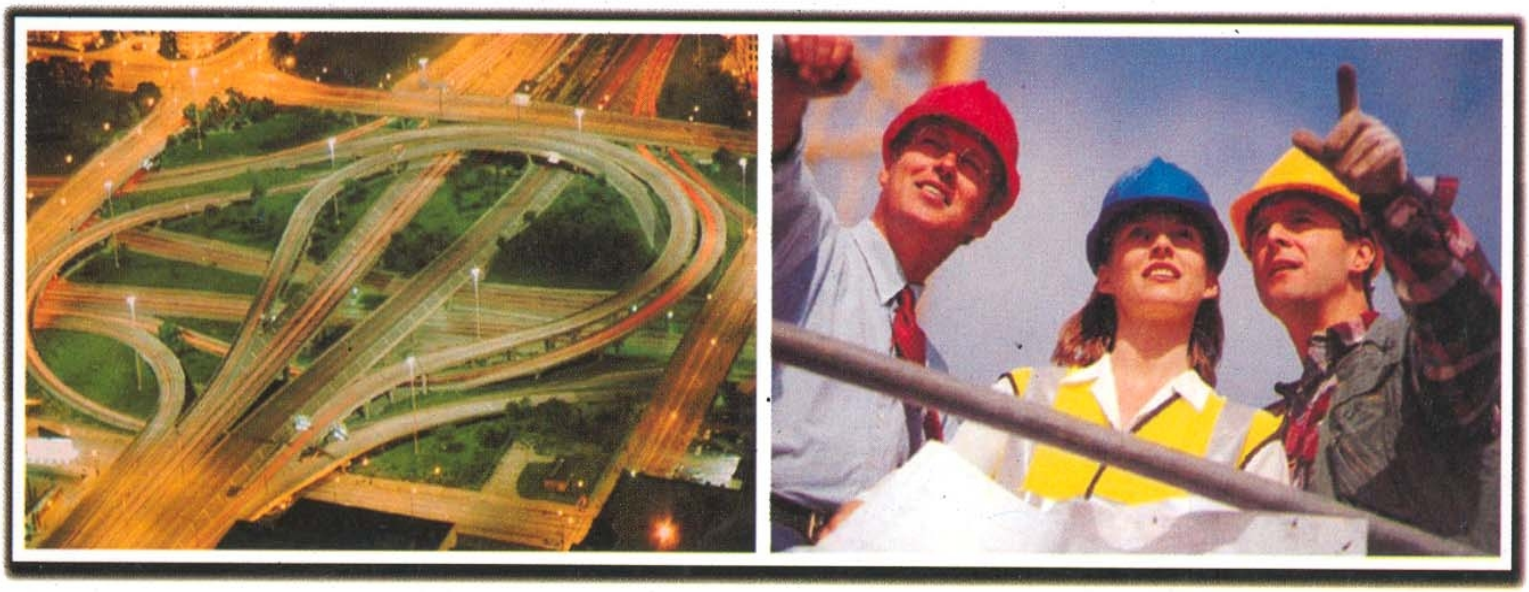
# Modern Project Management



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# PREFACE

Projects are more complex than they seem to appear because of recurring changes in resources, objectives, requirements and technology, etc. Therefore project management is truly a science to deal with systematic and cost effective presentation, execution, re-evaluation and reporting of an important activity. The project managers are the unsung heroes who in most cases stand outside the public eye but without whose talents and skills most neat ideas would never amount to anything. They are responsible for giving shape to products, systems and things, which we take for granted or marvel.

The rapid pace of change in technology has led to products or processes evolving at an accelerated pace. This accelerated pace has a direct impact on the frequency and conduct of projects–whether projects to develop products, systems and processes that compete in local, domestic or international markets. The projects may be anything from developing of a software, installation of an equipment, creation and developing new ways of meeting demand for energy, recreation, housing, communications, transportation and food or to resolve problems of pollution and disease.

This book attempts to explain the concepts of project management in a simple and effective manner. The need for the book was felt to provide a comprehensive coverage of concepts of projects and bridge the gap between the students and professionals. It gives a grasp over modern trends and techniques of project management. This book is useful for those involved in preparation and evaluation of feasibility study and those involved with selection, implementation and evaluation of projects. The presented material contains complete syllabus of Project Management subject to be taught at III'rd year B Tech, Mechanical and Production Engineering of UPTU Lucknow.

The chapters 1 and 2 are concerned with giving an overview of the characteristics and concepts of project management. The next two chapters involve the project identification, screening, selection and planning at a system level. Feasibility study forms an important part of project selection and planning has been discussed in detail. Chapter 5 involves structuring and controlling the most important resource of project, which is human resource. The role of project manager in project direction, coordination and control is explained in the next chapter. Network concepts are an integral part of project management to understand the entire project. Various types of questions and case study has been incorporated to explain the practical aspects and utility in solving complicated problems.

In addition to above, the application of total quality to project management has been discussed. The relevance of inventory control, material requirement planning and supply chain

management has been elaborated. With the growing application of computer-based techniques and the use of Internet, e-commerce has opened new visas for exploration in web based project management. A chapter based on the application of information technology in projects has been introduced keeping in view the future of project management.

Constructive criticism and suggestions will be appreciated for enhancing the utility of the book.

**R.C. Mishra**
**Tarun Soota**

# CONTENTS

1

# PROJECT MANAGEMENT OVERVIEW

## 1.1 INTRODUCTION

Project management as a science seems to have evolved around second world war and got much importance due to various nuclear aerospace and other defense programmes of USA in 1950's and 1960's. Project in simple terms is a collection of activities that are interrelated with a specific overall purpose. It is an organized endeavour to accomplish a specified non-routine and low volume task. Although projects are not repetitive they take significant amount of time to complete and are large scale and complex enough to be recognized as separate undertaking. Generally the amount of time that an individual or a work center is involved in a project is greater than it is in a typical manufacturing or service assignment. An operating person may work only with other operating people on a project that pertains to operations or the same person may work with a team of people from various functions who are assigned to study and solve a problem as to perform a task.

Developing and implementing a project requires several resources to be identified, mobilized and applied effectively to work tasks throughout the project life. Five basic project resource types can be readily identified *Manpower - Machinery – Materials – Methods-Information*. Project management is concerned with dynamic commitment of above-mentioned resources to ensure completion of the project.

Managing a project can be a complex and challenging assignment as all the aspects of the projects may be unique in nature and pose new problems everyday. Since projects are one of kind endeavour, there may be little in way of experience, normal working relationships, or established procedure to guide participants.

A project manager may have to coordinate many diverse effects and activities to achieve the project goals. Persons from various disciplines and various parts of the organization who have never worked together may be assigned to the projects for various spans of time. Subcontractors who are unfamiliar with the organization may be brought in to carry to out major portions of the project. A project may involve thousands of interrelated activities performed by persons employed by one of several subcontractors or by the sponsoring organization. It is an instrument of change and therefore unique. Project managers are essentially concerned with determining, procuring, allocating and utilizing the resources. They need awareness of the latest technologies and managerial skills to anticipate and handle problems and take people with them to the successful completion of the project.

Decision-making is essentially a part of project management. Today a project manager finds a lot of project management tools such as Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Quantitative Analysis Method, Decision Support Systems (DSS), Project quality control techniques, etc. These tools provide addition of information to

the manager. However he uses his judgement to take decisions based on this information. The use of computers in project management has dramatically increased the efficiency in the storage and retrieval of information, besides providing for rapid and accurate processing of information. This is why they are widely prevalent in the area of project management.

Some of the examples of Projects include :Introducing a new product, Producing a airplane, missile or large machine, Maintenance, Repair and Overhauling of machine, Selecting a software package, Developing a new office plan or layout, Implementing a new computer system, Constructing a bridge, dam, highway, and building, Starting up a new manufacturing or service facility, Relocating an office or factory, Instituting a reorganization.

Diverse areas using project management in recent years include Aerospace, Defense Industries, Engineering and Construction, Manufacturing, Electrical generation and Distribution, Process Plants, Crude Oil and Natural Gas Exploration, Development and Production, Infrastructure for various levels of Government, Research and Development, Data/Information Processing, Health Care and Biomedicine, Computer Hardware and Software, Educational Institutions and Ad Hoc Management Undertaking.

## 1.2 CHALLENGES IN PROJECT MANAGEMENT

Projects are increasingly being used in the public as well as private sectors of the world economies in the process of economic, social and national development to enable improved standard of living (improved health, education and housing facilities). In today's global business environment the only thing organizations can probably feel not changing is the rapid pace of change. Every new opportunity brings a challenge that change is sure to surface. Manufacturing industries are compelled to move away from relational setups to more responsive and dynamic ones. Fresh competition is pushing frontiers of every business to achieve higher level of service while evolving technology compresses product life cycles and demands that organizations adopt new technology or risk losing market share.

Inevitably projects are important tools in providing facts and figures for national planning. The nature and problems of implementation of large investment projects in sectors such as industry, minerals, power, transport, construction and communication, differ from those of development, village industries, social welfare, education, health, etc. In many of the developing countries the projects are set up with the purpose of receiving technical assistance or finance from foreign countries or international financial institutions (like World Bank, International Monetary Fund or International Finance Corporation) or to handle major programmes like industrial development, education reforms, etc. Hence the modalities of formulation and implementation for programmes and projects are different.

In this ever-changing environment retaining competitive edge means being able to anticipate and respond quickly to changing business conditions. This requires companies to be lean and agile which has been made possible by organization changes, effective information integration thorough concepts like ERP (Enterprise Resource Planning) and BPR (Business Process Reengineering). Such an environment calls for value addition in manufacturing besides finding out the best solution for product realization. New products have to be brought out in shorter spans and at competitive prices to meet rapidly altering product demand. Ability to bring product to market quickly is now enhanced through *Concurrent or Simultaneous engineering*. The concept that design and manufacturing are separate activities has been busted.

At present designer needs a good understanding of the manufacturing procedures and manufacturing engineer's need a good knowledge of the design methodologies. In future concurrent engineering concepts could be applied in wider areas covering marketing, service, finance etc.

There is a need to employ the latest manufacturing techniques of FMS (Flexible Manufacturing Systems), CIM (Computer Integrated Engineering), CAD/CAM (Computer Aided Design/Manufacturing), RPT (Rapid Prototyping) etc but blindly going for them may not help in optimization process. Concepts like TQM (Total Quality Management), JIT (Just in Time), Kanban, and Six Sigma have to be effectively applied. The ultimate winner will be the one who knows the full potential of the manufacturing technologies well and use them with imagination and farsightedness. With new materials, product ranges, miniaturization of product/parts and higher levels of precision, technology will definitely have a greater say in manufacturing profitability in coming years.

There is a need for solid information systems that support all aspects of business with power and feasibility, system that keep the company adaptable in every aspect. ERP (Enterprise Resource Planning) is information integration support system, which has evolved from MRP-I (Material Requirement Planning) and MRP-II (Manufacturing Resource Planning). ERP caters to diverse requirement of organizations and enables total supply chain integrations. SCM (Supply Chain Management) is a concept-evolved from ERP, which integrates external suppliers and buyers in process of optimization.

The ISO 9000 certification standards put forth by International Organization for Standardization (ISO) now play a major role in setting quality standards for global manufacturers and this have become symbol of quality and prestige. TQM advocates total quality commitment to customer satisfaction through continuous improvements and innovation in all aspect of business. If the companies and organizations fail to regard customer satisfaction in their products and services as a matter of corporate policy, at a par with profit making and continued existence they will put their profit and very existence at risk. The above newly acquired technologies have unleashed market forces, which are customer centric and are now expecting more and more out of these developments.

Many developments have appeared in industrial scene due to fast changing IT Sector. Many "dot-com" companies have come into existence. The business paradigm is in the lane of a major change. This is due to e-factors such as: *e-business, e-education, e-learning, e-biz, ERP, e-com, e-payment*, etc. The business through Internet will open-up newer definition and scope of supply-chain that is now more attractive due to features that are web-enabled. The e-culture incorporates the following

## *E-Factors*

- ERP
- E-biz
- E-learning
- E-payment and e-banking
- E-commerce
- E-procurement
- E-care (for customer, employee and business partner)
- E-marketing (personalized, marketing for customer)

Automation and evolving technology have created need to address issues like time-based competition, product development and customization, uncertainty in schedule and delivery, integration issues (supply chain, value chain, ERP), lean production and JIT, FMS, cellular manufacturing. It enables business (e-commerce), CRM **(**Customer Relationship Management**)** in the web-enabled business. Customer centric operations have emerged as the need of the

hour. Simplification of business processes is being resorted to by business everywhere and companies are going for an integrated management of Supplier- Customer Value Chain (SCM).

As a consequence of the process of economic liberalization, geographical boundaries are getting irrelevant in today's era of globalization. In such a situation the infrastructure bottlenecks have become more pronounced and the support system are unable to cope with the rising expectations of the business world.

With the rapid growth of Internet, people all over the world are getting connected. The common use of Internet includes Electronic mail, Usenet, Telnet, IRC, FTP (File Transfer Protocol), ARCHIE, GOPHER, VERONICA and www. The WWW (World Wide Web) is a vast collection of online documents and information distributed over *Internet*. The *Intranet* is an *internal Internet* of an organization, which is exclusive network of the organization using Internet. Modern business world has commercially benefited by the use of information technology on the Internet mainly by the use of E-commerce. E commerce is an extension of commerce on the Internet. E commerce is primarily selling products and services online on the Internet. The EDI technology is the inter-company computer-to-computer communication of the standard business transaction in a standard format using the VAN's (Value Added Networks). So with e-commerce geography loses its relevance, enabling companies to accept orders round the clock without having huge workforce. Other business transactions could include making tender documents available over the net, submitting tenders, placing orders by one business to its vendors, follow-up, etc.

## 1.3 ROLE OF LIBERALIZATION AND GLOBALIZATION

Before jumping into the market for any project, it is necessary to discover whether government policies exist relating to the particular area of business and if there are political concerns, which should be taken into account. It has been effort of Government of India to attract foreign investment to promote high priority industries and infrastructure projects by removing all hassles in form of inefficient and sometimes still slow-moving bureaucracy.

After independence from Britain 57 years ago, India developed a highly protected, semi-socialist economy (Industrial Resolution 1956), which created many restrictions on imports and exports. *The Monopolistic and Restrictive Trade practices Act* 1969 (MRTP) and *Foreign Exchange Regulation Act* 1976 (FERA) had ordered Indianization of foreign companies. The investment of foreign companies was restricted to forty percent. Structural and bureaucratic impediments were vigorously fostered, along with a distrust of foreign business.

The Industrial Policy Resolution 1990 and that of 1991 were prime documents of economic liberalization. Bold steps were taken for globalization of Indian Industry through collaboration of foreign companies. Multi-National Companies (MNC's) started coming to India and Indian products got tremendous International market. The Foreign exchange reserves have increased manifold, exports are getting higher and overall industrial growth has also increased. The barriers on imports and exports have been removed in accordance with policies of **WTO** (*World Trade Organization established in 1955 at Geneva*), which aims to reduce Trade barriers and permit free flow of goods in the world market. While it is imperative on part of G.O.I. to deregulate and decentralize, it is the duty of the states to see that cleared projects are implemented expeditiously.

Even as today the climate in India has seen a sea change, smashing barriers and actively seeking foreign investment, many companies still see it as a difficult market. India is rightly quoted to be an incomparable country, which is both frustrating and challenging at the same time. Foreign investors should be prepared to take India as it is with all of its difficulties,

contradictions and challenges. The rapid economic growth of the last few years has put heavy stress on India's infrastructural facilities. The projections of further expansion in key areas could snap the already strained lines of transportation unless massive programs of expansion and modernization are put in place. Problems include power demand shortfall, port traffic capacity mismatch, poor road conditions (only half of the country's roads are surfaced), low telephone penetration (1.4% of population). Although the Indian government is well aware of the need for reform and is pushing ahead in this area, business still has to deal with this situation

In the changed environment customers will have a free choice to select the product of their liking, with Indian firms competing with foreign firms. The Indian firm needs the technological dynamism to counter outdated products, inefficient technology and become internationally competitive.

## 1.4 FOREIGN INVESTMENT IN PROJECTS

Despite political uncertainty, bureaucratic hassles, shortage of power and infrastructural deficiencies, India presents a vast potential for overseas investment and is actively encouraging the entrance of foreign players into the market. No companies, of any size, aspiring to be a global player can, for long ignore this country, which is expected to become one of the top three emerging economies. The top motivating factors for the entry of foreign investors into India are market size and highly skilled manpower.

India is the fifth largest economy in the world and has the third largest GDP in the entire continent of Asia. It is also the second largest among emerging nations. (These indicators are based on purchasing power parity (PPP)) India is also one of the few markets in the world, which offers high prospects for growth and earning potential in practically all areas of business. With practically unlimited possibilities in India for overseas businesses, the world's most populous democracy has, until recently, failed to get the kind of enthusiastic attention generated by other emerging economies such as China (Annual FDI of China Vs India is $50 Billion to $4 Billion for year 2000).

In order to break the vicious circle of poverty (low savings-low income-low investment) and to put country on the path of development, foreign capital acts as catalyst. It is basically of two types foreign direct investment (FDI) and portfolio investment. The share of FDI inflows in total foreign investment rose sharply from about 56% in 2000-01 to almost 80% in 2002-03.

FDI (Foreign Direct Investment) flows are usually preferred over other forms of external finance because they are non-debt creating, non-volatile and their returns depend on performance of the projects financed by investors. FDI in India has constituted 1% of gross fixed capital formation in 1993, which went up to 4% in1997. The tenth plan approach paper postulates a GDP growth rate of 8% during 2002-7. Most of the manufacturing sector, mining sectors are on 100% automatic route, with foreign equity limits only in defense equipment (26%), oil marketing (74%), government owned refinery (26%). While infrastructure services highways and roads, ports, inland waterways, transport and urban infrastructure and courier services are 100% automatic route, telecom (49%), airports (74%), civil aviation (40%), oil and natural gas pipeline (51%) have limits on equity. As per CII (Confederation of Indian Industry) report 'Due to bureaucratic delays there are low levels of realization of FDI vis-à-vis proposals cleared'. It was indeed only $15 billion, which could be materialized out of $40 billion total Foreign Direct Investment (FDI) in India in the period 1991 to 1998 due to laxity both on part of Central Government and State governments.

*Exchange control* enables a country to control its foreign trade. All exporters are obliged to sell foreign currency they obtain to authorized government banks (RBI), where it is resold to importers, as state desires to import. The aim of exchange control is to keep exchange rates stable. The rate of exchange may be either higher /lower than the equilibrium rate of free market. In fact a country pegging the rate at a low level that is undervaluing its currency may do so to stimulate its export rate. Policy of overvaluation is employed to bolster up confidence in currency at home as to cheapen up imports during the time preparation of war.

During the fiscal year 2004, India's foreign exchange reserves swelled to astonishing heights (US$ 100 billion). Though welcome from the viewpoint of external security that it provides in India's external financial position, such large improvement in India's external position is unprecedented in India's own history. The story is also refreshingly different when compared with the current position of some of the other developing countries, barring some exceptions like China. It has been the effort of Government to maintain a positive trend, by reflecting the renewed stability of the rupee and relatively attractive valuations on Indian stock markets.

## 1.5 PROJECT IMPORTS AND IMPORT SUBSTITUTION

Most developing countries including India depend on imports to meet the project needs of equipment and machinery. The government of India also was exacerbated by the steeply rising international prices and had announced a series of rigid import control measures in view of tight balance of payments .The foreign exchange crunch may also be attributed to appreciation of foreign currencies, devaluation of India rupee, global inflation, increased Indian inflation, high export outstanding etc. There is an increasing awareness for import substitution or indigenization and for promoting self-reliance.

The following factors are relevant for the need of restricting imports and the difficulty in restricting them are:

- Depleting foreign exchange reserve and increasing trade gap
- Higher cost of imports due to falling value of Indian rupee. The precious foreign exchange is needed for more essential imports like crude oil, defense equipment etc.
- Restricted shipping cargo capacity with long transportation time
- Unfamiliar commodity specification and difficultly in meeting precise tolerance in view of huge investment needed.
- Non availability of research development etc at local industries making indigenization a tough experiment

Some other factors are improper testing equipment and inspection facilities, low employee morale due to poor wages, inability to meet warrantee commitments, delays in replacement of rejected material etc.

Timely/Speculative buying and use of right currencies based on exchange information provided by banking services will reduce import cost. Identifying need of foreign collaboration by sourcing items in India, consulting foreign trade counsels in India and Indian consuls abroad, visit to international trade fairs, participating in international professional organizations, pursuing directories published by different countries, etc can serve ***a good way of identifying international sources for projects***. This can help to save precious foreign exchange on imports. *So judicious balance* is to be sought which *moderates foreign exchange outflow* and gives *reasonable fillip development of indigenous technology*.

## 1.6 FORMS OF INTERNATIONAL BUSINESS

The concept of international business can be expressed with the help of following block diagram.

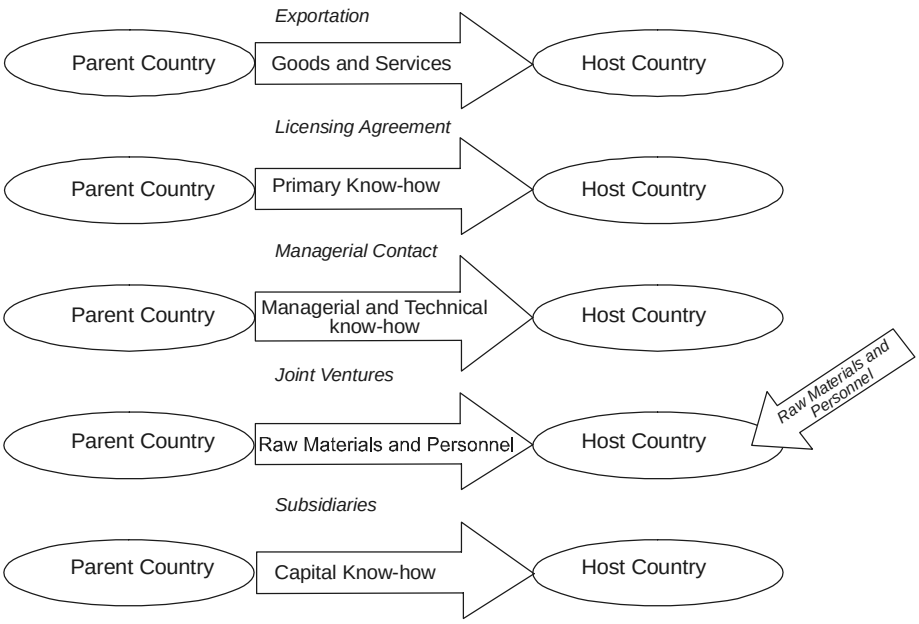



**Fig. 1.1** Comparison of forms of international business

International business has gained prominence in recent years with growth of large multinational corporations. The transactions include transfer of goods, services, technology, managerial knowledge and capital to other countries. Multinational Corporations (MNC's) have their headquarters in one country with their operations in many countries. The educational, social-cultural/ethical, political-legal and economic environments have a particular impact on international enterprises. The MNC's have developed different orientations for operating in foreign countries ranging from **ethnocentric** (the foreign operation is based on the parent company's views) to **geocentric** (the organization is viewed as an interdependent system operating in many countries that is truly international).

## 1.7 PUBLIC SECTOR PROJECTS

As compared to the capitalistic economy, which is based on private enterprise, socialist economy is founded by state ownership. India deliberately chose the planned path of mixed economy precisely to achieve the rapid quantum jump in industrial growth.. Public sector organizations formed with intention of accomplishing quick industrialization and raising the standard of living of people through developing key and basic industries eg. Iron and steel, aircraft, defense, fertilizers, etc. In our country the expansion of the pu blic sector was in accordance with Industrial Policy Resolution 1948 and 1956 and as per the directives of our Five-Year Economic Plans.

## 1.7.1 The Importance of 3E's

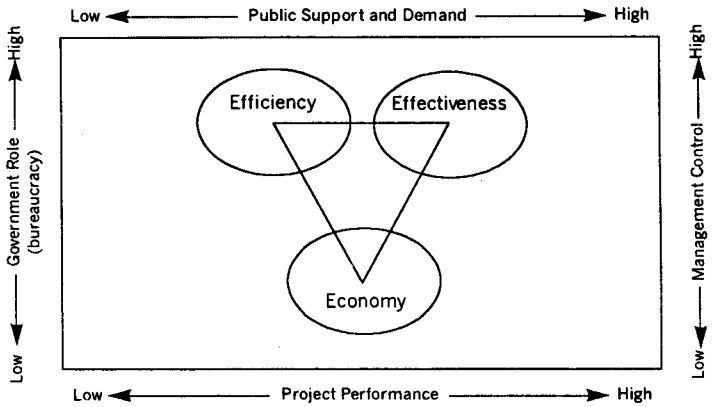



**Fig. 1.2** Thrift of 3E's

The importance of 3 E's, i.e. Efficiency, Effectiveness and Economy can be understood by the above figure.

The *objectives* of public sector projects/ enterprises were to help:

- The rapid economic growth and industrialization of the country and create necessary infrastructure to smoothen the process of growth and development without the growth of monopolies.
- To earn a fair rate of return on investment and thus generate resources for development
- To promote equitable redistribution of income and wealth
- To create adequate employment opportunities
- To promote balanced regional development through dispersal of industrial locations
- To assist in the development of small scale and ancillary industries
- To promote import substitution, save and earn foreign exchange for the economy, create self-sufficiency of nation

The *main Characteristics* of Public Corporation in capital technology, skill etc. include the followings:

- The public corporation is a body created by a law of parliament.
- It is owned by government: central, state or local bodies.
- Board of directors nominated by government manages it.
- It enjoys complete internal autonomy and is free from parliamentary or political control in the internal and routine management.
- It enjoys financial freedom and can raise financial resources independently (both local/ foreign capital). It has not to depend on budget appropriations. It has borrowing powers. The government guarantees its bond issues.
- The employees of the public corporations are not treated as civil servants of the government. The corporation is empowered to follow its own personal policies for recruitment, training, transfers and promotions.
- Its primary objective is to serve the public interest and hence it is accountable to the parliament for the policy decisions and the resultant functions.

- Profits earned are used for general welfare of society.
- Capital, raw material, fuel, power, transport are easily available to them.

## 1.7.2 Disadvantages of Public Corporations

Public sector projects are facing significant challenges to prove themselves upright by balancing through economy, efficiency and effectiveness. A question is being raised whether '*Public sector projects is an investment on White Elephants*?' They are suitable only for management of big enterprises, which needs special legislation, and hence its function is elaborate and time consuming. It is of rigid form and any change requires amendment. It has autonomy only on papers. In reality the ministers, government officers and politicians interfere in the working of such corporations. The very motive of removing monopoly is defeated as it creates monopoly in absence of competitions and they have no incentive or need of adopting new technique for improvement in working. They are marked by delay in decisions, wastage thus causing additional burden to the people in the form of taxation. It can rarely achieve efficiency level of private sector.

Some of the **principal reasons for failure** of major public works to finish on time and within budget include: Underestimation, Technological advancement and uncertainty, Late design changes, Correction of design errors, Increased safety requirements (Oil, nuclear plant; environmental), Poor industrial relations, Adverse site conditions, Funding availability (World Bank or ADB), Site acquisition, Quantity increase, Shortage of materials, Contractors financial difficulties, Inappropriate contract strategy, Inflation and interest changes, Exchange rates, Civil unrest/ political coups.

*What is required is to run our industries and manage our economy more efficiently and effectively rather mere labels like public sector or private enterprises*. This requires the public sector enterprises to be able to compete with the private sector on equal footing. Full accountability needs to be enforced in the public sector. The controls, licenses, etc must be removed to maximum extent to ensure removal of red-tapism. Incentives like tax- concessions, subsidies, etc should be resorted to as far as possible instead of controls for starting new industries in the backward regions. The table 1.1 shows the difference between the public and private sectors respectively.

**Table 1.1** Comparison of public and private sector projects

| ***Feature*** | ***Public Sector Projects*** | ***Private Sector Projects*** |
|---|---|---|
| Focus | Social welfare and economic growth | Individual firm or industry growth and profitability |
| Decisions | Decisions are taken at the policy level with the mutual interaction and consent of Planning commission and Finance Ministry | Decisions are made at the board level or management or consortium of industries |
| Functions | Facilitative and allocative functions.<br>Distributive functions<br>Remove market imperfections | Accumulative of economic power.<br>Market segmentation.<br>Exploit the situation of scarcity. |

*Contd...*

| | | |
|---|---|---|
| Governing Philosophy | Trustee of public capital and aims at providing minimum basic amenities of public utility kind.<br>Increases national wealth and supplies society.<br>Source of absorption of technology.<br>Common ownership of asset.<br>Employment security. | Growth of private capital.<br>Products and services are the outputs of such projects to gain profit.<br>Technology will match with the competition and capacity of the industry.<br>Insecurity in employment on such projects |
| Performance Measurement | Changes in national wealth and contribution to GDP are the yardsticks of performance of public sector projects.<br>Secondary indicators of performance are increase in employment opportunities, reduction of inconveniences in public life, internal resource mobilization and increased standard of living of the society.<br>Contribution towards the total government revenue. | Excess of actual return on investment over the estimated ones.<br>Increased market share.<br>Invigorated investor's interests towards the future projects.<br>Increased goodwill and credibility in the money market.<br>Mobilization of resources for private expansion.<br>Minimum duty and tax- penalties. |
| Scope and Time Span Involved | The perspective of public sector project is macroscopic and launch into complex nature of projects, which consumes longer period for execution.<br>Profit is not a criterion to break the private monopoly. | The perspective is microscopic which drives these projects through short-term periods of construction and results follow accordingly. |
| Accountability | Since the government initiates these projects by investing public revenue towards a social cause, they are totally accountable to the nation and able to justify such huge expenditure. | These are undertaken by a private entrepreneur with the help of few stakeholders and therefore answerable to investor and promoters. |

## 1.8 PROJECT MANAGEMENT *VS.* FUNCTIONAL MANAGEMENT

In general there exists relatively definable boundary between the project and functional manager. According to **Cleland and King** this interface can be defined by following relationships:

- **Project manager**
  - What is to be done?
  - When will the task be done?
  - How much money is available to do the task?
  - How well has the total project been done?

- **Functional manager**
  - Who will do the task?
  - Where will the task be done?
  - How will the task be done?
  - How well has the functional input been integrated into the project?

Project Management approach in preference to functional management can be better appreciated if we consider the following factors:

- All work has inter-dependence and inter-relationship with others.
- As work in inter-relationships are liable to change with time a static plan may not work instead it is required to adopt oneself to changed environment without losing sight of goal.
- Project Management requires grouping generalization and flexible approach as opposed to specialization and division of work.
- There is a need for trade-off accepting the lesser than the best for an overall benefit.
- In functional specialization the totality of work is often lost sight of, as function at specialization could mean. Someone only thinks, someone only talks and third person does the real work with such an arrangement no single individual except the chief executive can be held responsible for a work from A to Z. This necessarily creates problems of communication, co-ordination, commitment and control.
- Project Management approach is dedicating us to end objective and keeping the totality in focus all the time. A work can be done better if it is taken up as a whole and assigned to one responsibility center.
- Project Management deals with new, uncertain and risky situations. One cannot be expected to alternate one's management style to meet the requirements of such diverse situations all in the same day. Functional management deals mostly with a stable situation. The expertise needed for each is different

Company working in functional areas often engage themselves in project works. Some of the advantages of Project Management to companies are Better Control , Better Customer Relations, Shorter Product Development Time, Lower Program Costs, Improved Quality and Reliability, Higher Profit Margins, Better Control over program security, Better Project Visibility and Focus on Results, Improved Coordination among company divisions doing work on projects, Higher Morale and Better Mission Orientation for employees working on project, Accelerated Development of Managers due to breadth of project responsibilities

There may also be some disadvantages to functional companies that engage in Project Management works like: More complex internal operations, Inconsistency in applications of company policy, Lower utilization of personnel, Higher program costs, More difficult to manage, Lower profit margins, Tendency for functional groups to neglect their jobs and let the project organization do everything, Too much shifting of personnel from project to project, Duplication of functional skills in project organization. The table 1.2 shows the comparison between project and functional management.

**Table 1.2** Comparison of project management and functional management

| *Phenomenon* | *Project Management* | *Functional Management* |
|---|---|---|
| Line and Staff Organizational dichotomy | **Slag heap** of the hierarchical model continues, but line functions are placed in a support position. A web of authority and responsibility relationships exists. | Line functions have direct responsibility accomplishing the objectives; the line commands, are staff advices. |
| Secular principle | Elements of the vertical chain exist, but prime emphasis is placed on horizontal and diagonal workflow. Important business is conducted, as the legitimacy of the task requires. | The chain of authority relationships is from superior to subordinate throughout the organization. Central, crucial, and important business is conducted up and down the chain |
| Superior-subordinate relationship | Peer- to-peer, manager-to-technical expert, associate-to-associate, etc., relationships are used to conduct much of the salient features. | This is the most important relationship; if kept healthy, success will follow. All-important business is conducted through a pyramiding structure of superiors and subordinates. |
| Organizational objectives | Management of a project becomes a joint venture of many relatively independent organizations. Thus the objective becomes multilateral. | Organizational objectives are sought by the patent unit consisting of an army of sub organizations working within its environment. The objective is unilateral. |
| Unity of . direction | The project manager manages across functional and Organization lines to accomplish a common inter-organizational objective. | The general manager acts as the one head for a group of activity having the same plan. |
| Parity of authority and responsibility. | Considerable opportunity exists for the project manager's responsibility to exceed his authority. Support people are often responsible to other managers (functional) for pay, performance reports, promotions, etc. | Consistent with functional management; the integrity of the superior-subordinate relationship is maintained through functional authority staff service. |
| Time duration. | The project and hence the organization is final in duration. | Tends to perpetuate itself to provide continuing facilitative. |

## 1.9 TYPES OF PRODUCTION SYSTEMS WITH DIFFERENT DEGREES OF FLEXIBILITY

The figure given below shows the different types of systems used in practice with their varying degrees of flexibilities.

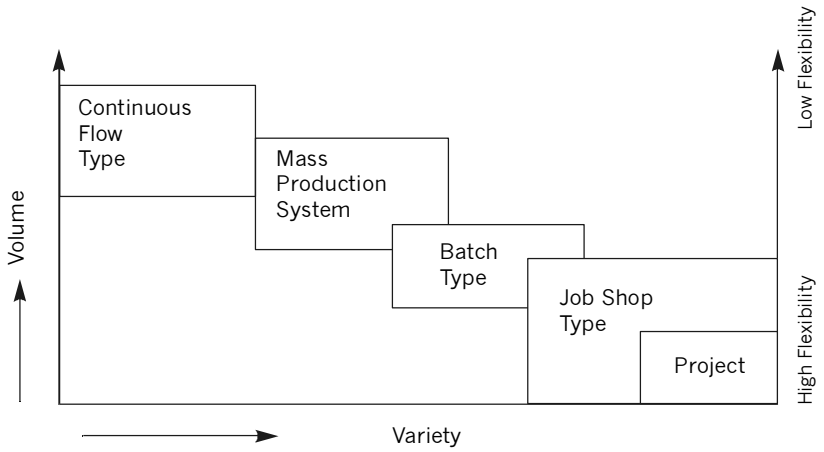



**Figure 1.3** Types of production systems

Projects are highly specialized jobs with each project requiring different type of skills. Lying at high-flexibility end of continuum is the low volume type of operation, often referred to as project. Each project is unique and different from other project and marks the beginning of a new chapter. Project can be said to a complex web of things, people and environment. The business grows with time and indefinite life as long as the product is acceptable in the market.

## 1.10 COMPARISON OF PROJECT AND TYPICAL BUSINESS

Management of a project differs in several ways from management of a typical business. The objective of a project team is to accomplish its assigned mission and disband. Few business aims to perform just one job and then cease to exist. Since a project is intended to have a finite life, employees are seldom hired with the intent of building a career with the project. Instead a project team is pulled together on an ad-hoc basis from amongst persons who normally have assignments in other parts of the organization. People may be assigned to work full time with the project until its completion or they may work only part of their time such as 2 days a week on the project and work rest of their time in their usual jobs or on other projects. A project may involve a short-term task that lasts only a matter of days or it may run for years. After projects completion the project team members are normally assigned back to their regular jobs, to other jobs in the organization or to other projects.

## 1.11 ZERO DATE OF A PROJECT

The zero date of a project signals the effective start of the project. It is an important part of project planning and establishment. The completion of projection will be counted from this point of time. It is important to ensure that all activities that effect project performance like arrangement of finance, infrastructure facilities, formation of new company, division, government clearance etc. besides time, cost and technical parameters are fully dealt/designed/established/started by this time.

This is usually the last step in establishing project but saying, *"Well begun is half done"* is nowhere more suited than in case of project.

## 1.12 PRE-PROJECT ACTIVITIES

All the activities, which must be completed before zero date, not only define the scope of main project activities but enable fixation of performance targets and hence zero date, include the following:

- Identification of product/project.
- Obtaining the required clearance from competent authorities
- Arrangement of raw materials, feed-stock etc
- Arrangement of technology and related know-how
- Finance arrangement
- Identification of relevant markets
- Determination of product/pattern and plant capacity.
- Selection of process licenser
- Site selection
- Preliminary capital cost estimate
- Investment decision
- Technology package finalization
- Overall implementation schedule
- Letter of Intent (LOI) for project
- Recruitment of key project personnel
- Finalization of strategies vis-à-vis manpower, fabrication and construction, workload forecast
- Conducting contour survey and benchmarking
- Conducting investigation of ground water
- Development of overall project plan
- Acquisition of site

## 1.13 PROJECT ACTIVITIES

Some of the fundamental activities that are undertaken while the project is executed can be classified as ongoing project activities and advance activities. Project activities include

- Procurement of equipment and material
- Transportation of equipment and materials to site
- Civil work for site development, building foundation etc.
- Fabrication and errection of structures, equipment and materials
- Pre-commissioning, commissioning and trial runs
- Performance tests

### 1.13.1 Advance Actions

Project activities, which start before zero date, so that overall project completion time is not effected. These activities start well in advance so as to pave the way for future project activities. Some of activities which have large lead-time particularly infrastructure should start during this period. Infrastructure facilities are those, which are essential to start and support construction activities, eg.

- Fencing /Boundary wall
- Approach road
- Preliminary soil investigation
- Power
- Water
- Railway siding
- Arrangement for fax /telephone/internet (communication network)
- Site office development
- Cement godown
- Transport system
- Registration for tax and company judiciary
- School building and guest house
- Markets, hospitals and other facilities
- Construction equipment
- Drainage and sewage plan
- Planning for housing, street park etc.

In critical cases temporary arrangement may be made to enable immediate start of work.

## 1.14 PERFORMANCE INDICATORS

Zero Date of a project may vary from project to project**.** In order to get project cleared from approving authorities a schedule may be fixed up which may be far from realistic. The vendors and contractors will only add to confusion by promising deliveries, which can make possible any thing on paper. Besides a defective design and subsequent modification / change to suit project requirements also increases time and cost. Anything done in a project, including time overrun would be reflected in the cost.

Time and cost over-runs of projects are common in India, particularly the public sector. Hence the project tends to become uneconomical and economic development is adversely effected. One of the reasons is delay in decision-making. In public sector those who make recommendations on extra costs or are dynamic decision makers avoid doing so for fear of harassment and humiliation in form of 'dreading questions and enquiries' against them. Also responsible is the cumbersome procedures for the delay.

Financial constraints have caused overrun of certain projects. In general it is pragmatic to start a project implementation only after receiving the required financial sanction with an assured disbursement plan relating to master plan. A delay in budget sanction will cause further delay and also cost over-run. An Annual Report of Ministry of Programmes Implementation for a recent year provides some alarming information about 184 central projects monitored by the **Ministry of Programme Implementation**.

- 119 Projects (about 65 per cent of total) have suffered time over-runs, which have gone as high as about 200 per cent. The average delay in commissioning these projects was about 3 years.
- 125 Projects (about 68 per cent of total) have suffered cost over-runs, which have been as high as 75 percent.
- Projects for which no time and cost over-runs have been indicated have mostly been taken up recently and it is likely that many of them will suffer from time and cost over-runs.

To prevent these over-runs Adequate formulation, Second project organization, Proper implementation planning, Advance action, Timely availability of funds, Judicious equipment tendering and procurement, Better contract management, Effective monitoring. However revision of time and cost targets should not be frowned upon since they cannot stay if the world around their changes. Instead they should motivate people to move forward. The Ministry of Project Implementation and **COPU** (Committee on Public Undertaking) have suggested some measures to reduce cost and time overrun. The team must ensure that no member whether a vendor, contractor, sub-contractor or a government department lags behind schedule because this can adversely affect other connected activity. If it occurs there should be no disowning of responsibility or pleading 'helplessness'. The members who cannot cope with the rest should be removed or pay the price for risk purchase or substitutes.

Diverse areas using Project Management in recent years include Aerospace, Defence Industries, Engineering and Construction, Manufacturing, Electrical Generation and Distribution, Process Plants, Crude Oil and Natural Gas Exploration, Development and Production, Infrastructure for various levels of Government, Research and Development, Data/ Information Processing, Health Care and Biomedicine, Computer Hardware and Software, Educational Institutions and Ad Hoc Management Undertaking.

## QUESTIONS

1. Explain why project management is required.
2. Enlist the challenges in any industrial project.
3. Explain the role of liberalization and globalization in context of project management.
4. Discuss various types of international businesses.
5. Compare private and public sector projects.
6. Differentiate between project management and financial management.
7. Enlist the pre-project activities associated with project management.
8. Highlight the importance of performance indicators.

2

# CONCEPTS OF PROJECT MANAGEMENT

**Project Definitions:** Project can be defined in the following ways:

- **Project is an organizational unit dedicated to the allotment of a goal the successful completion of a development product in time, within specified budget, in conformance with the pre-determined performance specifications**
- **It is a set of finite activities that are usually prepared only once and have well designed objectives, using a combination of human and non-human resources within limits of time**
- **It consists of a series of non-routine, interrelated activities with a goal that must be completed with a set amount of resources and within a set time limit.**
- **It is a proposal for investment to create and/or develop certain facilities in order to increase the production of goods and/or services in a community during a certain period of time. (UNIDO)**

## 2.1 PROJECT CHARACTERISTICS

The following points are inherent features associated with any project:

1. It is customary to use terms such as cement projects, power projects, refinery projects (not plant), *and the term project is replaced by plant as soon as the plant is operational or project is completed.* All works that can be interrelated and are being performed to serve a common purpose can be grouped together and termed a project, only if it is a composite affair. The difference from a plant is that project as a whole has to be completed in one shot, once and for all. So project has to achieve one mission, which may not be a physical objective or an end result e.g. holding an election, conducting a war, planning to prevent a riot.
2. Project is managed by a process of 'Planning-Organizing-Directing-Staffing-Monitoring-Controlling'. Various starting points of project are called **sources**. A project can have *a number of sources but one end or sink.*
3. **Focus**: Project has a fixed set of objectives/mission/goal. Project ceases to exist once the mission is achieved
4. **Lifespan**: Each project is time bound through the schedules.
5. **Unique**: No two projects are alike in their execution even if the plans are duplicated and therefore a single time activity.
6. **Unity in Diversity**: This is a global concept for any type of project since project is considered to be a *complex web of things, people and environment.*

7. **Flexibility**: Change and project are synonymous. Project is dynamic in nature and therefore modifications/changes in original plans, programmes and budgets are a normal feature.
8. **Team Spirit:** This involves coming together of different individuals from varied disciplines to bestow their knowledge, experience and credence towards a total performance.
9. **Risk and Uncertainty**: Every project has risk and uncertainty associated with it. The degree of risk and uncertainty will depend on how a project has passed through its various life-cycle phases. An ill-defined project will have extremely high degree of risk and uncertainty. Risk and uncertainty are not only part and parcel of R & D projects only; there simply cannot be a project without any risk and uncertainty in a real life situation.
10. **Statement of Work (SOW):** Project planning deals with specified tasks, operations or activities, which must be performed to achieve project goals. A project starts with ***statement of work***. It may be a written description of objectives (rules/regulations/ constraints/restriction) to be achieved with a brief statement of work to be done and a proposed schedule specifying the start and completion dates of the project. It could also contain certain performance measures in terms of budget, completion steps (***milestones***) and written reports to be supplied during the project completion.
11. **Implementation:** Every project needs resources or inputs where given inputs are to be converted to output through the process of implementation. The output in short run leads to outcomes while in the long run should result in impact.
12. **Task:** It is further subdivision of a project. It is usually not longer than several months in duration and is performed by one group or organization. Subtask may be used if needed to further subdivide the project into more meaningful pieces.
13. **Work Package:** These are a group of activities combined to be assignable to a single organization of unit. The package provides a description of what is to be done, when it is to be started and completed, the budget, measures of performance and specific events to be reached at points in time (milestones). Typical milestones may be completion of design, production of a prototype, the completed testing of the prototype and the approval of pilot run.
14. **Subcontracting:** It is subset of every project without which no project can be completed unless it is proprietary firm or small in nature. The survival of a company depends how wisely it selects its vendors and maintains good relations with them so that project is commissioned without time overrun and cost overrun. If there are several contractors their performance is rated according to quality, delivery, price service, etc. The activities of subcontracting include sending enquiries to subcontractor and placing order after negotiation with them on all relevant parameters. Adequate follow-up of subcontract orders is made by stage wise inspection before dispatch of finished machinery. The shop capacities are scrutinized adequately so that overloading the vendors is avoided. Needless to emphasize that vendor's facility for prompt delivery of quality items are assessed by techno-economic surveys and plant visits. Industrial directories, trade directories, supplier's catalogues, trade journals, newspaper advertisements and industrial exhibitions serve as useful source for locating subcontractors.
15. **Project Life Cycle:** Project life cycle commences when the idea chosen is found technically feasible, economically viable, and politically suitable and investment

proposal is approved. For a company executing projects either regularly or for the first time, it would be necessary for the chief executive to issue what may be called a ***project charter*** soon after project manager is appointed. The charter at its minimum may define project scope, project goals, name of project manager, and his directing authority. The project reviewing authority and request co-operation of all concerned in the execution of the project. An elaborate effort in this direction may produce what is known as ***project manual***.

These major events in projects are grouped under various heads.

- Conception / Identification: Acceptance of necessity, Identification of objectives, Project formulation
- Planning phase/Appraisal phase: Preparation of feasibility report, Appraisal of feasibility report, Investment decision.
- Execution phase of project: Issue of executive order, Implementation of project
- Follow up phase/monitoring phase: Project monitoring (data collection information gathering), Preparation of M.I.S. (Management Information system), Time management (time control) of project, Cost management (cost control) of project
- Feedback and analysis :Issue guidelines to future project, Project Clean up

16. **Feasibility Study:** Feasibility study of the project is the most exhaustive of all the planning stage. The project is systematically examined in depth at this stage for various aspects like technical, financial, economical, commercial, social, managerial and organizational. The purpose of this study is to examine if the project objectives are realistic, recommendation in preliminary study are technically sound; beneficial from financial, economical, social point of view; feasibility from social, cultural, ecological of view.

## 2.2 PROJECT OBJECTIVES AND FUNCTIONS

Project execution must be directed to achieve the project objectives. There are three primary objectives of a project to be met, which include:

- **Performance**: This is to satisfy the specified standards of performance/function, reliability and safety
- **Containment of expenditure within budgets** to ensure smooth running
- **Time Scale**: Timely implementation of project to be proven at time of launch

The last two objectives are linked to the resources, which are limited. But this may represent an over simplification of real intent of project objectives. A project may have many objectives, which must be clear to both project manager and the owner. Prioritizing the objectives is necessary for knowing the primary and secondary objectives.

Some of the typical objectives, not listed in any particular order, include:

- Quality of product
- Avoiding unproven equipment
- Safety during construction
- Designing for particular project life
- Safety for maintenance
- Minimizing start up time
- Enhanced public image
- Safety during operation
- Fastest completion time
- High level of automation
- Lowest capital investment
- Lowest operational costs
- Reliability of information
- Security of information
- Use of local sub-contractors
- Use of local suppliers

Project Management Institute (PMI) identifies *six basic functions* that project management must address. These are:

- Manage the project's *scope* to define the goals and the work to be done, in sufficient detail to facilitate understanding and correct performance by participants
- Manage the *human resources* involved in a project effectively
- Managing *communications* to see that appropriate parties are informed and have sufficient information to keep the project coordinated
- Manage *time* by planning and meeting schedules
- Manage *quality* so that project results are satisfactory
- Manage *costs* to see that project is performed at the minimum possible cost and within the budget, if possible

## 2.3 PROJECT CLASSIFICATION

The project can be classified in various ways

- **Based on Scope and Significance**

| | | |
|---|---|---|
| National | Development | *Location (Rural and Urban); |
| | | *Resources (Infrastructural, Production, Service, Mobilization) |
| | Maintenance | *Welfare (Microscopic and Macroscopic) |
| International | Foreign Investors (MNC's) | |
| | Joint Ventures | |

- **Based on Size and Scale**
  Large Scale, Medium Scale, Small Scale
- **Based on Ownership and Control**
  Public Sector, Private Sector, Joint Sector
- **Based on Degree of Change**
  Inventive, Discovery, Innovation, Adaptation
- **Based on Technology Involved**
  Conventional, Non-Conventional/Research and Development Projects/Developing a new Technology, High Technology and Low Technology
- **Based on Speed**
  Normal, Crash, Disaster
- **Based on Beneficiary**
  Industrial, Ancillary, Consumers
- **Based on Purpose**
  New Projects, Mergers, Diversification, Modernization, Replacement/Renewal, Upgradation, Maintenance, Balancing, Rehabilitation/Sick Unit Reorganization, Construction Projects e.g. Construction of house, building, bridges, roads, tunnels, etc., Management Projects, Manufacturing Projects

There are some projects which are difficult to classify into any category like conducting national elections, performing marriage, overhauling a machine, maintenance of machine, launching new weapon system, commissioning of a factory, conducting war, precursor planning to prevent riots.

## 2.4 PROJECT LIFE CYCLE

As defined by **Cleland and King** standard pattern of project life cycle passes through the following phases Conception phase, Definition phase, Production, Observation, Divestment and Post-Mortem. The phases one should follow one after another in sequence it really happens it is possible to find succeeding phases overlap of all phases. This overlapping may in fact be beneficial in compressing overall schedule.

The following figure is the original model of project life cycle, which is suitable for any type of project.

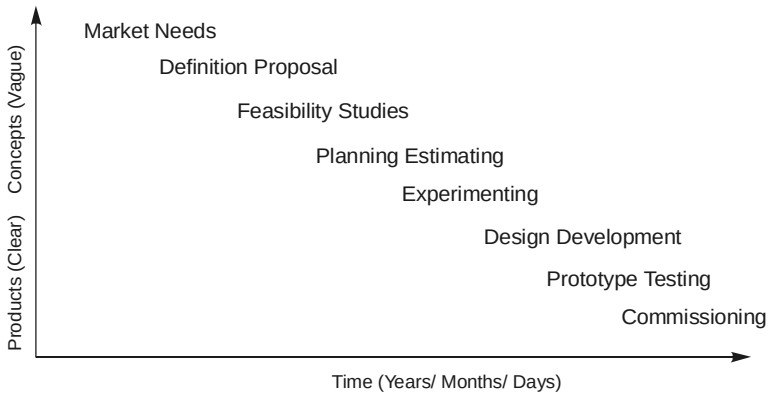



**Fig.2.1** Model of project life cycle

The Table 2.1 below shows the phases, stages and objectives of various projects

| ***Phase*** | ***Stage*** | ***Objective*** |
|---|---|---|
| Preparation or Initiation | 1.Identification of a project idea | Project and programme goals are identified and analyzed |
| | 2. Preliminary selection. | Project objectives and preliminary global schedule and cost estimates determined |
| | 3. Feasibility studies. | Ideas for possible solutions developed into alternative concepts; desirable technical solutions identified and classified. |
| | 4. Evaluation and decision making (post-feasibility) | Feasibility of envisaged concepts and relevant alternatives assessed, evaluated and categorized.<br>Decision on adoption of the most promising alternative solution; funding provided. |

*Contd...*

| | | |
|---|---|---|
| Implementation or construction | 5. Initial project planning, scheduling, designing and engineering | All detailed drawings, specification, bills of materials, schedules, plans, cost estimates and other relevant documents checked and approved. |
| | 6. Contracting and Procurement | Appropriate manpower, machinery, manufacturing and construction facilities, utilities, materials documentation and other relevant infrastructure components mobilized and available. |
| | 7. Facility construction and pre-operations | Complete, tested, 'debugged' and accepted product, facility or system (optimum performance, time and cost) |
| Operation | 8. Operations (an interface purpose and programmes continuity) | Product facility or system operational at all times and at optimum cost. |

**Source:** United Nations Publication: The initiation and implementation of Industrial Projects in developing countries—A System Approach

### 2.4.1 Project Life Cycle Curve

The curve below shows various phases in sequence and approximate effort involved in each phase, though in real life the phases will overlap. It can be seen that effort build up in a project is very slow but effort withdrawal is sharp. While this pattern is true for all projects, the percent of effort in different phases will not be same for all the projects.

The parabolic life cycle curve here represents the cumulative growth at any time. The *parabolic pattern* of ***growth, maturity and decay*** manifests itself in all phases of the project life. The knowledge of characteristic life cycle curves enables a project manager to ascertain the state of health of a particular project at any point of time. If actual progress in any of the sub-phases falls short of the qualifying work for that sub-phase, then that sub-phase is sick and requires treatment. Life cycle curve along with line of balance is very useful for management of project.

By and large all project have to pass through five phases as shown in the figure. Ideally these phases should follow one another in sequence but it rarely happens. It is possible to find the succeeding phase overlap with preceding ones or complete overlap of all phases. This overlapping may in fact be beneficial in compressing over all schedules.

#### *Phases in Project Life Cycle*

The five main phases are as follows:

1. Conception phase
2. Definition phase
3. Planning and organizing phase
4. Implementation phase
5. Project clean-up phase

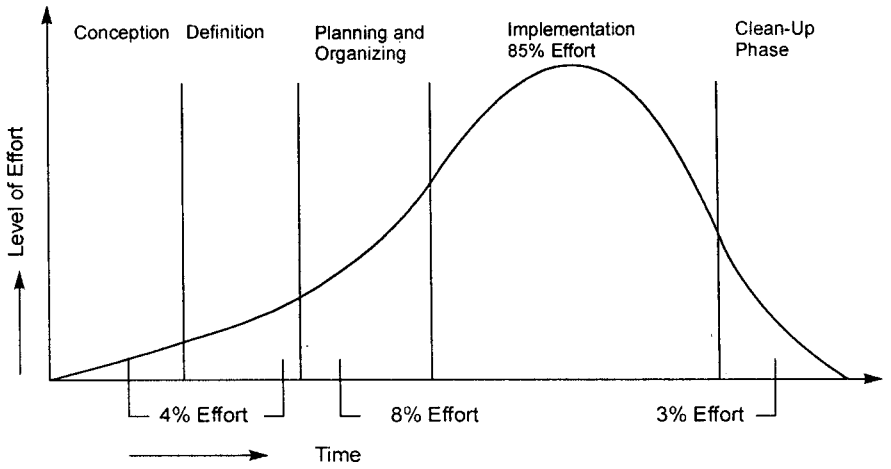



**Fig. 2.2** Phases in project life cycle

## 1. *Conception phase*

This phase is marked by acceptance of need and identification of objectives. Identification of a goal that is bound by definite time, cost and performance target. Suitable project have to be identified first. Project identification is at the heart of the entire project management process.

It deals with the basic issue of the purpose of organization its long and short terms goals, its strengths, its weakness, opportunities and threats (**SWOT** Analysis). It is a mixture of both formal and informal process. Project cannot be properly identified unless the organization identifies its position vis–a-vis the prevailing or anticipated environment. Project ideas emerge during analyzing problems conducting macro economic and social analysis, pressure from local people etc. Project identification is followed by a broad examination of the set of identified project ideas for their physical realizability, technical soundness, market compatibility, financial availability and socio-economic impact It is an idea generation phase in which existing problems are identified which may be non-utilization of either the available funds, capacity of plant, expertise or unfulfilled aspirations. The ideas have to be put in *black and white* after examining in the light of objective and constraints. This phase not properly addressed may cause project failure or project becoming a liability whereas a well-conceived project will go a long way for successful implementation.

## 2. *Definition phase*

This phase is marked by feasibility report, its appraisal and investment decision. This involves developing the idea generated during conception phase to produce documentation of details of project. These details cover all aspects necessary for customer and/or financial institution to make up their minds on project idea. *Ideally in this phase the bank authorities introduce strict appraisal procedure for clearance of a project fund*ing. Various agencies may examine the feasibility report from their respective angle e.g. Government agencies give more emphasis on socio-economic aspects (SCBA: Social Cost Benefit Analysis) while financial institution examine techno-financial viability along with managerial competence.

**Project Appraisal** deals with accessing the absolute and relative merits of project in order to make the critical *accept or reject decision* with respect to available projects.

- Market appraisal
  Surveys, projection
- Technical appraisal
  Product mix (Optimum in nature), Capacity / Plant size for entire plant and equipment, Process of manufacture, Engineering know-how and technical collaboration
- Financial appraisal
  Reasonableness of estimate of capital cost, Reasonableness of estimate of working results, Adequacy of rate of return (ROI: Return on Investment), Sources of finance, appropriateness of financing pattern, Evaluation of financial viability
- Economic appraisal
  Economic rate of return, Effective rate or protection, Domestic resource cost, SCBA (Social Cost Benefit Analysis), Risk/Sensitivity analysis
- Managerial appraisal
  Resourcefulness, Sound understanding of project, Implementation schedule: Clears some ambiguities of risk involved in going ahead in clear terms which helps in decision of accepting /dropping at this stage itself, Commitment
- Environmental
  Safeguard against damage, restoration measures

## 3. *Planning and organizing phase*

This phase effectively starts after definition but in actual practice it starts immediately after conception. Generally organizations may not formally identify this phase because of overlap. However this phase may be marked by preparation of Project Execution Plan. Following activities are mainly involved:

- Project infrastructure and enabling service.
- System design and basic engineering package.
- Organization and manpower.
- Schedules and budget
- Licensing and government clearance.
- Finance.
- Identification of Project Manager
- Design basis, General Condition for Purchase and Contracts.
- Work packaging.
- Site preparation

## 4. *Implementation phase*

This phase is marked by execution of project along with its controlling and monitoring. Major bulk of work (80-85%) of project is done in this phase only, so people want this phase to start early and finish in earliest possible time. There as is greater need for co-ordination, monitoring and control with application of all techniques of project management in this phase.

This phase itself being more or less the whole project, every attempt is made to *fast track* i.e. overlap the varying sub phases such as engineering, procurement, construction and commissioning to maximum extent (or) parallel running of phases. Fast tracking can be improved

if only agency is given the entire responsibility of design, supply and commissioning rather than different agencies.

Some of the activities are involved are given below:

- Preparation of Specification for Equipment and Machinery.
- Ordering of Equipment, Contracting.
- Drawing, Civil Construction and Errection of Machinery
- Instrumentation and Testing.
- Commissioning of Plant

### 5. *Project clean-up phase*

This phase involves handing over of the facilities built to the customer after successful guarantee (through test runs/trials) to ensure the customer satisfaction. In this phase the following activities are completed:

- Project accounts are closed.
- Drawing -documents - manuals are catalogued and handed over
- Outstanding payment made and dues collected
- Gradually the project personnel are shifted to other areas.

