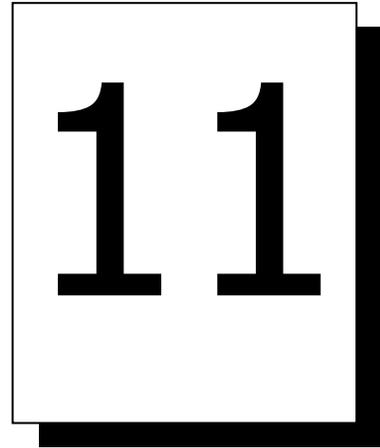


PROJECT MANAGEMENT



Unit Introduction

It takes lots of effort and planning to set up an organization. However once it is set into place and all the activities are fine-tuned the activities become repetitive in nature. Every day each worker and each executive have to carry out the same set of tasks. It applies both to the floor level worker and also those who manage the business. Now and then, in all organizations, certain tasks arise which the organization has never done before, nor are they equipped to deal with it. Such as buying an expensive automatic machine, moving to a new location, construction of a multi-storied Head Office, introducing information technology in the organization, etc. All these activities are non-recurring in nature. In such circumstance the traditional organizations are not equipped to handle additional efforts required to implement them. Therefore projects are created which are tailor-made to handle such activities. In this manner, the traditional organizations are not disturbed, and are allowed to do what they are good at doing. Project activities are one-time tasks. Therefore an understanding of the activities, their sequence of occurrence, and their need for resources is of paramount importance to the project planner. Project work must be planned and organized by methods that are completely different from those used for planning line organization. Hence this unit will discuss the functions and characteristics of project, its planning and control system including the project management tools.

Lesson One: Introduction to Project Management

Lesson objectives

After completing this lesson you will be able to:

- List the characteristics of a project
- Explain the concept of project management
- Discuss the function of project management
- Describe the pitfalls in implementing a project

Projects are unique in nature. They contain tasks that are non-recurring. In most cases, they have never been done before and may not be done again. Each of the tasks involve many people in the organization, yet it does not belong to any particular place in the organization. Therefore a project has been defined as a temporary process undertaken to create one or a few unit of a unique product or service whose attributes are progressively elaborated¹. This definition which is the most recent attempt to answer the questions of what to do? How to do it? How much will it cost? How long will it take? What are the resources required?

Project tasks are non-recurring i.e., they have never been done before or may not be done again.

Characteristics of Project

Projects are unique undertakings with a single objective, composed of numerous tasks, involve multiple of resources borrowed from various sources, have time and cost constraints. Given below (Table 11.1.1) is detailed explanation of the basic characteristics of a project.

Table 11.1.1: Characteristics of a project

a. Tasks	Multiple tasks called activities, unique and non-repetitive
b. Goal	Single main objective
c. Resource	Need to use variety of resources borrowed from the main organization
d. Time & Cost	Time is generally of prime importance and budget is low

(a) Tasks: Projects are composed of tasks, also called activities. They are non-repetitive in nature, operating on an interrelated set of items that inherently have technologically determined relationships. One activity must be completed before another can begin. Generally, these technological relationships are very difficult to break, or it does not make economic sense to violet them. Because of its uniqueness and non-repetitive nature the concerned organization may not have previous experience regarding how to carry out the activities. If the activity has to be carried out repetitively, over a long period of time, the option available is to give training to the people to be assigned to the project. The alternative available is to hire temporary workers from the market. Most projects are of short duration, as such, hiring or training does not make sense. In most cases, organizations do with whatever expertise it has in- house.

Project activities are non-repetitive in nature.

(b) Goal: Projects generally have a single objective to achieve. Once the goal is reached, the project is disbanded. The installation of an entertainment center by a house-owner with the help of his friends is a project. So is a picnic arranged for the students of Open University. Both are projects because they have only single

Project generally has a single objective to achieve.

¹ W.R. Duncan, Toward a Revised PMBOK Document, *Project Management Journal*, Vol. XXIV, 1993.

objective to achieve. It is very important that a project is formed to achieve a specific objective. It is equally important to remember that there may be very different emphasis on process-oriented and specialist-oriented work in a project. In a project, the process-oriented elements are important.

(c) Resources: Projects involve multiple of resources, both human and non-human. Generally there is a variety of resources, each with its own technologies, skills, and traits. This leads to conflict between resources. A project manager must be skilled in managing such conflict. Most of the resources required by the project are also borrowed from the parent organization. But line managers of the parent organization are reluctant to release the resources for the project, because they themselves need the resources. They have hired a person for a particular task, if he is loaned to the project, who is to carryout the task? So is true for all other resources. Problems are intensified if the project is highly process-oriented.

(d) Time and cost: Projects have time and budget limitation. Most projects require large investment prior to enjoyment of the benefits of the project. Interest on those funds is a major reason for emphasis on time. Also, a need exists for achieving the objective of the project, otherwise the project would not have been authorized. Line organizations also have a focus on time, but since they have repetitive set of activities, even if they fail to meet deadline in any one situation, they have opportunity to make-up for their failure in subsequent periods. There is no such opportunity for the project. A project is judged on whether or not it is completed on time and within budget. Penalties are associated with failure to meet deadlines.

Projects have time & budget limitation and are judged on whether or not it is completed on time and within

Activity: Think of any project and explain whether your chosen project also requires all the characteristics that are discussed in this lesson. Justify your opinion.

A major difference between the project & classical management is, in project the project manager does not staff the project but the classical manager does.

What is project management?

Project management has different meaning to different people. Quite often, people misunderstand the concept because they have ongoing projects where they apply the classical management concepts without any visible effect on the objective of the project. Classical management is considered to have five functions. Such as planning, organizing, staffing, controlling, and directing. One major difference between project management and classical management is that in project management the project manager does not staff the project. In most cases the staffing function is the domain of the line manager of the parent organization.

The project manager can only request for certain resources, but the final decision rests with the line manager of the concerned department. Another major difference is that the project manager has the added responsibility of integrating resources received from different departments into the project. It is one of the major problems faced by project manager. Specialists from different background have different attitudes and view the project objective from different perspectives. Project manager has to mold their views and attitudes to fit the organizational culture of the project. Finally, projects have very short life in comparison to the parent organization.

Functions of project management

Project Management Institute (PMI) has identified nine project management functions². The list of functions were created to,

- Set boundaries of project management profession,
- Identify the responsibilities of project managers,
- Define the skills required by the project manager.

Although PMI have categorized different functional areas of project management they are in fact interdigitated to a great degree. For example, when a project manager is scope managing he is also dealing with the issues of human resource as well as time. A short description of the functions is given below. These nine functions are:

- i. *Project integration management:* Project manager has to coordinate various processes and resources of the project. These processes are project plan development, project plan execution, and overall control. He also has to use different sources in the parent organization for project resources. He has to coordinate between project requirement and the line manager's willingness to make the resource available.
- ii. *Scope management:* Projects are created to achieve a specific objective. But during the life of the project people tend to change the scope of the project. This gives rise to scope management. Manager of the project is responsible to ensure that the objective of the project does not get distorted. At the same time the project should not take up more responsibilities than what is required to achieve the objective.
- iii. *Quality management:* For the products of a project to be considered satisfactory, certain standards of quality must be predetermined so the project manager knows in advance what he is to achieve. This leads to the need for quality management.
- iv. *Time management:* Projects have short life. Therefore, the manager has to plan very carefully to ensure that all the required activities are completed within the given time. They also have to develop effective monitoring system so that the manager can control the start and end of activities.
- v. *Cost management:* Use of resources cost money. It does not matter whether the resource is purchased or borrowed for the project, someone has to pay for the use of the resources. The project manager has to operate within budget.
- vi. *Risk management:* Outcome of the projects are always uncertain. Throughout its life cycle, the project passes through rapidly changing conditions that influences its activities, resource availability, its progress, etc. The project manager has to take steps to mitigate the possibility of the project failing to achieve its objective.
- vii. *Human resource management:* Projects consists of people borrowed from different departments of the parent organization. Their number, their skill level, their attitude towards the project, their working habit all vary because of their different orientations. It is the responsibility of the

Project manager has to coordinate between project requirement and the line manager's willingness to make the resource available.

² PMI Standards Committee, *A Guide to the Project Management Body of Knowledge*, Project Management Institute, Upper Darby, 1996.

project manager that the temporary team members interact among themselves, are motivated to work for the project, and have clear understanding of their role and responsibilities.

