Block-II

Project & Operations Management

Project Planning and Control

Block

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PROJECT PLANNING AND CONTROL

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BLOCK II: PROJECT PLANNING AND CONTROL

The second block of the course on Project & Operations Management deals with project planning and control. The block contains five units. The first unit focuses on the management of the project scope. The second unit examines the identification of the project activities. The third unit discusses activity sequencing, duration estimation and activity scheduling. The fourth and fifth units of the block explain project review and project control, respectively.

The first unit, *Management of Project Scope*, discusses the project initiation process and defines project deliverables. The unit focuses on scope planning and approval of the project overview statement. It also deals with the project definition statement. The unit also provides an idea about scope verification and scope change control.

The second unit, *Identifying Project Activities*, deals with the definition of an activity. The unit explains work breakdown structure (WBS) and its development. It also discusses the various tests for completeness of decomposition of activities. Finally, the unit provides an idea about the various approaches to defining deliverables in the WBS and about representing the WBS.

The third unit, *Activities: Sequencing, Estimating Duration, and Scheduling*, discusses the fundamentals of the project network diagram. The unit explains activity sequencing and activity duration. The unit also deals with schedule development and the various techniques for schedule development. Finally, the unit discusses schedule control.

The fourth unit, *Project Review*, explains the importance of project review. The unit discusses the various types of project reviews and the different stages involved in project review. The unit also deals with project status review meetings and the advantages of conducting them. Finally, the unit explains the various types of project status meetings.

The fifth unit, *Project Control*, explains the fundamentals of project control. The unit explains the objectives of control, control as a function of management and differentiates between control and risk. The unit also discusses the reasons for measuring duration and cost deviations. It deals with ways to balance the control system and control change. The unit also defines progress reporting system and describes the various types of project status reports. It provides information on the graphical reporting tools and project status review meetings. Finally, the unit explains the different ways to manage risk and quality.

Unit 6

Management of Project Scope

Structure

6.1 Introduction

In the last unit of the previous block, we have discussed about project selection. In this unit, we will discuss the management of project scope. Scope is a brief and accurate description of the end-products or deliverables to be expected from a project. It describes all the activities that have to be performed and identifies the resources that will be utilized for the successful completion of the project. Scope is also concerned with target outcomes, prospective customers, outputs and the financial and human resources required for completing the project.

The project manager and the client have to jointly discuss the objectives of the project. Exchanging views and information will enable them to determine the purpose of the project. This exchange of information will also help the project manager understand the client's expectations of the project and make the client aware of the project manager's method for executing the project. On the basis of this discussion, the client and the project manager prepare a project goal. They also identify a number of objectives that will help them reach that goal. The project goals, together with the objectives, determine the scope of the project.

This unit will discuss project initiation process and define project deliverables. It will then discuss scope planning and approval of the project overview statement. Then it will explain about the project definition statement. Finally, it would be discussing about scope verification and scope change control.

6.2 Objectives

By the end of this unit, students should be able to:

- Explain the project initiation phase.
- Define project deliverables.
- Explain scope planning.
- Find out how a project overview statement is approved.
- Discuss project definition statement.
- Explain the concepts of scope verification and scope change control.

6.3 Project Initiation

Projects are initiated only when an opportunity is recognized or when some need arises and is recognized as significant and can be fulfilled at practical cost. Project initiation phase includes formulating the problem, defining needs and user requirements, evaluating alternative solutions, and preparing a proposal to conduct the project. At the start of this phase, most of the activities will be in the hands of the customer for whom the project should be developed to fulfill their needs. By the end of this phase, the activities will be taken over by the contractor or the project developer. For example, a bank opens new branches in the countryside because of the growing demand for banking services in rural areas. A company starts a project for training its employees in 'Total Quality Management' because of a business need. A construction firm starts a project for a new type of structure because of a client's request. An electronics firm starts a new project for developing Internet ready-TVs due to technological advancement. The Election Commission of India conducts elections to meet a statutory requirement. In other words, projects are initiated because of specific requirements as exemplified in the Exhibit 6.1.