## 2.4.2 Project Visibility

Although the proof of progress of project can be given, but it may not be possible to produce *solid evidence* for verification. Project becomes visible or gains a concrete shape only with the passage of time. It has to be realized that project is not a plant. Release of payment is sometimes linked to solid proof of progress by the financing institutions. At any point in life cycle something will be *clearly visible, something nearly visible* but the rest will have to be imagined or projected. *So project is projecting all the time, to get an idea of reality.*

## 2.4.3 Project Cycle for an Engineering Project

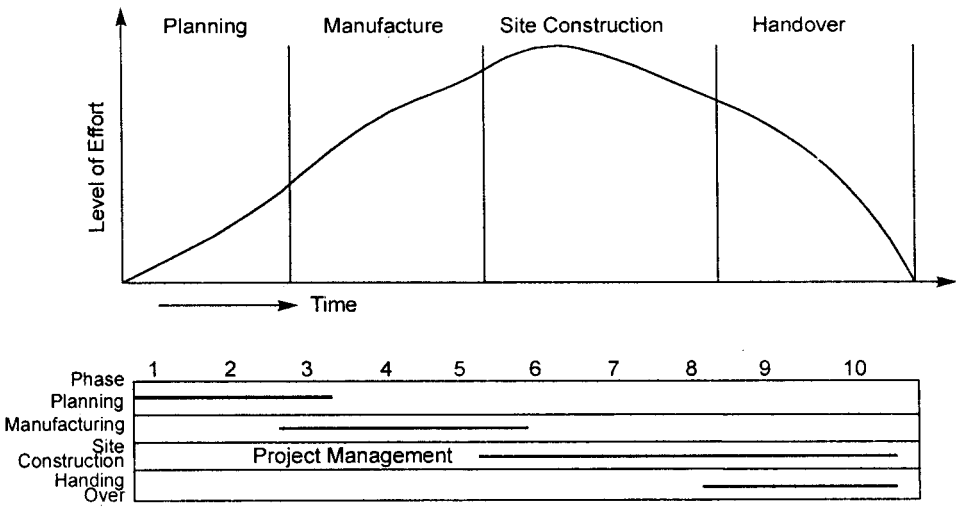



**Fig. 2.3** Project cycle

## 2.5 PROJECT MANAGEMENT DEFINITION

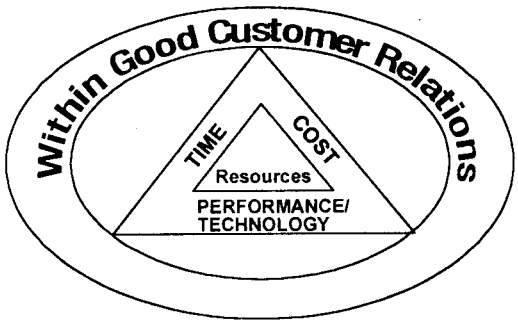



**Fig. 2.4** Project management overview

Project Management is literally an **'investment of resources'** to produce goods and services for consumption. The elements of project management control include programmed objectives, policy restriction, resource constraints, government regulations, process implication, review of output, feedback and revision of objectives. However the same can be defined as under:

- **Project Management is planning, organizing, monitoring and controlling of all aspects of a project and motivation of all involved to achieve project objectives of safety and within a defined time, cost and performance.**
- **Project Management is nothing but planning, directing and controlling of company resources for a relatively short-term project, which has been established for completion of specific goals. [Herold Kerzner]**
- **Project management is a scientific way of planning, implementing, monitoring and controlling the various aspects of project such as time, money, materials and other resources (e.g. manpower) with the intention of achieving the basic objectives or goals (technical, costs, time) while formulating a project.**
- **Defining what is to done, maintaining its integrity and ensuring that it is done and performed as desired, within time and cost budgets fixed for it through a modular work approach using organization and extra-organizational resources is what project management has to achieve.**
- **Project management involves co-ordination of group activity wherein the manager plans, organizes staff, directs and controls to achieve an objective with constraints on time, cost and performance of the end product.**

## 2.6. ELEMENTS OF PROJECT MANAGEMENT

The basic elements of project management include:

- Identification of the project.
- Technical and financial appraisal of the project.
- Economic or socio-economic appraisal of the project along with resources constraints. Review business justification
  - o Prepare cost/benefit analysis
  - o Prepare reports

- Proper formulation of project.
- Plan for implementation of the project
  - o Hard plan for next stage
  - o Soft plan for future stages
- Actual implementation of the project
- Monitoring the implementation to see that the project has not deviated considerably from the predefined targets, budgeted resources and time.
- Feedback and revision of objectives.
- Control action
  - o Record events
  - o Predict completion
  - o Report progress
  - o Rectification action for the deviations
- Policy restrictions
- Government regulation
- Manage staff
  - o Select and train
  - o Lead and manage
- Manage client relationship
  - o Plan client involvement
  - o Report progress
  - o Resolves problems
- Evaluation either at the end of the project or few years after the completion of the project to gain an insight as to what went right or wrong vis-a-vis predefined objectives of the project and what lessons can be learned so as to transmit the same knowledge to other similar or related projects to be executed is future

## 2.7 TECHNIQUES FOR PROJECT MANAGEMENT

Project Management is not only about Programme Evaluation and Review Techniques (PERT) or Critical Path Method (CPM). The scientific tools and techniques support and aid in the process of project management are not necessarily sufficient for its effective completion without the inputs from the human side. The scientific techniques will only tell what is right and what needs to be done, but it will require additional knowledge as to how it should be done and get it done through people through practical experience and human wisdom.

It needs to be emphasized that though techniques may be sound technically, but they may not deliver if manager is engaged in many tasks simultaneously. Throughout the life of project, the project manger has to seek a compromise between conflicting goals of technical performance, cost standard and time target. It is possible for manager to expedite actions if the priorities of management are articulated clearly. The techniques used are listed below which will be discussed at appropriate place.

### 1. *Project Selection Technique*

- Cost benefit analysis
- Risk and sensitivity analysis

### 2. *Project Execution Planning Techniques*

- Work breakdown structure (WBS)
- Project execution plan (PEP)
- Project responsibility matrix
- Project management manual

### 3. *Project Scheduling and Coordinating Techniques*

- Bar chart
- Project life cycle
- Line of balance (LOB)
- Networking techniques (PERT/CPM)

### 4. *Project Monitoring and Progressing Techniques*

- Progress measurement technique
- Performance monitoring technique
- Updating, reviewing and reporting technique

### 5. *Project Cost and Productivity Control Techniques*

- Productivity budgeting technique
- Value engineering
- Cost calculation using WBS

### 6. *Project Communications and Clean-up Techniques*

- Control room
- Computerized information systems

When we talk of tools and techniques, it should be clear that, mastering them all does not mean mastering project management. Besides attempts to combine different techniques have not been fruitful because '*perfection in work and time control*', '*cost control and time control*' are not agreeable. It is therefore, no surprise that trade offs are must and most project managers are content and obsessed with mere physical completion of project ignoring other areas of performance like time, cost or productivity. It is difficult to believe the computer based project management systems that promise to achieve everything, seeing the intricacies involved.

## 2.8 ROLES AND ATTRIBUTES FOR PROJECT MANAGER

The project manager's job is important and challenging. The manager is responsible for getting work performed but often has no direct, formal authority over most of the people who perform the job. The project manager often relies on broader knowledge of the project and skills at negotiation and persuasion to influence participants. A project manager may have the assistance of a staff if the project is large. Therefore it is important that the project leaders have an effective means of identifying and communicating the planned activities and the ways in which they are interrelated

*Considering the problems of project manager:*

- o Project is likely to change its shape and size with time. There is always scope for change till project is finally completed.

- Those required to work on project i.e. engineers, vendors, contractors, government bodies etc are almost a stranger to project manager with whom he has neither worked in past nor likely to work in future. They are independent bodies are not accountable to the project manger nor bound by corporate discipline which enables managers in all industrial organization to get things done.

### *The Basic Roles for a Project Manager Could be Broadly Grouped Under Following Heads :*

1. *Projectising* and problem solving. Projectising work as much as possible e.g. create a number of projects such as daily, weekly, monthly, quarterly, biannually and annual package activities of entire plant.
2. Defining and maintaining integrity of a project.
3. Development of Project Execution Plan. Organization for execution of the plan.
4. Setting of cost and time targets for each of the projects e.g. daily, weekly, monthly activities, etc
5. Development of systems and procedures for accomplishment of project objectives and targets.
6. Line up vendors and contractors for supply of materials and errection skills and contract management.
7. Negotiation for commitments and Man-management.
8. Non–human resource management including fiscal matters.
9. Direction and co-ordination of project activities. **Matrix** and co-ordinate with other departments for preparation of drawing, specification, procurement of materials, providing skills including labour and supervision.
10. Monitor and control these projects using schedules, budgets and contracts.
11. Satisfaction of customer, government and the public.
12. Achievements of project objectives, cash surplus and higher productivity

### *Attributes of a Good Project Manager are as Listed Below :*

1. Planning and organizational skills
2. Conflict resolving capacity
3. Ambition for achievement
4. Personnel management skills
5. Communication skills
6. Change orientation
7. Ability to solve problems in their totality
8. High energy levels
9. Ability to take suggestions
10. Understanding the views of project team members and having a sympathetic attitude towards them
11. Ability to develop alternative course of actions quickly
12. Knowledge of project management methods, tools and technology
13. Ability to make self evaluation
14. Effective time management

15. Capacity to relate current events to the project
16. Ability to handle project management software tools and package
17. Flair for sense of humor
18. Solving issues/problems immediately without postponing them
19. Initiative and risk taking ability
20. Familiarity with the organization
21. Tolerance for difference of opinion, delay, ambiguity
22. Conflict resolving capacity

No individual in our society, howsoever gifted, can be completed by himself, so for our survival, growth and prosperity we need to supplement each other. This holds goods for any system and project management is possible only through ***systems approach***. So if one accepts with humility that role of project manager is that of ***system integrator,*** than it is possible to supplement shortcoming of the project manager. It is the ***synergy*** that we need to bank upon to achieve something and not the *energy* of a few supermen for completing the giant project or completing the great task of elevating our standard of living through techno–economic projects.

## *QUESTIONS*

1. State the project characteristics related to project management.
2. Discuss project objectives and functions briefly.
3. How are the projects classified? Explain in brief.
4. What is the importance of project life cycle? Discuss.
5. Explain project elements used in practice.
6. Discuss the project management techniques.
7. Briefly write the role of a project manager.

3

# PROJECT SELECTION AND INITIATION

The key to success lies in getting into the right business at the right time. Identification of such opportunities requires imagination, sensitivity to environmental changes and realistic assessment of what the firm can do. The task is partly structured, partly unstructured, partly dependent on convergent thinking, partly dependent on divergent thinking; partly requiring objective analysis of quantifiable factors, partly requiring subjective evaluation of qualitative factors, partly amenable to control and partly dependant on fortuitous circumstances. The project takes shape to meet the customer's needs for goods and services. The whole concept of project can be to fit in the terms of finding a gap between customers needs for goods and services and filling the gap. The objective is to identify the investment opportunities, which are prima-fascie feasible, and promising, requiring merit examination and detailed appraisal. A realistic appraisal of corporate strengths and weaknesses is essential for identifying investment opportunities, which can be profitably exploited. The broad areas of corporate appraisal are market and distribution, production and operations, research and development, corporate resources and personnel, and finance and accounting. A promising investment idea enables a firm/entrepreneur to exploit opportunities in the environment by drawing on its competitive strengths. Besides the true new ideas, which are based on significant technological breakthrough, most of the project ideas involve combining existing fields of technology or offering variants of present product or service.

Before the project initiation there is a need to establish the project scope, time and cost targets/performance. In this context project feasibility is a device to document the need for the project and to record potential high-level solutions to solve the business problem at hand

## 3.1 GOVERNMENT REGULATIONS

In the developing nations like India, the government has to play a major role to ensure industrial and overall development of the country. It needs to spell out the priorities for the economy and lay the framework for development and resource allocation. Entrepreneurs are required to locate the profitable project opportunities within the framework for development. e.g. export promotion and import substitution may be a priority area. If the government announces its policy of development of backwards areas, entrepreneurs may find it easier and advantageous to set up their identified projects in such declared backwards areas in order to avail benefits both financial as well as non-financial.

Just as the government encourages the growth of certain sectors of industries, the government also de-motivates growth in certain sectors of industries which have already reached a level of saturation, since further investment in such sectors will not be in the national interest. Government may use the following instruments of control to effect the desired pattern of resource allocation.

- Fiscal policy (to overcome recession and control inflation in economy)
- Monetary policy (to stabilize the economy by changing the supply of money and rate of interest)
- Industrial licensing
- Control over capital issues
- Export promotion and import controls
- Control over foreign exchange and foreign collaboration
- Control over monopolies and restrictive trade practices
- Control over pricing and distribution of commodities

## 3.2 PROJECT IDENTIFICATION

### 3.2.1 Tapping of Project Ideas

To tap creativity of people and harness their entrepreneurial urges a conducive climate has to be fostered. It is conscious, deliberate and systematic effort by an organization to identify opportunities that can be profitably exploited. One has to think in the lines of rearrangement, modifications, reversal, magnification, reduction, substitution, adaptations and combinations. The stimulation of the project ideas is possible by a continuous monitoring of the market to find the unmet needs. By using the SWOT (*Strengths, Weaknesses, Opportunities and Threats*) analysis, clear articulation of objectives, prioritization and channellizing the efforts in right direction can be formulated.

Following points are useful for the stimulation of the project ideas

- Analyze performance of existing industries.
- Examine inputs and outputs of various industries (raw material, labour and other resources).
- Review imports and exports statistics
- Study plan outlays and government guidelines
- Data from various sources like financial institutions and development agencies (primary and secondary information)
- Study technological developments.
- Draw clues from consumption abroad
- Attend trade seminars (national and international)
- Analyses financial, economic and social trends.
- Identify unfulfilled psychological needs
- Explore possibility of reviving sick units

### 3.2.2 Identify Potential Problems

Another way for generating ideas may be to identify potential problems. When problems are anticipated early, they cease to be problems, as possibility of solving them exists. The following categories can be considered when trying to identify potential problems on projects.

- New technology: Unproven processes
- Prototype equipment: Scaled up equipment with an area of risk demanding reliability
- Site conditions: Unusual climates as well as challenges presented by outer space and bottom of the oceans
- Limited resources: Shortage of skilled technicians, limitation of space, restriction on spending

- Delays in obtaining permits
- Process control systems: complications in design, procurement and installation
- Difficult access: No conventional means of transport to site
- Labour: areas with history of labor turmoil
- Economic conditions: uncertain markets

Each project will have certain problems, which are obvious, and others, which may not be so apparent or may be hidden. The selection of the right project for future investment is crucial for long survival of the company as well as country. The selection of wrong project may precipitate failure to execute in spite of support from good management.

## 3.3 PROJECT SCREENING AND SELECTION CRITERIA

### 3.3.1 Preliminary Screening

Not all project ideas need to be analyzed in detail at a point of time for a particular region or for an organization. For instance in border areas of our country the priority is for security against external aggression, development of economy is the second priority. Preliminary screening is required to eliminate ideas which are not prima facie promising.

The following aspects are considered for screening:

- Image with the promoter (compatibility, offer prospects)
- Consistency with governmental priorities (national priorities, environmental effects, foreign exchange requirements, licensing difficulty)
- Availability of inputs (capital requirements, power supply, technical know-how, raw-materials)
- Adequacy of market (domestics market, market shares, exports, sales and distribution, economical, social and demographic trends, patent protection)
- Reasonableness of cost (material, labor/service, administrative, sales, distribution and factory overheads)
- Acceptability of risk (technological changes, competition from imports, vulnerability, substitutes, government control over price and distribution)

### 3.3.2 Selection Criteria

The main factors to be considered for project selection are listed below:

- Viability of project
- ROI (Returns on Investments), maximization of returns.
- Maintaining minimum market share, increase or consolidate the existing market share.
- Enabling the company or economy to enter new markets or areas of operation.
- Maximum utilization of the workforce available.
- Maximum or optimum utilization of technical resources (plant and machinery)
- Help the company or economy to improve its position.
- Risk and uncertainty are under the acceptable limits.
- Scope of the operations of the project is within the capabilities of a company or country.

Some of the appraisal criteria to judge the worthwhileness of the project are given in the table below. They can be divided into two broad areas i.e. discounting criteria and non-discounting criteria. The key discounting criteria are net present value, internal rate of return,

and the benefit cost ratio. The key non-discounting criteria are payback period and accounting rate of return.

**Table 3.1** Project appraisal criteria

| *Sl. no.* | *Criterion* | *Accept* | *Reject* |
|---|---|---|---|
| 1 | Payback period (PBP) | PBP< Target Period | PBP<Target Period |
| 2 | Accounting Rate of Return (ARR) | ARR>Target Period | ARR<Target Period |
| 3 | Net Present Value (NPV) | NPV>0 | NPV<0 |
| 4 | Internal Rate of Return (IRR) | IRR>cost of capital | IRR<cost of capital |
| 5 | Benefit Cost Ratio (BCR) | BCR>1 | BCR<1 |

## 3.4 INVESTMENT ALTERNATIVES EVALUATION

Following methods are used to evaluate alternatives:

### 3.4.1 Payback Put off or Recoupment Period

Pay back period is the time required to recover the original investment through income from the project. Assuming that the annual income the project before depreciation but after taxes is uniform,

$$\text{Playback Period} = \frac{\text{Investment} - \text{Salvage}}{\text{Operating advantage per year}}$$

$$P = \frac{C}{R}$$

Where P = Playback period in years
C = Original capital investment
R = Annual return expected

The cash flows taken for consideration are based on post tax interest exclusion principle. When the cash flow varies – then PBP is the time taken to recoup the investment. Initially a target period for PBP is kept on the basis of coat of capital , initial investment, liquidity situation and risk factor is fixed. If the PBP is lesser than the target period the project / investment is accepted.

#### *Advantages*

It is simple and popular technique. It gives very good importance to the consideration of the risk element. It is an indicator of the liquidity aspects of the project. It is based on cash flows. For projects financed with high borrowed money or for firms having problems of cash where fund is of greatest concern, this method finds wide use. This method is used for projects with risks and uncertainty. For projects where technological obsolescence is very less.

#### *Disadvantages*

It ignores true value of money. The method in no way indicates the profitability of investment. It dose not consider the whole life of the project. It concentrates on the recovery of initial investment. Payback period is no guarantee of the success of a project.

e.g., project A, B, C data are given follows:

**Table 3.2** Project details

| | *A* | *B* | *C* |
|---|---|---|---|
| Project cost | 150 | 150 | 150 lakhs |
| Operating life | 10 | 15 | 20 years |
| Annual income | First | First | First 15 |
| Payback period | 10 | 10 | 10 |

Project C is better because return is better.

### 3.4.2 Net Present Value

NPV of a project is equal to the sum of the present value of all associated cash flows.

$$\text{NPV} = \sum_{t=0}^{n} \frac{Ct}{(1+i)^t} - I$$

Where $Ct$ = cash flow occurring at the end of year t
$n$ = number of years of project life
$t$ = 0,1,2…….n
$(i)$ = cost of capital for the project = Interest
NPV > 0 Accept the project
$I$ = Initial outlay

It considers the time value of money and also the project entire life of assessment. NPV generally steadily decreases as the value of I increases. It is a simple and popular method Where (1+ I) is known as discount factor. The cash flow when t = 0 is the initial capital investment. This is as considered as outflow and is treated as negative cash flow. All incomes are positive cash-flows and known as cash in flow. This method is more – suitable for ranking projects. The higher than NPV , better is the project.

### 3.4.3 Average Rate of Return

$$\text{Average rate of return} = \frac{\text{Average annual profit after taxes}}{\text{Total outlay of the capital (investment)}}$$

It fails to take account of timing of cash flows and out flows. Time value of money is ignored. ROT must be higher than bank borrowing rate. This method is better than pay back period because it emphasizes profitability. It takes in account the whole project life. This method is quite useful for projects with short operating life.

### 3.4.4 Internal Rate of Return

IRR is that value of discount rate I when NPV = 0. Initially a target rate for IRR on the basis of the cost of capital, expected profit and risk premium is fixed. If the IRR > target rate project is accepted. It considers the time value of money. It considers entire life of the project. It helps in assessment of the risk of the project. Computation of IRR is tedious.

Terminal Value approach*:* TV of the reinvested inflows at the end of the project is computed. TV is discounted to equivalent value.

### 3.4.5 Benefit to Outflow Ratio

BOR = Benefit – outflow ratio
BOR > 1, Accept the project

$$\text{NBOR} = \frac{\text{NPV}}{\text{Initial cash flow}}$$

Net Benefit to outflow ratio
NBOR>0, Accept the project.

### 3.4.6 Accounting Rate of Return

$$\text{ARR} = \frac{\text{Average annual profits after taxes}}{\text{Average investment over the projet life}}$$

Initially a target rate for ARR on the basis of cost of capital, expected profit, the general business environment and risk premium is fixed. If ARR is greater than target rate, project is accepted. ARR is simple to use. It considers the entire life of project in its assessment. It does not consider the time value of money.

### 3.4.7 Dept Service Coverage Ratio

DSCR = profit after tax + Depreciation + Other non-cash charges + Interest / Interest + Annual loan repayment amount

DSCR = 1.5 to 2 is desirable.

### 3.4.8 Social Profitability (SP)

The method described so far have examined the financial yield from the projects. While the financial yield is importance for most industrial projects, there are other socio-economic considerations such as foreign exchange savings, development of backward areas, defense requirement, self reliance, etc. Which may carry more weightage with certain projects. These considerations are labeled as social profitability analysis. Social profitability analysis is mostly used for evaluating public sector projects where the principal objective may not be to maximize financial yield from the capital investment. It may also be relevant for private projects since the fund providing institutions would like to see that the national considerations are taken care of in private investments proposals. A particular project may involve a certain amount of foreign exchange for its construction as well as production. The net benefit through sale of produce, which otherwise would have been imported, may far out weigh the total foreign exchange consumed. Besides, implementation of the project may result in self-sufficiency in certain crucial areas. These benefits may be more important to the society than mere financial returns.

### 3.4.9 Break Even Analysis

BEA can be used to select project. Break even time of a project by which the project becomes economically viable. A project in which case BEP comes early is selected.

### 3.4.10 Profitability Index

$$\text{PI} = \frac{\text{Discounted cash inflows}}{\text{Discounted cash outflows}}$$

## 3.5 ESTABLISHING THE PROJECT SCOPE

A good project can be said to have four critical elements, which are the right project, at right time, at the right place, at the right price. Capital expenditure often involves substantial and irreversible financial commitments hence the management has a prime responsibility to be fully convinced about its feasibility. There are five phases in capital budgeting, which are planning, analysis, selection, implementation and review. The feasibility study is concerned with first three phases of capital budgeting viz planning, analysis and selection (evaluation).

Normally the project preparation consists of four stages as listed below:

- Pre-feasibility study
- Functional/support studies
- Feasibility study
- Detailed project analysis which leads to preparation of detailed project report

### *Pre-feasibility study*

The chief objectives of a pre-feasibility study are to determine

- Promising investment opportunities
- Justification for a detailed feasibility study
- Aspects critical to project necessitatin g in-depth investigation through functional/ support study such as laboratory trials, pilot plant tests, etc

The pre-feasibility study should examine:

- Finding of each facet of project
- Project background and history with respect to sponsors
- Major determinants and indicators
- Market potential and forecast, competitors and their market share
- Materials cost and availability
- Location and site
- Investment requirements
- Manpower requirements

It provides rough estimates of cost, means of finance, cost of production, sales revenue, financial profitability, and social benefits. Based on pre-feasibility study it is determined if further feasibility study is required.

### *Support studies (functional studies)*

The contents of the support studies differ based on the type, scope and purpose of project conceived. Support studies look at the specialized area of operations and are also labeled as functional study. They support investment pre-requisites of pre-feasibility and feasibility study. Support study are generally conducted in following areas:

- Market size and plant capacity
- Material input/ resource
- Location and site study
- Technology and rquipment study
- Laboratory and pilot plant test

### *Feasibility study*

After preliminary examination surveying project ideas are examined in more detail. Identifying the investment opportunities can be an intricate exercise because of variety of constraints,

complexities, interlinkages, risks and uncertainties. Feasibility report is prepared during definition phase of the project. The first step in feasibility study is generation of ideas, which in turn depends on creativity, innovative nature or ingenuity. The project is systematically examined in depth at this stage for various aspects like *market, technical, financial, economical, commercial, social, managerial, organizational and ecological analysis*. Based on the feasibility report decision is taken whether project should be *taken up, postponed or abandoned*.

Feasibility study gone wrong can become a continuous source of problem for project in the form of delays in completion and cost over-runs. There may be problem in scale and operating revenues, break-even volumes, profits before tax, availability of raw materials, quality of manpower, technology transfer etc.

On basis of this feasibility report, *the financial institutions consider the investment decision*. It is the first step to records project establishment, which involves:

1. Defining the technical configuration of the project.
2. Performance requirements for various technical system to be specified
3. Cost estimate for the project to be frozen.
4. Techno-commercial viability of project examined, apprised and approved.
5. Overall schedule for implementation drawn up.
6. Financial arrangement for implementation
7. Appointment of project manager for implementation
8. Pre-project activities to be completed and zero-date fixed.

The flow diagram given below gives systematic procedure to conduct the feasibility study.

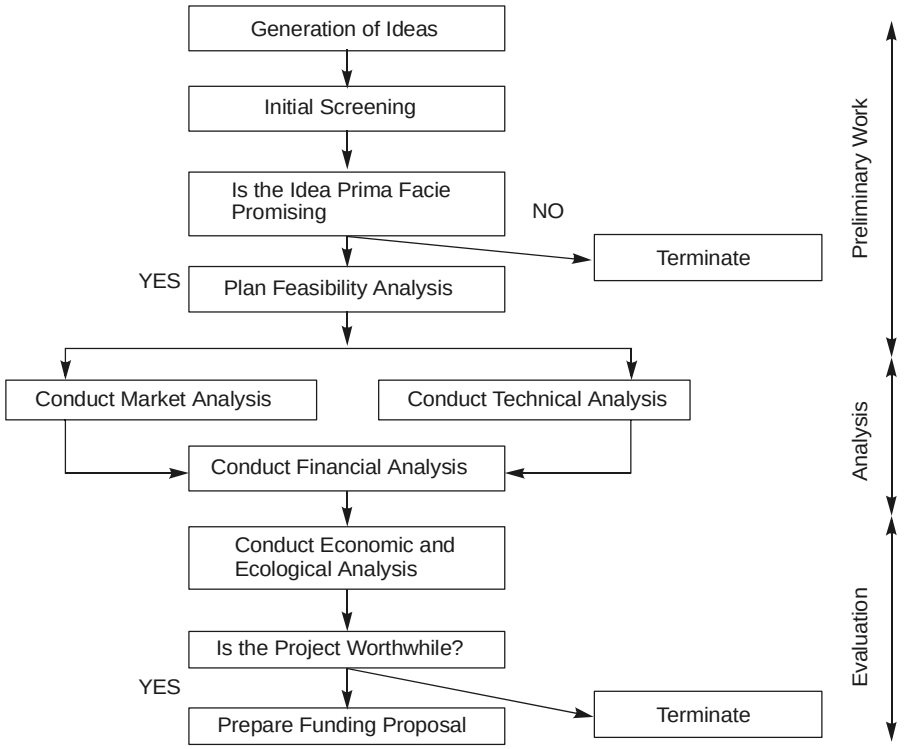



**Fig. 3.1** Feasibility study

All activities listed above before financial arrangement, come under the scope of feasibility study. Project manger may be required to update and validate feasibility report and work as per stipulation in report. Ideally nothing except project cost estimate (updated because of zero date shift) must be altered in the report. But changes in report become essential if there is a dramatic change in project environment.

The guidelines advocated by UNIDO to be kept in mind while conducting feasibility study are:

- Scope of the project
- Verification of alternatives and assumptions
- Procurement of the data for study
- Proposed cost structure
- Scheduling the operations
- Arranging for local and foreign exchange
- Inflation rate
- Contingencies and inflation
- Accuracies of cost estimates
- Regulation and laws governing industry
- The project team
- Cost studies
- Changes in foreign exchange rate
- Expansion projects
- Capacity (production)
- Agencies involved in conducting such study
- Capacity (production)

## 3.6 PROJECT FEASIBILITY REPORT

The feasibility study is conducted quite exhaustively by exploring many factors related to the project. Which will usually culminate in a formal written report (Project feasibility report)? The UNIDO has published the 'MANUAL FOR THE PREPARATION OF INDUSTRIAL FESABILITY STUDIES' to help the standardization of Industrial feasibility studies.

The framework provided has following major components:

- Need of project (project background and history)
- Executive summary
- Major inputs of project (5'M's Men, Material, Money, Machines, Methods and Facilities, Information)
- Demand and market study

  Demand projections, source of secondary and primary information, market analysis, forecasting techniques, sales forecasting and marketing
- Technical study

  Product pattern, process selection, raw materials requirement and availability, plant size and scale of operation, technical skills, operation study
- Location study and man power (skilled/ unskilled) requirements
- Financial study outlay and cost of project

  Capital investment, source of finance, break-even point, cash flow for project

- Economic study
  Profitability, cash flow analysis, benefits and costs in shadow prices
- Ecological study
  Environmental damage, restoration measures to be taken
- Cost benefit analysis
  Commercial aspects taking larger interest of overall social growth (SCBA-*Social Cost Benefit Analysis*), use of public sector and government role
- Project implementation

### 3.6.1 Detailed Project Report (DPR)

Preparation of a DPR is the preliminary phase of a project life cycle. The contents of a feasibility report are covered in a detailed, exhaustive manner. The contents of DPR cover:

- Deviations from feasibility report
- General details about the industrial concerns of promoters along with background experience
- Details of the proposed project
  - Plant capacity
  - Manufacturing process
  - Technical know how
  - Management team for project
  - Details of land, building, plant and machinery
  - Raw material requirements
  - Infrastructure facilities like power, water, transport facilities.
  - Effluents treatment arrangements
  - Labour requirements
- Project cost
- Means of finance
- Schedule for implementation
- Profitability and cash flow estimates
- Government approvals

The important parameters of project report are discussed as follows:

## 3.7 MARKET AND DEMAND STUDY

Market may be distinguished on the basis of:

- Area covered (local, national, international)
- Presence of competition (monopoly, duopoly, oligopoly, Pure competition)
- Quantity involved (retail, wholesale)
- Period of transaction (ready, future)
- Demographic variable (age, sex, income, occupation, education, nationality, etc)

Markets consist of all potential customers who might be willing and able to engage in the transaction for satisfying their need or want. A commodity or service has to be bought and sold which is only possible if there are buyers and sellers who are willing to exchange.

The block diagram given below indicates the steps for market and demand analysis

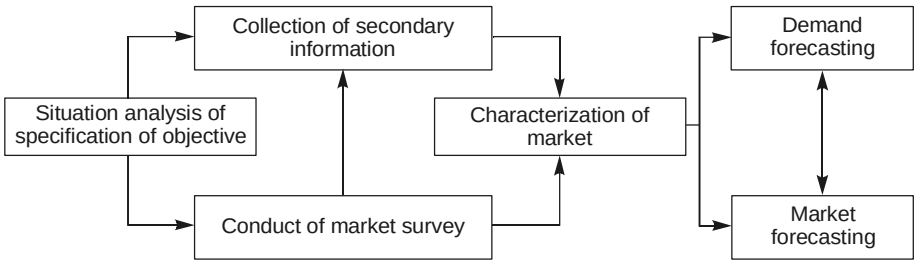



**Fig. 3.2** Market analysis

Market and demand study requires the information to be gathered from different sources (primary and secondary) to know the effective demand in the past and present, breakdown of demand, price, methods of distribution, sales promotion, consumers, supply, competition and government policy. The objectives must be clearly established for market and demand study.

This may be possible if we consider the following aspects:

- Potential and prospective buyers
- Current and projected demand
- Demand distribution with respect to sales and geography
- Break-up of demand
- Estimated price and warranty
- Channels of distribution
- Prospects for immediate sales

**Raw material:** It is required to establish the availability of raw material through companies supplying or producing them to avoid unnecessary delay.

**Technical study:** The entire spectrum of products which include co-products and by-products known as product pattern has to be determined using the available technology keeping in mind scale of operation, resources and economy. Process selection is possible by evaluation of various factors including size of investment, availability of know-how, raw material requirements, type of process, utility required, indigenous and foreign components required, disposal of by-products and effluents, etc.

**Location study:** Proper selection of site and its possession before zero date is necessary to meet targets relating to time and cost. Normally the financial institutions before sanction of loan inspect site through team of experts. Consideration for selection of project site may include the following: cost of land, availability of land, labour factors, approach to site and market, raw material, transportation, availability of power, incentives, drainage and effluent disposal. The targets may be missed and even viability of project may be lost if plant site has to be relocated at later date.

**Manpower:** Inspite of problem of large unemployment the industry is still on lookout for skilled manpower. The companies resort to training and upgradation in absence of its skill sets availability.

**Power:** Regular feature of irregular power supply will not only cause heavy losses but may damage plant machinery and equipment. If uninterrupted power supply is not available company may have to resort to standby generating systems.

**Effluent disposal:** There may be solid, liquid, gas or a combination of any of these type of effluents. The problem with site selection deals with existence of sold and liquid effluents with the limitation of dumping space. The effluents have to be discharged in a harmless manner without polluting the environment else discharge may not be permitted.

## 3.8 PRIMARY AND SECONDARY INFORMATION

Both secondary and/or primary source of information can be used as aid for the objectives of market study.

- The primary information represents information that is collected for first time to meet the specific purpose on hand.
- The secondary information indicates what is known and provides ways to proceed with primary information using further analysis. Secondary information is information already available but in some other context. It provides base and starting point for market and demand analysis.

### 3.8.1 General Sources of Secondary Information

The important sources are mentioned below:

- **Plan Documents:** Issued by planning commission these documents provide wealth of information on plan proposals, physical and financial targets, actual outlays, accomplishments, etc.
- **Census of India:** Publication of Govt of India provides information on population, household size and composition.
- **Guidelines to Industry:** This is an annual publication of ministry of Industrial Development, Ministry of Industry relating to present capacity, imports and exports, indigenous capability.
- **Economic Survey:** Publication of the ministry of finance, it provides the data on industrial production, prices, exports, agricultural production, national income etc.
- **National Sample Reports**: By using national representative sample these reports present information on economic and social aspect like pattern of consumption, distribution of industries and characteristics of economically active population.
- **Annual Reports from Ministry of Commerce and Industry:** Publication gives detailed review of industries, also provides information about new items manufactured and the list of protected industries.
- **Statistical Abstract of Indian Union:** An annual publication of Central Statistical Organization; it provides demographic information, estimates of national income, agricultural and industrial statistics.
- **India Year Book:** An annual publication of the Ministry of Information and Broadcasting, it provides a wide range of information on economic and other aspects.
- **Statistical Year Book:** Publication of United Nations provides world statistics relating to various aspects like population, demography, gross domestic publication, industrial production, international trade etc.
- **Import and Export and Statistics:** An annual publication of the ministry of commerce; it provides data on imports and exports for a very large number of items.
- **The Stock Exchange Directory:** Published by the Bombay Stock Exchange provides a picture of performance and financial statements for all listed companies.

- **Monthly Studies of Production of Industries:** Publication of the Central Statistical Organization (CSO) it provides data on production, number of units installed, capacity, statewise break-up, etc for several selected industries.
- **Reserve Bank of India Bulletin**: This provides information on production indices, prices, balance of payment position, exchange rates etc.

While secondary information is available economically and readily, its reliability, accuracy and relevance for purpose under consideration must be carefully examined. The factors to be considered include objective, source of information, timing of collection and publication, target population, choosing sample, editing, tabulation and analysis. Based on the information gathered from secondary sources, and through the market survey, the market for the product /service may be described in terms of effective demand, breakdown of demand, price, methods of distribution, sales promotion, consumers, supply, competition and government policy.

### 3.8.2 Primary Information

Primary information provides first hand specific information regarding the project being studied and appraised. It is required, as secondary information do not provide a comprehensive basis for market and demand analysis. Primary problems exit for market researcher in India due to heterogeneity of country, multiplicity of language and design of questionnaire. This information can be collected by market survey.

The market survey may either be an

- ☞ **Census survey:** (covering the entire population considered).

**OR**

- ☞ **Sample survey:** (sample of population is contacted/observed and relevant information gathered).

The market survey considers the factors like demand and rate of growth, segmentation of market, choice of products, price and income elasticity of demand, characteristics of buyers, motives for buying and fulfilling needs.

Sample survey involves following steps: defining the target population, selecting the sample size, developing questionnaire, recruiting and training investigators, obtaining information from sample of respondents (telephonically, mail, personal interview), scrutiny of the information, analysis and interpretation. Mistakes in survey may relate to imprecise questions, failure to understand questions, incorrect interpretation, deliberate distorted answers.

## 3.9 SOCIAL COST BENEFIT ANALYSIS (SCBA)

The main objective of an individual, a firm or a company in investing on a project is to earn the maximum possible returns for an investment or commercial profitability of a project. There are some projects, which may not be as attractive with respect to returns or profitability, but still they are undertaken for social cause. Such public projects like road, railway, bridge, transport, power project, irrigation projects etc have social implication but may not have commercial benefit.

SCBA considers the total impact that a project will have on an economy also taking into account the hidden factors. SCBA is a methodology for evaluating projects within the planning framework from social point of view. In SCBA the focus is on social costs and benefits of a project. These often tend to differ from the costs incurred in monetary terms and benefits earned in monetary terms by the project.

The principal reasons for discrepancy are, which may arise during the analysis include the following:

1. Market imperfections
2. Externalities
3. Taxes
4. Concern for saving
5. Concern for redistribution
6. Merit and demerit goods.

The main objectives of SCBA are as follows:

- Contribution of the project to the GDP (gross domestic product) of the economy.
- Contribution of the project to improve the benefits to the poorer section of the society and to reduce regional imbalance in growth and development.
- Contribution of the project in protecting/ improving the environment conditions.
- Justification of the use of scare resources of the economy by the project.

### 3.9.1 Approaches to SCBA

The suitability of an approach to a project depends on factors such as present level of development of the country, the extent and nature of future development that the country strives to achieve, etc. The market price of both inputs and outputs of a project are to be corrected suitably if they do not represent the real prices of inputs/outputs. Such corrected price of inputs/outputs is known as **shadow prices**. The shadow prices take care of the distortions in the market price by suitable adjustments in the market price.

There are two main approaches to social cost benefit analysis viz:

- **UNIDO Approach**
- **Little–Mirrless Approach**

Both approach use shadow price and discounted cash flow technique and are based on the principal of equity. UNIDO approach measures shadow prices in terms of domestic price while L-M approach measures shadow price in terms of international price. UNIDO approach measure costs and benefits in terms of consumption while the L-M approach measures cost and benefit in terms of uncommitted social income.

Though UNIDO approach is more popular,but none of the approaches can be said to have universal applications. Even modifications to the approaches may be sometimes necessary to be in tune with ground realities. UNIDO published a manual in 1972 under the title 'Guidelines for project evaluation' but it brought another manual titled 'Guide to practical project appraisal' to simplify the cost- benefit analysis of projects for practical application.

The UNIDO approach places emphasis on 'aggregate consumption', as it is one of the important parameters for measurement of the standard of living of people. Consumption level is measured by measuring *consumer surplus* and *consumer's willingness to pay* as calculation of aggregate consumption may be difficult for heterogeneous bundle of goods.

The UNIDO approach to social cost benefit analysis consists of following stages.

- Arriving at the financial profitability of the project based on market prices.
- Using shadow (economic/ efficiency) prices for the resources to arrive at the net benefit of the project.
- Adjustment of the net benefit for the project impact on saving and investment.

- Adjustment of the net benefit for the projects impact on income distribution.
- Adjustment for the impact of project on merit goods and demerit goods whose social valves differ from their economic valves.

Every stage of the approach measures the desirability of the project from a different angle. The financial analysis when done at market prices serves its purpose for private sector projects. For the public sector project the objective is the maximization of social welfare. Even for public sector projects financial appraisal is carried out on some lines as private sector, the difference is that the result are adjusted to reflect the social welfare implications.

## 3.10 PROJECT COST ESTIMATES

Cost estimate of a project is made by morphological breakdown of the project, estimating each component and then summing up the component estimates to arrive at over all cost estimate. To be able to assess correctly the fund requirement and plan for the same, the first step would be to identify what are the various capital, working and operating costs that are to be financed for a project. Though the entire fund is not required on the Zero date yet suitable arrangements have to be made in advance so that funds do not pose a constraint for meeting the project targets once the project starts. Decisions will have to be taken about the financial structure of the project identifying the portion of debt and equity of the total investment. Only then the various financial institutions can be approached for funding. Projects are coded at work breakdown level as shown to facilitate easy costing, handling of activities and grouping of costs.

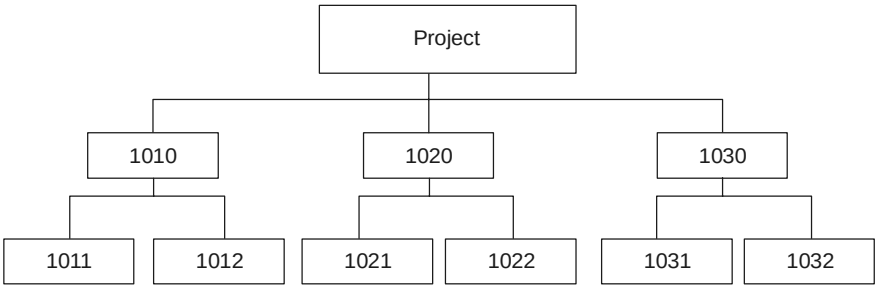



**Fig. 3.3** Work breakdown structure showing coding

Cost estimates for the project are used to assign fund requirement and ascertaining the economic viability of the project. Inaccurate cost estimate will cause the fund plan to be either *underestimated or overestimated*. Underestimated projects cause shortage of funds, which will in turn lead to suspension of project or considerable delay. Delay in turn will further increase the overall cost of project spending making it economically less viable or even sick. Overestimated project may fail to receive approval green signal due to low profitability. It may also dampen the prospects of other needy projects, which are unnecessarily deprived of funds. *So the accurate cost estimate not only gets the project cleared but also ensures its profitability*.

The various costs involved in a project can be grouped under the following sub-heads.

- Land and site development

  Cost of land, conveyance, leasehold, leveling, development, approach roads
- Building and civil works

  Main factory/plant, administrative building, laboratory, auxiliary services, go-downs, warehouses, severs, drainage

- Plant and machinery
  Cost of indigenous plants, imported machinery, cost of foundation/installation, cost of stores
- Technical know-how and consultancy fees
  Consultancy fees, training expenses, etc.
- Transport and erection charges
- Preliminary and pre-operative expenses
- Miscellaneous assets
  Items not part of direct manufacturing like furniture, tools, vehicles, boilers, transformers, firefighting equipment, etc.
- Provision for contingencies
  Unexpected rise in costs, taxes and excise duty, etc.
- Margin money for working capital
  Some portion of loan amount is blocked initially which is released at crises or at project completion

For calculating the pre-investment costs, it is sought to relate the costs of studies to the estimated number of man-months required. Cost per man-month are to be calculated in each individual case in respect of core-salaries, traveling, dearness, mapping, writing, and printing allowances and other office overheads. Investment costs of pre-investment studies are approximately as follows: An opportunity study ranges from 1 to 0.2 percent of the total cost, pre-feasibility study ranges from 1.5 to 0.25 percent, feasibility study ranges from 2 to 0.3 percent (depending on the size of the project)

### 3.10.1 Accuracy of Costs with Types of Estimates

**1. Order of Magnitude Estimate:**

Essentially there are five main types of estimates, which are as follows:

- *Investment per unit of output*

$$I_p = (I_e / C_e).\ C_p$$

Where $I_p$ = Investment required for proposed project
$I_e$ = Investment made for existing project
$C_e$ = Installed capacity for existing project
$C_p$ = Installed capacity for proposed project

- *Turn over ratio and capital ratio*
  Turn over ratio is the ratio between annual sales and investment in rupee,
  Capital ratio is the ratio between plant investment and annual sales

$$I_p = (I_e / T_e).\ T_p$$

Where $I_p$ = Investment required for proposed project
$I_e$ = Investment made for existing project
$T_e$ = Turnover for existing project
$T_p$ = Turnover for proposed project

- *Six tenth factors*
  Investment is assumyed to vary as a power of 0.6 of the ratio installed proposed to that of existing project

$$I_p = (C_p / C_e)^6 . I_e$$

Where $I_p$ = Investment required for proposed project
$I_e$ = Investment made for existing project
$C_e$ = Installed capacity for existing project
$C_p$ = Installed capacity for proposed project

- *Inflation index*

$I_P = I_e$. (Consumer price index at present)/(Consumer price index at investment time)

- *Location index*

**2. Study Estimate:** The accuracy of estimate at this stage is +/-30 %. Since a project is approved with this estimate project authorities count cost overrun on this estimate. As per guidelines a public sector project would require fresh approval if the cost overrun exceeds 20 %.

**3. Preliminary Estimate:** This estimate has an accuracy of +/- 20 %, and cost overrun of about 20%

**4. Definition Estimate:** This estimate has an accuracy of +/- 10 %, cost overrun of about 10%

**5. Detailed Estimate:** This estimate has an accuracy of +/- 5 %, cost overrun of about 5%.

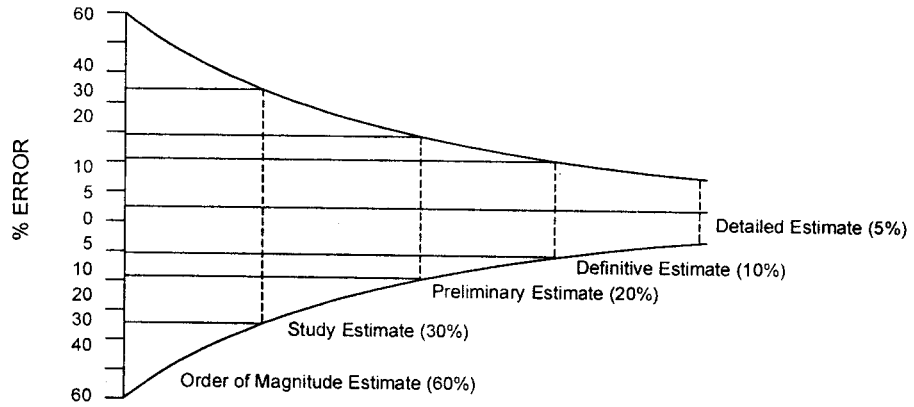



**Fig. 3.4 Cost estimates**

The estimates of investment and costs of production would go on changing as different studies are in progress. The ideal variation on these estimates can in all the cases be as follows: opportunity studies may vary +/- 30 %, pre-feasibility studies may vary +/- 20 %, feasibility studies may vary +/- 10 %. Therefore when preparing feasibility studies it would be incorrect to consider the costs by adding 30% variation rather than 10%

## 3.10.2 Comparison of Cost Estimation and Costing (Cost Accounting)

- Cost estimate done at start of project based on assumptions and previous experience. Costing is required at completion of project and it is based on facts.
- Cost estimating is process of determination anticipated or probable cost of a product before its manufacture is undertaken. Costing is the process of calculating actual cost of the product after it has been manufactured.

- Cost estimation tells whether it is profitable to start a project, thus aids managerial decision. Costing tells the profitability of a product after its manufacture.
- Cost estimation requires technical skills where as costing in the job of accounts.

## 3.11 COST-BENEFIT ANALYSIS (CBA)

CBA provides the information to make a sound and balanced business decision about the cost and benefits, or value, of various economic choices (for an investment). It is a methodology for management to use when decisions need to be made among competing alternatives. It enables the agency to quantify the activities of the existing and alternative processes on monetary and non-monetary basis. When the agency conducts a CBA, it is defining its objectives and alternatives in terms of costs and benefits. It is also defining important assumptions, factors, and judgments to build the cost and benefits used in comparing alternatives. The final product is a consistent document that enables the agency to understand what things cost and what benefits are associated with various alternatives.

It is important to identify and estimate costs and benefits using a common comprehensive structure (WBS) so that alternatives can be consistently compared and reflect accurate results/ conclusions. Solid advance planning and definition are essential in completing a timely and useful CBA in a exhaustive manner. Also many of activities will go through several iterations as various aspects of project are better defined. It can also be used as the basis to justify decisions, as a baseline to measure progress against stated goals, and as a guide to understanding the impact of proposed changes.

The underlying foundation for analyzing the costs and benefits of proposed solutions includes the following sequence:

1. Define the project, objectives, alternatives, assumptions, ground rules, and the elements to be cost.
2. Research the cost elements, analyze them, collect the appropriate data, decide on an estimating methodology, and then cost them all
3. Identify the principal functional and technical cost drivers and their sensitivity to changes in assumptions
4. Analyze risk items and perform sensitivity analysis, including collecting total lifecycle costs and benefits
5. Analyze the relative merit of alternatives
6. Present the results

Keep the approach flexible and tailorable so that the effort and results are consistent with the size and complexity of the alternatives being evaluated, the lifecycle phase, and the level and type of review being supported.

It is always helpful to know, in general, how the final product and its content should look. This knowledge will help the agency organize work as it progresses. The amount of detail and information included in a CBA depends on the size and complexity of the individual project. For very small projects, a short white paper or a few slides will suffice to cover the relevant information. Time and money spent on the analysis should be worth it. It should be a tool to help organize information so that economical decisions can be made.

### 3.11.1 CBA Might Include the Following

- Detailed cost estimates for individual alternatives, including the basis for estimating each work breakdown structure element

- A WBS outline and a dictionary that defines what is in each cost element
- Detailed schedules that can later be used to manage the project
- Specific references and guidance documents supporting the project
- Data sources and references to support the estimating methodology
- A glossary that defines abbreviations and terms used in the analysis

The document should accurately support agency recommendations irrespective of its structure.

### 3.11.2 Cost-Benefit Analysis Steps

The general steps for performing a CBA are listed below. Using this approach as a framework for developing a CBA will help the agency evaluate its status quo / alternative (as-is/to-be) processes, define the objectives more thoroughly, and address the alternatives consistently. Although the general outline should always be followed, the amount of detail used during each step will vary depending on the size and complexity of the individual project.

**1. Define the Project**. This step is the most critical. It forms the foundation for the rest of the effort. It includes identifying the problem to be solved, the objectives of the mission or function, and the alternatives that will satisfy the customer's needs while staying within environmental factors such as assumptions and constraints. It also includes defining the work breakdown structure deliverables to be costed and the assumptions and ground rules for the status quo and alternatives models. The WBS becomes the outline for the rest of the work to be done. The WBS will be updated on a regular basis as the analysis progresses.

**2. Research the Cost Elements**. This step includes researching the cost elements that make up the WBS, collecting appropriate cost-driver data, analyzing and validating the data, deciding on an estimating methodology, and then costing all the elements. The need is to develop future profiles of the current system and the projected profiles of alternative proposed systems.

The process of identifying, development, acquisition, operating costs and benefits is necessary even if the formulas and cost elements are not well defined using techniques such as parametric method, analogy method, bottoms-up engineering method, etc. The total cost of product taking into account its size, complexity and extent of work covers all differentiating costs for all elements used for research, design, develop, integrate, test, acquire, deploy, manage, operate and dispose of modified process or systems.

Techniques for estimating costs include the following:

- **Parametric method**: Collect all relevant historical data and derive cost estimating relationships that relate costs as dependant variable to one or more independent variables that reflects physical or performance characteristics of the system or process. The statistics, assumptions along with the database are used as supporting data on for each WBS element's cost estimate.
- **Analogy method**: This method uses the comparisons with the completed projects or catalog prices whose costs or benefits are known.
- **Bottoms-up engineering method**: This involves decomposing the project into discrete activities and elements such as labour material, etc and quantifying them
- **Actual cost method:** This method uses experience from prototypes, engineering, and testing to analyze cost and schedule variances and project completion estimates.

**3. Identify Cost Drivers**. Once the basic estimating is done, there is a need to identify the principal functional, technical, and schedule cost drivers and their potential sensitivity to changes in assumptions or project decisions in preparation for the next step.

**4. Analyze Risk and Sensitivity**. Once the costs are calculated for each lifecycle phase, they are then aggregated to show total lifecycle costs and benefits. Based on this information, the agency will identify the cost-risk items and perform sensitivity analysis to determine whether changes might alter the original recommendations or simply assess what happens if some sensitive cost element exceeds the current estimate. The sensitivity analysis tests the impact of risk and uncertainty to determine which conditions might change the ranking of alternatives. Some of the techniques of the analysis are:

- **Contingency analysis**: This analysis identifies how the alternatives might be affected by changing the criteria of evaluation or ground rules
- **Risk and uncertainty analysis:** Both of these are statistical techniques. Risk analysis is generally defined as the consequences of uncontrollable random events from a known probability distribution. The uncertainty analysis referred to as unknown unknowns has a unknown probability distribution.
- **Sensitivity analysis:** This uses some of the same statistical techniques as risk and uncertainty analysis to analyze how sensitive to change the ranking of alternatives based on major cost drivers
- **Parametric analysis:** This technique uses cost estimating results by using statistical techniques like curve fitting techniques to develop relationships and validate them

**5. Analyze Alternatives**. Next, analyze the relative merit of alternatives against each other, including their sensitivity to specified risks and potential changes. The results should also compare net benefits over time, return on investment (ROI), and show the break-even point for your investment.

Some common procedures involve:

- Present Value (PV) analysis
- Return on Investment
- Break even analysis

**6. Present the Results**. The final step is to put together presentation materials to support your analysis and recommendations. Depending on the size and complexity of the project, this could be as simple as a white paper or briefing, or it could be more formalized.

## 3.12 SOURCE OF FINANCE

There are basically two sources available for financing the fund requirement of a project internal sources and external source. The project is normally financed from external source unless it is very small. Generally no project is offered 100% assistance even if the project is highly profitable since the institutions expect a minimum stake for the promoter to ensure his involvement. The capital cost of the project will require to be financed basically through equity/owner and long-term debts. The break up (financial structure) between equity and long debts has to be decided before approaching a financial institution. Generally for working capital, short-term finance in the form of trade credit or loan from bank is preferred. For capital cost both intermediate and long-term finance are used in form of term loans, hire purchase, lease, fixed deposits, stocks (common and preferred) and debts.

To meet the cost of project the following means of finance are available.

- Shares (Ordinary/preference).
- Debenture
- Bonds
- Term loans.
- Deferred credit.

- Incentive sources.
- Unsecured loans
- Public deposits
- Leasing and hire purchase finance

**Shares**: There are two types of shares viz. equity/ordinary shares and preference shares. ***Equity*** shares represent contribution made by the owners of business the equity shareholders, who enjoy the rewards and bear the risk of ownership. Equity shares being risk capital carries no fixed rate of dividend. ***Preference*** shares represent the contributions made by preference shareholders and the divided paid on it is generally fixed.

**Debenture capital**: Debentures are instruments for raising long-term debt capital. Interest to debenture is a statuary obligation irrespective of the financial position. These are of two broad types

*Non-convertible debentures:* These are straight debt instruments and typically carry a fixed rate of interest with a maturity period of 5 to 9 years.

*Convertible debenture* as the name implies are debentures, which are convertible, wholly or partially into equity shares at the option of its holders. The conversion period and price are announced in advance.

**Bonds:** It is more or less similar to debenture. There is a tendency in India to use the term bond for public debt securities deposits by the governments and public sector enterprises.

**Terms loans**: Long term loans (5 to 10 years) are provided by financial institutions and commercial banks. Terms loans represent secured borrowing, which are very important source (major source) for financing new project as well as expansion, modernizing and renovation schemes of exiting firms. There are two broad types of term loans available in India, *rupee terms loans* and *foreign currency term loans*. While the former are given for financing land, building, civil works, indigenous plant and machinery and so on, the latter are provided for meeting the foreign currency expenditures towards the import of equipment and technical know how.

**Deferred credit**: The suppliers of plant and machinery may offer a deferred credit facility after getting bank guarantee, under which payment for purchase of plant and machinery can be made over a period of time.

**Incentive source**: The government and its agencies may provide financial support as incentive to certain types of promoters or for setting up industrial units in certain location. These incentives to certain areas may take the form of *seed capital assistance* (provided at a nominal rate of interest to enable the promoter to meet his contribution to the project) or *capital subsidy* (to attract industries to certain location) or tax deferment or exemption (particularly form sales tax) for a certain period.

**Unsecured loans**: These are typically provided by the promoters to bridge the gap between the promoters contribution (as required by the financial institutions) and the equity capital, the promoters can subscribe to.

**Public deposits**: Represent unsecured borrowing from the public at large.

**Leasing and hire purchase finance**: Represent a form of borrowing different from conventional term loans and debenture capital.

## 3.13 FINANCIAL STRUCTURE

It is the deciding of *debt-equity ratio*. A company with a high proportion of debt is said to be *high leveraged*. The general debt-equity norm is of 1.5 to 2. For an entrepreneur debt capital is cheaper compared to equity. This is because interest on debt is tax deductible, where as dividends

on-equity are paid out of net income after taxes. But debt capital has a disadvantage in form of fixed liabilities, which can be prosecutable in legal court if not repaid in time.

This associated risk is absent in equity capital. But the risk is worth taking, since cost of avoiding it is very high. If in order to avoid risk the company increases equity, the tax burden will increase thereby reducing dividend, inducing stockholders to sell their shares. So balance has to be struck between debt and equity. A highly leveraged (high debt) company can make large profit when demand is pitched high, but at time of recession it will also incur high losses. *Financial institutions* calculate the average debt service coverage ratio for the period, which the term loan is repayable. Normally financial institutions regard a debt service coverage ratio of 1.5 to 2 as satisfactory. If the ratio is less than 1.5 and the project is deemed otherwise desirable, a term loan of a longer maturity may be provide. By the same token if this ratio is significantly higher than 2, the maturity period of the loan may be shortened.

## 3.14 FINANCIAL INSTITUTIONS

There are several institutions functioning at national and state levels set up with the intension of financing the projects besides promoting new projects. Most projects are primarily financed through *debts or term loans*. There are several foreign financial institution which also provide funds to finance in developing countries. The national and international financial institutions are listed below:

### 3.14.1 National Financial Institutions

**Industrial Development Bank of India (IDBI)** This is the principal financial institution of India. It coordinates the activities of other financial institution, supplements their resources to plan and promote industries.

**Industrial Finance Corporation of India (IFCI)** It provides long-term loans under various schemes to industrial schemes to concerns both in the public and the private sectors.

**Industrial Credit and Investment Corporation of India (ICICI)** This is financial institution, which is mainly concerned with providing foreign currency loans to industrial concerns in the private sector.

**Industrial Reconstruction Corporation of India (IRCI)** It mainly provides soft loans for revival and revitalization of industrial units, which are closed down or are facing closure.

**State Financial Corporations (SFC)** These institutions provide loans to small and medium industrial units within their respective states. They also grant loans in foreign exchange for import of plant and machinery.

**Export-Import Bank of India (Exim Bank)** The Exim bank provides funds for promotion of exports of engineering and capital goods and related services from India. It provides credit to foreign companies and financial institution for import of Indian capital goods and services.

**Unit Trust of India (UTI)** This institution mobilizes the savings of the general public and invests them in various industrial units.

**Life Insurance Corporation (LIC)** It has now acquired the status of a development financial institution. It provides long-term finances to industrial units.

**The State Industrial Development Corporation (SIDC)** The functions of SIDCs are

- Industrial promotion activities such as project identification, preparation of feasibility reports, identifying entrepreneurs and assisting them in project implementation.
- Setting-up of industrial projects as sole owners or in the joint sector.
- Creation of infra-structural facilities.
- Providing term loans.

- Acting as agent of State/Central Government in respect of grant of subsidies SIDCs, thus are different from financial institution in the sense that they provide not only financial assistance but render all-round assistance in putting up an industrial unit.

### 3.14.2 Foreign Financial Institutions

1. **World Bank:** It is also the International Bank for Reconstruction and Development**.** World Bank funds to the less developed member countries for building infrastructure. Schools, irrigation dams, power plants, roads, water supply and sewerage, etc. are the specific projects, which have been aided by the World Bank.
2. **International Monetary Fund (IMF)** This is a part of the United Nations. It complements the World Bank's efforts to promote economic growth.
3. **International Finance Corporation (IFC)** It is a subsidiary of the World Bank and provides funds specifically for the private sector.
4. **International Development Association (IDA)** This is also a subsidiary of the World Bank. It provides soft loans to under-developed countries.
5. **United Nations Development Programme (UNDP)** and **United Nations Industrial Development Organization (UNIDO)** These two institutions of the United Nations provide funds to industrial projects throughout the world.
6. **Asian Development Bank (ADB)** This is the development bank for the Asian continent. This institution finances infrastructure projects and also new industrial units
7. **Non-Resident Indians (NRI)** Non-residents of Indian nationality or origin as well as overseas companies, partnership firms, trusts, societies and other corporate bodies owned directly or indirectly to extent of at-least 60% can invest in Indian projects.

The Financial institution, have strict procedures relating to sanction of funds. Negotiation for signing of loan agreement can only take place when the appraisal is affirmative. The main thrust of their appraisal is on cost-estimates; profitability analysis through techno-commercial aspects may also receive considerable attention.

## 3.15 DEMAND FORECASTING

Forecast is an inference of what is likely to happen in future. Types of forecasting include technological forecast, economic forecast and demand forecast.

**Method of Demand Forecasting**

- ***Subjective or Qualitative Approach:***
  - Field Sales Force (Persons in direct contact with customer).
  - Jury of Executives (Group of mangers help in expediting forecast)
  - Users Expectations (Using questionnaires/ telephonic surveys).
  - Delphi Method (Opinion of group of experts with a mail survey).
- ***Quantitative or Statistical Approach:***
  - ***Casual or Explanatory*** (Consumption level method, chain level method, end use method, econometric method, leading indicator method)
  - ***Time Series Projection:***
    - ***Smoothing*** (Moving averages (*simple and weighted*), single exponential smoothing, double exponential smoothing)
    - ***Decomposition*** (Additive, multiplicative)

### 3.15.1 Time Series Projection Method

- Trend Projection Method: This involves extrapolation of the past trend on to the future.
- Exponential Soothing Method: Forecasts are modified in light of observed errors.
- Moving Average Method: Forecast for next period represents a simple arithmetic average or a weighted arithmetic average of last few observations.

### 3.15.2 Casual Method

They are more analytical than preceding methods. Casual methods seek to develop forecasts on the basic of Cause-effect relationship specified in an explicit, quantitative manner.

*Chain ratio method*: Simple analytical approach, this method calls for applying a series of factors for developing a demand forecast

*Consumption level method*: Useful for a product that is directly consumed; this estimates the consumption level on the basis of elasticity coefficients, the important ones being the income elasticity of demand and price elasticity of demand.

*End use method*: Suitable for intermediate product; the end use method develops demand forecast on the basis of the consumption coefficient of the product for various users.

*Leading indicator method*: According to this method, observed changes in leading indicators are used to predicate the changes in lagging variables.

**Trend Projection:** This method involves determining the trend of consumptions by analysis of past consumption statistics and projection into the future of consumption by extrapolating.

