1. Introduction to Project Management

Introduction

Realization of these objectives requires systematic planning and careful implementation. To this effect, application of knowledge, skill, tools and techniques in the project environment, refers to project management. Project management in recent years has proliferated, reaching new heights of sophistication. It has emerged as a distinct area of management practices to meet the challenges of new economic environment, globalization process, rapid technological advancement, and quality concerns of the stakeholders.

Project Definition

Project in general refers to a new endeavor with specific objective and varies so widely that it is very difficult to precisely define it. Some of the commonly quoted definitions are as follows. Project is a temporary endeavor undertaken to create a unique product or service or result. (AMERICAN National Standard ANSI/PMI99-001-2004)

Project is a unique process, consist of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective confirming to specific requirements, including the constraints of time cost and resource.

(ISO10006)

Examples of project include Developing a watershed, Creating irrigation facility, Developing new variety of a crop, Developing new breed of an animal, Developing agro-processing centre, Construction of farm building, sting of a concentrated feed plant etc. It may be noted that each of these projects differ in composition, type, scope, size and time.

Project Characteristics

Despite above diversities, projects share the following common characteristics.
- Unique in nature.
- Have definite objectives (goals) to achieve.
- Requires set of resources.
- Have a specific time frame for completion with a definite start and finish.
- Involves risk and uncertainty.
- Requires cross-functional teams and interdisciplinary approach.

Project Performance Dimensions

Three major dimensions that define the project performance are scope, time, and resource. These parameters are interrelated and interactive. The relationship generally represented as an equilateral triangle. The relationship is shown in figure 1.
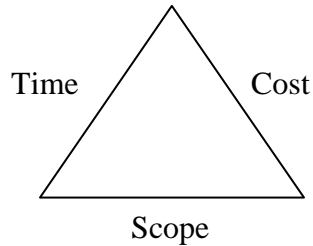
Time /\ Cost
Scope

Figure 1. Project performance dimensions

It is evident that any change in any one of dimensions would affect the other. For example, if the scope is enlarged, project would require more time for completion and the cost would also go up. If time is reduced the scope and cost would also be required to be reduced. Similarly any change in cost would be reflected in scope and time. Successful completion of the project would require accomplishment of specified goals within scheduled time and budget. In recent years a forth dimension, stakeholder satisfaction, is added to the project. However, the other school of management argues that this dimension is an inherent part of the scope of the project that defines the specifications to which the project is required to be implemented. Thus the performance of a project is measured by the degree to which these three parameters (scope, time and cost) are achieved.

Mathematically

Performance = f(Scope, Cost, Time)

In management literature, this equilateral triangle is also referred as the "Quality triangle" of the project.

Project Life Cycle

Every project, from conception to completion, passes through various phases of a life cycle synonym to life cycle of living beings. There is no universal consensus on the number of phases in a project cycle. An understanding of the life cycle is important to successful completion of the project as it facilitates to understand the logical sequence of events in the continuum of progress from start to finish. Typical project consists of four phases- Conceptualization, Planning,

Execution and Termination. Each phase is marked by one or more deliverables such as Concept note, Feasibility report, Implementation Plan, HRD plan, Resource allocation plan, Evaluation report etc.

Conceptualization Phase

Conception phase, starting with the seed of an idea, it covers identification of the product / service, Pre-feasibility, Feasibility studies and Appraisal and Approval. The project idea is conceptualized with initial considerations of all possible alternatives for achieving the project objectives. As the idea becomes established a proposal is developed setting out rationale, method, estimated costs, benefits and other details for appraisal of the stakeholders. After reaching a broad consensus on the proposal the feasibility dimensions are analyzed in detail.

Planning Phase

In this phase the project structure is planned based on project appraisal and approvals. Detailed plans for activity, finance, and resources are developed and integrated to the quality parameters. In the process major tasks need to be performed in this phase are

- Identification of activities and their sequencing
- Time frame for execution
- Estimation and budgeting
- Staffing

A Detailed Project Report (DPR) specifying various aspects of the project is finalized to facilitate execution in this phase.

Execution Phase

This phase of the project witnesses the concentrated activity where the plans are put into operation. Each activity is monitored, controlled and coordinated to achieve project objectives. Important activities in this phase are

- Communicating with stakeholders
- Reviewing progress
- Monitoring cost and time
- Controlling quality
- Managing changes

Termination Phase

This phase marks the completion of the project wherein the agreed deliverables are installed and project is put in to operation with arrangements for follow-up and evaluation.

Life Cycle path

The life cycle of a project from start to completion follows either a "S" shaped path or a "J " shaped path (Figure 2 and 3). In "S" shape path the progress is slow at the starting and terminal phase and is fast in the implementation phase. For example, implementation of watershed project. At the beginning detailed sectoral planning and coordination among various implementing agencies etc. makes progress slow and similarly towards termination, creating institutional arrangement for transfer and maintenance of assets to the stakeholders progresses slowly.
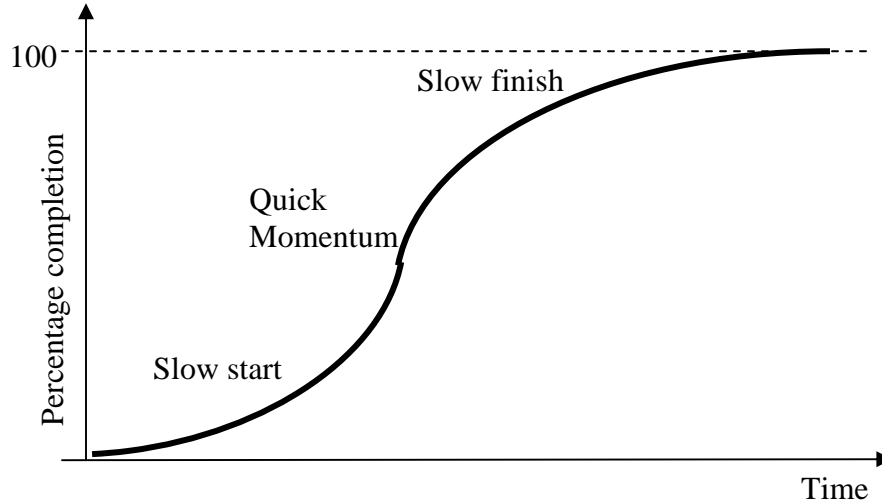
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Figure 2. Project life path –"S" shape

In "J" type cycle path the progress in beginning is slow and as the time moves on the progress of the project improves at fast rate. Example, in a developing an energy plantation. In this the land preparation progresses slowly and as soon as the land and seedling are transplantation is under taken. This is shown in figure 3.
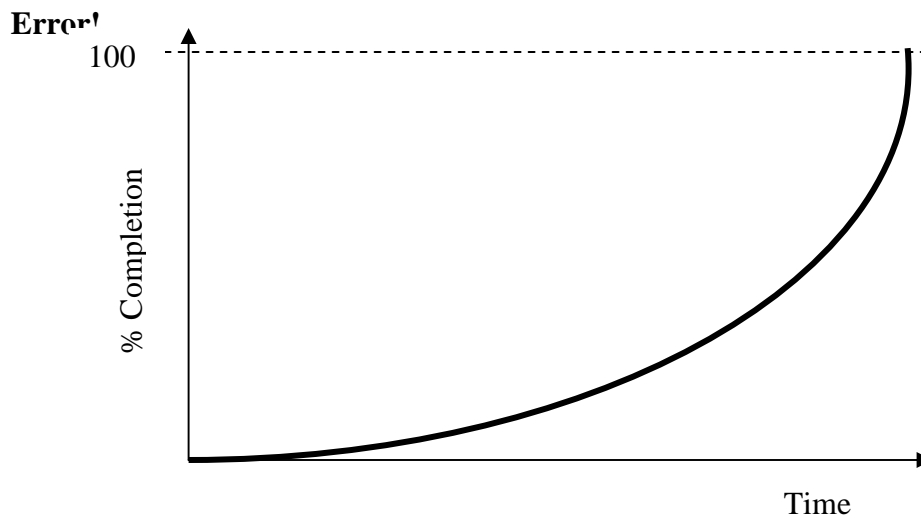
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100

% Completion

Time

Figure 3. Project life cycle path - "J" Shape

Project Classification

There is no standard classification of the projects. However considering project goals, these can be classified into two broad groups, industrial and developmental. Each of these groups can be further classified considering nature of work (repetitive, non-repetitive), completion time (long term, shot term etc), cost (large, small, etc.), level of risk (high, low, no-risk), mode of operation (build, build-operate-transfer etc).

Industrial projects also referred as commercial projects, which are undertaken to provide goods or services for meeting the growing needs of the customers and providing attractive returns to the investors/stake holders. Following the background, these projects are further grouped into two categories i.e., demand based and resource / supply based. The demand based projects are designed to satisfy the customers' felt as well the latent needs such as complex fertilizers, agro-processing infrastructure etc. The resource/ supply based projects are those which take advantage of the available resources like land, water, agricultural produce, raw material, minerals and even human resource. Projects triggered by successful R&D are also considered as supply based. Examples of resource based projects include food product units, metallurgical industries, oil refineries etc. Examples of projects based on human resource (skilled) availability include projects in IT sector, Clinical Research projects in bio services and others.

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Development projects are undertaken to facilitate the promotion and acceleration of overall economic development. These projects act as catalysts for economic development providing a cascading effect. Development projects cover sectors like irrigation, agriculture, infrastructure health and education.

The essential differences between Industrial projects and Developmental project aresumerised in the following table 1.

Table 1. Difference between Industrial and Developmental Projects

Dimension	Industrial Project	Developmental Project
Scale of Project	Limited	Large
Promoters	Entrepreneurs or corporates	Government, Public Sectors, NGOs
Investment	---	High
Gestation Period	---	High
Profitabilty	High, Considered on IRR (Internal Rate of Return)	Modest, Considered on ERR (Economic Rate of Return)
Finance	Stringent debt equity norms	Operates on higher debt-equity norms
Source of fund	National stock markets and from domestic financial institutions	International organizations like World Bank, IMF,ADB,DFID and others mostly as loan ,yet times providing for some grants.
Interest rates and repayment period:	Market rate and the repayment period is generally 7 to 10 years	Very low for borrowed funds and the repayment period extends up to 25 years and even beyond.

Project management

Project management is a distinct area of management that helps in handling projects. It has three key features to distinguish it from other forms of management and they include: a project manager, the project team and the project management system. The project management system comprises organization structure, information processing and decision-making and the procedures that facilitate integration of horizontal and vertical elements of the

project organization. The project management system focuses on integrated planning and control.

Benefits of Project Management Approach

The rationale for following project management approach is as follows.

- Project management approach will help in handling complex, costly and risky assignments by providing interdisciplinary approach in handling the assignments. Example: R&D organizations.

- Project management approaches help in handling assignments in a specified time frame with definite start and completion points .Example handling customer orders by Industries involved in production of capital goods.

- Project management approaches provide task orientation to personnel in an Organization in handling assignments. Example: Organizations in IT sector handling software development assignments for clients.

2. Project Identification and Formulation

Introduction

A project in the economic sense directly or indirectly adds to the economy of the Nation. However an introspection of the project performance clearly indicates that the situation is far from satisfactory. Most of the major and critical projects in public sector that too in crucial sectors like irrigation, agriculture, and infrastructure are plagued by tremendous time and cost overruns. Even in the private sector the performance is not all that satisfactory as is evident from the growing sickness in industry and rapid increase in non-performing assets (NPAS) of Banks and Financial Institutions. The reasons for time and cost over runs are several and they can be broadly classified under-technical, financial, procedural and managerial. Most of these problems mainly stem from inadequate project formulation and haphazard implementation.