Exhibit 6.1: Election Commission Initiates VVPAT project

The use of Electronic Voting Machines has revolutionized the Electoral System and introduction of Voter Verifiable Paper Audit Trail system has provided greater transparency to the poll process. Even though the EVM became the mainstay of the election process, many political parties were questioning the transparency and verifiability of the polling process in case doubt arises in the minds of the voters. Thus came the idea of initiating the development of VVPAT and the project was assigned to the two public sector undertakings, viz, ECIL and BEL. The VVPAT joined the EVM in providing a fool-proof election process and all the polling stations are now getting equipped with VVPAT.

Source: https://cdn.s3waas.gov.in/s301f78be6f7cad02658508fe4616098a9/uploads/2019/02/2019020939.pdf

6.4 Defining Project Deliverables

The Project Management Body of Knowledge (PMBOK) defines a project deliverable as 'any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or a part of a project'. Project deliverables are expected outputs over the life of the project. For example, for a software project, the deliverables in the early design phase of the project might be a list of specifications; in the next following phase, they could be software coding and a technical manual. In the next phase, the deliverables could deal with testing of prototypes and in the final project phase, the deliverables could be the final tests and approved software. A list of project deliverables is jointly prepared by the project manager and the client. This list of project deliverables is also called 'Conditions of Satisfaction'.

The list of project deliverables is developed in four steps. They are: request, clarification, response and agreement.

6.4.1 Request

In the first step, the client requests the project manager to undertake a project as per his/her requirements.

6.4.2 Clarification

In the second step, the project manager explains what he/she has understood by the request made by the client. This step is over only when the client feels that the project manager has understood the request made by him/her.

6.4.3 Response

In the third step, the project manager explains what he/she can do to fulfill the client's request. He/she informs the client of his/her capabilities, his/her schedule, and fees for undertaking the project.

6.4.4 Agreement

Based on the project manager's response, both parties continue their discussions. If both parties are still willing to ahead with the project, they establish the project norms in this step.

Finally, both parties examine each other's requests closely to determine how the project should be executed. The final agreement is documented in the "Project Overview Statement".

Activity: Krishna Rajan Electric Company, one of the leading electrical companies in India, wanted to establish the ERP systems throughout the firm. The project of implementing the ERP systems was given to Indosoft Systems Private Limited. Stephen Richards, the project manager of Indosoft Systems Private Limited and Ramesh Atul, a senior manager from Krishna Rajan Electric Company discussed what is to be accomplished in the project. They exchanged their views and ideas and finally listed the project deliverables.

What is a deliverable? Discuss the steps involved in the process of defining deliverables.

Answer:

Check Your Progress - 1

1. In which of the following stages do the project manager and the client discuss about going ahead with the project and establishing project norms?
   a. Request
   b. Clarification
   c. Response
   d. Agreement
2. Identify the statement that is **not true** with regard to project scope.
   a. Project scope is a brief and accurate description of the end products or deliverables to be expected from a project.
   b. It describes all the activities that have to be performed and identifies the resources that will be utilized for the successful completion of the project.
   c. It is concerned with target outcomes, prospective customers, outputs, and the financial and human resources required for completing the project.
   d. Only the project goals determine the scope of the project.
3. The objectives of a project should be jointly discussed by the project manager and the client. Such a discussion would
   i. enable the project manager and the client to determine the purpose of the project.
   ii. help the project manager understand the client's expectations of the project.
   iii. make the client aware of the project manager's method of executing the project.
   a. Only i and ii
   b. Only i and iii
   c. Only ii and iii
   d. i, ii, and iii

4. From the given sequences, identify the **correct** sequence of steps in which a list of project deliverables is developed.
   a. Request – Agreement – Response – Clarification
   b. Clarification – Response – Agreement – Request
   c. Request – Clarification – Response – Agreement
   d. Response – Agreement – Request – Clarification.
5. _____ describes all the activities that have to be performed and identifies the resources that will be utilized for the successful completion of the project.
   a. Project phase
   b. Project scope
   c. Project control
   d. Project deliverable
6. Identify the step in which the project manager explains what he/she can do to fulfill the client's request. In this step, the project manager informs the clients of his/her capabilities, schedule, and fees for undertaking the project.
   a. Request
   b. Clarification
   c. Response
   d. Agreement
7. 'Conditions of Satisfaction' is an expression used to represent
   a. the scope of the project.
   b. the list of project deliverables.
   c. exchange of views between the project manager and the client.
   d. the objectives of the project.
8. The final agreement between the project manager and the client regarding the project is documented in the
   a. project plan.
   b. aggregate project plan.
   c. project progress report.
   d. project overview statement.
9. In which of the following steps in developing the list of deliverables does the project manager explain what he/she has understood by the request made by the client?
   a. Request
   b. Clarification
   c. Response
   d. Agreement

6.5 Scope Planning

Scope planning involves development of the Scope Statement. The project manager uses tools like product analysis, cost/benefit analysis, and expert judgment to develop the scope of a project.

