control will yield rich returns to the manufacturer through savings in materials and man-hours lost, improving productivity and above all profitability through customer satisfaction.

6.1.2 Historical Review of Quality Control

With increase in technology development and the consequent diversity of products, the need for professionalism in every function became paramount. This led to a separate group of professionals for quality control.

a) In 1924 – Dr.W.A. Shewart of Bell Telephones, USA, introduced statistical control charts to control product variability during process.

b) 1940's Quality associations and societies come into being to spearhead and promote Quality.

   i) American Society for Quality Control was established in 1946.

   ii) The Japanese established Union of Japanese Scientists and Engineers (JUSE) which promoted Quality and Total Quality and Total Quality Control in Japan and formed a Quality Control Research group under its wing. Dr. K. Ishikawa was one of the members of that group.

iii) Though Indian Statistical Institute was established in 1931 it became active in 1940's thanks to the efforts of Prof. Mahalanobis, who served as Director of ISI.

c) In 1950s Dr. W. E. Edwards, one of the Statistical experts was invited to Japan and he taught the captains of Industry there Statistical Quality Control and the grateful Japanese instituted a medal in his name called "Deming Medal" be awarded every year for the best organizations practicing Quality and TQC.

d) In 1954 Dr. J. M. Juran went to Japan of the invitation of JUSE. He emphasized that Quality control should be a part of management control and that top management's leadership is essential for achievement of Quality. In fact, that was the beginning of development of Japanese company wide quality control (CWQC) which they have now christened as Company Wide Total Quality Management (CWTQM).

e) 1950's saw revolution in nation wide promotion of Quality control in Japan and JUSE, under the leadership of Dr. K. Ishikawa conceived a concept called Quality Control Circles, a team concept, to educate and train bottom line workers and enable them to build Quality into the products and take care of quality problems solvable by them. This system had world-wide acceptance.

f) 1970's – After the Japanese Quality revolution, the American Company's started to have a new look at Dr. Deming's and Dr. Juran's teachings on Quality.

g) 1980's – This period saw a renaissance of Quality and promotion of Quality awareness and education. This period also had been credited with the development of TQM and its promotion world wide. In the late 1980s automotive industries, on seeing the fierce competition from the Japanese automobile industries, adopted application of Statistical Quality Control Techniques to improve quality.

   In 1987 ISO 9000 Quality Systems Standards came into being and it was accepted as a global Quality Systems Standard and from 1990s certification become a necessity among trading countries for their products.

h) 1990's – ISO 9000 came to be accepted as global model for Quality management system and this followed by Environmental Management System (EMS) ISO 14000 and occupational safety and hazard system (OSHAS) ISO 18000.

i) 2000 – In the new millennium Quality has become the key to success of any organization. Many awards for Quality come into being (i) Malcolm Bald ridge Award (ii) European Quality Award and (iii) Deming Award.

Source : Total Quality Management - Published by :

Quality Circle Forum of India, Secunderabad

6.1.3 Quality Gurus

The significant contributions made by each of the quality experts is detailed below:

6.1.3.1 Joseph Juran

Joseph Juran is an internationally acclaimed quality guru, strongly influencing Japanese manufacturing practices. Joseph Juran's belief that "*quality does not happen by accident*" gave rise to the quality trilogy:

- Quality planning

- Quality control
- Quality improvement

The key steps in **implementing company-wide strategic goals** are:

- Identify customers and their needs – both internal and external – and work to meet those needs
- Create measures of quality, establish optimal quality goals and organise to meet them.
- Create processes capable of meeting quality goals in "real" operating conditions.

Joseph Juran recognised that the **common approach** to total quality management - quality awareness campaigns and slogans - **was not effective** as they did not have substance, and there is no short cut to quality. He believes quality must start at the top.

Juran's Trilogy could be better understood with the following expansion:

Quality Planning	Quality Control	Quality Improvement
• Determine who are the customers • Determine the needs of the customers • Develop product features that respond to the customers' needs. • Develop processes that are able to product those product featurers • Transfer the resulting plans to the operating forces.	• Choose control subjects – what to control? • Choose units of measurements–Evaluate Measurements • Establish standards of performance • Measure actual performance • Interpret the difference (actual versus standard) • Take action on difference	• Establish the infrastruc-ture needed to secure annual quality improvement • Identify the specific needs for improvement – the improvement projects • For each project establish a project team with clear responsibility for bringing the project to a successful conclusion • Provide the resources, motivation, and training needed by the teams to: • Diagnose the causes • Stimulate establishment of a remedy • Establish controls to hold the gains

6.1.3.2 Deming Philosophy or Deming's Fourteen Points for Top Management

1. Create Constancy of purpose towards improvement of products and services, with the aim to become competitive and stay in business and to provide jobs. Decide to whom the top management is responsible (all the stake holders, of course).
2. Adopt the new philosophy – we are in a new economic age. We can no longer live with the commonly accepted levels of delays, mistakes, defective materials and defective workmanship.

3. Cease dependence on inspection to achieve quality - Eliminate the need of inspection on a mass basic (i.e. 100% inspection) by building quality into the product in the first place. (This is possible by educating task performers in the use of Quality control tools and techniques to eliminate mistakes from happening and involving them in quality control in their work areas).
4. End the practice of amending business (contract for material supplies) on the basis of price tag. (i.e. lowest tenders against a tender). Instead depend on meaninggul measures of quality along with price. (evaluate venders against a set of norms first and consider price later).
5. Constantly improve the system of production and service. (i.e. constantly and periodically review design and technological processes and build in customer requirements and improve the economic costs of management).
6. Institute training on the job. (technologies are fast changing and therefore, people are to be trained continuously to update their knowledge and skills).
7. Institute leadership (Management should build a superior vision to bring out the best in people by facilitation). The supervision should be to help people, machines and gadgets to do a better job (Practice of preventive maintenance). Supervision of management is in need of improvement, as well as supervision of hourly workers.
8. Drive out fear so that everyone will work effectively for the company. (Fear thwarts people from giving their ideas. On the contrary empowerment will enable employees to freely come up with creative ideas for the improvement of their jobs).
9. Breakdown barriers between departments. (not seeing eye to eye between departmental managers has led to water-tight compartment working instead of common objectives and goals of the organization). People in research, design, sales and production must work as a team to foresee problems of production that may be encountered with various materials and specifications.
10. Eliminate slogans; exhortations and targets for the work force asking for zero defects and new levels of productivity with providing maps. (instead, the suggestion is to involve them in the planning process and setting goals of the company jointly so that their commitment is obtained).
11. Eliminate work standards that prescribe numerical quotas for the day. (Dr.Deming is of the opinion that work standards and quotas of production for day curbs initiative and creativity of the work force, who may give much better, qualitative out-put).
12. The barriers that stand between hourly worker and his pride to workmanship. The responsibility of the foremen should be changed from sheer quantity to quality.

    Do the same thing for people in management. This can be accomplished by the elimination of the rating on performance. (Instead, enhance their performance capabilities through continuous education and training and motivate them to higher levels of performance).
13. Institute vigorous programme of education and training and retraining (continual basis, periodically).
14. Create a structure in management to accomplish the transformation (create a top management care group to bring about the transformation).

6.1.3.3 Kaoru Ishikawa - Quality Circles

Kaoru Ishikawa led the concept and use of *Quality Circles*. The intended purpose of a Quality Circle is to;

- Support the improvement and development of the company
- Respect human relations in the workplace and increase job satisfaction
- Draw out employee potential

He believed quality must be **company wide** – including the product, service, management, the company itself and the people. Quality improvement must be company wide in order to be successful and sustainable.

He led the "*Total Quality Control*" movement with focus on statistical quality control techniques such as **control charts** and **Pareto charts.**

Many, including Juran and Crosby, consider Kaoru Ishikawa's teachings to be more successful in Japan than in the West. Quality circles are effective when management **understand** statistical quality management techniques and are **committed** to act on their recommendations.

6.1.3.4 Philip Crosby – "Zero Defects" and "Right First Time"

Philip Crosby is an American who promoted the phrases "*zero defects*" and "*right first time*". "Zero defects" doesn't mean mistakes never happen, rather that there is **no allowable number of errors** built into a product or process and that you get it right first time.

Philip Crosby believes **management** should take prime responsibility for quality, and workers only follow their managers' example. He defined the Four Absolutes of Quality Management.

The Four Absolutes of Quality Management

1. Quality is **conformance** to requirements
2. Quality **prevention** is preferable to quality inspection
3. **Zero defects** is the quality performance standard
4. Quality is measured in **monetary** terms – the price of non-conformance

Crosby's 14 Steps to Quality Improvement

1. Management is **committed to quality** – and this is clear to all
2. Create quality improvement teams – with (senior) representatives from all departments.
3. **Measure processes** to determine current and potential quality issues.
4. Calculate the cost of (poor) quality
5. **Raise quality awareness** of all employees
6. Take action to correct quality issues
7. **Monitor progress** of quality improvement – establish a zero defects committee.
8. Train supervisors in quality improvement
9. Hold "zero defects" **days**

10. Encourage employees to create their own quality improvement goals
11. Encourage employee communication with management about **obstacles to quality**
12. Recognise participants' effort
13. Create **quality councils**
14. Do it all over again – quality improvement does not end

Philip Crosby has broadened his approach to include wider improvement ideals. He defined the:

Five characteristics of an"Eternally Successful Organisation"

1. People **routinely** do things right first time
2. **Change** is anticipated and used to advantage
3. **Growth** is consistent and profitable
4. New products and services appear when **needed**
5. Everyone is **happy** to work there

Source : Lyndsay Swinton, Owner, Management for the rest of us

Link : www.mftrou.com

6.2 Total Quality Management

6.2.1 Definition

A management system that seeks the efficient achievement of the stakeholder expectations by focusing the efforts of every member of the organization on customer satisfaction and by using quality techniques in each of the sub - systems of the organization.

Joseph Maciariello & Calvin Kirby

6.2.2 Principles of TQM

From the above definition, we can deduce the principles of TQM.

6.2.2.1 Customer Focus

The purpose of business is to meet the needs of customer and it therefore follows that customer should be the focus of all the activities of an organization. In this context it would be relevant to note the observation of Peter Drucker "Quality in a product or service is not what the supplier puts in, it is what the customer gets out and is willing to pay for". In other words, the product should embody the voice of the customer.

Customers could be external, which is the idea with which, we are familiar. However, TQM envisages "Internal Customers" too, in the sense that each process should regard the subsequent process as its customer and satisfy its requirements. TQM is a customer oriented decision process aimed at satisfying internal and external customers.

6.2.2.2 Management Leadership

Management should lead the quality movement in the organization by creating a quality culture and work ethics involving everyone from top to bottom in quality. The management style should support and empower the individual and encourage goal-oriented team activity.

6.2.2.3 Belief in continuous improvement

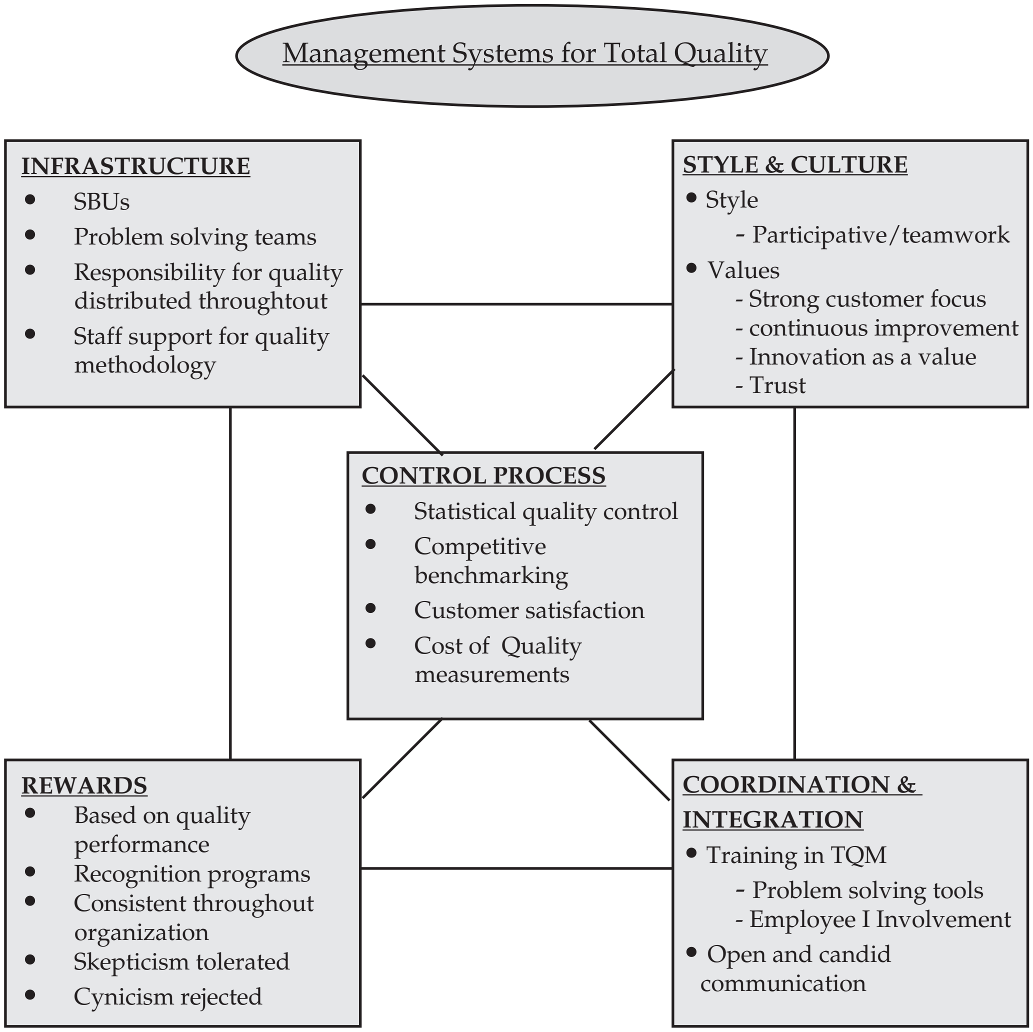
No organization can rest on its oars, but should continuously strive for improvement, realizing that quality is not a destination but a journey.

6.2.2.4 An emphasis on gathering objective data to support decision-making, instead of being guided by preconceived notions. The data obtained to be used as a feedback mechanism to take necessary corrective action.

6.2.2.5 Constantly seeking new techniques to support quality improvement

6.2.2.6 A belief in every member as to the importance of achieving excellence in all activities.

6.2.3 The TQM philosophy and procedure are depicted in the chart given below:



Source: Management Control Systems By Joseph Maciareillo & Calvin Kirby

6.2.4 Broader interpretation of TQM

The current thinking on TQM is moving from

Quality of product and service to

Quality of people (work force and community) to embrace also

Quality of environment.

The ISO 14000 standard discussed in para 6.7.1 exemplifies this.

Yet another thinking is towards Quality of Business Excellence of Organisations which is covered in para 6.8.

6.3 Quality Tools

6.3.1 Control Charts

6.3.1.1 Control charts as a means of maintaining a process in statistical control were pioneered by Dr.W.A.Shewhart an engineer in the Bell Telephone Laboratories, USA with a view to eliminating abnormal variations in process output by distinguishing variations due to special causes from those due to common causes.

Understanding variation is at the heart of much quality work. If you can control variation then you can deliver consistent products and services. If you can reduce variation, then you can deliver higher quality and hence sell more, at higher prices.

Drawing out the Histogram

The Histogram is a common tool used for showing the distribution of a set of measures and often appears in a bell-shaped 'Normal' or 'Gaussian' graph, where the majority of measures are clustered around the centre. What the Histogram does *not* show, however, is the way in which those measurements changed over *time*. If you turned a Histogram on its side, and 'pulled out' the measures as they appeared over time, they might appear as in Fig. 1.

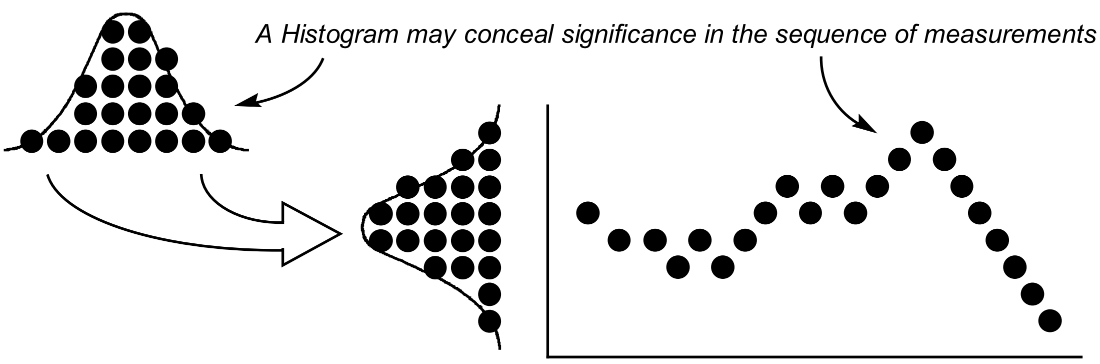


Fig. 1. Histogram and measures over time

What may be found here is that something interesting is going on. After some early fairly random variation, the measures go up and them go down in a nice straight line. The question here is 'Is this significant?' Is what *looks* like something important *actually* worth going to investigate? Can we safely ignore it or should we do something? Indeed *should* we ignore it, such that tampering with the process might just make things worse?

This is the purpose of Control Charts: to understand variation over time and decide whether investigation or action is appropriate or not.

Adding control limits

The Control Chart's first trick is to add horizontal lines, called 'Control Limits'. To show the centre of the distribution, an average (or 'mean') line is also added, as in Fig. 2. An important point here is that Control Limits are *calculated*. They are not 'action limits' that somebody estimates. They are used to show statistical significance and hence require the use of a simple, statistically-derived formula (this calculation will be discussed in a later article).

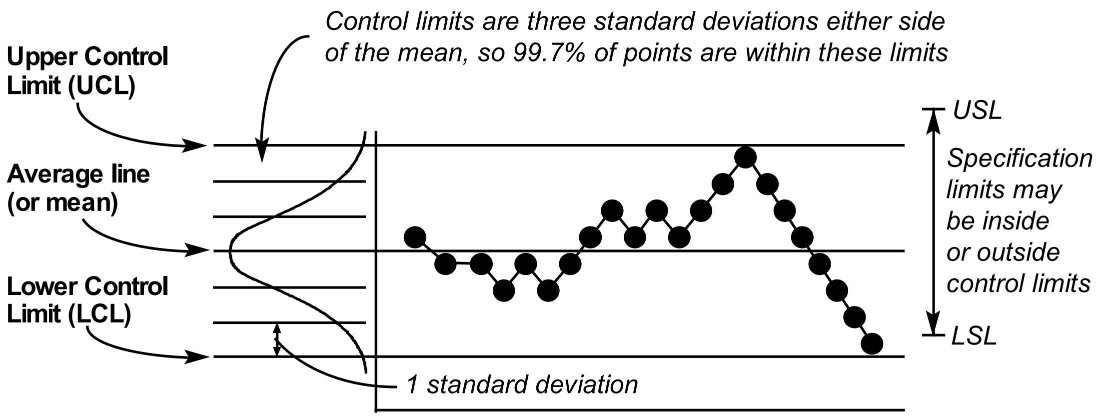


Fig. 2. Adding Control Limits

The control limits are known as the Upper Control Limit (UCL) and Lower Control Limit (LCL).