Project managers should have clear idea of the organization's hiring and firing policies.

viii. *Contract/Procurement management:* As stated previously, most of the resources of the project are acquired internally from the parent organization. But for the success of the project certain resources have to be hired or purchased from the external market. The project manager should have clear idea as to the organization's hiring and firing policies. He should also have good understanding about material or equipment procurement methods of the organization.

ix. *Communication management:* Explaining the plan, implementing the plan, collecting information about the progress of the project, obtaining feedback from the personnel involved in the project, informing the authority as to the status of the project, all of these falls under the purview of communication management.

Activity: What are the basic functional differences between project management and traditional management? Discuss your opinion.

Pitfalls in Project Management

There are several preconditions for the success of the project. The pitfalls can be grouped into the following headings:

1. Conceptualizing a project
2. Planning a project
3. Organizing a project
4. Controlling a project

Project fails because of lack of support from the parent organization or when objectives are not properly defined.

(1) Conceptualizing a Project: A project is undertaken, because the organization feels the need for a change, or a client has entrusted it with a set of tasks with a specific object to achieve. Relationship and understanding between the managers of parent and project organization is of utmost importance. In addition, if the project's goals or objectives are not properly defined, again the project will suffer. Thus a project fails because of (i) lack of support for it from the parent organization, or (ii) the goals or objectives are not properly defined.

i. *Insufficient support:* Project's goal should be in support of the main objective of the parent organization and project's activities should fit into the overall plans of the organization. Unfortunately, projects are viewed as threat to the authorities and responsibilities of the staff of the parent organization. For this reason, the projects are slowly choked to death by providing less and less of resources. Decisions are delayed, further hampering the activities of the project.

ii. *Goals and Policies:* At the very on-set of a project, the goals and policies of the project should be clearly defined. Valuable project times are lost because of the failure to ensure properly defined responsibilities and authorities of the staff in the project. An well defined policy and principle can create the desired hierarchy of authority and responsibilities. Without these there would be no harmony and project efficiency drops. In addition, if the goal is not properly defined, the

Without any harmony among various units of the organization the efficiency of project drops.

project would end up solving the wrong problem, or the project members would waste time in doing things those are not their responsibility.

(2) Planning of a Project: Planning implies what to do, how to do, when to do, and who is to do it. Planning means to recognize a problem, identify a set of alternatives, select an alternative and apply the alternative to solve the problem. Pitfalls in planning are in the area of level of planning, tolls of planning, plan range, and estimate of resources and cost.

- i. *Plan level:* Selection of plan level is very important for a project. Too broad a plan identifies the objectives of the project, but fails on detail. Too narrow a plan provides details of activities but fails to identify the objective of the project. Most project managers tend to plan activity by activity. While implementing such plan, the manager very often realizes that many of the activities are redundant, while others are over- or under-estimated. These leads to the manager sucked in the spiral of planning and replanning. In the process, the project may deviate from its original objective.
- ii. *Planning tools:* Planning tools are unwielding. PERT and CPM are two such tools used in project planning. The network drawing resulting from such tools may contain thousands of activities criss-crossing each other. These tools hamper communication rather than enhance it.
- iii. *Planning range:* In projects too much emphasis is given to activity completion time. Projects have to meet deadlines. A manager's efficiency is judged by his ability to ensure all activities are completed on time. But to the project members the activity completion time lies far into the future, thus they tend to fill time doing unnecessary works.
- iv. *Cost Estimate:* Because of over optimism or lack of understanding, the cost of the project is always under estimated. Or in order to sell the idea of the project, the promoters intentionally suppress the actual cost of the project. This invariably leads to cost over runs, which is not appreciated by the project sponsors.
- v. *Resource Estimate:* Most project managers plan use of resources often based on ideal circumstances. However, projects are undertaken to solve specific problem within a specific time. In addition, the knowledge of the staff, their availability and their devotion to the project are not ideal. Resources are borrowed from the parent organization where they themselves need the use of the resources. In most cases, they are shared rather than given up to the project for a full time. The line manager of the parent organization expects them to work in their original task in addition help in the project. While planning for a project most managers fail to recognize this problem.

For success of a project available resources should be used full time basis, not casually.

(3) Project organization: Activities of a project are distinct and separate from that of its parent organization. For this reason, a project should not be contained within an existing structure. If possible, it should be separated from the parent organization and given a formal structure. Many organizations fail to give a formal organizational structure to their projects. Even if a project is given a formal structure it suffers from the following pitfalls:

A project should have an independent and formal structure.

- i. *Inappropriate structure:* Most projects end up with identical structure as that of its parent organization. The traditional hierarchical bureaucratic structure, with steering committees and project managers, are best suited for long term technical projects like construction of bridges. But most projects are of short duration and involve process changes. Task-oriented matrix structure is most suited for this type of projects.
- ii. *Distribution of responsibility:* Authorities and responsibilities are not properly defined. With the assumption that projects are of short duration, many project managers fail to formulate a well defined boundaries of individual authorities and responsibilities. Where co-operation of team members are very essential for the success of the project, this type of ill defined boundaries lead to conflict and non-cooperation among the team members.
- iii. *Non-availability of key resources:* Most of the resources, like human resource, equipment and materials are generally provided by the parent organization. But the parent organizations do not have surplus of these resources and whatever resources they have they expect to use them. In most cases they are reluctant to release the resources for the project. Even if they do release the resources they expect the resources to keep on carryout their regular responsibilities in addition to the project activities.
- iv. *Project managers are technocrats:* Majority of the project managers are not suitable for the job for which they are selected. They are generally technocrats and not managers. They are good at the technical aspects of the project but with poor leadership quality. Project managers spend more time on the technical aspects of the project, neglecting their managerial responsibilities. Project managers should be selected on the basis of their leadership qualities and not on the merit of their technical skills.

Project manager should be selected on the basis of leadership qualities but not on the merit of his technical skills.

Without an appropriate control mechanism the project is bound to fail.

(4) Project control: Planning of a project and creating appropriate structure for the project are two important steps of project management. However, without an appropriate control mechanism the project is bound to fail. Control contributes to communication between different components of a project. It identifies variances between progress and plan. It provides methods to eliminate variations. The following can create pitfalls in controlling.

- i. *Purpose of control:* The main purpose of project control is to monitor progress, report any deviation, identify reasons for deviations, and take corrective steps so that the project is completed on time.
- ii. *Formalized communication:* Communication between manager and staff of the project should occur formally and at regular intervals. Contact should occur at set times, with a predefined agenda. If not, the staff loose respect for the review process and control become ineffective.
- iii. *Integrating plans and progress report:* Project plans should contain specific schedules as to when progress reports should be produced and evaluated. It should also specify the major contents of the report. Otherwise, progress reports become meaningless and has no relevance to project control. Ideal plan invite control and provides information to project manager to enable him to evaluate the progress of the project.

- iv. *Responsibilities and authorities:* Project managers should have the same formal authority as that of the line manager of the parent organization from whom he receives the resources of the project. Otherwise, the project manager, as subordinate, will be burdened with the responsibility of achieving the project goal without the authority to command the resources that he needs to borrow. Most projects are managed by people without charisma and as such will not be able to derive authority through their personality. They are dependent on positional power. Thus, their authority to control the project must be reflected in the organizational structure of the project.

Discussion questions

1. Define a project.
2. Describe the major characteristics of a project.
3. Explain, in brief, the functions of a project manager.
4. What do you mean by project management?
5. What are the different pitfalls in implementing a project?

Lesson Two: Project Planning and Organization

Lesson objectives

After completing this lesson you will be able to:

- Explain the different aspects of project plan
- Describe the procedure of project planning
- Discuss different types of organizations structures for project
- Identify the factors influencing specific organizational structure

What is Planning?