Product analysis is a technique for understanding the features and functions of a product. Techniques like 'Value Analysis' and 'Quality Function Deployment' help the project manager gain more information regarding the project. By increasing his/her knowledge of the project's product, the project manager can define the scope of the project more precisely. A cost/benefit analysis is necessary for studying the various tangible and intangible costs and benefits associated with the project. The project manager also consults experts to determine the scope of a project.

6.5.1 Scope of a Project

Project scope describes what is expected to deliver to the client/customer when the project is complete. It defines the results to be achieved in specific, tangible, and measurable terms, that is, the end result or mission of the project – a product or service for the client/customer. Therefore, the 'scope' of a project can be divided into 'product scope' and 'project scope'. Product scope details all the functions and features that are to be included in a product or service of a project. Project scope, however, details the work to be done to deliver a required product with specific features. The tools and techniques for managing product scope vary with the nature of the project. Scope definition focuses primarily on determining the project outputs and deliverables, not on time and cost, but time and cost will be treated as constraints in achieving the outputs and deliverables.

6.5.2 Drafting the Project Overview Statement

The scope of a project is documented in the "Project Overview Statement". The Project Overview Statement (POS) is also referred to as Initial Project Definition, Document of Understanding, Project Scope Statement or Statement of Work. It is a description of the project and includes a scope statement, but often goes far beyond that.

The Project Overview Statement should be very specific. For example, "Build a website like Amazon.com", is not a scope statement because it does not provide guidance for building the site. A good scope statement would identify the goal of the project and describe how that goal can be achieved. It should be expressed in a clear and precise manner so that all the project stakeholders understand what the project is all about. POS should describe what the project is, why it is being taken up, and what value it brings to the firm. All future decisions regarding the execution of the project and allocation of necessary resources will be based on the POS. The description may include project deliverable specifications and requirements, deliverable schedules, management procedures for communication, planning and handling risks and changes, project budget and key personnel responsible for administrative and work tasks.

A Project Overview Statement is not a static document. As the project progresses, it has to be revised or redefined. This is because over time the situation may change and the POS should be documented accordingly. Depending on the circumstances, it can be modified or rewritten, taking into consideration the opinions of all the project stakeholders. The scope statements of large, technological projects often have to be modified because of the high rate of technological change. The POS should be able to resolve any conflicts and misunderstandings that may arise among the project members.

6.5.3 Parts of POS

In general, the Project Overview Statement consists of five parts – project problem/ opportunity; project goal; project objectives; success criteria; and assumptions, risks, and obstacles.

The POS first identifies the reasons for undertaking the project and then proceeds to identify the project's goal. The 'project goal' is further broken down into a number of project objectives. The POS also mentions the criteria for the success of the project and the various risks, obstacles involved in the execution of the project.

State the Project Problem/Opportunity

The first part of a Project Overview Statement (POS) states the problem or opportunities that the project is going to address. This statement need not be defined rigidly. It should be written in such a way that all project stakeholders are able to understand it.

The gravity of the problem or the business value of the opportunity stated in this part will play a major role in getting the attention of the top management. Some of the situations that give rise to the problems or opportunities that form the basis of POS are discussed below.

Existing problem/opportunity areas: The POS can address any of the problems that the firm faces and offer a full or partial solution to the problems. If there are any opportunities in the market, the POS should explain how the firm can take advantage of the situation.

Customer request: Any of the requests made by the firm's internal or external customers can be mentioned in the 'list of deliverables' of a POS. The POS is thus a useful tool for forwarding customer requests to top management.

Corporate initiative: Employees are encouraged to submit their project ideas in a POS format. Senior management can then prioritize these proposals and identify the best proposal or idea for further consideration.

Mandated requirements: A change in customer preferences or legal requirements may also make a firm take up a project. The POS describes how the firm is going to respond to these mandatory requirements.

6.5.4 Project Goal

In the second part of the POS, the project goal is defined on the basis of the problem/opportunity stated in the first part of the POS. A project should have a goal that can catch the attention of top management.