If a point falls outside these limits, it indicates a statistically significant event (or 'special cause of variation') which should be investigated. This does not happen in Fig. 2.

Shifts, Trends and Cycles

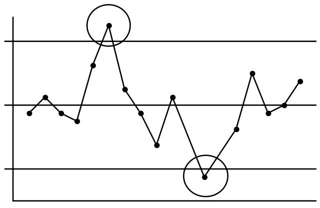
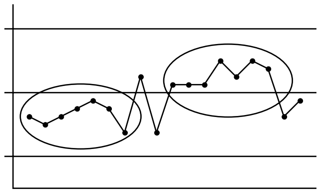
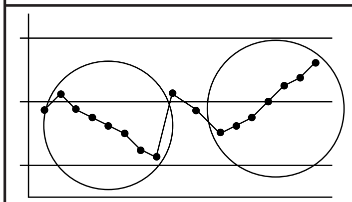
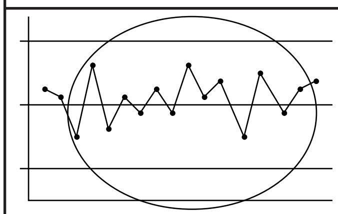
As well as being used to identify special causes of variation, the Control Chart also can be used to identify patterns within the sequence of measurements.

Shifts occur where the mean of a sequential set of measures has shifted from the overall mean of the whole set of measures. This is detected when seven or more sequential points appear, one after the other, on one side of the central average line.

Trends happen where a set of sequential measures keeps increasing or decreasing. Again, the magic number for statistical significance is seven.

Finally, *Cycles* occur where a repeating up-and-down pattern can be seen in the Control Chart. Seven cycles again is the number that indicates something significant is going on.

To summarise, the four ways of identifying statistical significance are shown in the table below.

Control Chart	Name	Description	Possible interpretation
	Special cause of variation	Point outside control limits.	Something unusual has happened. e.g. Person was interrupted.
	Shift	Seven or more consecutive points, all on one side of the central average line.	The overall average has changed. e.g. Showing result of process improvement.
	Trend	Seven or more consecutive points, all increasing or decreasing in value.	Gradual change in the process. e.g. A tool is wearing out.
	Cycle	Seven or more repeating patterns (possibly over several points).	Time-related effect. e.g. People changing with shifts.

6.3.1.2 Types of Control Chart

We look at the different types of Control Chart that you can use, and when each type should be used.

There are two types of measurement which you can measure and plot on a Control Chart.

- Variables answer the question 'how much?' and are measured in quantitative units, for example weight, voltage or time.
- Attributes answer the question 'how many?' and are measured as a count, for example the number of defects in a batch of products.

A trick that is used to make Control Charts more sensitive is to combine multiple measurements into a single point (this is called a 'subgroup'). This makes the chart more sensitive to variations, but does mean that you need more measurements. A Control Chart should have at least 25 points on it, which can mean several hundred measurements are needed.

Subgroups also mean that you can end up with two charts: one which considers the difference between subgroups and one which considers the difference within subgroups. Thus, for example, if you combined a day's readings in one subgroup (ie. one point on the chart), then using a single chart might miss variation within a single day (for example warming-up and lunchtime effects). The second chart copes with this problem.

When you are measuring variables, there are three types of Control Chart that you can use (X/MR, X-bar/R and X-bar/S). This decision is based on the number of measurements that you make and consequently how many measurements you can combine into a single point (subgroup). Variables charts are useful for such as measuring machine tool wear and predicting when the tool needs changing before it creates defective products. Variables charts are more sensitive to change than Attributes charts, but can be more difficult both in the identification of what to measure and also in the actual measurement.

A different attribute Control Chart is needed depending both on whether you are counting the number of defects per item or whether you are just counting total defects. Thus, for example, a production line might output 100 televisions, with 100 defects. This could mean that they are all defective or only one television is defective (or anything in between). The right attribute chart is also selected based on the whether there is constant number of measurements in each point (subgroup) on the chart. Thus there are four types of attribute chart to choose from (u, c, p and np).

Attribute charts are useful for both machine- and people-based processes. Data for them is often readily available and they are easily understood. It can thus be easier to start with these, then move on to Variables charts for more detailed analysis.

Fig. 3 shows a decision tree that you can use to identify the type of Control Chart you need.

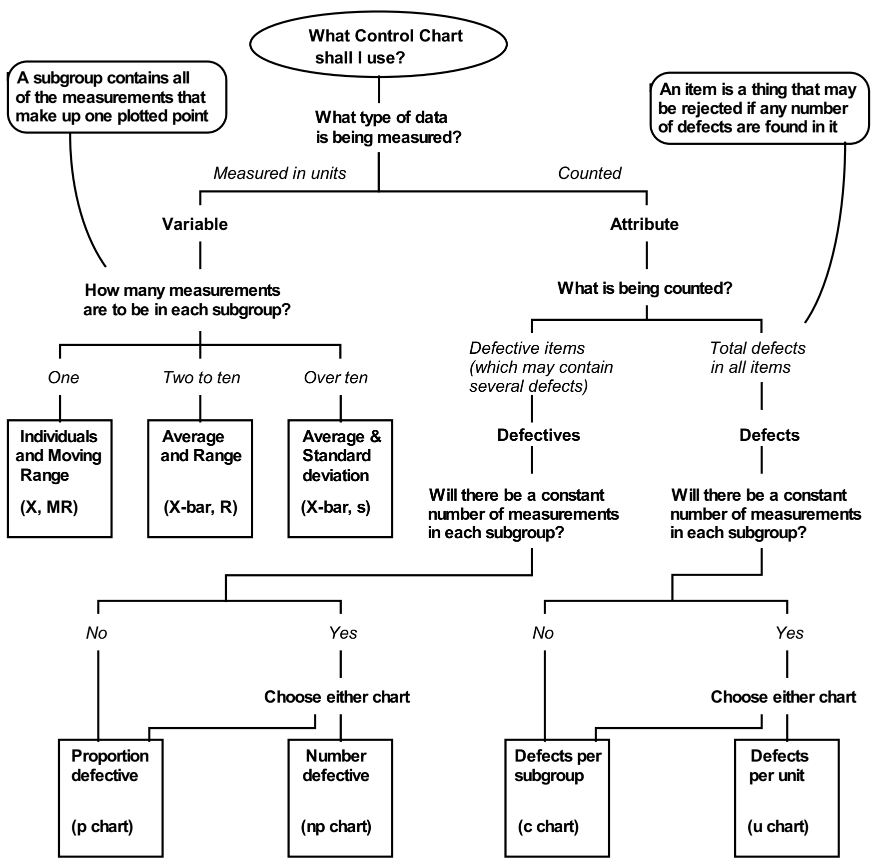


Fig. 3. Choosing the right type of Control Chart

6.3.1.3 Control Chart – producing the chart

Over the past two articles in the description of Control Charts we have discussed how to interpret them and the different types of chart you can use. We now look at the overall process for producing the chart. Calculations for these are quite involved and hence will be covered subsequently.

1. Identify the purpose of using the Control Chart. Typically this will be either to detect defects or to monitor a suspect or critical process.

2. Identify what you will need to measure and where in the process the measure should be made. Select measures on a combination on ease of measurement and and (of course) the chance that they will show problems that meets your purpose. Focus the measurement to minimise likely variation and maximise detection of specific issues, for examply by using a separate control chart for each of separate production lines being assessed.

3. Identify the type of Control Charts to use. This was discussed last time, in part 2 of this series. Briefly, for variables, you can choose X/MR, X-bar/R or X-bar/S charts, whilst for attributes, you can choose between u, c, p and np, depending on whether you are measuring defects or defectives, and whether subgroups contain the same number of measures.

4. Choose the *subgroup*. This is the group of measurements that will make up each plotted point on the Control Chart. Each subgroup typically contains the same number of measurements, although p- and c-charts are bounded by events, such as time (e.g. measurements per week), people or batches. Use the table below to decide how many measures you need in each subgroup.

Type of chart	Number of measurements taken for each subgroup
Individuals and Moving range (X, MR charts)	1 or 2
Average and Range (X-bar, R charts)	2 to 10 (typically 4 or 5)
Standard deviation (s chart)	Typically 10 or more (may be less)
Proportion defective (p chart)	50 or more (individual subgroups may vary). May be less if there are 4 or more defects per unit.
Number defective (np chart)	50 or more. May be less if there are 4 or more defects per unit.
Defects per unit (u chart)	50 or more (individual subgroups may vary)
Defects per subgroup (c chart)	50 or more

The subgroup should be selected with the aim of making the measurement *within* each subgroup as consistent as possible, whilst maximizing the chance of highlighting differences *between* subgroups. Further considerations for subgroups include:

- Synchronizing measurement points with other process variables, for example, measuring weekly rather than every four days.

- Using experience to determine subgroups, for example, known tool wear rates.

- Using larger subgroups, as they result in Control Charts which are more sensitive to change.
- Using smaller subgroups when they are expensive or time-consuming.
- Measuring more frequently when significant variation can occur over a short period.
- Initially measuring more, then reducing measurements as the data is understood.
- Using consecutive measurements, rather than a random sample, as this will result in less variation within the subgroup, with tighter, more sensitive control limits.
- Selecting subgroup measurement which seldom results in zero value points. For example, counting customer complaints per hour when there are only one or two per day, will give many points plotted on the zero line.

5. Prepare for measurement, including ensuring measurements will be made correctly and that people understand what is happening.
6. Make the measurements as planned in step 5.
7. Calculate mean and upper and lower control limits. This is quite an involved process and will be covered in later articles.
8. Draw the charts, including one plotted point for each subgroup, with a line drawn between successive points, horizontal lines for each of the central line and control limits, plus labelling and other information to help in interpretation. Note that although most control limits are straight lines, the p- and u- charts may have control limits that are different for each plotted point, as Fig. 4.

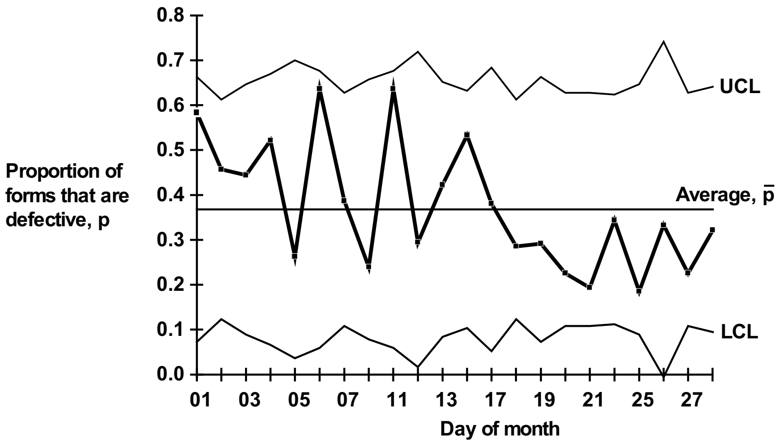


Fig 4. Example p-chart

9. Interpret the charts, looking for significant patterns and points, and act on the results. Typically this will involve finding for the cause of any identified significant set of points, followed by devising a method of correcting the problem.

6.3.1.4 Calculation detail for X-MR Control Charts

Control Charts, as described above, are used to detect statistically-significant variation in processes and hence enables variation and quality to be pro-actively controlled. There are seven types of control chart, each of which has a different calculation for the upper and lower control limits. The calculations for variables charts are explained below:

1. Calculate basic averages. The overall average that will create the centre line of the X chart is the simple average of all of the measures. Calculate the moving range as the difference between each measure and the one before it.

2. Calculate the upper and lower control limits for the two charts. This first requires calculating the standard deviation, S, of the whole set of measures. Note that this chart, whilst the easiest to calculate and using fewer measures, also gives the least sensitive results and should only be used when limited measures are available.

6.3.1.5

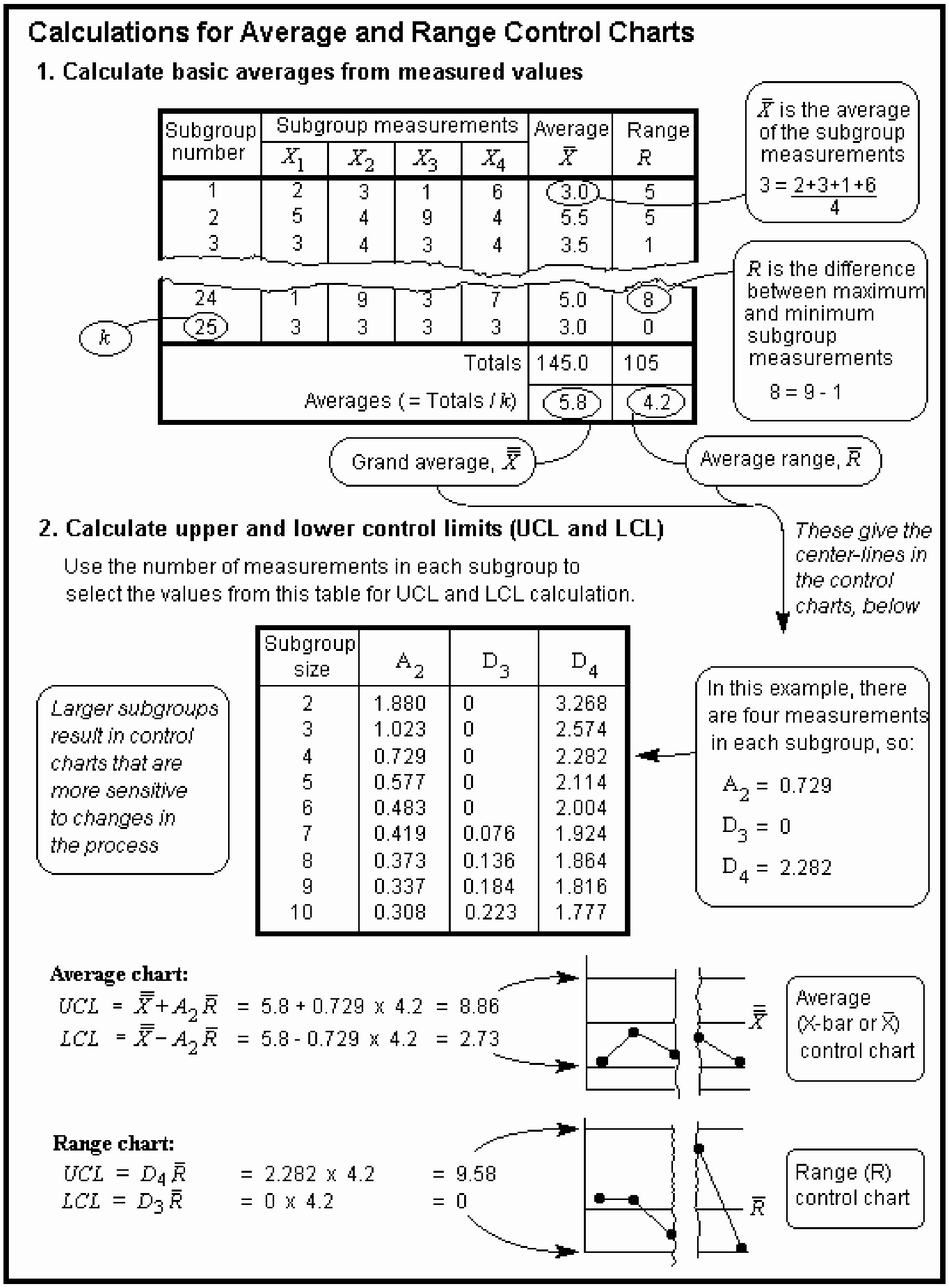
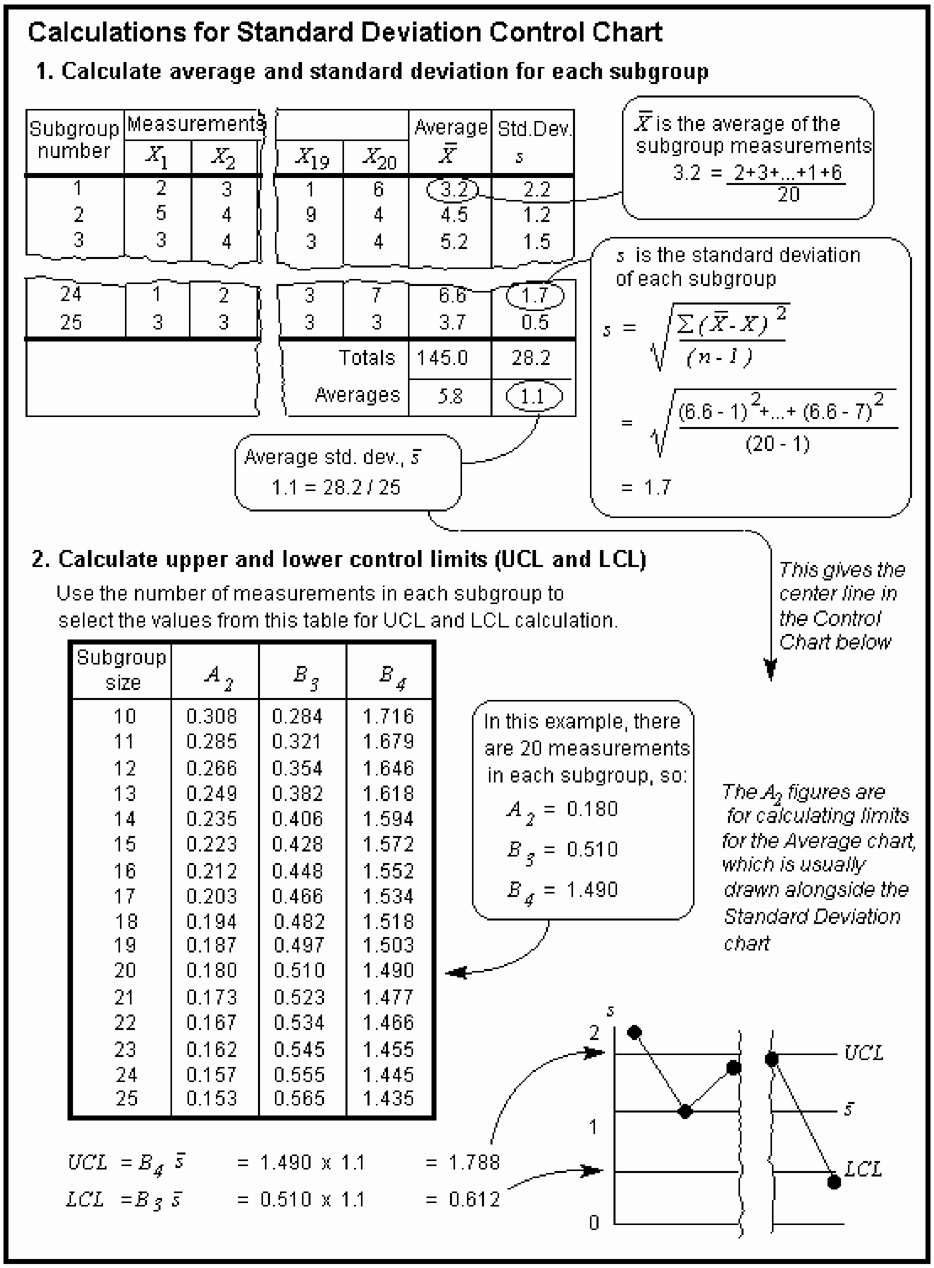


Fig. 5. Calculating X/MR control limits

6.3.1.6 Calculation detail for X-bar/S Control Charts

1. Calculate average and standard deviation for each subgroup in the standard manner (as a normal standard deviation calculation).
2. Calculate the upper and lower control limits. This again requires a magic constant to be used, based on the number of measures in each subgroup. A table for this is included in Fig.5.