Trend of consumption may be represented by:

Linear Relationship $Y_t = a + b.t$

Exponential Relationship $Y_t = a.b^t$

*Using log* $\log Y_t = \log a + b.t$

Polynomial Relationship $Y_t = a_0 + a_1.t + a_2.t^2 + \text{————} + a_n.t^n$

Polynomial of second degree $Y_t = a_0 + a_1 t + a_2 t^2$

### 3.15.3 Linear Trend Using Least Square Method

Finding or fitting a straight line by using *least square method*, which involves sum of squares of perpendicular distance to that line from a given set of points such that sum is minimum. It determines '*least-square line*' or line with '*minimum squared error*'.

$$Y_t = a + b.t$$

$Y_t$ = demand for year t (dependant variable)

$t$ = time variable (independent variable)

$a$ = intercept of relationship

$b$ = slope of relationship

$$b = \frac{n\Sigma t.Y_t - \Sigma t.\Sigma Y_t}{n\Sigma t^2 - (\Sigma t)^2}$$

Simple linear regression fits a line to a series of points between dependent and independent variable

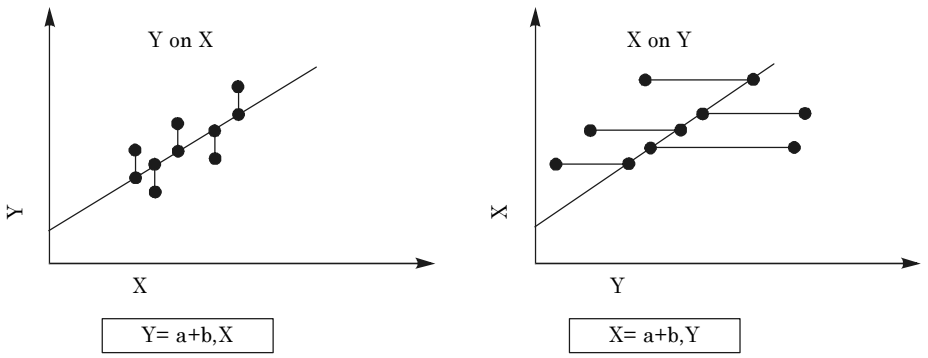



**Fig. 3.5** Project variables.

***Problem:*** The demand for a product varies with time as given in table below. Calculate the demand for the product in 14'th year.

| Time (yrs) (*T*) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demand (*Y*) | 10 | 13 | 14 | 17 | 18 | 18 | 19 | 20 | 22 | 23 | 22 | 24 | 24 | 25 |

***Solution***

**Table 3.3**

| *T (Time)* | *Y (Demand)* | *T.Y* | $T^2$ |
|---|---|---|---|
| 0 | 10 | 0 | 0 |
| 1 | 13 | 13 | 1 |
| 2 | 14 | 28 | 4 |
| 3 | 17 | 51 | 9 |
| 4 | 18 | 72 | 16 |
| 5 | 18 | 90 | 25 |
| 6 | 19 | 114 | 36 |
| 7 | 20 | 140 | 49 |
| 8 | 22 | 176 | 64 |
| 9 | 23 | 207 | 81 |
| 10 | 22 | 220 | 100 |
| 11 | 24 | 264 | 121 |
| 12 | 24 | 288 | 144 |
| 13 | 25 | 325 | 169 |
| $\Sigma T = 91$ | $\Sigma\Psi = 269$ | $\Sigma T.\Psi = 1198$ | $\Sigma T^2 = 819$ |

$$\frac{\Sigma T}{n} = \frac{91}{14} = 6.5$$

$$\frac{\Sigma T}{n} = \frac{269}{14} = 19.21$$

$$b = \frac{[n\Sigma t.Yt - \Sigma t.\Sigma Yt]}{[n\Sigma t^2 - (\Sigma t)^2]}$$

$$= \frac{[1998 - 1748.5]}{[819 - 591.5]} = 1.097$$

$$b = 1.097$$

$$a = \overline{Y} + \overline{T} = 19.21\text{-}1.097*6.5 = 12.08$$

Trend Line $Y = a+b.t = 12.08+1.097.T$

For the fourteenth year

Demand $(Y) = 12.08+1.097\ (14) = 27.438$

***Problem:*** A company wishes to invest in a project with an initial investment of Rs. 8500. The project is expected to yield a gross cash flow of Rs. 3000 annually for 4 years. The company's rate of discount is 10%. Calculate the net present value, Internal rate of return, Discount gross benefit cost ratio.

***Solution***

$$NPV = 3000\left(\frac{1}{1+0.1} + \frac{1}{(1+0.1)^2} + \frac{1}{(1+0.1)^3} + \frac{1}{(1+0.1)^4}\right)$$

$$= 3000\ (0.909 + 0.826 + 0.751 + O.683\ ) = 3000\ (3.169\ )$$

NPV = Rs. 9507

***Problem:*** M/s ABC and Co. is considering three project investment proposals. Each project has an investment outlay of Rs. 5,00,000. The company uses a criterion of payback period of three years. At present there is no constraint on the availability of fund for these projects; if all three projects meet the criterion, they can all be selected, The benefit and cost streams of three projects are estimated to be as follows:

## *Project 'X' Estimates*

**Table 3.4** Cost estimates

| *Period (year)* | *Revenue (Rs. 000)* | *Operating cost (Rs. 000)* |
|---|---|---|
| 1 | 850 | 600 |
| 2 | 850 | 650 |
| 3 | 850 | 650 |
| 4 | 750 | 650 |
| 5 | 750 | 650 |
| 6 | 700 | 650 |
| 7 | 700 | 650 |

## *Project 'Y' Estimates*

**Table 3.5** Cost estimates

| *Period (year)* | *Revenue (Rs. 000)* | *Operating cost (Rs. 000)* |
|---|---|---|
| 1 | 450 | 300 |
| 2 | 500 | 350 |
| 3 | 500 | 350 |
| 4 | 550 | 400 |
| 5 | 550 | 400 |
| 6 | 550 | 400 |
| 7 | 550 | 400 |
| 8 | 550 | 400 |
| 9 | 550 | 400 |
| 10 | 550 | 400 |

## *Project 'Z' Estimates*

**Table 3.6** Cost estimates

| *Period (year)* | *Revenue (Rs. 000)* | *Operating cost (Rs. 000)* |
|---|---|---|
| 1 | 1000 | 700 |
| 2 | 1000 | 700 |
| 3 | 1000 | 700 |
| 4 | 1000 | 700 |

Which projects should the company accept? What drawback of this selection criterion are highlighted by this problem?

***Solution***

The net revenue of the projects can be summarized as given below:

## *Net Revenue of Project*

**Table 3.7** Cost estimates

| *Year* | *X (Rs. Thousand)* | *Y (Rs. Thousand)* | *Z (Rs. Thousand)* |
|---|---|---|---|
| 1 | 250 | 150 | 300 |
| 2 | 200 | 150 | 300 |
| 3 | 150 | 150 | 300 |
| 4 | 100 | 150 | |
| 5 | 100 | 150 | |
| 6 | 50 | 150 | |
| 7 | 50 | 150 | |
| 8 | | 150 | |
| 9 | | 150 | |
| 10 | | 150 | |

- Project 'X' returns Rs. 4,50,000 in the first two years and Rs 6,00,000 in first three years. Since the investment has been Rs. 5,00,000, this is paid back with in three years. Thus, project 'X' satisfies the company's criterion and is selected.
- The payback period of 'Y' is more than three years because in three years the net revenue totals Rs. 4,50,000 falling short of initial investment thus this project is not accepted.
- Project 'Z' is estimated to payback (the initial investment) within two years and is therefore accepted.

***Problem:*** The estimated cash flows for two projects A and B are as follows:

**Table 3.8** Estimated cash flow

| *Year* | *Project A* | | *Year* | *Project B* | |
|---|---|---|---|---|---|
| | *Cost inflow (Rs. Thousand)* | *Cash outflow (Rs. Thousand)* | | *Cost inflow (Rs.Thousand)* | *Cash outflow (Rs.Thousand)* |
| 0 | | 100 (investment) | 0 | | 120 (investment) |
| 1 | 90 | 50 | 1 | 110 | 100 |
| 2 | 80 | 50 | 2 | 110 | 100 |
| 3 | 70 | 50 | 3 | 120 | 100 |
| 4 | 60 | 50 | 4 | 130 | 100 |
| 5 | 55 | 50 | 5 | 150 | 100 |
| | | | 6 | 150 | 110 |
| | | | 7 | 150 | 110 |
| | | | 8 | 120 | 110 |
| | | | 9 | 120 | 110 |

The organization appraising these projects uses a 90% rate of discount. What will be its decision on this projects A and B, if the value criterion is used ? Funds are not a constraint.

***Solution***

Since funds are not a constraints, let us consider the project one by one.

**Project A:** first convert the estimated cash flows into net cash flows. Outflows: will be given a –ve sign and the inflows a +ve sign.

**Table 3.9** Net cash flow

| *Year* | *Net cash flows (Rs.Thousand)* |
|---|---|
| 0 | –100 |
| 1 | +40 |
| 2 | +30 |
| 3 | +20 |
| 4 | +10 |
| 5 | +5 |

Then convert all the net cash flows to the base year (0) the present factor (P V Fi, n) for the various years corresponding to a discount rate of 9% are obtained.

**Table 3.10** Present value

| *Year* | *Net cash flow* | *P V Fi, n* | *Present value of cash flow(col.2 x col.3)* |
|---|---|---|---|
| **(1)** | **(2)** | **(3)** | **(4)** |
| 0 | –100 | 1.0000 | –100 |
| 1 | +40 | 0.9174 | +36.696 |
| 2 | +30 | 0.8417 | +25.251 |
| 3 | +20 | 0.7722 | +15.444 |
| 4 | +10 | 0.7084 | +7.084 |
| 5 | +5 | 0.6499 | +3.250 |

Total, i.e. NPV = –12.275.

The net present value (NPV) of project A being –ve , the project is being not accepted.

**Project B:** The net cash flow

**Table 3.11** Net cash flow

| *Year* | *Net cash flows (Rs.Thousand)* |
|---|---|
| 0 | –120 |
| 1 | +10 |
| 2 | +10 |
| 3 | +20 |
| 4 | +30 |
| 5 | +50 |
| 6 | +40 |
| 7 | +40 |
| 8 | +10 |
| 9 | +10 |

Convert all the net cash flow value of the base year zero (0). The present value factors (P V Fi, n) for the various year are corresponding to the discount at the rate of 9%. Present rate of net cash flow during a year n = net cash flow during the year 'n' x PVFi,n where I = 9%. The summation of the above value over the entire life of the project (including year zero) given the

net present value (NPV). The calculations are shown below:

**Table 3.12** Present value

| *Year* (1) | *Net cash flow* (2) | *P V Fi, n* (3) | *Present value of cash flow(col.2 x col.3)* (4) |
|---|---|---|---|
| 0 | –120 | 1.0000 | –120.000 |
| 1 | +10 | 0.9174 | 9.174 |
| 2 | +10 | 0.8417 | 8.417 |
| 3 | +20 | 0.7722 | 15.444 |
| 4 | +30 | 0.7084 | 21.252 |
| 5 | +50 | 0.6499 | 32.495 |
| 6 | +40 | 0.5963 | 23.852 |
| 7 | +40 | 0.5470 | 21.880 |
| 8 | +10 | 0.5019 | 5.019 |
| 9 | +10 | 0.4604 | 4.604 |

The NPV of project B being + ve, the project is accepted. Since NPV criterion, given due consideration to the time value of money, it is a theoretically sound criterion under the given assumption.

## *QUESTIONS*

1. Explain the role of Government in project selection.
2. Highlight the importance of feasibility study in project management.
3. What are the steps required in project identification? Explain briefly.
4. Discuss the contents of detailed project report.
5. For project selection discuss the requirements of information.
6. What is the impact of social cost benefit analysis on project selection? Explain.
7. Name the financial institutions, which help the development of projects.

4

# PROJECT PLANNING: A SYSTEMS APPROACH

## 4.1 PROJECT PLANNING

Planning is a primary function of management, which involves deciding in advance the future course of action. The process of project planning is to define each major task, estimate the time and resources required and provide a framework for management review and control. Planning will involve identifying and documenting scope, tasks, schedule, risks, quality and staffing needs. An adequate plan process and project plan will ensure that resources and team members will be identified so that the project will be successful. During the planning process the sequence and the logical inter-relationships between the various activities may be established. The process of project planning involves the following steps:

1. Defining the objectives and goals of the project
2. Making forecasts for achieving the goals
3. Identifying the various course of actions through available alternatives and assumptions.
4. Evaluating the resources available
5. Evaluating and selecting the available course of action for achieving the desired objective under the resource constraints.

**The basic tasks in planning process include the following:**

- Defining the technical approach used to solve the problem
- Defining and sequencing the tasks to be performed and identifying all deliverables associated with the project
- Defining the dependency relationship between tasks
- Estimating the resources required to perform each task
- Scheduling of all tasks to be performed
- Defining the budget for performing the tasks
- Defining the functional area used to execute the project
- Estimating each tasks duration
- Identifying the known risks in executing the project
- Defining the process used for ensuring quality
- Defining the process used for specifying and controlling requirements

**Project plan** is a formal, approved document used to guide both project execution and project control. The primary uses of the project plan are to document planning assumptions and decisions; to facilitate communication among stakeholders, and to document approved scope, cost, and schedule baselines. The project plan represents the basic tool for successfully executing a project. It forms the basis for all management efforts associated with the project. It is a record of plans that is expected to change over time. The project manager is responsible for bringing out the project plan, which should be accurate and complete as far as possible without being several volumes in length. It is a document that allows the project manager to manage the details, and not be managed by the details.

**The project plan should cover the following topics:**

- *General Project Information*: points of contact, phone numbers, etc.
- *Project Executive Summary*: Business Need/Problem, Statement of work, Project objectives and approach
- *Project Scope Statement*: provides a documented description of the project as to its output, approach, and content.
- *Critical Success Factors* :objectives and commitments
- *Work Breakdown Structure*: describes a deliverable-oriented grouping of project elements, which organize and define the total scope of the project.
- *Organizational Breakdown Structure*: provides an organization chart that defines the communications channels, responsibilities, and the authority of each participating person/unit.
- *Cost-Benefit Analysis*: provides the project team with information to make a balanced decision about the costs and benefits, or value, of various economic choices.
- *Resource Plan*: describes the major resources needed to proceed with the execution of the project.
- *Project Schedule*: provides the project schedule using a Gantt chart. The schedule must include milestones, task dependencies, task duration, work product delivery dates, quality milestones, configuration management milestones, and action items.
- *Risk Plan*: Provides a description of all risks identified for the project and a plan to integrate risk management throughout the project.
- *Procurement Plan:* Identifies those needs for the project, which can be met by purchasing products or services from outside of the agency.
- *Quality Plan*: Provides a Quality Plan that defines the person(s) responsible for project quality assurance, procedures used and resources required to conduct quality assurance.
- *Communications Plan*: Defines the information needs of the project stakeholders and the project team by documenting what, when, and how the information will be distributed.
- *Configuration Management Plan*: Provides the project team with a change management methodology for identifying and controlling the functional and physical design characteristics of a deliverable.
- *Project Budget Estimate*: Describes cost and budget considerations including an overview, additional resource requirements, and estimated cost at completion.

**Table. 4.1** Planning phase deliverables

| *System development life cycle deliverables* | *Project management planning phase deliverables* |
|---|---|
| • Work Statement<br>• Requirements Documents<br>• Solutions Documents<br>• Specifications Documents<br>• Design Schedules<br>• Detail Design Documents | • Project Scope Statement<br>• Critical Success Factors<br>• Work Breakdown Structure<br>• Cost-Benefit Analysis<br>• Resource Plan<br>• Project Schedule<br>• Risk Plan<br>• Procurement Plan<br>• Quality Plan<br>• Communications Plan<br>• Configuration Management Plan<br>• Project Budget Estimate |

## 4.2 CONCEPT OF SYSTEMS

As has been mentioned a team should consistently relate, support and supplement each other for the common cause. The system should be such as to force an individual to behave in accordance with the requirements and norms of working. Normally it is the task of project manager to identify, develop the system and work towards its smooth functioning. When there are thousands of variables both human and non-human in a project, the only way to combat the enormous uncertainties generated is to develop a sound **system** that would not only reduce varieties but also largely regulate themselves, thus reducing manager task.

Purely physical systems exist such as *man-man system, machine-machine system or man-machine systems*. But what managers will be required to deal with most of time are combined system of men, machine and paper work called **business systems**. Purchasing system involves purchase officers, vendors, materials specifications, general purchase conditions and purchase order.

**Procedure** is a planned sequence of operations for carrying out a recurring work involved in a system uniformly and consistently. In a purchase system procedures need to be developed for short-listing vendors, issuing enquiry to them, evaluation of offer and final placement of order. However system and procedures are quite exhaustive and vary with perceptions of two individuals. It is the lack of knowledge of systems and possession of comparatively more knowledge of procedures that makes people in business more procedure oriented rather than system oriented.

### 4.2.1 System Characteristics

- It is a set of finite elements.
- The elements are organized systematically
- The elements are inter-related
- System refers to a self-sufficient organic whole.
- System has a behavior characteristic of its own. (Individual elements lose their identify in pursuance of a common goal, striving for unity in diversity)
- System has a hierarchy.

## 4.3 TYPES OF SYSTEMS

Systems designed by man are referred to as *artificial system*s as opposed to *natural systems*. When a system controls its elements internally without requiring any external intervention, it is self-regulating system. If a system requires continuous intervention to remain viable it is *controlled system*. The other classification of system could be as follows:

*Closed System*: Systems that do not have any interaction with environment.

*Open System*: Constantly interacting with environment. It is very difficult for any project to run smoothly is real life, since as per ***Murphy law*** *if anything can go wrong it will*.

## 4.4 INFORMATION BOUND SYSTEM

When interacting elements are locked in loop comprising feed-forward and feed back information with the given suitable condition to induce self-control can make it like a natural system. Generally information bound systems are considered in context of computers. Information is fed as input, processed and then output is in form of useful information. The process of converting inputs (like resources) to outputs (like services) through management can be shown by following figure.

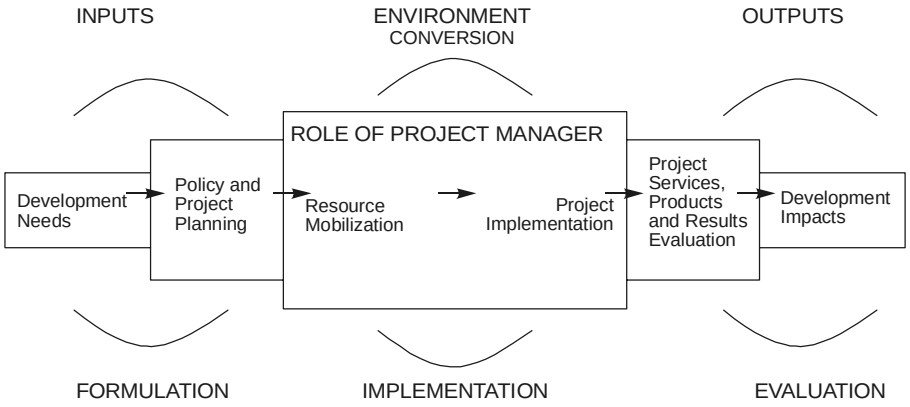



**Fig. 4.1** The conversion model showing phases of proect management activity

## 4.5 DESIGN OF SYSTEMS

Before designing a system the following things must be kept in mind:

- It should be as natural as possible
- It should be information bound system
- It should have a provision for external intervention

Design procedure for a system involves following activities:

- Conceive total physical system and its natural modules
- Connections between modules should be identified
- Provision for using information for self-control and forced control of project.

### *Model for Design of a Project Management System*

This involves working on different levels of interacting elements as follows:

| | |
|---|---|
| Organization | Man<br>Communication<br>Contracts<br>Financial Institution |
| Project hardware | Infrastructure facilities<br>Cost<br>Configuration<br>Utilities<br>Material |
| Resources and software | Finance<br>Design and engineering<br>Procurement<br>Installation and commissioning |

## 4.6 PROJECT MANAGEMENT SYSTEM

To ensure promotion of project work, certain key elements must be in place in the organization. In systems terminology, these components as a whole form project management systems, and each individual component is a subsystem. As all systems consist of inputs, outputs, and some process for converting those inputs into outputs, the same can be said for each component of a project management system.

According to Lewis the project management consists of seven components or subsystems as shown in figure. These are briefed below:

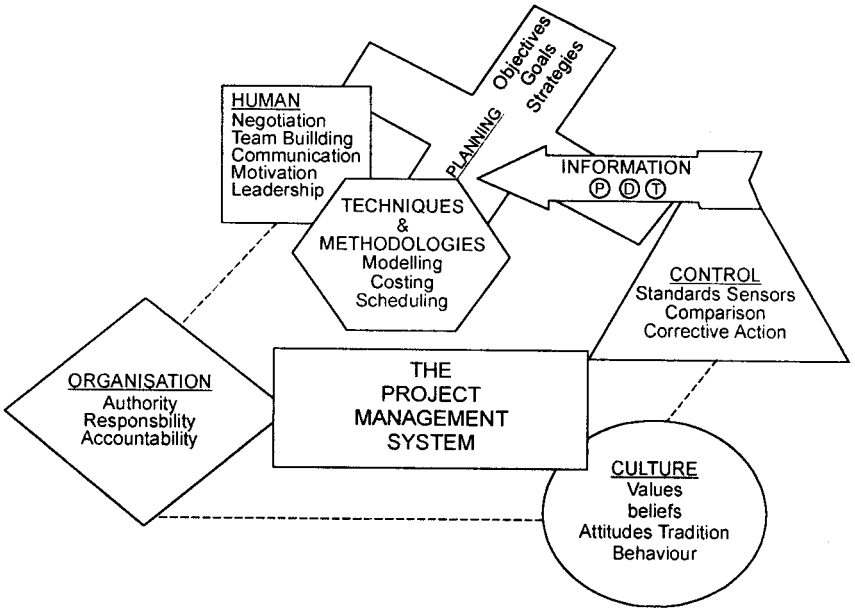



**Fig. 4.2** Project management system

1. *Project planning and design system*: the planning and design system is perhaps the most important and on it depends the successful completion of a project. Planning is seen as not producing results; it is concerned with laying down certain objectives, goals and strategies. Better results can be achieved if the design of the project work is systematized. For e.g. if the design of the project organization is structured on functional lines, where participants are concerned only about their functions, frequent outside intervention will be required for coordinating the various functional specialists
2. *Project information system*: In organizing the implementation of project work, the information system must be good. However, one of the problems some organizations have is that the data on project status is collected, fed into the computer, then processed and distributed at such large time intervals as to make the information useless in terms of control.
3. *Project control system*: Monitoring and control are the important subsets of the project implementation process. The objective of monitoring is to see deviations from the planned project performance. On the other hand, control is making decisions to redirect project inputs, resources and schedules in order to ensure that anticipated deviations do not materialize. The control system must use data 0n project status to determine where project stand in respect to the plan and initiate corrective measures if there is a significant deviation.
4. *Project techniques and execution system*: In order to ensure timely completion of a project, project manager makes use of certain techniques and methodologies. These may consist of certain technology such as, PERT and CPM scheduling and costing designs. In addition to these techniques, the project execution plan includes constructing plan, work packaging plan, procedure plan and human resource plan.
5. *Project organization system*: A systematic approach will enable the project manager to reduce the risk, which is inherent in most projects. An organization often headed by the project manager is set up for the purpose of securing coordinated efforts of all participants. This organization must define the limits of authority, responsibility and accountability of participants .If they have no authority, then they will feel no responsibility for their actions and project manager may has to make all decisions.
6. *Cultural system*: This may be added here that project organization operates in a given cultural environment. The culture of an organization is the totality of the values, traditions, beliefs and behaviors of the participants of project organization. Since change is resisted, it must be properly planned to avoid troubles.
7. *Human system*: Human resources system is perhaps the most important aspect of project management. Project techniques and methodologies are of no use if personnel lack adequate skills and motivation. A project manager needs very good interpersonal skill. These include the ability to provide good leadership for project team; the ability to deal with other constituents for needed resources; skill in motivating team members; and good communication skills.

Thus, a project management system enables the objectives of a project to be clearly defined and closely linked to the business objectives of an organization. It allows responsibilities for different constituents of the project to be allocated and agreed. The design philosophy is to create a set of interrelated element so that they can regulate and control themselves without outside intervention. System contract can reduce co-ordination and intervention points. If instead consultant does the design, owner does the procurement, various vendors supply the equipment and contractors of different trades are engaged in civil, mechanical and electrical works then controllability of system cannot be assured. Process systematization for better management starts with development of *Work Breakdown Structure (WBS).*

## 4.7 WORK BREAKDOWN STRUCTURE (WBS)

This techniques as the name implies breaks down the work into components and at the same time establishes the connections between components on the lines of family tree. This structure enables integration of people, hardware and software into total project work system. It depicts the hierarchy of systems breaking the overall system i.e. plant into individual systems and subsystems at different levels. The Work Breakdown Structure (WBS) provides the capability to break the scope into manageable activities, assign responsibility to deliver the project scope, and establish methods to structure the project scope into a form that improves visibility for management.

A WBS is a hierarchical representation of the products and services to be delivered on a project. Elements of scope are decomposed to a level that provides a clear understanding of what is to be delivered for purposes of planning, controlling, and managing project scope. It is neither a schedule nor an organizational representation of the project; instead, it is a definition of what is to be delivered. Once the scope is clearly understood, the project manager must determine who will deliver it and how it will be delivered. This is the one of the planning tool that must be used to ensure project success on any size project.

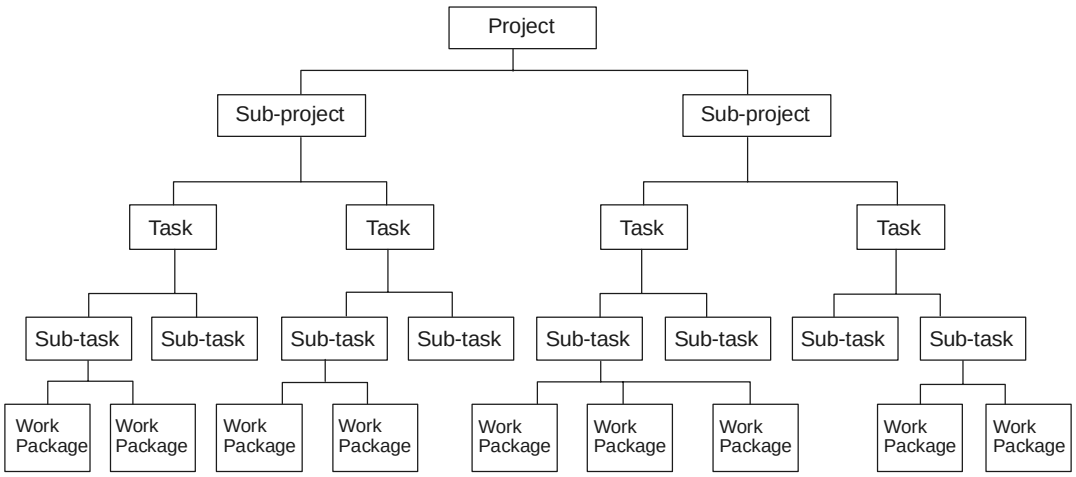



**Fig. 4.3** Work breakdown structure

### 4.7.1 Work Breakdown Structure Development

There are certain pieces of information needed to describe the WBS deliverable and then document it in the required format:

- **W B S Element or Number**. From the WBS the agency has built
- **W B S Task Name**. From the WBS the agency has built (e.g. software).
- **Task Effort/Duration**. From the WBS the agency has built (e.g. 55 hours of effort).
- **Resource Name**. The individual who is responsible for the execution of this specific
- task.
- **Element or Dictionary Description**. The definition, in simple terms, of the element and what it is intended to do for the project.
- **Cost**. The total cost for the WBS element.

### 4.7.2 Decompose WBS

The WBS is decomposed into discrete products and services to be delivered during the project. Higher-level elements represent groupings of products and services to be delivered. Decomposition identifies discrete products and services. Elements are decomposed in the following way:

- A discrete product or service is identified
- Responsibility to deliver the product or service is assigned to one individual or functional area
- Scope is clearly understood
- Cost is reasonably estimated
- The element is manageable
- Higher risk or more critical elements are decomposed to a lower level

A coding scheme can be used to simplify the complicated structure and identify the entire elements of the family tree that make up a complete project.

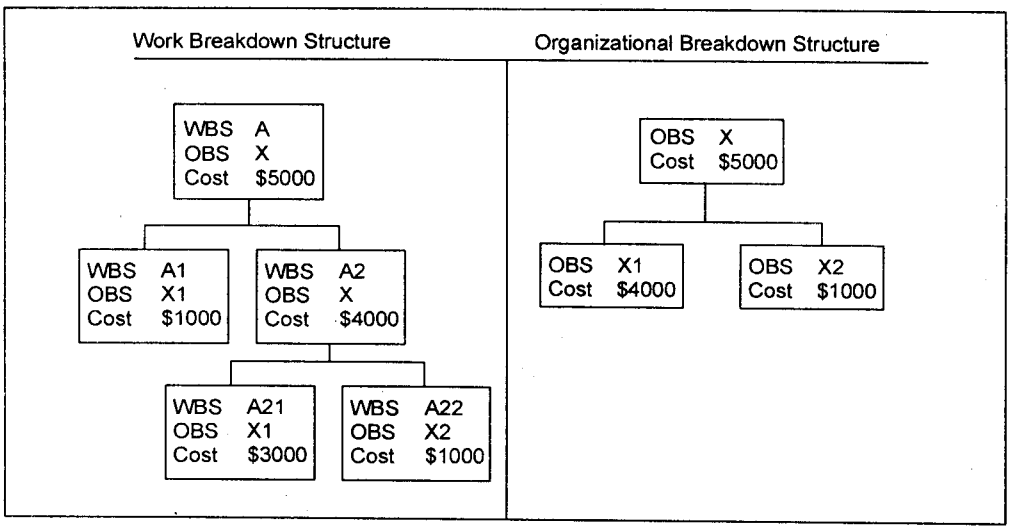



**Fig. 4.4** Work breakdown structure Vs organization breakdown structure

## 4.8 ORGANIZATIONAL BREAKDOWN STRUCTURE (OBS)

This represents the project organizational structure arranged and coded in a hierarchical format to improve communication throughout a project. The OBS assists in reporting project attributes that are the responsibility of an agency. The hierarchical nature of the OBS provides the ability to aggregate project information to higher levels until the top level is reached. The OBS is usually used with a WBS to ensure that all elements (scope) of a project are assigned to a responsible organization and controlled.

## 4.9 RESOURCE PLANNING

The resource-planning component includes the ability to plan and manage the resources required to deliver a project. This starts with the agency selection and assignment of the project team and includes the management of the resources assigned to that team. Every agency has a

limited number of resources to perform tasks. A project manager's primary role is to find a way to successfully execute a project within these resource constraints. Resource planning is comprised of establishing a team possessing the skills required to perform the work (labor resources), as well as scheduling the tools, equipment, and processes (non-labor resources) that enable the staff to complete the project.

1. **Labor Resources** Labor resources are also known as human resources. There are several parts to planning for the labor resource needs of a project:
   - Determining the resource pool
   - Estimating the skill requirements
   - Determining the size of the project team
   - Resource profiles
   - Forming the team
   - Creating resource charts
2. **Non-labor Assets** These resources include capital, infrastructure, etc.

## 4.10 SCHEDULE DEVELOPMENT

The project activities are associated with time to create a project schedule. The project schedule provides a graphical representation of predicted tasks, milestones, dependencies, resource requirements, task duration, and deadlines. The project's master schedule interrelates all tasks on a common time scale. The project schedule should be detailed enough to show each work breakdown structure task to be performed, name of the person responsible for completing the task, start and end date of each task, and expected duration of the task.

Like the development of each of the project plan components, developing a schedule is an iterative process. Milestones may suggest additional tasks, tasks that may require additional resources, and task completion may be measured by additional milestones. For large, complex projects, detailed sub-schedules may be required to show an adequate level of detail for each task. Once completed and approved by the project's key stakeholders, this schedule will be used to manage the project and will be known as the "Baseline Schedule". During the life of the project, actual progress is frequently compared with the baseline schedule, which allows for evaluation of execution activities. The accuracy of the planning process can also be assessed.

Basic efforts associated with developing a project schedule include the following:

- Define the type of schedule
- Define precise and measurable milestones
- Estimate task durations
- Define priorities
- Determine task relationships
- Identify lead/lag between related tasks
- Define the critical path
- Document assumptions
- Identify risks
- Review results

The type of schedule associated with a project relates to the complexity of the implementation. For large, complex projects with a multitude of interrelated tasks, a Network Logic Diagram (commonly referred to as a "PERT chart"– Program Evaluation and Review Technique) may be used.

### 4.10.1 Schedule Inputs

Inputs to schedule development include any aspect of the project that directly or indirectly effect how the project will be delivered. The following table may be used to give the list of inputs and how they are used to develop schedules.

**Table 4.1** Inputs in the schedule development

| ***Input*** | ***Comment*** |
|---|---|
| Scope | Each element of scope should have a defined schedule that depicts how it will be delivered |
| Agency | Assigning of the responsibility after identification of agency to deliver or conduct activity |
| Resources | The resources assigned to the agency will constrain schedules. The impact may be through either the number/availability or skill level of the team. |
| Strategy | Strategy refers to the business process or lifecycle process chosen for the project. Additionally, strategies will affect contracting or subcontracting, release strategies, or any aspect of the project that requires optional approaches ; for example, make/ buy alternatives. |
| Assumptions | Assumptions form a premise for a chosen solution; they are important in that they provide the rationale for a given solution. Assumptions should be reviewed continually, as they may be risks to the project (one may assume that the product will be available for test on a given date or that requirements will not change). |
| Constraints | Constraints are project attributes that restrict certain aspects of the project. Examples are :<br>Time-frame limits; Funding limits; Resource limits; Technical limits |
| Historical data | Historical information should be consulted. |
| Risk | Risk areas should be reviewed carefully and schedules developed to a level of detail that can provide control over them. Risk mitigation or contingency plans should be defined within the schedules as appropriate. |
| Dependencies | Dependencies define relationships between agencies and tasks and provide a logical sequencing of the schedule. Dependencies provide the basis to calculate the schedule and attributes of Critical Path Method (CPM) analysis. |
| Change | All changes in scope, strategy, and work effort should be used to develop and maintain schedules. |

## *QUESTIONS*

1. What is planning? Explain briefly
2. What is the importance of system concepts in project planning?
3. Enlist the types of systems used in practice.
4. Discuss work breakdown structure and organization breakdown structure.
5. How important is resource planning for project management. Explain
6. Explain the importance of schedule development in project planning.
7. Discuss the various techniques used in project planning.

5

# ORGANIZING HUMAN RESOURCES

Once the project proposal has been finalized and goals are set, the project manager has to act to achieve these goals. Manager is expected to execute the project work, which is inter-disciplinary in nature with the help of his subordinates. Both internal and external means can be exploited for implementation. For the different category of works specialist have to be employed. Therefore proper manpower restructuring is essential at this point. If the right person is not assigned to the right work, it will suffer. While assigning the work individuals qualification and experience must be examined critically. In the process certain portion of work contents can be delegated for quick action.

## 5.1 DELEGATION

Before delegating the authority the manager must examine what to delegate, when to delegate and how to delegate. Delegation is the entrusting of task to the subordinates. It becomes essential, as the manager cannot be expected to be at more than one place and doing more than one thing simultaneously. Project manager is expected to be delegating authority commensurate with tasks assigned to him. Delegation may be individual or institutional.

### 5.1.1 What to Delegate?

Assignment of any task without authority is not delegation. *Delegation* occurs when authority is passed to make commitments, use resource, issue instructions, demand adherence and take necessary steps for performance of task. As far as possible delegation should be in writing, but in case of institution delegation it should be in writing, appear formal and have legal overtones also. Mere delegation cannot ensure results unless person considers it his moral obligation or feels responsible. The responsibility may be expected to be passed on concurrently with delegation but this may not happen necessarily.

***Responsibility*** is an attitude of mind, which cannot be passed on in writing, It cannot be delegated but only authority can be delegated. When authority is delegated the delegate remains ***accountable*** to the delegatee about the use of authority. Moreover he assumes responsibility to the extent of authority he receives.

### 5.1.2 When to Delegate?

Delegation whether institutional or individual enhances one's capability of doing things. Delegation is required when:

- One is overburdened
- One does not have know-how
- Job needs specialization
- It can be done qualitatively, economically and on time

- Work is not secret in nature
- Work is routine

e.g. It may not be advisable to develop a full-fledged project engineering division if there are no further projects or its main business is only operation of plant.

### 5.1.3 How to Delegate?

To give a complete picture and also establish a basis of accountability the entire thing is to be put on record. Also it prevents overstepping the authority delegated either in anxiousness of completing task faster or hunger for power. So written delegation also provides the power to discipline delegate. Delegation may be followed by a process of negotiation/discussion in order to make sure delegatee is not unwilling else delegation may remain only on paper.

*The main problems* associated with delegation are:

- What tasks to retain and what to pass on and with what authority
- Packaging the work without overlap or leaving anything
- Delegate assuming the responsibility matching the authority delegated
- Trustworthiness of delegatee
- Control and intervention without unnecessary interference
- To ensure continuous flow of communication which is accurate and prompt
- To motivate delegatee to assume total responsibility and give best performance commensurate with authority delegated.

## 5.2 DOCUMENTING PROJECT AUTHORITY

Project manager should have broad authority over all elements of the project. Although a considerable amount of his authority depends on his personal abilities, his position will be strengthened by the publication of document to establish his modus operandi and his legal authority. As a minimum documentation like expressing in a policy manual, policy letters and standard operating procedures should delineate his role with respect to:

1. The focal position in the project activities.
2. The need for a deliberate conflict between project manager and finance manager.
3. The need of his influence to cut across functional and organizational lines to achieve unanimity of the project objectives.
4. Active participation in major management and technical decision to complete the project.
5. Collaborating (personal office / functional supervisors) in staffing the project.
6. Control over the allocation and expenditure of funds and active participation in major budgeting and scheduling deliberations.
7. Selection of subcontractors to support the project and negotiation of contracts.
8. Right in resolving conflicts which may endanger the project goals.
9. Having a voice in maintaining the integrity of the project team during the complete life of the project.
10. Establishing project plans through the co-ordination
11. Providing an information system for the project with sufficient data for the control of the project within permissible cost, schedule and technical parameters.
12. Providing leadership in the preparation of operational requirement, specifications, justifications and the bid package.

13. Maintaining prime customer liaison and contact on project matters.
14. Promoting technological and managerial improvements throughout the life of the project.
15. Establishing a project organization (a matrix organization) for the duration of the project. The publication of suitable policy media describing his modus operandi and his legal authority will do much to strengthen his position in the total project environment.

Project managers *failure to establish authority* relationships can result in*:*

- Poor communication channels
- Misleading information
- Antagonism, especially from informal organization
- Poor working relationship with superiors, subordinates, peers and associates

The specific *limits to authority* are listed below:

- Subordinate's competency (Capacity, skills, education, etc.)
- Constraint of company's policy particularly private sector
- Social constraints
- Legal limits (Government legislations, Company Act, etc.)

The common *sources of power and authority troubles* include:

- Poorly documented or no formal authority
- Power and authority perceived incorrectly
- Dual accountability of personnel
- Two bosses (who often disagree)
- The project organization encouraging individualism
- Subordinate relations stronger than peer or superior relations
- Shifting of personnel loyalties from vertical to horizontal lines
- Group decision making based upon the strongest group
- Ability to influence or administer awards and punishment
- Sharing recourses among several projects

## 5.3 MOTIVATION

Project manager must be aware of the needs of the project personnel and should try to fulfill them. Project managers must motivate by providing a feeling of pride or satisfaction, security of opportunity, security of approval, security of advancement, security of promotion, security of recognition, means of doing better job, not a means of keeping a job. The main theories for motivation are Moslow's theory, ERG theory, Theory X and Theory Y, etc which have been explained below.

### 5.3.1 Moslow's Hierarchy of Needs

According to Moslow the basic human needs identified in ascending order of importance can be classified broadly into five groups. Moslow's hierarchy of needs can be depicted in the form of pyramid as shown below:

- Level I: Physiological needs (Food, Water, Shelter, Warmth)
- Level II: Security or safety needs
- Level III: Affiliation or acceptance or social needs (accepted by others and society)

- Level IV: Esteem needs (power, prestige, status, and self confidence)
- Level V: Need for self-actualization

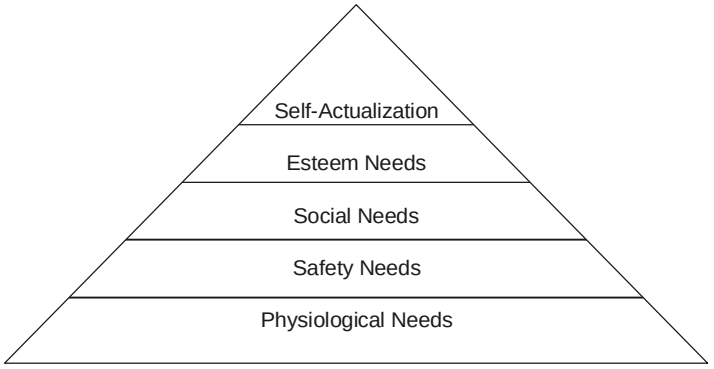



**Fig. 5.1** Moslow hierarchy

### 5.3.2 ERG Theory

- Unlike Moslow's hierarchy, the ERG theory allows for different levels of needs to be pursued simultaneously.
- The ERG theory allows the order of needs be different for different people.
- The ERG theory acknowledges that if a higher level needs remains unfulfilled, the person may regress to lower level needs that appear easier to satisfy. This is known as *frustration-regression principle*.

### 5.3.3 Theory *X* and Theory *Y*

Douglas McGregor defined assumptions that reveal the practices of managers in relation to employees. According to him –What managers said or exhibited in their behavior revealed their theories-in-use. Their predisposition led managers to pursue particular kinds of policies and relationships with employees.

A manager holding *theory X assumption* would believe that:

- People inherently dislike work
- People must be coerced or controlled to do work to achieve objectives.
- People prefer to be directed.
- Motivation occurs only at the physiological and safety levels.

A manager holding *theory Y assumption* would believe that:

- People view work as being as natural as play and rest.
- People will exercise self-direction and control towards achieving objectives they are committed to.
- People learn to accept and seek responsibility.

## 5.4 ORGANIZATION STRUCTURES

For efficient and effective working of any project, it is essential that organizational structure must be set up. Organizational structures demonstrate the project manager's authority. By virtue of this structure the delegation of powers, responsibility and accountability is automatically established. The working personnel know clearly to whom to report and therefore bypassing of

authority is eliminated. The general flow of authority can be explained with the help of pyramid and the block diagram shown below:

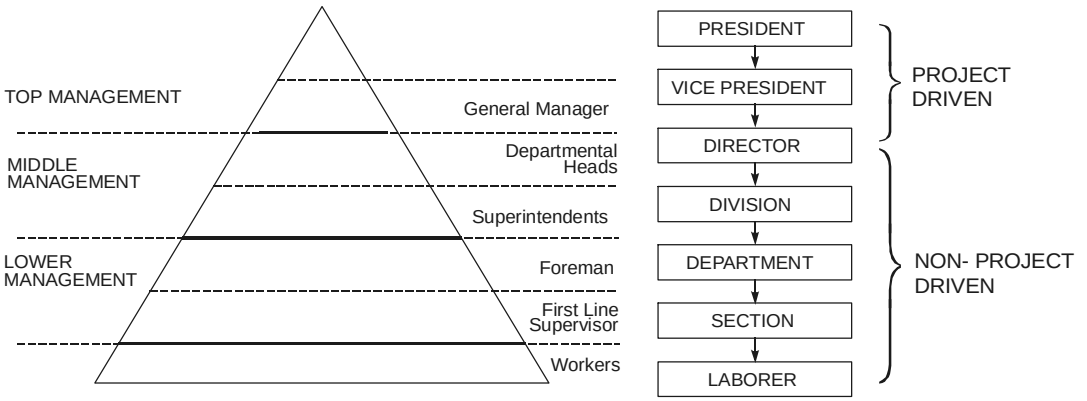



**Fig. 5.2** Organization structures

The *flow of authority* in an organization structure is in downward direction while *flow of responsibility* is in upward direction. *Traditional form* of organization is not suitable for project work since there is no means of integrating different departments levels below the top management. It does not facilitate effective communication, co-ordination and control. When several functional departments with different professional backgrounds and orientation are involved in project work under time and cost pressures, it may call for overlap of development, design procurement, construction and commissioning work.

The project managers in different organizations may function differently because of range of possibility for authority sharing. There is a need for entrusting an individual or group with the responsibility for integrating the activities and functions of various departments and external organizations involved in project work. Such an individual may be either *project manager or project co-ordinator*. Depending upon the authority given to person responsible for project following structures are possible.

## 5.4.1 Line and Staff Organization

The simplest form of organization is a line organization, which is preferred for a small setup.

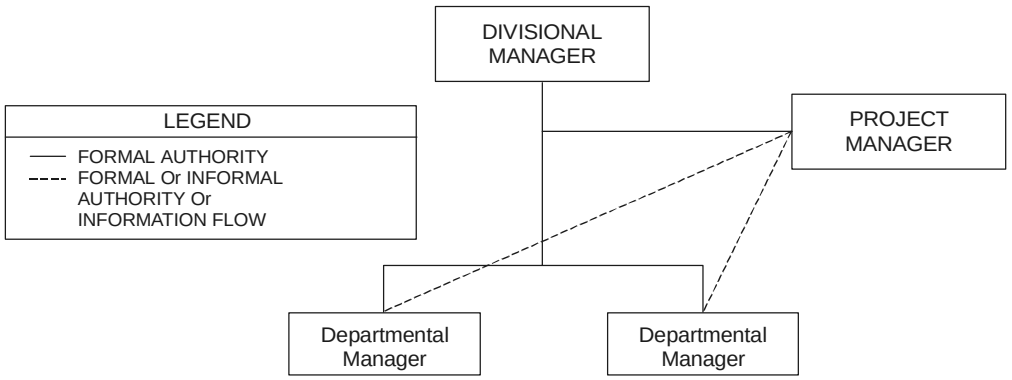



**Fig. 5.3** Line and staff organization

This overcomes the drawbacks of a pure line organization (which centralizes all work) and functional organization (diffuses work responsibility too much). *Staff* is a group of people with expert knowledge who are expected to provide advice and service at the time of attainment of objectives to line members. Project co-ordinator acts in a staff position to facilitate the co-ordination of the management in functional departments. He does not have authority and direct control, but he serves as *focal point* for receiving project related information and seeks to promote the cause of project by rendering advice, sharing information and providing assistance. He may gently coax line executives to strive for fulfillment of project goals.

This is a weak form of organization, because co-ordinator is unable to exert pressure, may feel unsure of his role and this form may be employed mostly for small projects. He acts as a link to Chief Executive who might be willing to control project directly but cannot devote much time to keep track of details. The advantages of line and staff organization include its usefulness for medium and large corporations and availability of experts. The disadvantages of line and staff organization are: organization structure is complex, co-ordination in different levels may be poor, cost of operation is high and more conflicts possible at different levels.

### 5.4.2 Consultant as Project Manager

Chief executive may appoint a consultant who may be an outsider to advise in project implementation. He will not have any authority but will collect information, analyzes it and communicates it to the chief executive. The advantage is a source of authentic, reliable and impartial information. The disadvantage of delegation may be outcome of both the above structures as there is no project manager in either arrangement.

### 5.4.3 Project Management as Specialized Staff Function

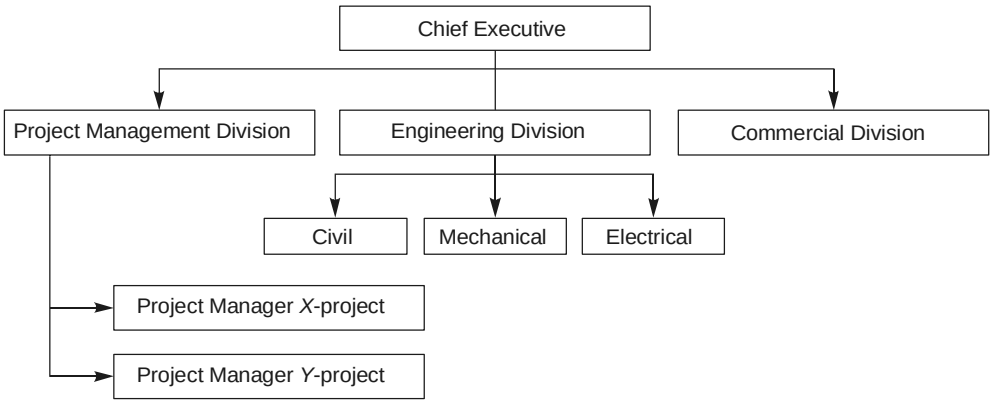



**Fig. 5.4** Staff functions

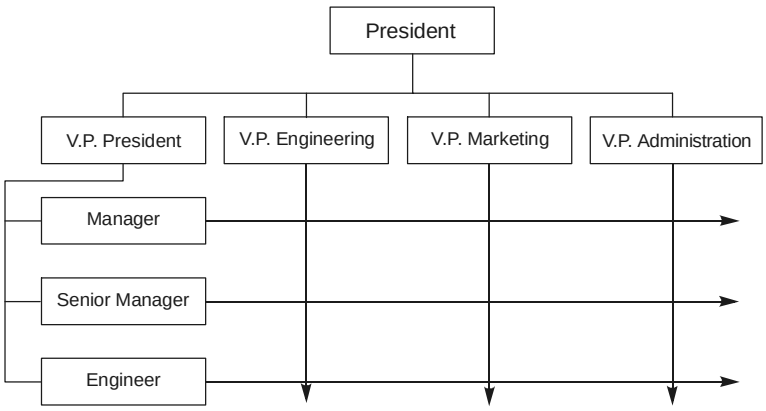
Most companies tend to use this arrangement when project management is used for first time in the company, as this does not require much change in the working of the organization. A specialist in project management can be hired under this system who is well versed with the tools and techniques of project management. His task will be to advise on various functions like schedules, budgets, and techniques but the final decision will rest with functional groups. The specialist may act as single focal point regarding communication between various functions and company. He may carry out services like collection and transmission of data, maintain records, measure progress, analyze and prepare progress reports.

The limitation in this arrangement is that the project manager is not entitled to direct or issue instruction to workforce and he is expected to take the responsibility without any authority. The direct communication with the workforce should be encouraged to take advantage of this arrangement.

### 5.4.4 Matrix Organization

The pure matrix organization evolves from above setup when arrangement of sharing authority between project manager and functional manager is formalized. In this structure different projects (rows of matrix) borrow resources from functional areas (columns).

Senior management decides whether the project manager has little, equal or more authority than functional managers with whom they negotiate for resources. The personnel working on project have a responsibility to their functional superior as well as project manager, which means that the authority is shared between project manager and functional manager. The project manager integrates the contribution of personnel in various functional departments towards realization of project objectives. The matrix form of organization is incongruent with the traditional organization theory since there is dual sub-ordination, responsibility and authority are not commensurate, and the hierarchical principal is ignored. The matrix form of organization involves greater organizational complexity and creates inherently conflictive situation. Yet it is effective for simultaneous pursuit of twin objectives: efficient utilization of resources and effective attainment of project objectives.




| PM \ F | | Functional Manager A | B | C |
|---|---|---|---|---|
| Project Manager | X | A1 | B1 | C1 |
| | Y | A2 | B2 | C2 |
| | Z | A3 | B3 | C3 |

**Fig. 5.5** Matrix organization

Some of the *advantages of a pure matrix organization* are as follows. It enables project control over all resources, including cost and personal. Policies can be set up independently provided that they do not contradict company policies. Authority to commit company resources by scheduling rests with the project manager. Rapid responses are possible to changes, conflicts and needs. Each person can be shown a career path even at the end of project. Key people can be shared thereby minimizing the costs. Strong technical base can be developed with knowledge being available for all projects on an equal footing. Better balance is possible between time, cost, and performance. Rapid development of specialists and generalists occurs. Authority and responsibility are shared.

Some of the *disadvantages of a pure matrix organization* are as follows. It enables multidimensional informational flow and work flow. Reporting to multiple managers with continuously changing priorities. Management goals may differ from project goals. Functional

managers may be biased according to their own set of priorities. Potential for continuous conflict due to ambiguous roles requiring full time attention. Difficulty in monitoring and control. Each project organization operates independently so duplication of efforts possible. Balance of time, cost, and performance must be monitored.

In addition to above-mentioned disadvantages, *Davis and Lawrence* have identified *nine matrix pathologies* which include power struggles, anarchy, groupitis, collapse during economic crunch, excessive overload, decision strangulation, sinking, layering, navel gazing.

### 5.4.5 Task Force Organization

This structure avoids confusion, mal-operation of matrix between project manager and functional manager by clearly giving authority to project manager. The project manager is delegated full authority to make decisions for the project but within the functional organization policies and procedures.

Personnel from functional organization are assigned to the task force, on either a full time or priority basis and may function under different roles. In all cases they continue to receive administrative support from their home organization. In some activities task force personnel are in effect on loan to the project manager. They operate completely under his direction and management and are not required to operate according to their functional organization policies.

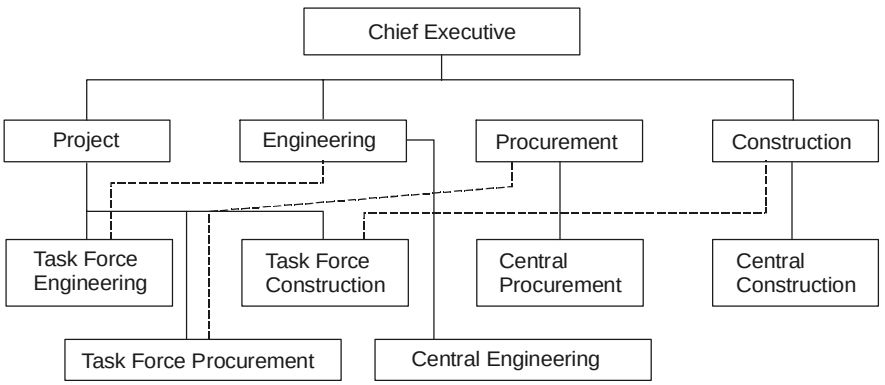



**Fig. 5.6** Task force organization

In another mode, while under obligation to the project manage for all project direction, they are constrained to follow home organizations policies and procedures. If project manager directions are asking violation of functional policies, the task force notifies both functional head and project manager. The dotted lines in figure indicate relationship between functional staff and functional manager, while other lines show project manager authority. Large and complex project involvement of multiple specialists from same discipline, while in small projects one specialist may cater for multiply disciplines.

### 5.4.6 Totally Projectized Organization

This structure evolves from task force, when project is long and complex. In such situation task force communication from parent functional organization is completely cut off. Such arrangement is desirable when project is either large and complex or graphically so located that there is no way of managing it without granting autonomy to team handling project. So it is like a mini-company in which project manager is chief executive and different senior functional

specialists who are capable to function independently without any support. The project manager should be a very senior person to justify delegation of so much authority by the company. Besides it may help to project manager to spend more time on administrative work besides main core activities. Therefore either total projectization or task force arrangement appear to be best arrangement for executing most projects, as project objectives get primary attention and project manager is delegated authority commensurate with the responsibility he has to undertake.

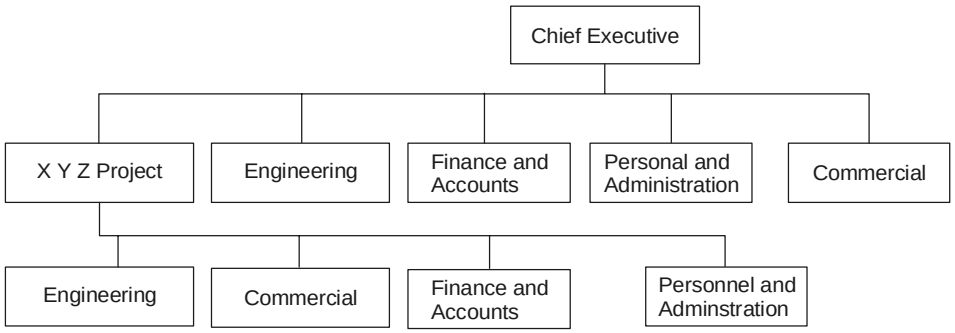



**Fig. 5.7** Totally projectised organization

*Advantages* of project organization form:

- It provides complete line authority over the project through a single project authority.
- Direct involvement of personnel helps to identify unprofitable project lines, develop strong communication channels and rapid reaction time.
- Expertise on a given project without sharing of key project personnel.
- Loyalty to the project with better morale due to identification.
- Flexibility in determining time, cost, and performance trade-offs.
- Interface management becomes easier as unit size is decreased allowing more for time for decision-making.

*Disadvantages* of project organization form:

- It is a costly preposition for a multi-product company due to duplication of effort, facilities and personnel
- Tendency to retain personnel on a project long after they are needed.
- Without strong functional groups technology suffers because policy of improvements for new programmes does not exists
- Control of functional specialists requires top-level co-ordination.
- Lack of opportunities for technical interchange between projects.
- Lack of career opportunities for project personnel.

## 5.5 COMPARISON OF FUNCTIONAL, MATRIX AND PROJECT ORGANIZATION

The traditional form of organization is based on the promise that there is a continuous flow of homogeneous output. The structure that best suited to manage continuous and routine operation is the functional organization. But *functional organization* often cannot accomplish unusually complex or markedly different projects because of the following inherent *limitations*. Functional executives are more concerned with their specialized framework rather than towards a unified project objective. The perspective of a project as whole is lost.

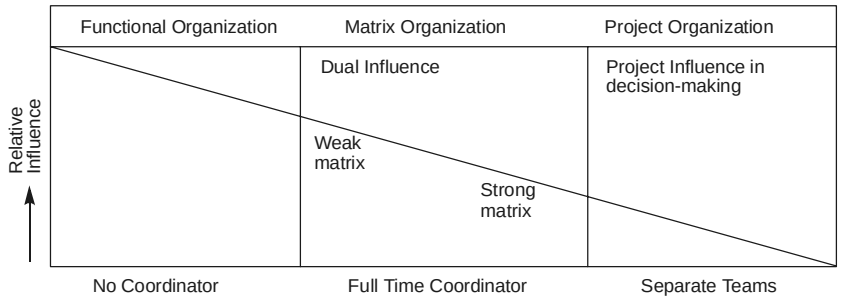



**Fig. 5.8** A Comparison of organization structure

Confining to only specific fragments of the work by functional people may lead to a grave impact on the project as well as the organization. The decision making process is slowed down by practice of passing the buck and waiting for replies, which may jeopardize the whole project. The linking effect in functional structures often delays the important project decisions from being made or prevents such crucial decision to arrive at that ultimately hampers the total project. The lack flexibility and responsiveness that is mandatory in a dynamic project environment often leads to sluggish performance of tasks.

## *Authority, Responsibility and Accountability for Project Manager*

Depending on the type of the organization the authority and accountability of the project manager varies. The table below shows the relationship between authority and accountability.

**Table 5.1** Relationshiop between authority and accountability

| *Sl.No.* | *Type of Organization* | *Authority* | *Accountability* |
|---|---|---|---|
| 1. | Project manager as staff | No decisions; only collates and communicates | No accountability |
| 2. | Consultant as project manager | No decisions; makes recommendations | No accountability |
| 3. | Project management as staff function | Decides overall schedules but does not direct staff | No accountability |
| 4. | Matrix organization | Decides on what is to be done at what cost | Can be held accountable for time and cost not for technical aspects |
| 5. | Task force | Decides on what, when and how is to be done and at what cost | Can be held account for time, cost and for technical aspects |
| 6. | Totally projectized organization | Decides everything like chief executive of the company | Is accountable for all aspects |

The figure below shown the relationship between Authority, Responsibility and Accountability of project

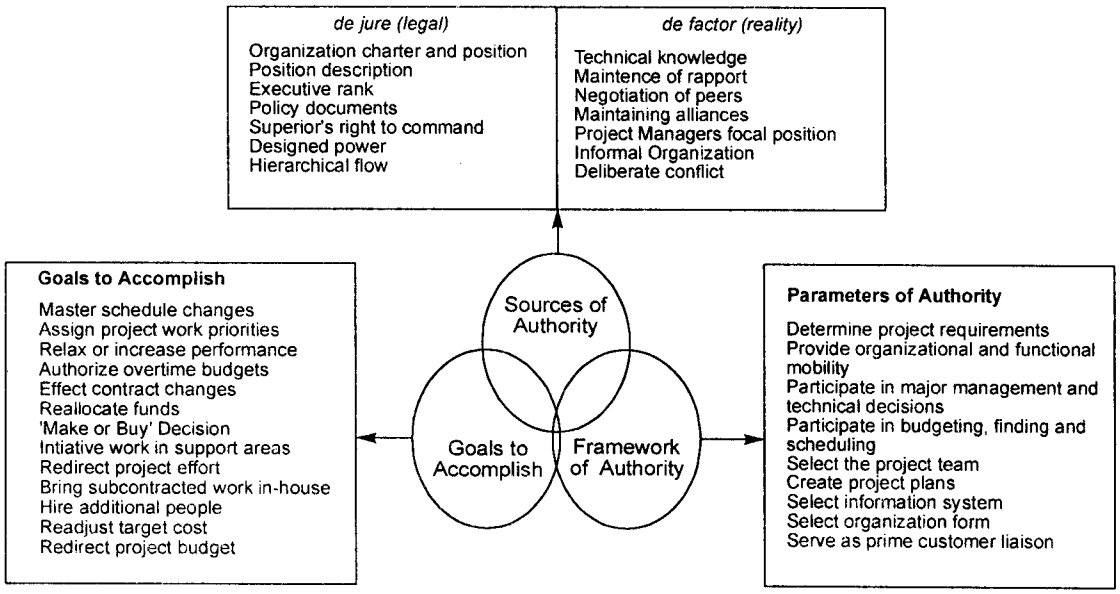



**Fig. 5.9** Authority, responsibility and accountability of project manager

Structuring of work and delegation of authority can serve no purpose if individual or agency do not strive for result or is held accountable. *Responsibility* comes when a person commits himself morally or accepts delegation of authority. *Contractual responsibility* is the responsibility accepted for the fear of withdrawal of authority or sanctions of any other form for non-achievement of result.