The project goal forms the purpose of the project and provides guidance to the entire project team. It helps everyone understand what the project is expected to accomplish. It is also a point of reference for clarifying questions that may arise about the scope of the project. The goal of the project should be stated clearly and precisely. Anyone who reads it should be able to understand it without any additional explanation from the project manager. Technical jargon, if used, should be explained.

The goal statement should be specific and easy to remember. The firm should be in a position to implement every point mentioned in the statement. The project goal statement should not mention any specific dates for starting or completing the project.

The goal statement should be 'SMART,' where S represents 'specific' (specific in addressing the purpose of the project); M represents 'measurable' (measurable indicators of the project's progress should be established); A represents 'assignable' (assignable to a person to complete it); R represents 'realistic' (states what can realistically be done with the available resources); and T represents 'time-relatedness' (time required for completing the project).

6.5.5 Project Objectives

The third part of the POS defines the objectives of the project. An objective statement is a more detailed version of the goal statement. These project objectives specify the exact boundaries of the project goal.

The project manager should ensure that the objective statement covers the following aspects of the project – an outcome (a statement of what the project is going to achieve), a time period (the expected start and completion date), a measure (the parameters for measuring the project's success), and an action plan (A plan for meeting the project's objectives).

Example: Sample Project Overview Statement			
Project Name:	*Project Manager:*		*Project Code:*
Start Date:			End Date:
Problem/Opportunity Statement :			
Project Goal Statement:			
Project Objectives Statement :			
Success Criteria:			
Assumptions, Risks and Obstacles:			
Prepared by	Date	Approved by	Date

Check Your Progress - 2

10. Identify the statement that is **not true** with regard to the project goal in the project overview statement.
    a. The project goal forms the purpose of the project and provides guidance to the entire project team.
    b. The goal of the project should be stated clearly and precisely.
    c. The project goal statement should mention specific dates for starting or completing the project.
    d. The goal statement should be specific and easy to remember.
11. Initial project definition, document of understanding, and statement of work are alternative terms used for
    a. project overview statement
    b. project plan
    c. project scope statement
    d. Both (a) and (c)
12. Which of the following statements is **false** regarding the project overview statement (POS)?
    a. POS should describe what the project is, why it is being taken up, and what value it brings to the firm.
    b. All future decisions regarding the execution of the project and allocation of necessary resources will be based on the POS.
    c. A POS is a static document that need not be changed, revised, or redefined.
    d. The POS should be able to resolve any conflicts and misunderstandings that may arise among project members.
13. Identify the parts of a project overview statement.
    i. Project goals and objectives
    ii. Assumptions, risks, and obstacles
    iii. Success criteria
    iv. Project problem/opportunity
    a. Only i, ii, and iii
    b. Only i, iii, and iv
    c. Only ii, iii, and iv
    d. i, ii, iii, and iv
14. Which of the following options **do not** form part of the process of stating the problems or opportunities in the project overview statement?
    i. The statement should explain the reason for taking up the project.

ii. The statement should be written in such a way that all the project stakeholders are able to understand it.

iii. The statement should state the outcome and the time period of the project.

iv. The statement should address the existing problems or opportunities faced by the organization.

a. Only i and ii

b. Only i and iii

c. Only ii and iii

d. Only iii and iv

15. Identify the techniques among the following options that the project manager uses to develop the scope of a project.

i. Product analysis

ii. Black box

iii. Cost/benefit analysis

iv. Expert judgment

a. Only i, ii, and iii

b. Only i, iii, and iv

c. Only ii, iii, and iv

d. i, ii, iii, and iv

16. Identify the characteristics of a good project overview statement (POS).

i. The POS should be very specific.

ii. The POS should identify the goal of the project.

iii. The POS is a static document that need not be changed, revised, or redefined.

iv. The POS should be expressed in a clear and precise manner so that all the project stakeholders understand what the project is all about.

a. Only i, ii, and iv

b. Only i, iii, and iv

c. Only ii, iii, and iv

d. i, ii, iii, and iv

17. The problems or opportunities stated in the project overview statement form the basis for

a. Defining the project scope.

b. Defining the project goal.

c. Screening the project.

d. Conducting the technical analysis of the project.