Note: the X-bar chart is calculated in exactly the same way as for the average and range charts.



Calculating X-bar/S control limits

Source : syque.com/quality_tools/tools/Tools73.htm

6.3.2 Cause-Effect Diagram

The Cause-Effect Diagram is one of the powerful tools for quality control. It is also called a Fishbone Diagram, because of its shape, or an Ishikawa Chart, after its originator, Kaoru Ishikawa, who first used it in 1943.

The Cause-Effect Diagram is used to identify and structure the causes of a given effect

6.3.2.1 When to use it

- Use it when investigating a problem, to identify and select key problem causes to investigate or address.
- Use it when the primary symptom (or effect) of a problem is known, but possible causes are not all clear.
- Use it when working in a group, to gain a common understanding of problem causes and their relationship.
- Use it to find other causal relationships, such as potential risks or causes of desired effects.
- Use it in preference to a Relations Diagram where there is one problem and causes are mostly hierarchical (this will be most cases).

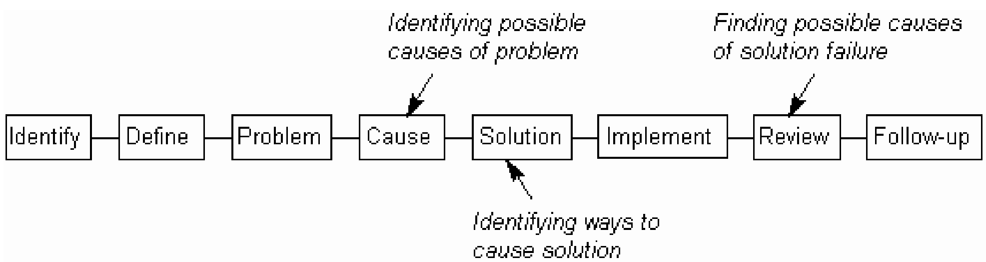


Fig. 6. Using the Cause-Effect Diagram in problem solving

6.3.2.2 How to understand it

Solutions to problems are often not easy to find, and those that at first appear to be obvious may address only symptoms rather than the true cause of the problem. Identifying causes as an intermediate step makes solutions both easier to find and also more likely to address the problem fully.

Causes tend to appear in chains (Fig. 1), where one cause is caused by another, and so on. Thus an accident may be caused by a puncture, which is caused by a weak tire wall, which is caused by imperfections in the rubber, etc. One cause may also be caused by a combination of other causes. Thus the puncture may be caused by a rough road surface and by sudden braking, as well as a weak tire, as illustrated.

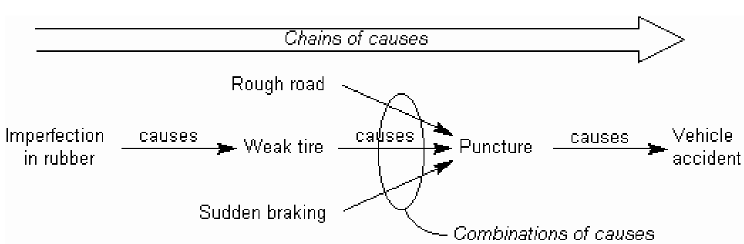


Fig. 7. Chains of causes

The Cause-Effect Diagram uses a specific layout to display the hierarchy of causes, as illustrated. The angled lines enable more detail to be added than lines at right angles to one another, especially in an informal situation where causes are being added 'on the fly'. Each line indicates either a named cause or a *cause area* which contributes to the cause line to which it is attached. A cause area is not a cause, but may contain causes. For example, a tire may be a cause area but may not be a cause of an accident. A smooth or punctured tire can be a cause. Cause areas tend to be nouns, whilst causes tend to use verbs.

When determining causes of a problem, the important causes that need to be addressed are seldom all known, let alone the effects of individual causes on the problem and on one another. The Cause-Effect Diagram is often used to address this by acting as an organizing structure within a Brainstorming session, in which case the causes on the final diagram may be a combination of known, suspected and other possible causes.

The Cause-Effect Diagram is often the result of divergent thinking about causes, and must be followed by convergence into the *key causes* which are to be addressed by further action. To prevent ineffective solutions, these need to be verified as being actual causes before finding solutions for them.

Root causes are those at the ends of chains of causes, and which consequently do not have any sub-causes. Root causes of key causes are often worth addressing.

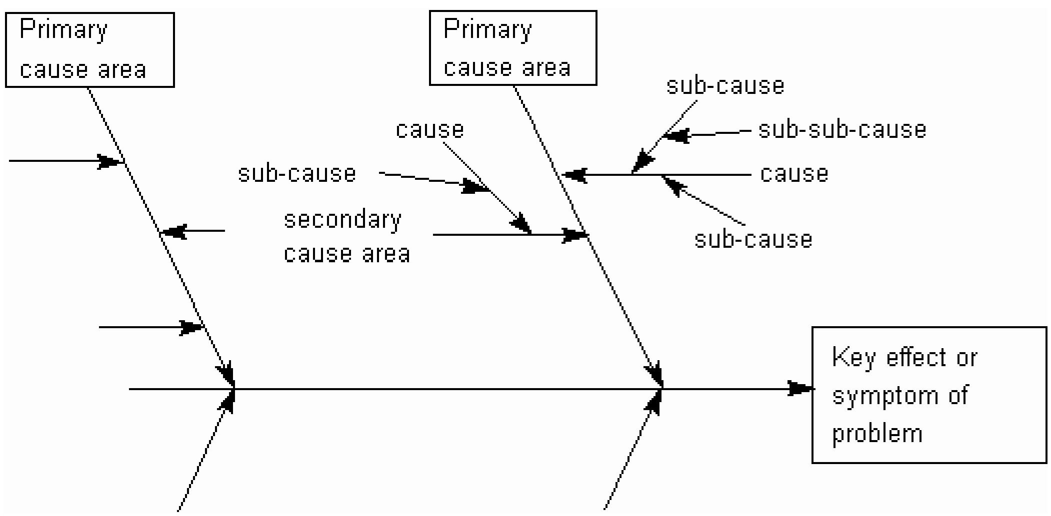


Fig. 8. The 'bones' of the Cause-Effect Diagram and finding root causes

A lopsided diagram can indicate an over-focus in one area, a lack of knowledge in other areas, or it can simply indicate that the causes are focused in the denser area. A sparse diagram may indicate a lack of general understanding of the problem or just a problem with few possible causes.

6.3.2.3 Example

The managing director of a weighing machine company received a number of irate letters, complaining of slow service and a constantly engaged telephone. Rather surprised, he asked his support and marketing managers to look into it. With two other people, they first defined the key symptom as 'lack of responsiveness to customers' and then met to brainstorm possible causes, using a Cause-Effect Diagram, as illustrated.

They used the 'Four Ms' (Manpower, Methods, Machines and Materials) as primary cause areas, and then added secondary cause areas before adding actual causes, thus helping to ensure that all possible causes were considered. Causes common to several areas were flagged with capital letters, and key causes to verify and address were circled.

On further investigation, they found that service visits were not well organized; engineers just picked up a pile of calls and did them in order. They consequently set up regions by engineer and sorted calls; this significantly reduced traveling time and increased service turnaround time. They also improved the telephone system and recommended a review of suppliers' quality procedures.

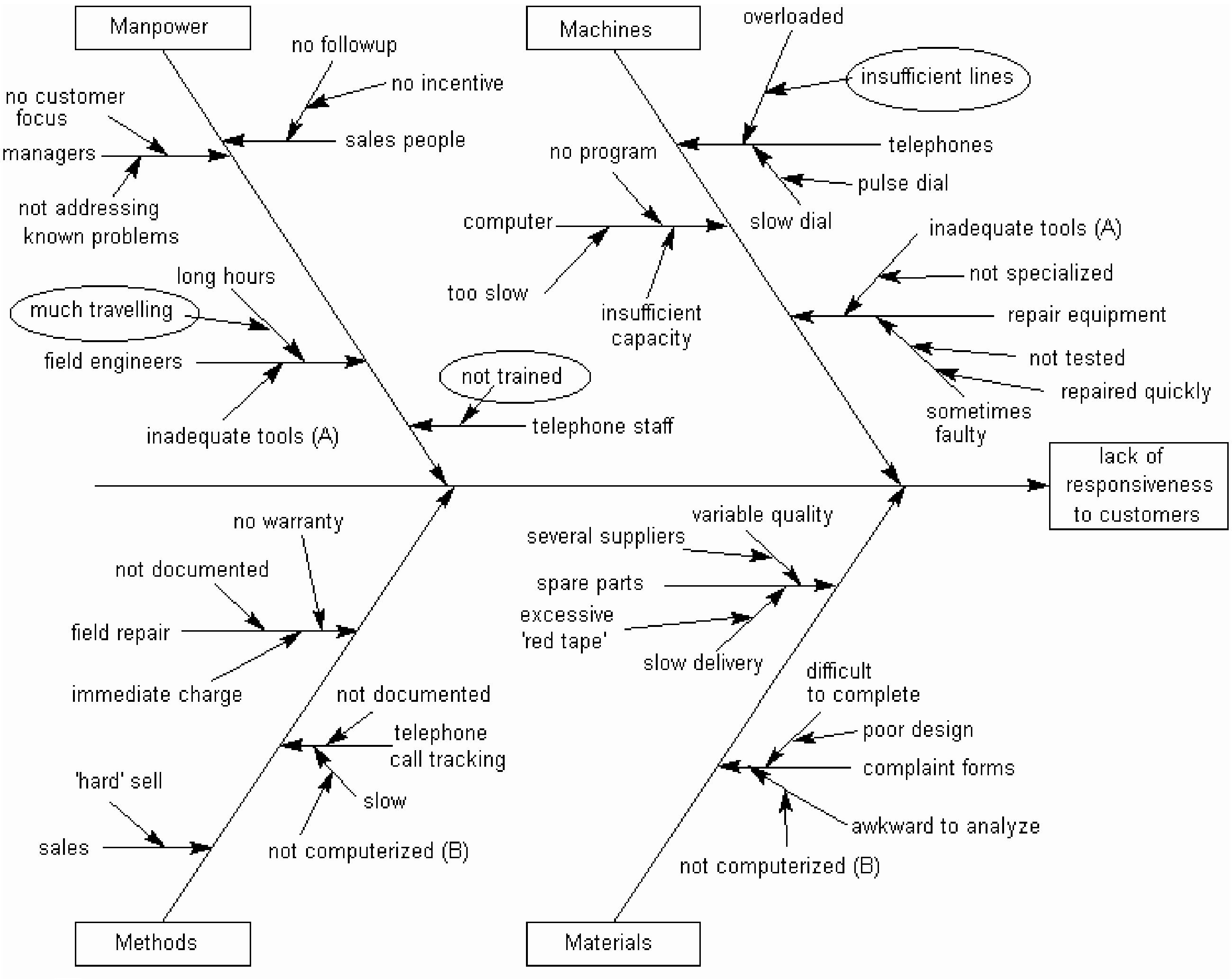


Fig. 9. Example Cause-Effect Diagram

Other examples

- A sales team, working to increase the number of customers putting the company on their shortlist for major purchases, identifies through a survey that the key problem is that the customers perceive the company as a producer of poor quality goods. They use a Cause-Effect Diagram to brainstorm possible causes of this.
- A pig farmer gets swine fever in her stock. To help ensure it never recurs, she uses a Cause-Effect Diagram to identify possible causes of the infection, and then checks if they can happen and implements preventive action to ensure none can happen in future.

- A wood turner notices that his chisels sometimes become blunt earlier than usual. He uses a Cause-Effect Diagram to identify potential causes. Checking up on these, he finds that this happens after working with oak. Consequently, he resharpens the chisels after turning each oak piece.

6.3.2.4 How to do it

1. Form a small team of people to work on the problem. Ideally, their knowledge and skills will be complementary, to give a broad but expert group. If it has not been already defined, meet first to define the key symptom or effect of the problem under scrutiny. Aim for a brief, clear phrase which describes what is happening to what, such as, 'Low sales of MkII Costor'.

   Make sure that only a single effect is described, as this may result in several sets of causes. For example, an effect of 'damp and dirty conditions' could have different causes of dampness and of dirt.

2. Write down the key effect or symptom at the center-right of the page (or whiteboard or flipchart, if you are doing it in a group), and draw a spine horizontally from it to the left.

3. Draw the main cause area 'ribs' (typically around four to six), one for each of what appears to be the primary cause areas. If these are uncertain, then the 'Four Ms' (Manpower, Methods, Machines and Materials) provide a good starting point, as illustrated in Fig. 10. In these gender-free days, an exact alternative is the four Ps (People, Processes, Plant and Parts).

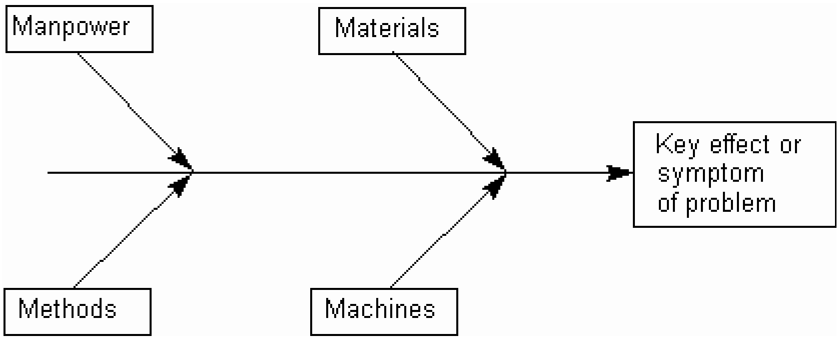


Fig. 10 The default 'Four Ms'

4. Use Brainstorming to build the diagram, adding causes or cause areas to the appropriate ribs or sub-ribs as they appear.

If a cause appears in several places, show the linkage by using the same capital letter next to each linked cause, as illustrated.

Beware of adding 'causes' which are actually solutions. These often are expressed as a negative; further consideration may find a truer cause. For example, a better cause than 'no heating' may be 'low ambient temperature', as it opens up the possibility of additional practical solutions, such as 'installing insulation'.

Beware also of things which are knock-on effects, rather than causes, e.g. given an effect of 'Inadequate telephone system', a sub-cause may be 'Insufficient lines', but 'Dissatisfied staff' is a knock-on effect.

Ways of finding more causes include:

- Keep asking 'Why?'. A popular phrase is, 'Ask Why five times'.
- Look at the diagram without talking. Look for patterns.
- Take a break. Do something to take your mind off your current line of thought.
- Involve other people, especially those who have expertise in the problem areas.
- Leave the chart on the wall for a few days to let ideas incubate and encourage passers-by to contribute.

If the diagram becomes lop-sided or cramped, you may want to reorganize the diagram with different major ribs.

5. Discuss why the found causes are there. Look for and circle key causes which require further attention. Avoid having too many key causes, as this may result in defocused activities. If there is no clear agreement, use a Voting system.
6. Consider the key causes again. Are any more important than others? If so, put a second circle around them, or put numbers next to them to show their relative priority.
7. If necessary, gather data to confirm key causes are real, and not just assumed. Repeat the process as necessary.
8. Plan and implement actions to address key causes.

Source: Wikipedia

6.3.3 Failure Mode and Effects Analysis

FMEA is used to identify and prioritize how items fail, and the effects of failure.

6.3.3.1 When to use it

- Use it when designing products or processes, to identify and avoid failure-prone designs.
- Use it when investigating why existing systems have failed, to help identify possible causes and remedies.
- Use it when investigating possible solutions, to help select one with an acceptable risk for the known benefit of implementing it.
- Use it when planning actions, in order to identify risks in the plan and hence identify countermeasures.

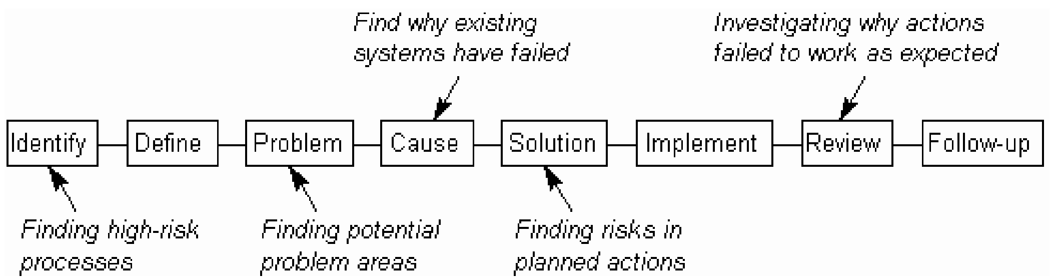


Fig. 11. Using FMEA in problem solving

6.3.3.2 How to understand it

Many problems are caused by systems which fail in unexpected ways, which can result in significant costs. An example of this could be where a new roofing compound is decomposed by acid rain, with the result that the manufacturers have to pay substantial warranty costs, as well as gaining a reputation for poor products. A detailed analysis of the possible ways in which a system might fail, and the possible effects of these failures may thus save significant future costs.

Failure Mode and Effects Analysis (commonly called *FMEA*) takes the dual step of first finding out *how* an item can fail, and then finding *what effect* this failure might have, as in Fig. 12 This second step thus helps to identify the importance of a failure mode, allowing identification of the key failure risks which must be addressed.