Projects are generally of short duration. However long duration projects are not uncommon. The activities involved in the project are not similar to those that people are used to doing in their regular jobs. Further project resources are limited and in most case loaned from the parent organization; deadlines have to be met and costs have to be kept down. Project planning can be defined as "the process of developing, in detail, all of the project criteria in accordance with the specific sequence. The planning is performed to the point that all work to be accomplished is readily identifiable to the team members and the customers."³

A well planned project proceeds more smoothly and succeeds more often than one that is not well planned. In addition, the project staffs function more effectively in a planned environment. Another good reason for planning is to create the ability to identify- *what went right and what went wrong* in terms of original plan. Without a plan the manager cannot evaluate the performance of the team members. Some of the reasons in support of planning a project are:

- *To obtain better understanding of the objectives of the project* - if the objective of the project is not clearly defined, the project may get burdened with tasks that may not have any relevance to the reason for which the project was created in the very first place.
- *To eliminate or reduce uncertainty and risk* - projects are carried out with borrowed resources and have time and cost restriction. Unless properly planned there would always be the risk of failing to meet the deadline.
- *To improve efficiency of operations* - well defined authority and responsibility without fighting for group/self interest increases efficiency of work.
- *To define work scope and responsibilities* - people should know what is expected of them and the areas where they have authority and responsibility.
- *To provide basis for monitoring work* - the project manager should have means to measure performances and demand compliance with the scope of work.

Well planned project works more smoothly and succeeds more often than one that is not well planned.

Activity: Is there any differences between organization planning and project planning? Justify your opinion logically.

³ Timothy J. Havranek, *Modern Project Management Techniques for the Environmental Remediation Industry*, St. Lucie Press, 1999.

Planning Procedure

Preparation of project plan is a straightforward and simple approach designed to combine two plans: the objective of the project and the methods of achieving the objective. A typical project plan includes the following steps:

1. Determine the mission of the project
2. Identify the goals and the objectives
3. Assess the need for segmentation
4. Plan for the events
5. Plan for the activities
6. Evaluate the plan

1. **Project mission:** Project mission is very important. The mission statement is all encompassing, establishing why the project is undertaken. Mission statements can be general or specific. However a project mission should not be considered as fixed, if required, it should be changeable. With change in circumstances it may be expanded, narrowed down or even dropped.
2. **Project objectives and goals:** Project objectives are outlined as specific goals to be accomplished. Planning becomes straightforward when the objectives are defined for key areas. Objectives can be established for every aspects of the project, for example, recruitment scope of worker, organization, procurement, management, etc.
3. **Need for segmentation:** Before creating a detail plan of the project, it is beneficial to ascertain whether the project should be divided into small sub-projects. When the project is of long duration and large in scope, and when certain set of activities can be done independently, it makes managerial sense to breakup the project into small sub-projects. It is much easier to manage small projects, with definite objectives, than a large project with multiple of objectives. Another reason for dividing a project into sub-projects is that it is not always possible to plan for a large project. Sub-projects are easier to plan in detail. But it is necessary to ensure that each sub-project has definite goal to achieve that directly contributes to the main goal of the bigger project.
4. **Event planning:** Once the objectives of the project has been defined and decision taken regarding whether to segment or not to segment the project, the next logical step is to plan for the events. Events are points in time when the project is to accomplish certain sub-objectives of the project. It is the points in time when the project would have accomplished certain objective that the monitoring team can evaluate for progress of the project. Events are logical conclusion of phases of sub-projects at desired point in time. Events describe within a particular time period what the project should achieve not how to achieve it.

Events are logical conclusion of phases of sub-projects at desired point in time.

Planners should first identify the events and then focus on the activity.

Events can be viewed as an outcome of some action or being at a stage at a certain time. For example, reaching office is an event, so is leaving office for home. Reaching office is the focus here, not how you reached the office. A person can reach office by using different modes of transport, like rickshaw, baby-taxi, taxicab, bus, or own car. But did he reach office in time

is more important, at this stage, than how he reached office. Thus, events indicate the achievement without describing the means of achieving. Most planners are activity focused and are not accustomed in thinking in terms of events. But planners should first identify the events and then focus on the activity. An event can be reached through multiple ways, and events should dictate the alternative, not the other way round.

Event planning is nothing but a plan showing the relationship between different events. To reach a specific event, all its preceding events have to be completed. For example, you cannot expect to end your journey, when you have not yet started your journey. End of journey event is dependent on the start of journey event. In order to reach an event, a series of activities has to be carried out. An event cannot occur until its previous events have been achieved. But this does not mean that all activities associated with a particular event are dependent on completion of a previous event. Activities of a succeeding event can start before that particular event has occurred. For example, the tabulator of final result of MBA examination of Open University can start preparing the result much ahead of submission of all the grades. Of course, announcement of the final result is dependent on submission of all grades.

An event cannot occur until its previous events have been achieved.

It may sometimes be the case that works on the next event cannot begin before the previous one has been reached. This is true when the activities of the succeeding events have to draw on the results of the preceding events. In such situation, the activities of the succeeding events have to wait for the completion of the preceding event. But it is essential to remember, though succeeding activities can start before the completion of previous events, no succeeding event can occur before its preceding event. A good event plan should contain the following:

- A detailed description of each event to be achieved,
- The condition, in terms of time and resource, necessary to achieve the event,
- Important decision-making points should be represented as events, and
- Events should be controllable.

It is desirable that the events have physical entity or concept easily understandable. For example, end of a lecture, beginning of a course is easily understandable. But the amount of knowledge imparted in a lecture or the amount of knowledge acquired during a course cannot be conceptualized so easily. So it is important that an event is described in such a way so that it is easy to ascertain its existence when it is reached.

Successful occurrence of an event implies successful completion of a phase of a project. For this reason, formulation of event plan should contain both a description of the desired situation and the description of the condition attached to achieve that event. This enables the manager to monitor the result and ascertain the quality of work.

5. **Activity Planning:** Activity planning follows event planning. Once the different checkpoints in the form of events have been identified, the logical

Activity plan describes how each event are to be accomplished within a given time and resource.

next step is to device means of reaching them. Activity plan describes how each event are to be accomplished within a given time and resource. It is more a micro level planning. Activity planning can be divided into the following four stages:

- i. *Identify all activities that must be performed to reach each event:* Each event is planned separately. At this stage all the activities that are required to reach a particular event are identified. Each activity is defined in term of the nature of work involved. Care should be taken to ensure that the activities fit into the time frame of the event.
- ii. *Identify all the resources required for each of the activities:* Activities are to be carried out by people, so a plan stating which activity is to be carried out by which person is very important. The parent organization, generally, provides most of the human and non-human resources for the project, so the responsibility chart showing who is to do what should have the approval of the parent organization. This would ensure that the project has the right person and right resources at the right time.
- iii. *Estimate the work input necessary for each activity:* After the resource persons have been identified and their responsibilities established, the amount of resources required is estimated. The project manager and the respective resource persons jointly decide the amount of inputs required. Resource requirement is expressed in term of man-hour, man-day or man-month.
- iv. *Put the work input of each activity into calendar time:* The last step is to relate all activities against calendar time. While doing so the preceding and succeeding relationship of the activities should be taken into consideration. The project manager should decide when each activity is to start and, based on the work content, decide when it is to end. Commonly used tools for scheduling activities are PERT and CPM. Time-scaled bar chart is also used. But since most of the resources are borrowed from the parent organization, the opinion of the line manager and also the concerned resource person should also be taken into consideration.

The project manager should decide when each activity is to start and, based on the work content, decide when it is to end.

When assigning activity to calendar time, the planner should identify the critical activities. Critical activities are such activities which, if delayed for any reason, would result in delay of the whole project. Identifying critical activities is important because the project manager needs to develop control mechanisms to ensure that the project does not get delayed. The project manager has to keep tight and effect control over the critical activities. It is also important because managers need to avoid assigning critical activities to persons who already have heavy workload or who will not be able to give full time effort to the project. In other words, he needs to ensure that right type of resources are assigned to all the critical activities.

Activity: Explain logically - in what ways the project planning differ from the activity planning.

6. **Evaluate the plan:** Once the draft project plan has been developed, it is necessary to carryout comprehensive evaluation of it. The first step is to

check whether the scope of the plan is balanced or not. The total plan should have the same level of detail. Planners do have the tendency to develop detail of the first part of the plan, and since they are uncertain about the later part of the plan they tend to propose a rough and fuzzy actions for it. This practice should be avoided. Next the event plan should be checked against expected results. Their logical construction must be checked, preferably by those who did not plan the project. Lastly, all activities of events should be evaluated for their necessity, resource requirements, time requirements, and feasibility. Critical activities should get special attention, because any delay of any of them would invariably lead to delay of the project.

At every level the total plan should be explained in detail.

Project Organization

Projects are often undertaken by organizations for a specific objective. In addition, projects have a specific narrow goal to achieve within a given time and resource. Project does not have any scope to amend mistakes, if any arises. The problems that a project manager faces are:

- What should be the structure of the project?
- Where should the project be positioned in respect to the existing structure?
- How much authority and autonomy be given to the project manager?
- What management practices should be used in the project?