18. Identify the statements that are **true** regarding the scope of a project.
    i. The scope of a project can be divided into product scope and project scope.
    ii. Product scope details all the functions and features that are to be included in a product or service of a project.
    iii. Project scope details the work to be done to deliver a required product with specific features.
    iv. The tools and techniques for managing product scope vary with the recruitment policy of the organization.
    a. Only i, ii, and iii
    b. Only i, iii, and iv
    c. Only ii, iii, and iv
    d. i, ii, iii, and iv

Success Criteria

The fourth part of the POS explains why the project is being taken up. It describes the business value of the project to the project firm and indicates when the project can be said to have successfully achieved its objectives. While preparing this part, the project manager should ensure that the success criteria are quantifiable and measurable. The success criteria of a project can be: increase in revenue, increase in market capitalization, etc. The success criteria should identify the exact benefits that the project can bring to the firm. Success criteria can also be presented in terms of quantifiable statements like reduced turnaround time to service a customer, decreased error rates, etc.

On the basis of the success criteria, the top management determines the business value of the project and allocates resources accordingly. For example, the success criteria can be written as follows: launching this innovative product in place of the present product will increase the firm's sales by 5 percent. If the top management of the firm is satisfied with the success criteria mentioned in the POS, it may ask the project manager to explain, in detail, how he plans to achieve the business value identified in the POS (i.e. an increase in the firm's sales). If top management is not satisfied with the success criteria mentioned in the POS, it might reject the project.

Assumptions, Risks and Obstacles

The fifth section of the POS mentions all the organizational or environmental factors that may affect the outcome of the project. The project manager uses this section of the POS to alert senior management about the risks or obstacles that may influence the project's activities. This part of the POS also mentions the contingency plans to be prepared to reduce the impact of the above risks on the project.

Some aspects of projects that are risk prone are discussed as follows.

Technological aspects: If the project firm does not have any experience in handling new technology, then the project manager should not choose technology-related projects. Since it is difficult to manage technical projects, non-technical firms do not encourage such projects.

Environmental aspects: To design a good POS, the project manager should understand the environment in which the project operates. Suppose the project sponsor suddenly leaves the project, the POS should solve this problem by recommending an alternative sponsor. It should also discuss how the right people can be acquired to work in crucial areas of the project.

Interpersonal aspects: Good interpersonal relationships among project team members are essential for the success of any project. All interpersonal problems should be brought to the attention of top management.

Cultural aspects: The POS should mention how the proposed project is suitable for the firm. If the project deliverables are completely different from what the firm is producing, then the project may not be accepted by top management.

Causal relationships: The solutions provided for correcting project problems depend on several assumptions. So, the project manager should mention the variables that are likely to affect the assumptions made in the project.

6.5.6 Attachments to POS

Usually, project managers submit a POS that is only one page long. But top managers often request a more detailed POS that provides additional information about the business value of the project. Apart from the POS, the top management usually requests the project manager to submit risk analysis and financial analysis reports. These reports help managers assess the economic value of the project.

Risk Analysis

This report describes the various risks associated with proposed project activities, their probability of occurrence and their severity. Particularly, in highly technical projects, the project manager should explain all the possible risks and their likely impact on project results. Formal procedures should also be mentioned to effectively deal with these risks in the POS.

This analysis also describes risk identification techniques, risk quantification, and other risk control measures. The project manager also prepares a contingency plan for dealing with risks. The top management of the firm analyzes all these risks before accepting the project.

Financial Analysis

The project manager also submits a financial analysis of the proposed project as an attachment to the POS. The following financial aspects of a project are analyzed:

Feasibility Analysis: A feasibility analysis is conducted to ensure that the proposed project is financially viable. To do so, a project manager must;

1. Define the problem/opportunity clearly
2. Define the scope of the project, what it includes and what it does not include
3. Identify alternative solutions for the problems
4. Rank the alternative solutions
5. State the expected time and costs required
6. Project the profits from the project
7. List the recommendations.

A thorough examination of the solution and the various alternatives will help the project manager win the confidence of top management.

Return on investment: The return on investment is the revenue likely to be generated over a life period of the project against the investments made into the project. Since return on investment is numerically expressed, it is easy for top management to identify the most profitable project.

Cost/benefit analysis: The cost/benefit analysis explains the economic and social justification for the proposed project. But it is difficult to analyze project costs and benefits as some intangible benefits cannot be quantified. Due to this, it is very difficult for the project manager to assess all the costs and benefits of the project. The top management uses its judgment to assess the project and decide whether it should accept it.