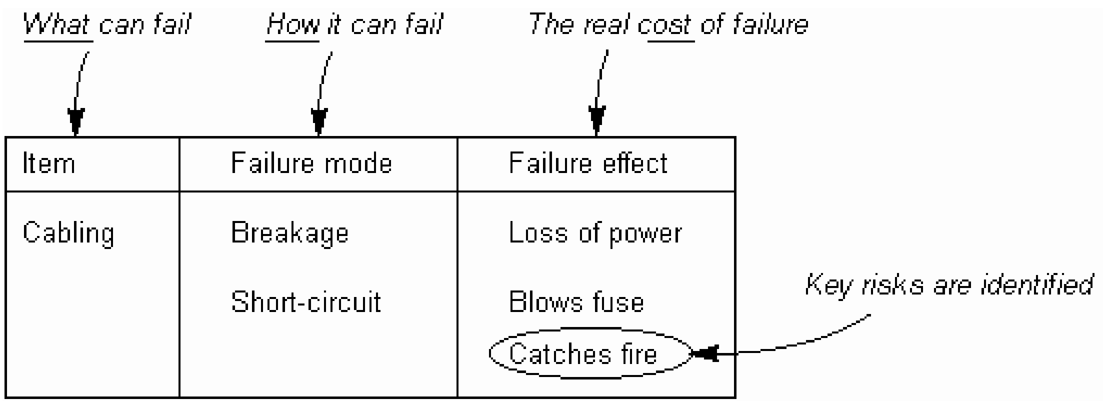


Fig. 12 Failure mode and effect

Criticality is a measure of importance that can be applied both to failure modes and to effects, allowing prioritization of remedial actions. A simple way of measuring failure mode criticality is to use the likelihood that it will occur in a given period. The criticality of a failure effect is the likelihood of that effect occurring due to *any* failure mode (see the illustration). Criticality may be further refined by also taking into account any other items which are considered to be important, such as severity of failure or chance of discovery by a customer.

Taking this extra step is performing *Failure Mode, Effects and Criticality Analysis*, or *FMECA*, although this often still referred to simply as FMEA.

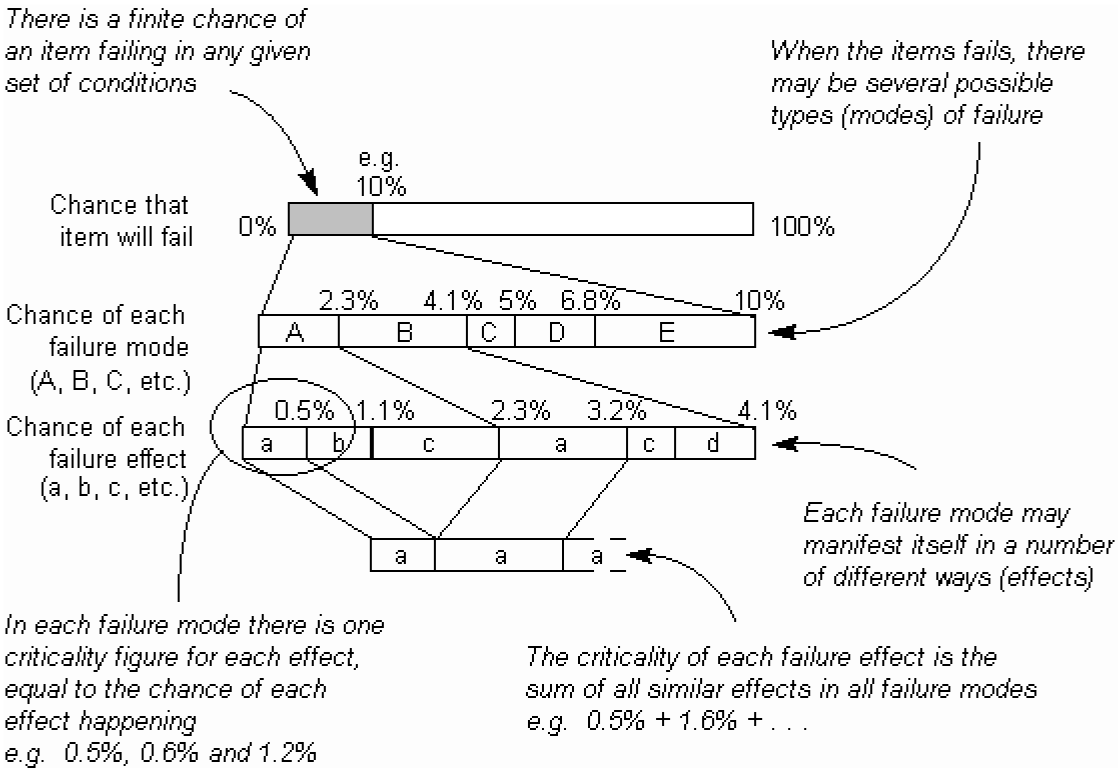


Fig. 13 Failure criticality

A limitation of FMEA is that although it goes into a lot of detail about the failure of individual components, it does not take combinations of failures into account. For example, the failure of a lift shaft drive may be inconvenient, but if the braking system has also failed, it could be catastrophic.

As with other numerical methods, figures are best derived from either actual measurement or controlled experiments. If these are not available, then estimates should be treated with appropriate caution.

6.3.3.3 Example

A developer of a word processor package received a number of complaints from its customer base about some specific features. On further investigation, it found that there were a limited number of effects that particularly annoyed customers. Working with their customers, they allocated severity ratings to these, as in the table below.

	Effect Severity
Corruption of hard disk	20
Loss of whole documents	10
Character loss	7
Printout scrambled	4

An FMEA table was used to record the results of failures found in user trace logs. Only modes that resulted in the target effects were recorded. Criticality calculations were weighted with the severity ratings to take account of the customer priorities. A part of one table is shown in the illustration.

The analysis found that the mode with the highest weighted criticality score was when the disk became full. Further investigation found the actual cause was an uncurbed temporary file. The simple measure of putting limitations on the size of this file significantly reduced the defect rate.

Item and (% chance of failure)	Failure mode		Effect of failure mode				
	Description	%	Description	%	Criticality x 10^6	Severity	Crit. x Severity
Autosave (0.5%)	Disk full	20%	Disk corrupt	5%	50	20	1000
			Document loss	8%	80	10	800
			Character loss	12%	120	7	840
	Network drive	8%	Disk corrupt	1%	4	20	20
Print (0.2%)	Disk full	80%	Printout corrupt	20%	320	2	640
			Disk corrupt	1%	40	20	800

Fig. 14 FMEA table

Other examples

- A new toaster design team uses FMEA to identify flaws in the design. This highlights ways in which the handle can stick and cause the toast to catch fire. This is prevented by adding a specific thermostatic safety release to the design.
- A boilermaker improvement team use FMEA to identify the failure modes that have caused certain pressure vessels to split. The result is the design of an effective and lasting solution.
- A secretary uses FMEA to highlight the possible undesirable effects of a room booking system not working properly, and consequently includes checks to reduce the chance of key effects of overbooking and key staff not being able to find rooms.

6.3.3.4 How to do it

1. Select the item to be analyzed. If it is a part of another item, then be clear about the boundary. For example, if the item is 'vehicle doors', it may mean passenger doors, but not the tailgate.
2. Identify the overall approach to be used. The FMEA may be a part of a larger set of failure analyses. In this case, the way that items are selected needs to be determined. Typical strategies include:
   - *Top-down analysis*, where the system being analyzed is broken into pieces and FMEAs done on the larger items first. For example, starting with a whole vehicle and then successively breaking down into lower levels, such as doors, then catches, then screws.
   - *Bottom-up analysis*, where the analyses of the smallest pieces are done first, followed by the higher level assemblies from which these are made. This is the reverse of top-down analysis.
   - *Component analysis*, where the FMEAs are done on the physical parts of the system. This will typically use components specifications to determine failure levels.
   - *Functional analysis*, where the analysis is of the intended functions and operation of the system. This is looking at failure from the product user's standpoint, rather than the engineer's, and will typically use product specifications to determine failure modes.

Also decide whether to perform criticality analysis. This will require more effort, but will result in a numerical value being given to failure modes and effects, thus helping with prioritization of subsequent actions.

If doing criticality analysis, determine how it will be calculated. The method below focuses just on the probability of failure modes and effects, although this can be extended to account for other important factors, as indicated in the following section on *Practical Variations*.

Where possible, this method should utilize actual data, for example from product defect records. Otherwise define a range categories and corresponding numerical scores, then use an allocation method, such as Voting. For example, levels of 'Chance of being found in system test' being scored on a scale of 1 to 5.

3. Identify the scope of failure to be examined. The scope defines the boundaries of the examination, and may include criteria such as time period, type of user, geography of use, etc.

   For example, 'All vehicle doors failing to operate properly in final inspection and test for all shifts'.

4. Design an appropriate table to capture the right information. This will vary, depending on factors such as if and how criticality is being measured, as in the illustration.

5. Identify items which may fail and which fall into the scope defined in step 2. This can be determined by asking, '*What* can fail?' and may include individual components and any combinations, sub-assemblies, etc.

   If this list becomes unmanageably large, then either reduce the scope of the FMEA, for example by examining just the catch mechanism rather than all parts of a door, or limit the detail of examination, for example by examining the catch mechanism as a whole, but not its individual components.

6. If doing criticality analysis, determine the chance of failure for each item identified in step 5. 7. If doing criticality analysis, identify the proportion of the time during the scope described in step 2 for each item identified in step 5 to fail. For example, if the scope is a defined test, then one item may only be exercised for 10% of the test time whilst another item is exercised for 90% of the time (and consequently has more opportunity to fail).

   If all items may fail at any time, then this factor may be ignored, as it is always 100%.

8. For each item identified in step 5, list all significant failure modes. These may be found by asking, '*How* can it fail?'. For example, a hinge can seize, wear, fracture, etc. This can be simplified by identifying a standard list of failure modes for the item being examined.

9. If doing criticality analysis, identify the chance of occurrence for each failure mode identified in step 8. If all possible failure modes for an item are identified, their chances of occurrence will total 100%.

10. For each failure mode identified in step 8, determine all significant effects that may be manifested. Ask, 'What is an undesirable result of the identified failure mode?'. Again, this can be simplified by using a standard list of effects (e.g. won't close, difficult to close, stuck closed, etc.).

    Note the difference between a failure mode and failure effect; a failure mode *results in* a failure effect. For example, a broken pedal may result in a cyclist falling off.

11. If doing criticality analysis, identify the chance of occurrence of each failure effect identified in step 10. If all possible failure effects are identified, they will total 100% for each item.

12. If doing criticality analysis, calculate the criticality of each failure effect identified in step 10, by multiplying together (a) the chance of the overall item failing (from step 6), the proportion of time that the item is at risk of failure (from step 7), the chance of the failure mode occurring (from step 9) and the chance of failure effect occurring (from step 10). This is illustrated in the illustration.

13. For each mode and effect that appears in more than one line in the table, usually because they are on a standard list, sum the criticality calculations from step 12 to determine its overall criticality rating

Chance of all possible failure modes for one item totals 100%

Chance of all possible failure effect for one failure mode need not total 100%, as effects may not always appear

Steps 5 & 6	*Step 7*	*Step 8*	*Step 9*	*Step 10*	*Step 11*	*Step 12*
Item and (% chance of failure)	Time item may fail	Failure mode		Effect of failure mode		Criticality
		Description	Chance	Description	Chance	x 10^6
Door hinge (0.5%)	100%	Fractured	12%	Can't close door	11%	66
				Difficult to close	79%	474
		Fatigued	8%	Can't close door	100%	400
		Worn	80%	Difficult to close	100%	4000
Door catch (1.2%)	20%	Seized	54%	Can't close door	25%	324
				Can't open door	75%	972

Criticality = Chance of item failure x Chance of failure mode x Chance of failure effect x Time item is at risk of failure

= 0.012 x 0.54 x 0.75 x 0.20 = 0.000972 = 972 x 10^6

The criticality of any mode or effect is the sum of the criticality of its components

Criticality of mode: Door hinge fracture
= 66 + 474 = 600

Criticality of effect: Can't close door
= 66 + 400 + 324 + . . .

Fig. 15 Building an FMEA table

14. Examine the criticality scores and identify those failure modes and effects which will require action to be taken, and determine appropriate steps to reduce the chance of undesirable failure. Actions may include:

- Redesigning items to make them likely to fail.
- Adding items to handle failure of other items.
- Adding warning systems to alert when an item fails.

Source: Wikipedia

6.3.4 Benchmarking

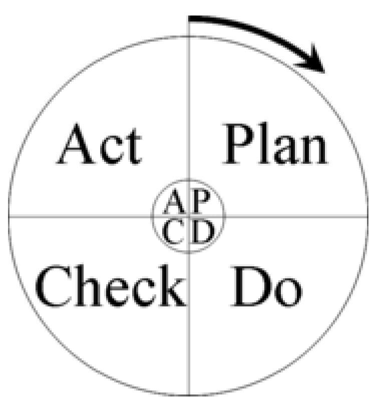
Quality has become a significant differentiator in today's world and every company is trying to leverage this aspect to gain competitive advantage. Benchmarking ,"a search for industry best practices that leads to superior performance",(the meaningful title given by Robert. (Camp for his book) is indeed a powerful tool for quality improvement...It is a method to bring the best practices of the marketplace into the organization not only to achieve parity with rivals but even to outperform them.

This technique was pioneered by Xerox to achieve "leadership through quality' and has been adopted by several companies world –wide.

For full description of this tool refer Chapter 2.

6.3.5 PDCA

PDCA ("**Plan-Do-Check-Act**") is an iterative four-step problem-solving process typically used in quality control. It is also known as the **Deming Cycle**, **Shewhart cycle**, **Deming Wheel**, or **Plan-Do-Study-Act**.



The Shewhart Cycle

PLAN

Establish the objectives and processes necessary to deliver results in accordance with the specifications.

DO

Implement the processes.

CHECK

Monitor and evaluate the processes and results against objectives and Specifications and report the outcome.

ACT

Apply actions to the outcome for necessary improvement. This means reviewing all steps (Plan, Do, Check, Act) and modifying the process to improve it before its next implementation.

PDCA was made popular by Dr. W. Edwards Deming, who is considered by many to be the father of modern quality control; however it was always referred to by him as the "Shewhart cycle." Later in Deming's career, he modified PDCA to "Plan, Do, Study, Act" (PDSA) so as to better describe his recommendations.

The concept of PDCA comes out of the Scientific Method. The scientific method can be written as "hypothesis" - "experiment" - "evaluation" or Plan, Do, and Check. Shewhart described manufacture under "control" - under statistical control - as a three step process of specification, production, and inspection. The also specifically related this to the Scientific Method of hypothesis, experiment and evaluation. Shewhart, says that the statistician "must help to change the demand [for goods] by showing... how to close up the tolerance range and to improve the quality of goods." Clearly, Shewhart intended the analyst to take action based on the conclusions of the evaluation. According to Deming during his lectures in Japan in the early 1950's the Japanese participants shortened the steps to the now traditional Plan, Do, Check, Act. Deming preferred Plan, Do, Study, Act because 'Study' has connotations in English closer to Shewhart's intent than "Check." In recognition of this perhaps we should make all references to PDSA, not PDCA.

A fundamental principle of the scientific method and PDSA, is iteration - once an hypothesis is confirmed (or negated), executing the cycle again will extend the knowledge further. Repeating the PDSA cycle can bring us closer to the goal, usually a perfect operation and output.

In Six Sigma programs, the PDSA cycle is called "Define, Measure, Analyze, Improve, Control" (DMAIC). The iterative nature of the cycle must be explicitly added to the DMAIC procedure.

PDSA should be repeatedly implemented in spirals of increasing knowledge of the system that converge on the ultimate goal, each cycle closer than the previous. One can envision an open coil spring, with each loop being one cycle of the Scientific Method - PDSA, and each complete cycle indicating an increase in our knowledge of the system under study. This approach is based on the belief that our knowledge and skills are limited, but improving. Especially at the start of a project, key information may not be known; the PDSA - scientific method - provides feedback to justify our guesses (hypotheses) and increase our knowledge. Rather than enter "analysis paralysis" to get it perfect the first time, it is better to be approximately right than exactly wrong. With the improved knowledge, we may choose to refine or alter the goal (ideal state). Certainly, the PDSA approach can bring us closer to whatever goal we choose.

PDCA has an inherent circular paradigm, it assumes that everything starts with Planning. Plan has a limited range of meaning. Shewart intended that experiments and quality control should be planned to deliver results in accordance with the specifications (see meaning above), which is good advice. However, Planning was not intended to cover aspects such as creativity, innovation, invention. In these aspects particularly when based upon imagination, it is often impossible or counterproductive to plan. Hence, PDCA is inapplicable in these situations.

- Source; Wikipedia

6.4 Contemporary Developments in Quality Management

Quality concepts are evolving along three pathways:

6.4.1 Approach to Product Defects

The early quality experts focused attention on controlling defects within an acceptable range of tolerances. The tolerances were lowered down over time and at present the acceptable limit is taken as six sigma i.e.

3.4 defects per one million parts produced . In other words the good production should be 9,999,964 per ten million parts produced. In fact quality standards are expressed not as a percentage but as parts per millions (ppm).

A further extension of this line of thinking is to aim at zero defects. Although in practice this may be difficult to achieve, it is a commendable objective to strive for.

6.4.2 Widening scope for application of quality concepts

The application of quality control is not limited to manufacturing operations only but should permeate into every function and activity of the organization. In fact quality should become a way of life for the organization. Moreover quality concepts are as much, if not more relevant, to "non-profit" institutions as for "with- profit". organizations. Service and government sectors too can and have made good use of these concepts.

6.4.3 Broadening the ambit of quality

The current thinking is to stretch the quality dimension to embrace quality of life of its people and of the society in which the organization operates...Ensuring quality of production processes so as not to cause environmental degradation, has become an imperative necessity. In short, quality is not just product quality but broader societal quality.

6.5 Cost of Quality and Non – Quality

"Quality costs but poor quality costs more"

Joseph M. Juran

6.5.1 INTRODUCTION

The vital importance of quality costing can be no better expressed than in the words of John Gilbert who states that "Quality costs matter because they are normally large (5% to 25% of sales revenue) but they are not normally measured by traditional methods. The result is that they are not known and therefore uncontrolled". By a proper and complete evaluation of the quality cost from the stage of design and development to production and service, the Management Accountant would help in creating a better awareness throughout the organization of the profound impact of poor quality and its repercussion on profitability. By this process, the entire company should be made to discard the antiquated notion of "Screening for Quality" and move on to "Planning for Quality" and to build in quality right from the stage of conception of product and thereby eliminating errors and failures ab initio. In other words "Doing things right, the first time and every time". In this direction it will be helpful to note that quality is not "conformance to specifications" but "fitness for use by the customers". In the words of John Gilbert, quality means "consistent conformance to customers' expectations".

6.5.2 Quality costs can be analyzed under two major categories.

a. Costs of quality assurance incurred by the manufacturer.

b. Costs of quality assurance at the user's end which are called "user quality costs".