Project Identification

Project identification is an important step in project formulation. These are conceived with the objective of meeting the market demand, exploiting natural resources or creating wealth. The project ideas for developmental projects come mainly from the national planning process, where as industrial projects usually stem from identification of commercial prospects and profit potential.

As projects are a means to achieving certain objectives, there may be several alternative projects that will meat these objectives. It is important to indicate all the other alternatives considered with justification in favour of the specific project proposed for consideration.

Sectoral studies, opportunity studies, support studies, project identification essentially focuses on screening the number of project ideas that come up based on information and data available and based on expert opinions and to come up with a limited number of project options which are promising.

Project Formulation

Project Formulation Concept

"Project Formulation" is the processes of presenting a project idea in a form in which it can be subjected to comparative appraisals for the purpose of determining in definitive terms the priority that should be attached to a project

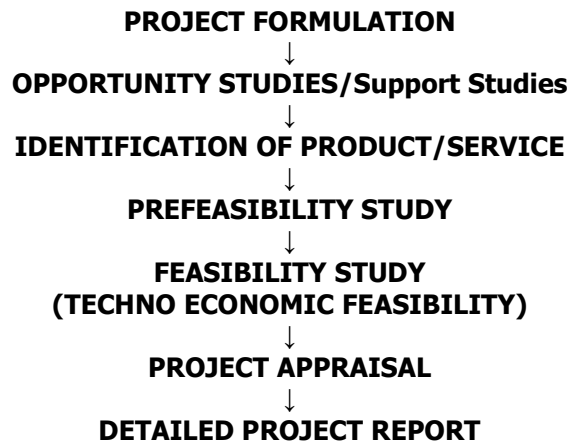under sever resource constraints.   Project Formulation involves the following steps (Figure 1).

PROJECT FORMULATION
↓
OPPORTUNITY STUDIES/Support Studies
↓
IDENTIFICATION OF PRODUCT/SERVICE
↓
PREFEASIBILITY STUDY
↓
FEASIBILITY STUDY
(TECHNO ECONOMIC FEASIBILITY)
↓
PROJECT APPRAISAL
↓
DETAILED PROJECT REPORT

Figure 1. Project Formulation –Schematic view

Opportunity Studies

An opportunity study identifies investment opportunities and is normally undertaken at macro level by agencies involved in economic planning and development. In general opportunity studies there are three types of study – Area Study, sectoral and Sub-sectoral Studies and Resource Based Studies. Opportunity Studies and Support studies provide sound basis for project identification.

Pre feasibility Studies / Opportunity Studies

A pre-feasibility study should be viewed as an intermediate stage between a project opportunity study and a detailed feasibility study, the difference being primarily the extent of details of the information obtained. It is the process of gathering facts and opinions pertaining to the project. This information is then vetted for the purpose of tentatively determining whether the project idea is worth pursuing furthering.   Pre feasibility study lays stress on assessing market potential, magnitude of investment, , technical feasibility, financial analysis, risk analysis etc.   The breadth and depth of pre feasibility depend upon the time available and the confidence of the decision maker. Pre feasibility studies help in preparing a project profile for presentation to various stakeholders including funding agencies to solicit their support to the project. It also throws light on aspects of the project that are critical in nature and necessitate further investigation through functional support studies.

Support studies are carried out before commissioning pre feasibility or a feasibility study of projects requiring large-scale investments. These studies also form an integral part of the feasibility studies. They cover one or more critical aspects of project in detail. The contents of the Support Study vary depending on the nature of the study and the project contemplated. Since it relates to a vital aspect of the project the conclusions should be clear enough to give a direction to the subsequent stage of project preparation.

Feasibility Study

Feasibility Study forms the backbone of Project Formulation and presents a balanced picture incorporating all aspects of possible concern.   The study investigates practicalities, ways of achieving objectives, strategy options, methodology, and predict likely outcome, risk and the consequences of each course of action. It becomes the foundation on which project definition and rationale will be based so that the quality is reflected in subsequent project activity. A well conducted study provides a sound base for decisions, clarifications of objectives, logical planning, minimal risk, and a successful cost effective project. Assessing feasibility of a proposal requires understanding of the STEEP factors. These are as under **S**ocial, **T**echnological, **E**cological, **E**conomic, and **P**olitical.

A feasibility study is not an end in itself but only a means to arrive at an investment decision. The preparation of a feasibility study report is often made difficulty by the number of alternatives (regarding the choice of technology, plant capacity, location, financing etc.) and assumptions on which the decisions are made. The project feasibility studies focus on
- Economic and Market Analysis
- Technical Analysis
- Market Analysis
- Financial Analysis
- Economic Benefits
- Project Risk and Uncertainty
- Management Aspects

Economic and Market Analysis

In the recent years the market analysis has undergone a paradigm shift. The demand forecast and projection of demand supply gap for products / services can no longer be based on extrapolation of past trends using statistical tools and techniques. One has to look at multiple parameters that influence the market. Demand projections are to be made keeping in view all possible developments. Review of the projects executed over the years suggests that many projects have failed not because of technological and financial problems but mainly because of the fact that the projects ignored customer requirements and market forces.

In market analysis a number of factors need to be considered covering – product specifications, pricing, channels of distribution, trade practices, threat of substitutes, domestic and international competition, opportunities for exports etc. It should aim at providing analysis of future market scenario so that the decision on project investment can be taken in an objective manner keeping in view the market risk and uncertainty.

Technical Analysis

Technical analysis is based on the description of the product and specifications and also the requirements of quality standards. The analysis encompasses available alternative technologies, selection of the most appropriate technology in terms of optimum combination of project components, implications of the acquisition of technology, and contractual aspects of licensing. Special attention is given to technical dimensions such as in project selection. The technology chosen should also keep in view the requirements of raw materials and other inputs in terms of quality and should ensure that the cost of production would be competitive. In brief the technical analysis included the following aspects.

Technology	-	Availability
	-	Alternatives
	-	Latest / state-of-art
	-	Other implications
Plant capacity	-	Market demand
	-	Technological parameters
Inputs	-	Raw materials
	-	Components
	-	Power
	-	Water
	-	Fuel
	-	Others

Availability skilled man power

\Location

Logistics

Environmental consideration – pollution, etc.,

Requirement buildings/ foundation

Other relevant details

Environmental Impact Studies:

All most all projects have some impact on environment. Current concern of environmental quality requires the environmental clearance for all projects. Therefore environ impact analysis needs to be undertaken before commencement of feasibility study.

Objectives of Environmental Impact Studies:

- To identify and describe the environmental resources/values (ER/Vs) or the environmental attributes (EA) which will be affected by the project (in a quantified manner as far as possible).
- To describe, measure and assess the environmental effects that the proposed project will have on the ER/Vs.
- To describe the alternatives to the proposed project which could accomplish the same results but with a different set of environmental effects

The environmental impact studies would facilitate providing necessary remedial measures in terms of the equipments and facilities to be provided in the project to comply with the environmental regulation specifications.

Financial Analysis

The Financial Analysis, examines the viability of the project from financial or commercial considerations and indicates the return on the investments. Some of the commonly used techniques for financial analysis are as follows.

- Pay-back period.
- Return on Investment (ROI)
- Net Present Value (NPV)

- Profitability Index(PI)/Benefit Cost Ratio
- Internal Rate of Return (IRR)

Pay-back Period

This is the simplest of all methods and calculates the time required to recover the initial project investment out of the subsequent cash flow. It is computed by dividing the investment amount by the sum of the annual returns (income – expenditure) until it is equal to the capital cost.

Example1. (Uniform annual return)

A farmer has invested about Rs. 20000/- in constructing a fish pond and gets annual net return of Rs.5000/- (difference between annual income and expenditure). The pay back period for the project is 4 years (20000/ 5000).

Example 2.(Varying annual return)

In a project Rs.1,00,000/- an initial investment of establishing a horticultural orchard. The annual cash flow is as under.

Time	Annual Income	Annual Expenditure	Annual return	Cumulative return
1st Year	60,000	30,000	30,000	30,000
2nd Year	70,000	30,000	40,000	70,000
3rd Year	85,000	25,000	60,000	1,30,000
Pay-back period = Two and half years				

The drawback in this method is that it ignores any return received after the payback period and assumes equal value for the income and expenditure irrespective of the time.

It is also possible that projects with high return on investments beyond the pay-back period may not get the deserved importance i.e., two projects having same pay-back period – one giving no return and the other providing large return after pay-back period will be treated equally, which is logically not correct.

Return on Investment (ROI);

The ROI is the annual return as percentage of the initial investment and is computed by dividing the annual return with investment. It is calculation is simple when the return is uniform. For example the ROI of the fish ponds is (5000/ 10000) X 100 = 50%. When the return is not uniform the average of annual returns over a period is used. For horticultural orchard average return is (1,30,000/3) = 43333. ROI = (43333/100000) X 100 = 43.3 %.

Computation of ROI also suffers from similar limitation as of pay-back period. It does not differentiate between two projects one yielding immediate return (lift irrigation project) and another project where return is received after some gestation period say about 2-3 years (developing new variety of crop).

Both the pay-back period and ROI are simple ones and more suited for quick analysis of the projects and sometimes provide inadequate measures of project viability. It is desirable to use these methods in conjunction with other discounted cash flow methods such as Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost ratio.

Discounted Cash Flow Analysis:

The principle of discounting is the reverse of compounding and takes the value of money over time. To understand his let us take an example of compounding first. Assuming return of 10 %, Rs 100 would grow to Rs110/- in the first year and Rs 121 in the second year. In a reverse statement, at a discount rate of 10% the return of Rs.110 in the next year is equivalent to Rs100 at present. In other words the present worth of next years return at a discount rate 10 % is only Rs.90.91 i.e., (100/110) Similarly Rs121 in the second year worth Rs 100/- at present or the present value of a return after two years is Rs. 82.64 (100/121). These values Rs.90.91 and rs.82.64 are known as present value of of future annual return of Rs.100 in first and second year respectively. Mathematically, the formula for computing present value (PV) of a cash flow "C_n" in "nth" year at a discount rate of "d" is as follows;

$PV = C_n / (1+d)^n$

The computed discount factor tables are also available for ready reference. In the financial analysis the present value is computed for both investment and returns. The results are presented in three different measures ie. NPV, B-C Ratio, and IRR.

Net Present Value (NPV)

Net Present Value is considered as one of the important measure for deciding the financial viability of a project. The sum of discounted values of the stream of investments in different years of project implementation gives present value of the cost (say C). Similarly sum of discounted returns yields the present value of benefits (say B). The net present value (NPV) of the project is the difference between these two values (B- C). Higher the value of NPV is always desirable for a project.

Benefit-Cost Ratio (B-C Ratio) or Profitability Index (PI);

The B-C Ratio also referred as Profitability Index (PI), reflect the profitability of a project and computed as the ratio of total present value of the returns to the total present value of the investments (B/C). Higher the ratio better is the return.

Internal Rate of Return (IRR):

Internal Rate of Return (IRR) indicates the limit or the rate of discount at which the project total present value of return (B) equals to total present value of investments (C) i.e. B-C = Zero. In other words it is the discount rate at which the NPV of the project is zero. The IRR is computed by iteration i.e. Computing NPV at different discount rate till the value is nearly zero. It is desirable to have projects with higher IRR.