The nature of a project structure depends on two opposing forces - the *push and pull* factors. The push factors favor an independent organization structure for the project, whereas, the pull factors prefer the project as an integral part of the sponsoring organization. There are reasons in support of both the views.

Push for Distinct Entity

A project that is separate from its parent organization has high chance of success. Among the several factors contributing to the success of a project with a separate and distinct entity the followings are some of the reasons for its success:

- *Low dependency on parent organization:* Projects with distinct entity have low dependency on the parent organization for its resources and manpower. Most projects have to share resources with its parent organization. In most cases the resources are expected to work in the project and also carryout their regular work in the parent organization. But a project completely separate and located away from its parent organization, simply because of logistic problem, do not have to share the resource, and have full authority over the period for which the resource is assigned to it.
- *Visible and measurable results:* Projects separated from the parent organization can produce results that are distinct and visible. This draws attention of the upper management. But the same outcome of a project that is part of the parent organization blends with the overall results of the organization and as such does not attract attention.
- *Less loss of priorities:* Independent projects suffer less over priorities. All projects have set goals and priorities, but projects integrated with the parent organization have to fight and overcome resistance from the line managers. Line managers feel projects as threats to their authority and attempts to undermine its efforts. They feel that what the project has been

An independent project has high chance of success.

Projects with distinct entity do not have to waste time on interfacing and coordinating with the parent organization.

entrusted to do, they can do it better. But instead of entrusting them with solving the problem creating a project implies the upper management does not have faith in their ability.

- *Time wasted in interfacing:* Projects with distinct entity do not have to waste time on interfacing and coordinating with the parent organization. Since the resources are borrowed from the parent organization, the project manager has to coordinate their availability, which is less cumbersome for managers of distinct entity. Once the resource is released for the project, it stays with the project till it is returned. But in an integrated project they do not borrow but share resources, as such co-ordination is much harder.
- *Amenable to direct control:* From the point of view of upper management, creating a distinct unit for a project has the advantage of making the project more visible and more amenable to direct control. Whereas, projects that blends with the existing structure are more in control of line managers and the upper managers have less formal authority to interfere.
- *Organizational culture:* Projects with distinct entity have the advantage of not being influenced by the existing culture of the parent organization. All organizations have a distinct work culture, which generally is not suitable for high pressure project works. In addition, these organizations have suppressed power struggle and conflicts, making it harder for the project manager to reduce project risks.

Pull for integration

Many line managers do not like the idea of an independent organization for a project and would prefer it to be contained within the existing structure. There are many arguments in support of this idea, and some of them are:

- *Economy of separate organization:* Distinct entity for a project in most cases is not supported on economic ground. Because of the nature of work, resources deputed to a project ends up under utilized. Whereas, the same resource may be in short supply in the main organization.
- *Jurisdiction of objectives and goals:* Many line managers feel that the project objective and activities falls within their jurisdiction, and as such, should be part of their department. But if a separate organization is created for the project, they feel penalized and resent the idea of loaning their best resources to the project. They create pressure to have the project integrated into their existing structure.
- *Temporary nature of project:* Because of the temporary nature of the project many resource persons ear-marked for the project resist transfer to the project. They fear loss of influence and continuity in their present status and perceived risk in reintegrating into their regular jobs.
- *Upper management over burdened with too many projects:* When there are large number of independent projects the upper management may become over-burdened with the task of monitoring and controlling them. In such situation, the upper management would be more motivated toward integrated projects, so that the line managers can supervise them.
- *Culture of organization:* Resistance to autonomous projects can also arise out of socio-cultural context of an organization. These are more subtle and difficult to change. Autonomous projects generally have distinct behavioral

pattern that differs greatly from that of the parent organization. Line managers do not like to contaminate the behavioral pattern of their best resources, by loaning them to project works.

In addition to the above mentioned factors, there are many more factors that contribute to the nature for organizational structure of a project. These additional factors are grouped into:

- Type of organizational structure available
- Organizational factors
- Project factors

The choice of an organizational structure for a project depends on this group of factors and the relationship between them. In the following section, we describe the factors in more detail.

Activity: Think of any project and contrast and critically evaluate between pull and push factors of project organization in your project.

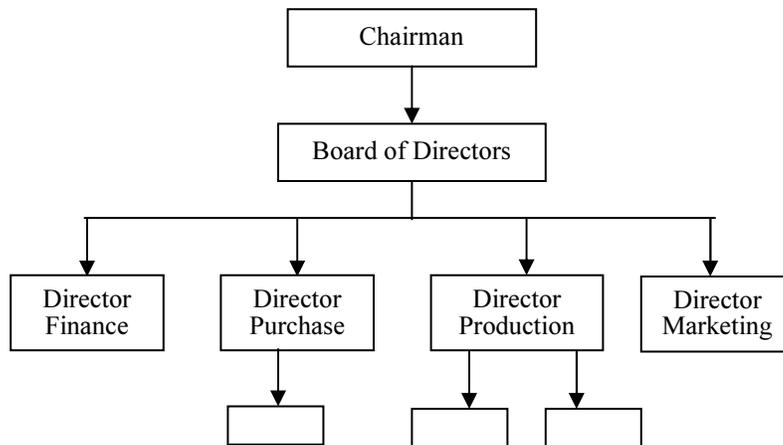
Type of Organization Structure

Organizations are complex system. There are many different types of organizational structures to chose from. Here we will describe three of the most common organizational structure, appropriate for projects:

- a) Functional structure
- b) Matrix structure
- c) Team structure

a) Functional structure: Functional structure is most common organizational structure. When works or activities are segregated according to specialization or nature of work, we call it functional structure. Most traditional organizations are functional, where we find activities grouped together according to the nature of work, like all accounts activities are carried in the Accounts Department, similarly, all production activities are done by the Production Department, etc.

Functional structure is pyramid shaped and are built on both vertical and hierarchical concept of authority.



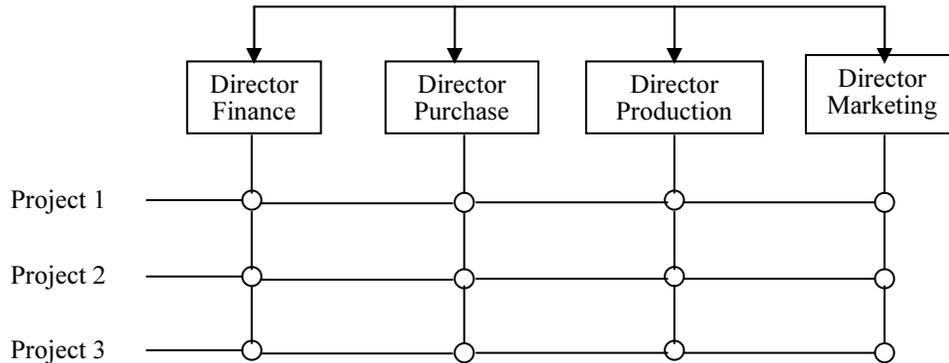
A typical functional structure

It is believed that people with same specialization, if grouped together under a single boss, can stimulate each other and efficiently achieve the objective of the organization. Functional organizations have a pyramid shape and are built on a vertical and hierarchical concept of authority. Each employee has a single boss, each has a well defined responsibility and authority, and flow of communication is vertical. These characteristics of a functional organization facilitate control and long term planning.

At times projects are integrated into the existing functional organization or independent organizations are created for the project with all the characteristics of a functional structure. Independent organization with functional structure is suited only for long term technical projects, like building bridges or dams. Projects integrated within existing functional structure frequently suffer from lack of priority in resource allocation. It also loses out in term of clarity of objective, inter-functional competition and internal power play.

Matrix structure consists of different functional areas that work independently but they cooperate in the accomplishment of the project objective.

b) Matrix structure: A matrix structure seeks to take advantage of a traditional structure without its disadvantages. A typical matrix organization consists of an independent project manager who has total authority over the objective of the project but borrows resources from different functional areas of the parent organization. It is a relationship of cooperation and interdependence. The matrix structure consists of different functional areas that work independently but they cooperate in the accomplishment of the project objective. In general, the specialists of each functional area of the project are under the authority of their respective supervisors in the parent organization. But when required by the project, they come temporarily under the supervision of the project manager. The project manager supervises a multidisciplinary team. The team size and composition changes with the change in the project requirement.