6.5.3 Internal Quality Costs

There are a measure of all costs directly associated with the achievement of complete conformance to product quality requirements. These are not just the cost of quality management or inspection function. Specifically quality costs are the sum total of

a. Prevention Costs - (Quality Engineering, Quality planning).

b. Appraisal Costs - Cost of appraising product for conformance torequirements.

c. Failure Costs - Costs incurred by failure to conform to requirements
   - I. Internal
   - II. External

Each of them, broadly, consists of:

a. Preventive Costs -
   * Design Quality Assurance
   * Test Equipment Design
   * Supplier Quality assurance
     Vendor rating
   * Central Quality Organization
     (with a strong Quality)
     Engineering function).

		*	Training
		*	Quality Planning
		*	Development Testing
		*	Process capability studies
		*	Product Reliability tests
b.	Appraisal Costs	- *	Inspection
		*	Testing
		*	Supplier Quality Assurance
		*	Test and inspection equipment maintenance, calibration and repair.
		*	Environmental and Reliability Testing.
		*	Production time spent in checking and sorting product
		*	Depreciation of inspection and Test Equipment.
c.	Failure Costs	- *	Scrap
	i. Internal (In Plant)	*	Rework
		*	Excess material provisioning/ procurement.
		*	Concession and Salvage
		*	Sub-standard performance
		*	Additional inspection, testing and assembly.
		*	Trouble shooting
		*	Reinspection and / or Retest
		*	Defect investigation
		*	Modifications necessitated by defects/failures
		*	Waiting time due to rectification, modification

ii) External (in user's place	* Warranty * LOSS OF CUSTOMER CONFIDENCE (LOSS OF BUSINESS- applicable to export orders, local customers. * Sending repair crew to repair at Customer's premises * Bringing back faulty goods, their repair and re transmittal • Cost of replacement

The above approach has been called the " PAF Model".

6.5.4 User Quality Costs:

In this approach an attempt is made to determine the costs incurred by the user when the purchased materials or equipment has problems. Such non – quality costs can be broadly grouped under seven categories as given below:

Category of user Quality Cost	Example	Categories of User Quality Costs
Cost of repairs	1A	Parts and material for failed items and any associated items which also must be replaced.
	1 B	Labour for replacing the failed items and Sociated items.
Cost of effectiveness loss	2 A	idle direct labour before and during a shutdown and during startup of a process
	2 B	Extra defective product made before, during the immediately after process shutdown
Cost of maintaining extra capacity because	3 A	Equipment parts and materials
of expected failure	3 B	Direct and indirect labour
Cost of damages	4 A	injuries to personnel
caused by a failed item	4 B	Training new personnel when a replacement is required
Lost income	5 A	Profit on production lost during downtime of failed item
	5 B	Monetary penalties incurred because downtime due to a failed item causes the user to miss schedules or impose other inconveniences on his customer
Extra investment cost	6 A	Special installation and /or Compared to

		competing products "running in" requirements.
	6 B	Special checkout and maintenance equipment
Extra operating & maintenance cost compared to competing products	7 A	Lower functional output per cycle of operation
	7 B	Special power and fuels

These costs can therefore be looked upon as cost of non-conformance (to customer's satisfaction).

A Simple mathematical model can be given for calculating user quality cost.

C_f = Sum of $1/(1+i)j\ (R_j + E_j + C_j + D_j + I_j)$
(1 to n)

Cj = Present value of user failure costs (Rupees)

n = number of years

i = years interest rate %

R = Repair Cost in the jith year (Rupees)

E = Effectiveness loss in the jth year (Rupees)

C = Extra capacity in the jth year (Rupees)

D = Damages in the jth year (Rupees)

I = income lost in the jth year (Rupees)

6.5.5 Benefits of User Quality Costs

a. When making purchase decisions for equipment one should not merely look at initial acquisition cost only but also take into account operational cost over the life span of the equipment

b. User quality costs will help the manufacturer to justify the higher price for his products over that of the competitor.

c. User quality costs also help the manufacturer to fix warranty period for his products.

6.5.6 Quality Costs – Process Analysis Model

The basis of Process Analysis is to understand the scope of the process which make up a business activity and to understand the relationship and interactions between the various activities of the process. This is usually done in the form of a flowchart.

When this is achieved, the cost of operating these process can be analyzed and calculated to obtain the Costs of Quality. Quality cost measurement measures the gap between the actual costs of a business and its potential performance if every activity in the business in being carried out in accordance with requirements, first time and every time.

Let, Total Quality Costs = TQC

Let, Cost of Conformance = COC

Let, Cost, of non – Conformance = CONC

Therefore, TQC = COC + CONC

This is the Process, Analysis model described in Part 1 of BS 6143: Guide to the economics of quality, published in 1992.

This method of quality costing means that the total cost of running the business is either part of COC or part of CONC. All costs are included somewhere.

It may be noted that COC is the sum of prevention and appraisal costs

CONC is the cost of failure.

6.5.7 Non- Monetary Measures

Management Accountants must refine the costing tools to measure customer satisfaction using criteria such as delays in deliveries, customer complaints, invoice errors, lead times etc., which greatly impact on business performance and ultimately profitability; in other words, he should not limit himself only to monetary yardsticks. In fact Management Accountants must learn to be bilingual, talking the language of money with Top Management and conversing in terms of physical and time parameters with the lower levels of Management.

6.5.8 Customer Measures

6.5.8.1 The purpose of business, says Peter Drucker, is to make and keep a customer. Hence keeping the customer satisfied, continuously is of vital importance to any business by tracking customer satisfaction ceaselessly, taking a “outside in” perspective.

Customer satisfaction can be measured by

i. Conducting surveys either through independent consultant or in–house personnel to obtain customer feedback on products sold and services rendered

ii. Deploying “ mystery shoppers” who will get a first hand experience of the behaviour of front dusk sales personnel.

iii. Number of customer complaints.

6.5.8.2 Products

In respect of product, the deficiencies in the product and its parts can be clearly brought out to enable remedial action to be taken.

6.5.8.3 Services

Service business is people intensive and personal interaction of sales staff with a diversity of customers, each with his or her individual propensities plays a big role in ensuring customer satisfaction. Important generic measures governing service quality are given below.

- Courtesy shown to customers
- Friendly and helpful attitude by providing necessary clarification regarding product location, characteristics etc.
- Pleasant greeting
- Ambience and cleanliness of the place
- Auxiliary services like provision of convenient carts, valet parking etc.

The example of a Call Centre will highlight the importance of evaluating performance from the customer's perspective rather than that of the firm. Empirical studies have shown that no other metric has a big impact on customer satisfaction than First Call Resolution (FCR). In fact, customer satisfaction drops by an average of 15% with each call back a customer must make. Time a call is put on hold is a key measure as delayed response may frustrate the customer. Purely quantitative measures like Average Handling Time, (AHT), no of calls handled, may not be appropriate measures and may even be counter productive.

Other customer measurers are

Customer Retention	-	Length of customer relationships
Customer Loyalty	-	Repeat purchases, referrals.

6.6 Practices of Continuous Improvement

6.6.1 Quality Circle-A way to Quality Improvement

6.6.1.1 Definition

Quality Circle is a small group of 6 to 12 employees doing similar work who voluntarily meet together on a regular basis to identify improvements in their respective work areas using proven techniques for analysing and solving work related problems coming in the way of achieving and sustaining excellence leading to mutual upliftment of employees as well as the organisation. It is "a way of capturing the creative and innovative power that lies within the work force".

6.6.1.2 Philosophy

Quality Circles is a people – building philosophy, providing self-motivation and happiness in improving environment without any compulsion or monetary benefits. It represents a philosophy of managing people specially those at the grass root level as well as a clearly defined mechanism and methodology for translating this philosophy into practice and a required structure to make it a way of life. It is bound to succeed where people are respected and are involved in decisions, concerning their work life, and in environments where peoples' capabilities are looked upon as assets to solve work-area problems.

The Quality Circle philosophy calls for a progressive attitude on the part of the management and their willingness to make adjustments, if necessary, in their style and culture. If workers are prepared to contribute their ideas, the management must be willing to create a congenial environment to encourage them to do so.

6.6.1.3 Concept

The concept of Quality Circle is primarily based upon recognition of the value of the worker as a human being, as someone who willingly activises on his job, his wisdom, intelligence, experience, attitude and feelings. It is based upon the human resource management considered as one of the key factors in the improvement of product quality & productivity. Quality Circle concept has three major attributes:

a. Quality Circle is a form of participation management.

b. Quality Circle is a human resource development technique.

c. Quality Circle is a problem solving technique.

6.6.1.4. Objective

The objectives of Quality Circles are multi-faced.

a) Change in Attitude.

From "I don't care" to "I do care"

Continuous improvement in quality of work life through humanisation of work.

b) Self Development

Bring out 'Hidden Potential' of people

People get to learn additional skills.

c) Development of Team Spirit

Individual Vs Team – "I could not do but we did it"

Eliminate inter departmental conflicts.

d) Improved Organisational Culture

Positive working environment.

Total involvement of people at all levels.

Higher motivational level.

Participate Management process.

6.6.1.5 Organisational Structure

A Quality Circle has an appropriate organisational structure for its effective and efficient performance. It varies from industry to industry, organisation to organisation. But it is useful to have a basic framework as a model. The structure of a Quality Circle consists of the following elements.

i. *A steering committee*: This is at the top of the structure. It is headed by a senior executive and includes representatives from the top management personnel and human resources development people. It establishes policy, plans and directs the program and meets usually once in a month.

ii. *Co-ordinator*: He may be a Personnel or Administrative officer who co-ordinates and supervises the work of the facilitators and administers the programme.

iii. *Facilitator*: He may be a senior supervisory officer. He co-ordiates the works of several quality circles through the Circle leaders.

iv. *Circle leader*: Leaders may be from lowest level workers or Supervisors. A Circle leader organises and conducts Circle activities.

v. *Circle members* : They may be staff workers. Without circle members the porgramme cannot exist. They are the lifeblood of quality circles. They should attend all meetings as far as possible, offer suggestions and ideas, participate actively in group process, take training seriously with a receptive attitude.The roles of Steering Committee, Co-0rdinator, Facilitator, Circle leader and Circle members are well defined.

6.6.1.6 Launching Quality Circles

The major prerequisite for initiating Quality Circles in any organisation is the total understanding of, as well as complete conviction and faith in the participative philosophy, on the part of the top and senior management. In the absence of a commitment from the Chief Executive to support the Quality Circle movement totally, it would be inadvisable to seriously attempt the starting of Quality Circles. The launching of Quality Circles involves the following steps: Expose middle level executives to the concept.

Explain the concept to the employees and invite them to volunteer as members of Quality Circles.

Nominate senior officers as facilitators. Form a steering committee.
Arrange training of co-ordinators, facilitators in basics of Quality Circle approach, implementation, techniques and operation. Later facilitator may provide training to Circle leaders and Circle members. A meeting should be fixed preferably one hour a week for the Quality Circle to meet. Formally inaugurate the Quality Circle. Arrange the necessary facilities for the Quality Circle meeting and its operation.

6.6.1.7 Training

Appropriate training for different sections of employees needs to be imparted. Without a proper understanding of the real concept of Quality Circles, both the workers and management might look at this philosophy with suspicion. Each group should know beforehand the commitments and implications involved as well as the benefit that can be obtained from Quality Circles. Such training comprises of :

Brief orientation programme for top management.
Programme for middle level executives.
Training of facilitators.
Training for Circle leaders and members.

6.6.1.8 Process of Operation

The operation of quality circles involves a set of sequential steps as under:

1 Problem identification: Identify a number of problems.

2 Problem selection : Decide the priority and select the problem to be taken up first.

3 Problem Analysis : Problem is clarified and analysed by basic problem solving methods.

4 Generate alternative solutions : Identify and evaluate causes and generate number of possible alternative solutions.

5 Select the most appropriate solution : Discuss and evaluate the alternative solutions by comparison in terms of investment and return from the investment. This enables to select the most appropriate solution.

6 Prepare plan of action : Prepare plan of action for converting the solution into reality which includes the considerations "who, what, when, where, why and how" of solving problems.

7 Present solution to management circle members present solution to management fore approval.

8 Implementation of solution : The management evaluates the recommended solution. Then it is tested and if successful, implemented on a full scale

The Quality Circles also are expected to develop internal leadership, reinforce worker morale and motivation, and encourage a strong sense of teamwork in an organisation.

A variety of benefits have been attributed to Quality Circles, including higher quality, improved productivity, greater upward flow of information, broader improved worker attitudes, job enrichment, and greater teamwork.

Problem quality circles often suffer from unrealistic expectations for fast results, lock of management commitment and support, resistance by middle management, resentment by non participants, inadequate training, lack of clear objectives and failure to get solutions implem

6.6.1.9. Applicability

Quality Circle was popularized in Japan by Kauro Ishikawa and was successfully applied in a variety of industries It's application is ,however not limited to industry only ;it can and has been profitably employed in government , service and non-orofit organizations

6.6.1.10.Applicabllity in Government

The Public Works Department of Government of Maharashtra is a good illustration for application in government

Some of the problems solved by the Quality Circles in P.W.D. of Maharashtra are as follows:

1 Eliminating delay in issuing observation memos after inspection of site.

2 Preventing accidents on highways.

3 Reducing electricity bill in office.

4 Avoiding duplication of work.

5 Removal of encroachment from Govt. land.

6 Speeding up pot-hole filling on roads during monsoon.

7 Upkeeping of service records of employees.

8 Maintaining Govt. offices clean.

9 Stream-lining reservation system of Govt. rest houses.

10 Improvement in maintenance of Govt. Hospital at Solapur

By solving this problem, it became possible to improve the quality of work in the field which ultimately brightened the image of the Department. The formation of Quality Circle also benefited employees by providing.

a) A systematic style of education that helped them grow.

b) Freedom to modify their work habits.

c) Opportunity to use their brain for development of the Department; and

d) Opportunity to work as a team.

e) The employees were also motivated to improve work culture, self improvement recognition and creativity in work.

Conclusion

Quality Circles are not limited to manufacturing firms only. They are applicable for variety of organisations where there is scope for group based solution of work related problems. Quality Circles are relevant for factories, firms, schools, hospitals, universities, research institutes, banks, government offices etc. The P.W.D. of Maharashtra has set an example for the Government organisations marching on the path of Quality Improvement.

Source: www.mahapwd.com/isoand quality circle/qc.htm

6.6.2 Kaizen

6.6.2.1 Meaning of Kaizen

Kaizen is a Japanese term comprising – KAI – change; ZEN – better (for the better).

It is a Japanese strategy for continuous improvement.

The interpretation of the meaning of improvement goes for beyond the Western perceptions about it. For the Western management improvement simply implies only improvement in equipments, processes and maintenance. But, the Japanese perception of improvement starts with the improvement of the human element. Thus, KAIZEN is a highly people oriented approach covering every aspect of human activities.

6.6.2.2 Kaizen's Starting Point: Setting the Right Mindset & Business Environment

- not a single day should go by without some kind of improvement being made somewhere in the company
- customer-driven strategy for improvement – any management activity should eventually lead to increased customer satisfaction
- quality first, not profit first – an enterprise can prosper only if customers who purchase its products or services are satisfied
- recognition that any corporation has problems and establishing a corporate culture where every one can freely admit these problems and suggest improvement
- problem solving is seen as cross-functional systemic and collaborative approach
- emphasis on <u>process</u> – establishing a way of thinking oriented at improving processes, and a management system that supports and acknowledges people's process-oriented efforts for improvement

6.6.2.3 Management has two major functions in KAIZEN --- maintenance and improvement. Management must

1. Create a conducive environment and encourage continuous improvement (technological, managerial and operative) and establish standards.
2. Maintaining the standards established.

Supervisors and workers have a greater role in maintenance function whereas top and middle management have a greater role in improvement function.

The important role of management in maintenance function of Kaizen are:

- Policies and procedures
- Establish the standards and Standard Operating Procedures
- Ensure that standards are followed by all
- Review and monitor improvements
- Educate and train people to enable them to follow the standards with emphasis on its importance to follow them.

In Kaizen, new standards are not static, though they are to be maintained. They, nevertheless, yield place to new standards as a part of continuous improvement, one succeeding the earlier one.

Though maintenance of standards play a vital part in worker's function, they are also expected to suggest small, incremental continuous improvements.

6.6.2.4 KAIZEN-People oriented approach

In KAIZEN process improvements are people-oriented. It provides opportunities for the participation and involvement of the workers through the creation of conducive environment, providing education, training and encouragement. It is different from just result oriented thinking and approach in western systems of management.

Though results are very important in a result oriented world for progress, for lasting continuous improvement as in KAIZEN, people focus is very much necessary.

Process–oriented approach calls for long–term outlook whereas only result oriented approach is short–term. All the Japanese concepts which are people focused are process–oriented approaches.

The concerns of a process-oriented and people-oriented manager should be:

1. Discipline
2. Time management
3. Skill development
4. Participation and involvement
5. Morale boosting
6. Communication (two-ways)

6.6.2.5 Hierarchy of Kaizen Involvement

Top Management	Middle Management and Staff	Supervisors	Workers
Be determined to introduce KAIZEN as a corporate strategy	Deploy and implement KAIZEN goals as directed by top management through policy deployment and cross-functional management	Use KAIZEN in functional roles	Engage in Kaizen through the suggestion system and small-group activities
Provide support and direction for KAIZEN by allocating resources		Formulate plans for KAIZEN and provide guidance to workers	
Establish policy for KAIZEN and cross-functional goals	Use KAIZEN in functional capabilities	Improve communication with workers and sustain high morale	Practice discipline in the workshop
Realize KAIZEN goals through policy deployment and audits	Establish, maintain, and upgrade standards	Support small-group activities (such as quality circles) and the individual suggestion systems	Engage in continuous self-development to become better problem solvers
Build systems, procedures, and structure conducive to KAIZEN	Make employees KAIZEN conscious through intensive training programs	Introduce discipline in the workshop	Enhance skills and job-performance expertise with cross-education
	Help employees develop skills and tools for problem solving	Provide KAIZEN suggestions	

6.6.2.6 Kaizen and Suggestion System

According to Masaaki Imai, "Japanese management makes a concerted effort to involve employees in KAIZEN through suggestions. Thus, the suggestion system is an integral part of the established management system".

Imai also states that the Quality Control System and suggestion system work in concert where the companies are active in KAIZEN.

Apparently KAIZEN also seems to be a form of suggestion system. "The suggestion system is an integral part of individual oriented KAIZEN" says Imai. From this statement of Imai it is clear that KAIZEN and individual suggestion system are inter-related, may be with some variations in practice. Whenever a suggestion is made by an employee and is implemented, then standards are established and he takes pride in it because it is based on his suggestion.

The systematic adoption of Kaizen strategy was instrumental for the phenomenal success of Toyota Motor Corporation. In the words of Eiji Toyoda, Chairman and C.E.O. of Toyota Motors "One of the features of the Japanese workers is that they use their brains as well as their hands. Our workers provide 1.5 million suggestions a year and 95% of them are put to practical use. There is an almost tangible concern for improvement in the air at Toyota".