## 5.6 PROJECT MANAGER'S DUTIES: MULTIDISCIPLINARY IN NATURE

The duties of a project manager are of a complex and multidisciplinary nature. The project manger must be able *to project the uncertainty and manage the same.* He should have the ability to apply the art of management by introducing a concept of unity in diversity. It can be

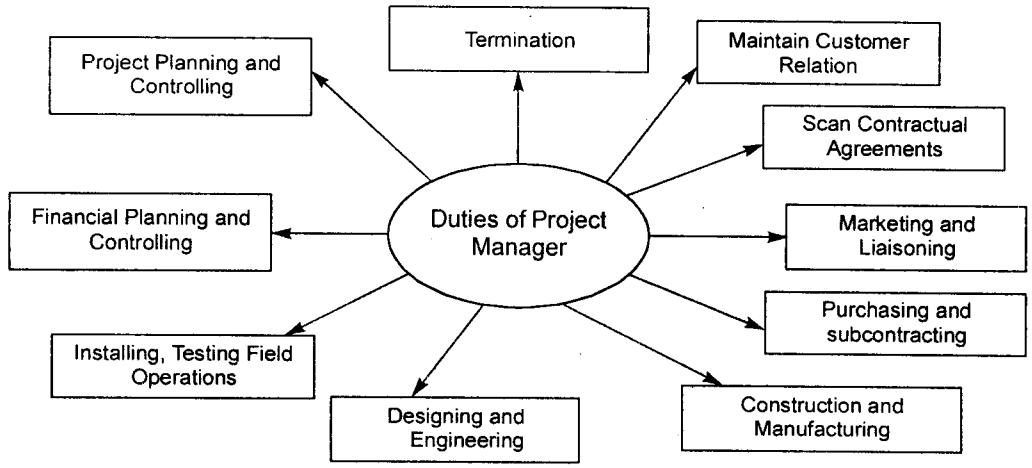



**Fig. 5.10** Duties of project manager

stated that a special breed of manager is required who have more than just a basic d*egree in engineering or management*. The project manager first projects at the *zero date* what has to come in his way till completion, continuously updates the network to project the current scenario, reviews the current scenario, takes corrective actions and then again makes fresh projections.

There could be several project managers in a project and their responsibility may very. But then each of them is only discharging certain limited role and responsibility, which have been delegated to them; they are not discharging the total function of project management.

The figure shown below shows the duties of project manager.

**Planning:** It is a critical stage for any project and it includes more than just planning and establishment of the authority relationships that must exist for the project duration. It requires anticipation of anything unforeseen and planning ahead because project environment is an ever-changing one. During planning phase project team develops a responsibility matrix, often referred as *LRC-Linear Responsibility Chart*. Not proper handling may reflect poorly on the project manger even if it not the manger's fault. Responsibility matrix contains element such as:

- General Management Responsibility
- Operation Management Responsibility
- Specialized Responsibility

**The following activities may be tested in responsibility matrix:**

- Raw Material Procurement
- Contact Vendors
- Prepare Purchase Orders
- Place Purchase Orders
- Quality Control Testing
- Prepare Inventory Report
- Prepare Bill of Materials
- Visit Vendors
- Authorize Expenditures
- Inspect Raw Materials
- Update Inventory File
- Withdraw Materials

**Organizing and Administering:** The project manager often has to perform many administrative tasks with little support from real administrators (line managers).

**Directing and Controlling:** Project manager is required to direct the project resources and monitor resource allocation. Directing is the implementing and carrying out (through others) of those approved plans that are necessary to achieve or exceed objectives. Controlling is a three-step process of measuring progress towards an objective, evaluating what remains to be done and taking necessary corrective action.

**Controlling** involves steps of measuring, evaluating, correcting

**Directing** involves steps like:

- **Staffing:** To see that a qualified person is selected for each position.
- **Delegating:** To delegate and then supervise work on the project. Delegating is assigning some work/responsibility/authority so that others can make maximum utilization of their abilities and then supervise work on project.
- **Motivating:** To encourage the project team in presence of normal pressures of work as well as political realities. Project manager is required to motivate the project team in the presence of normal pressures of work as well as political realities and pressures.
- **Supervising:** To supervise the work on project site and on going work continuously.

- **Interfacing and Co-ordination:** Project manager is required to mange the relationship within and outside the organization through paper interfacing and co-ordination amongst team numbers. To see that the activities are carried out in relation to their importance and with minimum of conflict.
- **Performing:** Project manager is required to execute direct tasks, which are within the capacity and competence of a manger with little help of subordinates.
- **Training:** Project manager is required to train members of the project team in applying project management method and tools in which they are involved.
- **Counseling:** Project manager is required to act as a counselor to the management on specific technical or business issues as well as to the staff on project and even individual issues.
- **Mediating:** Project manager is required to remove conflicts over resources and schedules.
- **Expediting:** Project manager is required to oversee and mange the total project development and implementation.

## 5.7 METHODS AND TECHNIQUES FOR DEVELOPING PROJECT MANAGERS

The complicated task of managing a project requires training of the various skills and techniques of project management. The short term training programmes are good to impart skills in preparation of network, development on performance budget, design of systems, performance measurement, project reviews, etc but they would not prepare a man to accept uncertainties without a grudge. To continuously project things he should be required to manage and above all manage a project through installation of self-controlling system.

- **Experiential Training/on the Job**
  - Working with the experienced professional leader
  - Working with project team member
  - Assigning a variety of project management responsibilities, consequently
  - Job rotation
  - Formal on the job training
  - Supporting multifunctional activities
  - Customer liaison activities
- **Conceptional Training/ Schooling**
  - Courses / seminars / workshops
  - Simulation /games / cases
  - Group exercises
  - Hands on exercises in using project management techniques
  - Professional meetings
  - Conventions, symposium
  - Readings, books, trade journals, professional magazines
- **Organizational Development**
  - Formally established, and project management functions
  - Proper project organization

- Proper support systems
- Project charter
- Project management directives, policies and procedures

## *QUESTIONS*

1. What is delegation? What, when and how to delegate? Explain.
2. How important is documenting project authority? Explain.
3. When motivation helps in project management? Explain.
4. Discuss the types of organization structures used in practice.
5. Explain the relationship between authority, responsibility and accountability.
6. Explain the duties of a project manager.
7. What are the techniques used for training project manager.

6

# PROJECT DIRECTION, CO-ORDINATION AND CONTROL

## 6.1 WORK SCHEDULE

To ensure proper and smooth working of a project it should be scheduled. The work schedule should cover initial operation as well as installation period. To avoid losses arising from idle capacity and deterioration of stocks of material, schedule should be drawn up with care and realism so that the commissioning of plant is reasonably synchronized with the availability of the basic input. The purpose of work schedule is to:

- Anticipate problems likely to arise during installation phase and suggest possible means for coping with them.
- To establish the phasing of investments taking into account the availability of finances.
- To develop a plan of operations covering the initial period (running in period)

Any discrepancy in schedule may result in lack of input like raw material and power in adequate quality when plant is ready for commissioning or plant is not ready when the raw material arrives. Preparing a schedule requires consideration of following: type of schedule, identification of measurable milestones, estimation of task durations, defining priorities, determining task relationships, identification of lag between related tasks, define of the critical path, documenting of the assumptions, identification of the risks and review of the results. Since it is the responsibility of project authorities to ensure implementation they may assume schedule to suit themselves. But since the project authorities stake in any industrial unit may be only 10% of the investment, it is the financial institutions that will need to be convinced about the reasonableness of the estimate. Past experience may not help in changed environment, so schedule has to be modified to reflect the strategy for indigenization and Indian industrial conditions including productivity.

Milestones pertaining to a point in time and should be used as management checkpoints to measure accomplishment of the schedule. The number of tasks and milestones are to be identified to relate to what is known about the product, the level of risk, and the level of detail required of management. The result is a listing of tasks and milestones required to deliver the product. The completion of key actions is denoted by milestones, which are unique to each project. A completion has no duration,. for example, deliverables often are represented as milestones, while the effort to produce the deliverable is referred to as a “task”.

## 6.2 BAR CHART

The schedule is likely to be in form of bar–chart because the details included are so few and so broad-based that developments of network would not add to any accuracy. Besides this form of

presentation suits financial planning and economic evaluation. Contingency provision may not be included to keep schedule tight. *Overall Schedule* tries to adhere to the overall project completion target set by feasibility schedule. Also since this schedule service as ***mother document*** for subsequent detailed schedule utmost attention is given to make target realizable by incorporating time allowance at key milestones. Generally inbuilt allowance of 20% in time schedule is used, as in case of cost estimate for proper correspondence between them.

## 6.3 MANAGEMENT EFFORTS SCHEDULE

Usually project faces much of its problems at the start and takes it time to stabilize. Therefore till the project acquires its stability, external intervention is required for its survival. The management's external intervention in usually in three forms

1. Direction
2. Co-ordination
3. Control

All these activities usually force a result rather than depending on self-regulating mechanism.

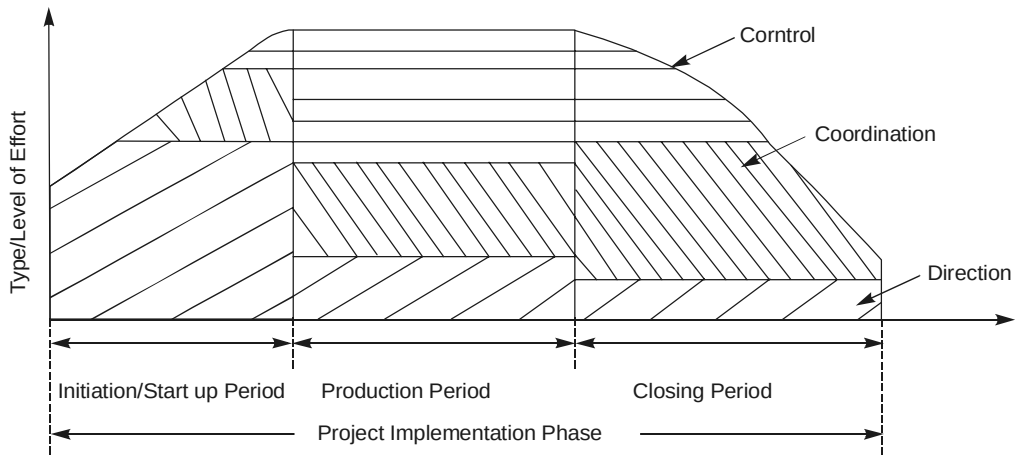



**Fig. 6.1** Management efforts schedule

The project can be divided into three periods according to the management efforts schedule which are listed below:

1. *Initiation / Start-up period*: requires lot of direction and co-ordination with little or no control.
2. *Production period*: once the project stabilizes the need of direction reduces, with co-ordination and control gaining predominance over direction.
3. *Closing period*: In this period the need for control reduces, with virtually no direction. Co-ordination plays a lead role for achieving results.

So for ensuring smooth progress of project and its successful implementation project direction, co-ordination and control are all required at some time but in right proportions and at right time, which has to be decided by the project manager.

### 6.3.1 Project Direction

It is the use of authority along the proper channels; ensuring that plans or schedules are enforced. When the schedules are authorized they can become working documents even work order. If the authorization is not there the plan, schedule may not go into work and scheduling system may change into mere paper work. So it follows that mere development of plans, systems and procedures would not produce better results unless authorized for proper implementation. This authority is enjoyed by project manager who delegates it to other members.

#### *Project Initiation or Start-up*

This provides start soon after issue of project charter and maximum direction is required at this stage. The project charter merely defines the broad scope of work and overall time and cost target but may not go into details. The charter authorizes project manager to spell out the details and issue directives for realization. At start up everything is vague, no one knows exactly what to do. The project manager during this period directs for:

- Scope of work
- Specification of results for completed work
- Division of work–Imported Vs. Indigenous, etc.
- Schedule and budget of work
- Systems and procedure for work.
- Authority and accountability for work.
- Co-ordination and control of work.

The success of project depends heavily on teamwork so directions can be formulated in form of project manual thorough involvement of project participants with instruction for strict adherence.

#### *Project Workshop or Kick Off Meeting*

The finalization of the scope of work, budgets, schedules and various other item listed earlier is normally initiated with project kick up meeting. The project manager in this meeting may make presentation regarding the scope of project, performance objectives, budget etc and provide clarification that any participant may seek for understanding the project and the extent of his involvement. The participants are then asked to draw up detailed work list with information or resource inputs and efforts required. The kick off meeting can be followed by a workshop where the overall project schedule, project execution plan and systems and procedures may be finalized after a through examination of various pros and cons. The kick off meeting and start up workshop may achieve the following results: co–ordination of project requirement and that of participating agencies, establishment of direction and controls, team building and communications.

#### *Project Direction During Production Stage*

During the production stage directions may refer to approvals of work schedules detailed budgets, specification, purchase order, work orders, construction drawings, miscellaneous expenses, change in baseline etc. Directions, which do not effect baseline or project goals are lower level directions. It is to be provided at appropriate levels down the hierarchy on day-to-day basis.

### *Purchase Order and Work Orders*

Direction to internal departments in organization can be passed through project charters, project manuals, circulars, inter-office memoranda, group meeting and personal meeting, which may not be on record. But direction to vendors and contractors must be on record along with the commitments and agreed corrective actions. The record of proceedings in form of *minute of meeting* (MOM) must be drawn and signed by all attended parties. The main directions to contractors are passed in documents form containing:

- Technical direction (specification, drawing)
- Commercial direction (delivery schedule, sequence, insurance, method of invoicing)
- Managerial direction (schedules, reports, meeting)
- Administrative direction (inspection notice, correspondence)

### *Communication*

It is said that for every bit of action there must be a communication and for every bit of communication there must be feedback communication. According to peter Ducker 60 percent of management problems are caused in whole or in part by faulty management communication. A two-way communication is not merely passing a message either top-down or bottom-up but it includes understanding of the message by the recipient. If the message does not get understood it cannot be effective communication. The receiver similarly has a responsibility for clarification and confirmation of his understanding. Communication becomes faster and effective with the use of latest technology. Communication devices are available to the user to bridge the gap like telex, telephone, hotlines, courier, Internet, etc.

## 6.3.2 Project Co-ordination

Co-ordination in a project is important because of need for simultaneous working, fast tracking or harmonious functioning. There are various activities, which can be started at the same time to save time in project completion. If a vendor is able to dispatch equipment earlier then the stipulated date, it will not do any good if work cannot be expedited. If all equipments are delivered, any work for erection left need for co-ordination will be much less. But if delivery and erection proceed simultaneously, it would serve no purpose to send equipment first and core equipment later. The coordination of all such activities is essential for its success to avoid either crowding of men or machine or shortage of items at critical time. Hence one cannot proceed in the execution of project without proper co-ordination.

The physical co-ordination includes the following:

- Squad check
- Co-ordination meeting
- Communication

Timing matching is again important for effective working of different groups working in a project.

## 6.3.3 Project Control

The control and controlling in the on going process which enables the project to flow on a pre-determined course. Take the example of motorcar to understand the terms '**control**' and '**controlling**'. The car has an accelerator steering, gear changer, brake, rear view mirror etc. that act as controls for the driver.

Using these controls the driver can manipulate the following:

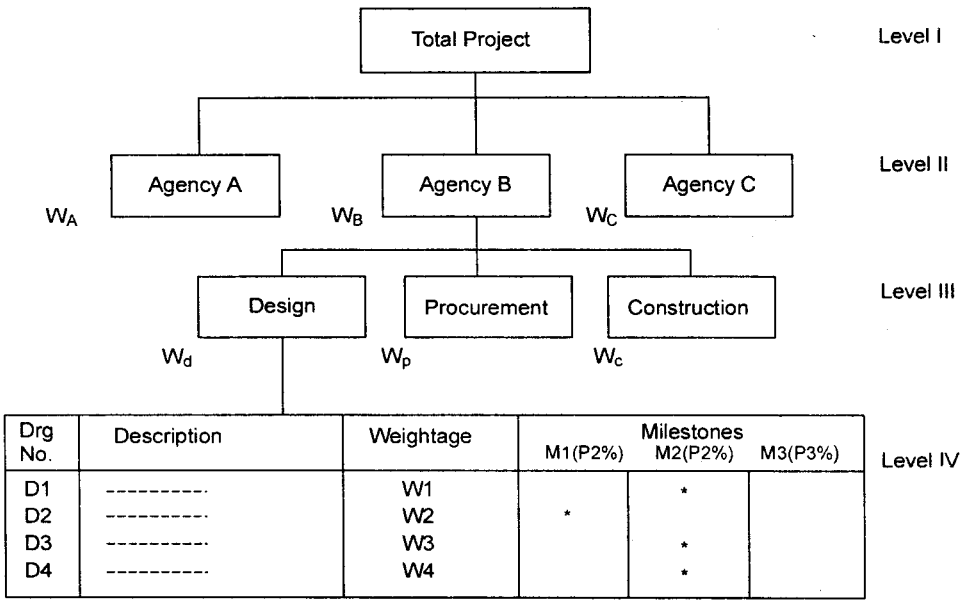
- Controls speed
- Ensures safety to self, car and third party
- Reaches destination while coping with various traffic conditions
- Reach on desired time
- Economize cost of running the vehicle

So designer provides controls and driver does the controlling part of it.

*The completion of work (100 percent completion) is the primary objective.* The basis of program control should be the tasks, which occur at the last level of Work Breakdown Structure (WBS), which is discussed in the following article.

## 6.4 PROGRESS MEASUREMENT

The complicated task of progress measurement has been illustrated with the help of work breakdown structure requiring aggregation of tasks and assigning of weightage to each WBS level using different milestones and proportion to the cost contribution in total project.




| Drg No. | Description | Weightage | Milestones M1(P2%) | M2(P2%) | M3(P3%) |
|---|---|---|---|---|---|
| D1 | ---------- | W1 | | * | |
| D2 | ---------- | W2 | * | | |
| D3 | ---------- | W3 | | * | |
| D4 | ---------- | W4 | | * | |

**Fig. 6.2** Progress measurement

Since all tasks cannot be measured by same units or milestone therefore weightage are assigned to each WBS level in proportion to the cost or effort contribution. Each level has contribution towards total installed cost/ effort of project. For aggregating either for scheduling or measuring actual progress we may use bottom-up approach i.e. starting from bottom. Using the figures and starting from level IV (bottoms-up approach).

$$\text{Design Progress} = \frac{W_1P_2 + W_2P_1 + W_3P_2 + W_4P_2}{W_1 + W_2 + W_3 + W_4} = D\%$$

Similarly computing procurement progress = $P$ %

Similarly computing construction progress = $C$ %

Now computing progress at $B$ using level III figures

$$\text{Progress of Agency} = \frac{W_D D + W_P P + W_C C}{W_D + W_P + W_C} = B\%$$

Similarly taking progress of other agency as $A$%, $B$%, $C$% for $A$, $B$, $C$ respectively

$$\text{Total Project Progress} = \frac{W_A A + W_B B + W_C C}{W_D + W_P + W_C} = P\%$$

### 6.4.1 Project Expedition and Follow-up

Expediting is a project management function and is required is all phases of project and for all aspects of work. Expediting engineer may be assigned the task of engaging vendors for timely manufacture and supply of equipment. This may be justified since industrial construction projects, equipment and material constitute nearly 70 percent of total project cost and invariably project are delayed due to late delivery of equipment or materials.

*The objective of expediting* is to ensure that equipment of right quality is delivered at the site, in right sequence and on right time to meet requirements of project. As per *Murphy law* '*if any thing can go wrong it will*' so it is necessary to *follow up* all commitments on a day-to-day basis till project is completed.

## 6.5 PROJECT CONTROL THROUGH LINE OF BALANCE (LOB)

For performance measurement in any phase the requirements of subsequent phases must be known so that the progress achieved in preceding phases can support the progress required in the successive phase. It is a matter of concern if actual progress in any phase of project falls short of the minimum requirement to support the feasible progress of downstream phases and project as a whole. In that case '*latest permissible situation'* is the bottom line, not the commitments with the help of *LOB (line of balance)* as shown below.

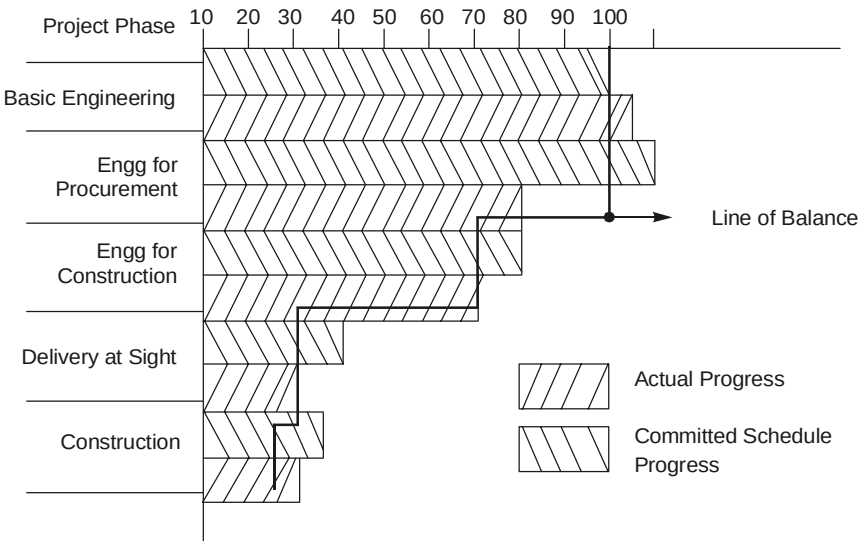



**Fig.6.3** Project control

Life cycle curves can be fitted into any project duration to reflect requirement of project and are drawn on *percent progress vs. percent duration axis*. As seen in the figure of LOB all areas except basic engineering are behind the schedule, *but the area, which requires expediting, is engineering for procurement*. This requires immediate steps to prevent delay, in form of release of requisition quickly.

## 6.6 COMMITTED ACTIVITY TARGETS AND RESERVED ACTIVITY TARGETS (CATS AND RATS)

CAT and RAT refer to Committed and Reserved Activity Targets respectively are control tools in the hands of project manager. The CAT would always try to swallow RAT as in the real world. Project management should try to maintain distance between the committed and reserved targets till the end. These schedules can be exhibited graphically in S-curve form as shown. The CAT schedule will be detailed and developed in squared network form where as RAT will be maintained in case from only. This will avoid any possible confusion and also of compliancy that may develop in the mind of execution agencies if the RAT schedule were made public. The RAT schedule were the key milestones where as CAT schedule will have all important activities and all milestones however the key milestones will be specially highlighted in the CAT schedule and these will be the targets which the project consultants would consider and make every effort to achieve.

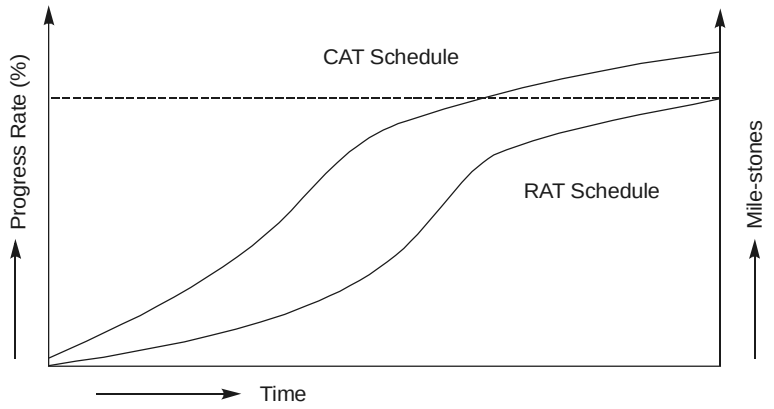



**Fig. 6.4** CAT–Vs–RAT

If the achievement of key milestones is delayed beyond the RAT schedule then only slippage will be accepted for reporting to financial institution and general public. The CAT and RAT schedule should be revised every time the cost estimates are revised so that a correspondence between cost and time schedule is maintained. With each revision the gap between the CAT and RAT will get progressively reduced. The CAT schedule at each revision will be based on actual commitments and information as available upto that stage the RAT schedule will add some allowance to the extent of inaccuracy anticipated at that stage.

## QUESTIONS

1. Discuss work schedule in context of project management.
2. Enlist the importance of Bar chart in project management.
3. Write the steps required for project direction.
4. How project control is exercised in project management?
5. How lone of balance helps in project management? Discuss briefly.
6. Explain the significance of Committed Activity Targets (CATS) and Reserved Activity Targets (RATS).
7. Explain the significance of work breakdown structure for project measurement.

7

# CONTRACTS MANAGEMENT

## 7.1 INTRODUCTION

Contract is an arrangement for acquiring authority over the external organizations for participation in the execution of the project. There is a trend in project management to buy from outside in case of excess work, need for specification, know-how or if it is possible to make it better qualitatively and economically. Since an external party is not bound by the in-house organizational discipline, a business contract is required for an assured behavior from the members of external organization. It may be required in an environment where authority relationships and responsibility delineations are unclear or inexistent. The survival of a company depends how wisely it selects its vendors and maintains good relations with them so that project is commissioned without time overrun and cost overrun.

Contracting is based on the principle that throughout the world, large and small industries are essentially interdependent, as it is not economically viable for any large unit to produce its entire requirement. Hence there is a need to subcontract or buy from outside source; particularly subassemblies and machinery. It is generally a subset of every project without which no project can be completed unless it is proprietary firm or small in nature.

The following techniques are generally used for making purchases. Spot purchases are resorted to in case of extreme urgency. The tender may be invited from one reliable supplier when purchasing monopolistic items, when the quality is of extreme importance or for purchasing 'C' class items (e.g. clips, pins, pencils, etc.) required urgently. This is known as a *single tender*. Tender may be published in newspapers, trade journals, magazines etc., for procuring materials of desired specifications. This system gets wide publicity, as it is open to every body. The vendor has to deposit an earnest money with the tender information. It is also called as *open* or *press* tender. Representatives of various sales organizations often approach various organizations to register themselves as vendors. In this system few reliable or registered vendors are written letters to send the price and other details for a particular commodity. After receiving tenders from vendors they are opened on due date and comparative statement is prepared. It is also called as *closed* or *limited* tender:

## 7.2 CONTRACTS

All projects cannot be executed with in-house resources and project manager has to requisition extra–organizational resources for project execution. Such an agreement can be termed as contract and authority so acquired is **contractual authority.** If this authority is acquired in house, through contract then it is **internal** contracting. All other contracts for the acquisition of authority can be termed as **business** contracts. Business contract is an agreement between two or more parties in writing, to do or not to do certain things. It is enforceable by law and legal consideration for payment in form of money.

The following elements have been recognized essential for a contract as per *Indian contract Act* 1872 and 1940. *Mutual assent* of offer and acceptance. *Consideration* to be made in return of specific promise contained in the offer of promiser. *Competence* of parties to be ensured. Under the law any person who has attained majority or is of sound mind or not debarred by law to which he is a subject may enter into contract. Hence it follows that minors and persons of unsound mind cannot enter into contract nor can any insolvent person do so. The anus of proving a party incompetent falls upon the person alleging it, as otherwise competency is presumed. *Lawfulness* of the object should be ensured. It should not be injurious to public interest or contrary to general social welfare.

The sequence of events resulting in business contract is as follows:

**Table 7.1** Contract sequence

| | |
|---|---|
| **Enquiry** | Issue of NIT (Notice Inviting Tender) to selected parties or to the notice papers by the project authority and sale of tender document. |
| **Offer** | Submission of tender document by the bidder. |
| **Acceptance** | Communication from the recipient of the offer to the bidder indicating intent to enter into an agreement and acceptance of same by bidder. |
| **Agreement** | Offer and consideration as accepted given a legal form and content duly signed by competent authorities of both parties. |
| **Contract** | It consists of an agreement on stamped paper, a details letter of intent with agreed variations and the original tender document. |

Simple *Notice Inviting Tender (NIT)* must be issued to select parties who are in similar business of contracting, or notice may be published in newspaper offering the opportunity to serve the project under defined conditions and rules. The NIT (notice inviting tenders) will act as an offer to public who may be interested in rendering the requisite service under preset conditions. The procedure of NIT as shown above, is generally followed in any contract before reaching the pre-qualification stage.

The format for Notice Inviting Tender (NIT) is given below:

**Table 7.2** NIT

XYZ PORT TRUST
MARINE DEPARTMENT–XYZ-100001

Sealed tenders are invited in two cover bids from qualified and experienced firms for carrying out pilotage perations for vessels calling at XYZ Port on contract for a period of two years.

| Tender No | Name of the work | Contract period | E.M.D | Cost of tender document | Sale period | Date of receipt | Date of opening |
|---|---|---|---|---|---|---|---|
| M–100/8/2002/Tech | Providing pilotage operations for vessels calling at XYZ Port on contract basis | 2 Years | 2.5% of rate quoted subject to the maximum of Rs. 1.00 Lacs | Rs. 1500/- in person. Rs. 1700/- by post. Spare copy Rs. 500/- | 0301-03 TO 23-01-03 | 30-01-03 15.30Hrs. | 30-01-03 15.30Hrs. |

The tender document can be had from the office of the Deputy conservator, XYZ Port Trust, Administrative Building XYZ 100001 with a request in writing on payment of Rs. 1500/-(Separe Copy Rs. 500/-)either by cash or demand draft in favour of Financial Adviser & Chief Accounts Officer, XYZ Port Trust, XYZ 100001. For further details, visit the port website *www.xyzport.com* before applying for tender document

*Deputy Conservator.*

## 7.3 TENDER

It is an offer to carry out the service with details description of terms and condition. A tender or quotation is in the form of a written letter or a published document (in news paper). The aim is to find price for procuring certain materials or to get a particular work done within the desired period and under specified conditions.

### 7.3.1 Factors Effecting Tender

- What are the pre and post qualification for being eligible to bid?
- What are the terms of the notice calling for tenders?
- Is it a single tender, a limited tender or global tender.
- Is it a sealed or open tender?
- What is the validity of the offer?
- Is there a repeat option?
- Is it a rate-contract tender?
- Or is the bid - a one time bid
- Are there pre-award meeting.
- Deviation permissible under the bid.
- Is there bid guarantee.
- Does the tenderer lease with the authorities concerned or is it the purview of project authority.
- Who is going to handle the matters of octroi entry tax, custom, demurrages and transit loss?

## 7.4 TENDERING PROCEDURE

The risks associated with the projects can become manifold if contractor selected for specific work is not competent technically, financially or managerially. So ensuring qualification of contractor is must.

Tendering procedure involves following:

- Pre-qualification of contractors
- Preparation of tender documents
- Mode of floatation of enquiry
- Receipt of tender
- Guidelines for evaluation of tenders
- Selection of contractor

### 7.4.1 Pre-qualification of Contractor

Notifications are issued 'in press', 'at embassies' etc with details of purchaser, project, tender submission date and instruction for applying for pre-qualification and its submission date. The pre-qualification document seeks information about financial statement, experience in specific work, and availability of resources like labour, plant, and technical aspects.

The data supplied by contractor is evaluated for short listing based on:

- Previous experience and contracts
- Past turnover and fund availability
- Necessary infrastructure, technical manpower and equipment
- Credibility and job performance

### 7.4.2 Preparation of Tender Documents

The purchaser prepares tender document in a detailed and clean manner as far as possible to define technical aspects and purchaser or contractor's share of responsibility. Tender document should include

1. Letter of invitation to tender
2. Instruction to tenderer
3. General Conditions of Contract (GCC)
4. Technical specification
5. Special conditions of contract
6. Scope drawing
7. Bill of quantities
8. General information about site
9. Form of tender

*General Conditions of Contract* (GCC): There are standard contract documents to ensure that parties entering into contract are appropriately protected against risks. It is advisable for parties entering into contract to take one of these documents rather than making on their own. This is because it is more likely to be more neutral without any inclination. Inclination is possible towards the party which frames and drafts contract. Some of the clauses include the following things: definition of terms, contractor to inform himself fully, security for due performance, Mistakes in information, patents rights, liability for accidents and damage, limitation on contractors liability, variation in scope, delivery, manner of execution, etc

### 7.4.3 Receipt and Evaluation of Tenders

There may be a pre-bid conference to clarify various issues to the tenderer's. Queries can be clarified through correspondence till due date for bidding. *On due date bids may be opened in front of tenderer's present*. The late submitters are disqualified. The tenders are evaluated from technical, commercial, contractual and managerial angles. Clarifications may be sought from contractor. *Normally the lowest bidder who is also technically and managerially acceptable is awarded the contract*. Agreement is signed on stamped paper. The contractor, for an insurance against uncertainties in dealing, may require form of guarantee.

### 7.4.4 Selection of Contractor

It should be noted that price should not be the only criteria for selection of contract/bid. A contract presumes that parties entering into a contact are competent and normal. The general condition for contracts (GCC) also lists provisions to protect against uncertainties arising during a normal course of work. The contactor selected for a specific work should be competent technically, financially or managerially else the risks may multiply manifold. Therefore a well laid out procedure must be adopted for pre-qualification of contactor. Certain factors such as financial capacity, technical infrastructure available and past experience have to be kept in mind before selection of the contractor.

#### *Objectives for Rating the Supplier*

The essence of purchasing is the rational selection of the supplier. Besides identifying potential and reliable vendors, maintaining updated records on their performance is vital for purchasing operations. The consequences of choosing the wrong type of suppliers are serious both financially and operationally. A supplier's default may sometimes be more serious than a

buyer's mistakes. It is necessary to educate the supplier with a view to improve his performance. It is desirable to compare one vendor's performance with other to improve the overall reliability. Just as buyer tries to rate the supplier, seller also rates the buyer with regard to his authority, technical knowledge, professionalism, and commitment to promise. Purchase department has a sole responsibility for the choice of supplier and placing the order. Hence it is necessary to access the vendor's performance on an objective basis, based on price, delivery, quality and service aspects, in order to fulfill the objective of getting a quality product at minimum costs. Unless the vendor sends material of proper quality, all the previous efforts and time spent by the buyer become useless and delays while the replacement and settlement causes loss. The technical, managerial, financial, personnel, and service aspects are must for making vendor's rating.

**The following things should be kept in mind for vendor rating:**

- Vendor's reputation as a reliable and financial strong company.
- Suppliers proven integrity by past performance.
- Supplier's commitment for warranty, guarantee and quality.
- Supplier's cost reduction programmes by using scientific method.
- Labour – management relationship in the seller's plant.
- Adequate design and development wing for technological challenges.
- Supplier's capability for analytical engineering, installation and commission engineering.
- Capacity to train buyer's engineer.
- Ability to meet challenging and new task by technical leadership.
- Research efforts leading to general advances.
- Quality to the after- sales- service and spare parts availability.
- Dependability and reasonable price to other sales-service.
- Ability to provide maintenance contract needs of the buyer.
- Assurance and conformance of minimum delivery time schedules.
- Reserve production facilities for emergency requirements.
- Supplier diverting to other customer in terms intended for one.
- Vendor not becoming insolvent after taking money.
- Selling a range of full time of related items.
- Credit availability and financial arrangement of seller.
- Local contracts and their technical competence to help.
- Supplier's reputation enhancing product sales of buying firm.
- Vendor's capacity to provide selling aids, drawings etc.
- Managerial effectiveness of suppliers organization ownership pattern, and professionalisation of personnel.
- Status and operational reliability of seller's plants.
- Financial status of supplier, certified by bankers.
- Record of labour disputes at seller's plant and their impact on buyer's requirement.

## *Vendor Difficulties*

The large range, variety, sizes and number due to technological upgradation, forces the vendors to be highly selective in stocking the spares leading to customer dissatisfaction.

Communication and transportation bottleneck with customers located in far-flung areas is a major issue. Officers often blame the suppliers for all troubles without following the maintenance schedule of equipment and operating them according to service manuals.

### 7.4.5 Seller's Frustrations

The buyer does not have sufficient authority to exercise sound judgment in taking decision creating embarrassing situations. The delay in account settlement is one of the major deterrent for a seller. Unwarranted and wavering policies are sometimes adopted by the buyer in rejecting goods, when not needed. Inordinate delays in buying decisions with continuous change in delivery orders leading to even abrupt cancellation of order without notice. The buyer does not adhere to recommended operating and maintenance manuals and communication on problems observed not reported immediately.

#### *Vender Rating Index (VRI)*

VRI given below can help in selecting of contractors. If there are several contractors their performance is rated according to:

- Quality
- Delivery
- Price
- Service

VRI = VRI (Quality) * A + VRI (Delivery) * B + VRI (Price) * C

Where A, B, C are the weights given to 3 venders rating index based on quality, delivery and price by material manager.

- VRI (Quality) = Number Rejected/Number Received
- VRI (Delivery) = Number delivered on schedule/Number of delivery
- VRI (Price) = Lowest price bid/Price bid by vender

## 7.5 ROLE OF RESPONSIBILITY, REIMBURSEMENT AND RISK IN CONTRACTS

### 7.5.1 Responsibility or Scope of Work

Most of the problems in contracting arise because of improper definition of scope or assigning of responsibilities. The parties involved may have different understanding regarding scope of work and responsibility giving rise to utter confusion. This may even lead to charges of evasion of responsibility, extra claims, ill feeling, strained relationships and above all delay and additional cost in completion of the project. There are reasons for allowing ambiguities in contract, which are both technical and political. The owner may not like to define everything clearly and technically in order to keep some flexibility to play with scope of work. The contractor may not like clear definition since he may not be able to make extra claims and earn disproportionately high reimbursement for any additional work. But it is in interest of both parties to the keep ambiguities to the minimum.

**Responsibility involves following major issues:**

- What to parcel out to contractor and what to retain
- How to define work parcels so that contractors know their scope precisely and there is no overlapping, undefined unallocated or ambiguous work areas
- Deciding the relevant performance parameters for fulfillment of which contractors must assume responsibility.

### 7.5.2 Reimbursement

This is more important for contractor than the owner. The type of reimbursement can be mainly lump-sum or cost plus. Generally the owner prefers **lump-sum** contract since he can know at very early stage his project liability and also if he is going to be within approved budget or not. His anxieties will be less. The owner's impression that '*lump-sum contract is more economical than cost plus*' may not prove right, since while building detail he has to take contingencies.

### 7.5.3 Risk

It is very difficult to forecast the outcome of project in separate parts. The significance of risk can be understood from the fact that maximum content on contract deals with it. The contract itself is considered an instrument for transfer of risk from owner to the contractor, which the contractor resists. But while contractor risks only his fee, owner runs the risk of not having any plant at all. Only small risks can be covered by insurance, which is not a financial policy. However most of the risks are usually covered when contracts are awarded through a proven contracting process.

***Owner's risk* is due to the following factors:**

- Will the contractor be able to carry out work as per specification
- Can the work be completed within quoted cost and time
- Will the plant perform at the required level
- Will contractor stay on job till its completion
- Will contractor co-operate with owner and rectify defects later
- Will relationship click
- Does he understand his intent fully

***Contractor's risk* is due to the following factors:**

- Termination of work before its completion
- Prompt payments and making of projects
- Reimbursement for extra claims honoured
- Penalization for failures beyond his control
- Interruptions in progress and change of scope
- Compensation for pure escalation

## 7.6 TYPES OF CONTRACTS

Selection of the type of contract for the project requires proper judgment. So decision is made after considering total project environment, availability of contractors, criticality involved, ongoing economic activity and workload of contractor.

Broadly the business contracts can be divided into two groups. These are:

1. Turn-key contracts
2. Non turn-key contracts
    - Piece work contract
    - Lump-sum contract
    - Cost plus contract
    - Labour contract
    - EPC contract

### 7.6.1 Turn-key Contract

There is a general observation that by reducing the number of contractor better project can be ensured. In a turn-key project a single contractor has complete responsibility to supply the owner a plant which is complete and ready for the owner to operate by simply turning the key. Turn-key is not necessarily a fixed price-lump-sum contract but it is quite possible to enter into a turnkey reimbursement contract. This allows consultancy organization to undertake projects without capability of supply and finance.

Since the contractor of a turnkey project is expected to do everything right from scratch, the scope of contract covers all areas of the project, viz., design, engineering, construction, structural work, supply and erection of plant and machinery, supply of spares, testing and commissioning. Since a single contractor does the entire work, turnkey contract agreements invariably have a clause on performance guarantee.

### 7.6.2 Piece-work Contract

In this method of contract, the contractor agrees to execute a specific work for a specified rate with out reference to the quantity/magnitude of the work involved, or the time taken for completing the specified work.

### 7.6.3 Lump-sum Contract

In this system, the contractor agrees to execute the work completely in all respects, within the stipulated time, in accordance with the drawings, designs and detailed specifications and for an agreed sum. Payment of the agreed sum to the contractor is made on the strength of a work-completion certificate issued by the engineering-charge. Since this type of contract is used for major project, time of completion of work is a crucial factor. The time limit with in which in the work is to be completed is given in the contract and penalty for slow progress is also included as one of the conditions of the contract.

### 7.6.4 The Cost Plus Percentage Contract

The cost plus percentage is pre-determined and provided in the contract. It is meant to take care of overhead charges and also to provide the contractor with some profit margin. In this method the contractor uses his own materials, labour and executes the work according to the drawing and specification. The contractor keeps proper accounts of the material and labour charges. The owner keeps close control during execution to ensure the quality of material and specification. After completion of work the contractor is paid some percentage above the actual cost of execution.

### 7.6.5 Labour Contract

Thus, the contract is entered into only for the labour portion of the project. This type of contract is chosen when the project promoters do not want to compromise on the quality of material to be used.

### 7.6.6 EPC (Engineering, Procurement and Construction)

This method of contracting is a step behind the turnkey approach where the contractor is responsible for complete engineering, procurement and construction of entire project complex. The contractor is also responsible for process design and basic engineering of 'open art process units' although process design and basic engineering of licensed units is obtained from process

licensers through the EPC contractor or directly by the owner. EPC represents traditional approach where MSC (multi-split contracts) require project implementation (execution) to be performed in different phases by different contractors. The turn-key project management may be said to be its breed.

## 7.7 TYPES OF REIMBURSEMENTS *VS* TYPES OF CONTRACTS

The table given below summarizes the various types of contracts and reimbursements used in practice:

**Table 7.3** Reimbursement of contracts

| *S No.* | *Type of Reimbursement* | *Type of Contracts* |
|---|---|---|
| 1. | Lump-sum contract<br>Lump-sum<br>Negotiated lump-sum | System contract, Know-how contractor, Turkey contract, Management contract, Detailed engineering contract |
| 2. | Cost plus contract<br>Cost plus percent fee (Installed plant cost + percentage fee turn key contract)<br>Cost plus fixed fee<br>Cost plus with guaranteed maximum<br>Cost plus incentive and guaranteed maximum (target cost contract)<br>Fixed rate contract (Agreed rates per man hour/ per man day) | Prime contract |
| 3. | Item rate contract (Contractor offers a unit rate against each item, either approximate quantity introduced or not mentioned) | Supply contract |
| 4. | Convertible contract | |
| 5. | Hybrid Contracts<br>Lump-sum + Item rate<br>Lump-sum + Cost plus<br>Lump-sum + Fixed rate | |

## 7.8 SUB-CONTRACT

The main contractor can entrust some of the work to the sub-contractor when a major work is undertaken. In that case there can be separate contract between the main contractor and his sub-contractors. The project promoters are not liable to make any payment to the sub-contractor, which is the liability of the main contractor. In some sensitive works, if it is felt that sub-contract shall not be permitted, suitable clauses to this effect should be incorporated in the main contract.

## 7.9 TEAM BUILDING

Any amount of contractual clauses cannot make a team; instead working in teams prevents need for contract. It has to be emphasized that contract or no contract the success of a project will depend on whether the people who have been brought into its fold will willingly co-operate with each other or not. The people participating in a project must work as a team and project manager could use the 7'Cs model for building up the team. They are

- **C**onceiving,
- **C**oncurring,
- **C**ommitting,
- **C**ommunicating,
- **C**o-ordinating,
- **C**ounseling
- **C**ontrolling.

They should consistently relate, support and supplement each other for the common cause.

## 7.10 EARNEST MONEY DEPOSIT (EMD)

Before entering into a contract a contractor has to bid for it. While bidding in his specialized area a nominal amount of money is to be deposited along with necessary tender documents. This ensures his active participation in competing with other similar contractors and acts as a guarantee for his commitment towards the offer he has made to the project authorities. This nominal amount deposited while bidding, labeled as *earnest money deposit*. It is associated with all the major and minor works these days. Essentially this clause is included to safeguard the interests of genuine contractors and prevent frisky contractors from spoiling the competitive terrain. The money generally varies between 2.5% to 3.5% of the value of tender. In many of contracts the amount so deposited is refundable if the bidder fails to strikes the contract. But in some cases the authorities may forfeit the amount. In all probability the earnest money acts as a protective agent indicating seriousness of the party in bidding.

## 7.11 RETENTION

Retention money is generally considered as contractual safeguard and not as a cheap form of finance. This is the amount of money due to a contractor for executing the contract during the project implementation. In general the money due to a contractor is not released in lump-sum, instead is remitted in different installments. Usually the payments are made as follows

- 10 per cent of the contract amount with the order
- 80 per cent of the contract amount or work completed, on delivery
- 5 per cent of the remaining amount on take over
- 5 per cent, i.e. balance on final acceptance

While fixing the level of retention money one should consider that no higher amount is retained than what is reasonably necessary. Where the works are completed and taken over in sections, the retention money should be released on a sectional basis. Therefore it is some percentage of the bill value, which is retained by the project authorities at the time of making payments. In general, retention money may be paid after completion of the project or after the maintenance period. Percentage deduction towards retention varies from bill to bill and ranges from 5% to 10% of the bill amount.

## 7.12 LETTER OF INTENT (LOI)

This is letter issued to the successful tender intimating about his/her offer being accepted. LOI is issued before signing of the contract by the two parties. The successful tenderer is required to intimate any condition with in the stipulated time. Issue of LOI by the project promoters and acceptance of the same by the successful tenderer does not obviate the need for signing a contract. Since LOI is not a legal document, the two parties have to necessarily execute the contract by signing the contract agreement.

## 7.13 ENSURING BETTER CONTRACT MANAGEMENT

Since a substantial portion of project is typically executed through contracts, proper management of contracts is critical to the successful implementation of project. Following points are to be kept in mind for ensuring better contracts management:

- The competence and capability of all the contractors must be ensured -one weak link can jeopardize the timely performance of the contract.
- Proper discipline must be inculcated among the contractors and suppliers by insisting that they should develop realistic and detailed resource and time plan, which are congruent with the project plan.
- Penalties, which may be guaranteed, must be imposed for failure to meet contractual obligations like wise incentives may be offered for good performance.
- Help should be extended to contractors and suppliers when they have genuine problem-they should be regarded as partners in a common pursuit.
- Project authorities must retain latitude to off load contract (partially or wholly) to other parties well in time where delays are anticipated).
- Number of contract packages should be kept to minimum to ensure effective co-ordination.

If global tenders are floated for a turnkey project it is likely to be bagged by foreign suppliers. Though the dependence of foreign suppliers seems to be advantageous from point of view of time and cost but it would also mean out flow of foreign exchange and not encouraging indigenous technology. While over reliance on indigenous supplier may mean delays and technical performance uncertainties. So judicious balance is to be sought which moderates foreign exchange outflow and given reasonable fillip to development of indigenous technology.

## 7.14 BOOT PROJECTS

BOOT stands for Build-Own-Operate-Transfer is a latest outgrowth of hue and cry over boosting private sector involvement in development of major projects. This term was introduced by Turkish Prime Minister and is becoming trend in developing countries for encouraging private investment by offering several concessions. Using BOOT government involves private sector for a infrastructure or transportation project (Normally public sector project) building initial operation and after a limited period (say a 25 year concession) transfer back to government.

BOOT can be defined as ' A project based on granting of concession by the principal, usually a government to a promoter sometimes known as concessionaire who is responsible for constructing, financing, operating and maintaining the facility over the period of concession before transferring the facility at no cost to the principal as fully operational facility. During concession period the promoter owns and operates the facility and tries to recover the costs of investment, maintenance while operating the facility to result in a margin of project.

### 7.14.1 The Major Components of BOOT Project Include

- **Build design**: procure, manage, construct and finance the project implementation.
- **Own**: Own the asset during concession period and the license for the equipment used.
- **Operate**: manage and operate plant, carry out maintenance, deliver product/ service and receive off take payment
- **Transfer**: Hand over the plant in operating condition at the end of the concession period.

### 7.14.2 Projects Suitable for BOOT Contracts

Country highways, bridges and tunnels, water, gas or oil pipelines and hydroelectric facilities are considered suitable projects as a private economic equilibrium is obtainable. However the subsidies are often necessary for high-speed train network and light rail trains as prices paid by user are often low and government generally prefer to control prices. The characteristics of BOOT projects are particularly appropriate for infrastructure development projects such as highways roads, mass transit railway and power generation and as such they have a political dimension of public welfare that is not the feature of other privately finance projects.

### 7.14.3 Advantages of BOOT Projects

- Promoting private investment
- Completing projects on time without cost overcomes
- Good management and efficient operation
- Transfer of new and advanced technology
- Utilizing foreign companies resource
- Injecting new foreign capital into the economy
- Providing additional financial source for priority sector project
- Allowing no inroads on public dept
- Releasing the burden on public budget for infrastructure development
- Creating positive effect on the credibility of the host country.

The other variations of the *BOOT* structure are

- DBFO (design-build-finance-operate)
- DCMF (design-constructed-managed-finance)
- BOO (build-own-operate)
- BOLT (build-operate-lease-transfer)
- RLT (rehabilitate-lease-transfer), etc. schemes.

***Example:*** ABC supplier has made 17 deliveries on time out of 20 orders placed on them has given an average of 5% rejects and delivered items at the performance index of Rs. 110/- when the average price performance index is Rs. 100/- weightage, for delivery 40, quality 30, price 30. What is rating?

***Solution***

Delivery Index= (No of lots delivered on schedule/ Total no of lots delivered) × 100

$D = (17/20) \times 100$

$D = 85$

Quality index = ( No. of lots accepted/total no. of lots) × 100

$Q$ = ((100-5)/100) × 100

$Q$ = 95

Price index = (Lowest acceptable price index/price bid by the vendor) × 100

$P$ = (100/110) × 100

$P$ = 90.90

Overall vendor efficiency index = (0.40 × $D$) + (0.30 × $Q$) + (0.30 × $P$)

= 89.77

**Table 7.4** Vendor ratings

| *Factor* | *Weightage* | *Performance* | *Evaluation* |
|---|---|---|---|
| Delivery | 40 | 17/20 | 40 × 17/20 = 34 |
| Quality | 30 | (100 – 5)/100 | 30 × 95/100 = 285 |
| Price | 30 | 100/100 | 30 × 100/110 =898 |

## *QUESTIONS*

1. Explain what is contracts management.
2. Discuss the procedure for awarding contracts.
3. Discuss the tendering procedure in brief.
4. On what basis the selection of vender is made. Explain briefly.
5. Explain the role of responsibility, reimbursement and risk in contracts management.
6. Discuss the types of contracts used in practice.
7. How does sub-contacting help in project management? Briefly explain.
8. Enlist the advantages of BOOT projects.

8

# PROJECT MANAGEMENT PERFORMANCE AND CLOSE OUT

Ideally a project will be considered totally successful if it gets completed on time, within budget and performs exactly to the designer's specifications. But this is a tall order and many projects would not meet these requirements. Tradeoffs have to be accepted between various performance parameters for effective management of a project.

Project may be considered a total failure in following cases:

- Abandoned half way or kept in abeyance or completed with a changed concept
- Does not produce as specified in terms of quality of produce
- Becomes sick soon after going into commercial production

So in real life a project cannot be considered either a total success or a total failure-it would fit somewhere in between. The investor, project manager and also the public who are watching the project are all very keen to know how the project is being managed, while in progress.

## 8.1 FACTORS INFLUENCING PROJECT SUCCESS

**The following factors have an influence over the direction of project success:**

- Clearly defined goals
- Support of top management
- Competent project manager
- Competant team members
- Sufficient project resources
- Client involvement in defining needs and requirement
- Adequate communication channels
- Involvement of all parties in project review and corrections
- Consulting with users and keeping them informed
- Technology being implemented has been reviewed and critiqued and works well
- Clients understand the usefulness of the project
- Control measures to keep project on track
- Daily trouble shooting and resolution of problems

## 8.2 FACTORS RESPONSIBLE FOR PROJECT FAILURE

**The following factors have an influence over the direction of project failure:**

- Inadequate skills reflected in approach
- Unsupportive top management

- Project manager unable to cope up with the demands of project
- Ignoring the systematic nature of projects with hardware, software, and other resources handled precisely in an independant manner
- Inadequte communication in the project
- Failure to involve the user
- Inadequte project planning
- Insufficient project definition
- Improper estimation of time and resources
- Incorrect scheduling and handling of resources
- Enormous changes during the last implementation phase
- Inadequate control
- Project termination poorly planned

## 8.3 PERFORMANCE INDICATORS

**The following performance indicaters will give a clear idea about the program of the project.**

- Time Overrun
- Cost Overrun
- Project Sickness
- Productivity
- Value Analysis

### 8.3.1 Time Overrun

The zero dates are not same and the meaning of completion may also differ from project to project. But many people would not be interested in the technicalities of a schedule. In order to get a project cleared through the approving authorities a schedule may be fixed up which can be far from realitic. The vendors and contractors would only add to the confusion by promising deliveries, which can make anything possible on paper. Besides a defective design and subsequent modification/change to suit the project's requirements also increases time and cost. How much time a project eventually takes and who contributed to overruns—these are questions that no one can answer without doing some research. In such circumstances for most projects, *time overruns* cannot be used as *true indicators* for project management performace.

### 8.3.2 Cost Overrun

The situation, however, is not so vague regarding cost. While time can be misquoted, cost cannot. Anything done to a project, including time overrun would be reflected in the cost. If a project is not managed well, its cost will go up; conversely, if a project is managed well, its cost should come down. Therefore, cost can be used as an indicator for project management performance. But cost estimates in a project, as we have discussed before, are to be revised at various stages to improve their accuracy, and they invariably increase after every revision. *Cost overrun*, the expression, which is used to represent the variance between the original sanctioned cost and the final cost incurred, would then provide no indication of managerial performance.

### 8.3.3 Project Sickness

Whatever a project manager does with respect to the resources will be reflected in the cost. The project manager also provides resons to justify the cost of plant which, to be called successful, must produce a *saleable output*. The ratio of this output to the cost incurred for putting up the plant could be an indicator for project management performance also indicating the state of health of the plant.

Considering cement plant example, a project will be considered to be healthy when the plant produces cement conforming to ISI specification at a saleable cost. The performance of a particular cement project will be considered better than another only if the cost per tonne of cement produced by it is lower than the other, possible only by use of better technology. The performance of the plant is also dependent on *quality* of project management. The quality of the plant and equipment selected will decide the cost of utilities, repairs and maintenance. Depreciation, which makes a contibution of almost 33% to the production cost, is due to installed cost for which management alone is responsible.

If a project is implemented at a lower installed cost, the plant performance will be so much better; if not, the plant faces the risk of falling sick. The plant performance can not be measured till the project goes into commercial production, but the project manager is fully responsible for both *installed cost per tonne and production cost per tonne e*lse a project may fall sick. The project may also fall sick later due to mismanagemet of its operations, but the project manager cannot be held resposible if the installed cost per tonne was at par with the industry average and perfomace parameters were achieved exactly as per specification.

### 8.3.4 Productivity as Performance Indicator

Installed cost per tonne reflects the productivity of project execution just as operating cost per tonne reflects the productivity of an operating plant. A productivity indicator reflects how resources have been utilized either for production of goods and services or for creation of facilities for the same. Therefore, productivity must be measured not merely for evaluating the performance of project management but mainly to ensure profitability of plant and ward off sickness.

### 8.3.5 Value as Performance Indicator

Value engineering effort should be aimed at controlling the scope and specifications, since scope for cost control is maximum during design end engineering phases. Value engineering encourages increase in quality if it can be attained at no extra cost. Value can be expressed as performance, improves only when performancr is achieved at no extra cost or when cost can be reduced for desired level of performance.

## 8.4 APPROACHES TO PERFORMANCE ANALYSIS

Many good projects as well as project management structures have failed because the inability of the system to evaluate its performance. Performance of system as well as personnel is to be measured at regular intervals. This involves considering of factor such as techinal judgement, work planning, communication, co-operation, initiative, quality, work hebits, profit contribution, notivation level, etc.

Mordern method of performance analysis (also called Earned Value Analysis) provides an analytical framework forproject control by estimating factors like cost variance, time variance, schedule variance, cost performance index, schedule performance index, estimated cost performance index etc.

### *Budgeted Cost for Work Scheduled (BCWS)*

It is the value of the work that should have been completed at the scheduled date as planned. It includes budgets for all work packages, in process work and overheads.

### *Budget Cost for Work Performed (BCWP)*

It is the budegeted cost for completed work. This is computed by taking the sum of the budgeted costs of all work packages actually completed, in process work, overheads in addition to the subjective estimates of the work packages yet to be completed.

### *Actual Cost for Work Performed (ACWP)*

It is the cost actually incurred in completing the wok accomplished with in a particular time period.

### *Budget Cost for Total Work (BCTW)*

It is sum total of the budgeted cost for the entire project work.

### *Additional Cost for Completion (ACC)*

It is the estimated additional cost required for completing the project.

### *Cost Variance (CV)*

It is the difference between the actual expenditure made in the project till the date of review and value of work accomplished for the expences incurred

$$CV = ACWP - BCWP$$

### *Cost Performance Index*

$$CP\ Index = BCWP/ACWP$$

### *Schedule Variance (SV)*

It is the difference between the value of work that has actually been completed and value of work schedule to have been completed.

Schedule Variance = Budget cost of work performed – Budget cost for work schedule

$$SV = BCWP-BCWS$$

### *Schedule Performance Index*

Schedule performance Index = Budeget cost for work performed/Budeget cost for work schedule

$$SP\ Index = BCWP/BCWS$$

### *Time Variance (TV)*

It gives the time difference equivalent of the value of work to stay on schedule.

### *Estimated Cost Performance Index*

ECP Index = Budget cost for total work/Actual cost for work performed+Additional cost for completion.

$$ECP\ Index = BCTW/(ACWP + ACC)$$

***Question:*** A company has bagged a fixed cost contract for the supply, installation, testing and commisioning of 100 computers of same specification at a cost of 300 Lakhs. The company had estimated that it couled supply install and commission 10 computers per day so that the entire work couled be comleted in 10 days time. The project status was reviewied often the completion of 8 days. It was noted that at the time of rivew only 60 computers have been installed and the cost incurred was Rs 190 Lakhs. It was estimated at the time of review that a sum of 130 Lakhs wouled be required for comleting the pending work viz. installation of remanning 40 computers. Make performance analysis by arriving at the various connected parameters.

***Solution***

Work scheduled per day 10 computers install a time work scheduled for 8 days × 10 = 80

Budget cost of one installation 300/100 = 3 Lakhs

Budeget cost for work scheduled (BCWS) = 80 × 3 = 240 Lakhs

After 8 days only 60 computers have been installed

Budget cost for work performed (BCWP) = 60 × 3 = 180 Lakhs

Cost Variance (CV) = BCWP – ACWP = 180-190 = (-) 10 Lakhs

Cost Perfornance Index (CP Index) = BCWP/ACWP = 180/190 = 0.947

Scheduled variance in cost terms (SV) = BCWS –BCWP = 240 –180 = 60 Lakhs

Scheduled performance Index (SP Index) = BCWP/ BCWS =180/240 = 0.75

No. of installing required to be completed after 8 days = 8 × 10 = 80

No. of actual installing complete = 60

Short fall = 80 – 60 = 20

Time variance is the time equivalent of work, which has to be completed to stay in schedule i.e. the number of days required to make good the shortfall of 20.

Time Variance (TV) = Short fall/ Rate of installation per day = 20/10 = 2 days

Estimated cost performance index

ECP Index = BCTW / (ACWP+ACC) = 300/(190+130) = 0.9375

## 8.5 PERFORMANCE IMPROVEMENT

A comparison of 'Do it yourself' and 'Turnkey approach' to contract

### 8.5.1 Do It Yourself Trap

Project management perfomance is ultimately gauged by the cost therefore people would are *tempted to exploit every means to reduce cost*. It is a normal belief that doing everything ourselves is the cheapest way to do it. Thinking along this line of action the owner may try get all work done inhouse In such case he engages a team, which will fabricate as much as possible at his shop, order only those items which are mostly proprietary in nature, engage labour contractors for construction and supervise the design, look after procurement and construction work. Unfortunately these may be the project, which have *maximum time and cost overrun* defeating the very objective of their setup. They are also the ones where quality is ignored. The main drawback with this thought is that it imposes a tremendous load of coordination on a working group, which has no experience nor is equipped with the tools and techniques of project coordination. The persons working with a production background do not have the experience of working in an uncertain and dynamic work environment, which is characteristic

of a project. Therefore in most cases they are not able to project or foresee what may happen and take necessary actions leading to excesses in schedules and budgets.