Break-even analysis: Through this analysis, the project manager determines when the project will arrive at a 'no profit-no loss' situation. The top management accepts the project if the expected time for reaching a break-even situation is less than the 'threshold time' it has in mind.

Activity: The management of Gayatri Machine Works has decided to set up a unit that manufactures the machine tools required for the firm. Srikanth Reddy, the in-charge of this project, has prepared the project scope statement and sent it to the top management for approval. The top management called Reddy and asked him to submit more reports regarding the feasibility and economic value of the project. What are the reports that Reddy should include with the project scope statement? Explain their significance.

Answer:

Check Your Progress - 3

19. Identify the financial analysis technique that explains the economic and social justification for the proposed project.
    a. Feasibility analysis
    b. Return on investment
    c. Cost/benefit analysis
    d. Break-even analysis
20. Which of the following options is used by the project manager to determine when the project will arrive at a 'no profit-no loss' situation?
    a. Feasibility analysis
    b. Return on investment
    c. Cost/ benefit analysis
    d. Break-even analysis
21. Identify the statement that is **not true** regarding risk analysis reports.
    a. The risk analysis report describes the various risks associated with proposed project activities, their probability of occurrence, and their severity.
    b. Risk analysis describes risk identification techniques, risk quantification, and other risk control measures.
    c. The risk analysis report does not include any mention of the formal procedures to deal with the risks in the project overview statement.
    d. Both (a) and (b)
22. Environmental, technological, and interpersonal aspects may affect the outcome of the project. These are mentioned under the _____ section of the project overview statement.
    a. Project goal
    b. Success criteria
    c. Project problem/ opportunity
    d. Assumptions, risks, and obstacles
23. Return on investment is
    a. The sum of the approved cost estimates (including any overhead allocation) for activities completed during a given period.
    b. Total costs incurred (direct and indirect) in accomplishing work during a given time period.
    c. The revenue likely to be generated over the life period of the project against the investments made in it.
    d. The measurable, tangible, and verifiable outcome or result that must be produced to complete a project.

24. Arrange the following options based on the sequence in which the project manager conducts a feasibility analysis of the project.
    i. Rank the alternative solutions
    ii. Define the scope of the project, what it includes and what it does not
    iii. Define the problem/opportunity clearly
    iv. State the expected time and costs required
    v. List the recommendations
    vi. Project the profits from the project
    vii. Identify alternative solutions for the problems
    a. iii-i-vii-ii-v-iv-vi
    b. iii-ii-vii-i-iv-vi-v
    c. iii-v-ii-iv-vi-i-vii
    d. iii-iv-vi-v-i-vii-ii
25. Which among the following analyses is/are used to assess the economic value of the project?
    a. Risk analysis
    b. Financial analysis
    c. Critical path method
    d. Both (a) and (b)

6.6 Approval of POS

After preparing the POS, the project manager sends it to top management for approval. Top management examines the proposed project to see if it adds any business value to the firm. The project manager can be asked some questions by the management regarding the content of the POS. For example, management may ask the project manager to expand or contract the scope of the project. They can also question the validity of the financial analysis and ask the project manager to justify some of his statements. Depending on the explanation given by the project manager, management will decide if the project is worth undertaking.

Approval of the POS indicates that

- Top management is interested in undertaking the project
- The client feels that the project has been understood and a satisfactory solution has been offered
- Top management feels that the project is well defined.

The management may ask the project manager to identify the resources necessary for executing the project. Estimates of time and cost can be provided later by the project manager during the detailed planning stage.

6.6.1 Participants in the Approval Process

The project manager, project team members, project clients, top management of the firm and functional heads are the important participants in the project approval process.

6.6.2 Project Manager

The role of the project manager is crucial. He should draft the POS in such a way that top management can easily understand it. Moreover, he should persuade management to approve the project. He should direct the entire project team and close the project through satisfying the client.

6.6.3 Project Team Members

Usually, the project manager has some prospective team members in mind. He can consult these members and use their expertise to develop the POS or review the already prepared POS.

6.6.4 Project Clients

Since the project must be acceptable to the project client, the role of the project client is very significant. Sometimes the project client himself behaves like a project manager, when he is fully aware of the project.