Matrix structure

A matrix organization has to cooperate and coordinate its activities with the parent organization. The two must collaborate if the project is to succeed. A project manager is responsible for, attaining the objective, delivery on time, minimize project cost, and liaison with the clients. Further the parent organization provides, all type of resources, technical know-how, back-up support, hiring and training, and monitor and evaluate the project performance.

c) Team structure: When the project is of short duration, small in size and requires creativity, team approach to organizational structure is very common.

Recruitment into the project teams is informal, as is reporting relationship. A project manager or team leader recruits the resources that the project needs to form the team both from the parent organization and from external sources.

A team differs from the more typical *working group* because:

- The members of the team have a common commitment and believe that transcends individual priorities.
- The leadership role is shared and rotated rather than held by a single individual.
- Open-ended discussion, rather than managed agenda are the norm.
- Performance of the whole team as a single unit is evaluated, that reflect the joint efforts of all members of the team.

Activity: Do you think without any structure it is possible for a project to continue its success? Discuss your opinion.

Choice of a Structure

Selection of an organizational structure for a project depends on the degree of autonomy given to the project manager. The degree of autonomy can vary between zero to full autonomy. If no autonomy is given then the project has to be totally integrated into the existing structure. On the other hand, full autonomy leads to a distinct and separate organization for the project. The following steps should be followed in determining appropriate project structure:

- The existing organizational structure should be evaluated for its ability and work load
- The decision maker should evaluate all the organizational factors
- The decision maker should also evaluate all the project factors
- Based on the evaluations determine the degree of autonomy to give to the project
- Based on the desired degree of autonomy, decide whether to create separate entity or integrated structure
- Select the appropriate organizational structure for the project.

By following these steps, upper management can evaluate complex situations to arrive at an appropriate structure. In addition to these steps, the selection should also depend on:

- i. Availability of right person to act as project manager,
- ii. Role and status offered to the project manager,
- iii. Degree of control over resources given to the project manager,
- iv. Degree of control given to the manager over the content of the project, and
- v. The degree of operational autonomy given to him.

Implementing an appropriate level of autonomy for a project requires the upper management to make decision on each of these factors.

Selection of structure for a project depends on the degree of autonomy given to the project manager.

Discussion questions

1. Define the term Planning, and justify what aspects should be taken into consideration while planning for a project.
2. Describe, in brief, the different steps in project planning process.
3. What are the factors favoring a separate organizational structures of a project?
4. Explain the factors favoring project as an integral part of the sponsoring organization.
5. Describe, in brief, different organizational structure appropriate for a project.
6. Explain what do you mean by matrix structure.
7. Describe the different organizational factors influencing the choice of a project structure.
8. Describe the project factors that contribute to the type of a project.
9. Assume that your office have decided to computerize the whole working system. What type of organizational structure would you propose. Why?

Lesson Three:

Project Control

Lesson objectives

After completing this lesson you will be able to:

- Explain the principles of project control
- Describe the procedure of project control strategies

The term control has different meaning to different people. Project control means monitoring progress of the activities, at predetermined point in time, report on the progress and take corrective steps, if needed, and while there is time to take those steps. *Monitoring* means checking the output of the project against the planned and desired output. *Reporting* is describing what has occurred and what the situation is. *Control* involves analyzing the situation, deciding what to do and finally doing it. Control is the crux of project management. Without it the manager cannot evaluate the progress of the project and would not know whether any corrective measures are required or not. It is not a good thing if a project is off schedule and no one is aware of it. Nor is it desirable to know of the fact when it is too late to do anything about it. Project plans provide mechanism called control that keeps track of what is happening in the project and if any deviation occurs it is detected at an early stage so corrective measures can be taken on time.

Control report should be followed by discussion between the concerned parties.

Principles of Control

Good plans provide the genesis of control mechanism. Thus, plans of the project should be consulted in developing the control methods. In addition, it should adhere to the following three principles:

- Reporting should be according to prescribed method
 - Criteria of measurement should be defined before the project starts, and
 - Reporting should relate to the plan.
- *Reporting should be according to prescribed method:* Good reporting is very essential for the success of control. Reporting should be done according to a set pattern. This means that it should be prepared according to a prescribed format and submitted at fixed intervals. In no way should there be any deviation as to the time of submission. Otherwise, people will tend to neglect its submission. Report on activity should be done more frequently than on events. Events have a longer time horizon than activities as such, reports on it can be less frequent. In general, a report should be prepared every time an event is to occur.

Whatever the frequency of reporting, it should be structured in such a manner that it can quickly and easily detect variances between the actual output and planned output. Early detection of variance is essential to ensure quick and cheap remedies. Too long a delay in detecting variances makes it expensive to correct the errors. Many project managers prefer exception reporting only. It means they report progress of the project only if they detect variances. This approach should be avoided, because reporting is a means of communication. It enables managers to know what is happening in the project. Managers do

Reporting should be structured so that it can quickly and easily detect variances between actual and the planned output.

not only want to know what is going wrong, rather they would also like to know how satisfactory the progress is.

Report should be followed by discussion between the concerned parties.

- *Criteria of measurement should be defined ahead of start of the project:* Control methods and criteria should be defined before the start of the project. Subjects that should be part of the report should be identified and the methods to measure them should be established in advance. It is important to make reporting as simple as possible. In many situations only a *Yes* or a *No* is sufficient. If elaboration is desired, it should be done in a supplementary section of the report. It is preferable that no free text be allowed in the main report, otherwise, the report becomes trivial. Report should be followed by discussion between the concerned parties. As reports should only focus on pre-determined criteria, so should the discussion. The discussion should be directed towards finding out the causes of variance, if any, and identifying actions to put back the project on track.
- *Reporting should relate to plan:* It is important that the report relates directly to the plan. Many propose that the report should be done on forms that also show the actual plan. In this manner, each time a report is submitted the evaluator can easily relate the progress against the plan. Reporting along with the plan also has the advantage of the right person receiving the report and has the authority to do something about the recommendation of the report.

Control of Activities

Activities are the driving forces of any project.

Activities are the driving forces of any project. They not only consume resources and time, but also contribute to the progress of the project. Activity plans are generally drawn up and documented on the responsibility chart. Following the principles of control, progress report is presented on the chart. Figure below shows a typical responsibility chart.

Weeks →									Job Description	Responsible Personnel				Comments
1	2	3	4	5	6	7	8	9						
	■	■	■	■					Plan for the project	RK	AJ			
	■	■		■	■	■	■		Collect resources for the project	AK	LR	DB		
		■	■		■	■	■		Transport material to site	BB	AR			
			■	■		■	■		Oxygenate the lake	JA	MM	KA	DB	
						■	■		Landscape the lake	KL	LA	CA	AN	

Employee Responsibility Chart

For activities the following areas are important to control:

1. Use of resources
 2. Start and end of activities
 3. Quality of work, and
 4. Responsibility Chart.
1. **Use of Resources:** All activities use resources. Resources can be experts, space, furniture, computer time, or even raw materials. These resources are scarce therefore monitoring the use of resources is very important. While

preparing report on resource usage, it is important to determine the amount of each resource used, amount required in the future and also the amount that has been allocated in the plan. To monitor the overall usage of resources a simple summary can be drawn up and compared with that of planned usage. It is important to report deviation of usage, if any, and also to identify the causes of deviation. If the deviation of usage is too frequent it implies there was serious miscalculation while planning the project. In such case, the estimation method should be re-examined and reevaluated.

It is important to determine the amount of each resource used, amount required in the future and also the amount that has been allocated in the plan.

2. **Time Schedule:** Activity time is another factor that is important and need to be monitored and controlled. The plan should contain expected completion date for each activity. If the activity is critical it is very important to ensure that the activity should start on time and completed on time, otherwise, the duration of the project would get extended, with its undesired consequences. If the schedule of the activity cannot be met, it is important to identify the reasons for the failure. Causes for failure can be many, of them, as stated previously, overrating the ability of the project members; unforeseen interruption in the work due to strikes or illness of members or natural calamity; failure of the parent organization to release resources on time; deliberate downgrading of the project activities by the line manager; poor management. Without knowing the actual cause of delay, it is not possible to work out the right solution. Causes of delay have to be identified as early as possible and appropriate corrective measures adopted.
3. **Quality of work:** Now a day quality consideration is as important as using the resources within budgeted amount and meeting deadlines. One of the frequent causes of delay in projects result from the failure to meet quality of work. This leads to repeat those activities, already done but fails quality. Therefore, there is sufficient ground for asking whether the work being carried out is of quality. Quality should always be measurable, so that the expert working in the activity knows what is expected from him and at the same time the person evaluating the work knows what to measure. Quality control presupposes that people are aware of what quality is and how to measure it. In practice the best method of ensuring quality is to select methods which one knows would give good results.
4. **Responsibility chart:** Responsibility chart is a good tool to measure the performance of the project. The chart shows in detail who is to work in which activity, what they are expected to produce and how long they are expected to work. It is therefore important to have report on whether the plan described in the responsibility chart is being followed, or whether there is any deviation.