6.6.2.7 Improvement

Improvement can be broken down between Kaizen and innovation. Kaizen signifies small improvements made in the status quo as a result of ongoing efforts. Innovation involves a drastic improvement in the status quo as a result of large investment in new technology and/or equipment.

The differences between Kaizen and innovation as given by Maasaki Imai are given below:

	KAIZEN	INNOVATION
1. Effect	Long-term and long-lasting but not dramatic	Short-term but dramatic
2. Pace	Small steps	Big steps
3. Time frame	Continuous and incremental	Intermittent and non-incremental
4. Change	Gradual and constant	Abrupt and volatile
5. Involvement	Everybody	Select few “champions”
6. Approach	Collectivism, group efforts systems approach	Rugged individualism, individual ideas and efforts
7. Mode	Maintenance and improvement	Scrap and rebuild
8. Spark	Conventional know-how and state of the art	Technological break - through, new inventions, new theories
9. Practical requirements	Requires little investment but great effort to maintain it	Requires large investment but little effort to maintain it
10. Effort Orientation	People	Technology
11. Evaluation criteria	Process and efforts for better results	Results for profits
12. Advantage	Works well in slow-growth economy	Better suited to fast-growth economy

The suggestions for improvement emanating at various levels are discussed by all concerned and a consensus is reached, with or without modification, to the original proposal. It is a bottom-up decision process based on consensus at every level. This decision-making process known as “ringisho” is a striking feature of Japanese management. Though this process may seem to be slow, it ensures that conflicts are smoothened out and everyone understands and appreciates the value of the decision. Thus the commitment of those directly responsible for implementation is ensured, paving the way for a smooth and successful implementation.

6.6.3 Five S - Concept

The Five S concept is an integrated concept for house - keeping or workplace management evolved by the Japanese. The Five Ss are;

SEIRI - Organization or re-organization.

SEITON- Neatness

SEISO - Cleaning

SEIKETSU - Standardization

SHITSUKE - Discipline

Brief description of each S

Seiri

The literal meaning of the Japanese word `SEIRI' is to `straighten and contain'. It can be understood as discard unnecessary things i.e., get rid of waste and put things in such a way as to have quick access. This is how `straighten and contain' can be interpreted.

If we apply this idea to a factory, office, house, farm or shop, waste of time in searching for an item and having unnecessary things taking up space will be reduced. Developing a system can bring consistency in what we do. `SEIRI' thus means `organization' or more appropriately `Reorganization'.

Practice of `SEIRI' involves several steps. They are,

- Planning and training
- Method of sorting
- Categorisation (use-frequency classification)
- Survey (stock verification and similar checks)
- Cleaning

Procedure for `Seiri'

- Form of a tem.
- Decide on the scope of the operation (what workplace and zones) and the targets that group has to achieve.
- Get ready.
- Define objective and teach people to recognize what is unnecessary, what to discard what things to save so that they can be accessed later.
- Put red tag for unnecessary items and yellow tags for the items to be sent to stores.
- Apply stratification management.

Seiton

While `SEIRI' helps us to decide what are the items needed, `SEITON' helps to decide the way things are to be placed so that our working is smooth. `SEITON' involves safety and productivity.

Three rules to be followed for this are:

- Decide where things need to be placed
- Keep things in that place
- Always follow the system

In short, a place for a thing and the thing in its place.

Points to be remembered are

- Keeping things in the best way

- What to keep, where to keep, how to keep and how much to keep.
- Having ground rules for organizing things neatly.
- Marking areas and cautions.
- Proper place for things:

  Jigs, fixtures, tools and cables, consumables, storing defective items, emergency items, storage of liquids and fire hazard items.
- Filling removable containers.

Seiso

The literal meaning of the word `SEISO' is clean up. It means take up the job of cleaning. Such cleaning is not restricted merely to the machines, table, kitchen cabinet etc., i.e., whichever we have taken up. It should be extended to the entire surroundings.

Cleaning is getting rid of bad things and purifying. Cleaning first calls for an inspection and then acting on it.

The essence of cleaning is not just making things or place clean. Thorough cleaning will help us to quickly defect or see defects with our eyes. Abnormal sound can be observed and by touching with hands one can feel vibration, temperature etc. Observation by looking, listening and feeling (LLF) at the time of cleaning, can identify abnormalities like abnormal smell, discolouration, loose parts, knocking, abnormal sounds, over heating, leaks and dispersion, vibration and shaking, misses and skipping, irregular movement, abrasion, trash and dirt, damage, etc. These can be quickly discovered and attended to. Hence we can say Seiso is to reveal potential defects.

Points to be remembered

- Who should do the cleaning? Is it a separate function?
- Assigning roles and responsibilities
- Providing implements and tools
- Making SEISO a day-to-day routine
- Care of special and sophisticated equipment
- Education on SEISO

Seiketsu

Seiri, Seiton and Seiso are easy to do once, but it is very difficult to maintain. To maintain, we have to standardize the system. Seiketsu is nothing but standardization. In Five S this means ensuring whatever cleanliness and orderliness have been achieved through Seiri, Seiton and Seiso, they are maintained. We should keep a strict control over the situation.

We cannot achieve this by one time effort of carrying out the activities of cleaning. We should make sure that whatever is achieved is not allowed to deteriorate. If we face any problem, our capabilities coupled with the system should be able to overcome that problem. Hence Seiketsu is only complete when its horizons have been expanded to include the entire working environment.

Points to be remembered are

- Standardization is to systematize.
- Knowledge of putting the finger of the trouble spots
- Imparting knowledge systematically
- Visual Management
- Sensory alertness and control
- Position marking
- Ways of promotion of Seiketsu
- Incentive at workshop level.
- Incentive at the factory level.

Shitsuke

Shitsuke means discipline. Discipline is following a system, which calls for changing from our present unsystematic way of adherence to set procedures. Systems function in an orderly manner.

If you make the task of bringing changes as teamwork you will find it easier. It is due to two reasons. One, instead of as an individual if we do things as a team, it becomes fun and not a work that is disliked. Secondly, if the job is difficult, teamwork makes it easier. Tougher the job, easier the teamwork makes it.

Points to be remembered are:

- Routine and complacency
- Make the tasks small or big a habit
- Instructions/communications should be clear

Source;

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6.6.4 Six Sigma

6.6.4.1. Six Sigma is a set of practices originally developed by Motorola to systematically improve processes by eliminating defects. A defect is defined as non-conformity of a product or service to its specifications.

While the particulars of the methodology were originally formulated by Bill Smith at Motorola in 1986, Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects. Like its predecessors, Six Sigma asserts the following:

- Continuous efforts to reduce variation in process outputs is key to business success
- Manufacturing and business processes can be measured, analyzed, improved and controlled
- Succeeding at achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management

The term "Six Sigma" refers to the ability of highly capable processes to produce output within specification. In particular, processes that operate with six sigma quality produce at defect levels below 3.4 defects per (one) million opportunities (DPMO). Six Sigma's implicit goal is to improve all processes to that level of quality or better.

Six Sigma is a registered service mark and trademark of Motorola, Inc.[4] Motorola has reported over US$17 billion in savings[5] from Six Sigma as of 2006.

In addition to Motorola, companies that adopted Six Sigma methodologies early on and continue to practice it today include Honeywell International (previously known as Allied Signal) and General Electric (introduced by Jack Welch).

6.6.4.2 Methodologies

Six Sigma has two key methodologies: DMAIC and DMADV, both inspired by W. Edwards Deming's Plan-Do-Check-Act Cycle: DMAIC is used to improve an existing business process, and DMADV is used to create new product or process designs for predictable, defect-free performance.

DMAIC

Basic methodology consists of the following five (5) steps:

Define the process improvement goals that are consistent with customer demands and enterprise strategy.

Measure the current process and collect relevant data for future comparison.

Analyze to verify relationship and causality of factors. Determine what the relationship is, and attempt to ensure that all factors have been considered.

Improve or optimize the process based upon the analysis using techniques like Design of Experiments.

Control to ensure that any variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

DMIADV

Basic methodology consists of the following five steps:

Define the goals of the design activity that are consistent with customer demands and enterprise strategy.

Measure and identify CTQs (critical to qualities), product capabilities, production process capability, and risk assessments.

Analyze to develop and design alternatives, create high-level design and evaluate design capability to select the best design.

Design details, optimize the design, and plan for design verification. This phase may require simulations.

Verify the design, set up pilot runs, implement production process and handover to process owners.

Some people have used DMAIC**R** (Realize). Others contend that focusing on the financial gains realized through Six Sigma is counter-productive and that said financial gains are simply byproducts of a good process improvement.

6.6.4.3 Statistics and robustness

The core of the Six Sigma methodology is a data-driven, systematic approach to problem solving, with a focus on customer impact. Statistical tools and analysis are often useful in the process. However, it is a mistake to view the core of the Six Sigma methodology as statistics; an acceptable Six Sigma project can be started with only rudimentary statistical tools.

Still, some professional statisticians criticize Six Sigma because practitioners have highly varied levels of understanding of the statistics involved.

Six Sigma as a problem-solving approach has traditionally been used in fields such as business, engineering, and production processes

6.6.4.4 Implementation roles

One of the key innovations of Six Sigma is the professionalizing of quality management functions. Prior to Six Sigma, Quality Management in practice was largely relegated to the production floor and to statisticians in a separate quality department. Six Sigma borrows martial arts ranking terminology to define a hierarchy (and career path) that cuts across all business functions and a promotion path straight into the executive suite.

Six Sigma identifies several key roles for its successful implementation.

Executive Leadership includes CEO and other key top management team members. They are responsible for setting up a vision for Six Sigma implementation. They also empower the other role holders with the freedom and resources to explore new ideas for breakthrough improvements.

Champions are responsible for the Six Sigma implementation across the organization in an integrated manner. The Executive Leadership draws them from the upper management. Champions also act as mentors to Black Belts. At GE this level of certification is now called "Quality Leader".

Master Black Belts, identified by champions, act as in-house expert coaches for the organization on Six Sigma. They devote 100% of their time to Six Sigma. They assist champions and guide Black Belts and Green Belts. Apart from the usual rigour of statistics, their time is spent on ensuring integrated deployment of Six Sigma across various functions and departments.

Experts this level of skill is used primarily within Aerospace and Defense Business Sectors. Experts work across company boundaries, improving services, processes, and products for their suppliers, their entire campuses, and for their customers. Raytheon Incorporated was one of the first companies to introduce Experts to their organizations. At Raytheon, Experts work not only across multiple sites, but across business divisions, incorporating lessons learned throughout the company.[citation needed]

Black Belts operate under Master Black Belts to apply Six Sigma methodology to specific projects. They devote 100% of their time to Six Sigma. They primarily focus on Six Sigma project execution, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.

Green Belts are the employees who take up Six Sigma implementation along with their other job responsibilities. They operate under the guidance of Black Belts and support them in achieving the overall results.

Yellow Belts are employees who have been trained in Six Sigma techniques as part of a corporate-wide initiative, but have not completed a Six Sigma project and are not expected to actively engage in quality improvement activities[10].

In many recent programs, Green Belts and Black Belts are empowered to initiate, expand, and lead projects in their area of responsibility.

Source: Wikipedia

6.7 External Quality Standards

6.7.1 ISO 9001:2000 Quality System

Introduction

ISO (International Organisation for Standardisation) is a federation of National Standards bodies with a membership of over 100 countries. It is based at Geneva, Switzerland.

ISO brought out in 1987 a set of standards on quality system referred to as ISO 9000 series on Quality Management System.

ISO 9000 is a generic standard for quality system. There is a recognition that it is not necessary to provide Quality Management System (QMS) models suited to the needs of various industry sectors, nor to provide sunsets of one model in order to satisfy the needs of organisation involved in a more limited range of activities. Hence the previous 3 models in the form of ISO 9001, ISO 9002 and ISO 9003 of 1994 have been dispensed with and only ISO 9001:2000 is provided. The intention is that this model may be adopted to suit the needs of individual organization.

Process Approach

ISO 9000:2000 standard promotes the adoption of a process approach to QMS to enhance interested party satisfaction by meeting interested party requirements.

An organization to function effectively and efficiently has to identify and manage numerous linked activities. An activity using resources and managed to transform inputs into outputs is considered as a process.

The application of a System of Processes within an organization together with identification and interactions and managing of these processes is termed "Process approach".

Process approach in QMS highlights the importance of :

- Understanding and fulfilling requirements.
- The need to consider processes in terms of added value.
- Obtaining process performance and effectiveness.
- Continual improvement of processes based on objective measurement.

Model of a process based QMS is shown below.

Quality management principles for improved organization performance

The adoption of a QMS should be a strategic decision by top management for survival and growth of the organization. It has been clearly demonstrated and proven that those organizations that focus their efforts firmly onto understanding the needs and expectation of their customers and then systematically set about planning and managing their operations in order to deliver in a consistent and reliable fashion at an overall acceptance cost generally survive and grow.

ISO 9001:2000 is based on 8 Quality Management principles.

A Quality Management Principle is a comprehensive and fundamental rule or belief, for leading and operating an organization aimed at continually improving performance over the long-term by focusing on customers while addressing the needs of all other stakeholders.

Eight Quality Management Principles have been identified. These are :

Principle 1 : Customer Focus

Principle 2 : Leadership

Principle 3 : Involvement of People

Principle 4 : Process Approach

Principle 5 : System approach to management

Principle 6 : Continual Improvement

Principle 7 : Factual approach to decision making

Principle 8 : Mutually beneficial supplier relationships

PRINCIPLE-1 : CUSTOMER FOCUS

Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.

PRINCIPLE-2 : LEADERSHIP

Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving organization's objectives.

PRINCIPLE-3 : INVOLVEMENT OF PEOPLE

People of all levels are the essence of an organization and their full involvement enables their abilities to be used for the organizations benefit.

PRINCIPLE-4 : PROCESS APPROACH

A desired result is achieved more efficiently when activities and related resources are managed as a process.

PRINCIPLE-5 : SYSTEM APPROACH TO MANAGEMENT

Identifying, understanding and managing interrelated processes as a system contributes to organization's effectiveness and efficiency in achieving its objectives.

PRINCIPLE-6 : CONTINUAL IMPROVEMENT

Continual improvement of the organisation's overall performance should be a permanent objective of the organization.

PRINCIPLE-7 : FACTUAL APPROACH TO DECISION MAKING

Effective decisions are based on the analysis of data and information.

PRINCIPLE-8 : MUTUALLY BENEFICIAL SUPPLIER RELATIONSHIPS

An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

5. **STRUCTURE AND FEATURES OF ISO 9000:2000 FAMILY**

There are 4 standards – ISO 9000, ISO 9001, ISO 9004 and ISO 10011 (to be replaced by ISO 19011 when issued)

- ISO 9000:2000: Quality Management Systems – Fundamentals and vocabulary. This describes the terminology for QMS.
- ISO 9001:2000: Quality Management Systems – Requirements. This specifies QMS for use where an organization's capability to provide products that meet customer and applicable regulatory requirements needs to be demonstrated.
- ISO 9004:2000: Quality Management Systems – Guidelines for performance improvements. This provides guidance on QMS including processes for continual improvement that contribute to the satisfaction of an organization's customers and other interested parties.
- ISO 19011:2002: Provides guidance on managing and conducting QMS and EMS audits.

Relations between ISO 9001:2000 and ISO 9004:2000

Intention, is that these two standards form a `Consistent' pair of Quality Management System standards designed to be used together and also suitable for use independently. Structure of both documents is very similar in order to facilitate combined used. However, the intentions behind both the standards is different.

ISO 9001:2000 – Scope

General

This international standard specifies requirements for a quality management system where an organization

a) needs to demonstrate the ability to consistently provide product that meets customer and applicable regulatory requirements and

b) aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements.

NOTE: In this International Standard, the term `product' applies only to the product intended for or required by a customer.

Application (Key points)

All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.

Where any requirements of this International Standard cannot be applied due to the nature of an organization and its product, this can be considered for exclusion (Exclusions are restricted to requirements within clause 7).

ISO 9001 provides model for quality system that may be used, as a basis for development of a Quality System to suit particular organizations needs.

It may be used in a contractual situations between two parties where the organization needs to demonstrate capability to design and supply product. The requirements in the standard are preventative in nature.

ISO 9001 does not relate to the product, but only to the Quality System that is applied during the process of designing, producing, installing and servicing the product.

ISO 9004:2000

This is not intended for any contractual or certification purposes.

The standard provides guidelines beyond the requirements given in ISO 9001:2000 in order to consider both the effectiveness and efficiency of the QMS and consequently the potential for improvement of the performance of an organization.

The focus of the standard is the achievement of ongoing improvement measured through the satisfaction of customers and the interested parties.

The standard is headed in the direction of many of the major National and International award schemes such as Malcolm Balridge National Quality Award, European Quality Award, Deming Award, Rajiv Gandhi National Quality Award etc.

Permissible exclusions

Excluding elements of the standard is permitted provided an organization clearly identifies why certain elements of ISO 9001:2000 are decided to be not applicable to that particular organization. This is limited to particular processes in Clause 7 (Product realization) of the standard, provided exclusions do not affect organizations ability or responsibility, to provide product that fulfils customer and applicable regulatory requirements.

Terminology used in ISO 9001:2000

Quality

Degree to which a set of inherent characteristics fulfils requirements.

Quality Policy

Overall intentions and direction of an organization related to quality as formally expressed by top management.

Quality Objective

Something sought or aimed for related to quality.

Quality Management

Coordinated activities to direct and control an organization with regard to quality.

Quality Planning

Part of quality management focused on setting quality objectives and specifying necessary operational processes and related processes to fulfil quality objectives.

Quality Control

Part of Quality management focused on providing confidence that quality requirements will be fulfilled.

Quality Improvement

Part of quality management focused on increasing the ability to fulfil quality requirements. (Requirements can be related to any aspect such as effectiveness, efficiency or traceability).

Process

Set of interrelated or interacting activities which transforms inputs into outputs.

Product	Result of Process
Conformity	Fulfillment of a requirement.
Non-Conformity	Non-fulfillment of a requirement.
Correction	Action taken to eliminate a detected non-conformity.
Corrective Action	Action taken to eliminate the cause of a detected non-conformity or other undesirable situations.
Preventive Action	Action taken to eliminate the cause of a potential non-conformity or other undesirable potential situations.
Quality Manual	Document specifying the quality management system of an organization.

Requirements of ISO Standards

1) Quality Management System

- Organization shall establish, document, implement, maintain and continually improve the QMS.
- Organization shall
- Identify the processes needed for QMS.
- Determine sequence and interaction of these processes.
- Determine criteria and methods required to ensure effective operation and control of the processes.
- Ensure availability of resources and information to support the operation and monitoring of the processes.
- Measure, monitor and analyse these processes.
- Implement action to achieve planned results and continual improvement of these processes.
- Control includes control of outsourced processes, if any, and shall be identified within QMS.