Risk and Uncertainty

Risk and Uncertainty are associated with every project. Risk is related to occurrence of adverse consequences and is quantifiable. It is analysed through probability of occurrences. Where as uncertainty refers to inherently unpredictable dimensions and is assessed through sensitivity analysis. It is therefore necessary to analyse these dimensions during formulation and appraisal phase of the programme. Factors attributing to risk and uncertainties of a project are grouped under the following;
- Technical –relates to project scope, change in technology, quality and quantity of inputs, activity times, estimation errors etc.
- Economical- pertains to market, cost, competitive environment, change in policy, exchange rate etc.

- Socio-political- includes dimensions such as labour, stakeholders etc.
- Environmental – factors could be level of pollution, environmental degradation etc.

Economic Benefits:

Apart from the financial benefits (in terms of Return on Investment) the economic benefits of the project are also analyzed in the feasibility study. The economic benefits include employment generation, economic development of the area where the project is located, foreign exchange savings in case of import substitutes or earning of foreign exchange in case of export oriented projects and others.

Management Aspects:

Management aspects are becoming very important in project feasibility studies. The management aspects cover the background of promoters, management philosophy, the organization set up and staffing for project implementation phase as well as operational phase, the aspects of decentralization and delegation, systems and procedures, the method of execution and finally the accountability.

Time Frame for Project Implementation:

The feasibility study also presents a broad time frame for project implementation. The time frame influences preoperative expenses and cost escalations which will impact the profitability and viability of the project.

Feasibility Report:

Based on the feasibility studies the Techno economic feasibility report or the project report is prepared to facilitate project evaluation and appraisal and investment decisions.

Project Appraisal

The project appraisal is the process of critical examination and analysis of the proposal in totality. The appraisal goes beyond the analysis presented in the feasibility report. At this stage, if required compilation of additional information and further analysis of project dimensions are

undertaken. At the end of the process an appraisal note is prepared for facilitating decision on the project implementation.

The appraisal process generally concentrates on the following aspects.

- **Market Appraisal:** Focusing on demand projections, adequacy of marketing infrastructure and competence of the key marketing personnel.
- **Technical Appraisal:** Covering product mix, Capacity, Process of manufacture engineering know-how and technical collaboration, Raw materials and consumables, Location and site, Building, Plant and equipments, Manpower requirements and Break-even point.
- **Environmental Appraisal**: Impact on land use and micro-environment, commitment of natural resources, and Government policy.
- **Financial Appraisal:** Capital, rate of return, specifications, contingencies, cost projection, capacity utilization, and financing pattern.
- **Economic Appraisal:** Considered as a supportive appraisal it reviews economic rate of return, effective rate of protection and domestic resource cost.
- **Managerial Appraisal:** Focuses on promoters, organization structure, managerial personnel, and HR management.
- **Social Cost Benefit Analysis (SCBA):** Social Cost Benefit Analysis is a methodology for evaluating projects from the social point of view and focuses on social cost and benefits of a project. There often tend to differ from the costs incurred in monetary terms and benefits earned in monetary terms by the project. SCBA may be based on UNIDO method or the Little-Mirriles (L-M) approach. Under UNIDO method the net benefits of the project are considered in terms of economic (efficiency) prices also referred to as shadow prices. As per the L-M approach the outputs and inputs of a project are classified into (1) traded goods and services (2) Non traded goods and services; and (3) Labor. All over the world including India currently the focus is on Economic Rate of Return (ERR) based on SCBA assume importance in project formulation and investment decisions.

Detailed Project Report (DPR)

Once the projects are appraised and the investment decisions are made a Detailed Project Report (DPR) is prepared. It provides all the relevant details including design drawings, specifications, detailed cost estimates etc. and this would act as a blue print for project implementation.

Project Management Techniques

Introduction

Project management involves decision making for the planning, organizing, coordination, monitoring and control of a number of interrelated time bound activities. Project Manager therefore, often depends on tools and techniques that are effective enough not only for drawing-up the best possible initial plan but also capable of projecting instantaneously the impact of deviations so as to initiate necessary corrective measures. The search for an effective tool has resulted in development of a variety of techniques. These project management techniques can be classified under two broad categories i.e., Bar Charts and Networks.

Bar Charts

Bar charts are the pictorial representation of various tasks required to be performed for accomplishment of the project objectives. These charts have formed the basis of development of many other project management techniques.

Gantt Chart

Henry L Gantt (1861 – 1919) around 1917 developed a system of bar charts for scheduling and reporting progress of a project. These charts latter were known as **Gantt Charts**.   It is a pictorial representation specifying the start and finish time for various tasks to be performed in a project on a horizontal time-scale. Each project is broken down to physically identifiable and controllable units, called the Tasks. These tasks are indicated by means of a bar, preferably at equi-distance in the vertical axis and time is plotted in the horizontal axis (Figure 1).   In this figure "Task A" is land preparation, "Task B" is procurement of inputs etc. Land preparation (Task A) takes five days starting from day one. However in practice the time scale is superimposed on a calendar i.e., if land preparation starts on 1st June it would be completed by 5th June.

Length of the bar indicates required time for the task whereas the width has no significance. Though the bar chart is comprehensive, convenient, and very effective, it has the following limitations:

- Like many other graphical techniques are often difficult to handle large number of tasks in other words a complex project.

- Does not indicate the inter relationship between the tasks i.e., if one activity overruns time what would be the impact on project completion.
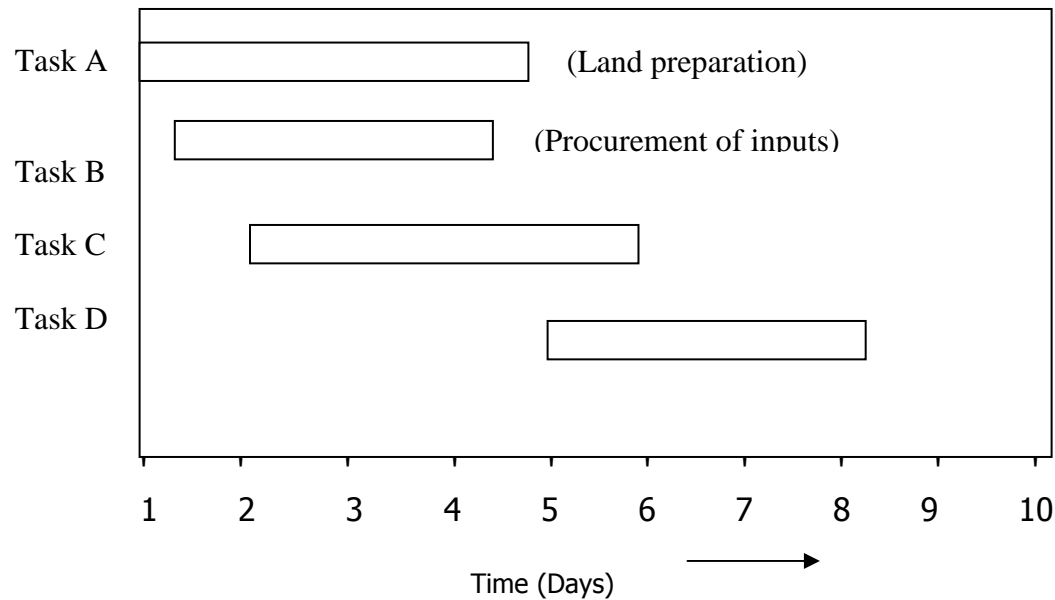

Figure 1: Bar Chart

Milestone Chart

Milestone chart is an improvement over the bar chart (Gantt chart) by introducing the concept of milestone. The milestone, represented by a circle over a task in the bar chart indicates completion of a specific phase of the task (Figure 2). For example land preparation (Task A) includes ploughing and leveling. From the simple bar chart it is difficult to monitor progress of the ploughing. Introduction of a milestone on day 3 would specify that the ploughing would be completed by day 3 of the project i.e. 3rd June. In a milestone chart a task is broken down in to specific phases (activities) and after accomplishment of each of the specific activity a milestone is reached or in other words an event occurs. The chart also shows the sequential relationship among the milestones or events within the same task but not the relationship among milestones contained in different tasks. For example in figure 2, the milestone 2 of task A cannot be reached until the milestone 1 is crossed and the activity between milestone 1 and 2 is over. Similarly, in task B the milestone 4 can begin only after completion of milestone 3. But the relationship between the milestone of task A and task B is not indicated in the milestone chart. Other weaknesses of this chart are as follows:

- Does not show interdependence between tasks.

- Does not indicate critical activities.

- Does not consider the concept of uncertainty in accomplishing the task.

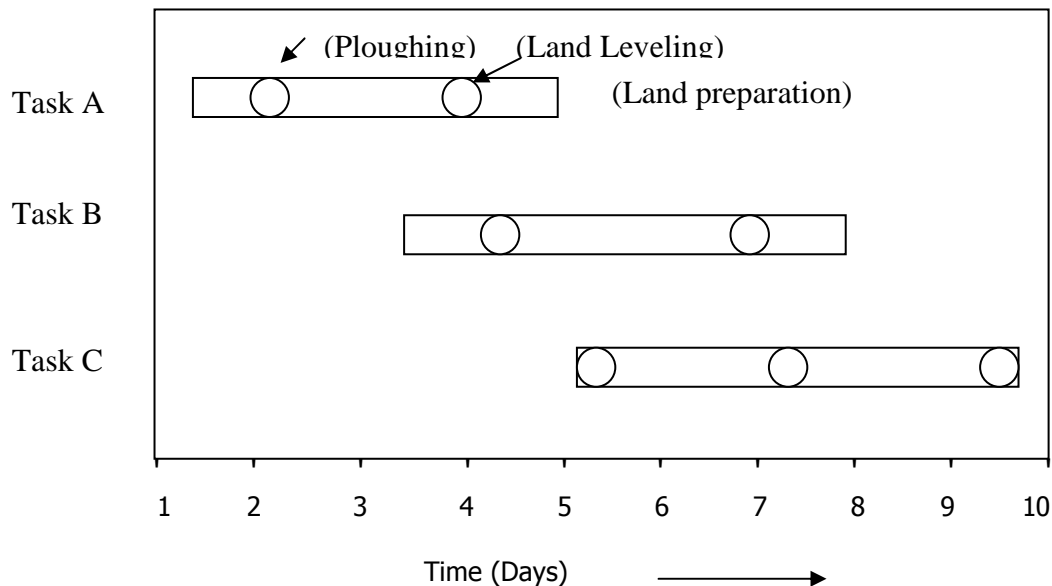- Very cumbersome to draw the chart for large projects.

Figure 2: Milestone Chart

Networks

The network is a logical extension of Gantt's milestone chart incorporating the modifications so as to illustrate interrelationship between and among all the milestones in an entire project. The two best-known techniques for network analysis are Programme Evaluation and review Technique (PERT) and Critical Path Method (CPM). These two techniques were developed almost simultaneously during 1956-1958. PERT was developed for US navy for scheduling the research and development activities for Polaris missiles programme. CPM was developed by E.I. du Pont de Nemours & Company as an application to construction project. Though these two methods were developed simultaneously they have striking similarity and the significant difference is that the time estimates for activities is assumed deterministic in CPM and probabilistic in PERT. There is also little distinction in terms of application of these concepts. PERT is used where emphasis is on scheduling and monitoring the project and CPM is used

where emphasis is on optimizing resource allocation. However, now-a-days the two techniques are used synonymously in network analysis and the differences are considered to be historical.