One of the frequent causes of delays in projects results from the failure to meet quality of work.

Control of Events

Deviations at the activity level result either in delay of the project or over the budget use of resources. For these reasons, the activities need to be regulated, monitored and controlled rigorously. Continuous monitoring of the critical activities and frequent monitoring of the non-critical activities need to be carried out to ascertain any discrepancy between the plan and the actual situation. If any discrepancy is noted the causes should be identified as quickly as possible so that corrective measures can be taken before it is too late.

One responsibility of the project manager is to report on how the project is developing in relation to the event plan.

Occurrence of event depends on the success of the activities. If activities are carefully monitored and deviations avoided, events would occur as scheduled. Events are outcome of successful activities. They are sub-goals of the project. They are different check-points of the project. It is the responsibility of the project manager to report on how the project is developing in relation to the event plan. Activity plans are too detailed for understanding the project in the global sense. Event plan can be viewed as the global plan of the project. It tells whether a particular check-point has been reached but does not tell how and with what the goal was reached. Upper management is more interested in knowing whether the event has been achieved or not, but not on details. Thus event controls are carried out at long intervals and at or near the scheduled date of event occurring. There are two aspects covered in event control. These are the events and their mutual dependencies, and the other is expected completion dates of events.

- i. *Events and its dependencies:* Events play a central role in project management. Events represent different sub-goals that the project should achieve, before it can achieve the main goal. Depending on the nature of the project the sub-goals can be, for example, start of the project, laying foundation stone, hiring the right project manager, completion of piling work, etc. Events not only act as a check-points they also have important intrinsic value. It provides strong signal to the upper management as to the state of the project. It also signals the possibility of subsequent events occurring. It also signals the completion of a certain set of activities.
- ii. *Completion date:* Events are scheduled to occur at predetermined date in the future. If any event fail to occur as planned, it implies that activities prior to its occurrence are delayed, and if no corrective measures were taken, the succeeding events would also be delayed. For this reason events completion dates are important to upper management. Any variation from the anticipated completion date for an event should be reported. Equally important is clarifying the causes for its occurrence.

Discussion questions

1. What do you mean by control?
2. What are the major purposes of control?
3. Explain the basic principle of controlling.
4. In activity control what are the major factors that need to be controlled?
5. Explain what do you mean by event control.

Lesson Four: Project Management Tools

Lesson objectives

After completing this lesson you will be able to:

- Explain the important terms of project management tools
- Describe the basic steps of PERT and CPM

PERT is basically a tool for risk management and CPM is used for cost management.

In the past, most project managers had their own method of scheduling and controlling project works. In the late 50's of the last century, Du-Pont Corporation and Lockheed Corporation, independently, developed network-diagramming methods that have become standard tools of project management of scheduling and control. Du-Pont proposed the Critical Path Method (CPM) and Lockheed advocated Program Evaluation Review Technique (PERT). PERT and CPM are similar in their approach, however, two distinctions are usually made. The first relates to the way in which activity duration is estimated and the second relates to cost. PERT assumes that duration of activities are random variables that involve considerable variance, whereas, CPM assumes it to be deterministic variables. Because of the randomness of activity time, PERT concentrates on risk analysis in project completion time. The second difference between the two is that CPM allows an explicit estimate of costs in addition to time. Thus, PERT is basically a tool for risk management and CPM is used for cost management. Extension of both PERT and CPM allow the management to manage other resources in addition to time and money, to trade off resources, to analyze different types of schedules, and to balance the use of resources.

Definition of terms used in PERT and CPM

In order to explain how to use PERT and CPM in planning, organizing and control of projects, it would be helpful to explain and define some of the terms commonly used. CPM assumes that varying the quality of resources used in the project can intentionally vary activity time. The higher the quality of resource and technology used in an activity the quicker the activity can be completed but at a higher cost, and vice versa.

- i. *Activity*: The tasks that need to be carried out to achieve the objective of the project is called an activity. An activity is an effort that uses resource and takes certain amount of time for completion. It is the lowest level of work element that can be performed independent of other elements. For example, studying for MBA examination, training employees, typing reports, etc.
- ii. *Events*: Also known as milestones, refer to checkpoints in the project to recognize certain accomplishment. It is a point in time without duration. It is said to have occurred when all activities leading to it are completed, and it does not consume any resources. For example, start of an examination, end of board meeting, arrival of a new machine, etc.
- iii. *Project*: A collection of activities and events with a definite goal is a project. For example, getting an MBA degree, installing a new machine, opening a new department, building a new bridge, etc.
- iv. *Network*: When sequence of activities and events of a project with a beginning and an end is represented by a diagram it is called a network.

Network shows the relationships between the activities and events of a project in graph.

- v. *Path:* A series of adjacent activities from the start of the project to the end is called a path. A network generally contain multiple of such paths.
- vi. *Critical activities and events:* In a project some activities and events are important and some are not. These activities or events are important in the sense that if any of them get delayed for any reason it would delay the project completion time. From scheduling point of view such activities or events are called critical.
- vii. *Critical path:* Among the paths in the network one or two paths contain all the critical activities and events. These paths are called critical paths. If any of the activities or events of the critical path gets delayed, it would affect the project completion time. In term of time the critical paths in the network are the longest of the paths. The main emphasis of PERT and CPM is to identify these critical paths, so that effective monitoring and control be applied to activities on the critical path.
- viii. *Float or slack:* The non-critical activities or events are on non-critical paths that generally have shorter time duration than the critical paths. These activities or events have more time than they need to complete. The surplus time that they have is known as float or slack.

The critical paths in the network are the longest of the paths, in term of time.

Activity: Do you think there are significant differences between PERT and CPM procedure? Why or why not? Discuss your opinion logically.

The PERT and CPM Procedure

Although PERT and CPM were developed independently, they are based on the network representation of project plan. The only difference between them occurs when time and cost of the projects are estimated. Otherwise the procedure of planning and control are the same. Effective project management includes a number of steps required to ensure timely completion of project. The following steps are common for both PERT and CPM:

1. Analyze the project to define the activities and events,
 2. Sequence the activities,
 3. Estimate times and costs of activities and events,
 4. Draw the network,
 5. Analyze events and activities to find critical path, and
 6. Monitor and control.
1. **Project Analysis:** As a first step the project manager has to identify all the activities that must be performed in order to reach the objective. Project managers generally use work breakdown structure to define the activities and their scopes. A work breakdown structure is a task-oriented, project-specific group of activities broken down into manageable work packages. By using work breakdown structure the manager attempts to ensure:
 - Manageability, in that, specific responsibility can be assigned,
 - Integratability, so that the total project can be seen as the summation of the lower level activities, and

- Measurability, to be able to measure the performance against a quantifiable standard.

Each activity should be clearly defined so that clear cut responsibilities and authorities can be assigned to individual expert or team of experts.

Activity sequencing deals with the connections and interdependencies that exist within a project.

2. **Sequence the activities:** Once the content of each activity is defined in term of work breakdown structure, scope of work, and written list of assumptions, the sequence of execution is determined. Activity sequencing deals with the connections and interdependencies that exist within a project. For example, you cannot sit for an examination before enrolling for a course. Thus, sitting for an examination is dependent on enrollment. The earlier activity in a dependency relationship is called the predecessor activity and the later is called the succeeding activity. Dependency can be technical or discretionary. Technical dependency occurs as a result of the technology used or the nature of work. For example, remove cap of pen before usage. Technical dependency is also known as *hard logic* because it must be adhered to while drawing the network. Discretionary dependency is also called *soft logic* because it is not mandatory. It is an outcome of *best practices* or conventions. The network planner can alter sequence at his own discretion. For example, pay-and-ride or ride-and-pay sequence can be altered without affecting the outcome. This type of dependency is not technology dependent rather convention dependent.