2) Management Responsibility

To specify what should management do to develop and maintain an effective and efficient QMS and improve the same.

- Management Commitment
- Customer Focus

- Quality Policy
- Planning
- Responsibility, authority and communication
- Management review

3) Resource Management
   - Provision of resources
   - Human Resources
   - Infrastructure
   - Work environment

4) Product Realization
   - Planning of product realization
   - Customer related processes
   - Design and development
   - Purchasing
   - Production and service provision
   - Control of monitoring and measuring devices

5) Measurement, Analysis and Improvement
   - Monitoring and Measurement
   - Control of non-conforming product
   - Analysis of data
   - Improvement

6.7.2 QS 9000 Standards (Replaced by ISO/TS/16949)

QS 9000 is a set of quality system requirements, jointly published by the big 3 American automobile manufacturers viz: Ford Motor Co., Daimier Chrysler Corporation and General Motors Corporation for the adherence of their main suppliers.

This is applicable to the direct suppliers of

- Production or Service parts
- Production materials
- Heat treating, painting, plating or other finishing services

And also to some suppliers who are supplying to direct suppliers

The requirements are to

- Ensure that suppliers' product meet the specification and announced product description of the organizations

- Ensure that the suppliers' quality system is consistently implemented and verified.
- Ensure that they have systems for the continuous improvement so that they are in a position to meet the changing demands of the company.

This specification has now been replaced by ISO/TS/16949 – a similar `sector specification' for automobile sector, issued by the ISO organization.

ISO/TS/16949

The QS 9000 specification, which was prepared by the Chrysler Corporation, Ford Motor Co., and General Motors Corporation of the USA, basically addressed itself only to the requirements of the automotive industry of the USA though it was adopted by others also.

The technical committee of ISO was in the process of preparing Global standards – sector specific-applicable to specific products sectors. In that process, the Standard TS/16949 was prepared for global implementation. This specification was jointly prepared by the International Automotive Task Force (IATF) and Japan Manufacturers Association (JAMA) with support from ISO/TC 176.

The QS 9000 standard now stands replaced by this International Standard ISO 16949:2002.

Whereas support functions of an organization like Design Centres, Corporate, HQ and Distribution centres can be certified as stand-alone functions against the requirements of ISO 9001, it cannot be done in the case of TS/16949. The certification should cover the entire automotive supply chain.

The requirements of this standard is generally same as those of the ISO 9001:2000 with additional requirements of the automotive sector.

Some of the major additional requirements relate to the

- Mandatory requirement of a `multi disciplinary approach' to product design involving the organization's design, manufacturing, engineering, quality, production and other appropriate personnel.
- Specific requirements for expressing the `product design outputs' like design FMEA reliability results, product error-proofing etc. and `Manufacturing process design output' like manufacturing process flow charts, manufacturing process FMEA's data for quality, reliability, maintainability and measurability, results for error-proofing activities etc.
- Focus on timely completion of the deliveries.
- The organization should perform supplier quality management system development with the goal of supplier conformity with this technical specification (ISO 16949) and, as first step, the suppliers should be certified to ISO 9001:2000 by an accredited third party certification body.
- Appropriate statistical tools for each process shall be identified during advance planning and included in the control plan. Basic statistical concepts like variation, control (stability), process capability and over adjustment shall have to be understood and utilized throughout the organization.
- Requirement of a `control plan' at the system, sub-system, component/and or material level for the product supplied including those for processes producing bulk materials as well as parts and have a control plan for `pre-launch and production' that takes into account the design FMEA and manufacturing FMEA outputs.

6.7.3 ISO 14001 – Environmental Management Systems

The Environmental Management System enables an organization to formulate policy and objectives taking into consideration legislative requirements and significant environmental impacts and specifies the environmental performance criteria. The scope of the Environmental Management System of an organization consists of :

- Implement, maintain and improve EMS.
- Conformance to the stated policies and objectives.
- Demonstrate conformance to the EMS through certification.

Environment Management System of an organization shall consider the following issues:

- Improvement to the Quality of life
- Benefits to society
- Commitment to the future generations
- Minimization of environment risk
- Prevention of pollution
- Environment care and continuous improvements
- Save resources

ISO 14001 EMS - Requirements

Organizations to establish and maintain an environmental management system, comprising the following:

1. Environmental policy
   - Driving force for the whole EMS of the organization and ensures that the environmental performance is improved.
   - It must be appropriate to the nature, scale and environmental impacts of the Organization.
   - Commitment to continual improvement and prevention of pollution.
   - Commitment to comply with relevant legislation and regulations.
   - Provides framework setting and reviewing of objectives and targets.
   - Is documented, implemented and communicated to all employees.
   - Is available to public.
2. Environmental planning
   - Specific objectives and measurable targets to be set to lower levels of pollution
   - Responsibility and structure for implementation to be defined, documented and communicated to all levels and functions of the organization
   - Management Representative to be appointed for implementation of EMS and to report conformance of EMS to top management

- Training needs to be identified and awareness created of environmental issues
- EMS documentation to be ensured by preparing an Environmental Manual with specific tasks and work instructions
- Potential for accidents and emergency situations to be identified with timely response procedures

3. Environmental Operational Controls – to be monitored to ensure conformance and taking corrective actions.
4. EMS Audit – Periodical audits to be conducted and report submitted for management review to assess adequacy and effectiveness of the system.

The need for EMS documentation

The purpose of document requirements of ISO 14001 is to ensure that there is adequate documentation to support the EMS. In addition to the specified environmental management manual, the organization must control all documentation relating to EMS. The EMS documentation does three important things.

- It provides the means of control for all the relevant data and information which form the care of the EMS.
- It gives instructions to the relevant personnel, so that they know what they need to do to meet the objectives and targets of EMS.
- It provides framework for the auditors for assessing the level of compliance with the standard.

In these respects, EMS documentation is very similar in principle, to any other types of controlled documentation which support the management of systems. Documentation requirements are similar to document control in ISO 9000.

6.8 Global Awards for Best Practices and Business Performance

6.8.1 Malcolm Baldrige National Quality Award

The **Malcolm Baldrige National Quality Award** is given by the United States National Institute of Standards and Technology. Through the actions of the National Productivity Advisory Committee chaired by Jack Grayson, it was established by the Malcolm Baldrige National Quality Improvement Act of 1987 - Public Law 100-107 and named for Malcolm Baldrige, who served as United States Secretary of Commerce during the Reagan administration from 1981 to 1987. The program recognizes quality service in the business, health care, education, and non-profit sectors. This is the only quality award that is actually awarded by the President of the United States. The original stated purpose of the award were to

- promote quality awareness
- recognizing quality achievements of the US companies
- publicize successful quality strategies

The current award criteria are stated to have three important roles in strengthening US competitiveness:

- To help improve organizational performance practices, capabilities and results
- To facilitate communication and sharing of the best practice information among US organizations of all types

- To serve as a working tool for understanding and managing performance and for guiding planning and opportunities for learning

The criteria are designed to help organizations use an aligned approach to organizational performance management that results in:

- Delivery of ever-improving value to customers, contributing to market success
- Improvement in overall organizational effectiveness and capabilities
- Organizational and personal

Baldrige criteria

The Baldrige performance excellence criteria are a framework that any organization can use to improve overall performance. Seven categories make up the award criteria:

Leadership – Examines how senior executives guide the organization and how the organization addresses its responsibilities to the public and practices good citizenship.

Strategic planning – Examines how the organization sets strategic directions and how it determines key action plans.

Customer and market focus – Examines how the organization determines requirements and expectations of customers and markets; builds relationships with customers; and acquires, satisfies, and retains customers.

Measurement, analysis, and knowledge management – Examines the management, effective use, analysis, and improvement of data and information to support key organization processes and the organization's performance management system.

Workforce focus – Examines how the organization enables its workforce to develop its full potential and how the workforce is aligned with the organization's objectives.

Process management – Examines aspects of how key production/delivery and support processes are designed, managed, and improved.

Results – Examines the organization's performance and improvement in its key business areas: customer satisfaction and information to support key organization processes and the organization's performance management potential and how the workforce is aligned with the organization's objectives.

Source : Wikipedia

6.8.2 European Foundation for Quality Management (EFQM)

EFQM a non-profit membership foundation, is the primary source for organizations in Europe looking to excel in their market and in their business. Founded in 1989 by the CEOs of prominent European businesses, EFQM is now the hub of excellent, globally minded organizations of all sizes and sectors, and both private and public. Specifically designed to help organizations achieve excellence in their business initiatives, the EFQM organization works to capture the best practices of globally-minded organizations and to turn this knowledge into practical resources for the business community. EFQM is a vibrant network of organizations that share the same ambitions to drive excellence through the organization and aspire to reach excellence.

The **EFQM Excellence Model** is a framework for organizational management systems, promoted by the **European Foundation for Quality Management** (EFQM) and designed for helping organizations in their drive towards being more competitive.

Regardless of sector, size, structure or maturity, to be successful, organizations need to establish an appropriate management system. The EFQM Excellence Model is a practical tool to help organizations do this by measuring where they are on the path to excellence; helping them understand the gaps; and then stimulating solutions.

Over the years a number of research studies have investigated the correlation between the adoption of holistic Models, such as the EFQM Excellence Model, and improved organisational results. The majority of such studies show a positive linkage.

The model can be used in four ways:

1. As a framework which organisations can use to help them develop their vision and goals for the future in a tangible, measurable way.
2. As a framework which organisations can use to help them identify and understand the systemic nature of their business, the key linkages and cause and effect relationships.
3. As the basis for the EFQM Excellence Award, a process which allows Europe to recognise its most successful organisations and promote them as role models of excellence for others to learn from.
4. As a diagnostic tool for assessing the current health of the organisation. Through this process an organisation is better able to balance its priorities, allocate resources and generate realistic business plans.

   This fourth, diagnostic use, is also known as self-assessment.

Self-assessment has wide applicability to organisations large and small, in the public as well as the private sectors. Increasingly organisations are using outputs from self-assessment as part of their business planning process and use the EFQM model as a basis for operational and

The EFQM Excellence Model is a non-prescriptive framework based on nine criteria. Five of these are ‘enablers’ and four are ‘results’. The ‘enabler’ criteria cover what an organisation does. The ‘results’ criteria cover what an organisation achieves. ‘Results’ are caused by ‘enablers’ and feedback from ‘results’ help to improve ‘enablers’.

The model, which recognises there are many approaches to achieving sustainable excellence in all aspects of performance, is based on the premise that excellent results with respect to performance, customers, people and society are achieved through leadership driving policy and strategy, that is delivered through people partnerships and resources, and processes.

Source: Wikipedia

6.8.3 Deming Prize

The Deming Prize is one of the highest awards on TQM in the world. The Deming Prize established in December 1950 in honour of W. Edwards Deming was originally designed to reward Japanese Companies for major advances in quality improvement. Over the years it has grown under the guidance of Japanese Union of Scientists and Engineers (JUSE) to where it is now available to Non-Japanese Companies, although usually operating in Japan and also to individuals recognised as having made major contributions to the advancement of quality.

JUSE gives the following awards:

- Deming Application Prize for Organizations
- Deming Prize for individuals
- Quality Control Award for Factories
- Deming Medal

The prizes are waste mainly on finding out how effectively the organization is implementing TQM by focusing on the quality of its products and services.

Deming Prize Criteria

1. "Under clear management leadership, reflecting management principles, type of industry or business, scope and business environment the applicant has established business objectives and strategies that are challenging and customer oriented.
2. TQM has been implemented properly to achieve business objectives and strategies as mentioned in item No.1 above.
3. As an outcome item No.2, the outstanding results have been obtained for business objectives and strategies as stated in item No. 1."

Source: JUSE

Deming Application Prize Winners in India

S.No.	Name of the Company	Year
1.	Sundaram Clayton Ltd. (Brakes Division)	1998
2.	Sundaram Brakelinings Ltd.	2001
3.	TVS Motor Company Ltd.	2002
4.	Brakes India Ltd. (Foundry Division)	2003
5.	Mahindra & Mahindra Ltd. (Farm Equipment Sector)	2003
6.	Rane Brake Linings Ltd.	2003
7.	Sona Koyo Steering Systems Ltd.	2003
8.	Indo Gulf Fertilizers Ltd.	2004
9.	Lucas TVS Ltd.	2004
10.	SRF Ltd. Industrial Synthetics Business	2004
11.	Rane Engine Valves Ltd.	2005
12.	Rane TRW Steering Systems Ltd. (Steering Gear Division)	2005
13.	Krishna Maruti Ltd. (Seat Division)	2005
14.	Asahi India Glass Ltd. (Auto Glass Division)	2007
15.	Rane (Madras) Ltd.	2007

Notes

BIT QUESTIONS FROM ALL CHAPTERS

1. A company has the following budget based on orders from home market:

	Rs	Rs
Sales (2000 units)		10,000
Cost of Sales		
Direct Material	1,000	
Direct Labour	4,000	
Variable Overhead	1,000	
Fixed Overhead	3,000	9,000
		1,000

At this level of output, the company has spare capacity and it is therefore planning to develop export market. It believes that it will be able to sell an additional 750 units – the limit of its production due to a shortage of raw materials. No additional fixed costs would be incurred and selling price and variable costs per unit would be the same as for the home market.

Before launching its export campaign, however, the company is approached by a home buyer who wishes to purchase 200 deluxe models which twice as much materials as the standard model. What is the minimum price which should be charged if this order is accepted?

2. An investment in new machinery is being considered. The machine will cost Rs. 40,000 and will last for seven years. It is expected to yield savings in raw material cost of Rs. 4,000 p.a. (due to lower wastage) and it is hoped also to achieve labour savings of Rs. 7,000 p.a., however the arrangement have not yet been discussed with the trade union. The company's cost of capital is 12%. What percentage change in the estimated labour savings will render the project not viable? Given that the present value of an annuity for 7 years at 12% = Rs. 4.564.

3. The annual demand for an item of raw material is 3,000 units and the purchase price is Rs. 100 per unit. The incremental cost of processing an order is Rs. 150 and the carrying cost per annum is 10 per unit. What is the optimal order quantity and the total relevant cost of this order quantity?

4 Star Bicycle Company; produced and sold 1,10,000 bicycle annually, under the brand name 'Smart' with a price tag Rs. 899. Like all other players in the industry, Star too was running under capacity. The manufacturing cost of these cycles was-material Rs. 300, labour Rs. 200 and Manufacturing Rs. 300, 40% of the manufacturing cost was variable. General and administration expenses were 50% of labour cost.

Star has now received a proposal to sell 25,000 bicycles per year under the brand name 'Jeet' to a chain store at a price of Rs. 800. The brand will be exclusive for the chain stores as they will market it as their own product. Expenditure for producing 'Jeet' will be the same as that of Star as design of 'Jeet' will exactly be same as that of 'Star' with only some cosmetic changes. To produce 'Jeet' however, Rs. 6,00,000 additional fund will be required on an average. Further it estimated that sale of 'Jeet' through the chain store will reduce the sale of 'Star' by 10,000 units.

You are required to calculate the relevant cost of 'Jeet', given that the weighted average cost of capital Star Co. is 15%.

5. ABC Ltd. Initiated a quality improvement program at the beginning of the year. Efforts were made to reduce the number of defective units produced. By the end of the year, reports from the production manager revealed that scrap and rework had both decreased. Though pleased with the success, the President of the company wanted some assessment of the financial impact of the improvements. To make this assessment, the following financial data were collected for the current and preceding year:-

	Preceding Year (2001-2002)	**Current Year (2002-2003)**
	Rs	Rs
Sales	1,00,00,000	1,00,00,000
Scrap	4,00,000	3,00,000
Rework	6,00,000	4,00,000
Product inspection	1,00,000	1,25,000
Product warranty	8,00,000	6,00,000
Quality training	40,000	80,000
Materials inspection	60,000	40,000

You are required to: -

i) Classify the costs as prevention, appraisal, internal failure, or external failure

ii) Compute the profit that has increased because of quality improvements?

6. A company has forecast sales and cost of sales for the coming year as Rs. 25 lakhs and Rs. 18 lakhs respectively.

   The inventory turnover has been taken as 9 times per year. In case the inventory turnover increases to 12 times and the short term interest rate on working capital is taken as 10%, what will be saving in cost?

7. Given the projects:

	t_0	t_1	t_2	NPV
A	-100	-200	+50	+40
B	-150	+70	+70	+20
C	-200	-120	-30	+50

   External capital is limited to 190 at t_0, 110 at t_1 and zero at t_2.

   Formulate the problem into an LP, assuming projects are divisible.

   Cash generated from these investments can be reinvested in other projects in the same year.

8. A company has the capacity of production of 80,000 units and presently sells 20,000 units at Rs. 100 each. The demand is sensitive to selling price and it has been observed that with every reduction of Rs. 10 in selling price the demand is doubled. What should be the target cost at full capacity if profit margin on sale is taken as 25%?

9 If the direct labour cost is reduced by 20% with every doubling of output, what will be the cost of labour for the sixteenth unit produced as an approximate percentage of the cost of the first unit produced?

10. The operating costs of a department over a five-year period were as follows:

Year	Cost Index	Rs	Hours worked
1	100	32,250	8,625
2	115	36,593	8,410
3	120	39,888	9,120
4	130	42,406	8,810
5	134	40,602	7,650

Estimated cost for year 6 when the cost index will be 140 and hours worked will be 8,720.

11. A division of a company employee's capital of Rs. 2 million and its return on capital is 12%. It is considering a new project requiring fresh capital of 5,00,000 and expected to yield profits of Rs. 90,000 per annum. The company's interest rate is 10% p.a. If the new project is implemented, what will be the division's residual income?

12. When the time taken by the first unit is 10 hours and the learning rate is 80%, the average time taken for each of 20 units produced would be?

13. A Ltd., which manufactures small electronic circuits, has a capacity to produce 4 lakh units. The market demand is sensitive to the sale price and it has been estimated that the company could sell 1 lakh units when the price is Rs. 50 per circuit. Thereafter the demand would double for each Rs. 5 fall in the selling price. The company expects a minimum margin of 25%, what will be the target cost of the company to sell at full capacity?

14. The budgeted sales and cost of sales of Rahaman Brother for the coming year are Rs. 15 respectively. The current level of inventory turnover is 5 times. Considering that the inventory is financed at an average cost of 10% p.a. What will be the expected cost saving for the budget period by doubling inventory turnover.

15 A company determines its selling price by marking up variable costs 60%. In addition, the company uses frequent selling price mark down to stimulate sales. If the mark down average 10%, what is the company's contribution margin ratio?

16. B Ltd. Has earned net profit of Rs. 1 lakh, and its overall P/V ratio and margin of safety are 25% and 50% respectively. What is the total fixed cost of the company?

17. B Ltd. Which manufactures components for VCD, has a capacity to produce 4 lakh units. The market demand is sensitive to the sale price and the company could sell 1 lakh units at a price of Rs. 50 each. The demand thereafter would double for each Rs. 5 per unit fall in the selling price. The company expects a minimum margin of 25%. What would be the target cost of the company to sell at full capacity utilization?