Both CPM and PERT describe the work plan of project where arrows and circles respectively indicate the activities and events in the project. This arrow or network diagram includes all the activities and events that should be completed to reach the project objectives. The activities and events are laid in a planned sequence of their accomplishments. However, there are two types of notations used in the network diagram. They are as under,

1. Activity-on-Arrow (AOA), and

2. 2. Activity-on-Node (AON).

In AOA notation, the arrow represents the work to be done and the circle represents an event – either the beginning 0f another activity or completion of previous one. This is shown in figure 3.
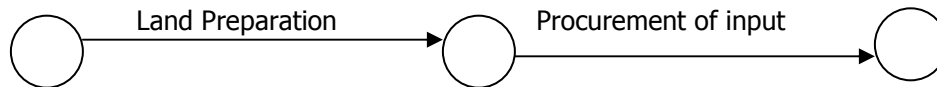

Figure 3. Activity on Arrow

For AON notation, a box (or node) is used to show the task itself and the arrow simply show the sequence in which work is done. This is shown in figure 4.
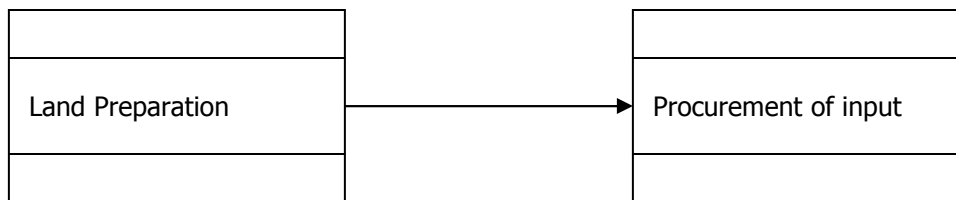

Figure 4. AON Diagram

Most project management software usually uses AON diagram. AOA network diagram are usually associated with the PERT diagram. This would be used in the following sections.

1.3.1 Programme Evaluation and Review Technique (PERT)

The PERT technique is a method of minimizing trouble spots, programme bottlenecks, delays and interruptions by determining critical activities before they occur so that various activities in the project can be coordinated.

PERT terminology

Some of the terms frequently used in PERT are as follows.

Activity : A recognizable work item of a project requiring time and resource for its completion.

Dummy Activity: An activity that indicates precedence relationship and requires no time nor resource.

Critical Activity: Activities on the critical path having zero slack / float time.

Critical Path: The longest time path connecting the critical activities in the project network. The total time on this path is the shortest duration of the project.

Event: An instantaneous point in time signifying completion or beginning of an activity.

Burst Event: An event which gives rise to more than one activity.

Merge Event: The event which occurs only when more than one activity are accomplished.

Expected Time: The weighted average of the estimated optimistic, most likely and pessimistic time duration of a project activity:

$$\text{Expected Time } (T_E) = \frac{T_o + 4 T_M + T_P}{6}$$

where T_o is the Optimistic time, T_M is the Most likely time

T_P is the Pessimistic time

Earliest Start Time (EST): The earliest possible time at which the event can occur. The EST also denotes the Earliest Start Time (EST) of an activity as activities emanate from events. The EST of an activity is the time before which it can not commence without affecting the immediate preceding activity.

Latest Start Time (LST): The latest time at which the event can take place. Also referred as the Latest Start Time (LST) indicating the latest time at which an activity can begin without delaying the project completion time.

Slack: The amount of spare time available between completion of an activity and beginning of next activity.

Steps For Network Analysis

The six steps of network analysis are as follows.

1. Prepare the list of activities

2. Define the inter relationship among the activities.

3. Estimate the activity duration

4. Assemble the activities in the form of a flow diagram

5. Draw the network

6. Analyze the network i.e. compute EST and LST; identify critical events, critical path and critical activities.

Step1: Prepare the list of activities

An activity in a project is the lowest level of resource consuming, time-bound work having a specified beginning and endpoint. It should be quantifiable, measurable, costable, and discrete. The total project is subdivided into activities and each activity is given an alphabetical symbol / code. When the number of activities is more than 26, alphanumeric or multi -alphabet codes can be used. This involves a detailed delineation of the activities to be performed to complete the project. There is no limit to the number of activities to which the project should be splitted. However, it is advisable to limit the number to the minimum required from managerial consideration for avoiding unnecessary complexity. In a simple project it may be easier to identify the activity. In complex projects project activities are identified by splitting it into different hierarchical levels (sub-projects). For example in the activities of a watershed project could be broken down in to sub-projects such as agricultural sub-projects, Soil & water conservation sub-projects, Aforestation sub-project etc. For each of these subprojects the activities could be identified. Depending on the size and nature of the project sub-projects could be further divided into sub-sub project.

For illustration of the process, a simple example of creating facility for lift irrigation in a farm would be used in the following text. Some of the assumptions are as under.

1. It is assumed that the competent authority has approved the project and the project scheduling starts with the activity of "Site selection".
2. Irrigation would be provided from a newly dug well.
3. Field channels from the well would be laid after its digging.
4. Suitable pump would be procured and installed for lifting water.
5. Specification for the pump is finalized based on the groundwater prospecting data before digging.
6. Pump and other inputs would not be procured until the site is selected.
7. Pump would be installed after digging the well.

With above assumptions, the activities of the project are listed in Table 1. It may be noted the list is not exhaustive. The list would be different with different set of assumption or the perception of the project manager. More activities could be added to the list or some of the activities could be further subdivided. The number of activities in this example has been delineated and limited to only six numbers with objective of simplicity and to demonstrate the process of networking.

Table 1. List of activity

Sr. No	Activity	Symbol / Code
1.	Site selection	**A**
2.	Digging well	B
3.	Laying field channels	C
4.	Procurement of Pump	D
5.	Installation of pump	E
6.	Test run	F

Step 2: Define the inter relationship among the activities

The relationship among the activities could be defined by specifying the preceding and succeeding activity. Preceding activity for an activity is its immediate predecessor, i.e. the activity that needs to be completed before the start of the new activity. In the given example, selection of the site precedes digging of well. In other words the site needs to be selected before digging of the well. Thus the activity "Selection of site" becomes proceeding activity to the activity of "Digging the well" Succeeding activity is the one that immediately starts after completion of the activity. "Digging well" is the succeeding activity to "Selection of site".

In PERT the interrelationship is generally defined using the preceding activity. Only the terminating activities will not have any preceding activity. And all other activities must appear at least once as a preceding activity in the table. The inter relationship among the activities listed in the example is as in Table 2.

Table 2. Interrelationship of activities

Sr. No	Activity	Symbol	Preceding activity
1.	Site selection	A	----
2.	Digging well	B	A
3.	Laying field channels	C	B
4.	Procurement of Pump	D	A
5.	Installation of pump	E	B, D
6.	Test run	F	C, E

Step 3: Estimation of activity time

The activity time is the time, which is actually expected to be expended in carrying out the activity. In deterministic cases as in CPM one time estimate is used. In probabilistic cases as

in PERT, the activity time has some kind of probabilistic distribution and is the weighted average of three time estimates (Optimistic time, Pessimistic time and Most likely time) for each activity. The expected time for each activity is computed as following:

$$\text{Expected Time } (T_E) = \frac{T_o + 4T_M + T_P}{6}$$

where T_o is the Optimistic time,(minimum time assuming every thing goes well)

T_M is the Most likely time, (modal time required under normal circumstances)

T_P is the Pessimistic time, (maximum time assuming every thing goes wrong)

Example: Estimation of estimated time for the activity "Site selection"

For this activity the tree time estimates i.e., Optimistic, Most likely and Pessimistic times are 4, 6 and 14 days respectively.

i.e. $T_O = 4$, $T_M = 6$, and $T_P = 14$.

$$T_E = \frac{4 + 4*6 + 14}{6} = \frac{4+24+14}{6} = \frac{42}{6} = 7 \text{ days}$$

Three time estimates, optimistic, pessimistic and most likely, could the decided on past experiences in execution of similar activities or from the feedback from individuals with relevance experience. The three time estimates and computed estimated time for the project activities are given in Table 3.

Table 3. Activity time estimates

Sr. No	Activity	Symbol	Preceding activity	Time (Days)			
				Optimistic Time T_O	Most likely time T_M	Pessimistic time T_P	Estimated time T_E
1.	Site selection	A	----	4	6	14	7
2.	Digging well	B	A	2	3	4	3
3.	Laying field channels	C	B	7	16	19	15
4.	Procurement of Pump	D	A	4	7	10	7
5.	Installation of pump	E	D, B	3	4	11	3

| 6. | Test run | F | C, E | 1 | 2 | 3 | 2 |

Network Diagram

Having decided on activities, their relationship and duration (estimated time of the activity), next step is to draw the network diagram of the project. PERT network is a schematic model that depicts the sequential relationship among the activities that must be completed to accomplish the project.

Step 4: Assemble the activities in the form of a flow chart.

In a flow chart the activity and its duration is shown in a box. The boxes are connected with lines according to the preceding and succeeding activity relationship. The flow charts do not give details like start and completion time of each activity until unless it is super imposed on a calendar. It also does not facilitate computation of various slacks. However, the critical path for the project can be identified by comparing the various path lengths (sum of activity time, from start to finish, on any path). The longest path in the chart is the critical path. The flow diagram for the project considered for illustration is as in Figure 5 .
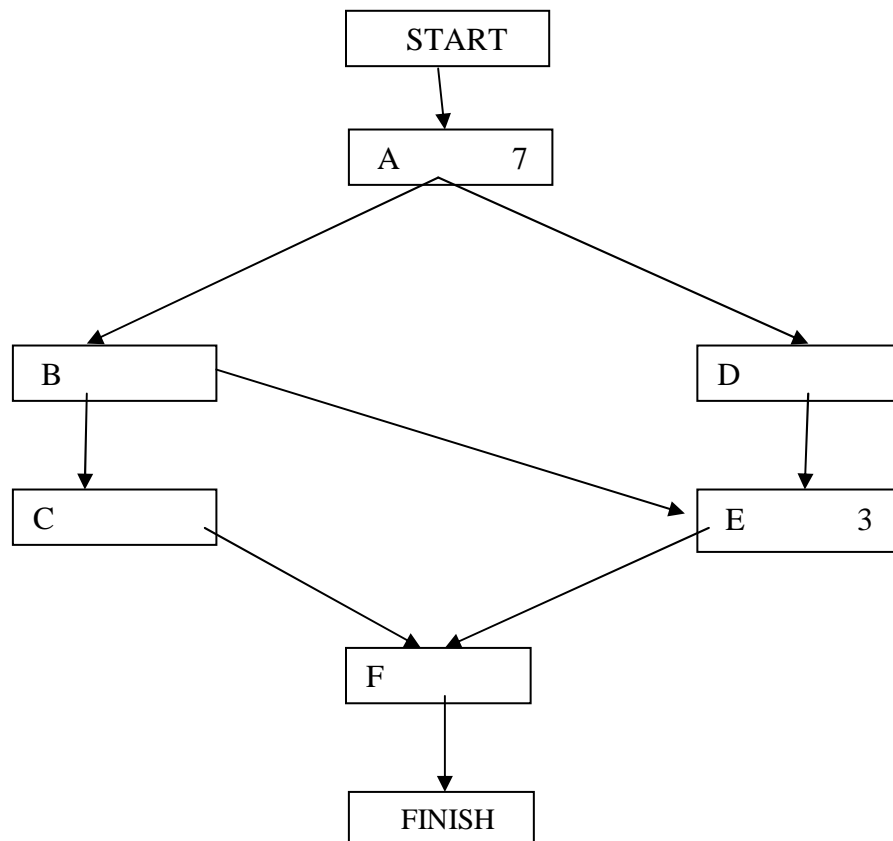
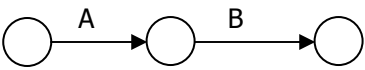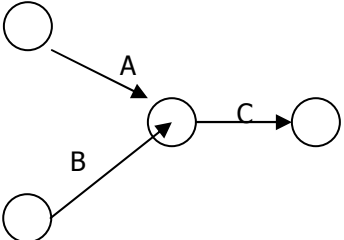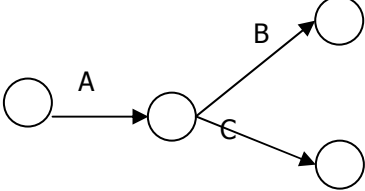Figure 5. The flow diagram
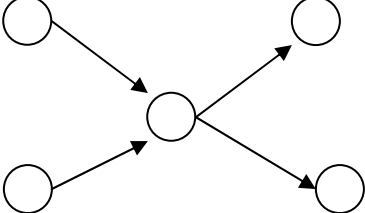
Path I A-B-E-F   7+3+3+2 = 15
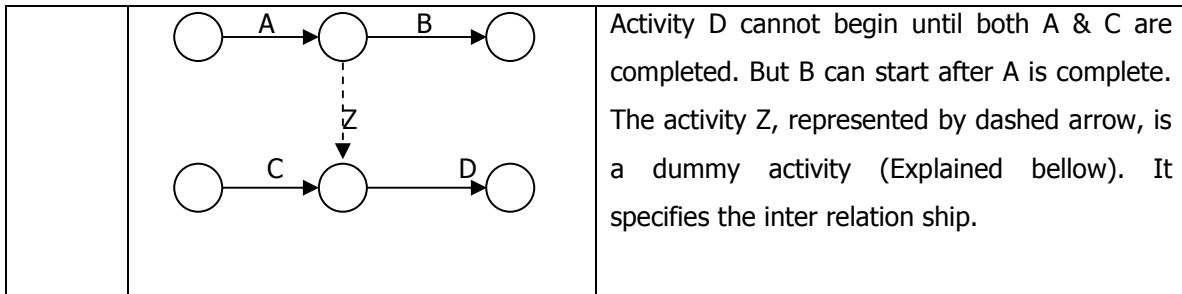
Path II A-B-C-F   7+3+15+2 = 27