To avoid any possible difficulty during operation, the operating people may expand the scope of the project for the sake of unlimited flexibilities, increasing the cost of the project. Further, the scope never gets frozen fast, as there is no hurry to package it out to any one at minimum cost. The operating personel have higher priorities for modifications, which would ensure better operation of the plant rather than completing the project on time bound schedule. Further the project team with a ***production*** background invariably turns out incomplete purchase specifications and commercial conditions, which are sometimes, exploited by vendors and contractors to the extent that the *extras* tend to surpass original price. The owner may find himself tied to a contract with many of these unscruplous types who are only intersted in picking up payments without any business ethics. A project in such a case faces acute problem and does not get completed easily.

Almost similar situation exists at the ***construction site*** with the contractors. Since competitive bidding does not leave much margin to the contractors, they continuously look for *extras* to improve their margin. If the owner's supervision is not experienced, the contractor may do certain things, which may not be in the interest of the project. The contractor may build defensive records with legal overtones, which not only increase the cost burden for the owner, but also land him in the court. Thus 'do it yourself' concept may become a trap for some because *cost of not having enough experience outweights any apparent advantage in one's handling the project all on one's own*.

### 8.5.2 The Turn-key Trap

The lack of expertise may induce the owner to go for a turnkey approach for efficient execution of a project. The owner in this arrangemnt expects the turnkey contractor to take care of all troubles of project execution and hand over the key to the owner when the plant is ready for operation. Some believe this to be the surest way to complete the project not only in the shortest possible time but also at least cost.

But things may not work in the desired way. Since a turnkey contractor has to earn a profit from his supplies therefore he will go for the tightest possible design and compromise the quality of work as long as it does not affect his grarantees. If there is a heavy penalty for schedule overrun he may engage a team of advocates to build up defensive records and bail him out. Instead of paying penaltly a turnkey contractor may earn more by delaying a project, as the owner wil be too willing to accept substandard things and pay additional prices for items for the sake of schedule.

#### *A Case Study: A Turnkey Approach**

XYZ Company Ltd wanted to deversify into a new product line. Since they did not have the necessary know-how, and also wanted to put the product in the market at the earliest they decided to go for a turnkey contract. They were aware that going turn-key may cost them more; but they were hopeful that the revenue from early production would outweigh the additional cost. Since the XYZ Company did not have the know-how they appointed a technical consultant to prepare the bid package, evaluate the bids and make recommendation. Though

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**** Source :*** S Choudhary, *Project Management* (Tata McGraw Hili, 1988)

the company was keen to float the enquiry immediately, it could not be done as the consultant took several months to prepare the bid package. The company was not prepared for this and wanted to make up the delay by setting a still tighter completion target for the turnkey contractors.

The bidders did not agree to submit their bids by the due date and the date had to be extended. When the bids were finally received the owner was disappointed to find that no one had agreed to deliver the plant by the target set by him. Also, the prices quoted by the bidders were much higher than his estimate. The owner had to engage himself in prolonged discussions for reduction of price and improvement in schedule. Since all the bidders were manufacturers of the main plant equipment they were not keen to take up civil and electrical work. The owner agreed to take out this part of the work from the bidders scope as it was explained to him that this would bring down the cost of the project. The bidders also suggested that the owner should procure the proprietary items on which they are adding their 'mark ups'. But the owner did not agree as it would dilute the turnkey responsibility and also increases coordination and hence disturb the project schedule. As there was recession in industry, the bidders were keen to win the contract and, therefore, accepted the owner's stipulation that for the items not manufactured by them they should work as the owner's agents and receive a fee for their services. The owner would reimburse the successful bidder for the cost of these items.

The owner did not stop at this stage. He started negotiation simultaniously with all the bidders in order get a heavy discount on the price of the main plant and machinery and also a crash schedule. Finally, he could make one bidder agree to his crash schedule but on condition that there would be no delay in the release of payments. The bidder also insisted on a 25% advance along with the *letter of intent (LOI) and an unconditional letter of credit (L/C)* for the entire contract amount after six months of issue of the LOI. The owner agreed to pay the advance in a phased manner. It was agreed that release of advances would be linked to a programme of supply of load data and general arrangement drawings by the vendor. This, the owner thought, would ensure him to make the civil work ready in time for erection of the plant and machinery. The owner also made the contractor agree to a penalty/bonus clause in order to ensure that the contractor makes all out efforts to complete the project on a crash schedule and meets guaranteed performance.

The project started slipping almost from the first day. Expect for the first lot of load data and drawings, the contractor could not stick to his drawing release schedule as he was not able to place orders for bought outs as per plan. He could not even start manufacture of main plant and machinery in his shop immediately due to delay in supply of manufacturing drawings, non-availability of materials and existing shop-load. It soon became clear that the rate of progress demanded by the contract was not achieveable. The contractor, however, attributed the delay to uncertainty perecieved at his end about the project due to the owner's not finalising the agreement. The signing of the agreement was delayed from the owner's end by almost three months but the contractor assured that the owner would make up the delay in the subsequent months.

The following months brought tremendous pressure on the contractor for the supply of load data and *general arrangement* (GA) drawings. The owner had already lined up a civil contractor and was unable to feed the civil contractor the structural drawings according to the agreed time schedule. However, submission of load data and GA drawings to the owner was getting more and more delayed. It was observed that the contractor did not pass on any advance

to his sub-vendors in a like manner as was done by the owner. Accordingly, sub-vendor data were getting delayed. However, at owner's insistence, a team was sent to the various sun-vendors' offices and the team collected considerable amount of data across the table. It soon became clear that the first shipment of equipment from the contractor's own shop is not likely to take place as scheduled unless vigorously expedited by the owner. Regular review meetings were held with the contractor's shop personnel and while manufacturing progress improved, it became clear that the slippage, which had already occurred, could not be recovered. After several months had passed, the owner decided to take up the matter with the contractor's top management so that the contract received out-of-order priority.

Interestingly the contractor's top management started defending the slippage on the grounds of delayed signing of contract and non-opening of letter of credit. The owner explained that the financial institutions would not permit him to lock-up his money by opening a letter of credit since no material was ready for despatch. The contractor, however, was insistent that the letter of credit must be opened immediately as per the contract to enable him to step up progress. He also made a claim that substantial plant and machinery was ready but could not be despatched due to lack of a letter of credit. The turnkey contractor meanwhile lined up a new group of professionals as their erection sub-contractor with the idea that a new group would be cooperative and put in their best effort. This was, however, not acceptable to owner. Since considerable slippage had already taken place, it was considered essential to have a contractor with an excellent track record so that a part of the slippage could be recovered during erection. The erection contract was, therefore, terminatied and a new contractor approved by the owner was engaged.

The owner opened a letter of credit for the despatch of items declared ready by the turnkey contractor. Considerable time was spent in settling the terms. Soon the owner discovered that what the contractor claimed as ready and despatched were not erectable. The contractor despatched whatever was ready, whereas the owner insisted that the turnkey contractor must send items in erectable sequence. The contractor, however, maintained that this was not possible but promised to ensure erectable deliveries as far as practicable. Since material were not arriving at site as planned the erection contractor did not mobilise as promised. Materials, which had reached the site, lay idle either because they were not erectable or errection labour was not available. The situation was intolerable as far as the owner was concerned but he was not in position either to rectify the situation or cancel the contract.

The turnkey contractor, on the other hand, suggested that the owner should directly take charge of erection as the situation at the site was a creation of the erection contractor who had been appoined on the owner's recommendation. The turnkey contractor also expressed his inability to despatch equipment in an erectable sequence, as he was unable to pick-up all the ready materials from the various sub-vendors with the limited funds that the owner had allowed him. He threatened that unless a letter of credit for the entire balance amount was opened immediately he would stop all despatches. But the owner was not convinced that he should open the balance letter of credit when all the items were not ready for despatch. He felt that if the letter of credit was opened for the entire balance amount the contractor would take it easy and his project would get further delalyed. He was convinced that he had not so far received a fair deal from the contractor and, therefore, there was no reason for him to oblige the contractor. The contractor, on the other hand, concluded that the owner was short of fund and, therefore, there was no point in expediting the project.

Therefore a lesson that can be learned from above is that the turnkey contract may lead the owner to a state of helplessness putting all his plans hayway. Having put all the eggs in one basket the owner is left with no opportunity to remedy things at a later date. Improper slection of the contractor may lead him to a path of endless troubles. For the selection of a turnkey contractor the schedule or cost quoted is of secondary importance. Instead turnkey contractor must have an excellent track record in management of projects and integrity, which is above reproach.

## 8.6 PROJECT CLOSE OUT

The last major phase of a project's life cycle is project close out. It is done once for all when all defined projects objectives are met and the user has accepted the project. Project close out includes the following activities, particularly for a very large project.

- Redistributing resources, staff facilities, equipment and other related systems including building if any.
- Closing out financial issues regarding labour disputes etc.
- Completing, collecting and recording of projects records.
- Documenting the success of the project.
- Conducting a lessons learned session.
- Celebrating project success.

The close out phase of a project can be divided in the following categories:

### 8.6.1 Administrative Closure

This involves preparation of closure documents of the project being handed over to the customer as well as other administrative actions to ensure that the project and its assets are redistributed. Delivering closure documentation does not simply mean getting an approval or acceptance from the customer but evolves series of steps to ensure that product meets the expected specifications listed in the design document. The document produced is called the " Post Implementation Evaluation Report (PIER)". The other areas included in administrative closure are, archiving, facilities, and personnel reassignment.

(*i*) *Post Implementation Evaluation Report (PIER):* It records the successes and failure of the project with historical record of the planned and actual budget schedule. Other selected metrics on the project can also be collected, based on documented procedures. The report also contains recommendations for future projects of similar size and scope. The PIER should normally contain the information about, project sign off, staffing and skills, project organizational structure, schedule cost, risk quality configuration, customer expectation management and lesson learned.

(*ii*) *Preparation of report:* It is the responsibility of the project manager to prepare the report with imput from the entire team, customers and the major stakeholders. If all the project members cannot be consulted a few must be taken in to confidence before preparation of the report.

(*iii*) *Other important administrative documents:* There are some other documents associated with the closure of the project and include customer project sign off and project documentation.

(*iv*) *Collection of project archive data:* Historic project data is an important source of information to help improve future projects. The following project data is required.

- Project notebook
- Project plan

- Correspondence
- Meeting notes
- Status report
- Contract file
- Technical documents
- Files, program, notes etc.

The hard copy of the records should be stored. The other administrative closure process is the reassignment and reallocation of agency personnel and equipment that have been used during the project.

### 8.6.2 Financial Closure

Financial closure is the process of completing all financial and budgetary aspects of the project being completed. It is of two types

- External financial closure
- Internal financial closure.

#### (*i*) *Project account closure*

It is an internal process that formalizes the termination of a project for the staff with in the agency. The dates set during planning stage must be met, otherwise the project may run for indefinite period of time allowing personnel to apply resources and labour against it. Project by definition have limited budgeted life spans, so it is necessary to terminate them at some point.

The project completion date for a project is the date that all project related activities needed to produce a product should be completed. Any further work done on the product beyond this date should be considered on operations and maintenance cost.

Most project have account numbers associated with them that allow the financial departments to track labour hours and resource procurement. These numbers should be decoded in a formal manner to avoid their abuse.

The staff members must be informed well in time about the closure of the project for the following reasons:

- The staff employed will know in advance beyond which they can not change their time and resources.
- Management will be able to plan their resources and to use them in a new venture.
- Setting a date provides a sense of responsibility and urgency to resolve issues and complete the job in time.

#### (*ii*) *Processes of contract closure*

It is the process of terminating contract that outside organizations or business have with the agency as pert of the being performed. These contracts may be in the form of vehicle, technical support, or any other services. This can be discontinued for various reasons, including contract completion early termination or failure to perform. It is a simple process, but due care should be exercised to elevate legal complicacies.

In order to close a contract it is important to collect all the pertinent documentation for review, which will include all original contract and supporting documents such as schedules contract changes and performance reports. These should be reviewed thoroughly to ensure that there are no unrealized contract issues that could open up legal liability.

In order to close a contract formally, a written document must be provided stating completion of the contract and reason for termination. It is desirable to keep a complete set of contractual records for the project in a safe and accessible place in case they need to be referenced at any point of time in future.

### 8.6.3 Financial Audit

It is through examination of a project by an evaluation team and includes detailed overview of the project's financial procedures, budgets, records etc. Audit can be done department wise or budget as a whole depending upon the size of the project . This can be done any time throughout the project period.

The basic aim of the financial audit is to determine where, in measurable terms, the actual costs on the project may have overrun or underrun and determine the cause of the variation. It also investigates into the ethical and financial responsibility of the staff involved in the project. This also aims at to provide an opportunity for the project managers and agencies to learn where they can improve financially on the implementation of similar project in future.

#### *Audit Information Requirements*

To make accurate audit following information is necessary for assessment:

- Budget plans (staff and resources base line)
- Staff time sheets
- Contracts with external organizations
- Procurement guidelines
- Purchase orders
- Budget status reports
- Change control results

Teams either internal or external to the state agency depending upon the size expertise and experience may perform the financial audit. The audit team should be allowed to have full accessibility to the project record and project staff to make well-informed and unbiased assessment of the financial health of the project, care must be taken to avoid misunderstanding, and auditors must avoid comments that may be construed as critical.

### 8.6.4 Celebration of Success

One step of the closeout phase is the customer's acceptance of the system. This is a critical and important step, as the customer decides when the project is completed. Success is defined at the early stages of planning the project i.e. initiation phase and is not tied to only budget and schedule. A project may be considered as most successful even though the cost schedule may exceed the time limits.

The questions that can determine success include:

- Were the success objectives achieved?
- Do the stakeholder and customers view in a positive manner?
- Was the project well managed?
- Did the team worked together and knew wrong and right?

The success of the project can be celebrated in the form of a formal party, and appreciating the efforts of the team members through gifts and certificates.

## QUESTIONS

1. Discuss the importance of performance measurements used in project management.
2. Enlist the performance indicators used in project management.
3. Explain the approaches used for performance analysis.
4. How can the performance can be improved in project management?
5. Compare the 'do it yourself' and 'turnkey approach'.
6. Discuss the various factors involved in project close-out.
7. Enlist the factors which influence the project success and failure.

9

# NETWORK TECHNIQUES

The use of network techniques is very common for any project. It helps in calculating the project time and can be useful to optimise the overall completion time using the concept of crashing of activities. The discription presented here will help the readers to control and expedite the project with optimal cost.

## 9.1 TRANSITION FROM GANTT CHART TO NETWORK DIAGRAM

Gantt progress chart is a bar chart that gives a comparative picture between actual performance and planned performance i.e. how the planned performance is keeping pace with the fixed targets. Due to the shortcoming or inadequacies of the bar chart in meeting the requirements of the modern day management, efforts were made to modify it by adding new elements. One important modification that forms a link in the evolution of the Gantt chart into PERT/CPM Network is called *Milestone system*.

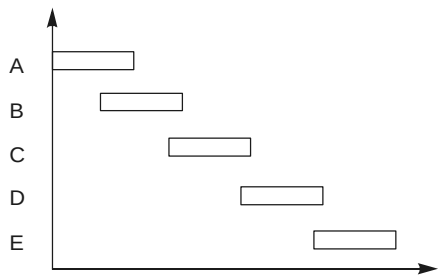



**Fig. 9.1** Gantt chart

Milestones are key points or events in time, which can be identified when completed as the project progresses. They act as reference points for the management. In a Gantt chart, a bar which represents a long-term job is broken down into several pieces, each of which represents a identifiable major event. While the milestone was definitely an improvement on the bar chart, it still had one great deficiency i.e. it did not clearly show the interdependencies between events. In a milestone chart, the events are in chronological order, but not in a logical sequence. A natural extension of the milestone chart was **network**, where arrows connect events in a logical sequence. This led to the evolution of network techniques.

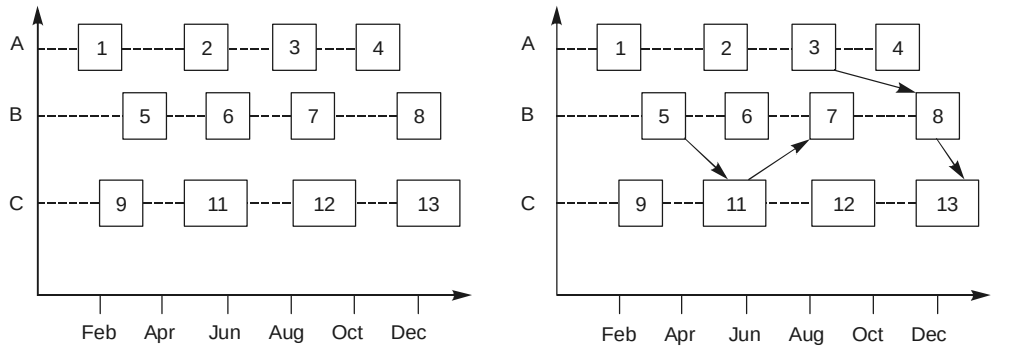



**Fig. 9.2** Gantt chart and milestones

## 9.2 PROBLEMS WITH THE BAR CHARTS

The need of network technique was felt because the conventional bar chart had their limitations as listed below:

- Bar chart becomes too cumbersome while dealing with big and complex projects when considered in detail and efforts were to find out interaction/interdependence.
- Bar chart does not indicate which tasks should be given priorities as regards the resources (i.e. men, money, materials, machinery, etc)
- The changes in schedule cannot be evaluated.
- It does not tell tolerance in activity times.
- It does not show continuing interrelationships of activities.

So from Gantt or Bar chart it is not clear that which are the activities dependant on each other and which are dependant.

## 9.3 SCHEDULING

The network is a graphical representation of the interrelationships among all activities in the project. Developing the network forces detailed planning of the project and provides a valuable communication tool. After the activities have been identified and the network has been drawn the next step is to assign expected time duration to the activities. The expected duration depends on the planned crew size work method equipment and working hours. A particular level of resource must be assumed to be available when the work is to be performed. The following conditions may exist when the estimates are made:

- The person who is in charge of an activity or activities assumes that some customary and reasonable level of resource will be used and specify an expected duration for the activity. Some completion data is determined. This approach is in keeping with the theory of Critical Path Method (CPM).
- In some actual application a completion time or milestone data is specified and the estimated amount of resources is adjusted so that the duration will be less than equal to the desired amount of time. This approach is in keeping with the theory Programme Evaluation and Review Technique (PERT).

### 9.3.1 Advantages of Network Scheduling

Network based scheduling techniques can be beneficial in many ways if they are properly used. Like all other scheduling techniques, however, they are not panaceas or substitutes for good management judgment. Since scheduling is an attempt to plan future work, the required work times are estimated. No technique will make poor estimates any better. Scheduling can help plan work, but the accuracy of plans and schedules depends on the accuracy of the time estimates used in their development. Knowledgeable people and/or reliable techniques should be used to provide the time estimates.

Assuming that the estimates for a network scheduling method are as good as those for other scheduling methods, the network techniques may offer some advantages:

1. They lead to planning a project to the selected level of details so that all parts of the project and their intended order of accomplishment are known.
2. They provide a fairly accurate estimate of the length of time it will take to complete the project and the activities that must be kept on time to meet the schedule.
3. They provide a graphical picture and standardized vocabulary to aid in understanding work assignments and communicating among people involved in the project.
4. They provide a means to track progress on a project (that is, show where work is with respect to the plan).
5. They identify and focus attention on potentially troublesome activities to facilitate management by exception.
6. They provide a means of estimating the time and cost impact of changes in the project plan at any stage.

## 9.4 NETWORK BASED SCHEDULING TECHNIQUES

The biggest advance in project scheduling since the development of the *Gantt Chart* in 1917 was made between 1956 and 1958. During this period, two new scheduling techniques were developed that have much in common, although they were developed independently. These techniques are the *Program Evaluation and Review Technique* (**PERT**) and the *Critical Path Method* (**CPM**). Both are based on the use of a network or graphical model to depict the work tasks being scheduled. Both were designed to schedule long-duration projects that were to be performed only once or in low volume. Computer programs are available for both PERT and CPM, which are helpful in developing timely information about large projects, particularly those that are to be updated and revised several times before completion. Following techniques can be used to solve a problem through a network:

- PERT: Programme Evaluation and Review Technique
- CPM: Critical Path Method
- RAMS: Resource Allocation and Multi-project Scheduling
- GERT: Graphical Evaluation and Review Technique
- MOSS: Multi Operation Scheduling System
- COPAC: Critical Operating Production Allocation Control
- LCS: Least Cost Scheduling
- MAP: Man Power Allocation Procedure
- RPSM: Resource Planning and Scheduling Method

However PERT and CPM are most commonly used techniques. *CPM* was developed by E.I. Du Pont de Nemours and Company in conjunction with the Remington Rand Corporation.

Du Pont described a technique to improve the scheduling of construction and extensive maintenance shutdowns of its production facilities. Most activities to be scheduled with this technique were similar to previously performed construction and maintenance, so the length of time the tasks were expected to require was treated as though it were a *deterministic* (known) number.

*PERT* was developed under the auspices of the U.S. Navy's special projects Office working with representatives of Lockheed and Booz, Allen and Hamilton. The technique was developed to assist in managing the development of the Polaris missile-submarine system. This project required the coordination of more than 250 prime contractors and over 9000 subcontractors including suppliers and other agencies: an immense management and scheduling challenge. Since many of the activities involved in this project had never been performed before, the time that they might require was uncertain and consequently was treated as *probabilistic variable*.

Finally the cost of applying critical path methods to a project is sometimes used as a basis for criticism. However the cost of applying PERT/CPM rarely exceeds 2% of the total project cost. When used with added features of work breakdown structure and various reports, it is more expensive but rarely exceeds 5 % of the total project costs. Thus added cost is generally outweighed by the savings from improved scheduling and reduced project cost.

## 9.5 STEPS IN USING NETWORK TECHNIQUES

**Three major steps are involved in the use of network scheduling:**

- *Planning the project.*
  - Analyze the project by determining all the individual activities
  - Show the planned sequence of these activities on a network
- *Scheduling the project.*
  - Estimate how long it will take to perform each activity
  - Perform computations to locate the critical path. This information will also provide information for scheduling
  - Use this information to develop a more economical and efficient schedule
- *Monitoring the project.*
  - Use the plan and schedule to control and monitor progress
  - Revise and update the schedule throughout execution of the project so that the schedule represents the current plans and current status of progress.

## 9.6 SOME OF THE ASSUMPTIONS IN *PERT* OR *CPM* ARE GIVEN BELOW

- Project activities can be identified as entities (there is a clear beginning and ending point for each activity).
- Project activity sequence relationships can be specified and networked.
- Project control should focus on critical path
- The activity times in PERT follow the *Beta Distribution* with the variance of the project assumed to equal the sum of the variances along the critical path.

### 9.6.1 Symbols Used in Network

#### 1. *Activity by* ⟶ *(arrow)*

Arrow can have any size or slope. It starts from ***tail*** and ends at the ***head*** of arrow e.g., assembly of parts, mixing of concrete, preparing budget etc.

### 2. *Dummy Activity ----→ (broken arrow)*

These activities consume no time. This is introduced to prevent dangling. This happens when an activity ends with out being joined to end event, so breaking continuity.

### 3. *Event O (circle or node)*

Event is represented by node. Event takes no time but it connects two or more activities. Events may be classified into three categories *merge event, burst event, merge and burst event* e.g. design completed, pipe line laid, started issue, tested.

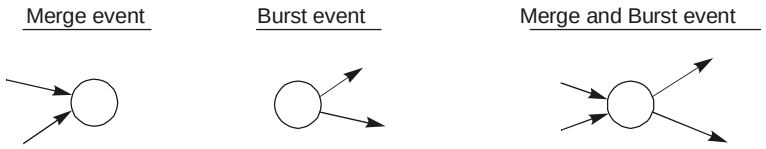



**Fig. 9.3** Events directions

## TERMINOLOGIES USED IN NETWORKS INCLUDE THE FOLLOWING

### *Network*

It is the graphic representations of projects operations composed of activities and events to achieve objective of project showing planning sequence.

### *Event (node)*

It is a recognizable as particular instant of time and does not consume time or source. Generally represented on network by circle, rectangle or hexagon.

### *Activity*

It is a task or item that consumes time, money, effort etc. It lies between preceding and succeeding events.

### *Float or Slack*

The term ***slack*** time refers to an ***event-controlled network*** and ***float*** time refers to the ***activity network***. But generally float and slack are used inter changeably. ***Float or Slack*** is defined, as amount of time an activity can be delayed without effecting the duration of project. On a critical path, the float is zero. So float gives an indication criticalness of an activity. An activity with little float, stands a good chance of delaying project and should be carefully monitored.

| | | |
|---|---|---|
| ES (a) | = | Early start time of activity 'a' |
| EF (a) | = | Early finish time of activity 'a' |
| LS (a) | = | Late start time of activity 'a' |
| LF (a) | = | Late finish time of activity 'a' |
| t | = | duration of the activity considered |
| TF | = | total float |
| FF | = | Free float |
| IF | = | Independent float |

### *Total Duration*

Total duration of time available for any job is the difference between its earliest start time and latest finish time. If activity 1-2 is considered then.

Maximum Time Available = LF (1-2) – ES (1-2)

### *Earliest Start Time (ES)*

This is the earliest occurrence time for the event from which the activity arrow originates.

### *Earliest Finish Time (EF)*

This is the earliest occurrence time for the event from which activity arrow originates plus duration for the activity

$$EF(a) = ES(a) + t$$

### *Latest Start Time (LS)*

This is the latest occurrence time for the node at which activity arrow terminates minus the duration for the activity

$$LS = LF - t$$

### *Latest Finish Time (LF)*

This is the latest occurrence time for the node at which activity arrow terminates.

## 9.7 PRECEDENCE RELATIONSHIPS

Some activities cannot be performed until other activities have been completed. This type of requirement establishes a technical *precedence relationship*. There may sometimes be options as to the way activities may be performed, but management's prerogatives or differences in costs lead to a particular planned sequence of activities. Other activities may be performed independently. Task independence and precedence relationships should be incorporated into the job plan and indicated on the project network.

## 9.8 NETWORKING CONVENTIONS: *AON* AND *AOA*

A network is a graph using circles and arrows to represent the planned relationships among the activities required to complete a project. Either of two conventions can be used to develop a network. One uses circles to represent the project activities, with arrows linking them together to show the sequence in which they are to be performed. This is called the *activity-on-node (AON) convention*, or Precedence notation. An alternative is to show the activities as arrows and use circles to connect predecessor and successor activities. This method is called the *activity-on-arrow (AOA) convention*. With this convention, the circles or nodes represent events, which are points in time at which activities begin or end. An event consumes no resources, whereas an activity consumes time and other resources.

A network is drawn after all activities and their relationships have been defined. There is no proven best approach to the identification of activities. Some people start with what they believe to be logically the first activity and proceed in what they believe to be chronological order; others may start with the last activity and work backward; still others list activities in random sequence. After the activities are identified, one may ask:

1. Which activity must immediately precede this one?

2. Which activity must immediately follow this one?
3. Can this activity be accomplished without dependence on some other activity?

The activity that must be performed just before a particular activity is its **predecessor** activity; the one that follows is its **successor** activity. Activities, which can be accomplished concurrently, are known as **concurrent** activities.

An activity in the AOA convention is often identified by numbers indicating the starting and ending events. This identification system is called *i-j* notation (*i* represents the number of the starting event, and *j* represents the number of the ending event). This notation makes it necessary for every activity to have a unique *i-j* pair. A *dummy activity* (indicated by dashed arrow) consumes no time or other resources but is used merely to indicate a precedence relationship. A dummy activity may be used to keep two activities from having the same starting and ending nodes. With the activity-on-arrow convention, dummy activities also may be needed in other instances to indicate precedence relationships. A single number or letter can identify activities in the AON convention, and there is no need for dummy activities when this convention is used. Generally the AON convention is easier to learn because it consistently uses arrows only to indicate precedence. In contrast, some arrows (solid) are activities, and other arrows (dashed) indicate precedence requirements when the AOA convention is used. Two errors in network diagrams common to both AON and AOA method are dangling and looping which are outlined under the rules for network construction.

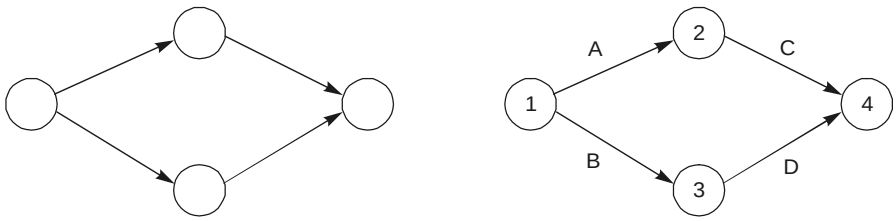



**Fig.** 9.4 Comparison of AON and AOA

## 9.9 RULES FOR NETWORK CONSTRUCTION

1. There should not be duplication of activities i.e. no redundancy. Each activity is represented by one and only one arrow in the network.
2. Draw arrows in straight lines, avoid curved lines and crossing of activities.
3. Avoid looping in that, draw arrows from left to right and not in between right to left resulting in looping.
4. No hard and fast rule in numbering events. As far as possible number them in ascending order from left to right. For rigorous numbering follow Fulkerson rule(given below).
5. The length of arrow need not be scaled or proportioned to duration. This rule is necessary to avoid looping and back tracking.
6. An event cannot occur until all activities leading to it are completed and no activity can begin until its immediate preceding event has occurred.
7. Each activity must have a tail and head event. No two or more activities must have the same head and tail events.

8. Dangling must be avoided in a network diagram. It happens when an activity ends with out being joined to end event, so breaking continuity because of precedence relationship not being identified.

## 9.10 FULKERSON RULES FOR NUMBERING NODES

- Initial event is marked no. 1, which have arrows emerging out but none entering.
- Delete all arrows emerging from event no. 1. This will result at least one more initial event. Denote some as no. 2. Continue process till all events exhausted or numbered.
- Number at head of any arrows always greater than node number at its tail.
- No node is numbered until its all-preceding events are numbered.
- There is only one starting and one finishing node i.e. all activities are uniquely represented by one starting and one finishing event.
- There is no duplicate number for a number.

## 9.11 STATISTICAL METHOD OF DERIVING: SINGLE TIME ESTIMATE

Looking statistically all estimates are a prediction of probability. There are two well-known distributions considered for the analysis viz "***Normal-Distribution***" and "***Beta-Distribution***". As per normal distribution, which is symmetric about mean the probability of occurrence can be increased by increasing standard deviation.

$$\bar{X} \pm s = 68.27 \text{ Area}$$

$$\bar{X} \pm 2s = 95.45 \text{ Area}$$

$$\bar{X} \pm 3s = 99.73 \text{ Area}$$

However it is assumed that expected time for an activity in PERT model follows Beta Distribution and each has its own ***mean*** 'm' and ***standard deviation*** 'σ'. The estimated time for an activity can be better described by a probability distribution of activity times with following characteristics:

- Small probability (say one in hundred) of reaching the most optimistic time (shortest time) symbol as '*a*'.
- Small probability (say one in hundred) of reaching of most pessimistic time (longest time) symbolized as '*b*'.
- One and only one most likely time symbolized as '*m*' which would be free to move between the two extremes of expected time.
- Ability to measure uncertainty is estimating

$a$ = Optimistic Time
$b$ = Pessimistic Time
$m$ = Most Likely Time

Single Time Estimate (Expected Time) $t_e = \dfrac{(a + 4m + b)}{6}$

σ (Standard Deviation) $= \Sigma\,[(b\text{-}a)/6]^2\}^{1/2}$

Therefore to have all these four attributes one specific probability curve is necessary and none other than Beta distribution can be a better fit in this situation.

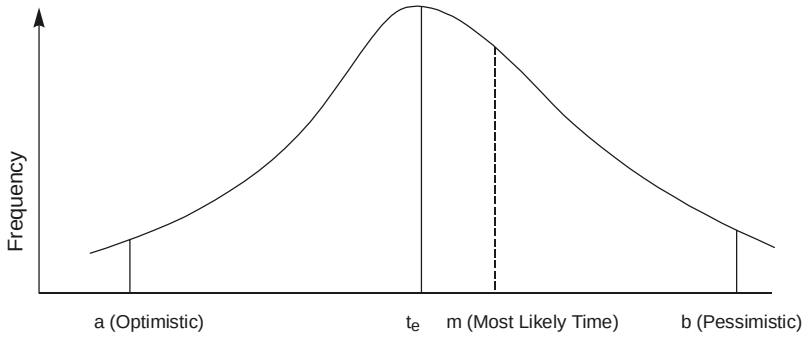



**Fig. 9.5** Normal distribution

If each of the activities of a network have their own 'b' (Beta distribution) with means $m_1$ $\mu_2 ... \mu_n$ and standard deviations $\sigma_1 \sigma_2 ... \sigma_n$ respectively. Then according to **Central Limit Theorem** distribution of time for the completion of the project as a whole will approximately be a normal distribution curve with mean and variance as given as follows:

$$\text{Mean} = \mu_1 + \mu_2 + ... + \mu_n .$$
$$\text{Variance} = \Sigma (\sigma_1^2 + \sigma_2^2 + ... + \sigma_n^2).$$

## 9.12 DETERMINATION OF FLOATS AND SLACK TIMES

Float allows some flexibility in scheduling activities. An activity can be intentionally delayed if the delay will result in a more uniform workload or provides some other advantage. Some amount of float should be retained if possible because ***float is like insurance***. The float is useful under the following conditions: uncertain material deliveries, possible strikes, delayed drawing approvals and so on, it is wise to have a time cushion if it can be afforded.

More than one activity may require the same resources and may be planned to occur at the same time. Networking and scheduling data provided by the scheduling method will reveal such conflicts so that readjustments can be planned to determine the times at which various activities can occur. It is necessary to calculate the earliest date at which each activity can be performed and how much each activity can be delayed without interfering with projects scheduled completion. *ES and EF of the activities are calculated in the forward direction of project. LS and LF of the activities are calculated in the backward direction from the end of the project after equating the EF of the entire project and LF of the entire project.*

### *Total Float Value*

| | |
|---|---|
| Negative | Resources not adequate |
| Zero | Resources just sufficient |
| Positive | Resources are extra so flexibility exists for contingency delays |

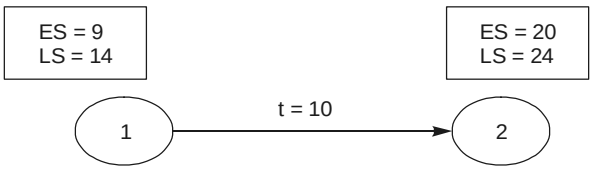
There are mainly three kinds of Floats:

### 9.12.1 Total Float

Amount of time by which the completion of an activity could be delayed beyond the earliest completion time without effecting the overall project duration time. It is measured by the

maximum time of the difference between maximum time available to perform activity and activity duration time or the difference between latest start time and earliest start time.

$$TS(a) = LS(a) - ES(a)$$
$$TS(a) = LF(a) - (ES(a) + t)$$
$$TS(a) = LF(a) - EF(a) \qquad \{If\ ES(a) + t = EF(a)\}$$



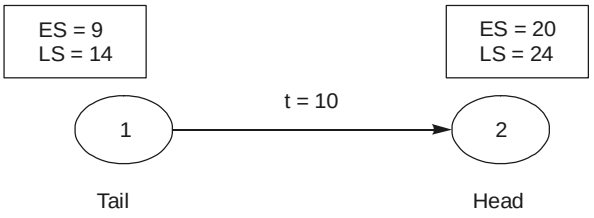

For Activity 1-2, ES = 9 and LS = 14
Then Total Float for (1-2) = 14 – 9 = 5

## 9.12.2 Free Float

Time by which the completion of an event can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent (succeeding) activity. It is based on the possibility that all events occur at their earliest times i.e. all activities start as early as possible.

Free float for an activity is the difference between its earliest finish time and the earliest start time for its successor activity. It is that portion of the total float within which an activity can be manipulated without affecting the floats of subsequent activity. So for all activities, the free float can take the values from 'Total Float' to 'Zero' but cannot exceed Total float. Free float is useful for rescheduling the activities with minimum disruption of earlier plans.

| | | |
|---|---|---|
| FF (I-J) | = | (Earliest time for event 'J'-Earliest time for event 'I') – Activity time for (I-J) |
| FS (a) | = | Minimum of ES times of all immediate successors of activity 'a'– EF (a) |
| FF | = | ES (Succeeding) – EF (Activity) |
| FF | = | Total Float – Slack at Head Event |




Free Float (FF) = (EF –ES) – t
= (20 – 9) –10 = 1

## 9.12.3 Independent Float

The amount of time by which the start of an activity can be delayed without effecting the earliest start time of any immediately following activities, assuming that the proceeding activity has finished at its latest finish time.

It is the portion of the total float, which an activity may be delayed for start without effecting floats of proceeding activities.

Independent Float ($IF_{IJ}$) = $(EF_J - LS_I) - t_{IJ}$

Independent Float = ES (succeeding activity) – LF (activity)

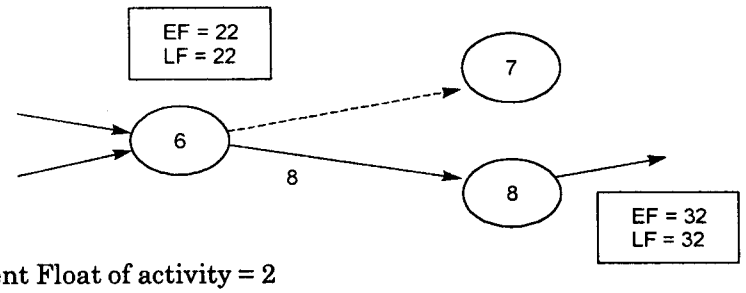
Independent Float = Free float – Slack at tail event (proceeding event)

Considering activity (1–2)

Independent Float (1–2) = (20 – 14) –10 = – 4

Or also IF = FF – Slack at tail = 1– 5 = –4

Considering activity 6-8 shown in the below figure, latest time for the job preceding 6-8 is 22 and the earliest start time for the job succeeding 6-8 is 32. The difference between them is 10, but activity takes only 8 units of time. Its independent float therefore is 2 units of time.




Independent Float of activity = 2

The negative independent float is always taken zero. This float is concerned with prior and subsequent activities. It is observed that the relationship between the different types of floats is as follows

| Independent Float | ≤ | Free Float | ≤ | Total Float |
|---|---|---|---|---|

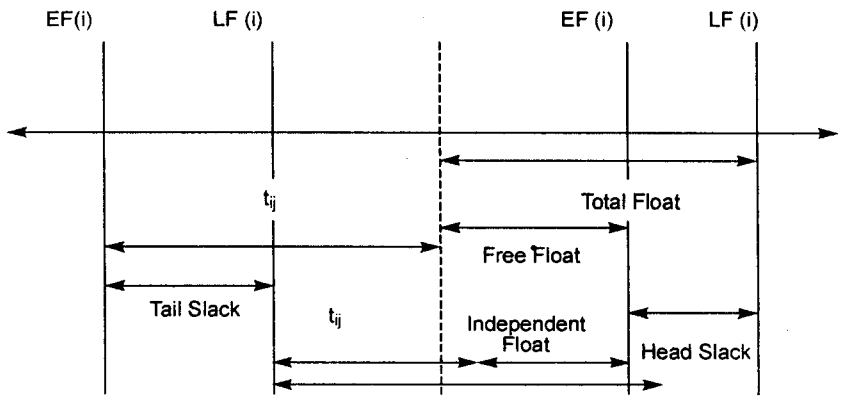
## 9.12.4 Event Slacks

For any given event the event slack is defined as the difference between latest event and earliest event times. For an activity (I, J); I and J are 'Head and Tail' nodes or events.

| | | |
|---|---|---|
| Head Event slack | = | LF (J) – EF (J) |
| Tail Event slack | = | LF (I) – EF (I) |

## 9.12.5 Time Scale Representation of Floats and Slacks

The various floats and slacks for an activity (I-j) can be represented on time scale as



## 9.13 CRITICAL PATH

A critical path is a chain of sequential activities beginning at the project start and ending its completion. Several or many path may exist through the network. Work may proceed on many independent path concurrently, but of course work may proceed on an activity only after all the necessary predecessor activities in its path have been completed. All the activities, hence all the paths, must be completed before the project is finished.

*The path through the network that has the longest expected completion time and is expected to determine the completion date of the project is called the critical path*.

Often activities that are not on the critical path can be delayed without causing a delay in the completion of the project. On the other hand activities on the critical path if delayed cause a delay in the entire project. In other words there is no float along the critical path

### 9.13.1 Forward Pass (ES, EF)

The early start and early finish for each activity are found by calculation performed in sequence from left to right in the network. This series of calculations is called for *forward pass*. First we assign a project day usually 0, to the start of the first activity, to represent the ES for that activity. Then we obtain the ES and EF for each activity by making forward pass through the network, from left to right. The duration of an activity is added to its ES to obtain the EF. The ES of an activity is set equal to the EF of its predecessor if there is only one. If an activity has more than one predecessor, its ES is equal to the latest EF of its predecessors. For example, if the early start for activity M in figure is day 10, its early finish is day 15. If the early start for activity R is day 12, its early finish day 18. Even though one of its predecessors (activity M) is completed on day 15 activity P cannot begin until day 18 when the latest of all its predecessors is finished. The forward pass is continued until we reach the right hand side of the network. At this point we have the EF of the final activity, which is the earliest the project can be completed (if the activities take the time that was estimated).

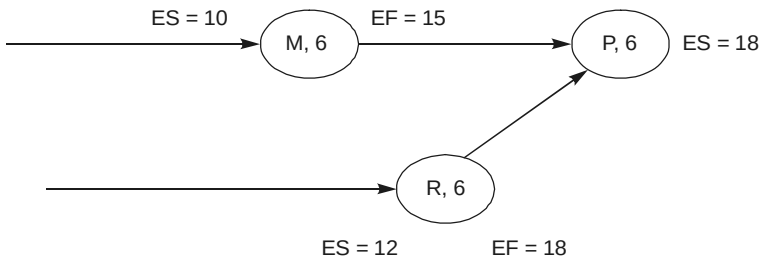



**Fig. 9.6** Relationship

### 9.13.2 Backward Pass (LF, LS)

The LF and LS dates are calculated by means of a backward pass from right to left though the network. *The LF of the last activity is usually set equal to the EF of the project*. Starting with the last activity subtract the activity duration form LF to obtain LS. The LF for an activity is set equal to the LS for its successors if there is only one. It is set equal to the earliest or smallest LS of all successors if there is more than one successor.

## 9.14 PROBABILITY OF COMPLETION TIME

We assume a normal distribution table (see Appendix) for calculating probability. For this distribution $Z$ – value tables are available. In a normal distribution curve the chances of the project being completed within the mean time is 50%. This is obtained by dividing the area to the left of mean by total areas.

If $T_E$ =mean time = 41.7 days and
$T_S$ =Actual or Desired Time = 45 days
$s$ =1.2 days

$$Z = \frac{\text{Deviation}}{\text{Standard Deviation}} = \frac{(45 - 41.7)}{1.2} = 2.75$$

Standard Deviation = 1.2

This expresses area under

[$X_{mean}$ + 2.75.$s$ (Standard Deviation)]

From $Z$ – value table in Appendix we get

0.497 x 2 = 0.994

Or Area = 99.4

So the probability of competing project in desired time is 99.4%.

***Example1:*** Draw the network diagram for the activities of a maintenance job of a part of refinery

**Table 9.1** Refinery date

| *Activity* | *Description of Activity* | *Predecessor Activity* |
|---|---|---|
| A | Dismantle the pipe line | None |
| B | Disassemble other fittings | A |
| C | Remove valves and check them | B |
| D | Clean the valves and check them | C, E |
| E | Clean the pipe lines and others | B |
| F | Replace the defective items | C, E |
| G | Layout the assembly lines | F |
| H | Assemble the valves | G |
| I | Do the final connections | H, D |
| J | Test the fittings | I |

***Solution***

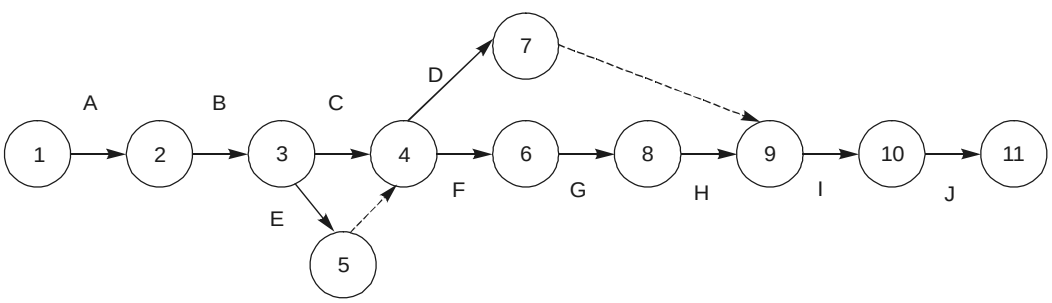



**Fig. 9.7** Network

***Example 2:*** A project consists of seven activities. Activities P, Q, R run simultaneously. The relationships among the various activities is as follows:

| *Activity* | *Immediate Successor* |
|---|---|
| P | S |
| Q | T |
| R | U |

Activity 'V' is the last operation of the project and it is also immediate successor to S,T and U. Draw the network of the project.

***Solution***

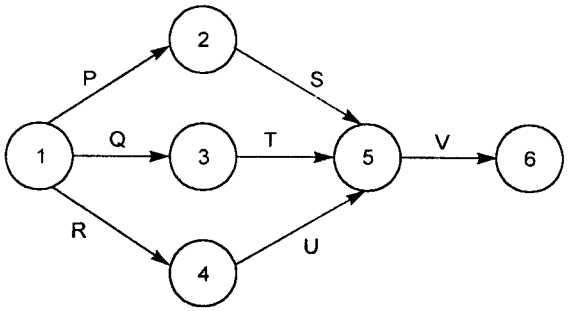



**Fig. 9.8 Network**

***Example 3.*** Draw the network of the project with following situations

P is the prerequisite for S

Q is the prerequisite for S and T

R is the prerequisite for T

S and T are the prerequisite for U

***Solution***

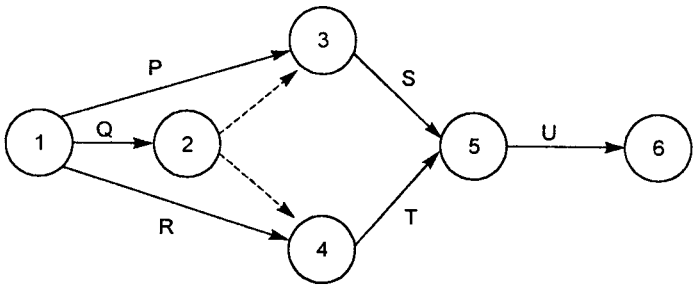



**Fig. 9.9 Network**

***Example 4.*** Project with following data is to be implemented. Draw the network and find the critical path.

| *Activity* | *Predecessor* | *Duration (days)* | *Cost (Rs Day)* |
|---|---|---|---|
| A | - | 2 | 50 |
| B | - | 4 | 50 |
| C | A | 1 | 40 |
| D | B | 2 | 100 |
| E | A, B | 3 | 100 |
| F | E | 2 | 60 |

1. What is minimum duration of project
2. Draw a Gantt chart for early start schedule
3. Determine peak requirement money and day on which it occurs above schedule

***Solution***

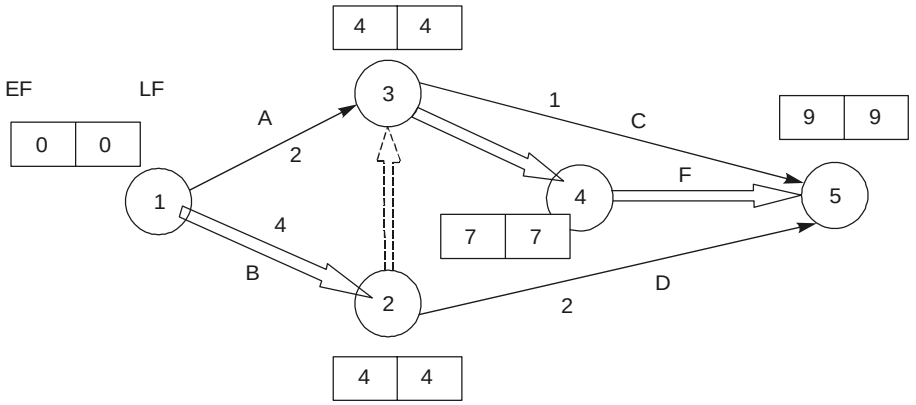
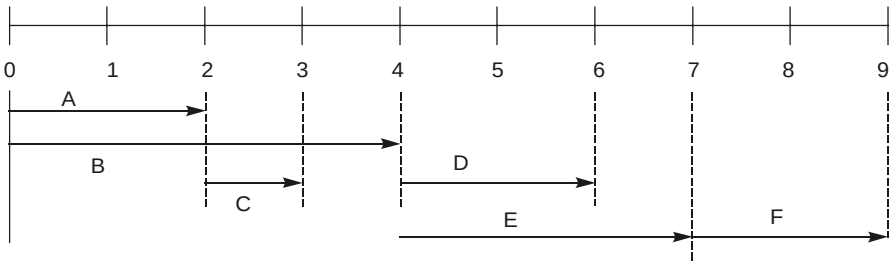



**Fig. 9.10** Network

Critical Pat 1-2-3-4-5
Minimum time = 9 days

**Table 9.2** Activity relationship

| *Activity* | *t* | *ES (EF – t)* | *EF* | *LS (LF – t)* | *LF* | *Event Slack (LS –ES) (LF –EF)* | *On Critical path* |
|---|---|---|---|---|---|---|---|
| A | 2 | 0 | 2 | 2 | 4 | 2 | No |
| B | 4 | 0 | 4 | 0 | 4 | 0 | Yes |
| C | 1 | 4 | 5 | 8 | 9 | 4 | No |
| D | 2 | 4 | 6 | 7 | 9 | 3 | No |
| E | 3 | 4 | 7 | 4 | 7 | 0 | Yes |
| F | 2 | 7 | 9 | 7 | 9 | 0 | Yes |




Requirement of Money

| | | |
|---|---|---|
| Day 1 | Activity | A+B = 50*2 |
| Day 2 | Activity | A+B = 50*2 |
| Day 3 | Activity | B+C = 50+40 |
| Day 4 | Activity | B = 50 |
| Day 5 | Activity | D+E = 200 |
| Day 6 | Activity | D+E = 200 |
| Day 7 | Activity | E = 100 |
| Day 8 | Activity | F = 60 |
| Day 9 | Activity | F = 60 |

Therefore the peak requirement is Rs.200 on day 5 and 6.

***Example 5.*** Draw the network using AON system and find Critical Path for Computer Design Project.

**Table 9.3** Activity relationship

| ***Activity*** | ***Designation*** | ***Immediate Predecessors*** | ***Time in Weeks*** |
|---|---|---|---|
| Design | A | _ | 21 |
| Built proto type | B | A | 5 |
| Evaluate | C | A | 7 |
| Test prototype | D | B | 2 |
| Write equipment report | E | C, D | 5 |
| Write method report | F | C, D | 8 |
| Write final report | G | E, F | 2 |

***Solution***

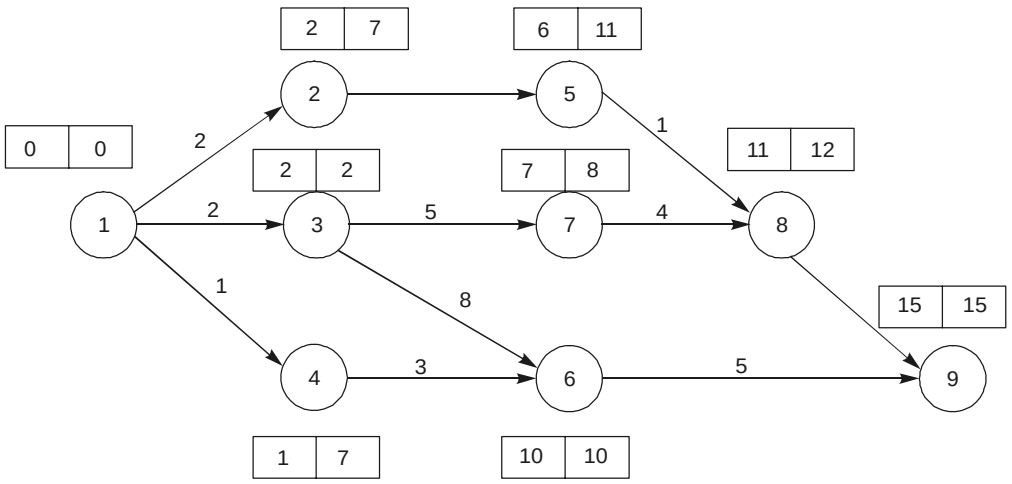



**Fig. 9.11** Network

There are one two critical path throughout network. The first critical path includes activities A - C - F - G and the second path includes A – B – D – F – G. Only activity E is not on critical path because there is a slack of 3 on it. All other have zero slack.

**Table. 9.4** Activity relationship

| *Activity* | *t* | *ES* | *EF* | *LS* | *LF* | *Slack* | *On Critical Path* |
|---|---|---|---|---|---|---|---|
| A | 21 | 0 | 21 | 0 | 21 | 0 | Yes |
| B | 5 | 21 | 26 | 21 | 26 | 0 | Yes |
| C | 7 | 21 | 28 | 21 | 28 | 0 | Yes |
| D | 2 | 26 | 28 | 26 | 28 | 0 | Yes |
| E | 5 | 28 | 33 | 31 | 36 | 3 | No |
| F | 8 | 28 | 36 | 28 | 36 | 0 | Yes |
| G | 2 | 36 | 38 | 36 | 38 | 0 | Yes |

***Example 6:*** A project has the following time schedule

| *Activity* | 1-2 | 1-3 | 1-4 | 2-5 | 3-6 | 3-7 | 4-6 | 5-8 | 6-9 | 7-8 | 8-9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Time (months)* | 2 | 2 | 1 | 4 | 8 | 5 | 3 | 1 | 5 | 4 | 3 |

Construct a PERT network and compute

- Critical path and its duration
- Total float for each activity

Also find the minimum number of cranes the project must have for its activities 2-5, 3-7 and 8-9 without delaying the project. Then is there any change required in the PERT network.

***Solution***

**Steps**

1. Moving forward find EF times (choosing the Maximum at activity intersection)
2. Maximum EF = LF = Critical Path Time.
3. Return path find LF (Choosing the Minimum at activity intersection)
4. Note LF, EF from network (Except activity intersections)

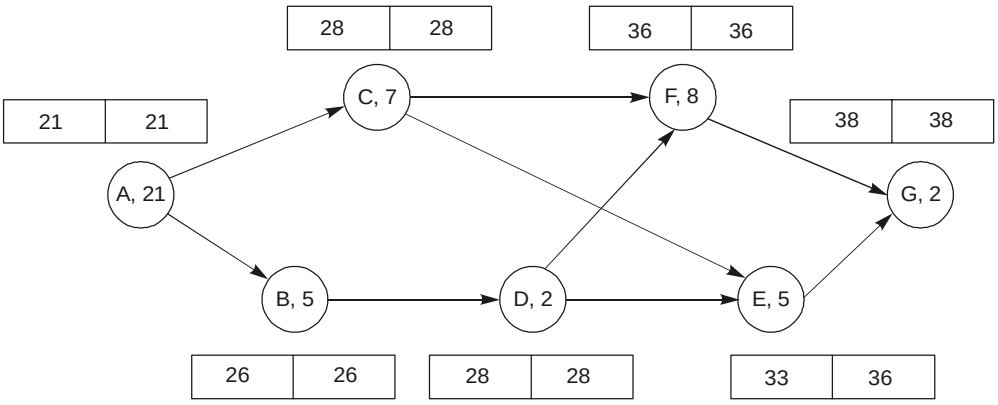



**Fig. 9.12** Network

**Table 9.5** Activity relationship

| *Activity* | *Duration* | *ES* | *EF* | *LS* | *LF* | *TF* |
|---|---|---|---|---|---|---|
| 1 –2 | 2 | 0 | 2 | 5 | 7 | 5 |
| 1 –3 | 2 | 0 | 2 | 0 | 2 | 0 |
| 1 – 4 | 1 | 0 | 1 | 6 | 7 | 6 |
| 2 – 5 | 4 | 2 | 6 | 7 | 11 | 5 |
| 3 – 6 | 8 | 2 | 10 | 2 | 10 | 0 |
| 3 – 7 | 5 | 2 | 7 | 3 | 8 | 1 |
| 4 – 6 | 3 | 1 | 4 | 5 | 10 | 6 |
| 5 – 8 | 1 | 6 | 7 | 11 | 12 | 5 |
| 6 – 9 | 5 | 10 | 15 | 10 | 15 | 0 |
| 7 –8 | 4 | 7 | 11 | 8 | 12 | 1 |
| 8 – 9 | 3 | 11 | 14 | 12 | 15 | 1 |

Critical path is 1 – 3 – 6 – 9 with duration 15 Months

**Minimum number of cranes**

- Finish 3 – 7 at 7 with one crane
- Finish 2 –5 at 7 + 4 =11 with same crane
- Finish 5 – 8 at 11 + 1 =12 with same crane
- Finish 8 – 9 at 12 +3 = 15 with same crane

Therefore one crane will be sufficient if start time of following activities are:

- Activities 2 – 5 — 7
- Activities 5 –8 — 11
- Activities 8 – 9 — 12

***Example 7.*** Considering a small maintenance project as given below, plan it with the help of CPM.

**Table 9.6** Activity relationship

| *Activity* | *Duration* | *Predecessor* |
|---|---|---|
| A | 11 | Nil |
| B | 3 | Nil |
| C | 5 | Nil |
| D | 0 | A |
| E | 2 | A |
| F | 1 | B |
| G | 12 | B |
| H | 6 | C, F |
| I | 7 | D, H |
| J | 3 | E |

Compute the following for each job:

Early start time (ES), Late start time (LS), Early finish time (EF), Late finish time (LF), Total Float (TF), Free float (FF), Minimum total duration of the project. If all the jobs have been scheduled to start as early as possible and that the work has been in schedule up to the end of week 5. There is strike on week 6 causing a delay of 1 week. Draw a CPM diagram for the jobs remaining to be done when work resumes on week 7.

***Solution***

Network representing the given project:

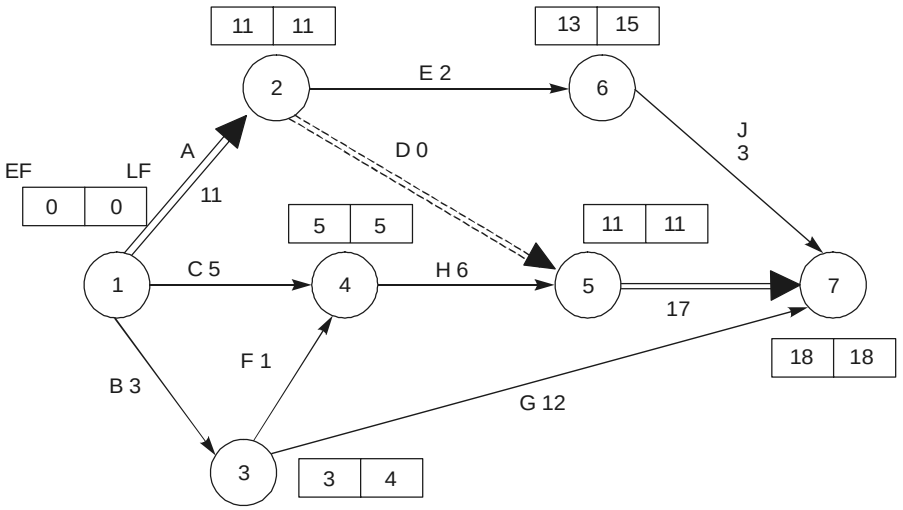



**Fig. 9.13** Network

The ES, EF, LS, LF, TS, FS have been computed as discuss earlier and entered in the below.