18. A company issues commercial paper for Rs. 2 crore with a maturity period of 90 days. The interest rate is 12% p.a. What is the net amount received by the company?

19. If back orders can be taken (at an added cost per item back ordered)

    a) EOQ will decrease

    b) EOQ will increase

c) Lead time will decrease

d) No change will occur. Back orders do not affect the EOQ model

20. Which of the following would decrease unit contribution margin the most?

a) 15% decrease in selling price

b) 15% increase in variable costs

c) 15% decrease in variable costs

d) 15% decrease in fixed costs

21. When allocating service department costs to production departments, the method that does not consider different cost behavior patterns is the

a) Step method

b) Reciprocal method

c) Single-rate method

d) Dual-rate method.

22. The information relating to the direct material cost of a company is as under:

	Rs
Standard price per unit	3.60
Actual quantity purchased in units	1,600
Standard quantity allowed for actual production in units	1.450
Material price variance on purchase (favourable)	240

What is the actual purchase price per unit?

23. A company has 2,000 units of an absolute item which are carried in inventory at the original purchase price of Rs. 30,000. If these items are reworked for Rs. 10,000, they can be sold for Rs. 18,000. Alternatively, they can be sold as scrap for Rs.3,000 in the market. In a decision model used to analyze the reworking proposal, the opportunity cost should be taken as

24. A company produces two joint products, P and V. In a year, further processing costs beyond split-off point spent were Rs. 8,000 and Rs.12,000 for 800 units of P and 400 units of V respectively. P sells at Rs. 25 and V sells at Rs. 50 per unit. A sum of Rs. 9,000 of joint cost were allocated to product P based on the net realization method. What were the total joint cost in the year?

25. A company is to market a new product. It can produce up to 1,50,000 units of this product. The following are the estimated cost data:

	Fixed Cost	Variable Cost
For production up to 75,000 units	Rs. 8,00,000	60%
Exceeding 75,000 units	Rs. 12,00,000	50%

Sale price is expected to be Rs. 25 per unit.

How many units must the company sell to break even?

26. The following details relate to two competing companies, Alps and Himalayas, for identical projects:

    i) The net present value (NPV) of Alps is Rs. 20,000 and its internal rate of return (IRR) is 18%.

    ii) For the same life period, Himalayas' estimated cash flows are:

Year	Rs. '000
0	(450)
1	300
2	200
3	100

And its cost of capital is 15%.

Which one of the following combinations is correct concerning the NPV and the IRR of the two projects?

Projects	
Alps	Himalayas
A) Higher NPV	Higher IRR
B) Higher NPV	Lower IRR
C) Lower NPV	Higher IRR
D) Lower NPV	Lower IRR

27. Nulook Ltd. Uses a JIT system and back flush accounting. It does not use a raw material stock control account During May, 8000 units were produced and sold. The standard cost per unit is Rs. 100; this includes materials of Rs. 45. During May, Rs. 4,80,000 of conversion costs were incurred.

    The debit balance on cost of goods sold account for May was

    a) Rs. 8,00,000

    b) Rs. 8,40,000

    c) Rs. 8,80,000

    d) Rs.9,20,000

28. A concern sells three products. The budgeted fixed cost for the period is R. 6,00,000. The budgeted contribution to sales ratio (C/S ratio) and the sales mix are as under

Product	C/S ratio	Mix
Super	25%	20%
Premium	40%	40%
Best	30%	40%

What is the Break Even sales revenue?

a) Rs. 30,10,181

b) Rs. 15,23,312

c) Rs. 18,18,181

d) Rs. 17,60,500

29. The selling price of product P is set at Rs. 1,500 for each unit and sales for the coming year are expected to be 500 units.

    If the company requires a return of 15% in the coming year on its investment of Rs. 15,00,000 in product P. the TARGET cost for each unit for the coming year is.

    a) Rs. 930

    b) Rs. 990

    c) Rs. 1,050

    d) Rs.1,110

30 A company makes and sells a single product. The selling price and marginal revenue equations are:

Selling price = Rs. 50 – Re. 0.001X

Marginal revenue = Rs. 50 – Re. 0.002 X

Where X is the product the company makes. The variable costs amount to Rs. 20 per unit and the fixed costs are Rs. 1,00,000.

In order to maximize the profit, the selling price should be

a) Rs. 25

b) Rs. 30

c) Rs. 35

d) Rs. 40

31 A company produces two products, X and Y, which pass through two production processes, P and Q. The time taken to make each product in each process is:

	Product X	Product Y
Process P	6 mins	10 mins
Process Q	20 mins	15 mins

The company offers a 16 hour day and the process have an average down time each day of

Process p	3 hours
Process Q	2 hours

The cost and revenue for each unit of each product are:

	Product X	Product Y
Direct Material	15	15
Direct labour	17	12
Variable O H	8	6
Fixed Costs	8	6
Total Cost	48	39
Selling price	90	80

Sales demand restricts the output of X and Y to 40 and 60 units a day respectively.

The daily production plan that would maximize the THROUGHPUT contribution is:

a) 40 units of X

b) 36 units of X and 4 units of Y

c) 34 units of X and 5 units of Y

d) 56 units of Y

32. The total cost of manufacturing a component is as under at a capacity of 50,000 units of production

	Rs
Prime cost	10.00
Variable overheads	2.40
Fixed Overheads	4.00
	16.40

The selling price is Rs. 21 per unit. The variable selling and administrative expenses is 60 paise per component extra. During the next quarter only 10,000 units can be produced and sold. Management plans to shut down the plant estimating that the fixed manufacturing cost can be reduced to Rs. 74,000 per quarter. When the plant is operating, the fixed overheads are incurred at a uniform rate throughout the year. Additional costs of plant shutdown for the quarter are estimated at Rs. 14,000.

The shut down pint for the quarter in units of product will be

a) 25,000

b) 14,000

c) 11,000

d) 20,000

33. Division J of NZ Ltd. Produced the following results in the last financial year:

	Rs ('000)
Net Profit	720
Capital employed in fixed assets	3,000
Capital employed: net current assets	200

For performance appraisal purposes, all divisional assets are valued at original cost. The division is considering a project which will increase annual net profit in Rs. 50,000 that will required average stock levels to increase by Rs. 60,000 and fixed assets to increase by Rs. 2,00,000.

NZ Ltd imposes a 16% capital charge on its divisions. Given these circumstances, will the appraisal criteria Return on Investment (ROI) and Residual Income (RI) motivate division? J management to accept the project?

	ROI	RI
A	YES	YES
B	YES	NO
C	NO	NO
D	NO	YES

34. A company manufactures two products using common material handling facility. The total budgeted material handling cost is Rs. 60,000. The other details are:

	Product X	Product Y
Number of units produced	30	30
Material moves per product line	5	15
Direct labour hour per unit	200	200

Under activity based costing system the material handling cost to be allocated to product X (per unit) would be:

a) Rs. 1,000

b) Rs. 500

c) Rs. 1,500

d) Rs. 2,500

35. When a manager is concerned with monitoring total cost, total revenue, and net profit conditioned upon the level of productivity, an accountant should normally recommended.

	Flexible Budgeting	Standard Costing
A	Yes	Yes
B	Yes	No
C	No	Yes
D	No	No

36. A company's approach to a make-or-buy-decision

a) Depends on whether the company is operating at or below normal volume

b) Involves an analysis of avoidable costs

c) Should use absorption (full) costing

d) Should use activity-based-costing

37. A company operates throughput accounting system. The details of product X per unit are as under.

Selling Price	Rs. 50
Material Cost	Rs. 20
Conversion cost	Rs. 15
Time on bottleneck resources	10 minutes

The return per hour for product X is

A) Rs. 210 C) Rs. 300
B) Rs. 180 D) Rs. 90

38. A firm engaged in the profession of rendering software services provides three different kinds of services to its clients. The following are the data relating to these services.

Types of services	A	B	C
	Rs./job	Rs./job	Rs./job
Annual fee	3,000	2,400	1,800
Annual variable costs	1,350	800	810
Annual fixed costs	600	320	225

The total annual fixed costs are budgeted at Rs. 5,74,200 and none of these costs are specific to any type of service provided by the firm.

The firm has estimated the number of service contracts to be sold in the next year in the proportion of 20%, 30% and 50% respectively for the three types of services namely A, B and C.

The annual revenue needed by the firm to break even is

A) Rs. 3,16,800 C) Rs. 5,74,200
B) Rs. 9,76,800 D) Rs. 7,20,000

39. A company has estimated the selling prices and the variable costs of one of its products as under:

Selling Price (per unit)		Variable costs (per unit)	
Probability	Rs	Probability	Rs
0.25	60	0.25	30
0.45	75	0.40	45
0.30	90	0.35	60

The company will be able to produce and sell 4,000 units in a month irrespective of the selling price. The selling price and variable cost per unit are independent of each other. The specific fixed cost relating to this product is Rs. 20,000. The probability that the monthly net profit of the product will be $\geq$ Rs. 1,20,000 is

A) 0.2525 C) 0.3825
B) 0.4512 D) 0.3075

40. The current price of a product is Rs. 8,000 per unit and it has been estimated that for every Rs. 200 per unit reduction in price. The current level of sale, which is 10 units, can be increased by 1 unit. The existing capacity of the company allows a production of 15 units of the product. The variable cost is Rs. 4,000 per unit for the first 10 units, thereafter each unit will cost Rs. 400 more than the preceding one. The most profitable level of output for the company for the product will be

A) 11 units C) 13 units
B) 12 units D) 14 units

41. In calculating the life cycle costs of a product, which of the following items would be included?

i) Planning and concept design costs

ii) Preliminary and detailed design costs

iii) Testing costs

iv) Production costs

v) Distribution costs

A) All of the above C) ii), iv) and v)
B) iv) and v) D) iv)

42. Market research has revealed that the maximum demand lies for products X and Y. the standard variable costs per unit of the products are as follows:

	X (Rs)	Y(Rs)
Materials (Rs 40 per Kg)	200	160
Other variable costs	400	440
Total variable costs	600	600

The Management Accountant determined the optimal production plan by using graphical linear programming. He noticed that the optimal plan was given at any point on the part of the feasible region that was formed by the constraint line for the availability of materials.

If the selling price of Product X is Rs. 1,000, the selling price of Product Y is (Rs)

A 800
B 860
C 920
D 980

43. In a project consisting of ten activities an activity M with duration of 17 days starts with event 1 and ends with event 2. If the earliest occurrence time and the latest occurrence time of event 2 are the 27th and the 46th day respectively and the total float of the activity is 20 days, then free float of the activity is

A 0 (zero) day
B 1 day
C -20 days
D +20 days

44. A company which sells three products furnishes the following sales information for November, 2006:

	Budgeted		Actual	
	Units	Price/unit	Units	Price/unit
X	200	50	210	52
Y	300	25	330	24
Z	500	18	440	19

The Expected size of the market was 5,000 units and the size of the market for November, 2006 was 5,300 units.

The market share variance and sales mix variance are:

	Market share variance	Sales mix variance
A	1,590 F	2,120 A
B	170 F	1,590 F
C	2,120 A	700 F
D	530 A	1,420 A

45. A company is preparing a quotation for a new product. The time taken for the first unit is 30 hours. The company expects 85% learning curve (index is – 0.2345). the company desires that the quotation should be based on the time taken for the final output within the learning period which is expected to end after the company has produced 200 units.

    The time per unit of product to be used for the quotation is:

    A 13.34 hours
    B 25.50 hours
    C 30.00 hours
    D 6.67 hours

46. The normal capacity of a company is 5,000 units of product P per month. The company planned to produce an output of 4,800 units in November 2006 and accordingly prepared the following budget of expenses:

	Rs
Variable direct costs	48,000
Variable production overheads	19,200
Fixed Production overheads	40,000
Total	1,07,200

The company had an opening stock of 400 units on 1st November 2006 and at the November 2006, the closing stock was 600 units. The selling price is Rs. 25 per unit. The actual output produced and fixed costs incurred during November 2006 were same as budgeted. There is no change in the rate of variable costs.

The profit for November 2006 as per absorption costing method is:

A Rs. 3,200 lower than under marginal costing method
B Rs. 1,600 higher than under marginal costing method
C Equal to the profit under marginal costing method
D Rs. 4,800 higher than under marginal costing method

47. If the time taken to produce the first unit of a product is 4000 hrs, what will be the total time taken to produce the 5th to 8th unit of the product, when a 90% learning curve applies?

    a) 10,500 hours

    b) 12,968 hours

    c) 9,560 hours

    d) 10,368 hours

48. In a process, three raw materials are mixed together to produce a product. The standard mix of inputs required to produce 160 kgs of finished product is as under:

Raw Material	Kgs	Price/Kg (Rs)
A	100	150
B	60	200
C	40	250

During May 2007, the company produced 920 Kgs of output and the actual consumption of raw materials is as under:

Raw Material	Kgs	Price/Kg (Rs)
A	595	140
B	330	212
C	255	270

The material yield and mix variances respectively for May, 2007 are

a) Rs. 5,550 (A) and Rs. 8,000 (A)

b) Rs. 700 (F) and Rs. 5,500 (A)

c) Rs. 5,550 (A) and Rs. 700 (A)

d) Rs. 11,500 (A) and Rs. 1,180 (F)

(A) or (F) under brackets after the figures denotes 'Adverse' or 'Favourable'.

49. A company proposes to undertake a capital project. The life of the project is 4 years and the annual cash inflows are estimated at Rs. 40,000. The internal rate of return of the project is 15% and the cumulative present value factor for 15% for 4 years is 2.855. The profitability index is 1.064.

The nest present value of the project is

A) Rs. 7,309 B) Rs. 10,000 C) Rs. 10,000 D) Rs. 14,200

50. Back flush costing is most likely to be used when

a) Management desires sequential tracking of costs

b) A Just-in-Time inventory philosophy has been adopted

c) The company carries significant amount of inventory

d) Actual production costs are debited to work-in-progress.

51. A particular job requires 800 ikgs of a material. 500 kgs of the particular material is currently in stock. The original price of the material was Rs. 300 but current resale value of the same has been determined as Rs. 200. The current replacement price of the material is Re. 0.80 per kg.

A) Rs. 640 B) Rs. 440 C) Rs. 300 D) Rs. 540

52. A company presently sells 90,000 units of a product at a price of Rs. 100 per unit. The variable cost of the product is Rs. 42 per unit. The annual fixed costs amount to Rs. 24 lacs.

Sales quantity	Probability
100000 units	0.45
120000 units	0.55

The finance director has stated that at either of the aforesaid higher sales and production levels, the variable cost per unit with the associated probability of it occurring will be as under:

Variable cost per unit	Probability
Rs. 40	0.40
Rs. 36	0.60

The probability that the reduction of selling price to Rs. 90 will increase the overall profit will be:

A: 0.82 B: 0.21 C: 0.25 D: 0.18

53. Appliances Division of a company has reported an annual operating profit of Rs. 402 lacs after charging Rs. 60 lacs of full cost of launching a new product that is expected to last three years. The risk adjusted cost of capital of the Appliances Division is 11% and the division is paying interest on substantial bank loan at 8%. The historical cost of the division as per its balance sheet is Rs. 1000 lacs and the replacement cost is estimated at Rs. 1,720 lacs.

Ignore taxation.

The EVA of the Appliances Division in lacs of rupees is:

A: 308 B: 309.6 C: 332 D: 252.8

54. A company has developed a new product and just completed the manufacture of the first four units of the product. The first unit took 3 hours to manufacture and the first four units together took 8.3667 hours to produce. The learning curve rate is:

A: 69.5% B: 59.6% C: 75.0% D: 83.5%

55. Zee Ltd., is preparing its annual Profit plan. As part of its analysis of the Profitability of individual products, the accountant estimates the amount of overhead that should be allocated to the individual product lines from the information given below:

	Wall Mirrors	Specialty Windows
Unit Products	25	25
Material moves / Product line	5	15
Direct labour hrs./units	200	200

Budgeted material handing costs Rs. 50,000

Under Activity – Based – Costing (ABC), the material handling costs allocated to one unit of Wall mirrors would be:

A) Rs. 100 B) Rs. 500 C) Rs. 1,500 D) Rs. 2,500

56. A mobile phone manufacturer, Siemens Ltd., is planning to introduce a new mobile phone. The potential market over the next year is 10,00,000 units.

    Siemens Ltd. has the capacity to produce 4,00,000 units and could sell 1,00,000 units at a price of Rs. 50. Demand would double for each Rs. 5 fall in the selling price.

    The Company has an 80% cost experience curve for similar products. The cost of the first batch of 1000 phones was Rs. 1,03,000.

    What is Siemens Ltd.'s target cost/unit to the nearest Re?

    A) Rs. 40 B) Rs. 30 C) Rs. 32 D) Rs. 37.50

57. It is appropriate to view the value chain from the customer's perspective, with each link being seen as the customer of the previous link
58. One of the goals JIT seeks to achieve is batch sizes of one.
59. Examples of value added and non-value added activities are 'move time' and 'storage time' respectively.
60. JIT manufacturing, based as it is on 'push through philosophy' helps to provide the right parts at the right time in the quantity.
61. A 'cost of quality report' indicates the total cost to the organization of producing products or services conforming with quality of requirements.
62. A balanced score card studies the performance of management by comparing a financial achievement with the amount spent thereon.
63. While using a matrix method, in the event of close-down of a service centre (say, own generated electricity) the number of units of service number of units produced internally by the diagonal element of the concerned service. In the inverse of the matrix
64. Safety stock is that level of stock that is stored in fire-proof insurable storage.
65. Differential cost decision excludes fixed cost and qualitative factors.
66. Back Flash Accounting compares profit with the cost of producing a product.
67. EVA encourages short-term performance.
68. The useful purpose that budgets seek to serve include coordinating the activities of the various parts of the organization and ensuring that the parts are in harmony with each other.
69. To convert the assignment problem into a maximization problem, all elements of the matrix are deducted from the highest element in the matrix.
70. In a transportation problem VAM stands for Vogel's approximation method.

Answers

27.	"B" is correct
28.	"C" is correct
29.	"C" is correct
30.	"C" is correct
31.	"D" is correct
32.	"B" is correct
33.	"D" is Correct
34.	"B" is correct.
35.	"A" is correct
36.	"B" is correct.
37.	"B" is correct.
38.	"B" is correct.
39.	"D" is correct.
40.	"B" is correct.
41.	"A" is correct.
42.	"C" is correct.
43.	"B" is correct.
44.	"C" is correct.
45.	"D" is correct.
46.	"B" is correct.
47.	"D" is correct.
48.	"C" is correct.
49.	"A" is correct.
50.	"B" is correct.
51.	"B" is correct.
57.	T
58.	T
59.	F
60.	F
61.	F
62.	F
63.	T
64.	F
65.	F
66.	F
67.	F
68.	T
69.	T
70	T