Path III A-D-E-F   7+7+3+2 = 19

Path II i.e., A-B-C-F being the longest path (27 days) is the Critical path .

Step 5: Draw the network

This graphical representation of the project shows the precedence relationship among the activities. An arrow generally represents activities in the diagram while a circle represents event. Each activity starts with an event and end in an event. Activities in a project are performed either sequentially i.e. one after another or they are undertaken concurrently i.e. simultaneously. To draw the network it requires the knowledge of specifying which activities must be completed before other activities can be started, which activities can be performed in parallel, and which activities immediately succeed other activities. Some of the common combination of activity in a project is as follows,

Sl No	Diagram	Logic
1		Activity "A" is preceding activity of "B". i.e. activity 'A" need to be completed before start of activity "B". In other words "B" starts after "A" is finished.
2		Activity "A" and "B" are concurrent. Activity "C" cannot start until both the activities "A" and "B" are completed.
3		Activity "B" and "C" are concurrent activities. Any one of these cannot start until activity "A" is completed.
4		Neither activity C nor D can start until both the activities A and B are completed. But C and D can start independently.
5		

| | | Activity D cannot begin until both A & C are completed. But B can start after A is complete. The activity Z, represented by dashed arrow, is a dummy activity (Explained bellow). It specifies the inter relation ship. |

Dummy Activity:

For example in a project Crop 2 is to be raised in same plot of land after harvesting of Crop 1. The activities and there inter relation could be as under

Sl No	Activity	Code	Preceding activity
1	Harvesting of Crop-1	A	-
2	Sale of Crop – 1	B	A
3	Raising nursery of Crop-2	C	-
4	Transplanting Crop-2	D	A, C

The network diagram of the above project would be as follows
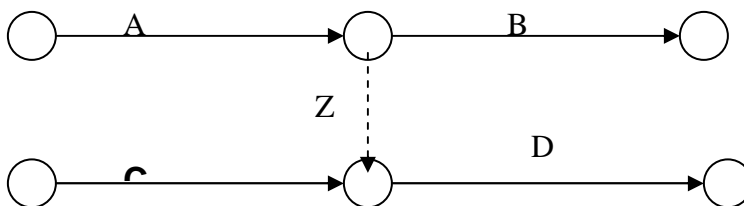
The activity "Z", represented by dashed arrow in the diagram, is a dummy activity. This does not consume any resource i.e. have zero time and zero cost. This only represents the logical relation among the activities.

Rules for Drawing the Network:
1. Each activity is represented by one and only one arrow in the network
2. All the arrows must run from left to right.
3. Dotted line arrows represent dummy activities.
4. A circle represents an event.
5. Every activity starts and ends with an event.
6. No two activities can be identified by the same head and tail event.

7. Do not use dummy activity unless required to reflect the logic.
8. Avoid Looping and crossing of activity arrows by repositioning.
9. Every Activity, except the first and the last, must have at least one preceding and one succeeding activity.
10. Danglers, isolated activities must be avoided.
11. For coding use alphabets for all activities including the dummy activity and numbers for events.

12. Standard representation of the event :
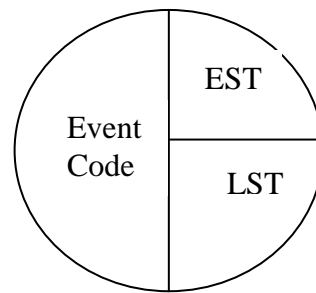
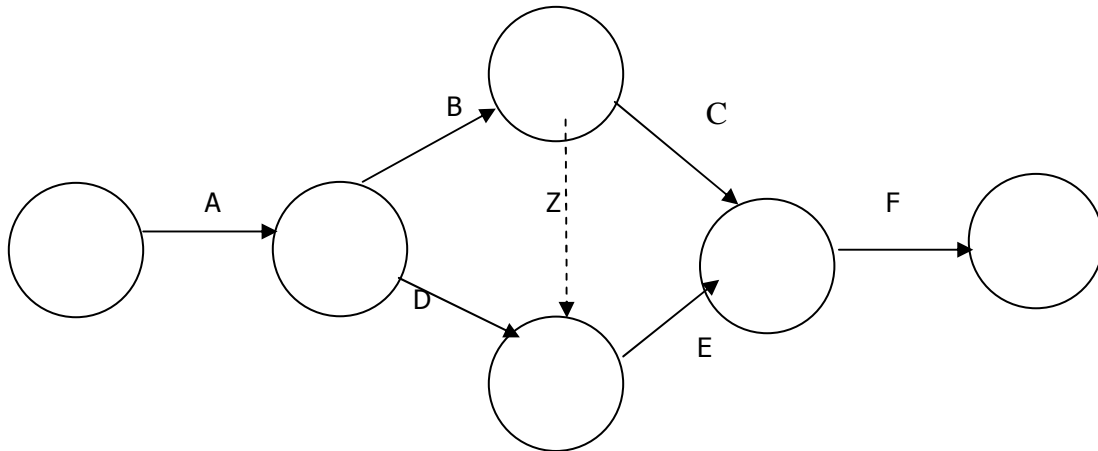The network diagram for the project detailed in Table 4 is as follows (Figure 6)..

Figure 6. Activity inter-relationship

Network Analysis

Introduction

Network analysis helps the manager to calculate the duration and identify critical activities in a project. Critical activities are those activities, which determine the overall duration of the project. The duration of the project is not necessarily the simple arithmetical sum of the individual activity durations because several activities occur concurrently in the project. Project duration would be equal to the sum of all individual activity durations only when all the activities in the project are sequential. The starting and finishing time for each individual activity is calculated through the network analysis. These computations provide a strong base for determining the work schedule. The network analysis includes the following.

  a. Event numbering
  b. Computation of the Earliest Start Time (EST)
  c. Computation of the Latest Start Time (LST)
  d. Computation of Earliest Finish Time (EFT)
  e. Computation of the Latest Finish Time (LFT)
  f. Identification of Critical Path
  g. Computation of Slack or Float

Event Numbering

It is common practice to number every event in the network so that they are not duplicated, every event is identified with a reference number in the network and every activity is identified by its preceding and succeeding event numbers. There are two systems in vogue for numbering events:

1.   Random numbering system
2.   Sequential numbering system

Random numbering system; In this system, events of a network are numbered randomly, thereby avoiding the difficulty in numbering extra events due to insertion of new jobs.

Sequential numbering system: In this system the events are numbered successively from the beginning to the end of the network. For any individual job, the head (succeeding) event must bear a higher number than the tail (preceding) event.

Fulkerson has reduced this sequential numbering to the following routine;

1.   Find the initial event and number it '1' (An initial event is one which has arrows emerging

from it but none entering it).

2. Now delete all the arrows emerging from the already numbered event(s). This will create at least one new initial event.

3. Number all the new initial events '2', '3' and so on till the final event is reached (the final event is one which has no arrows emerging from it).

The complete sequential numbering system described above is inconvenient when extra jobs have to be inserted. Extra jobs often mean extra events; when these events are numbered, all the events following them must be renumbered. One way to overcome this difficulty is to use tens only like 10 for the first event, 20 for the second event and so on. The event numbering of the network diagram for the project below (Table 1) is shown in figure 1.

Table 1. Lift Irrigation in the farm.

Sr. No	Activity	Symbol	Preceding activity	Time (Days)
1.	Site selection	A	----	7
2.	Digging well	B	A	3
3.	Laying field channels	C	B	15
4.	Procurement of Pump	D	A	7
5.	Installation of pump	E	D, B	3
6.	Test run	F	C, E	2
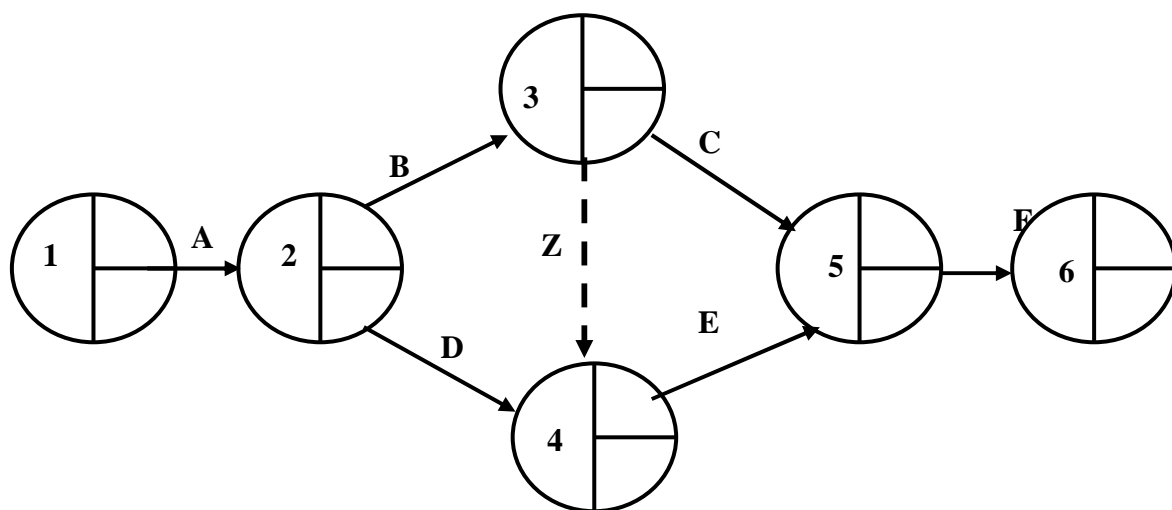
Step 6: Computing Earliest Start Time (EST) and Latest Start Time (LST)

The EST represents the time before which the activity cannot begin and LST refers to the latest time by which the activity must begin. The EST and LST are computed in two phases. The EST is calculated first in the forward pass beginning from the start event. For the start event the EST is always set to zero so that it can be scaled to any convenient calendar date at a later stage. The EST at the last event is generally considered to be the project duration i.e. the minimum time required for project completion. Therefore, EST and LST are equal at the end event. LST for other events is then calculated through backward pass starting from the end event. Steps involved in computation are listed below.