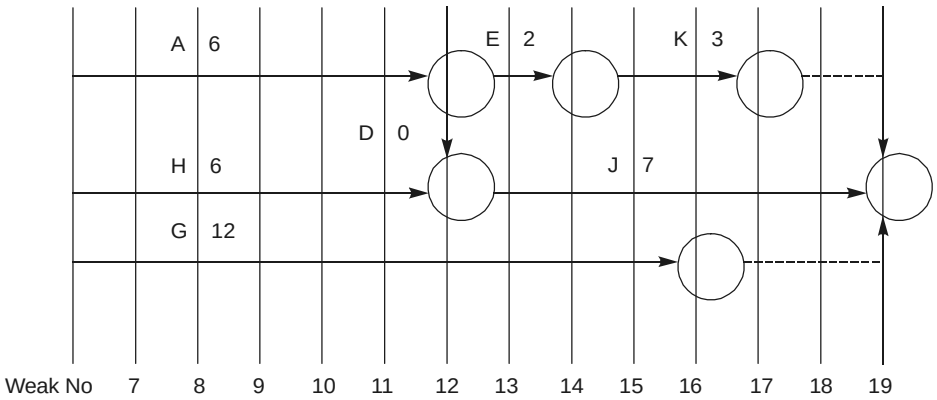
**Table 9.7** Activity relationship

| *Activity* | *Duration* | *ES* | *EF* | *LS* | *LF* | *TS* | *Slack at Head* | *FS* |
|---|---|---|---|---|---|---|---|---|
| A | 11 | 0 | 11 | 0 | 11 | 0 | 0 | - |
| B | 3 | 0 | 3 | 1 | 4 | 1 | 1 | - |
| C | 5 | 0 | 5 | 0 | 5 | 0 | 0 | - |
| D | 0 | 11 | 11 | 11 | 11 | 0 | 0 | - |
| E | 2 | 11 | 13 | 13 | 15 | 2 | 2 | - |
| F | 1 | 3 | 4 | 4 | 5 | 1 | 0 | 1 |
| G | 12 | 3 | 15 | 6 | 18 | 3 | 0 | 3 |
| H | 6 | 5 | 11 | 5 | 11 | 0 | 0 | - |
| I | 7 | 11 | 18 | 11 | 18 | 0 | 0 | |
| J | 3 | 13 | 16 | 15 | 18 | 2 | 0 | 2 |

FS for ending activities will be taken as 0 (Zero)

The minimum duration of the project is 18 weeks.

Figure shown is a squared CPM network, which depicts the jobs yet to be done on week 7.




***Example 8:*** For Network given find Total Float (TF), Free Float (FF) and Independent Float (IF)

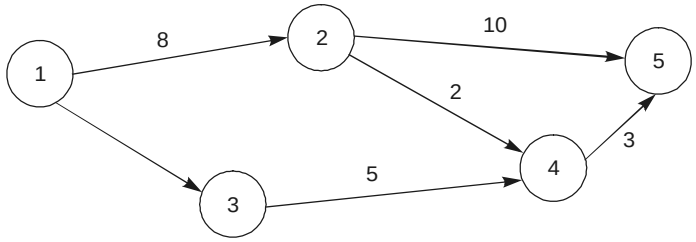



**Fig.9.14** Network

***Solution***

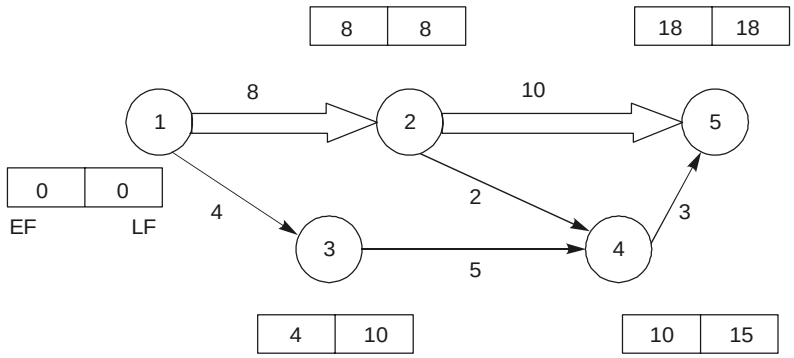



**Fig. 9.15** Network

**Table 9.8** Activity relationship

| *Activity* | *T* | *ES* | *EF (1+2)* | *LS (5-1)* | *LF* | *TF (4-2) (5-3)* | *Slack at head event* | *FF (6-7)* | *Slack at tail evet* | *IF (8-9)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
| 1 – 2 | 8 | 0 | 8 | 0 | 8 | 0 | 0 | 0 | 0 | 0 |
| 1 – 3 | 4 | 0 | 4 | 6 | 10 | 6 | 6 | 0 | 0 | 0 |
| 2 – 4 | 2 | 8 | 10 | 13 | 15 | 5 | 5 | 0 | 0 | 0 |
| 2 – 5 | 10 | 8 | 18 | 8 | 18 | 0 | 0 | 0 | 0 | 0 |
| 3 – 4 | 5 | 4 | 9 | 10 | 15 | 6 | 5 | 1 | 6 | -5 (taken as 0) |
| 4 – 5 | 3 | 10 | 13 | 15 | 18 | 5 | 0 | 5 | 5 | 0 |

Total float = 0 on the Critical Path, which is 1 – 2 – 5

***Example 9:*** Draw PERT Network

- Find expected time and variance for each activity
- Probability of completing project in 32 days.
- Total project duration

**Table. 9.9** Activity relationship

| *Activity* | *Estimated Time* | | |
|---|---|---|---|
| | $T_O$ | $T_M$ | $T_P$ |
| 1 – 2 | 6 | 9 | 18 |
| 1 – 3 | 5 | 8 | 17 |
| 2 – 4 | 4 | 7 | 22 |
| 3 – 4 | 4 | 7 | 16 |
| 4 – 5 | 4 | 10 | 22 |
| 2 – 5 | 4 | 7 | 10 |
| 3 - 5 | 2 | 5 | 8 |

***Solution***

**Table 9.10** Activity relationship

| Activity | Direction (Expected Time) | ES | EF | LS | LF | Float | Variance |
|---|---|---|---|---|---|---|---|
| 1 – 2 | (6 + 4x9+18) / 6 = 10 | 0 | 10 | 0 | 10 | 0 | ((18 – 6)/ 6) ² = 4 |
| 1 – 3 | (5 + 8 x 4 + 17) / 6 = 9 | 0 | 9 | 16 | 25 | 16 | ((17 – 5)/ 6) ² = 4 |
| 2 – 4 | (4 + 4 x 7 + 22) / 6 = 9 | 10 | 19 | 10 | 19 | 0 | ((22 – 4)/ 6)² = 9 |
| 3 – 4 | (4 + 4 x 7 +16) / 6 = 8 | 9 | 17 | 11 | 19 | 2 | ((16 –4)/ 6)² = 4 |
| 4 – 5 | (4 + 4 x 10 + 22) / 6 =11 | 19 | 30 | 19 | 30 | 0 | ((22- 4)/ 6) ² = 9 |
| 2 – 5 | (4 + 4 x 7 + 10) / 6 = 7 | 10 | 17 | 23 | 30 | 13 | ((10 –4)/ 6)² = 1 |
| 3 - 5 | (2 + 4 x 5 + 8) / 6 = 5 | 9 | 14 | 25 | 30 | 16 | ((8 – 2)/ 6)² = 1 |

Critical Path $= 1 - 2 - 4 - 5$

Variance along critical path $= \Sigma\sigma^2 = \sigma^2_{1\text{-}2} + \sigma^2_{2\text{-}4} + \sigma^2_{4\text{-}5}$

$= \sigma = 22^{1/2} = 4.69$

$Z = (T_S - T_E)/\sigma = 32 - 30)/4.69 = 0.42$

From Normal Distribution Table: $P = 65.54$ %

***Example 10:*** Using the three time estimates of the activities draw the AON network for Computer Design Project and find probability of completing project in 35 weeks.

***Solution***

**Table 9.11** Activity relationship

| Activity | Designation | Immediate Predecessors | Time Estimates | | |
|---|---|---|---|---|---|
| | | | *a* | *b* | *c* |
| Design | A | - | 10 | 22 | 28 |
| Built Prototype | B | A | 4 | 4 | 10 |
| Evaluate equipment | C | A | 4 | 6 | 14 |
| Test prototype | D | B | 1 | 2 | 3 |
| Write equipment report | E | C, D | 1 | 5 | 9 |
| Write method report | F | C, D | 7 | 8 | 9 |
| Write final report | G | E, F | 2 | 2 | 2 |

**Table 9.12** Activity relationship

| Designation | Time Estimates | | | Expected Time ($t_e$) (a+4m+b)/6 | Activity Variances (b-a) ²/ 6 |
|---|---|---|---|---|---|
| | *a* | *b* | *c* | | |
| A | 10 | 22 | 28 | 21 | 9 |
| B | 4 | 4 | 10 | 5 | 1 |
| C | 4 | 6 | 14 | 7 | 2 7/9 |
| D | 1 | 2 | 3 | 2 | 1/9 |
| E | 1 | 5 | 9 | 5 | 1 7/9 |
| F | 7 | 8 | 9 | 8 | 1/9 |
| G | 2 | 2 | 2 | 2 | 0 |

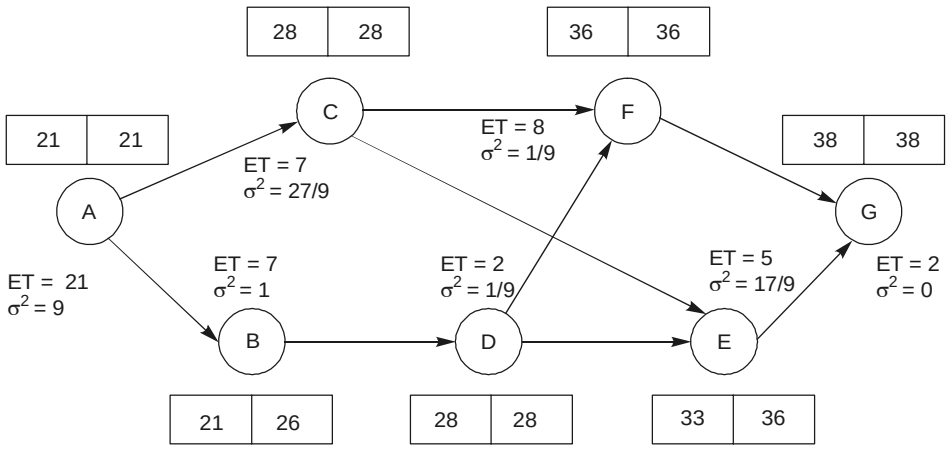



**Fig. 9.16** Network

Where

$a$ = Optimistic Path

$m$ = Most Likely Time

$c$ = Pessimistic Time

$t_e$ = Expected Time=$(a + 4.m + b)/6$

Variances= $\Sigma\sigma^2 = \Sigma\,(b - a)^2/6$

The project network was created the same as done previously with the only difference being that the activity times are weighted averages. We determine critical path as before taking these values as if they were single numbers. The difference between single time estimate and three time estimates (*optimistic, most likely, pessimistic*) is in computing probabilities for completion.

There are two critical paths throughout network. The first critical path includes activities *A*, *C*, *F*, *G* the second path includes *A*, *B*, *D*, *F*, *G*. Only activity *E* is not on critical path. Using Conservative approach we choose largest total variance which needs maximum attention. So variance associated with activities *A*, *C*, *F*, and *G*.

For Critical Path $\Sigma\,\sigma^2 = 9 + 2\ 7/9 + 1/9 + 0 = 11.89$

Probability of completing project in 35 Weeks.

Expected Completion Time ($T_E$)= 38 Weeks

$D$ = Actual Completion Time = 35 Weeks

$\Sigma\,\sigma^2$ = Variance =11.89

$Z = (D - T_e)/\,(\Sigma\,\sigma^2{}_{\text{Critical Path}})^{1/2} = (35 - 38)/(11.89)^{1/2} = -0.87$

$P\,(D<35) = P\,(Z < -0.87) = P\,(Z > -0.87)$ Since symmetric

$= 0.5 - P\,(0 < Z < -0.87)$

$= 0.5 - 0.31$

$= 0.19$

From the Normal Distribution Tables we find that at value of Z = - 0.87 gives a probability of 0.19. This means project Manager has only 19 Percent Probability of completing the critical path ACEG. Since there is another critical path and other paths that might become critical, the probability of completing the project in 35 Weeks is actually less than 0.19.

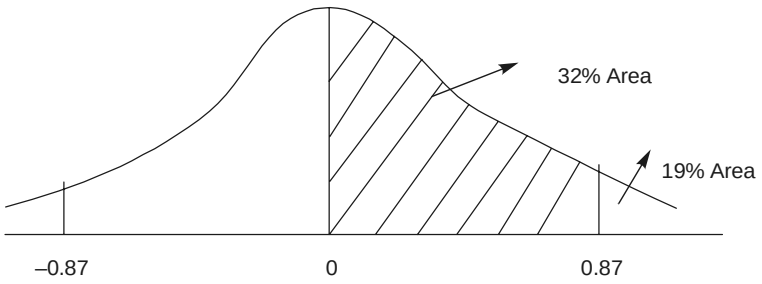



**Fig.9.17** Normal distribution curve

***Example 11:*** Consider a project for which the time estimates are given in the table below construct the PERT network what in the critical path. Find the probability of completing the project before 23 days.

**Table 9.13** Activity relationship

| *Activity* | *Estimated Time (Days)* | | |
|---|---|---|---|
| | *Most Optimistic* $T_o$ | *Most Likely Time* $T_m$ | *Most Pessimistic* $T_p$ |
| 1-2 | 2 | 5 | 8 |
| 1-3 | 1 | 4 | 7 |
| 2-3 | 0 | 0 | 0 |
| 2-4 | 2 | 4 | 6 |
| 2-6 | 5 | 7 | 12 |
| 3-4 | 3 | 5 | 10 |
| 3-5 | 3 | 6 | 9 |
| 4-5 | 4 | 6 | 10 |
| 4-6 | 2 | 5 | 8 |
| 5-6 | 2 | 4 | 6 |

***Solution***

First calculating the estimated average expected time and variance of each activity.

**Table 9.14** Activity relationship

| Activity | Estimated Time (Days) | | | Expected time $T_e = (T_o + 4T_m + T_p)/6$ | Variance $\{(T_p - T_o)/6\}^2$ |
|---|---|---|---|---|---|
| | $T_o$ | $T_m$ | $T_p$ | | |
| 1-2 | 2 | 5 | 8 | 5 | 1 |
| 1-3 | 1 | 4 | 7 | 4 | 1 |
| 2-3 | 0 | 0 | 0 | 0 | 0 |
| 2-4 | 2 | 4 | 6 | 4 | 16/36 |
| 2-6 | 5 | 7 | 12 | 7.5 | 49/36 |
| 3-4 | 3 | 5 | 10 | 5.5 | 49/36 |
| 3-5 | 3 | 6 | 9 | 6 | 1 |
| 4-5 | 4 | 6 | 10 | 6.33 | 1 |
| 4-6 | 2 | 5 | 8 | 5 | 1 |
| 5-6 | 2 | 4 | 6 | 4 | 16/36 |

The network is drawn below; the critical path is shown by double line arrow (1-2 –3- 4-5 6)

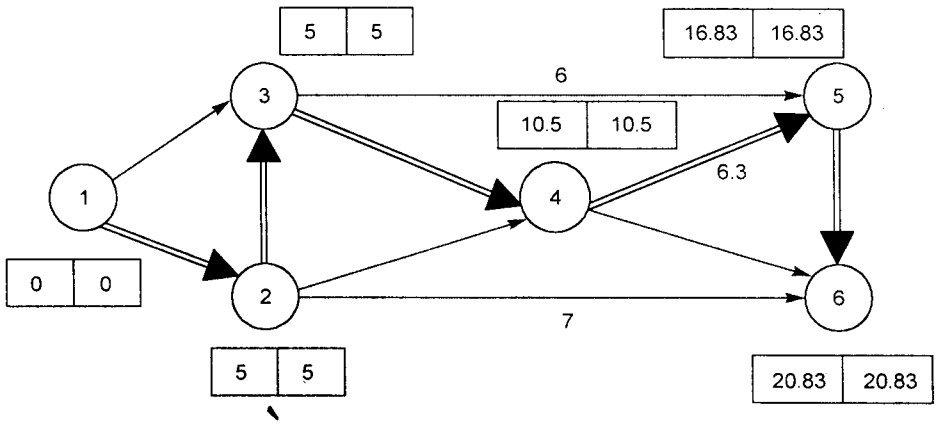



**Fig. 9.18** Network

Total expected project completion time = 20.83 days

Total variance along critical path $V_t^2 = 1 + 0 + 49/36 + 1 + 16/36$

$V_t^2 = 3.8$

Probability that project will be over by 23 days

$P(T < 23) = P\{(T - T_e) / V_t\} < = \{(23 - T_e)/ V_t\}$

$= P(Z <= \{(23 - 20.83) / (3.8)^{1/2}\} = P(Z < 1.11)$

$= 0.8665$

To find the value of probability in right hand side of above expression refer normal distribution Table. For $Z = 1.11$ the area under the normal curve is 0.8665.

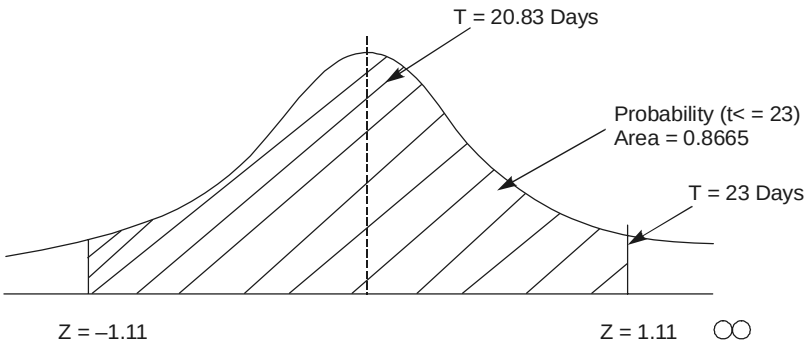



**Fig. 9.19** Normal distribution

## DIFFERENCE BETWEEN *CPM* AND *PERT*

CPM originated from construction project while PERT evolved from R & D projects. Both CPM and PERT share same approach for constructing the project network and for determining the critical path of the network.

There are some basic differences between PERT and CPM. PERT is associated with uncertainty in the time estimates for activity while in CPM these estimates are treated as fairly deterministic. CPM is also extended to *cost-time trade-off decisions*. As the project completion time is squeezed the time for the lowest project cost is the optional decision for project planning PERT is considered event oriented while CPM is mainly activity oriented.

**Table 9.15**

| | ***PERT*** | ***CPM*** |
|---|---|---|
| 1. | Time estimate are probabilistic with uncertainty in time duration. Three time estimates | Time estimate are deterministic with known time durations. Single time estimate. |
| 2. | Event oriented. | Activity oriented. |
| 3. | Focused on time | Focused on time-cost trade off. |
| 4. | More suitable for new projects. | More suited for repetitive projects. |
| 5. | Most costly to maintain | Easy to maintain |
| 6. | Suitable for complex projects where uncertain timing like research programmes | Suitable where problems of resource allocation exist like construction projects |
| 7. | Dummy activity required for proper sequencing | Use of dummy activity not necessary |

## 9.15 CRASHING OF NETWORK (TIME COST RELATIONSHIP)

***Introduction***: In CPM/PERT network techniques, time is related to cost and the object is to develop an optimum time-cost relationship. The ultimate object of the network techniques is not only to bring improvement in planning, scheduling and control of project but also to assess

possibility of arriving at a feasible and desirable time –cost relationship. The policy of every organization is to reduce the target time so that the time saved can be utilized for additional production or otherwise. Furthermore, every organization wants to accomplish the desired objective at minimum cost also. Sometimes it may be desirable to extend project duration if there is considerable saving in costs. Thus time–cost relationship is of great significance in project management.

Having drawn the network identifying the critical path is the first step cost analysis. Critical path represent the longest activity chain therefore any attempted either at reducing the overall time of project or reducing cost of operation or both requires conditional in project time is possible by allocating additional resource along critical path. For example if we are prepared to employ a person on overtime work could be prepared and completed earlier but at some additional cost. Similarly by increasing workforce we may again reduce the time of a particular activity. By doing so, we have diverted manpower from some other activity, which in turn might increase the activity time of later. In case it is possible that additional resources can be diverted from non-critical path activities and consequently the increase in duration of such activities and consequently the increase in duration of such activities is less than the slack, such diversion will not increase the cost of the project otherwise it increases cost. So time reduction is possible by following techniques:

- Controlling activities along critical path.
- Increase in resources like manpower. (Possible to shift from non-critical path activities.)
- Overtime operation.
- Subcontracting or external resources in form of men and material.
- Combination of above.

Only reducing the duration of the critical activities in the project network can reduce the overall project duration. To reduce the scheduled time, non-critical activities can be considered as potential pools of resources for diverting to critical activities.

Crashing on non-critical path subject to the condition, the crashing is limited without upsetting critical path. This cycle is again repeated by un-crashing and crashing till desired result is obtained. For bigger projects, trial and error method is not feasible. Linear programming and use of computers are found very popular and useful in such cases.

***Total project costs***: The total project cost is the sum of direct costs and indirect costs. The direct cost represents the expenditure, which can be directly allocated to different activities in a project, like labour, material etc. Indirect cost consists of overheads, depreciation, insurance, supervisory cost etc. The longer the project takes to complete, the higher are the indirect costs. Figure shows the indirect cost curve, direct cost curve and the corresponding total cost curve.

From the total cost curve of figure it is clear that the minimum total cost is obtained at some duration known as the optimum duration. The corresponding cost is known as minimum cost. If the duration of the project is increased, total cost will increase, while if the project duration is decreased to the crash value, project cost will be highest.

The duration of the project can be shortened by systematic analysis of critical path activities crashing costs and corresponding costs effect of indirect costs. For this time costs relationship should be critically examined fig shows a generalized curve between direct cost and project duration (time).

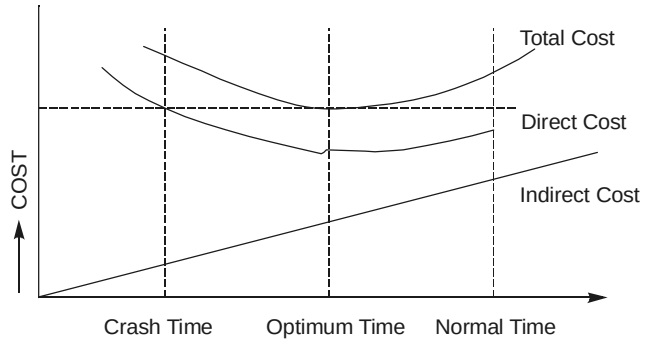



**Fig. 9.20** Time-cost relationship

The project has the highest cost corresponding to the crash duration and has normal cost corresponding to the normal duration. Thus we have two types of times defined below:

(*i*) *Normal time*. A normal time is the standard time associated, with normal resource of the organization to perform the activity.

(*ii*) *Crash time*. Crash time is the minimum possible time in which an activity can be completed by employing extra resources. Crash time is that time, beyond which the activity cannot be shortened by any amount of increase in resources.

(*iii*) *Normal costs*: the expenditure incurred on normal resources for completing any activity in normal time is known as normal costs.

(*iv*) *Crash costs*. The total expenditure incurred on normal and additional resource for crashing the time is known as crashed costs.

The cost slope formula can be represented as:

$$\text{The slope} = \frac{\text{Crsshed cost} - \text{Normal costs}}{\text{Normal time} - \text{Cash time}}$$

Cost slope represents the extra cost of shortening the duration of the activity by one time unit. For reducing the activity duration the management may agree for extra expenditure but to keep this expenditure minimum we must concentrate on those activities for which cost slope is minimum.

It can be observed that shortening the project duration leads to increase in direct costs but decrease in overhead (indirect) costs and the strategy will be justified only when it results in net saving. The normal tendency of every manufacturer is to produce at minimum cost and to have most efficient use of human resources. But in emergencies or sudden rush of orders if production is to be increased by increasing rate of production then naturally additional expenditure are to be introduced (e.g. working over time or in two shifts) which will result in extra expenditure. Manufacturer will be tempted to crash the time only when the profit earned from additional production is more than the extra expenditure on crashing.

## *Step in Time Cost Optimization*

The times cost optimization is done in the following steps:

1. **Establish:** Direct cost time relationship for various activities of the project, by analyzing past cost records.

2. **Determine:** Cost slopes for various activities and arrange them in ascending order of cost slope.
3. **Compute:** Direct cost for the network with normal duration of activities.
4. **Crash:** The activities in the critical path as per ranking i.e. starting with the activity having the lowest slope.
5. **Continue:** Crashing the critical activities in the ascending order of slope.
6. **Crash:** Parallel non critical activities which have become critical by the reduction of critical path duration due crashing in step 4 and 5
7. **Continue:** Crashing process through step 4 to 6, till a stage is reached beyond which no further crashing is possible.
8. **Find:** Total cost of project at every stage adding indirect cost the direct costs determined above.
9. **Plot:** Total costs duration curve
10. **Pick-up:** The optimum duration corresponding to which least total project cost is obtained.

***Example 12.*** For a network shown in figure, normal time, crash time, AND normal costs are given in the table. Contract the network by crashing it to optimum value and calculate the optimum project cost. Indirect cost is given as Rs. 100 per day.

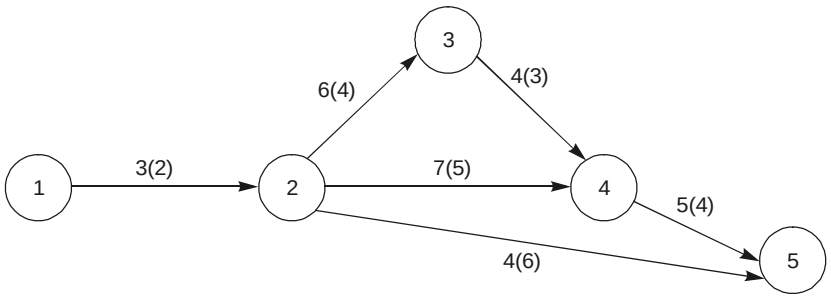



**Fig. 9.21** Network

**Table 9.16** Activity relationship

| *Activity* | *Normal* | | *Crash* | |
|---|---|---|---|---|
| | *Time (days)* | *Cost (Rs.)* | *Time (days)* | *Cost (Rs.)* |
| 1-2 | 3 | 300 | 2 | 400 |
| 2-3 | 6 | 480 | 4 | 520 |
| 2-4 | 7 | 2100 | 5 | 2500 |
| 2-5 | 8 | 400 | 6 | 600 |
| 3-4 | 4 | 320 | 3 | 360 |
| 4-5 | 5 | 500 | 4 | 520 |

***Solution***

From the network diagram critical path is 1- 2- 3 – 4- 5 and the project duration is 18 days. To contract the network in first stage we must identify those activities on critical path, which have cost slopes less than the indirect cost. The slopes are calculated as under.

**Table 9.17** Activity relationship

| Activity | Normal | | Crash | | Crash Cost Normal Cost | Normal Time Crash Time | Cost Slope |
|---|---|---|---|---|---|---|---|
| | Time (days) | Cost (Rs.) | Time (days) | Cost (Rs.) | $C_c - N_c$ | $N_t - C_t$ | $\frac{C_c - N_c}{N_t - C_t}$ |
| 1-2 | 3 | 300 | 2 | 400 | 100 | 1 | 100 |
| 2-3 | 6 | 480 | 4 | 520 | 40 | 2 | 20 |
| 2-4 | 7 | 2100 | 5 | 2500 | 400 | 2 | 200 |
| 2-5 | 8 | 400 | 6 | 600 | 200 | 2 | 100 |
| 3-4 | 4 | 320 | 3 | 360 | 40 | 1 | 40 |
| 4-5 | 5 | 500 | 4 | 520 | 20 | 1 | 20 |

Now for crashing we consider all possible paths in the network and the corresponding durations in tabular from as under.

| Path | Sequence | Target Time | Time Crashed at Various Stages | | |
|---|---|---|---|---|---|
| | | | 2-3 | 4-5 | 3-4 |
| $P_1$ | 1-2-3-4-5 | 18 | 16 | 15 | 14 |
| $P_2$ | 1-2-4-5 | 15 | 15 | 14 | 14 |
| $P_3$ | 1-2-5 | 11 | 11 | 11 | 11 |

Critical path activities 2-3 and 4-5 have least cost slopes.

Therefore, crashing the activities 2-3 and 4-5 by 2 days and 1 day respectively.

Project duration = 18 – 3 = 15 days.

Cost of project = Normal cost + Extra crashing cost + Indirect cost

= (300 +480 +2100 +400 +320 +500)+ (2 × 20 + 1× 20) + 15 × 100

= Rs 5600/-

In second stage crashing the least cost slope activity 3-4 on critical path by 1 day. Project duration = 14 days.

Cost of project = Normal cost + extra crashing cost + indirect cost

= 4100+ (20 × 2 + 1 × 20 + 1 × 40) + 14 × 100 = Rs 5600/-

The total project cost with normal activities (without crashing)

= Normal cost + Indirect cost for 18 days = 4100 + 1800 = Rs 5900/-

Therefore, the optimum cost of the project is Rs 5600/-.

***Example 13:*** A Small marketing project consists of the jobs in the table given below. With each job is listed, its normal time and a minimum or crash time (in days). The cost in (Rs per Day) of crashing each job is also given.

**Table 9.18** Activity relationship

| *Job (I-J)* | *Normal Duration (in days)* | *Minimum (Crash) Duration in Days* | *Cost of Crashing (Rs per day)* |
|---|---|---|---|
| 1-2 | 9 | 6 | 20 |
| 1-3 | 8 | 5 | 25 |
| 1-4 | 15 | 10 | 20 |
| 2-4 | 5 | 3 | 10 |
| 3-4 | 10 | 6 | 15 |
| 4-5 | 2 | 1 | 40 |

- What are the normal project length and the minimum project length?
- Determine the minimum crashing costs schedules ranging from normal length down to and including, the minimum length schedule i.e. if L is the length of normal schedule, find the costs of schedule which are L, L-1, L-2 and so on, long days
- Overhead Costs total Rs 60/day. What is the optimal length schedule duration of each job for your solution

***Solution***

(*a*) Construct the network considering the normal duration of the project as given below.

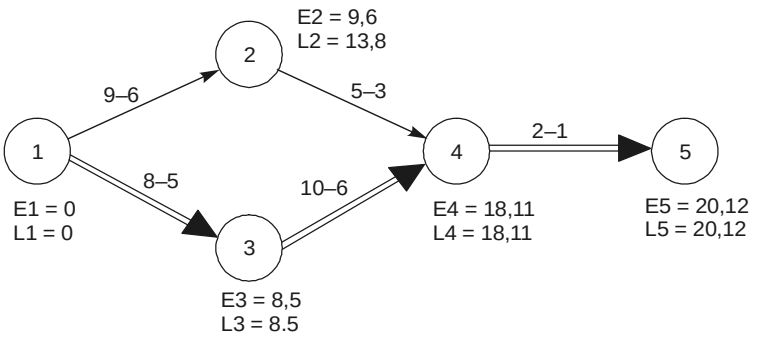



**Fig. 9.22** Network

The critical path is 1-3-4-5 with the normal duration 20 days and minimum project length is 12 days.

(*b*) Since the present schedule consumes more time, the duration can be reduced by crashing some of the activities. Also since the project duration is controlled by the activities lying on the critical path, the duration of some of the activities lying on the critical path can be reduced.

*Step I*: First, reduce the duration of that activity which involves the minimum cost. Since the activity (3,4) involves minimum cost, the duration of this activity can be compressed from 10 days to 9 days resulting on total cost for 19 days schedule becomes equal to = Rs.15 +19*60 = Rs.1155.

*Step II*: Again since the critical path remains unchanged, the duration of activity (3,4) can be reduced further from 9 days to 8 days resulting in an additional cost of Rs. 2*15 *i.e.* Rs.30. So the total cost for 18 days schedule becomes = Rs. 30+18*60 = Rs.1110/-.

*Step III*: Continue this procedure till the total cost starts increasing. The calculations may be compiled in the following table:

**Table 9.19** Activity costs

| *Normal Project Length (Days)* | *Crashing Cost (Days/Rs.)* | *Overhead @ Rs.60/Day* | *Total Cost (Rs.)* |
|---|---|---|---|
| 20 | — | 20*60 | 1200 |
| 19 | 1*15=15 | 19*60 | 1155 |
| 18 | 2*15=30 | 18*60 | 1110 |
| 17 | 3*15=45 | 17*60 | 1065 |
| 16 | 3*15+1*40=85 | 16*60 | 1045 |
| 15 | 4*15+1*40+1*30=130 | 15*60 | 1030 |
| 14 | 4*15+1*40+2*30+1*25+1*10=195 | 14*60 | 1035 |

(*c*) Since the total cost starts Increasing for 14 days duration, the minimum total cost of Rs. 1030/- occurs for 15 days duration. Hence the optimum length of the schedule is 15 days. Optimum duration of each job is as follows:

| Job | (1,2) | (1,3) | (1,4) | (2,4) | (3,4) | (4,5) |
|---|---|---|---|---|---|---|
| Opt duration (Days) | 9 | 8 | 14 | 5 | 6 | 1 |

## 9.16 *CPM* UPDATING A PROJECT

During the process of implementing the project plan according to the network, one of the following possibilities may arise:

1. Some or all the activities are in progress as per the schedule.
2. Some or all the activities are ahead of schedule.
3. Some or all the activities are lying behind the schedule.

If all the activities are progressing as per the schedule there is no need for updating the network. However, many times the network designed during planning may not adhere to the schedule when put to work, because situation sometimes keeps on changing and during actual execution they may differ than that actual assumed at the planning stage. Following are few reasons for deviation between the schedule and actual progress during execution.

- Errors made in estimating the expected time to complete the activity (under estimation or over estimation).
- Unforeseen circumstance, like delay in availability of resource as planned, equipment /machinery breakdown etc.
- Natural calamity.

It is therefore possible that inspite of best efforts, some activities may need more for completion than originally planned or some new activities may also crop up. To ensure that the schedule time is maintained it is necessary to review the progress of project and re draw the network diagram according to latest requirement. During redrafting schedule dates are revised but if it is not possible to delay the project, then activities on new critical path are accelerated by allocating extra resources, in order to adhere to schedule dates.

The process of reviewing the progress of project execution is known **updating**. Updating is also defined as the process of replanning and rescheduling based on the results, which serve as guidance for decision by performing calculation made by taking into consideration the new knowledge and latest information at an intermediate of the project thus modifying the original network.

## 9.16.1 Data Required for Updating

The following information is necessary to update the plan at an intermediate stage of execution of a project:

1. Original network;
2. Original network calculation chart;
3. Stage at which updating is being done i.e., a point in time of updating;
4. Execution position of the project at that stage and
5. New information and knowledge, which will affect the duration time of the activities to be performed.

### *Step in the Updating Process*

1. **Describe:** the point in time at which updating is to be done according to the original plan.
2. **Record:** what has happened actually till the updating point.
3. **Summarize:** the information obtained in the tabular from as given below.
4. **Place:** the information contained in the updating table on to the original network. This is done by
   - Assigning the time of update as the earliest occurrence time for the tail event of the project.
   - Allowing zero time duration for all activities, which have been completed.
   - Entering the remaining estimated duration of those activities which are in progress:
   - Entering the estimated duration based on new information of activities, which are still to be started.
5. **Perform:** Calculation of EST and LFT and mark these on the network know as update network.

**Table 9.20** Activity relationship

| *Activity* | *Whether Completed or Not* | | *If in Progress* | *Completion Required* |
|---|---|---|---|---|
| | Yes / No | If yes, time taken for completion | Additional time required for | For activities yet to begin completion |
| | | | | |

***Example 14.*** Show the network of a project, which is to be update at the end of 10 days. The following condition exit at the time updating:

1. Activity 1-4 was completed as originally planned.
2. Activity 1-3 was executed more rapidly than originally schedule and it took 6 days for its completion.
3. Activity 3-4 started following the completion of activity 1-3 and was finished at the end of $9^{th}$ day.
4. Activity 4-5 was started following the completion of activity 3-4 (i.e. at the end of $9^{th}$ day) and still required 4 more days for its completion.
5. Completion of activity 1-2 was delayed drastically and it requires 8 more days for its completion.
6. Activity 2-7 will commence following the completion of activity 1-2 and will required 7 days for its completion instead of 6 days originally estimated.
7. The time required to perform activity 5-8 has been revised based on the experience on the project gained to this point it now requires 7 days place of 6 days originally planned.
8. No other activities have been started, and the originally time estimates for these activities still appear to be accurate.

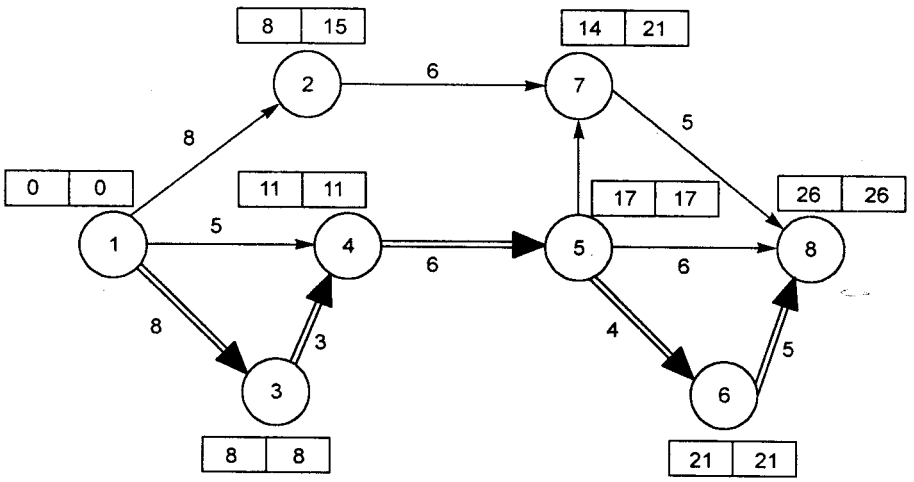



**Fig. 9.23** Network

***Solution***

Show the originally network with EST and LFT marked. The critical path is shown by double line arrows (1-3-4-5-6-8).

Table below gives details of execution of the activities at the end of 10 days.

**Table 9.21** Activity relationship

| Activity | Whether Completed | | Additional time required for activities in progress (days) | Completion time required for activities yet to begin (days) |
|---|---|---|---|---|
| | Yes/No | If yes, time taken (days) | | |
| 1 | 2 | 3 | 4 | 5 |
| 1-2 | No | | 8 | |
| 1-3 | Yes | 6 | | - |
| 1-4 | Yes | 5 | | - |
| 2-7 | - | - | - | 7 |
| 3-4 | Yes | 3 | | |
| 4-5 | No | - | 4 | - |
| 5-6 | No | | | 4 |
| 5-7 | No | | | 3 |
| 5-8 | No | - | - | 8 |
| 6-8 | No | | | 5 |
| 7-8 | No | | | 5 |

The updated network can be drawn on the basis of data form the table. For those activities, which have been already completed, completion time is taken to be zero, since they require zero time after the 10th day. Also the earliest start time and latest finish time of each event is calculated with reference to original starting date of the project. This can be achieved by taking EST for event I as equal to 10 days.

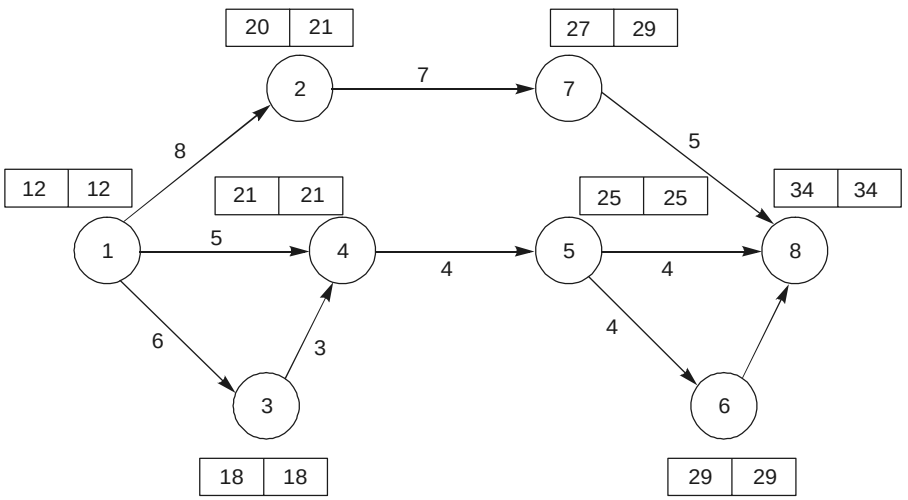



**Fig. 9.24** Network

The updated network is shown. The critical path remains unchanged (i.e., 1-3-4-5-6-8). The project duration will be 34 days instead of 26 days originally scheduled.

On the day of updating the remaining duration of project = 34 – 12 = 22 days.

## 9.17 RESOURCE ALLOCATION

Every project consists of number of activities. There may be activities, which are to be performed simultaneously and may require common resource. The requirements of resource to execute these simultaneous activities may exceed the available resources. However, at some other period of the execution of the same project, there may be very few activities, which may require these resources. Hence the requirement of a particular type of resource may not be uniform during the project duration (labour, capital, equipment).

Every management wants to allocate the limited resources equipments to various activities in such a manner that there is best possible use of resources at disposal. PERT and CPM techniques provide valuable guidelines for most systematic and economic allocation of resources. The presence of slack or float for some of the activities enables the management to delay that activity for some time and use these resource to some more urgent activities on critical path. The resource allocation procedure consists of two main activities namely resource smoothing and resource leveling.

There are many activities in a project requiring varying levels of resource. In the resource leveling process, the activities are so re scheduled that the maximum of peak resource requirement does not exceed the limit of available resource. The available resources should however not be less than the maximum number of quantity required for any activity of the project. In rescheduling the available floats are first used. If by doing so, the resources requirement for these activities is decreased. Thus in the source leveling process, the project duration, initially planned, might be increased.

## 9.18 RESOURCE SMOOTHING

The time scaled version of various activities and their resource requirement with corresponding floats if any is used for resource smoothing. The periods of maximum demand for resource are located and the activities according to their float values are shifted for balancing the resource needs and availability. Thus intelligent utilization of floats can smoothen demand of resource to a great extent.

### *Steps in Resource Allocation*

(*a*) Resource requirements for each activity are listed for each item of resource i.e. men, machine, material etc.

(*b*) The category wise availability of different resource both with respect to quantity and time is also listed.

(*c*) The allocation resource to activities lying on the critical path is given top priority but for non-critical activity some compromise can be made. When several jobs compete for the same resource given preference to one with least slacks.

***Example 15:*** Given the following information suggest some appropriate allocation schedule for the following project consisting of 14 activities:

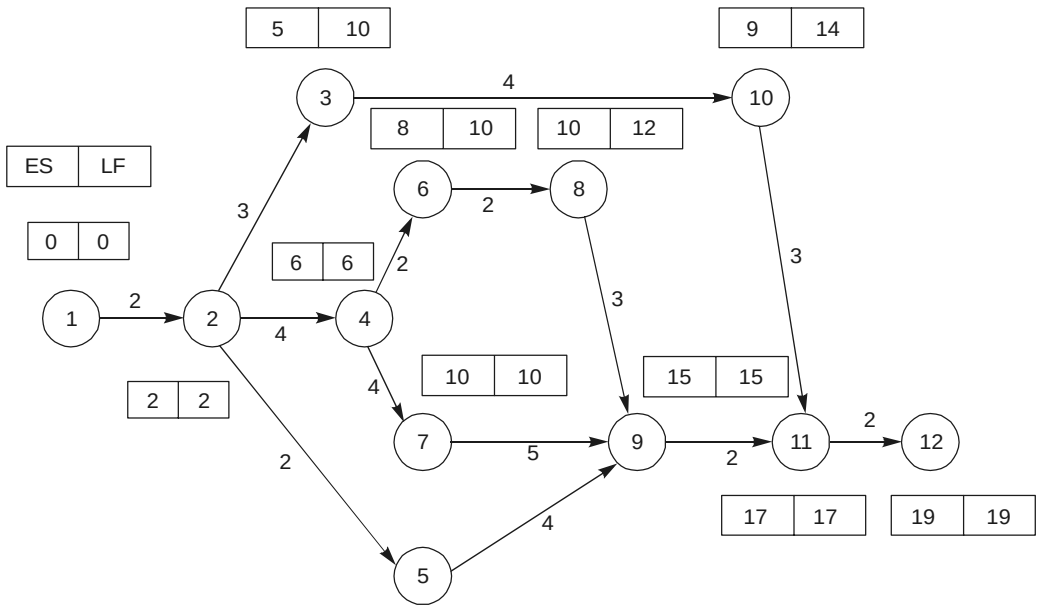



**Fig. 9.25** Network

**Table 9.22** Activity relationship

| *Activity* | *Duration* | *Men* | *Activity* | *Duration* | *Men* |
|---|---|---|---|---|---|
| 1-2 | 2 | 1 | 5-9 | 4 | 5 |
| 2-3 | 3 | 2 | 6-8 | 2 | 1 |
| 2-4 | 4 | 3 | 7-9 | 5 | 1 |
| 2-5 | 2 | 1 | 8-9 | 3 | - |
| 3-10 | 4 | 2 | 9-11 | 2 | 1 |
| 4-6 | 2 | 3 | 10-11 | 3 | 1 |
| 4-7 | 4 | 3 | 11-12 | 2 | 1 |

***Solution***

The first step is to determine critical path. The network in figure shows EST and LFT (after commutation) for various activities. The critical path (marked by thick arrows) is 1-2-4-7-9-11-12. with a project duration of 19 days. Now resource allocation can be made on the basis of their availability and using the following criterion:

(*i*) Resource allocation based on EST

(*ii*) Resource allocation based on LST.

(*iii*) Resource allocation with limited availability of the resource.

The earliest start time of various activities is calculated then a time scaled network is drawn by taking the critical activities on horizontal line and slack activities (having float) above it as shown in figure:

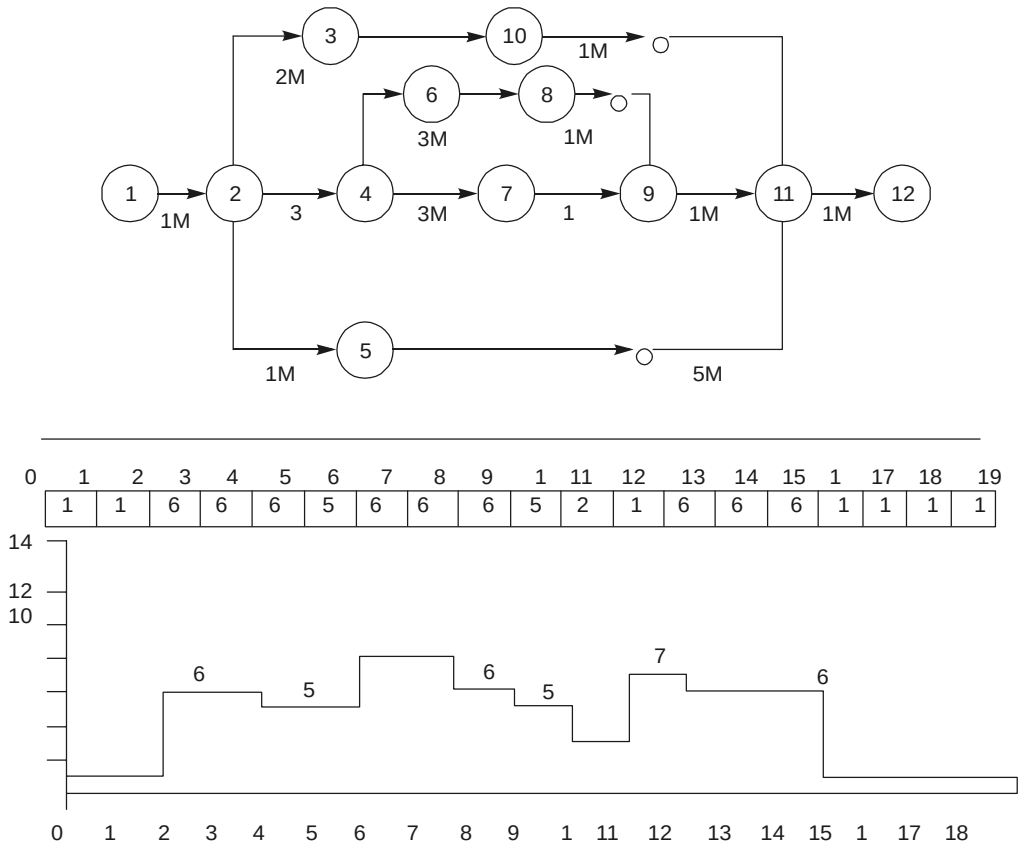



**Fig. 9.26** Network

From the network diagram, if we allocated the resource without considering the float available for the non critical activities there is a peak requirement of men of 7$^{th}$ and 8$^{th}$ day (5 men for activity 5-9,3 for activity 4-7,3 for activity 4-6 and 2 for activity 3-10 (which is yet to complete). Total requirement of men on 7$^{th}$ & 8$^{th}$ day will be 13; also the requirement of men from 11$^{th}$ day will be very less. By inspection we fined that the activity 5-9 has float of 7days.

Hence the start of activity 5-9 can be shifted by 7 days, this will be given encouraging result, as this activity requires 5 men. Thus activity 5-9 can stared after 11$^{th}$ day instead of after 4$^{th}$ day. We find that the peak demand of men has been decreased from (13 for 7$^{th}$ and 8$^{th}$ day) to 8.

Similarly we can shift activity 8-9 by its total float of 2 days thus following this procedure it is always possible to smoothen the resource without affecting the project duration. Thus

allocation of men can be represented as:

**Table 9.23** Activity times

| *Days Number* | *Men Busy* | *Days Number* | *Men Busy* |
|---|---|---|---|
| 0-2 | 1 | 9-10 | 5 |
| 2-4 | 6 | 10-11 | 2 |
| 4-6 | 5 | 11-12 | 7 |
| 6-8 | 8 | 12-15 | 6 |
| 8-9 | 6 | 15-19 | 1 |

## 9.19 ILLUSTRATIVE CASE STUDY

Streamline construction Associates (SCA) of Maharashtra did general construction work. In June 1994, the company had three jobs and a four stores addition to a shopping center.

The owner of the shopping center, Mr. Chedda, desires to open a tyre sales service and wheel alignment unit in his shopping center. On June 15, 1994 he decided to proceed at one to arrange for the construction of a suitable place to house the tyre shop in one corner of the shopping center parking lot. He then called Mr. Ahuja, the president of SCA, to arrange a meeting to discuss the plans for building. During their meeting Mr. Chedda and Mr. Ahuja agreed that a suitable building for the new tyre shop would be a single- story frame structure somewhat similar in exterior design of a petrol- Diesel Lub-Oil Dispensing station that SCA had under construction at that time.

Although the time was short, Mr. Chedda was anxious to have the tyre shop building completed by the time the shop should be tied up with the opening of the four stores in the new addition on the 15$^{th}$ of August 1994. The construction schedule demanded that the tyre shop be completed in 55 days (working days) after 20$^{th}$ June 1994. In the initial analysis of the project Mr. Kumble, SCAs planning expert, noted the following construction relationship is generally observed for construction of this type:

(*a*) A preliminary set of specification would have to be completed before work could begin on the set of blueprints and before the foundation excavation could begin. After the excavation was completed the concrete could be poured, and allowed to set and cure.

(*b*) The preparation of bill of material (other than cement, sand and granite jelly which were available from stock) would have to be deferred until the final set of blueprints was prepared. When the bill of materials was completed it would be used to prepare order for lumber and other items. Construction of the frame could not begin until the lumber had arrived at the construction site and the foundation has to be set and cured.

(*c*) After the frame was completed, electrical work, erection of lathe, plumbing, installation of millwork and installation of siding could begin.

(*d*) Painting of the interior walls could not start until the electrical work, plastering of the walls could not begin until the lathes were erected.

(*e*) The final interior decorating work would not begin until the interior walls were painted and the trim is installed. Installation of trim could not begin until the mill work was completely installed.

(*f*) Painting of the building's exterior could not proceed until the windows and exterior doors were installed. Installation of the windows and doors, in turn, could not start until the siding was in place.

After studying a plans and construction schedule of the petrol station under construction. Mr. Kumble developed an estimate of the time required to complete each step of the building of the tyre shop. The estimate (Exhibit 1) were is most cases developed from the figure given to Mr. Kumble by the foreman of the petrol station job. Mr. Kumble had found in the past that figures of this type were usually quite accurate. One exception to this was the figures obtained from the carpenter foreman, who was sometimes a little too pessimistic about his estimates.

As he studied the time estimates he had put together for the tyre shop job, Mr. Kumble realized that some of the steps would to be rushed in order to complete the job in 55 days. To provide more usable information on the effects of rushing some of the construction steps, Mr. Kumble estimated the extra cost of reducing the normal time required for each step by one or more days (Exhibit 1). The cost could increase the cost of tyre shop over what might be called the cost under optimal conditions, (the cost incurred if each step could be performed at normal pace without undue rushing, overtime, etc). Realizing that any extra costs should be kept at an absolute minimum, Mr. Kumble tried to develop a construction schedule, which rushed only those activities where the extra cost was not too high. After several hours of work Mr. Kumble devised the following tentative construction plan:

Deciding that the plan needed further work. Mr. Kumble put all his notes on and tyre shop into his brief-case to do further work at home that evening. He also put a booklet. The management implication of PERT published by a management-consulting firm into his briefcase

**Table 9.24** Activity times & costs

| Step | | Estimated Time to Execute Step | Reduction (Days possible) | Cost in Rs. (Additional) |
|---|---|---|---|---|
| A | Preparation of preliminary specification | | 2 | 200 |
| | | 10 | 3 | 2,400 |
| B | Excavate foundation | 5 | 1 | 4,000 |
| C | Pore concrete | 6 | 1 | 3,600 |
| D | Electric work | 5 | 2 | 4,000 |
| E | Lathe work | 2 | 1 | 400 |
| F | Plumbing | 6 | 2 | 1,600 |
| G | Plaster walls | 4 | 1 | 800 |
| H | Pain interior walls | 5 | 1 | 1,400 |
| | | - | 2 | 3,000 |
| I | Mill work installation | 10 | 2 | 4,000 |
| | | | 3 | 7,000 |
| J | Trim installation | 8 | 2 | 1,800 |
| | | | 3 | 3,000 |
| K | Erect frame and roof | 15 | 2 | 20,000 |
| | | | 4 | 50,000 |

*Contd...*

| Step | | Estimated Time to Execute Step | Reduction (Days possible) | Cost in Rs. (Additional) |
|---|---|---|---|---|
| L | Final interior decoration | 8 | 2 | 2,000 |
| | | | 4 | 8,000 |
| M | Installation of siding | 7 | 1 | 2,000 |
| | | | 3 | 12,000 |
| N | Paint exterior | 7 | 1 | 2,000 |
| | | | 2 | 3,000 |
| O | Blueprints finalized | 5 | 2 | 1,400 |
| | | | 3 | 2,400 |
| P | Prepare bill of materials and order lumber | 3 | 1 | 1,000 |
| | | | 2 | 3,400 |
| Q | Time required to receive lumber after order is sent | 8 | 2 | 2,000 |
| | | | 4 | 5,000 |
| R | Window and exterior door installation | 6 | 1 | 2,000 |
| S | Concrete setting and curing | 6 | 2 | 2,000 |

Draw a revised construction schedule that Mr. Kumble might have conceived to complete the project in crash time of 55 days and find out the minimum crash cost, i.e., additional.

## Hint

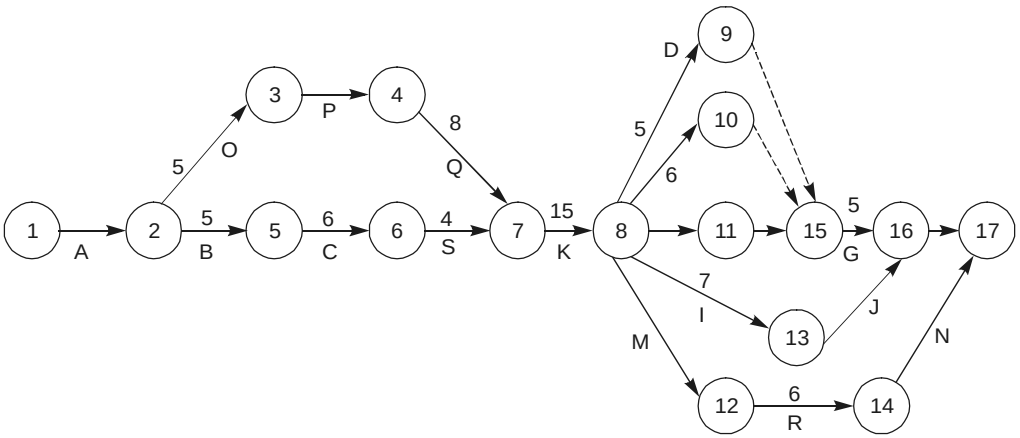



**Fig. 9.27** Network

(*b*) Critical Path → A+B+C+S+K+I+J+L = 68 days

**Table 9.25** Time and Cost relationship

| *Activity (Rs, in 000)* | *Normal Time* | *Crashed Time* | *Additional Costs* |
|---|---|---|---|
| A | 10 | 7 | 2,400 |
| P | 3 | 2 | 1,000 |
| S | 6 | 4 | 2,000 |
| I | 10 | 7 | 7,000 |
| J | 8 | 5 | 3,000 |
| L | 8 | 6 | 2,000 |
| N | 7 | 5 | 3,000 |
| | | | 20,400 |

(*c*) Alternative paths (after crashing) as can be seen in the network.

1. ABCSKIJL = 55 days
2. ABCSKMRN = 55 days
3. AOPQKIJL = 55 days
4. AOPQKMRN = 55 days

Mr. Kumble might conceive a plan that has a little more chance of crashing at minimum possible cost if required in future. Therefore, out of four alternative path he many select the last path, *i.e.*, AOPQKMRN as there is still a possibility of crashing 'Q' and 'R' activities at a minimum increment of Rs. 7,000 cost to the present crash cost of Rs. 20,400.

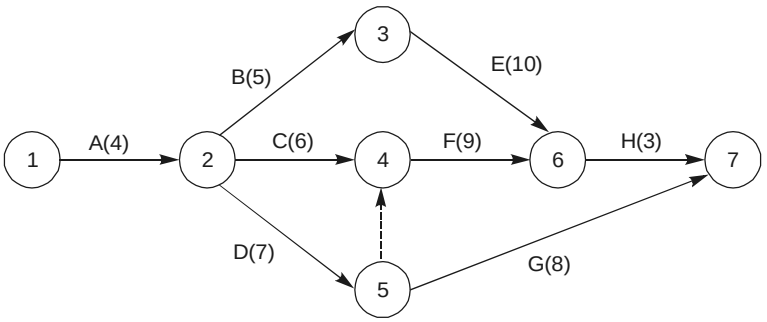
## QUESTIONS

1. What were the problems in bar charts that led to evolution of network?
2. What is the difference in network convention AON and AOA?
3. What is the need for statistical method of deriving single time estimate?
4. Explain the terms:
   - Float
   - Total Float
   - Free Float
   - Independent Float
   - Event Slacks.
5. How does network analysis help in large complex projects?
6. What purpose is served by including dummy activities in network diagram?
7. Explain CPM technique and its importance in network analysis.
8. Explain PERT and its importance in network analysis. What are the requirements for application of PERT techniques?
9. Illustrate with examples the essential difference between PERT and CPM techniques. Under what conditions would you use PERT instead of CPM in project management.

10. Draw the network for the following data given in the table and explain.

| *Activity* | *Duration (weeks)* | *Predecessors* |
|---|---|---|
| A | 2 | None |
| B | 2 | None |
| C | 7 | A |
| D | 12 | A |
| E | 10 | B |
| F | 3 | D,E |
| G | 4 | C,F |

11. Find the critical path and project duration for the following project network.




12. For processing a job at a data processing center, certain steps need to be taken. These jobs can be described as follows:

| *Job* | *Description* | *Immediate Predecessors* | *Time (minutes)* |
|---|---|---|---|
| A | Design flowchart and write Fortran statements | -- | 180 |
| B | Punch control cards | A | 30 |
| C | Punch comment cards | A | 20 |
| D | Punch programme cards | A | 60 |
| E | Obtain brown folder | B, C, D | 10 |
| F | Put deck together | B, C, D | 20 |
| G | Submit deck | E, F | 10 |

Draw a critical-path arrow diagram and indicate the critical path. What is the minimum time required for completion?

What is the free float of job C?

13. Draw the arrow diagram, identity the critical path and compute total and free floats for the activities in the project of planning a rural piped-water supply.

| *Activity Identification* | *Activity Description Predecessor(s)* | *Immediate Duration (week)* | *Expected (week)* |
|---|---|---|---|
| A | Excavation of well | -- | 8 |
| B | Collection of 10% popular contribution | a | 9 |
| C | Completion of well | b | 7 |
| D | Detailed plans of supply system | a | 15 |
| E | Pump house contribution | c, d | 4 |
| F | Stand post contribution | e | 1 |
| G | Contribution of reservoir | d | 4 |
| H | Laying of pipelines | e, g | 5 |
| I | Roadside tabs | h, f | 4 |

14. A project comprises eight independent activities. Draw the diagram for the project and identify its critical path. What is the expected time to complete the project? Calculate the total and free floats for non-critical activities. What is the probability of completing the project in 20 weeks or less? Time estimates (in weeks) are as follows where $a$ = most optimistic time, $m$ = most likely time, $b$ = most pessimistic time.

| *Activity* | *Predecessor* | *a* | *m* | *b* |
|---|---|---|---|---|
| A | - | 1 | 3 | 5 |
| B | - | 2 | 3 | 4 |
| C | - | 3 | 4 | 5 |
| D | A | 2 | 9 | 10 |
| E | C | 4 | 5 | 6 |
| F | B, D, E | 5 | 6 | 13 |
| G | A | 2 | 4 | 6 |
| H | C | 1 | 3 | 6 |

15. A Market research company( *QQ* )has been commissioned by the food manufacturer *ZZ* to carry out research market in a new product development product, prior to a test market launch. The table below lists required activities and their duration's, in weeks:

| | *Activity* | *Immediate Predecessor* | *Duration (weeks)* |
|---|---|---|---|
| A | Group discussions | - | 6 |
| B | Finish product development | - | 4 |
| C | Usage and attitude study | A | 20 |
| D | Blind testing (users) | B | 12 |

*Contd...*

| | Activity | Immediate Predecessor | Duration (week) |
|---|---|---|---|
| E | Blind testing (non-users) | B | 11 |
| F | Pricing research | C | 5 |
| G | Data analysis | C, D, E | 4 |
| H | Development expert system | E | 30 |
| I | Positioning, imagery | G | 8 |
| J | Packaging tests | G | 10 |
| K | Promotion studies | F, I | 7 |
| L | Marketing mix assessment | H, J, K | 6 |
| M | Production set-ups | H, J, K | 4 |
| N | Home placements tests | L | 10 |
| O | Pre-test market analysis | M, N | 3 |

(*a*) Draw the new product development network. State and explain the critical path, and its duration.