3. **Estimate activity time and cost:** The next step is to estimate the time and cost required to complete each activity. Time estimate involves assessing the number of work periods required to complete each task. The work periods can be in hours, days, weeks, or months. Activity completion time is dependent on the quality of resource used, availability of resources, and proper integration of the resources into the project. To ensure a good estimation of time the following guideline should be used by the managers,

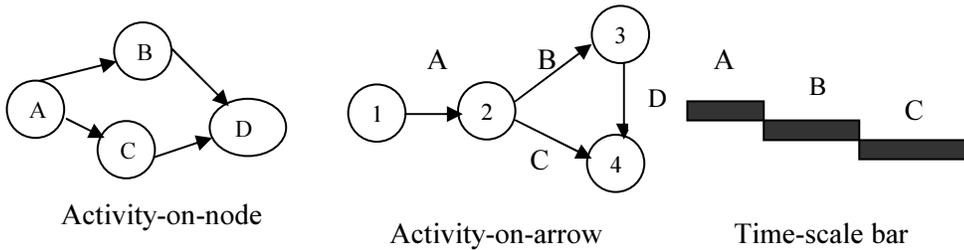
- Consult the expert or group of experts who will be responsible for the activity,
- Use consistent time units for all activities,
- Make all time estimates realistic,
- Assume normal level of work load,
- Assume a normal work day, and
- Be willing to breakup activities into smaller units (if required).

PERT and CPM estimate time differently. CPM takes a deterministic (certain) approach to activity time, whereas, PERT takes a probabilistic approach. PERT assumes that the duration of activities are unknown or cannot be estimated accurately, so uses three estimates with an averaging procedure. Cost estimates are relatively easy. Cost estimate refers to the procedure of estimating the cost of completing each activity. Once the activities have been identified, resources allocated to the activity, duration of usage determined, and then the company's rate sheets can be consulted to find the cost that would be incurred to complete the activity.

4. **Develop the network diagram:** The three most commonly used network methods are:

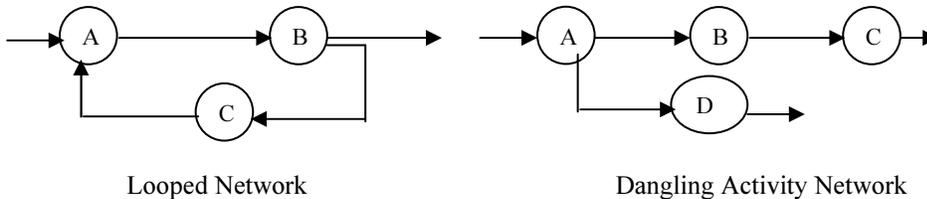
- Activity-on-node diagram,
- Activity-on-arrow diagram, and
- Time-scaled bar diagram.

The first two methods use circles and arrows to represent events and activities respectively. When the circles represent the activities and the arrows are used to show the direction of flow of time it is called activity-on-node method. When the circles represent events and arrows represent activities it is called activity-on-arrow method. Time-scaled method uses bars to represent both activity and time. The figure below shows all the three methods.



While the network is drawn, care should be taken to ensure that:

- There is no loop in the network. While drawing a network it may seem appropriate to add loop in it, but projects should never be planned in that manner. Once into the loop, one can never get out and the project would go on forever.
- There are no dangling activities or events. A dangling activity is one that has not been connected back into the network. Such activity should be connected back; otherwise, the network would have two endings.



The following steps represent the general process of construction of network diagram:

- Review all the activities and identify activities with no preceding activities. Draw a starting and an end event for the activity. Draw an arrow to connect the events. Draw the network from left to right. Give the events consecutive numbers and give the arrow its name. We will be using activity-on-arrow method. If there are more than one activity with no preceding activities, then start all these activities from the same starting event. But they should have different end events.
- Identify the activity that has just been drawn. Identify all of its succeeding activities. Draw all these activities from the end event of the preceding activity.

- Repeat the process for all of the preceding activities.
- Repeat the process till end of the network is reached. Ensure all the last activities have the same end event.

While drawing the network, it is desirable to keep to bare minimum the discretionary dependencies relationship. Always use the technical dependency relationship. If possible, it is better to use start-to-finish links to maximize concurrency. Finally be sure to link only the lowest level activity elements in the work breakdown structure.

Activity: How the network design can help a production manager in project management? Justify your opinion.

Major purposes of project planning using network diagram is to identify the critical path.

5. **Analyze the events and activities:** In any project, there is generally one sequence of activities that determine the overall duration of the project. They together take the longest time to complete. Such activities are called critical activities. The route in which they are is called critical path. One of the major purposes of project planning using network diagram is to identify the critical path. Because any delay in the start of any of the activities on the critical path would result in delay in the project completion. Also any delay in completion of one of the critical activity would delay the start of its succeeding activities. Therefore management would like to ensure that all the activities on the critical path have the right type of resources and they start on the right time and are completed on the right time. Otherwise the project is bound to get delayed. Thus the purposes of network analysis is to

- Identify activities on the critical path,
- Estimate duration of the critical path,
- Identify resources required for the critical activities,
- Identify the type of control and supervision required to monitor critical activities,
- Identify activities on the non-critical paths,
- Determine the floats or slack available for each non-critical activities, and
- Adjust (delay or hasten) start of non-critical activities in such a manner so that resource usage can be scheduled in a leveled manner.

The method of finding critical path embodies two basic sets of calculations: forward pass and backward pass calculations that are discussed below.

Forward pass is carried out to find the early start and early finish time for each activity.

- Forward pass calculation:* Forward pass calculations are carried out first. The calculations are performed from *left to right*, starting from the beginning event progressing through the network till it reaches the last event. It is carried out to find the early start and early finish time for each activity. This calculation enables the planner to schedule subsequent activities and mobilize the required resources.
- Backward pass calculation:* Backward pass calculations are carried out to find the latest time that an activity can start or finish without delaying the project. The calculations are done from *right to left*,

starting from the last event and progressing towards the beginning of the project. Forward pass calculation for the last event must be completed before backward pass calculation can begin. In order to begin backward pass calculation the earliest time of the last event is set equal to the latest finish date of the event.

Backward pass carried out to find the latest time allocable to start an activity.

Number of terms like latest finish or earliest start were used, while explaining the forward and backward pass calculations. A short description of the terms are given below:

- *Earliest Date (T_E)*: By definition the earliest date for an event to occur is immediately after all the preceding activities have been completed.
- *Latest Allowable Date (L_T)*: The latest allowable date for each event is the latest date that an event can occur without causing delay in the project completion time.
- *Earliest Start (ES)*: The earliest time that an activity can start, subject to all its preceding activities have been completed.
- *Earliest Finish (EF)*: The earliest an activity can finish, calculated by adding the activity time with the earliest start date.
- *Latest Finish (LF)*: The latest an activity can finish without delaying the project completion time.
- *Latest Start (LS)*: The latest that an activity can start calculated by subtracting the activity time from latest finish date.

6. **Monitoring and Control:** Network is drawn to identify critical path with its critical activities. It also helps to identify the non-critical activities with their floats. Based on the information provided and using the principle of management by exception, it is possible to develop a management system with very tight supervisory control over critical activities, with lesser control over activities with small floats and least control over activities with large floats. The reasoning is that delay of critical activities delays project completion so they should be monitored very strictly. Delay of non-critical activities, on the other hand have floats, does not delay project completion time so do not require quality monitoring. Costs can be saved by not providing continuous supervision over them. However while the activities are being carried out, management may realize that certain critical activities cannot be completed on time. In such situation management may:

Delay of critical activities means delay in project completion.

- Transfer additional resources to the activity or improve the quality of resources used to ensure timely completion,
- Relax technical specification or reduce the quality requirement,
- Change the scope of the project and consequently the amount of work,
- Change the sequence of activities, if possible, or
- Start succeeding activities, if possible, while the preceding activities are still in progress.

Critique of PERT and CPM

PERT and CPM are popular tools among the project planners. Now-a-days many powerful easy-to-use computer software packages are available for analyzing

projects. Most of them are based on the concept of PERT or CPM or combination of both. Since the softwares are so easy to use they are popular among the planners. But project managers should be aware of the good and the bad points of the network techniques. A summary of the good and bad points follows:

Good points of PERT and CPM

- Graphs are the backbone of PERT and CPM. Graph helps to perceive quickly the relationship between different activities of the network.
- PERT and CPM are useful in scheduling & controlling activities of small and large projects and good at pointing out who is responsible for various activities.
- PERT is helpful in risk analysis and CPM is useful in monitoring cost overruns.
- PERT and CPM do not require complex mathematical calculations.
- Critical path and slack analysis help identifying activities that need to be monitored very stringently.