EST	LST
Through forward pass	Through backward pass
Calculation begins from start event	Calculation stars from end event
Proceeds from left to right	Proceeds from right to left
At start event EST is Zero	At end event LST equals to EST
Adding the activity time to EST	Subtracting the activity time from LST
At a merge event take maximum value	At a burst event take minimum value

Example: Computation of EST

EST of an activity = EST of preceding activity + Activity duration

EST at start event 1 (for activity A) is Zero. To compute EST at event number 2, add 7 i.e. the duration of activity A to zero. This is also the EST for both activities B and D starting from event 2. Continuing, EST at event 3 is 10 i.e. (7+3). At event 4, being a merge event, will have two estimates of EST (considering Dummy activity Z and activity D). It is 10 (10+0) and 14 (7+7). In cases where there is more than one estimate the maximum the estimates is considered. In this exercise maximum of 10 and 14 i.e. 14 is the EST at event 4. It is also EST of activity E. EST for the network is computed figure 2   and table2 .
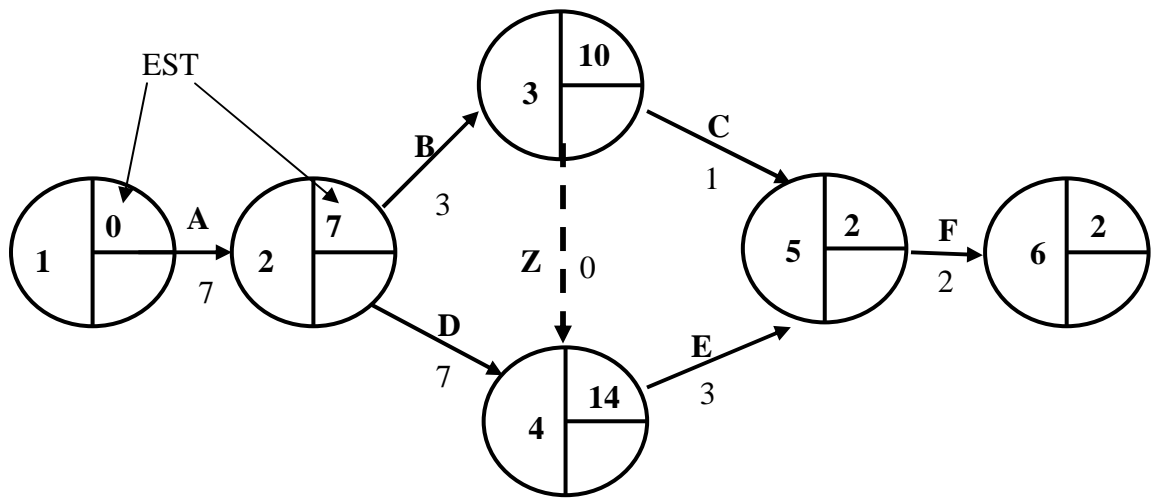
Figure 2. Computation of EST

Example: Computation of LST

LST of an activity = LST of succeeding activity – Activity duration

Computation of LST starts from the end event of the project and proceeds backward. At the end event the LST is equal to the EST In this example at the event 6, the LST is equal to the EST and it is 27. At event 5, the LST is 27-2=25. Similarly at event 4 it is 25-3=22. Event 3 being a burst event (i.e. more than one activity emanating from this event) will have two estimates of LST and in such cases only the minimum value of the LST is considered. Accordingly at event 3, the two estimates are 22-0=22 and 25-15=10. Minimum of these two values 10 is the LST at event 3. Similarly at event 2 it is the minimum of 10-3=7 and 22-7=15 i.e. 7. Accordingly at event 1, LST is 7-7=0 which is equal to the EST at the start event. Both the EST and LST values for the project activities are presented in figure 3 . and table 2 .

Table 2. The EST and LST of activities

Event No.	EST		Event No.	LST
1	0		6	27
2	0+7 = 7		5	27-2 = 25
3	7+3 = 10		4	25-3= 22
4	Max. (7+7=14, 10+0=10) = 10		3	Min.(25-15=10,25-0=25) =10

33

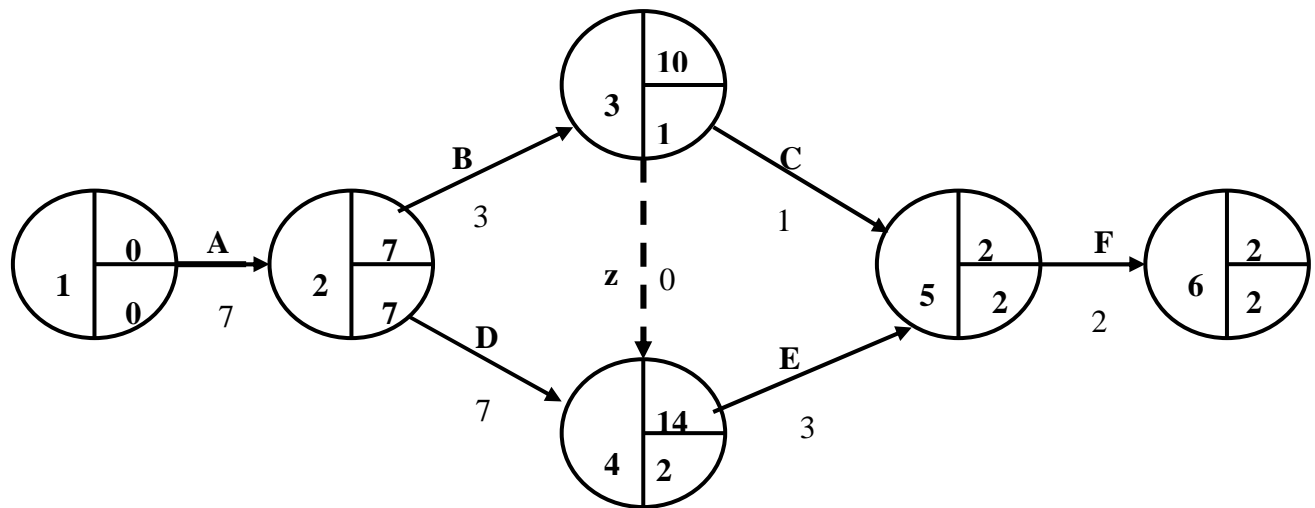| 5	Max. (10+15=25, 14+3=17) = 25		2	Min. (10-3=7, 22-7=15) = 15
6	25+2 = 27		1	7-7=0

Figure 3. The EST and LST of activities

Computation of the Earliest Finish Time (EFT) and the Latest Finish Time (LFT)

The EFT for each activity is calculated starting from the first activity, which commences

after the start event. It is given by

EFT of an activity + EST of preceding activity + activity duration.

The calculation of LFT starts from the last activity of the network or from the computed LST and is given by,

LFT = Latest Starting Time (LST) of succeeding event

The various computed for the project is given in table 3.

Table 3. Computed times for the activities

Sl No	Activity	Duration	EST	LST	EFT	LFT
1	A	7	0	0	7	7
2	B	3	7	7	10	10
3	C	15	10	10	25	25
4	D	7	7	15	14	22
5	E	3	14	22	17	25
6	F	2	25	25	27	27

Calculation Of Slacks / Floats

Slack or float is used to indicate the spare time available with in a non-critical activity. However, in general slack relates to an event and floats to an activity. These are important for smoothening the resource utilization in a project. The various floats and slacks are computed as follows

a. Event Slack = LST-EST

b. Total Flot is the time available for an activity over and above the requirement for its completion.

   Total Float = LST of end event – EST of Starting event- Duration of reference activity

c. Free Float is the time available for an activity to expand without influencing the later activities.

   Free Float = EST of end event – EST of starting event – Duration of reference activity.

d. Independent Float is the time with which an activity can expand without influencing the preceding or succeeding activities. Seldom the independent float could be negative. In such cases it would be considered to be equal to zero.

   Independent float = EST of end event – LST of starting event – Duration of reference activity.

Floats and their relation ship

Various floats and their relationship is shown in Figure 3 . It may be observed that

Total Float is more than or equal to free float. And free float is more than or equal to independent float. I.e. TF>= FF >= IF
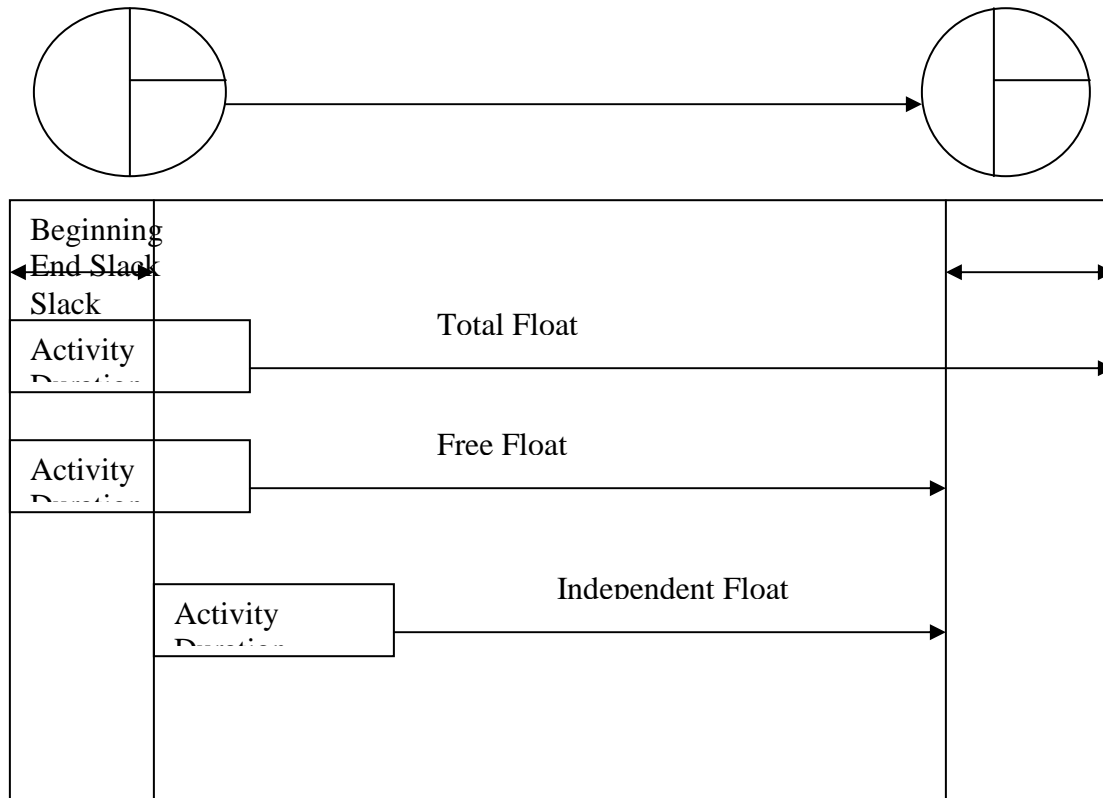
Figure 4. Relationship between the floats

Identification of Critical Events

The critical events of the project are identified by the event slack i.e. the difference between LST and EST. For critical events this slack is zero i.e. the value of LST and EST are equal. The event slack computed for all the events of the project are as follows Table 4:

Table 4. Event Slacks

Event No	LST	EST	Event slack	Critical / NC
1	0	0	0	Critical
2	7	7	0	Critical
3	10	10	0	Critical
4	14	22	8	Not Critical
5	25	25	0	Critical
6	27	27	0	Critical

With above values of EST, LST and event slack the Critical Events are 1,23,5, and 6.