(*b*) Interpret *R* and *S* on this diagram.

(*c*) Prepare a table of the earliest start and finish times, the latest start and finish times, and the total and free float. Explain the importance of the 'float' for management.

16. A project which is about to start comprises the activities listed in the table below:

| Activity | Immediately Preceding Activities | Duration (weeks) |
|---|---|---|
| A | None | 4 |
| B | A | 13 |
| C | A | 5 |
| D | C | 11 |
| E | C | 3 |
| F | D, E | 4 |
| G | None | 3 |
| H | A, G | 5 |
| I | G | 4 |
| J | H | 17 |
| K | H | 2 |
| L | J, K | 3 |
| M | F, L | 3 |
| N | B, M | 3 |
| O | I, M | 2 |
| P | O | 3 |
| Q | N, P | 4 |

Ignoring holiday periods, the project must be completed by the end of week 38. If the project is delayed beyond this date, it is estimated that it will cost the firm Rs. 30,000 a week.

(1) Draw a critical path network to represent the project and determine the critical path. What is the earliest time at which the project can be completed and what penalty cost (if any) will be incurred?

(2) Activity *K* is a two week course to train new salesman. The hotel which will be used for the course has been booked for weeks 12 and 13. In the light of your analysis should this booking be changed?

(3) If activities *L* and *E* can be done in parallel, some savings can be made as they use common resources. What are the minimum saving that must be made to justify these activities being done at the same time?

(4) Briefly outline how the critical path method can be adapted to deal with projects where the activity duration involve uncertainty.

17. XYZ Ltd. Planning a project to introduce a new product, has listed the following necessary activities:

| ***Activity*** | ***Preceding Activity*** | ***Expected Time Weeks*** |
|---|---|---|
| A | - | 6 |
| B | - | 3 |
| C | A | 5 |
| D | A | 4 |
| E | A | 3 |
| F | C | 3 |
| G | D | 5 |
| H | B, D, E | 5 |
| I | H | 2 |
| J | I, G, F | 3 |

- Draw the critical path network for the project and determine the critical path and its duration.
- If the start of activity B is delayed by 3 weeks, activity E by 2 weeks and activities G by 2 weeks, how is the total time for the project affected?
- Assume that time given in the above table are the expected times of the activities, the durations of which are normally distributed with the following standard deviations:

| ***Activity*** | ***A*** | ***B*** | ***C*** | ***D*** | ***E*** | ***F*** | ***G*** | ***H*** | ***I*** | ***J*** |
|---|---|---|---|---|---|---|---|---|---|---|
| Standard Deviation | 1 | 0.5 | 1 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 1 |

Ignoring the delays referred to in (ii) and the possible effect of uncertainty in non-critical activities, determine a 95% confidence interval for the expected time on the critical path.

- The cost of the project is estimated to be Rs. 10,00, 000. If it is completed within 24 weeks, the expected returns should be about Rs. 1,00,00,000 but if the deadline of 24 weeks is not met, the product will fail to penetrate the market a net revenue of only Rs. 2,00,00,000 is expected. Determine the expected profit on this subject. For simplicity, you should ignore the delays referred to in (ii) and the possible effect of uncertainty in non-critical activities.

18. The following is a table showing details of a project:

| *Task* | *Immediate Predecessor* | *Normal Time (weeks)* | *Cost (Rs. 000)* | *Crash Time (weeks)* | *Cost (Rs. 000)* |
|---|---|---|---|---|---|
| A | - | 10 | 20 | 7 | 30 |
| B | - | 8 | 15 | 6 | 20 |
| C | B | 5 | 8 | 4 | 14 |
| D | B | 6 | 11 | 4 | 15 |
| E | B | 8 | 9 | 5 | 15 |
| F | E | 5 | 5 | 4 | 8 |
| G | A, D, C | 12 | 3 | 8 | 4 |

Indirect cost is Rs. 400 per day. Find the optimal duration and the associated minimum project cost.

10

# MATERIAL REQUIREMENT PLANNING

Material Requirement Planning (MRP) has evolved over time from payroll, inventory control techniques. Assembly operations involving thousands of parts such as automobile manufacturer led to large inventories. The need to bring down large inventory levels associated with these inventories led to early MRP systems that planned order releases. It is different from techniques like economic order quantities (EOQ) and safety stock calculations and deals with dependant inventory items.

## 10.1 DRAWBACKS OF SERVICE LEVELS AND SAFETY STOCK COMPUTATIONS

It is not uncommon for the practicing production managers to come across situation where out of 10 raw materials needed at a point of time to run a particular product line, excepting for one raw material, all the rest (nine) are available. And for want of one, the production of the product-line cannot be undertaken. If there are 10 different materials each with 95% service level for the stock, there is a feeling that stock-out will occur only 5% of item. But probability for all ten material available simultaneously is = $(0.95)^{10}$ = 0.6 So only 60% of time actual availability is ensured.

## 10.2 TYPE OF INVENTORY

### Independent demand inventory

Inventory consists of the finished products, service parts, and other item whose demand arises more directly from the uncertain market environment. Thus distribution inventories often have an independent and highly uncertain demand. Dependent demands can often be calculated, whereas independent demands usually require some kind of forecasting.

### Dependent demand inventory

It consist of the raw materials, components and sub- assemblies that are used in the production of parent or end items. e.g. The demand for computer keyboard depends on the demand for the parent items computers. Manufacturing inventory is largely dependent and predictable. This is where the role of material requirement planning arises.

## 10.3 *MRP* VERSUS ORDER–POINT SYSTEMS

Prior to the advent of MRP, typical manufacturing companies managed all inventories with order – point systems as there was no other alternative. Some of the key distinctions between

MRP and order–point systems are summarized in the table below.

Comparison of MRP and Order–point systems:

**Table 10.1** MRP and order-point

| | ***MRP*** | ***Order-point*** |
|---|---|---|
| Demand | Dependent | Independent |
| Order philosophy | Requirements | Replacement |
| Forecast | Based on master schedule | Based on past demand |
| Control concept | Control all times | ABC |
| Objectives | Meet manufacturing needs | Meet customer needs |
| Lot sizing | Discrete | EOQ |
| Demand pattern | Lumpy but predictable | Random |
| Type of inventory | Work-in-process and raw material | Finished goods and spare parts |

## 10.4 AGGREGATE PLANNING

It is planning the estimate of inventory in order to make sure, down the line of manufacturing or assembly, does not stop abruptly for the want of a item. It is the *capacity planning* at the *macro-level*. Given the sales forecast, factory capacity, aggregate inventory levels and size of workforce, the manager must decide at what 'rate of production' to operate a plant over an 'Intermediate Planning Horizon.' Demand forecast is useful for making an estimate of the inventory items required in future.

Demand forecast is of three types:

- Short range forecast.
- Medium range forecast.
- Long range forecast.

Aggregate planning is used for medium range forecast. Plans do not necessarily have to be detailed as to provide specific instruction for daily or weekly operation such as loading, sequencing, expediting and dispatching. It is thus a macro level exercise designated to plan by converting resource requirements of several products into *one common unit*. **Master scheduling** is the next level exercise following aggregate planning, which aims to find out product wise planning over the intermediate planning horizon.

Aggregate planning is of generally of two types as follows:

- Top Level Aggregate Planning
- Rough Cut Capacity Planning (RCCP)

A ggregate planning aims to find the best combination of various available capacities to match requirement at most economical cost. Either *pure or mixed strategic* may be employed. The nature of decisions for different capacities may vary as follows.

The different capacities used to manufacture products are:

- Regular Time Production Capacity.
- Sub-contracting Capacity.
- Overtime Capacity.
- Hiring and Firing Capacity.

## 10.5 MATERIAL REQUIREMENT PLANNING (MRP OR MRPI)

Material Requirement Planning (MRP) works with the theme '*Getting the right material at right place at right time*'. When we encounter products with sub-assemblies and components namely dependant items, we need to do material requirement planning (MRP) to manufacture the specified number of final products as per Master Production Schedule (MPS). It is a technique for determining the quantity and timing for an acquisition of dependant items needed to satisfy the master production schedule (MPS).

MRP has a logical approach to the problem of determining the number of parts, components and materials needed to produce each end item. MRP also provides the time schedule specifying when each of these materials, parts and components need to be ordered or produced. MRP involves *working backward*, from schedule quantities and need dates for end items specified in MPS to determine the requirement of components needed to meet MPS. So MRPI is a r*equirement calculator*.

So MRP is a simple system of calculating (arithmetically) the requirements of the input materials at different points of time based on plan or schedule for production of finished products. Usually *MRP is a computer system* and a part of inventory control tool. However it does not include use of feedback for tracking the actual progress of orders or for readjustment of order in response to actual requirement.

*Planned Order Release:* This is to ensure the proper time phasing and accurate planning of sub-assembly items.

It determines:

- What component needed
- How many needed
- When needed
- When ordered
- When completed/received

**The basic inputs for MRP are:**

- Product structure or *Bill of Materials* (*BOM*)
- *Master Production Schedule* for assembly.
- *Economic Order Quantity (EOQ)*
  Carrying cost and set-up cost details.
- *Beginning Inventory*
  Gross requirement, Scheduled receipts, On hand inventory, Net room, Planned order release.

**The outputs reports of MRP are:**

- **Primary Reports**
  - Planned order schedule to be released at future date.
  - Order release notices to execute planned order.
  - Changes in due dates of open orders due to rescheduling.
  - Cancellation or Suspensions of pen orders due to cancellation or suspension of orders on MPS.
  - Inventory status data.
- **Secondary Reports**
  - Performance control reports.

- Planning reports.
- Exception reports.

## 10.6 CAPACITY REQUIREMENT PLANNING (CRP)

It is the next level exercise after material requirement planning. It is required to ensure the proper synchronization between the plans and capacity available for the plans. It is a system for determining if a planned production schedule can be accompanied with available capacity and if not make adjustment if necessary.

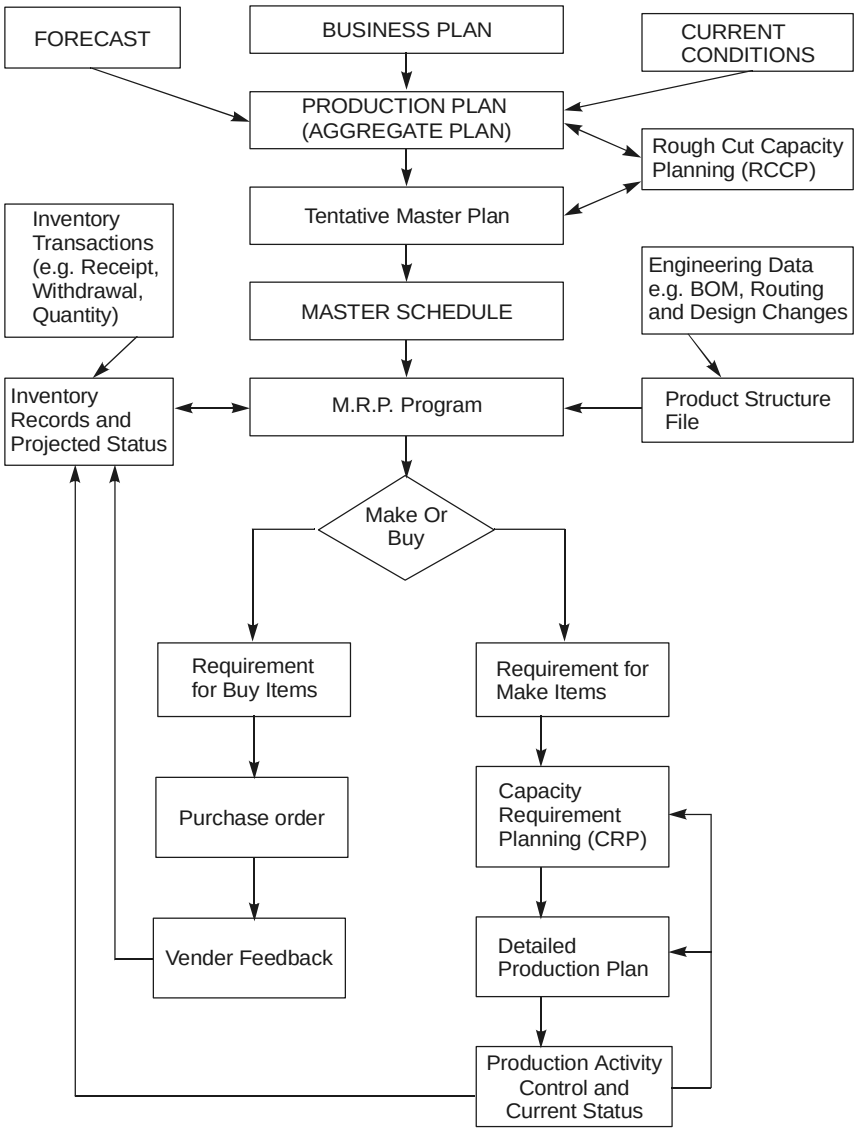



**Fig 10.1** Information flow for planning and control with project management

## 10.7 BILL OF MATERIALS (BOM)

It is a listing of all components (sub-assemblies and materials) that go into a assembled item. It is also known as *product structure***.** It frequently includes the part numbers and quantity required per assembly. If a firm has planned to manufacture fire extinguishes whose product structure is shown. It is known that a fire extinguishes has a cylinder, a value assembly and two handle bars. The Bill of Material explosions have been shown in the following figure.

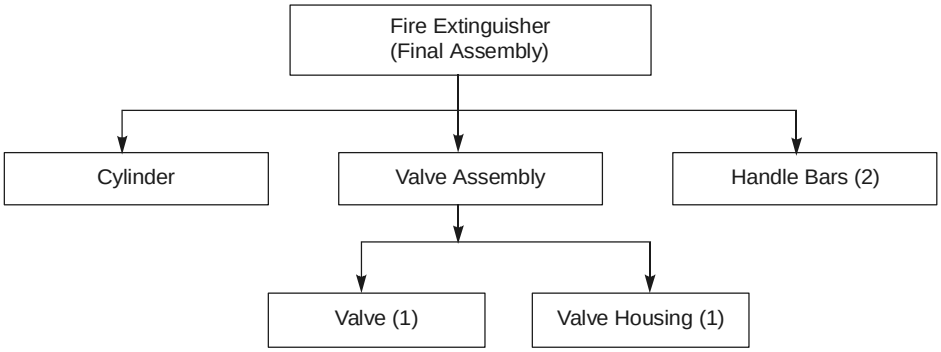



**Fig 10.2** BOM explosion for a fire extinguisher

Each value assembly requires a value and a value housing. The order quantities, lead times and stock at hand at the beginning of period, for the above components/assemblies are shown. *Lead-time* is the time interval between placement of order and receipt of materials. The Bill of Materials (BOM) for the fire extinguisher is shown below.

**Table 10.2** Unit requirements and lead time

| *Part* | *No. of Units Requirement* | *Lead Time (Week)* |
|---|---|---|
| Fire Extinguisher | 1 | 1 |
| Cylinder | 1 | 2 |
| Value Assemblies | 1 | 1 |
| Value | 1 | 1 |
| Value Housing | 1 | 1 |
| Handle Bars | 2 | 1 |

## 10.8 MASTER PRODUCTION SCHEDULE (MPS)

It is the list of what end products are to be produced, how many of each product is to be produced and when products are likely to be ready for shipment. Master Production Scheduling is the operation of dis-aggregation of the overall plan into mare specific designations of specific products to be made in specific time period. It is the capacity planning at micro level.

## 10.9 BENEFITS OF MRP

- Reduction in work-in-process inventory
- Priority benefits

- Effective utilization of resources
- Improved customer service
- Reduction in lead time
- Increased productivity
- Quicker response to changes in demand
- Reduction in finished goods inventory, raw materials, components and parts and safety stocks

### 10.9.1 Limitations of MRP

- Incorrect supplier lead time or manufacturing lead time causes incorrect calculations
- Highly computational approach may cause any accuracy to aggravate to large extent
- Product structure must be assembly oriented
- Valid master production schedule must exist

## 10.10 CLOSED LOOP MRP

When MRP is extended to include feedback and control of vendor orders and production operations it is closed loop MRP. This helps to update MRP and schedules can use this information:

- To expedite orders to keep parts on schedule.
- To de-expedite orders that will not be needed until later than originally expected.

## 10.11 MANUFACTURING RESOURCE PLANNING (MRP II)

The original resource planning covered only materials. However as computer grew and applications expanded, so did the breadth of MRP. Soon it considered resources as well as materials and was called MRP II (Manufacturing Resource Planning). The complete MRP program included 20 or so modules controlling the entire system from *order entry through scheduling, inventory control, finance, accounting, accounts payable and so on*. Today MRP impacts the entire system and includes Just In Time (**J.I.T**), Kanban and Computer Integrated Manufacturing (**C.I.M**). When the capabilities of closed loop MRP are extended to provide information financial resources in manufacturing company systems, it is called as MRP II. So it combines closed loop MRP with *human and financial resources*.

Information from closed loop MRP helps companies develop realistic plans and improve their performance in achieving those plans. MRP II includes strategic financial planning as well as production planning through the use of **simulation** capabilities to answer **what-if question**. What-if capabilities are routinely used to evaluate alternate plans. MRP II is a means of simulation on assumed plans on inventory investment levels, expansion needs, workforce requirement useful in co-coordinating marketing, finance, engineering and manufacturing efforts to achieve complete business plan.

## 10.12 COMPARISON BETWEEN MRP-I AND MRP-II

### *Material Requirement Planning (MRP-I )*

- Reduction in inventory
- Improve customer service.
- Quicker response to change in demand.
- Greater productivity.

### *Manufacturing Resource Planning (MRP II)*

- It is an information system used to plan and control inventories and capacity in manufacturing system.
- Strategic financial planning as well as production planning.
- Make a join decision.

## 10.13 ENTERPRISE RESOURCE PLANNING

Enterprise Resource Planning (ERP) covers the techniques and concepts employed for integrated management of business as a whole, from the viewpoint of effective use of management resources to improve efficiency of the enterprise.

### 10.13.1 Evolution of ERP

Evolution of ERP can be traced through following path

- Payroll Preparation.
- Inventory Control Techniques
- Material Requirement Planning (MRP) (1970's)
- Manufacturing Resource Planning (MRP II) (1980's)
- Enterprise Resource Planning (ERP)
- SCM (Supply Chain Management)
- CRM (Customer Relationship Management).

The first generation MRP systems started using computer databases to store lead time and order quantity and processing logic to implement Bill of Materials '*BOM explosions*' to help in planning order releases with time phasing of subassemblies and components in a discrete manufacturing environment.

As a logical extension of MRP systems Manufacturing Resources Planning (MRP II) systems progressed to cover the entire manufacturing function. This typically included machine loading and scheduling in addition to Material Requirement Planning (MRP). It provides facilities to check the feasibility of a production schedule considering the constraints.

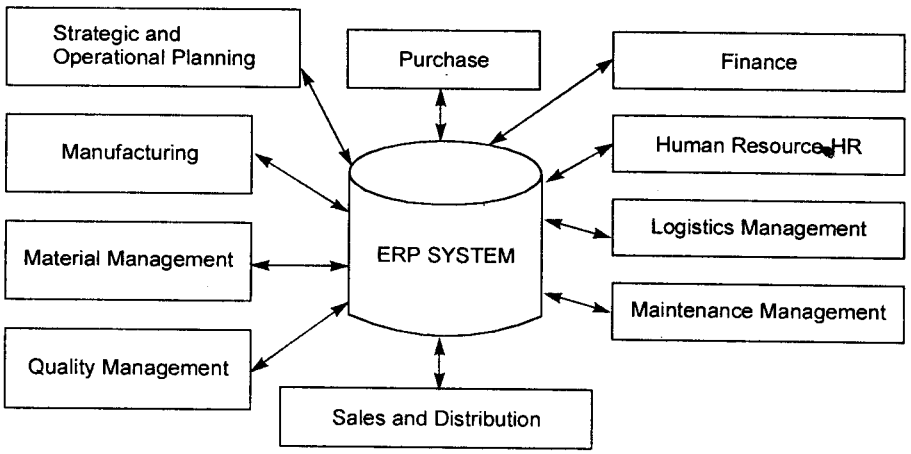



**Fig 10.3** Information integration through ERP systems of the islands of information

While MRP and MRP II systems were fairly successful due to the advantages of organized databases, computational logic and processing power of computers, many organizations had to develop an elasticity to survive a recession and also have capacity to exploit a boom due to unprecedented global competition, customer focus and reduced product life cycles. This turbulence in business environment is forcing organizations to adopt a strategic of focus and agility to meet the market demands by adopting the best business practices in the industry at earliest possible time. This requires corporate strategy to be integrated into computer information system.

ERP systems address this need, embody the latest ***Client/Server*** and object orient technology in relational database environment and seamlessly distribute information across finance, sales, distribution, materials, and manufacturing disciplines at the same time offering tight inter linkages. The latest ERP systems should be designed to support:

- Multi currency needs.
- Multi site platform (Unix, C)
- Multilingual needs.

ERP systems are a set of integrated business software modules providing operational, managerial and strategic information for improving productivity, quality and competitiveness of business. Since ERP systems cover the entire organizational information need and not selected islands of organizations there is a total transformation in the way of working, bringing a new culture, structure and procedure to the organization. ERP systems also relieve the operational managers of the routine decisions and fire fighting and provide them with time to concentrate on long term planning and ability to monitor overall organizational progress.

ERP has found its natural position as a leading edge information methodology to cater to diverse requirements of the organizations across manufacturing, finance and distribution logistics functions within the organizations and enabling the total supply chain integration.

**ERP may be said to be integration of all functions of Management:**

- Management Information Systems (MIS)
- Decision Support Systems (DSS)
- Electronic Date Processing (EDP)
- Knowledge Based System (KBS)

**Some of the leading ERP packages include:**

- S A P R/3 (Germany)
- B A A N
- People Soft
- Oracle
- J. D. Edwards

**Some of the advantages associated with ERP:**

- Reduced lead-time enabling early launch of the product.
- Reduced WIP, as much as 60 percent of work in process inventory can be reduced.
- Improved performance and efficiency of system.
- Improved quality of product.
- Throughput is increased.
- Cycle time of product is reduced.

## 10.14 SUPPLY CHAIN MANAGEMENT

The supply-chain as the name indicates is linking together of organizations. Purchasing department may have a number of suppliers, which in turn may have its own set of suppliers. The concept of Supply Chain Management (SCM) is to apply a '*systems approach'* to managing the entire flow of information, materials and services from raw-materials suppliers through factories and warehouses to the end customer.

So the three main entities involved are:

- Manufacturer
- Supplier
- Customer

The focus is on system optimization by controlling cycle time, inventory levels processes. The tools for supply chain management are

- Forecasting
- Aggregate planning
- Inventory planning
- Scheduling

Using a common database, we make decisions as action on one node effects all other nodes. **Outsourcing** is a term used to describe when a firm purchases materials, assemblies and other services that were initially done inside the company from sources outside the company. Outsourcing allows a firm to focus on activities that represent its core competencies. This is because of the realization that any organization cannot be superior to competition in all aspects of manufacturing or services. Thus a '*make or buy decision'* is made which helps the firm to concentrate on its main mission besides allowing its mare flexibility and leanness.

## 10.15 BUSINESS PROCESS RE-ENGINEERING (BPR)

Re-engineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical measures of performance such as cost, quality, service and speed. Re-engineering takes a fresh look at what the organization is trying to do in all its business progress and then eliminate non value-added steps and computerizing the remaining ones to achieve the desired outcome.

It is the critical analysis and redesign of existing business process to achieve breakthrough improvements in performance measures. It strives to streamline an operation and adopt it to existing market realities.

### 10.15.1 The 7 R's of Re-engineering

Re-engineering may look for radical changes through discontinuous thinking, process of unlearning or breaking connections and routine framework. '*process selection saves rupees while process optimization saves paise*'. This may be said to be the essence of Re-engineering. Therefore, a new paradigm shift in approach to run the enterprise is needed which may be brought through re-orchestrating of the enterprise.

Re-engineering is not downsizing or only automation. It involves '*redefining and rethinking everything*.' To incorporate re-engineering, six peripheral and central R's are needed.

These are:

- Re-orchestrate as the central theme for all activities (management/leadership)
- Realization, Requirement, Rethink, Redesign, Retool, and Reevaluate as peripheral themes.

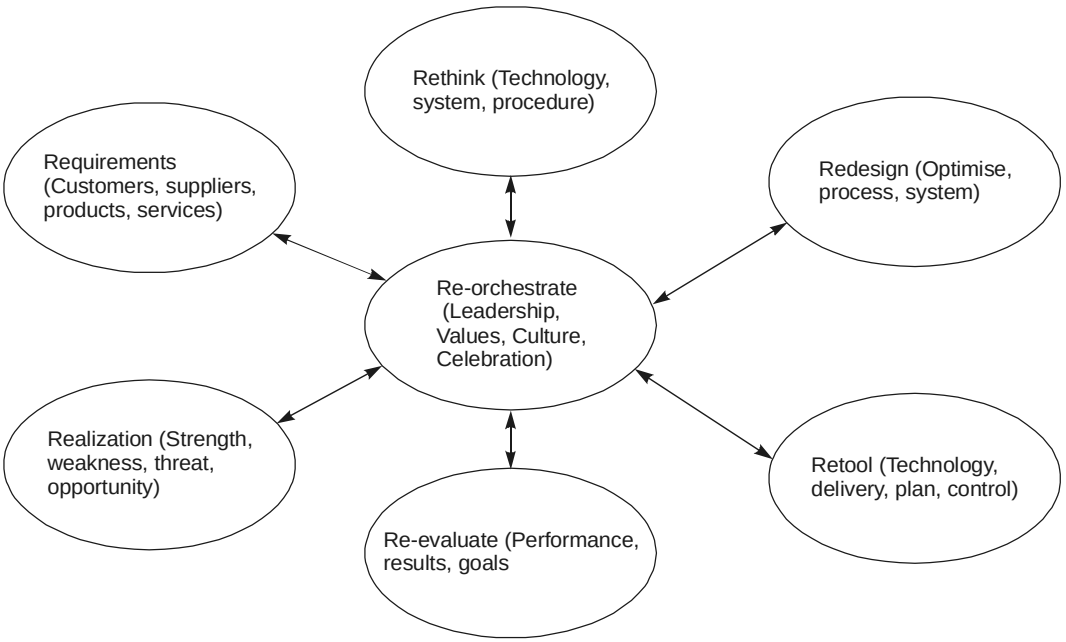



**Fig. 10.4** Re-engineeing wheel

## 10.15.2 Principles of Re-engineering

- Organize around outcomes, not tasks
- Have those who use the output of the process, perform the process
- Merge Information- Processing work into the real work that produces information
- Treat geographically dispersed resources as though they were centralized
- Link parallel activities instead of integrating their results
- Put the decision point where work is performed and build control into the process
- Capture information once- at the source

## 10.15.3 The Re-engineering Process

Process reengineering requires innovation. What is still essential is a disciplined approach to the effort. There is a six-step plan for process re-engineering.

- Step1: State a case for action
- Step 2: Identify the process of re-engineering
- Step 3: Evaluate enablers of re-engineering

- Step 4: Understand the current process
- Step 5: Create a new process design
- Step 6: Implement the re-engineered process

## *QUESTIONS*

1. What is the difference between MRP-I and MRP-II.
2. What are the inputs and outputs of MRP
3. Explain the following terms
   - Bill of Materials
   - Master Production Schedule
   - B.O.M Explosions
4. Explain what is capacity requirement planning
5. Discuss what is Enterprise Resource Planning
6. What is Business Process Re-engineering

11

# INTERNET AND E-COMMERCE

## 11.1 HISTORY OF INTERNET AND WEB

The Internet has taken its place beside the telephone and television as an important part of people's lives. The evolution of Internet can be traced in the need to share information between two or more computers located at distant places. The Internet was developed form a network of four computers by US Department of Defense in 1969. This network was developed to experiment with networks and share resources among DOD (Department of Defense) funded research contractors. This network was named APRANET (Advance Research Projects Administration Network.). Eventually APRANET evolved into formidable military and non-military computer networks as thousands of smaller networks mainly from the universities and educational institute joined thus increasing the data traffic tremendously. In mid 1980's a US organization called NSF (National Science Foundation) assigned five supercomputers to manage the ever-increasing data transmission load. In April 1995, T3 NSFNET backbone was replaced by NAPs (Network accesses point). Incidentally, the WEB technology has revolutionized the date distribution networks and boosted the popularity of the Internet to a very large extent. The WWW includes most of the commercial, educational and networking sites, which are sources of information, business development and e-commerce. Today more than 20 million computers are connected to the Internet. The WWW (World Wide Web) has been immensely popular because of its simple graphic nature and easy accessibility.

## 11.2 INTERNET

It is a global network of computer networks. It is a conglomeration of computer networks and other connected machines all over the world. The machines and the computer networks are interconnected therefore the intercommunication information accessibility and exchange is possible. The computers may be connected through various media such as fiber optic cables; telephone lines or by means of satellite. Though the Internet is a network of heterogeneous mix of technologies and operating systems, the intercommunication is not a problem because of TCP/IP (Transmission control protocol/ Internet protocol). This feature of the Internet has made it the most cherished medium of communication worldwide in the modern age.

The **Internet** is a mesh of inter linked networks which include million of servers, housing incalculable amounts of data. The machines and the computer networks are interconnected therefore the intercommunication information accessibility and exchange is possible. The people can use their stand-alone computers or their local area network workstations to send messages or exchange files with the people using computers in another region be it in another company, another state, another country anywhere provided all the machines involved in communication are connected within the Internet. Internet offers a variety of services such as Electronic Mail,

Telnet, File Transfer etc. and with the help of software, it provides access to remote data stored in other computers.

## 11.3 NETWORK OF NETWORKS

The Internet may be thought of as a huge network comprising of various small network, on which a user can store information and share it. In an organization there may be several departments such as accounts, personnel, marketing, sales, finance, purchase, manufacturing, stores and warehousing, logistics, legal etc. Each department has its own LAN with the information systems according to its functional requirement. Since the functions of the various departments also require information from the other departments therefore it is needed to interconnect these LANs to share information. Further, suppose that the organization has also several offices in the different geographic locations. In this case, there exists a need to interconnect these regional offices with one another and with the head office for the purpose of communication in order to coordinate the business activities of the organization. These regional networks are interconnections based on the geography as well as the management functions of the organization. The regional network based on geography implies that the offices in a particular region, be it city, state or group of states, may be grouped together and integrated with other similar regional networks and the head office. The regional network based on the functions implies that all the similar functional departments be interconnected in a group. For example, the finance function such as accounts receivable may be grouped with accounts payable into a financial accounting network. When these regional networks are connected together onto a corporate network, the network so created is a typical example of 'network of networks'. This type of network of the networks is also referred to as a ***backbone.***

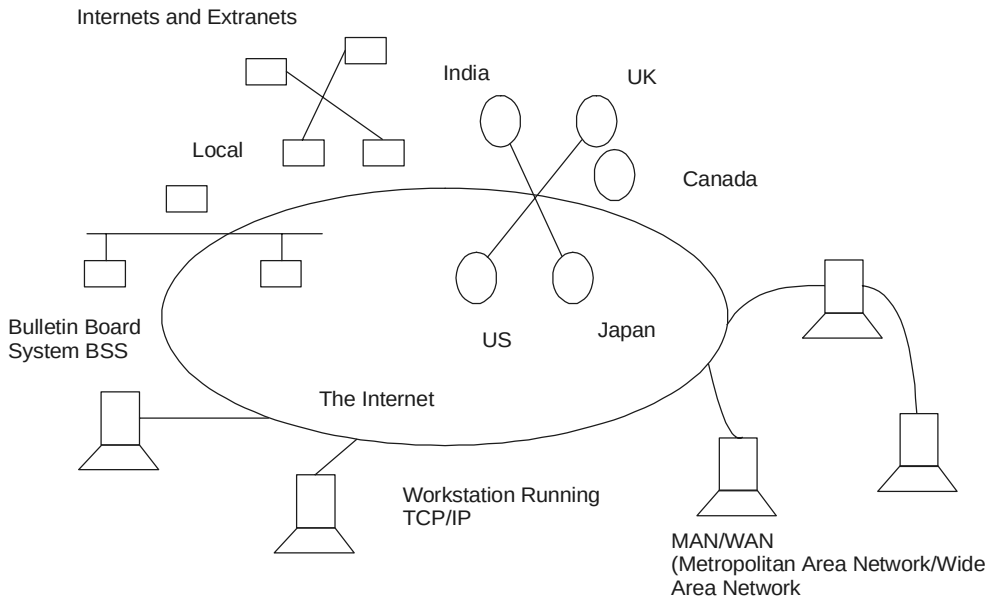



**Fig 11.1** Network of networks

There exists a need to interconnect various organizations with their backbones connected to each other at physical network meeting points. These physical network-meeting points are referred to as the ***gateways***. If we generalize the above example to incorporate the global society as a whole to be a part of a global communication network the model of Internet can be extrapolated.

The network of computers installed within a room or building is called ***Local Area Network*** *(LAN).* When the connectivity of the computers crosses the boundaries of a building and the user gets access to the computers located in different areas of the city, the network is called ***Metropolitan Area Network*** *(MAN)* and when it crosses the city/town then this type of networking is called ***Wide Area Network*** *(WAN).* There are a few large networks owned by some major companies like America On Line, CompuServe etc.

The Internet is thus a decentralized global network of millions of computers and computer networks. These networks are used to communicate messages for information to each other and they all follow a *common set of protocols called TCP/IP.* These protocols make the Internet an effective and efficient tool for communications between different people and organizations. *Thus, this wonderful interoperability is because of the TCP/IP communication suite used by the systems connected in the Internet.* The people can use their computers connected to the ***gateway*** (physical network-meeting points) via modem or the leased line to avail the services of and ***ISP*** (Internet Service Provider) to send messages or exchange files with the people using their computers in another region, in another country or anywhere which are similarly connected to the gateway of the Internet in their part of region. e.g. ***Satyam, BSNL*** is an important ISP. The ISPs provide registration service and assistance for the connected network under the auspices of the organization known as ***IANA*** (*Internet Assigned Numbers Authority*).

The ISPs generally use a very high bandwidth communication lines such as T1 or T3 lines. A single T1 line is capable of handling 1.54 megabits of information per second which approx. equal to 27 phone lines and T3 is capable of handling 45 megabits of information per second. The existence of the Internet is attributed to a cooperative society of the users of the internet. The domain of users of the Internet in popularly known as ***Cyberspace***. The cyberspace refers to the location of the user while traversing the virtual geography of the Internet. ***No single entity owns the Internet***. For example, each computer connected into the Internet is owned by somebody or an enterprise. The telephone companies which provide the telephone network infrastructure to carry the ***packets of information*** are also part of this cooperative society.

## 11.4 COMMON PROTOCOLS USED IN INTERNET

To establish a link between two computers on the Internet, it is required to frame certain rules and regulations so that the data communication between the computers may take place. *A protocol means a set of rules, which is accepted globally*. To establish a link between two or more computers, it is required to define the address of the computer. This address must be unique. TCP/IP is divided into two set of protocols one is called **TCP** or ***Transmission Control Protocol*** and other is called **IP** or ***Internet Protocol.***

**Transmission Control Protocol** – This deals with packets over networks. The packets are small pieces of data meant for effective and safe communication over the network. These packets have to follow a long path, traversing from one computer or node to another computer. This process is called routing. The TCP also ensures the safe delivery at the destination and the assembling of all the packets to get the complete lot of data at the destination computers.

**Internet Protocol**: This mainly deals with the address of computers. The Internet Protocol decides the address of computer to be labeled on the packet. This allows various computers or intermediate nodes to read the address of the destination computer and route the packet to the destination node.

**Simple Mail Transfer Protocol (SMTP)**: Used for delivery of E-mail. When an E-mail is to be sent, then the Mail Transfer Program contacts the remote machine and forms a TCP connection over which the mail is transferred. Once the connection is established, then Simple Mail Transfer Protocol identifies the sender itself, specified the recipient of mail and then transfers the E-mail message.

**Point-to-Point Protocol (PPP)**: This is used when the Internet is accessed using a telephone line. The PPP is the set of rules, which specify how the data will be communicated over telephone line from your computer when the connection with your ISP has been established. This protocol is used in connection with SLIP (Serial Line Internet Protocol). The protocol allows the user to use GUI based web browsers like Netscape and MS Internet Explorer. Internet Service providers use the PPP and SLIP account to enable users to view graphics on the Internet. These accounts assign and IP address to your computer when a connection is established.

## 11.5 COMMON USE OF INTERNET

1. Electronic Mail
2. Usenet
3. Telnet
4. IRC (Internet Really Chat)
5. FTP (File Transfer Protocol)
6. Archie
7. Gopher
8. Veronica
9. World Wide Web

### 11.5.1 Electronic Mail

E-mail requires a communication network and no postal stamps or a paper envelop. Thus, E-mail is a cost effective, reliable and efficient mode of communication in comparison to most other means of communications such as faxing, courier or other postal services. Like fax, it is an instantaneous document transmission service and is more reliable than the fax. The faxing or the postal services are only more effective when the other person to whom the message is being sent is not a part of the communication network to receive the E-mail. One of the salient features of the E-mail technology is that a system can be built to send an automated response back to the users who send message to a company. This allows the user to use his computer for sending message to another computer without requiring the receiving person to be logged onto the destination computer at the time of it being sent i.e. allows asynchronous communication. A prompt acknowledgement of the E-mail satisfies the sender that his message has been received and is in pipeline to be appropriately responded. (SMTP is used to transfer emails). Besides the regular services provided by the ISPs some also facilitate free of cost E-mail services. E-mail on internet may include more than just text using a system MIME (Multi purpose Internet Mail Extension) which allows multimedia to be included in an E-mail.

### 11.5.2 Usenet

Usenet is an asynchronous, one to many communications, which consists of various newsgroups. This implies that someone prepares the information and anyone who is interested can read it whenever he feels like. The building block of USENET is the newsgroups.

### 11.5.3 Telnet

It is a service on the Internet, which allows the users to log on to a remote system, and used various services available on that host. The user must have the necessary USER ID and the Password for access to the remote system to use TELNET utility. The users can used this utility to access huge databases, catalogues or libraries of various servers and used the information for commercial or research purposes.

### 11.5.4 IRC (Internet Really Chat)

It is a service on the net that allows the users to communicate real time. It is one of the most important utilities availed by the corporate sector or the users having common interest to communicate online in a conference mode sparing the travel time. It is a synchronous communication, which requires all the participants to log on to their terminals simultaneously enabling many to many communications.

### 11.5.5 File Transfer Protocol

It is a utility to copy files from the remote hosts to the user host and vice-versa. The process of file transfer from the remote host to the user machine is popularly known as downloading files.

### 11.5.6 Archie

It is a collection of servers. Each of these servers is a responsible for keeping track of file locations in several different FTP sites. All of the ARCHIE servers communicate and pool their information into a huge database, which is required to be updated periodically. The user can search this database using the keyword.

### 11.5.7 Gopher

It is a menu driven system that enables the users to navigate within the Internet resources of information. Gopher space refers to the group of large number of specialized libraries, which are interconnected.

### 11.5.8 Veronica

(Very *easy, rodent oriented, netwide index to the computer achieves*)**:** It is a search tool, which enables to quick scan Gopher space for particular files.

### 11.5.9 World Wide Web

It is a vast collection of online documents and information distributed over the Internet. These online documents are known was **Web Pages**. These web pages are stored on machines using a multi-threading and multitasking operating system such as Unix or Windows NT. These machines are particularly known as **Servers**. These pages are accessed by user of Internet connected machine. This is the most popular system, which facilitates the convenient access to the plethora of information available on the Internet. The WebPages are formatted in a language called **HTML**. The WebPages can be viewed by using **web browsers**.

A **Website** is a set of WebPages containing pertinent information about a company's business. **Web browsers** are programs, which are, used in viewing webpages. Most popular web browsers are MS Explorer and Netscape Navigator. When you use the web browser for netsurfing it acts as a client and connects you to the desired server after specifying the **URL** address (Universal Resource Locator). The opening page of a Web site generally signifying the top of site hierarchy and providing relevant links to other web pages in the web site is known as **Home Page**. The users can access a web site of a particular company and retrieve the relevant information about the company's profile, products and future plans. Through some of the web sites the user may shop and conduct financial transactions online.

## 11.6 INTERNET ADDRESS

### *Domain Names*

As many organizations, educational institutes, private and public units and commercial firms develop and maintain their websites, it is necessary to categorize these websites. Domain name identifies the general class in which particular websites are grouped. It also indicates the address and type of server. There may be one or more dots in a particular domain name. Domain name of an organization represents the type of organization or the country it belongs to. Commonly used domain organizations are as follows:

**Table 11.1** Domain organizations

| ***Organizational*** | | ***Geographic*** | |
|---|---|---|---|
| .com | For commercial organizations (business) | .au | Australia |
| .edu | Educational organizations (schools, colleges, universities) | .ca | Canada |
| gov | Government organizations | .uk | England |
| .mil | Military (army, navy, etc.) | .in | India |
| .net | Network service related | .fr | France |
| .org | Organization | .uk | U.K. |
| ac | Academic | | |

**IP Address** – The IP address is an actual address of a node or computer or server on the Internet. This number is unique for each node. These addresses are of following type: 144.16.202.19 (IP address is divided into four blocks or numbers each separated by a dot)

**Email address-** Username@address of Server. type of sever and its location.

e.g. rkag@unisa.edu.au

## 11.7 INTRANET

Intranet is an internal Internet of an organisation, which is an exclusive network of the organization using Internet technology. An Intranet differs from a conventional LAN in two ways. Firstly, unlike conventional LAN which may not necessarily be using Internet protocol TCP/IP, Intranet links more than one kind of networking technology-using TCP/IP. Since, conceptually, Intranet is an exclusive network of an organization and TCP/IP is an open protocol

for communication of the varied networking technologies, it uses a firewall to keep the larger Internet out of the internal information resources of an organization.

A ***firewall*** is a computer or set of computers that use filtering and specialized routing to prevent the people from using information resources of the organization who do not belong to the organization. The people of the organization may or may not be able to use all the resources of the larger Internet depending upon the design of the Internet. Take a case of a computer network in an organization, which has various LAN components based Novell or Banyan technology. If these varied components are able to communicate via a TCP/IP link then such a network may be referred to as an intranet. A corporate intranet can provide a host of services to a company. An intranet Web server is a handy and economical tool for publishing write-once, read-many documents within an organization. In case, an organization decides to grant server access to selected business partners and clients, it can create an '***Extranet***' by letting those users connect to its intranet using a remote-access server or a leased line with a router.

A combination of intranets and extranets enabled ABB to integrate over 60,000 users in a worldwide corporate network, which is spanned in more than 80 countries. The extranets of the ABB connect over 100 external companies, which are business partners, suppliers or the clients of the company. These days, the most popular Intranet applications are ERP (Enterprise Resource Planning) systems. Some of the prominent ERP systems available are SAP R/3 from SAP AG (Germany), BAAN IV from Baan Co. (Netherlands), Peoplesoft applications, Marshal from Ramco Systems, Oracle Applications, MFG/PRO from QAD Inc. and J D Edwards ERP systems.

## 11.8 COMMERCIAL BENEFITS OF INTERNET

Modern business world is becoming increasingly keen to find ways to the users information technology on the Internet to exploit the advantages of doing business electronically. Some of these benefits are:

### 11.8.1 A Very Large Potential Customer Base

The sellers and buyers are not constrained by any time restrictions. They can transact business at their convenience. The buyer can send order electronically to the seller via e-mail or an order form in the Web Site of the seller. Geographic boundaries have become all redundant. The operating hours for e-commerce are limited only by the software and hardware behind the Web site.

### 11.8.2 Augmented Revenue Potential

The Web has opened up a huge new sales and distribution channel. Merchants can leverage the tremendous geographical coverage and sheer volume of Web users to establish a global market presence at an extremely low cost.

### 11.8.3 Reduced Costs

Electronic commerce has facilitated for merchants to drastically reduce the costs associated with holding large physical inventories. Most businesses on the Internet today hold no inventory and also offer a range of products from several manufacturers by having linked up their own order-entry systems with the manufacturers systems for fulfillment of orders.

### 11.8.4 An Efficient and Swift Time to Market

Internet commerce enables business to bring products to market much faster than any other traditional physical technique. Products, descriptions, and prices can be quickly added to a Web server and immediately made available to the buying public.

### 11.8.5 Improved Customer Relations

Online commerce enables merchants to form interactive, personal relationships with customers – alerting them about products that suit their particular interests. This results in impetus towards consistent new product development and research on the basis of the customer's feedback.

### 11.8.6 Faster Customer Response

Since the Internet provides 24-hour access, customers can go directly to the latest and centrally maintained information sources. As a typical example, the financial institutions can offer fully secure Internet banking services to allow customers to review their accounts, transfer funds and schedule payments.

### 11.8.7 Enriching Information and Compelling Shopping Experience

The information on the Web, which is organized as hyper-linked text and therefore easily navigable, can make the user tremendously brand aware and a savvy customer or an intelligent marketer in a very less time. The shopping experience using the Internet by navigating through various Web pages containing images, voice, video organized interesting multimedia presentations and dynamically updated data can be a highly compelling, time saving and intelligent.

### 11.8.8 Self-service

The Internet can save time and money and improve order accuracy by eliminating unnecessary intermediaries in the business chain between buyer and seller. The efficiency in sales for the seller and cost benefit to the buyer cultivates a close relationship between the two, which is harbinger to the improved quality in the products and services.

### 11.8.9 Advertising

The business houses can put attractive click-able banners on popular web sites which once clicked would take the web surfer to their Web sites and introduce them to their products and services. This can boost the business potential of the business houses by increasing their sales and improving upon their image in the corporate world.

## 11.9 ELECTRONIC COMMERCE (E-COMMERCE)

E-commerce has broken down the geographical barriers and brought together customers across the globe. Although concept of E-Commerce started in 1995, is still in its infancy, it has already made a huge impact on the traditional methods of doing business. Till the beginning of 2003 there were 60 lakhs of Internet connections and 16 millions of Internet users. E-Commerce revenues in India rose dramatically over last three years. During 2003-4, ecommerce is expected to generate 30 million dollars, with approximate user base of 1 million. In India major share of ecommerce revenue is being generated from B2C market than from B2B. Traditionally,

commerce is a dynamic business process, which enables the interaction between a buyer and seller for a business transaction. *E-Commerce is an extension of the commerce on the Internet, which involves selling products and services online on the Internet*. Consumers use the Internet to shop, bank and invest online. Most consumers use credit or debit cards to pay for online purchases, but other payment methods, like e-wallets are becoming common. E-Commerce is broadly defined as the method of buying and selling products and services electronically. It involves buying products without ever going to a shop. It covers activities like in query about product and its features, delivery of information about product and services and finally payments through electronic medium. E-Commerce can be termed as a part of E business, which is a broader concept encompassing a range of business activities.

The impact of e-commerce be can seen in almost all areas of business, whether it is customer service, rapid product design, customized design of product, identifying the potential customers and transmitting electronically relevant information to customers about new products. The traditional business is based on the basic infrastructure support of transportation, electricity, communication, etc. Similarly E-Commerce requires high-speed communication and exchange of information through information superhighways, which is possible by proper bandwidth. It requires a nested collection of high-speed date links designed according to long standing, well designed rules and regulations. The information superhighways should have proper support from telephone wires, wireless radio links, satellite, cable T.V. wire, etc.

There are three main parties involved in E-Commerce.

- B: Business
- C: Consumer
- G: Government

This leads to five major models in E-Commerce deals:

- B2B: Business to Business
- B2C: Business to Consumer
- C2C: Consumer to Consumer
- B2G: Business to Government
- C2G: Consumer to Government

The foundation for successful E-Commerce lies in an effective Internet public relations strategy. E-commerce is extension of an online cash register. Before a business can expect to engage in successful e-commerce, Internet public relations and marketing must play a crucial role in laying the foundation for effective sales. In order to make a consumer willing to engage in e-commerce with a business, the business must present an image of reliability, trustworthiness, quality, professionalism and responsibility.

A customer oriented business transaction involves all the activities starting from

- Search and identification of product
- Price negotiation
- Delivery time
- Order
- Processing of order by manufacturer
- Delivery of product
- Realization of payment through electronic currency. (Credit and debit cards)

E-commerce has a tremendous impact on the structure of business supply chains. The companies worldwide are adopting the Web based network to integrate its suppliers for efficiency in the commerce and major cost savings. These solutions have given rise to the virtual enterprises in which the scope of their business is expanding at a brisk rate. An important example in this context is a prominent automobile company Chrysler Corp. this company is linked with its suppliers through a Web based network. An estimated annual savings as a result of this network is to the tune of $2billion per annum. E-commerce based integration of supply chains has retrograding impact on the intermediaries in the business because the manufacturers have direct communication links with the suppliers and the buyers.

One of the international major E-commerce sites is the Cisco connection Web site. This Web site is available in 14 international languages. Other example of a successful e-commerce Web site is an online bookstore from a company called Amazon. The user may surf Amazon.com to chose from the range of books priced at a lower rate than regular retail book store and make an order online using his credit card facility.

Though the growth of the E-commerce has been phenomenal over the years, the major surge in the popularity of E-commerce will depend upon the resolving of the security issues involved in this type of trade. Over the years, many users have deterred shopping online because of their concern about the vulnerability or risk involved in use of their credit cards online. Major risks include frauds, thefts and viruses. However, this risk has now been reduced considerably due to development of secure Internet protocols and payment systems. Major technology in vogue and expected to be used in future also for the purpose of security is the public key encryption. The popularity of this technology is owing to it's lower costs. The feasibility of e-commerce has increased owing to the widespread use of the Internet, the development of the security standards and protocols and the additions of the electronic payment systems. Most of these organizations generally offer real-time secure digital signature based authentication services and act as an intermediary between the customer, the merchant and the credit card clearing house.

## 11.10 E-CASH

Most online shoppers use credit or debit cards to pay for their online purchases. The debit card may be an **A**utomated **T**eller **M**achine (**ATM**) **card** that can be used for retail purchases. To complete a debit card transaction a *Personal Identification Number* (PIN) may be required along with *some form of a signature or other identification, or a combination of these identifiers*. Some cards have both **credit** and **debit** features. The payment option can be selected at the point-of-sale. Although a debit card may look like a credit card, the money for debit purchases is transferred almost immediately from the bank account to the merchant's accoun*t*. In addition, the liability limits for a lost or stolen debit card and its unauthorized use are different from the liability if the credit card is lost, stolen or used without authorization.

New electronic payment systems also referred to as '*electronic money*' or '*e-mone*y' with the goal of making purchase simpler. The '**stored-value**' cards allow transferring cash value to a card. They are commonly used on public transportation, at colleges and universities and at gas stations. Some stored-value cards work offline, say, to buy a candy bar at a vending machine; others work online, for example, to buy an item from a website; some have both offline and online features. Some cards can be '*reloaded*' with additional value, at a cash machine; other cards are '*disposable*'. Some stored-value cards contain computer chips that make them '*Smart*'

cards: These cards can act like a credit card as well as a debit card, and also can contain stored value.

**Smart** cards are similar to the credit and debit cards containing a microprocessor chip with memory capable of holding more information than the traditional magnetic strip. The chip can store significantly greeter amounts of date, estimated to be 80 times more than a magnetic strip. This card contains a encrypted key that is compared to the secret key stored on the customer's computer. Whenever the customer pays for an item from his smart card the value is deduction from the card. Some new Internet-based payment systems allow value to be transmitted through computers, sometimes called '**E-wallets**'. E-wallets can be used to make very small online or offline payments. 'E-wallets' may work by using some form of stored value or by automatically accessing an account you've set up through a computer system connected to your credit or debit card account.

Major advantages of E-Commerce are:

- Reduction in price of products due to open electronic market and reduced paper work.
- Reduced time for delivery as order is processed instantaneously.
- Improved relationship with the customer due to fast communication.
- The need for retailers and wholesalers reduced due to on line processing enabling reduction in price of product.
- Broader network increasing the customer base as distant geographic boundaries can avail the services.
- Customer can give feedback and get instant information from companies.

Besides business to customer online transactions one of the most important implications of the e-commerce has been EDI (Electronic Data Interchange) over the Internet to facilitate an online business globally.

## 11.11 ELECTRONIC DATA INTERCHANGE (EDI)

The EDI technology connotes the intercompany computer-to-computer communication of the standard business transaction in a ***standard format*** using the VANs (Value Added Network) and the Internet. The medium of the Internet has several advantages over VAN systems in conduction the EDI. Traditionally, VAN providers charge for EDI on per transaction basis therefore the organizations tend to transmit transactions in a batch to their customers to save on costs. Over the Internet the connection charges are fixed therefore the organizations prefer to transmit transactions on requirement basis. Thus, the Internet not only speeds up the transaction time and enables more efficient real-time commerce. EDI is the preferred mode of business in the automobile, rail-road, chemical, grocery, pharmaceutical, paper products, metals, oil and gas, ocean freight, office products and the warehousing industry. The major benefit of using EDI is that the use of paperless transactions in globally understandable formats results in cost savings as well s better efficiency.

EDI services are primarily integrated into industrial trade operations through the purchase function. The corporate users especially with the overseas transactions cannot afford to ignore EDI because most of the European trade organizations insist all its trading partners to switch over to EDI in order to maintain the business. In India, the Government has initiated several steps for a comprehensive and time bound implementation of EDI technology by all the organizations involved in overseas trade. The most prominent organization that offers EDI

infrastructure in India is VSNL (Videsh Sanchar Nigam Ltd). Some of the important customers of VSNL infrastructure for EDI facility. NIC (National Informatics Centre) also offers EDI facilities through its VAN infrastructure. The important private company joint ventures offering EDI facilities using their VANs are Global Telecom Services Ltd./General Electric Information Systems, Satyam Infoway/Sterling US, Mahindra Network Services/Singapore Network Services Pvt.Ltd. A Chennai based Indian company Satyam Infoway (P) Ltd is implementing a pilot project for the Indian automobile industry represented by ACMA (Automotive Component Manufacturers Association). This would speed up the transaction cycle of the industy. The project covers 11 major companies like Bajaj Auto, Telco, Mahindra and Mahindra, Ashok Leyland, Brakes India, Mico, Shriram Pistons, Sundaram Clayton, Sundaram Fasteners, Lucas TVS and Remsons Industries. Though the benefits of EDI are perceptible, there are certain legal issues, which need to be resolved to enhance its popularity in the business world. The major legal issue is that Indian laws do not accept electronic data as the evidence of a business transaction. However, this hurdle may not choke the development of the EDI because it has got the global acceptance.

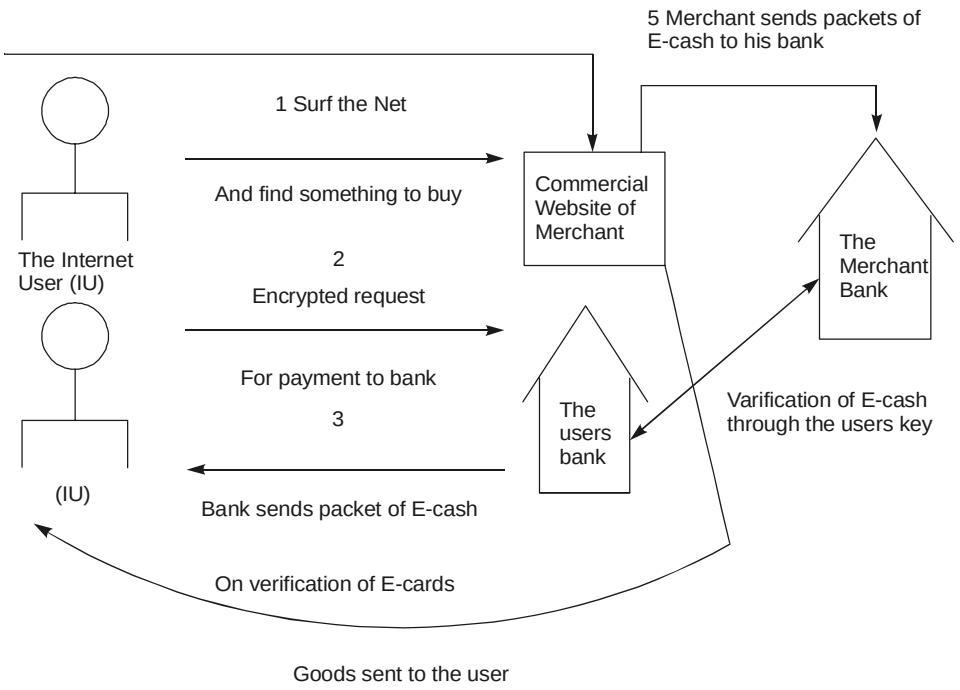



**Fig 11.2** Illustration of E-commerce-E-cash system

## 11.12 INFORMATION TECHNOLOGY ACT

The Information Technology Act passed by the parliament of India in May 2000 is the second cyber law in the whole of South Asia after Singapore. With this India has joined the select band of nations in the world that have legislated cyber laws. The IT Act 2000 promotes legal infrastructure in the cyber world.

The act makes e-mail as a valid and legal form of communication in India, which can be duly produced and applied before law. Legal entities can use digital signatures having legal validity to carry out their transactions online. With the growth of Internet worldwide, cyber laws deals with numerous legal issues. This may vary from Domain names to Intellectual Property rights to electronic commerce to encryption, electronic contracts, cyber crimes, to online banking and so on.

## QUESTIONS

1. 'Internet is a network of network'. Explain the statement.
2. What is the need of protocols used in Internet. What are the commonly used protocols.
3. What are the common uses of internet.
4. What are the commercial applications of internet.
5. Explain the terms.
   - World Wide Web
   - Internet Address
   - Domain Names
6. What is the difference between Internet and Intranet.
7. Explain the significance of E-commerce.
8. Explain the terms.
   - E-cash
   - Smart card
9. What is a Electronic Data Interface (EDI).

12

# TOTAL QUALITY MANAGEMENT

## 12.1 INTRODUCTION

Over the past two decades, engineering industries have witnessed an unprecedented emphasis on quality in all aspects of the business including the product development It is currently the yardstick for any one to enter into global markets. This has led to standardization of quality system and the concept of Total Quality Management (TQM). Quality has undergone conceptual change with process of evolution. Initially it was associated with *inspection* and later on covered the areas of process control, quality assurance, total quality management and strategic quality management.

In the first two phases (that is inspection and process control) the quality was mostly confined to shop floor activities. The concept of quality assurance took care of design process. *A wider coverage involving people and the system* brought out the 'Total Quality Management' concept. A further step based on the definition of quality as the fitness for the purpose as seen by the customer brought out the concept of 'Strategic Quality Management' (SQM) encompassing the quality of the product throughout its life. Today the industries do not talk much on quality but take actions to achieve it. They know that it is the most critical factor for their existence.

Quality and productivity are two measures of value ratio, quality describes a great deal about the numerator of value ratio and productivity helps to describe denominator. The business units of '*return of investment'* (ROI) and '*return on sales'* (ROS) also have a high positive co-relation with relative quality. Improved quality is often advantageous even if it does not increase the market share. There is evidence to suggest that customer prefers better quality products though at a price which may be slightly higher. In addition to the above information there is support in operation management literature that better quality and its control can actually reduce costs. This fact may not be obvious. But in manufacturing much of the capacity, labour and material can be wasted making items incorrectly (scrap) and then screening the bad items from the good and reworking those, which are defective.

Hence it is less expensive to make things right first time than to make them over and do it right on the final try. It is less costly to provide satisfactory service to a customer the first time than to do it the second time after providing the service once and having to deal with dissatisfied customers. Imagine the strategic advantage a company can achieve through quality. The company may actually lower costs but it may be able to sell its products at higher price than its competitor. Such a company can earn higher profits even in the face of serious price competition. It might gain market share which often leads to economics of scale and higher profit.

TQM is an active approach in encompassing company wide operating philosophy and system for continuous improvement of quality. It demands co-operation from everyone in the company from top management down to the workers. TQM owes its origin to two Americans

**W.E. Deming** and **J.M. Juran** who launched it first in Japan, which was on the process of rebuilding its economy devastated by World War-II. The Japanese highest award for quality is named after Deming, namely **'***Deming prize'*. Various Techniques for TQM such as SQC, SPC, Quality circles, QFD, and PDCA, all expect an acceptable reference with regard to product-process quality that achieved leads to different higher reference.

## 12.2 WHAT IS QUALITY?

In olden days quality was considered synonymous with inspection. Quality means a predictable degree of uniformity and dependability at low cost, suited to the market. The definition of quality has seen a transformation with time which can be seen from definitions given below.