Weak points of PERT and CPM

- Activities need to be defined very clearly which, in most cases, is not possible at the beginning of project analysis. Similarly, the relationship between the activities are not easy to specify.
- In CPM the assumption of linear relationship between resource and cost do not hold true in many situation.
- Time estimate in PERT is assumed to follow a Beta Distribution, which is hard to verify. Further, in many cases, time & cost estimates are deliberately fudged by the planners to avoid recrimination at the end of the project.
- Too much emphasis is placed on the critical route, the need to monitor the near critical paths are overlooked.

Discussion questions:

1. Define activity, events, critical path, and floats.
2. Explain, in brief, the different steps of analyzing network.
3. Explain the process of drawing a network.
4. What do you mean by Forward Pass and Backward Pass?
5. Explain what do you mean by Earliest Date, Earliest Start, Last Date, and Last Finish.
6. What are the main purposes of analyzing activities?
7. Explain how to draw a network.
8. What are the strong and weak points of network techniques?

**Case
Analysis**

The Pert Studebaker

By Sue Perrott Siferd, Arizona State University, USA

The new director of service operations for Roberts's Auto Sales and Services (RASAS) started work at the beginning of the year. It is now mid February, RASAS consists of three car dealerships that sell and service several makes of American and Japanese cars, two auto parts stores, a large body shop and car painting business, and an auto salvage yard. Vikky Roberts, owner of RASAS, went into the car business more than 20 years ago when she inherited a Studebaker dealership from her father. The Studebaker Corporation was on the wane when she obtained the business, but she was able to capitalize on her knowledge and experience to build her business into the diversified and successful "miniempire" it is today. Her motto, "Sell 'em today, repair 'em tomorrow!" reflects a strategy that she refers to in private as "Get 'em coming and going."

Roberts has always retained a soft spot in her heart for Studebaker automobiles. They were manufactured in South Bend, Indiana, from 1919 to 1966, and many are still operable today because of a vast number of collectors and loyal fans. Roberts has just acquired a 1963 Studebaker Avanti that needs a lot of restoration. She has also noted the public's growing interest in the restoration of vintage automobiles.

Roberts is thinking of expanding into the vintage car restoration business and needs help in assessing the feasibility of such a move. She also wants to restore her 1963 Avanti to mint condition, or as close to mint condition as possible. If she decides to go into restoring business, she can use the Avanti as an exhibit in sales and advertising and take it to auto shows to attract business for the new shop.

Roberts believes that many people want the thrill of restoring an old car themselves but don't have time to run down all the old parts. Still others just want to own a vintage auto because it is different, and many of them have plenty of money to pay someone to restore an auto for them.

Roberts wants the business to appeal to both types of people. For the first group, she envisions serving as a parts broker for NOS ("new old stock"), new parts that were manufactured many years ago, packaged in their original cartons. It can be a time-consuming process to find the right part. RASAS could also machine new parts to replicate those that are hard to find or no longer exist.

In addition, RASAS could assemble a library of parts and body manuals for old cars, to serve as an information resource for do-it-yourself restorers. The do-it-yourselfers could come to RASAS for help in compiling their parts lists, and RASAS could acquire the parts for them. For others RASAS would take charge of the entire restoration.

Roberts asks the new director of service operations to take a good look at her Avanti and determine what needs to be done to restore it to the condition it was in when it came from the factory more than 30 years ago. She wants to restore it in time to exhibit it at the National Studebaker Meet beginning July 15 in

Springfield, Missouri. If the car wins first prize in its category, it will be a real public relations coup for RASAS – especially if Roberts decides to enter this new venture. Even if she doesn't, the car will be a showpiece for the rest of the business.

Roberts asks the director of service operations to prepare a report about what is involved in restoring the car and whether it can be done in time for the Springfield meet this summer. PERT/CPM is to be used to determine if the July 15 date is feasible. The parts manager, the body shop manager, and the chief mechanic have provided the following estimates of times and tasks that need to be done, as well as cost estimates.

- Order all needed materials and parts (upholstery, windshield, carburetor, and oil pump). Time: 2 days. Cost (phone calls and labor): \$100.
- Receive upholstery material for seat covers. Can't do until order is placed. Time: 30 days. Cost \$250.
- Receive windshield. Can't do until order is placed. Time: 10 days. Cost \$130.
- Receive carburetor and oil pump. Can't do until order is placed. Time: 7 days. Cost \$180.
- Remove chrome from body. Can do immediately. Time: 1 day. Cost \$50.
- Remove body (doors, hood, trunk, and fenders) from frame. Can't do until chrome is removed. Time: 1 day. Cost \$150.
- Have fenders repaired by body shop. Can't do until body is removed from frame. Time: 4 days. Cost: \$200.
- Repair doors, trunk, and hood. Can't do until body is removed from frame. Time: 6 days. Cost: \$300.
- Pull engine from chassis. Do after body is removed from frame. Time: 1 day. Cost \$ 50.
- Remove rust from frame. Do after engine has been pulled from chassis. Time: 3 days. Cost \$ 300.
- Regrind engine valves. Have to pull engine from chassis first. Time: 5 days. Cost \$500.
- Replace carburetor and oil pump. Do after engine has been pulled from chassis and after carburetor and oil pump have been received. Time: 1 day. Cost \$50.
- Rechrome the chrome parts. Chrome must have been removed from the body first. Time: 3 days. Cost: \$150.
- Reinstall engine. Do after valves are reground and carburetor and oil pump have been installed. Time: 1 day. Cost: \$150.
- Put doors, hood, and trunk back on frame. The doors, hood, and trunk must have been repaired. The frame also has to have had its rust removed. Time: 1 day. Cost: \$80.
- Rebuild transmission and replace brakes. Do so after the engine has been reinstalled and the doors, hood, and trunk are back on the frame. Time: 4 days. Cost: \$700.
- Replace windshield. Windshield must have been received. Time: 1 day. Cost \$70.
- Put fenders back on. The fenders must already have been repaired and the transmission rebuilt and the brakes replaced. Time: 1 day. Cost: \$60.

- Paint car. Can't do until the fenders are back on and windshield replaced. Time: 4 days. Cost: \$ 1700.
- Reupholster interior of car. Must have first received upholstery material. Car must also have been painted. Time: 7 days. Cost: \$1200.
- Put chrome parts back on. Car has to have been painted and chrome parts rechromed. Time: 1 days. Cost: \$50.
- Pull car to Studebaker show in Springfield, Missouri. Must have completed reupholstery of interior and have put chrome parts back on. Time: 2 days. Cost: \$500.

Roberts wants to limit expenditures on this project to what could be recovered by selling the restored car. She has already spent \$1500 to acquire the car.

In addition, she wants a brief report on some of the aspects of the proposed business, such as how it fits in with RASAS's other businesses and what RASAS's operations task should be with regard to cost, quality, customer service, and flexibility.

According to *Turning Wheels*, a publication for owners and drivers of Studebakers, and other books on car restoration, there are various categories of restoration. A basic restoration gets the car looking great and running, but a mint condition restoration puts the car back in original condition – as it was “when it rolled off the line.” When restored cars compete, a car in mint condition has an advantage over one that is just a basic restoration. As cars are restored, they can also be customized. That is, something is put on the car that couldn't have been on the original. Customized cars compete in a separate class. Roberts wants a mint condition restoration, without customization. (The proposed new business would accept any kind of restoration a customer wants.)

A restored 1963 Avanti can probably be sold for \$15,000. Thus the total budget can't exceed \$13,500 (\$15,000 minus the \$1500 Roberts has already spent). Even though much of the work will be done by Roberts's own employees, labor and materials costs must be considered. All relevant cost have been included in the cost estimates.

Case questions

1. Using the information provided, prepare the report that Roberts requested, assuming that the project will begin in late February of the current year. Thus 100 working days are available to complete the project, including transporting the car to Springfield before the meet begins. Your report should briefly discuss the aspects of the proposed new business, such as the competitive priorities, that Roberts asked about.
2. Construct a table containing the project activities, with a letter assigned to each activity, the time estimates, and precedence relationships from which you will assemble the network diagram.
3. Prepare a project budget showing the cost of each activity and the total for the project.