Identification of Critical Activity

An activity can be called as critical activity if the following conditions are satisfied.

i.   LST and EST are equal at the head event

ii.   LST and EST are equal at tail event

iii.   Difference between EST at head and tail event of the activity equals to the activity time.

iv.   Difference between LST at head and tail event of the activity equals to the activity time.

Review of computation results suggests that the critical activities in the project are A, B, C, and F.

Identification of Critical Path

The critical path is the chain of critical activity spanning the network from start to end i.e. the path joining all the critical events. It is also the longest path from start to end of the project network. Alternatively therefore comparing all the possible path lengths can identify the critical path (see flow diagram). The critical path time is the shortest duration of the project. The critical path is denoted preferably by denoting the critical events on the path.

Critical path for the project is, A – B –C – F.

The critical path of the project can also be denoted in terms of the event numbers. In the present project it is 1- 2–3 – 5-6. To distinguish the critical path from other paths in the project, it is preferable to use a thicker line to demarcate the critical path. It is quite possible that a project can have multiple critical paths. In such case the length of all the critical paths will be equal.

Critical Path and Project Management:

The critical path time being the shortest project time any delay in completion of any of the activity on the critical path would delay the entire project. Therefore it is the critical activity that needs to be monitored for timely completion of the project. However, the activities with positive event slack could be rescheduled within the available time frame for efficient utilization i.e. smoothing of the demand on the available resources. If the duration of the project requires to be reduced, activities on the critical path will be the ones to be considered for completion at an early date with allocation of additional resources.

Network Revision

So far the steps involved in developing the initial network provided two basic pieces of information an estimate of the project duration and the critical path.

The initial network constructed is examined to convert it into a valid, practical network which satisfies the project requirements and provides the basis for effective implementation and control. This process is called network revision.

The purpose of revision is two-fold. Firstly, it is concerned with improving the quality of the information in the network; information about the relationships and durations of activities. Secondly, it is concerned with ensuring that the final network satisfied the project objectives. These relate to four factors; time, cost, resources and performance.

Reviewing the relationships: The first task is to review the activities and their relationships. Some relationships may not have been shown properly in the initial network. A sequence of activities which at first sight appear to need serial representation, can sometimes be arranged to take place in parallel with one another. Often it is s only a part of an activity which really conditions the start of the following activity, and in these cases, the activity can be subdivided and part of it depicted on the network as occurring in parallel with other activities. If the activity thus treated is on the critical path, a useful shortening of the project duration can be achieved.

Reviewing the duration of activities: At the revision stage, the activity durations must be re-examined in the light of information about the project duration and critical path. Work may have to be analyzed in greater detail, suppliers may have to be contacted for confirmation of current delivery periods and so on. Less accurate estimates can usually be tolerated for activities with plenty of float.

For some activities, the duration is variable. The time required to carry out the work depends almost entirely upon the quality or accuracy of performance specified. Estimates for research and development work and producing advertising copy or design work may be of this type. One approach for reviewing the duration of the activities when they are not critical is the use of the concept of available time.

One useful little check, which can be applied to the activity durations, is to calculate the parentage of even number durations in the network. Because of a fairly general bias towards even numbers, the percentage is rarely as low as the theoretical 50%.

Project objectives while in theory, the objectives of every project should be clearly defined at the outset, in practice this is not always done. On the other hand, the initial network assists and

forces the clear definition of project objectives. Statement about objectives is usually expressed in term of time, cost, resources and performance. It will be realized that the objectives stated in terms of one factor may conflict with others. For example, it may not be possible to complete a project in the shortest time and at minimum cost. If a network is to be checked to see whether it satisfies the project objectives, then these objectives must have been stated in such a way as to recognize and assign priority to their relationships.

Meeting time objectives; It is likely that the project duration calculated from the initial network may not be acceptable to the management. This means that at the revision stage, the network must be modified to satisfy any time limits set for the project. If the project duration is to be reduced, the critical activities must be subjected first to careful examination. Changes in the relationships in turn affect the time along the concerned path as discussed earlier.

But once the possibilities for changes in relationships have been exhausted, the scope for reduction in the duration of critical activities must be examined. In some cases, this may mean diverting resources from non critical activities to critical, ones. In others, this may mean the use of more labour, more machines; overtime work or extra shifts.

Meeting cost objectives: The cost of a project is usually given in terms of an estimate which may be required for such purposes as establishing feasibility, finding out return on investment, obtaining approval or getting out a price for a job, etc. The time involved will be important and a realistic cost target cannot be set without a careful study of the plan embodied in the network. The plan will determine in broad terms the pattern of expenditure over the period of the project. The network can be used to investigate this pattern of expenditure and the results can be compared with the availability of money. The network may indicate a pattern of expenditure in excess of what is possible, in which case the plan will have to be modified.

Certain activities can be speeded up or slowed down depending upon the amount of money spent on them. The network can be used to examine the relationship between total time and total cost, and the project duration established for which the total cost is minimum. These aspects will be discussed in more detail later.

Meeting resource objectives: The initial network is drawn without considering the resources as this does not affect the relationships between activities. However, if the resources are limited, the plan must be examined to see to what extent it will have to be modified in the light of resource availability. Activities which are independent may have to be made dependent upon one another because they will be done by the same machine or by the same man. For example, a

number of fitting jobs may be unrelated in the network, but if there is only one fitter to whom this work can be allocated then the jobs will have to be done one after the other. If the jobs have sufficient float to allow this, the project completion date will remain unaffected; but if the float is inadequate, an additional fitter has to be employed or a later completion date accepted. The plan. should be modified accordingly.

Another aspect which should be considered at this stage is the relationship between to duration of an activity and the resources allotted to it. The original duration assumes normal resources but for some activities, this time may be varied by altering resources put on the job. Thus certain critical activities may be speeded up by putting on additional resources, while activities with plenty of float may be allowed to take longer time with less resources, thus releasing men for more critical activities.

Examination of the network can throw some light on the resource implications of the plan in a general way. Often a detailed analysis of the network is necessary, if the information is going to lead to management action. The analysis of network with respect to resources will be discussed in detail later.

Meeting the performance objectives: There are two ways in which the plan influences the specification of the project. Firstly, it will embody methods of working and procedures which influence performance and these may have to be revised in order to effect a reduction in the project duration. It may be necessary to find alternative ways of doing things which are less satisfactory and the implications of these decisions must be carefully evaluated in relation to the project as a whole and the possible effect on the specification.

The second aspect, already mentioned, is the relationship between performance and time for certain activities. Any reduction in the time allowed for development work and testing may affect ultimate performance and the plan must be checked to establish whether the original specification can still be met. In this way the network can give some indication of the relationship between time and performance, allowing the decisions to be made which are consistent with overall project objectives.

The final network: There are usually a number of ways in which the plan can be revised to meet project objectives and each will have different implications. The use of network to simulate these alternatives can help in finding the right balance between the objectives. Many changes will be made to the initial network before a final plan can be agreed upon and on the basis of the final plan detailed work schedules are worked out.

maximum and the minimum is only one person. The manpower demand for the project duration after rescheduling the activity C is shown in figure 6.
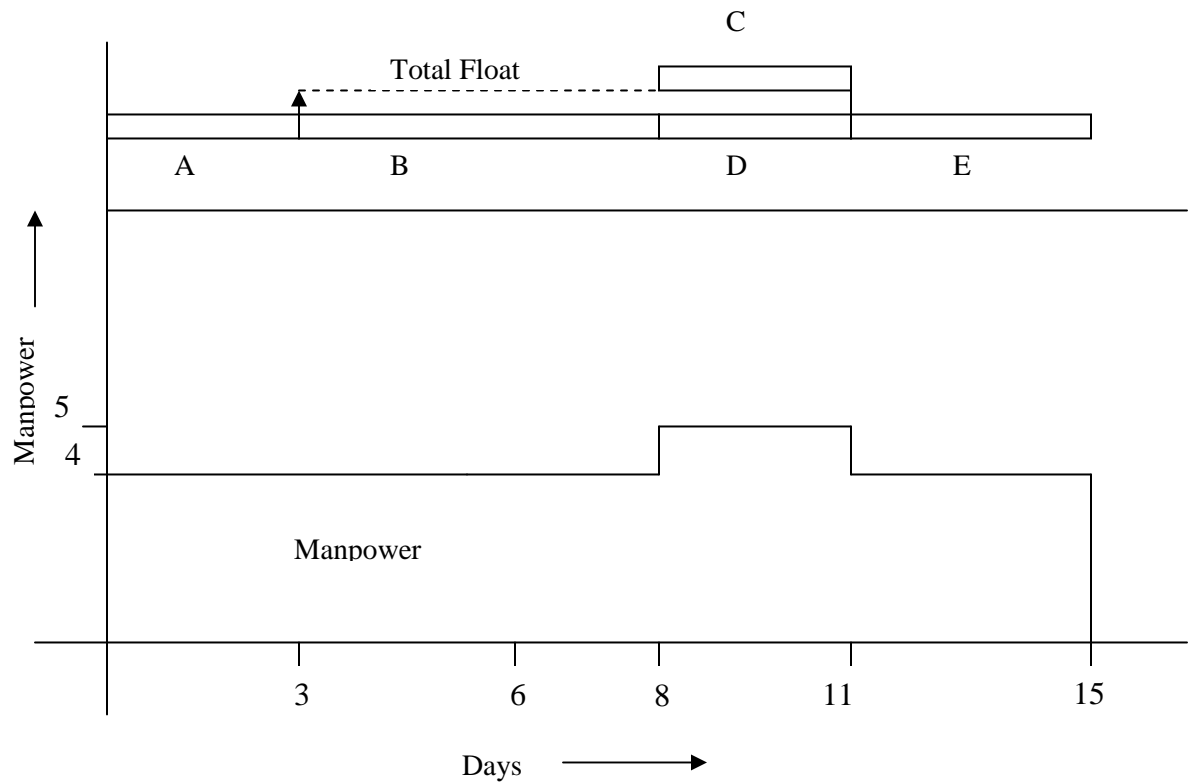
Figure 6. Revised schedule of activities.

The resource smoothing is a technique applied to distribute the resources load evenly through out the project period. In agricultural projects where the field operations are highly dependent on weather, cropping pattern, crop characteristics, application of this technique would be limited to the use of implements or to the operation those are not bound by natural phenomena.

Project Crashing and Project Control

Time-Cost Relationship Of An Activity

The time required for the performance of an activity is estimated according to the quantity of resources. Except for fixed duration activities such as crop duration, gestation period etc it is possible to mange the duration of an activity by varying the quantity of resource. If cost is not a constraint, putting more resources to the activity duration could reduce be reduced. This in other word means time and cost of a project are inversely related. The relationship between cost of an activity and its duration may take the form of the curve as depicted in figure 1.