### 12.2.1 Definition

- Quality is about doing thing right
- First time and satisfying customers and minimizing costs, maximizing profits
- The totality of features and characteristics of product, service and process, which bears on its ability to satisfy a given need. (British Standard Definition)
- The total composite product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product or service in use will meet expectations of the customer. (Armand Feigenbaum)
- '… doing thins right the first time….. every time.' — *W. Edwards Deming (1986)*
- '…fitness for use, as judged by the user'. — *Joseph M Juran (1989)*
- '… conformance to requirements.' — *Philip B. Crossby (1979)*

## 12.3 CHARACTERISTICS OF QUALITY

1. Quality depends upon evaluation made by persons external to the company that produces goods or services (Customer satisfaction).
2. Quality is a dynamic, moving target. Goods or services must be improved over time as competitors improve. What was quality product yesterday may not be one tomorrow.
3. Quality requires composite of attributes to satisfy a range of expectations of numerous customers or potential customers.
4. Quality often means different things to different people. Company or an Organization may try to serve a variety of persons many of whom possibly expect a different set of attributes or emphasize different attributes to different degrees. A company that wants to provide quality to a particular market segment must learn what attributes are important to that particular market.

## 12.4 QUALITY ATTRIBUTES FOR PRODUCTS AND SERVICES

According to Garvin there can be at least eight aspects of product or service to see that it satisfies customer.

1. Performance: such as color and clarity of picture on a television.
2. Features: such as whether the TV has remote control.
3. Reliability: probability to run without repair.
4. Serviceability: how difficult and expensive it is to repair and how long it will take. Good maintainability offsets reliability criteria.
5. Durability: how long it will last.

6. Conformance: It measures how well the product meets the specifications or target set by its designer.
7. Aesthetic characteristics: how an item looks, feels, tastes or smells. These are more subjective and sometimes more difficult to measure objectively.
8. Perceived quality: feeling of confidence in the level of quality that customers develop on the basis of what they do see, their prior experiences and reputation of the company. Service quality is often more difficult to describe in quantifiable measures that can be used with in a company to see if work practices are consistent and correct.

### 12.4.1 Five Major Quality Attributes for Services

1. Reliability: ability to perform the promised service dependably and accurately.
2. Responsiveness: the willingness to help customers and provide prompt service.
3. Tangibles: physical facilities, equipment and the appearance of personnel.
4. Assurance: the knowledge and courtesy of employees & their ability to convey trust and confidence.
5. Empathy: the caring, individual attention provided to customers.

Perception of service quality is affected not only by, what is provided but also by the way the customer is treated when the service is provided. It might appear that quality is very expensive to achieve with so many attributes of the product to consider and all parts of a company involved in trying to satisfy many customers. Quality does cost-but the failure to achieve quality may cost even more.

## 12.5 COST OF QUALITY

Cost of quality is a combination of following costs:

- Costs to control quality (prevention and appraisal)
- Costs of failure to control quality (internal and external failures)

Cost of quality becomes the cost to the company, of doing things wrong, of not conforming to the specification. Quality costs can be divided into four major categories the first two include the costs to try to control quality and the second two include the costs that result from failure to control quality.

**1.** ***Prevention costs:*** The cost of preventing defective work is usually extended before the product is made or service rendered. These costs include:

- Design reviews and drawing checks
- Quality orientation program, education and training
- Process control
- Process orientations
- Suppliers evaluation and presentation
- Workers training

**2.** ***Appraisal costs:*** The cost of appraisal is incurred for auditing service procedures to make sure they conform to prescribed work practices. These include

- Process capability measurement (e.g. control charts)
- Tests, gauges and test equipment
- Prototype inspection and tests
- In process and final inspection and tests
- Checking material furnished by suppliers
- Work in process goods testing and inspections.

**3. *Internal failure cost:*** Internal failure cost is applicable when the product is in factory and not been sold. These costs include.

- Expenses for producing items that are scrapped.
- Redesign.
- Reworking and downtime.
- Retesting defective items.
- Lost value of items sold as seconds.
- Cost of delays.
- Administration time to review non
- conforming materials for disposition
- Scrap

4. ***External failure costs****:* These costs are applicable to goods when product has been sold. These cost include.

- Warranty cost.
- Product liability (insurance and settlements)
- Consumer affairs (dealing primarily with customer complaints about quality).
- Field service (mostly repairs of what should have worked).
- Product returns, recalls.

It is estimated that cost of correcting their own mistakes i.e. cost of failing to control quality may be as high as 40 percent of sales for some companies and that the industry average is about 25 percent. Companies may find that money spent on good program to control quality is more than repaid by reductions in their cost of internal and external failure. It has been found that *cost of bad quality is in essence-infinite to a company* that goes out of business because its customers demand high quality and can obtain it elsewhere**.** The best way to keep quality cost low is to make items correctly the first time and avoid the customer associated with poor quality.

It is usual belief that quality problem starts on factory floor. In fact they are more likely to start in place other than factory —in product design, manufacturing, engineering, training, purchasing, customer order processing or elsewhere. W. Edward Deming, one of the most famous gurus of quality insists that '*management is responsible for 80 percent of the quality problem in a factory and workers are responsible for only 20 percent'* . Some estimate that product in design itself is responsible for 50 % or more of a product quality problems.

Typical breakup of **Cost of Quality** (COQ): A survey conducted concludes the typical breakup costs of quality for a company as shown below:

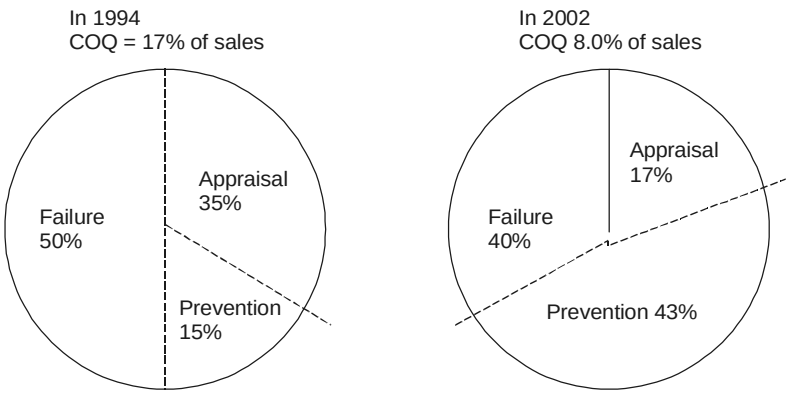



**Fig 12.1** Breakup of cost of quality (COQ)

From above breakup it is found that after company redirected its corporate culture towards improving quality then its cost of quality reduced from 17 per cent of sales to about 8 percent of sales.

## 12.6 TRADITIONAL VIEW OF COSTS AND ZERO DEFECT COSTS

Quality is an operation improved only when every body involved, those who handle the product and those who do not become aware that their tasks can effect and that they may need to redirect their procedures and habits towards preventing mistakes. The goal is therefore to have zero defects, or making the product perfect. But at what cost, this is the point of debate. The workers and managers must analyze the mistake to determine why particular defects are originated in to the product. Both must work in a cohesive manner to remove them. The setting of zero defect standard and the importance of removing all causes of errors in the process have been debated. As the number of defects change how do the total cost of quality (sum of failure, detection and prevention) change. Figure below shows the two opposing views on the issue.

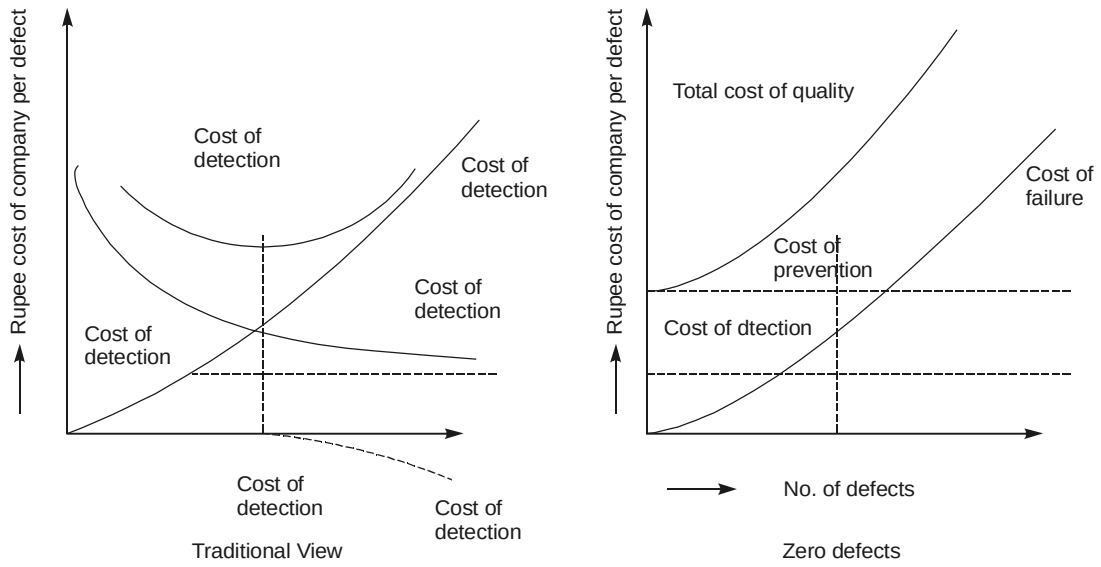



**Fig 12.2** Comparison of cost

According to traditional view '*lowest cost is achieved at zero level of defects'*. This is because returns are diminished as more and more errors are found / eliminated and fewer error persist. The last errors are thought to be the toughest to find and correct. According to zero defect view, the causes of defects in the product are so simple although numerous, that it may take no more expenditure to remove the last cause error than to remove the first. It may take longer time for last source of error but the steps to correct likely to be rather simple.

## 12.7 EVOLUTION OF QUALITY MANAGEMENT

Quality systems have been evolving rapidly in recent years. During the past 20 years simple inspection activities have been supplemented by quality control. And quality assurances has been developed and refined:

- Inspection
- Quality Control
- Quality Assurance
- Total Quality Management

## *Levels in Evolution of Quality Management*

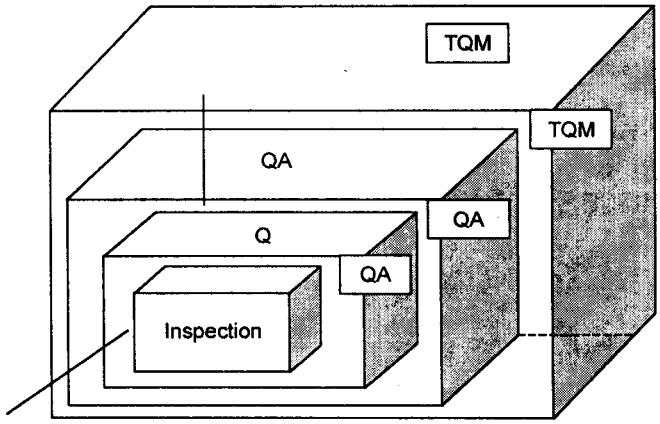



**Fig 12.3** Levels in evolution of quality management

***(i)* Inspection:** Under a simple inspection based system one or more characteristics of a product is/are examined measured or tested and compared with specified requirement to asses its conformity. The system is applied to the incoming goods manufacturing components and assemblies at appropriate point in manufacturing process. Goods or products, which do not conform to specification, may be scrapped, reworked or passed on concessions. This system is, of the fact; screening process with no prevention, content with identification of supplies operations or worker producing non-conforming product.

***(ii)* Quality Control:** Under the quality control following things are used

- Raw materials and intermediate stage product testing
- Some self inspection by operator
- Lagging process performance data
- Feedback of process information to operators, setters and production supervisors
- Use of basic statistics
- Process control.

***(iii)* Quality Assurance:** It contains all those planned and systematic actions required to provide adequate confidence that a product or service will satisfy given requirement for quality (ISO 8402-1986)

- Statistical Process Control (SPC)
- Failure mode and effect analysis
- Involvement of non–production operations
- Use of quality costs
- Comprehensive quality manuals
- Advanced quality planning
- System audits & third party approval.

Above all shift in emphasis from mere detection toward preventing of non-conformance.

**(*iv*) Total Quality Management:** The fourth and highest level involves the application of quality management principles to *all aspects of the business*. Quality management is defined in ISO 8402 (1986) as that aspect of the overall management function that determines and implements the quality policy and as such is the responsibility of top management. Individual departmental system and requirements to meet this standard may not be higher than for a quality assurance level of quality management but they will pervade the whole organization including sales, finance, personnel and other functions. It would also expect the spread of total quality management philosophy to extend beyond the organization itself to include partnership with suppliers and customers. Total quality is quality in entirety taking care of all-important aspects viz; cost, safety, prompt service, design, environment protection etc.

Total quality management uses a variety of method to involve, motivate and imbibe people at all organization levels with the *philosophy that improvement is a way of life*. Key features of the total quality management are employee's involvement and development and a teamwork approach in dealing with the important activities.

## 12.8 TQM DEFINITIONS

- **Total quality management in a culture/philosophy advocating total commitment to customer satisfaction through continuous improvement and innovation in all aspect of business.**
- **Managing the entire organization so that it excels on all dimensions of product and service that are important to the customer (*conformance to specification*)**
- **Enlightened approach to quality emphasizing building quality into the product by studying and improving activities that effect quality from marketing–through–design–to–manufacturing.**
- **TQM is an integrated organizational approach for delighting customers (both internal and external)**
- **by meeting their needs and expectations on a continuous basis through everyone involved with the organization working on continuous improvement in all products, services and processes along with proper problem solving methodology.**

It demands co-operation from every one in the company from top management down to the worker. The philosophy of TQM extends beyond product quality & covers quality of life of people. In fact the *primary concern of TQ M is people*, then comes the product.' When speaking of quality writes **Masaki Imai**, ' *one tends to think in terms of product quality*'. Nothing could be further from truth. *In TQM the first and foremost concern is with the quality of people*. Instilling quality into people has always been fundamental to TQM. A company able to build quality into its people is already half way to word producing quality product. According to **Kauro Ishikawa** (CWQC) total quality is '… satisfying the external and internal customers' requirements.'

## 12.9 TQM TRIANGLE

TQM triangle may be used as Joiner/Deming/Crosby triangle. An organized approach is required for managing for total quality for effectiveness and competitiveness involving each and every activity and person at all levels in the organization.

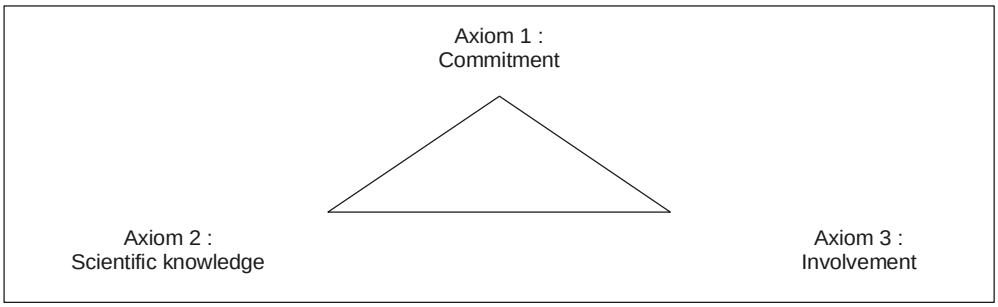



**Fig 12.4** TQM triangle

Customer in T Q M culture is not intended to mean only final customer of product, but each of individual or department, which is in process of chain to the external customer.

### 12.9.1 Axiom 1: Commitment to (never ending quality improvement and innovation)

The management commitment to continually improving the quality of product and service sounds an obvious necessity. Improvement in everything can assist and enhance innovation-an absolute necessity in the competitive markets of today. Quality is a major determining factor in the choice of consumer who is not prepared any more to accept the second best however attractive the price.

Managing partnership and demonstration by example are the best ways convincing the workforce that managers are serious about quality. Action is needed not just words and declarations eg *publication of signed quality policy quality. Slogans, posters, exhortations for quality improvement do not achieve anything other than frustration, anxiety and isolation*. This is because majority of workforce is already committed, only right conditions and environment are required. Continuous training is required i.e. willingness on the part of management to invest in future development of workforce (regarding it as an asset not commodity).

### 12.9.2 Axioms 2: Scientific Knowledge

There is no excuse any more for passing the responsibility for quality to others. Tools do exist, like tools for manager, technicians etc. There is no excuse any more not to use them. It provides a *common language*, which facilitate communication between different departments and between individuals. This helps in providing *exact boundaries* to fairly separate everybody's duty, where their duty ends and where those of management begins (no passing blames). All employees can take responsibility of quality of their own tasks.

Avoiding major errors, cutting down firefighting and wastes. *Prevention is better than cure. Do it right first time.* Prevention needs statistical tools for predictability. This is because no amount of mass inspection can improve or compensate for bad quality. Role of TQM quality department restricted to co-ordination, education and support of scientific tools throughout the organization. Every individual can identify necessary tools to pinpoint & prevent major problem rather than depending on quality department.

### 12.9.3 Axioms 3: Involvement

*Total quality management is not about particular process or department or about responsibility of a particular quality manager. It concerns everybody in company and it requires social attitude and network of relationship.* Management commitment without motivated workforce is not useful. Scientific knowledge without involvement or adaptability of needs of people is a waste. *High salary and monetary awards can motivate for only short term taking pride in one's work, being involved in the achievement of excellence are the real motivations for the long term.*

The capacity for solving problems increases many times when there is common effort. When problems are discussed in brainstorming session, they are more likely to be examined critically and in detail. Achievement of a real **team spirit** pre-supposes *absence of fear and mistrust, absence of communication barriers, absence of secrecy and competitive feeling, absence of individualism and isolation.*

## 12.10 MAJOR CONSEQUENCES OF TOTAL QUALITY

Managers need to define objectives they wish to be met in short or long run. The primary objectives are improvement and innovation. Generally the issues considered by the managers are as follows:

- Customer satisfaction
- Meeting specification
- Larger market share
- Higher productivity
- Zero defect
- X % increase in sale
- Y % decrease in cost
- Removal of downtime, scrap and rework

Instead if total quality is taken to be objective all the above objectives will become mere consequences. It is clear that investment in quality pays off as corporate success.

This success will be measured by:

- Customer satisfaction
- Profits and market share
- Improved employees morale
- Innovations (necessity for future survival)
- Team work & effective communication
- Respect for management as well as workforce

This will ensure a TQM environment, which will ensure:

- Fewer complaints
- Non
- Static updating never immune to further development
- Happier working environment
- Improved industrial relations.
- Employee fear is eliminated
- Employee takes pride in their work
- Employee feels respected and accepted
- Employee feels part of team
- Employee strives for not only own interest but for whole organization.

## 12.11 VALUABLE TOOLS FOR QUALITY

Tools for quality attainment can be broadly classified in the following two main categories.

- Management tools for quality
- Statistical tools for quality

Both types of tools are for any process and can be used by anybody from top managers to the shop floor engineer. Both have common aim, attainment of quality. Although first category will be most useful to the managers where as second to people concerned with technical side of process. Most outstanding management tools are the principles advocated by Dr. Deming. Techniques under the banner of Statistical process control (SPC) and methods advocated by **Dr. Taguchi**. The Generic tools of TQM are those developed for statistical process control (SPC) the tracking tool, which include pareto analysis, histogram, check sheet, cause and effect diagram (fishbone diagram), scatter diagram, run charts, control-charts, etc.

***SPC Tools Commonly Used for Problem Solving and Continuous Improvement***

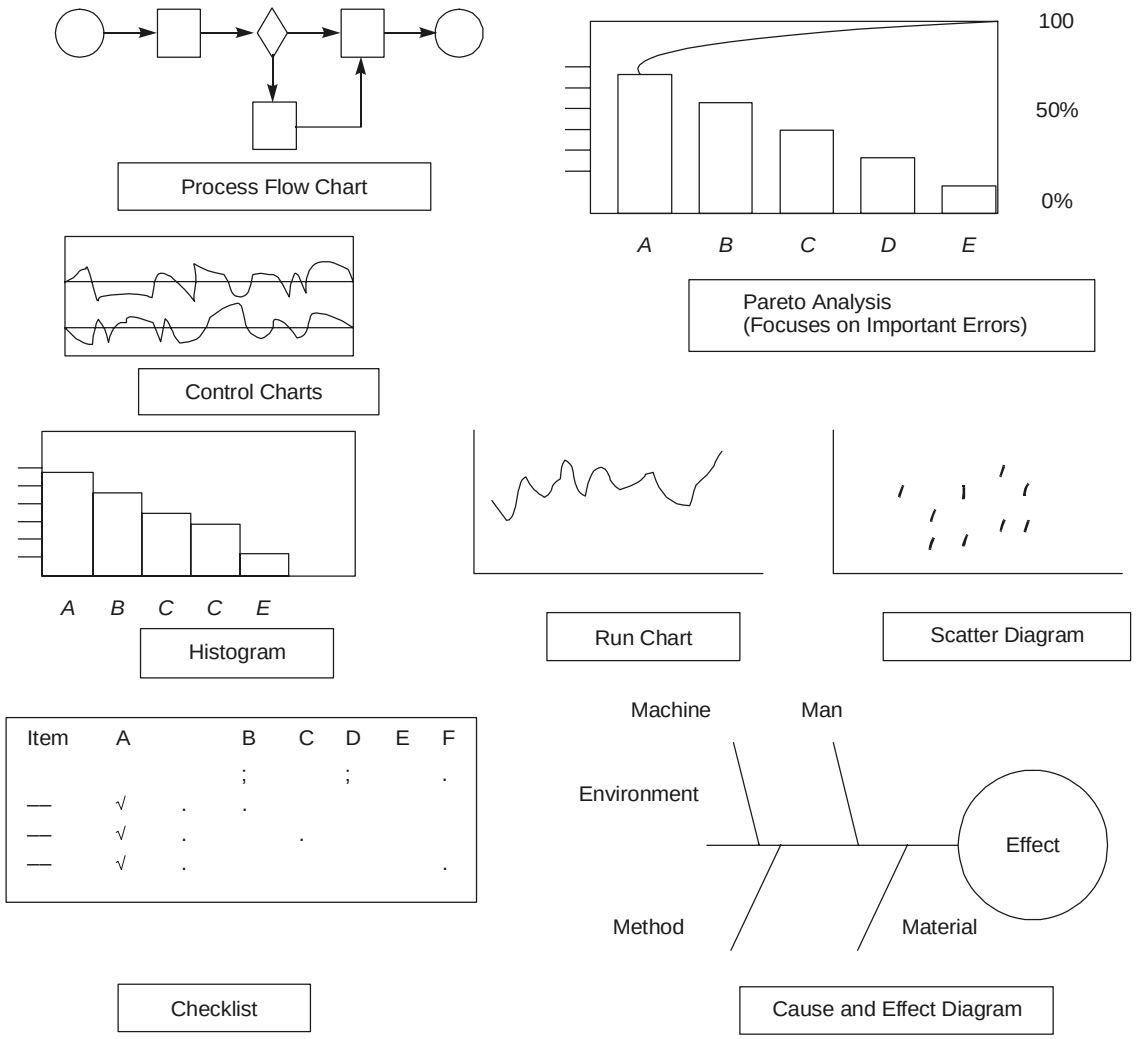
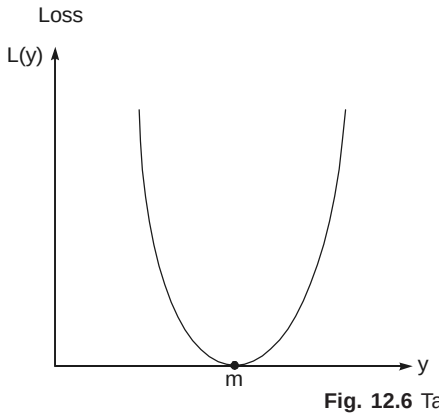



**Fig 12.5** Statistical tools for quality

## 12.12 TAGUCHI APPROACH

The approach to quality promoted by Taguchi is based on cost associeted with poor quality and its impact on corporate profitability also considering the losses to the society. He developed a mathematical model in which loss is a quadratic function of deviation of quality from its target value.



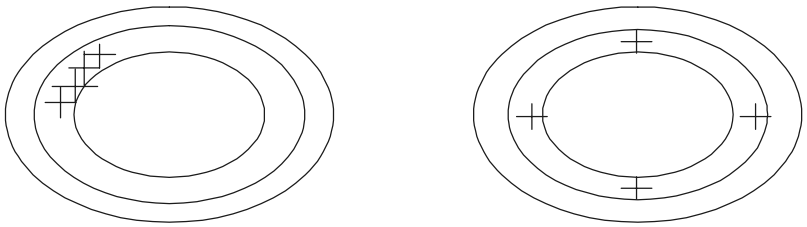

$$L(y) = K (y - m)^2$$

where

y = actual measurement
m = target value
L = Loss as a function of 'y'
K = Constant

**Fig. 12.6** Taguchi loss functions

Taguchi states that it is necessary to be 'accurate', it be better to be '*Precise while being accurate*' than to be '*Accurate but imprecise'*. Thus in taguchi philosophy definition of quality changed from '*achieving conformance to specification*' to '*minimizing the variability while achieving target*'. This concept can be explained with the help of figure shown below.



LESS ACCURATE BUT
LESS VARIABLE

MORE ACCURATE BUT
MORE VARIABLE

**Fig. 12.7** Taguchi concept

## 12.13 DEMING APPROACH

According to Deming there are fourteen principles for making TQM successful which are stated below.

- Create constancy of purpose for continual improvement of product and service.
- Adopt the new philosophy for economic stability.
- Cease dependence on inspection to achieve quality.
- End the practice of awarding business on price tag alone.
- Improve constantly and forever the system of production and service.
- Institute training on the job.
- Adopt and institute modern methods of supervision and leadership.
- Drive out fear to encourage two way communication.

- Break down barriers between departments and individuals.
- Eliminate the use of slogans, posters and exhortations.
- Eliminate work standards (MBO) and numerical quotes.
- Remove barriers that rob the hourly worker of right to pride in workmanship.
- Institute a vigorous programme of education and retraining.
- Define top managements permanent commitment to ever improving quality and productivity.

### 12.13.1 Deming Cycle

Deming used a tool for problem solving and continuous improvement. This tool is called **PDCA** (*Plan-Do-Check-Act*) cycle (also called **Deming wheel**).

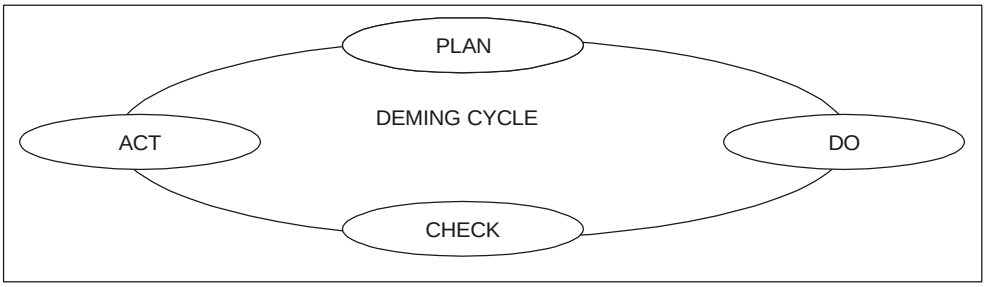



**Fig. 12.8** Deming cycle

- **Plan:** Establish the objectives and processes necessary to deliver results in accordance with customer requirements and the organization's policies.
- **Do:** Implement the process.
- **Check:** Monitor and measure processes and product against polices, objectives and requirement for the product and report the results.
- **Act:** Take actions to continually improve process performance.

This methodology can be applied to all processes.

## 12.14 QUALITY CIRCLES: SMALL GROUP ACTIVITIES

The role played by quality circles in transforming the Japanese industry generally characterized by low quality of product to one which excels in quality and low costs has made it very popular in other countries too. The quality circle concept developed in Japan in 1960's. Much of the development was due to early work of Quality Experts Juran (emphasis on good group process in suggestions from employees) and Deming (emphasis on statistical quality control).

The Japanese call quality circles as **S**mall **G**roup **I**mprovement **A**ctivities (SGIA). Over the years there have been many types of group with names representing their objectives e.g.

- Safety groups
- Productivity committees
- Zero defect movements
- Quality control (QC) circles
- Mini-think-tanks, etc.

The most widely used name is '**QC Circle**' pioneered in Japan in 1962 by **Prof. Ishikava** (creator for Cause and Effect Diagram also). Initially as in the case for many other groups, QC

circle represented study groups typically consisting of six to ten people aiming towards educational development of their members.

### 12.14.1 What is Quality Circle

It is a informal group of five to twelve employees from same work area whose members meet occasionally on voluntary basis (say for 1 hour weekly) with the main intension of problem solving under supervision of circle facilitator using scientific tools in systematic way. Comprising these groups are people from management and workforce as well as from suppliers and sub-contractors. These people work together on an equal basis for solving problems they themselves selected.

**Advantages of quality circles:**

- This strengthens team spirit.
- Helps in setting and attaining reasonable targets.
- Improves morale, greater sense of belongingness.
- Improves communication in an organization.
- Promotes cost reduction exercise.
- Promotes personnel and leadership development.
- Harmonize managers-workers relationship.
- Promotes initiative and substantially develops the ability to solve problems.

The existence of QC circles was not restricted to manufacturing industry, thousands of QC circles flourished in service sector, administration, sales and office work etc.

## 12.15 CONTROL CHARTS

Control Charts are used to separate out the assignable cause of quality variation. They are used to distinguish between inherent random variability of a process and the variability attributable to assignable causes. They accomplish this through an appropriate choice of control limits calculated from the laws of probability. Random samples of work in process are taken and inspected. Data collected are then presented graphically in chart form. The control limits are derived and are directly related to +/- **3σ** limits, which become a basis to judge variations in process.

If a machine be set to produce work to given dimension, then two changes in product quality can occur

- The mean size at which the machine is set may shift due to tool wear or setting may have moved.
- The process variability may charge. (Range may increase).

## 12.16 ISO 9000 CERTIFICATION: A BUSINESS DECISION

"**ISO**" is a word, derived from the Greek *isos*, meaning "equal ", which is the root of the prefix " *iso*-" that occurs in a host of terms, such as " isometric " (of equal measure or dimensions) and "isonomy" (equality of laws, or of people before the law). These standards were first published in **1987**. Each year since then has seen the addition of other standards, which better clarify the system for users. **In 1994**, in recognition of its many improvements, a highly successful second edition of ISO 9000 standards was published. Further changes introduced in **2000**.

It is essential that ISO certification come as the result of a real desire to improve the quality and competitiveness of a company. Too many companies undertake this venture simply

to obtain the certificate. This manner of viewing the certification process shows not only an absence of vision and strategy within the company but a lack of commitment to respect customer requirements and achieve quality and customer satisfaction. It is of prime importance that upper management involves itself formally in the process, that employees be involved and consulted, that precise objectives be set and that all steps be followed and respected. It is also necessary that the standard be well understood and the registrar with whom one will be working be carefully chosen as should the consultant who will assist in the realization of this fruitful undertaking.

## 12.16.1 ISO 9000 Quality System

*In simplest terms ISO 9000 directs you to document what you do and then do as you documented*. TQM requires and assumes that an effective quality assurance system exists and is followed. *ISO 9000 may be considered as a path towards TQM*. It becomes a baseline from which to start quality improvement activities. Using ISO 9000 standard for this assessment would provide an excellent measurement criteria and a structural approach to periodic evaluation of the quality system. It is designed to ensure adequacy of a given quality system and use audits to ensure its adherence to it. If ISO 9000 standard is integrated into TQM from start it can become a long-term critical success factor.

ISO 9000 certification standards put forth by **International Organization for standardization** (**ISO** in Geneva) now play a major role for setting quality standards for global manufactures. It is recognized as a symbol of quality and prestige. To date 95 countries have approved those standards for voluntary application in both manufacturing and service sectors. ISO 9000 certification does not necessarily relate to the quality of a company product or services but signifies that a company has fully documented its quality control procedures what ever they are and is abiding by them.

There are five standards in ISO 9000 **(**1987**)** series from *ISO 9000- to-ISO 9004*

### *Guidelines for use:*

**ISO 9000 :** Guidelines for selection and use of quality management and quality assurance standards.

**ISO 9004 :** Guidelines for quality management and quality system elements.

## 12.16.2 Quality System

**ISO 9001 :** Model for assurance of quality systems for design and development, production, installation and servicing.

**ISO 9002 :** Model for the assurance of quality systems for production and installation.

**ISO 9003 :** Model for the assurance of the quality systems for inspection and test.

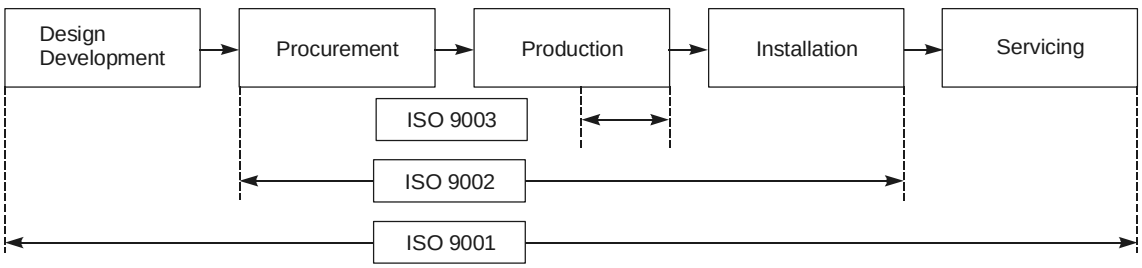



**Fig12.9** ISO model for certification

*While ISO 9000 and 9004 establish guidelines for operations. ISO 9001, 9002, and 9003 are well-defined standards*. There are 20 elements in ISO 9000 standards that relate to how the system operates and how well it is performing. Each of these elements applies in varying degree to three standards 9001, 9002, 9003 (ISO 9001 contains all of them). Highest level is 9001 with quite some work and expense. ISO 9000 is somewhat intentionally vague. ISO 9000 is valuable to the firms because it provides a framework so they can access themselves where they are and where they would like to be. *The ISO organization itself does not conduct quality system verification, nor does it attribute ISO 9000 certificates***.** These responsibilities are left to registrars.

ISO 9000 Clause (1994)

- ISO 9001
- ISO 9002
- ISO 9003
- Management Responsibility
- Quality System
- Contract Review
- Design Control
- Document and Data Control
- Purchasing
- Control of Customer
- Supplied Product
- Product Identification and
- Traceability
- Process Control
- Inspection and Testing
- Control of Inspection, Measuring and Test Equipment
- Inspection and Test Status
- Control of Nonconforming Product
- Corrective and Preventive Action
- Handling, Storage, Packaging,
- Preservation and Delivery
- Control of Quality Records
- Internal Quality Audits
- Training
- Servicing
- Statistical Techniques

### 12.16.3 Advantages of ISO 9000 Certification

Advantages for the certified company and its customers

- Both production and service companies benefit from ISO 9000 certification.
- ISO standards increase customer and supplier confidence by assuring the excellence of the certified company's quality system.
- This confidence brings a better perception of quality, which in turn brings less apprehension and fewer external audits.

- In addition, better communication with supplier's leads to improved provisioning cycles and reduced stockpiling.
- Obligatory procedure controls permit a rigorous review of processes while corrective and preventive actions attack problems at their source.
- In this way, process efficiency improves and rejections or errors are reduced, allowing for increased capacity and production.
- The downline effect of corrective and preventive actions contributes to increased profits for certified companies.

The certification process requires companies to document all of their critical processes. Consequently, they find themselves with better documentation of all their processes, particularly those that have a direct impact on the management of their operations. Beyond this, the standards yield positive changes within the company culture, as they focus attention on the quality system, on customer satisfaction and on teamwork.

### 12.16.4 There are 3 Forms of Certification

- First party: A firm audits itself against ISO 9000 standards.
- Second party: A customers audits its supplies.
- Third party: A 'qualified' national or international.

Standards or certifying agency serves as auditor. The best certification of a firm is through a third party. So ISO 9000 is all about confidence that the task will be done as promised. The 20 ISO 9000 elements are management responsibility, quality system, contract review, deigns control, document control, purchasing, customers supplied material, product identification and tractability, process control, inspection and testing, control of nonconforming product, corrective action, handling, storage and delivering, quality records, internal quality audits, training, serving, statistical techniques.

**Revisions in standards:** There has been certain revisions in ISO standards in 2000 from its earlier version of 1994. **ISO 9001** 2000 *replaces* **ISO 9001** 1994, ISO 9002 1994,and ISO 9003 1994. Instead of 20 sections, the new standard now has 6 sections**.**

- Scope normative references and definitions
- Quality management system
- Management responsibility
- Resource management
- Product realization
- Measurement, analysis and improvement

The first element contains the definitions, scope and symbols for the guidelines. *The old ISO 9002 and ISO 9003 series of standards has been discontinued*. So if a company is ISO 9002 or ISO 9003 certified, it has to have to become ISO 9001 2000 certified. The 1994 editions of ISO 9001, ISO 9002 and ISO 9003 standards are consolidated into the single ISO 9001:2000 standard. Because of the generic nature of the standard, exclusions of some requirements are allowed in clause. A guidance document on 'application' is available on the ISO TC 176/SC2 web site. All companies will now register to ISO 9001. You will identify and document requirements that do not apply to your business. For example, if you do not perform design and development functions, you will identify them as permissible exclusions in your quality manual.

### 12.16.5 Eight Steps to ISO 9000 Certification

1. Evaluation of existing quality procedures against the requirements of the appropriate ISO standards
2. Identification of corrective action needed to conform with ISO 9000 series standards
3. Preparation of a quality assurance programme
4. Definition, documentation and implementation of new procedures
5. Preparation of a quality manual
6. Pre assessment meeting with registrar to analyze quality manual
7. Actual assessment visit
8. Certification

## *QUESTIONS*

1. Explain what is quality. How is it different than total quality.
2. What are the quality attributes for products and services.
3. Discuss what is quality and its characteristics.
4. Explain what is meant by costs of quality.
5. Compare the traditional view of costs and zero defects costs.
6. Explain the levels of quality evolution.
7. What is Total Quality Management? Explain.
8. Explain the three TQM axioms along with the joiner triangle.
9. What are the major achievements of total quality.
10. What are the tools of quality
11. What are are control charts
12. Discuss the uses of ISO Certification

13

# INFORMATION TECHNOLOGY AND FUTURE OF PROJECT MANAGEMENT

Information is vital for the success of any organization and the same is also applicable to project management. The need of information arises at every stage, starting from initiation, planning, execution, control and upto close out of the project. Some common problems associated with it are listed below:

1. The continuity among management efforts does not remain consistent because someone in the organization needs to provide leadership and accountability for high level planning.
2. It is a case, to find that technical experts have the fundamental project management skills to carry out high level planning functions for any thing other than technical requirements.
3. There is always lack of knowledge of fundamental project management practices.
4. Technical requirements may change on a daily basis and therefore information related to it must be updated.
5. Impact of budget on the project is must be visualized and taken care off during project management.
6. Information management is critical because any deviation from actual conditions may change the fate of the project.

## 13.1 ROLE OF INFORMATION AT VARIOUS STAGES OF PROJECT

1. Initiation stage
2. Planning stage
3. Execution stage
4. Control stage

### 13.1.1 Information at Initiation Stage

The information regarding the following will be required at this stage.

#### *Information About Product Description*

The detailed information about the product will be required at this stage in the form of product description statement with in the project concept document. The information required to create a document such as feasibility study on system development life cycle (SDLC) may be used in

production description statement. But it is important to treat each effort as a separate entity and creates them separately. It must be kept in mind that product description statement is much less formal and detailed then the feasibility study.

### *Information About Feasibility Study*

It is the management development tool that provides an indication how the proposed information will be used to meet out the plans of the organization. Careful consideration should be given to this effort, because it will provide an assertion of how the product might be received and used by the customer, The information that is brought together here will be used to support the project concept document from a business needs and strategy perspective.

### *Information About Concept Document*

It is most important document created at project inception stage, which outlines the objectives, goals, characteristics and other components of the project. The project concept document will not hold all of the answers to all of the questions about the project being considered but it should provide enough information, both technically and objectively, to make decision to issue project charter.

### *Information About Project Charter*

Most of the data contained within the project charter outlines the administrative role and responsibilities that are a part of all projects. The person who manages the initiation phase of a project may not be the same person who is assigned as the project manager during the reminder of the project. Therefore his skill and responsibilities must be well defined in advance.

## 13.1.2 Information at Planning Stage

Project planning is the most important phase of any type of project. It is during this phase that the document baseline and processes that will be used to guide all the work to be done in the project will be created. Being able to manage communication, budgets, risk and the other assorted project management competencies is of infinite importance because these processes create the infrastructure that allows technical project staff to commit themselves to producing quality documents and deliverables. The following information will be required as a part of system development cycle.

- Work statement
- Requirements documents
- Solution documents
- Specification documents
- Design schedules
- Detail design documents

However, the information listed below will form the part of project planning document.

- Project scope statement
- Critical success factor
- Work break down structure
- Cost–benefit analysis
- Resource plan
- Risk plan

- Procurement plan
- Quality plan
- Communication plan
- Configuration management plan
- Project budget estimate
- Project planning transition checklist.

The sum of the above all elements create the project plan from which the whole project flows. None of these documents can be created in isolation and impact from technical staff will be needed. The project manager is responsible for initiating, planning, execution, controlling and closing, as opposed to being involved with the technical development of the product itself. The valid information about above all will be required at appropriate time for successful completion of any project. Project management is about planning. To quote *Peter Drunker* 'Plan worthless but planning is invaluable.'

### 13.1.3 Information at Execution Stage

The activities, which take place during execution phase, include, such as information distribution, project administration, procurement, scope verification and other project management efforts. Once a project moves into the execution phase, the project team and the necessary resources to carry out the project should be in phase and ready to perform project activities.

The project plan execution process ensures that planned project activities are carried out in an effective and efficient way while ensuring that measurements against project plans, specifications and the original project feasibility concept continue to be collected, analyzed and acted upon throughout project life cycle. Without a defined project execution process each project team would execute project using its own best practices, experiences, methods, certain control, tracking and corrective action activities would be missed.

The information about quality standards must be made available during this phase to monitor the project performance. The stakeholders must be informed about the project status will project execution is in progress. Joint project reviews are a good way to being visibility to all areas of project. The provide an opportunity to discuss important issues and make management decisions on the project with input from several sources. Joint project review can involve the project manager, project team member, project stakeholders and agency management depending upon the issues being discussed. The frequency and topics being covered at these meeting should be outlined in the communications plan.

The procedures defining the process to update schedules to depict current work efforts are key to ensuring that accurate schedule is maintained. Data collection and validation evolves the following:

- Collecting and validating schedule status, for example data that reflects start, finish and estimate to complete work.
- Validating data attributes and association and used to report schedule information.
- Validation work efforts to ensure that the schedules accurately depict the way work is being accomplished and reported.

Risk identification, monitoring and resolution are key tools for successfully completing a project. Information about all above should be available to the project manager, which can be obtained through risk identification meetings, execution review meeting and project status meetings. Reports are the, one form of information update which should be submitted to both

executive management and project team. Although the frequency of the reports may sometime vary, and should match with the meeting held. The status reports should include the following:

- Current activity status
- Significant accomplishment for the current period
- Planned activities for the next period
- Financial status
- Technical status issues
- Previous action plan
- Last risk update status

The following may also be attached with the status report:

- Updated Gantt charts
- Recovery plans for activities not on schedules–defined by project team as being late.
- Correction action plans for expected problems
- Resolution to arranged action items.

### 13.1.4 Information at Control Stage

In this section information needs for control phase are discussed. The project control is a formal process in project management that involves comparing actual performance with planned performance taking corrective action to yield desired outcome when significant differences exists. Control is vital for keeping projects with in scope, cost, schedule and with in acceptable quality because there are so many variables that may come into play.

The information required at this stage is related to the various phases of the project control, which are discussed below:

(*i*) Scope Control: The efforts by the project team can give the customer some thing other than, or in addition to, the original stated requirements. Doing any work that is outside or the beyond the stated work, as called out in the original requirements, is considered "scope creep" or "expansion of scope" which must have not been included in the original budget. The changes, if approved, must be effectively and clearly communicated to the team to prevent conflicting work.

(*ii*) Schedule control: It is one of the most difficult important activities with in project control. The project schedule can be affected by any number of issues from resources to funding. Vendors, weather, any thing in between. The ability of the project manager to manage the schedule of a project and deliver it on time is a high – visibility concern for project success from a customer point of view.

Performance measurement is used by agencies when they adopt techniques such as Earned Value Management (EVM) to help asses the magnitude of any variations that do occur. An important part of schedule control is to decide if the schedule variation requires corrective action. Performance measures provide some external rules to assist management in making a decision on more than just a gut feeling about the significance. For example, a minor delay on a non- critical activity may have little effect on the overall project, while a much shorter delay on a near critical activity may require immediate action. Therefore, the relationship of the project schedule to capabilities of the system development life cycle needs to be understood well a head of time to develop an adequate but flexible project schedule.

(*iii*) Cost Control: It is a process highly valued by project stakeholder as the cost of project and their resources is changing at an alarming rate. A project manager must be able to monitor the actual budgets of labour and resources against the baselines as laid out in the project budget estimate.

Setting budget limits and monitoring variances on budgets must be done early and often. Budget problems tend to compound themselves if left unattended. The information as regards to cost control on the following factors will be essential or desirable.

- Influencing factors that create changes to the project Budget Estimate.
- Managing the actual changes when and as they occur.
- Monitoring cost performance to detect variances from the project plan.
- Preventing incorrect, inappropriate, or unauthorized changes from being included in the project budget estimate.
- Informing appropriate stakeholder of authorized changes.

(*iv*) Quality Control: Instituting quality control with in a project is a very important variable. Setting up quality audits and management processes that are carried out continually during the development and testing phases of the system development life cycle is absolutely critical for delivering acceptable project. Quality is a valuable commodity and customer's expectations for the availability and reliability of the system are high, which can only be maintained through rigorous quality planning control. The information related to all aspects must be available to the project manager for effective implementation of quality control.

(*v*) Risk Control: All projects involve some degree of risk it is the use and expense of new or unknown technologies that provide the greatest risk to the project manager. Dealing with the issues through techniques such as risk avoidance or mitigation may even compound itself in other areas, such as cost and schedule.

Creation and constant updating of risk worksheets and plans are the key to control the risk throughout a project having a plans and procedures in place to control risk events when they occur is crucial to being able to deliver projects on time and within scope. The project manager must devote themselves to identifying planning for, and dealing with risk on a daily basis. The tools and techniques for risk control include, workaround are unplanned response to negative risk event. Here the sense of response was not defined in advanced of the risk event occurring. Additional risk response development. If the risk event was anticipated or the effect is greater than expected, the planned response may not be adequate, and it will be necessary to repeat the response development process and perhaps the risk quantification process as well. The future of project management will now rest on the use of computers to meet out the changing needs of the customer.

## 13.2 COMPUTER PROJECT MANAGEMENT SYSTEM (CPMS)

When the size of the project increases it becomes difficult and at times even impossible to plan, schedule, budget and control project activities through manual techniques. Here the need for computer based project management arises, which has become popular in recent years because of low cost PC's and high quality software available.

The increasing complexity in the projects with pressures of time and cost has led to the introduction of CPMS. Most project management softwares offer such features as network scheduling, resource management and to lesser extent cost control and performance analysis.

A sophisticated CPMS can assist in numerous planning and control tasks throughout the entire project life cycle from conception to close out. Software that make use of Internet technology further to expand upon these capabilities. Among commercial available CPMS there is considerable verification in technical capabilities, flexibility, of use, interface and integration capability. As a result their usefulness varies.

Most larger CPMS provide integrated planning, scheduling, costing, control and reporting functions. These systems utilize practically all of the planning and control techniques. Project managers have dozens of kind of project software packages to choose from software packages vary greatly in capability and flexibility as in price. As choosing the right software were not enough of a problem, the project manager must determine the right combination of computer and peripheral devices – processors, monitors, printers, plotters, modems and database and web servers.

However the project management softwares should be as far as possible compatible with the software currently being used in the organization. It should have the capacity to handle multiple projects together involving a wide range of problems. It should be suitable supported by graphs and reports in various formats. It should be easy to learn and implement. As far as possible it should have the facility to operate on the existing network environment.

Some of the popular software packages are listed below:

- Microsoft project
- Harvard total project manager
- Project schedule
- Project planner
- PRISM
- INSTAPLAN
- ACTION LIST
- C – COST
- Artemis
- Primavera
- Trakker
- Welcom

Though many software package are available today, which promise to do everything yet only few are comprehensive in their coverage. Some of the popular software are:

### 13.2.1 Microsoft Project 2000

It supports functions like scheduling, budgeting, resource management, analysis, reporting and communication. It also offers facility to manage multiple projects besides allowing for shoring of resources between various projects. It is compatible with MS office applications. It carries its own database and is compatible with SQL server or oracle databases.

### 13.2.2 Project Scheduler

This works with an SQL database and is MS office compatible. Information from multiple projects or subprojects can be managed or revel company wide resources utilization.

### 13.2.3 Prism

It is the software package developed by Tata consultancy services. It determines the sequence of activities and the duration with in which each activity must be completed in order to meet a

given project schedule. Given the budget, it can determine the minimum time within which the project must be completed. Prism automatically schedules the activities based on the resources requirement of each activity and referring to the resource pool for the availability of resources. It provides many pre – designed reports and a powerful graphics for the user for bar charts, time-cost, trade-off curves, resources histograms, cash flow graphs, network diagrams etc.

### 13.2.4 INSTA-PLAN

Insta-plan is a software package developed by WIPRO. It provides project-planning facilities and also has presentation features. It is simple to use with its reports and presentation and is gaining acceptance.

## 13.3 FUTURE OF PROJECT MANAGEMENT

A project manager can shape the destiny of a project and consequently the education, training and development of a project manager becomes as important to all those concerned with the successful implementation of the project. Yet it must be realized that project management is not possible only by tools and techniques ignoring the element of *human wisdom*. It has to be clear that if work is to be finished to near completion, a sacrifice in time and cost factors must be made. Similarly if work is to be completed in time, one should not be rigid on costs and specification. The growth of computer based project management system has made things easier for the project manager.

Most of the project management software products include the capability to take advantage of *web-based technology*. A *project web-site* and web based project software are extremely helpful when team members are located at different sites. The project manager can communicate with them send instructions, collect feedback and aggregate the provided information to create an overview of the entire project. The major benefits of web based project management include immediate availability of project information, efficiency and accessibility for communicating with workers, easy of learning and usage, real time communication.

A project team meeting held between members who are geographically dispersed via video-conferencing, voice mail, chatting is no longer a distant dream anymore. The information conveyed over a network can be either a spreadsheet, word document, power point presentation, charts, graphics, engineering design or video files. As long as team members have access to a computer and a browser they can participate in a meeting and contribute with inputs.

## *QUESTIONS*

1. What is the role of information technology in project management?
2. What is the role of information at various stages of project?
3. Explain the significance of computer based project management.
4. Project the future of project management in current scenario.
5. What are the softwares commonly used for computer project management systems.

# APPENDIX – A

## FINANCIAL ASSISTANCE APPLICATION PROCEDURE

The central financial institutions have prescribed common application form, which seeks information about the project along following lines. The information deals with:

- General name, nature of industry, etc.
- Promoter's information with brief write up about past performance.
- Particulars of industrial concern with audited balance sheet, profit and loss account of last five years, etc.
- Particulars of project. These include details about capacity, process, technical arrangements, management, plant and machinery, land and building, labour, effluents, etc.
- Cost of profit under different heads like land, building, plant and machinery, etc.
- Means of financing which include share capital (equity and preference) rupee loans, debentures, etc.
- Marketing and selling arrangements.
- Profitability and cash flow: The estimates of cost of production and working results for the first ten years of operation as per form XI and XII respectively.
- Government consents.
- Declaration.

## LIST OF FORMS

The following is the list of forms to be submitted along with the application for financed assistance.

I Letter addressed to the bankers
II Existing long-term borrowing
III Existing short-term borrowing
IV Distribution of shareholding
V Particulars of building
VI Particulars of imported machinery
VII Particulars of indigenous machinery
VIII Raw material requirements
IX Estimates of the cost of project
IXA Calculation of contingency
IXB Calculation of margin money

X Means of financing
XA Proposal for raising share capital
XB Sources of expenditures incurred
XI Estimates of cost of production
XII Estimates of working results
XIIA Estimates of production and sales
XIIB Calculation of wages and salaries
XIII Unit cost of production
XIV Cash flow statement
XV Projected balance sheet

Some of the important forms have been included.

## ESTIMATION OF WORKING RESULTS

The profitability projection is prepared after obtaining the estimates of sales revenue and cost of production. The estimate of working result is a statement in the format of application form XII used by all India institution. This statement should be perceived for ten years. Detailed working shall be provided for ten years for the calculation of depreciation (straight-line and income tax method), interest, taxation etc.

***As per Statement in Form XII***

| | 1 2 3 4 ..... .....10 (Ten Years) |
|---|---|
| A | Cost of Production |
| B | Total Administrative Expenses<br>– Administrative salaries<br>– Remuneration to directors<br>– Professional fees<br>– Light/postage/telegrams<br>– Telephones/office supplies<br>– Insurance/stationery |
| C | Total Sales Expenses |
| D | Royalty and Know-how Payable. |
| E | Total Cost of Production (A+B+C+D) |
| F | Expected Sales (As per statement in Form XII-A) |
| G | Gross Profit before Interest (F-E)<br>– Financial Expenses<br>– Interest on term loans<br>– Interest on borrow for working capital<br>– Guarantee commission |
| H | Total Financial Expenses |
| I | Depreciation |
| J | Operating Profit (G-H-I) |
| K | Other Income, if any (Give Details) |
| L | Preliminary Expenses Written Off. |
| M | Profit/Loss before Taxation (J+K-L) |

| | |
|---|---|
| N | Provision for Taxation. |
| O | Profit after Tax (M-N)<br>– Less dividend on<br>– Preference capital<br>– Equity capital (with rate) |
| P | Retained Profit<br>– Add depreciation<br>– Preliminary expenses (written off) |
| Q | Net Cash Accrual (P+I+L) |

## CASH FLOW STATEMENT

***FORM XIV***

### Sources of funds

1. Share issue
2. Profit before taxation with interest added back
3. Depreciation provision for the year
4. Development rebate reserve
5. Increase in secured medium and long term borrowing for the project
6. Other medium and long-term loans
7. Increase in unsecured loans and deposits
8. Increase in bank borrowing for working capital
9. Increase in liabilities for defined payment (including interest) to machinery suppliers
10. Sale of fixed assets
11. Sale of investments
12. Other income (total details) total (A)

### Disposition of funds

- Capital expenditure for the project
- Other normal capital expenditure
- Increase in working capital (current assets other than cash – current liabilities other than bank borrowing)
- Decrease in secured medium and long term borrowing
  - All India institute
  - SRC's
  - Banks
- Decrease in unsecured loan and deposits
- Decrease in bank borrowing for working capital
- Decrease in liabilities for deferred payment (including interest) to machinery suppliers
- Increase in investments in other companies
- Interest on term loans
- Interest bank borrowing for working capital
- Taxation
- Dividends-equity, preference
- Other expenditure Total (B)
- Net surplus/deficit (A – B)

## PROJECTED BALANCE SHEETS

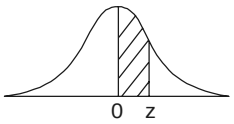
### *FORM XV*

Format of balance sheet prescribed by the companies act

| *Liabilities* | *Assets* |
|---|---|
| Share capital | Fixed assets |
| Reserve and surplus | Investments |
| Secured loans | Current assets, loans and advances |
| Unsecured loans | Miscellaneous expenditures and losses |
| Current liabilities and provisions | |

# APPENDIX – B

## AREAS OF THE STANDARD NORMAL DISTRIBUTION




An entry in the table is the proportion under the entire curve which is between $z = 0$ and a positive value of $z$. Areas for negative values of $z$ are obtained by symmetry.

| *z* | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| 0.7 | .2580 | .2611 | .2642 | .2673 | .2703 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |

*Contd...*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |

# APPENDIX – C

## THE PRESENT VALUE OF ONE RUPEE

| Year | 9% | 10% | 11% | 12% | 13% | 14% | 15% | 16% | 17% | 18% | 19% | 20% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.917 | 0.909 | 0.901 | 0.893 | 0.885 | 0.877 | 0.870 | 0.862 | 0.855 | 0.847 | 0.840 | 0.833 |
| 2 | 0.842 | 0.826 | 0.812 | 0.797 | 0.783 | 0.769 | 0.756 | 0.743 | 0.731 | 0.718 | 0.706 | 0.694 |
| 3 | 0.772 | 0.751 | 0.731 | 0.712 | 0.693 | 0.675 | 0.658 | 0.641 | 0.624 | 0.609 | 0.593 | 0.579 |
| 4 | 0.708 | 0.683 | 0.659 | 0.636 | 0.613 | 0.592 | 0.572 | 0.552 | 0.534 | 0.516 | 0.499 | 0.482 |
| 5 | 0.650 | 0.621 | 0.593 | 0.567 | 0.543 | 0.519 | 0.497 | 0.476 | 0.456 | 0.437 | 0.419 | 0.402 |
| 6 | 0.596 | 0.564 | 0.535 | 0.507 | 0.480 | 0.456 | 0.432 | 0.410 | 0.390 | 0.370 | 0.352 | 0.335 |
| 7 | 0.547 | 0.513 | 0.482 | 0.452 | 0.425 | 0.400 | 0.376 | 0.354 | 0.333 | 0.314 | 0.296 | 0.279 |
| 8 | 0.502 | 0.467 | 0.434 | 0.404 | 0.376 | 0.351 | 0.327 | 0.305 | 0.285 | 0.266 | 0.249 | 0.233 |
| 9 | 0.460 | 0.424 | 0.391 | 0.361 | 0.333 | 0.308 | 0.284 | 0.263 | 0.243 | 0.225 | 0.209 | 0.194 |
| 10 | 0.422 | 0.386 | 0.352 | 0.322 | 0.295 | 0.270 | 0.247 | 0.227 | 0.210 | 0.000 | 0.176 | 0.162 |
| 11 | 0.388 | 0.350 | 0.317 | 0.287 | 0.261 | 0.237 | 0.215 | 0.195 | 0.178 | 0.162 | 0.148 | 0.135 |
| 12 | 0.356 | 0.319 | 0.286 | 0.257 | 0.231 | 0.208 | 0.187 | 0.168 | 0.152 | 0.137 | 0.124 | 0.112 |
| 13 | 0.326 | 0.290 | 0.258 | 0.229 | 0.204 | 0.182 | 0.163 | 0.145 | 0.130 | 0.116 | 0.104 | 0.093 |
| 14 | 0.299 | 0.263 | 0.232 | 0.205 | 0.181 | 0.160 | 0.141 | 0.125 | 0.111 | 0.099 | 0.088 | 0.078 |
| 15 | 0.275 | 0.239 | 0.209 | 0.183 | 0.160 | 0.140 | 0.123 | 0.108 | 0.095 | 0.084 | 0.074 | 0.065 |
| 16 | 0.252 | 0.218 | 0.188 | 0.163 | 0.141 | 0.123 | 0.107 | 0.093 | 0.081 | 0.071 | 0.062 | 0.054 |
| 17 | 0.231 | 0.198 | 0.170 | 0.146 | 0.125 | 0.108 | 0.093 | 0.080 | 0.069 | 0.060 | 0.052 | 0.045 |
| 18 | 0.212 | 0.180 | 0.153 | 0.130 | 0.111 | 0.095 | 0.081 | 0.069 | 0.059 | 0.051 | 0.044 | 0.038 |

*Contd...*

| Year | 9% | 10% | 11% | 12% | 13% | 14% | 15% | 16% | 17% | 18% | 19% | 20% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 0.194 | 0.164 | 0.138 | 0.116 | 0.098 | 0.083 | 0.070 | 0.060 | 0.051 | 0.043 | 0.037 | 0.031 |
| 20 | 0.178 | 0.149 | 0.124 | 0.104 | 0.087 | 0.073 | 0.061 | 0.051 | 0.043 | 0.037 | 0.031 | 0.026 |
| 21 | 0.164 | 0.135 | 0.112 | 0.093 | 0.077 | 0.064 | 0.053 | 0.044 | 0.037 | 0.031 | 0.026 | 0.022 |
| 22 | 0.150 | 0.123 | 0.101 | 0.083 | 0.068 | 0.056 | 0.046 | 0.038 | 0.032 | 0.026 | 0.022 | 0.018 |
| 23 | 0.138 | 0.112 | 0.091 | 0.074 | 0.060 | 0.049 | 0.040 | 0.033 | 0.027 | 0.022 | 0.018 | 0.015 |
| 24 | 0.126 | 0.102 | 0.082 | 0.066 | 0.053 | 0.043 | 0.035 | 0.028 | 0.023 | 0.019 | 0.015 | 0.013 |
| 25 | 0.116 | 0.092 | 0.074 | 0.059 | 0.047 | 0.038 | 0.030 | 0.024 | 0.020 | 0.016 | 0.013 | 0.010 |
| 30 | 0.075 | 0.057 | 0.044 | 0.033 | 0.026 | 0.020 | 0.015 | 0.012 | 0.009 | 0.007 | 0.005 | 0.004 |
| 35 | 0.049 | 0.036 | 0.026 | 0.019 | 0.014 | 0.010 | 0.008 | 0.006 | 0.004 | 0.003 | 0.002 | 0.002 |
| 40 | 0.032 | 0.022 | 0.015 | 0.011 | 0.008 | 0.005 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 |
| 45 | 0.021 | 0.014 | 0.009 | 0.006 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 |
| 50 | 0.013 | 0.009 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |

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