Figure 1. Time-Cost relationship
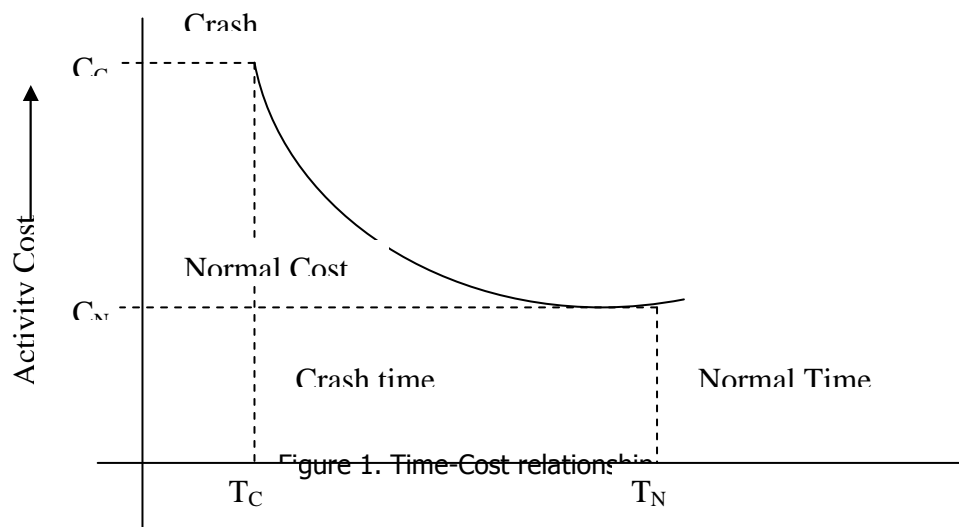
The time for the act Activity Duration called *Normal time* and the minimum time for the activity is called *crash time*. The costs associated with these times are called respectively the *normal cost* and the *crash cost.* Although it is possible to estimate the time and cost associated with the normal and crash conditions for each activity it is difficult to estimate the time and cost at any intermediate stage between these two points. To overcome this difficulty, it is assumed that the relationship between the time and cost as linear in the range between normal and crash situations.

Project Crashing

Project crashing is an exercise carried out to reduce the time of a project by investing more money. This becomes necessary when the dead line has to be met. For crashing only the critical are considered since duration of the project could be reduced by crashing these activities only. It is possible that when a project is crashed another non-critical activity may become critical and in the next cycle this has to be considered for further crashing. The steps involved in

crashing are as under.

    a. Identify critical path and critical activity

    b. Compute crash cost slope i.e. (Crash cost – Normal cost) / (Normal Time – Crash Time)

    c. Select the activity with the least cost slope i.e. minimum crash cost per time.

    d. Check for the critical path.

  As the project shortening (crashing) continues, a point is reached at which no further crashing is possible. At this point, some activities might not have reached their crash points. If these activities are crashed further, costs are increased with no saving in project duration.
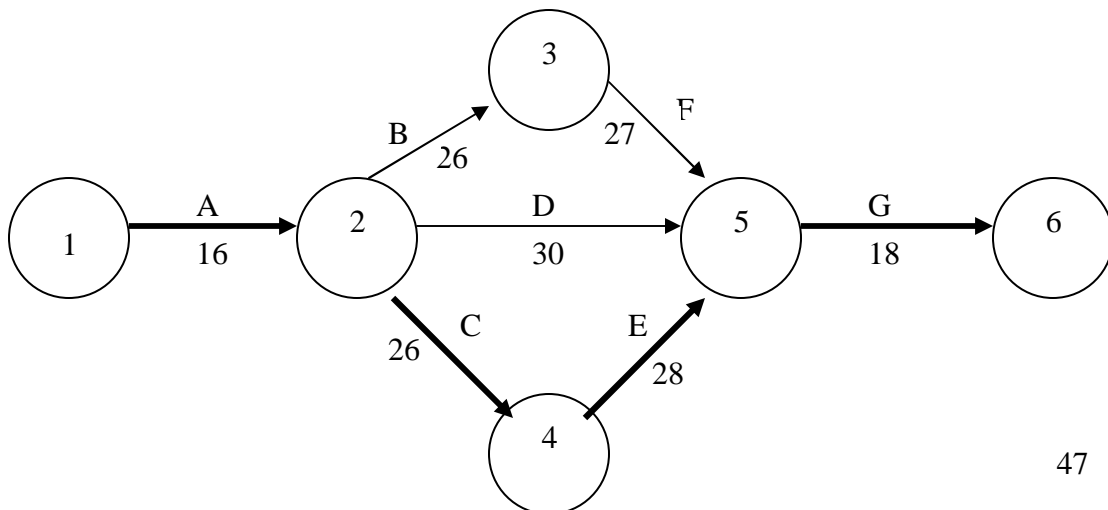
Project Crashing Example

The principles of project crashing are illustrated with the help of the example. Activity table of the project and the network diagram are shown in Table1 and Figure 1 respectively. Table 2 presents the normal and crash parameters.

Project: Development of Agro-Technology Demonstration Blocks

Table 1. Activity Table

Sl No	Activity	Symbol	Preceding activity	Duration (Weeks)
1	Leveling the land	A	-	16
2	Stone pitching	B	A	26
3	Raising seedling	C	A	26
4	Establishment of irrigation system	D	A	30
5	Development of drainage system	E	C	28
6	Making pits and transplantation	F	B	27
7	Erection of fencing	G	D,E,F	18

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The table below describes some of the main views in Project.

Calendar:	Shows the view in the form of a calendar.
Gantt Chart:	A diagrammatic view of the Tasks and their time scale. This chart can also show the relationship between Tasks and the Critical Path. It usually shows the task entry form alongside the Gantt chart.
Network Diagram Chart:	Network Diagram is an acronym for Programme Evaluation Review Technique. This view represents each Task as a box with relevant information within it. The layout of the boxes on the chart and the lines that link the boxes represent the structure of the project.
Task Usage:	The Task Usage view displays project tasks with their assigned resources grouped underneath them.
Tracking Gantt:	The Tracking Gantt view displays two task bars, one on top of the other, for each task. The lower bar shows baseline start and finish dates, and the upper bar shows scheduled start and finish dates (or if the task has already started, meaning that the percentage complete is greater than zero, the upper bar shows the actual start and finish dates).
Resource Graph:	A graphical representation of a single resource and its utilisation.
Resource Sheet:	A list of all the resources for the project.
Resource Usage:	This is a view that shows the use in hours per day for each resource.
More Views:	Allows the showing of combination views as well as details of a single Task
Table:(Entry):	Changes the form alongside the Gantt chart.
Reports:	Takes you into Report Wizard.
Toolbars:	Allows you to change the Toolbar display.
View Bar:	Activates the View bar, located vertically on the left of the screen.
Zoom:	Changes the amount of information you can see on screen, from days to years.

The Tracking Gantt View

When you initially set up your project with tasks and dates, and then save the project with a baseline, the Tracking Gantt view displays those tasks as shown in the following example.
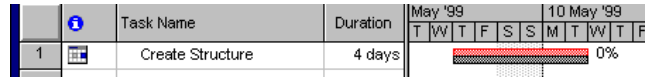
The baseline bars and the scheduled or actual bars are synchronized. However, if the start date of task slips by, say, 2 days, the red scheduled bar will extend 2 days beyond the lower baseline bar.

Because the tasks are linked, the slipping of task 2 will cause a ripple effect, making its successor tasks slip by 2 days as well.

You can use the Tracking Gantt view to:

- See how tasks progress across time and evaluate the slippage of tasks. You can track progress by comparing baseline and scheduled or actual start and finish dates and by checking the completion percentage of each task.

- View tasks graphically while still having access to detailed information about the tasks.

- Create a project by entering tasks and the amount of time each task will take.

- Establish sequential dependencies between tasks by linking them. When you link tasks, you can see how a change in the duration of one task affects the start and finish dates of other tasks and the project finish date.

- Assign personnel and other resources to tasks.

MS Project - Menus

The File Menu

The File menu is typical of the windows environment. The command which pertains to MS Project is:

Properties:	Provides basic information on the Project.

The Edit Menu

The Edit menu is also typical of the windows environment. Commands which pertain to MS Project include:

Link Tasks:	Create links between tasks.
Unlink Tasks:	Break an existing link.
Go To:	Go to a task or resource. (Depends on view.)

The Insert Menu

Among other things allows you to insert new rows for tasks or columns for information. You can also go to the Task information dialog box to add more detailed information to the current task.

The Format Menu

This changes dramatically when different views are selected. The following are the principal selections.

For a Network Diagram the choices are:

Text Styles:	Modifies the size, and type of the selected text.
Box Styles:	Changes the appearance of the Network Diagram boxes.
Layout:	Allows you to customise the way links are shown.
Layout Now:	Redraws to show changes made to links etc.

For the GANTT chart the choices are:

Font:	Used to change the font.
Bar:	Change the selected Gantt Bar style
Timescale:	Allows you to set the displayed time at anything from years to minutes.
Gridlines:	Allows you to display or hide Gridlines and change their appearance.
Gantt Chart Wizard:	Takes you through the programs method of setting up your Gantt chart.
Text Styles:	Change the font, size and colours
Bar Styles:	Change all Gantt bars.
Details:	Details of the Gantt chart
Layout:	Change the way the bars are displayed including links.

The Tools Menu
The main choices here are Change Working Time, Tracking and Multiple Projects.

Assign Resources:	Apply various filters to the tasks.
Level Resources:	Shows resource levelling information
Change Working Time:	Format a new Calendar.
Tracking:	Check the progress.
Links Between Projects:	Set up sub projects and links.

The Project Menu
This menu is for retrieving information on the project and its components. Some of the options launch sub menus. The commands are fairly self-explanatory and will become clearer later in this course.

There are also the usual Window and Help options.

You will find that the menu choices may change depending on the view selected. If this happens it simply means that the option you wanted is not available for that view.

MS Project - The Tool Bars
The Buttons provide quick access to some of the commands available from the pull down menus. The default arrangement of the toolbars is the Standard and Formatting bars active.

The formatting bar is virtually identical to the same thing in other Office applications, except it has the Outline tools attached to it. These tools are for promoting and demoting tasks, Collapsing and expanding sub tasks plus the usual Text format and alignment buttons.

The **Standard** toolbar contains the following buttons:

It is not necessary to complete all the fields at entry time, as more information is added so the system will update the boxes. It is only necessary to enter the data that has been determined in the design stage.

☞ **To enter task descriptions and durations one cell at a time:**

- In the Task Name column, select the first available cell and type the name of the task.

- Press **TAB**

- In the Duration column, type the value of the duration. If the duration is anything other than days, type **m** for minutes, **h** for hours, or **w** for weeks.

- Press **ENTER**

- Press **LEFT ARROW** to return to the Task Name column and repeat steps 1 through 4 as required.

☞ **To enter task descriptions and durations by selecting a range:**

- Select the first cell (the numbered cell) of the desired range.

- Drag the mouse through the range of cells you want to include.

- In the first cell, type the desired information.

- Press **TAB**

- In the Duration column, type the appropriate information.

- Repeat steps 4 and 5 as required.

Note: Pressing **SHIFT+TAB** moves to the previous cell without deselecting the range. Clicking your mouse inside or outside the range will deselect the range.