6.6.5 Top Management of the Firm

Since top management provides guidance to the firm, their approval is a must for the project.

6.6.6 Functional Heads

Project deliverables can be produced only when several functions are properly coordinated. The cooperation of the functional heads is necessary to make the project a success. For example, if attaining a required level of quality is an important project deliverable, the contribution of the head of the quality department is important for making the project a success.

6.7 Project Definition Statement

The Project Definition Statement (PDS) is similar to the POS, but the people who are involved in the preparation of the statement are different. When preparing the PDS, the project manager discusses with the project team members, not the project client. However, the PDS has the same five parts-structures as the POS: project problem/opportunity, project goal, project objectives, success criteria, and assumptions, risks, and obstacles.

The PDS provides more detailed information about the project as it is used as a reference point by the project team for executing the project. The PDS keeps the entire project team moving in the right direction and also provides guidance to new project team members.

Unlike the POS, the PDS is circulated only among the members of the project team. As a result, technical jargon is used in the document. Since the POS does

not the provide project teams the level of detail required, PDS works as a more useful tool in project execution.

Activity: A state government gave WindSoft the project of developing a wide area network connecting all district offices to facilitate e-governance in the state. Richard Williams, the project manager from WindSoft and the IT Secretary of the state government, Amar Singh, discussed scope of the project. Later, both of them documented the scope of the project in the form of a Project Overview Statement. Williams then prepared a Project Definition Statement after consulting his project team members. Explain the importance of a Project Overview Statement and how is it different from a Project Definition Statement? Do you think both documents are necessary for a particular project?

Answer:

Check Your Progress - 4

26. Identify the statement that is **not true** regarding the approval of the project overview statement (POS).
    a. The top management feels that the project is well defined.
    b. The top management is interested in undertaking the project.
    c. The client feels that the project has been understood and a satisfactory solution has been offered.
    d. The top management wants the estimates of time and cost to be provided by the project manager in the POS.
27. Identify the statement that is **not true** regarding the project definition statement (PDS).
    a. The PDS provides more detailed information about the project as it is used as a reference point by the project team for executing the project.
    b. While preparing the PDS, the project manager holds discussions with the project client.
    c. The PDS keeps the entire project team moving in the right direction and also provides guidance to new project team members.
    d. Both (a) and (c)
28. Which of the statements explain the role of the project manager in the approval of the project overview statement (POS)?
    i. The project manager should draft the POS in such a way that the top management can easily understand it.
    ii. The project manager persuades the management to approve the project.

iii. The project manager directs the entire project team.

iv. The project manager closes the project by satisfying the client.

a. Only i, ii, and iii

b. Only i, iii, and iv

c. Only ii, iii, and iv

d. i, ii, iii, and iv

6.8 Scope Verification

The Project Management Body of Knowledge (PMBOK) defines 'scope verification' as a process that formalizes the acceptance of the project scope by the project stakeholders. Here, the project manager reviews the fully or partially completed deliverables (called work results) to ensure that they have been completed as per the specifications. The documents that describe the project's products or services are also reviewed by the project manager during scope verification phase. After defining the scope of the project, the project stakeholders should formally approve it before proceeding further. It is very crucial to get the scope verification by the key stakeholders and project approval will be possible only when the project scope verification is done and approved. Scope verification is the process of verifying that the project scope statement is the baseline for the upcoming project and getting acceptance and agreement from all the project stakeholders that the project scope is correct. During the scope verification process, all the concerned project stakeholders should see and formally accept the project scope statement that becomes the scope baseline for the project. Any changes to the project scope can be done through an acceptable scope change control process. The future project work results and deliverables should be properly reviewed to ensure that they meet with the same defined in the scope definition that was accepted at the beginning of the project.

Scope verification avoids any reworks in the project and promotes better project scope control. It ensures exact delivery of what the customer required and minimization of project scope changes. Therefore, a well-defined project scope can ease the process of scope verification and contribute to the success of project.

Scope verification can be compared to project quality control. Scope verification refers to the acceptability of project deliverables by the customer, whereas quality control refers to conformance to specifications as set by the project developer. Scope verification includes verifying acceptability of specifications and standards previously set, whereas quality control refers to verifying the adherence to those specifications and standards.

The project manager also examines and tests the project processes and products to assess their conformity to project requirements. The project can formally be said to have started only after scope verification. The formal acceptance of a project and its deliverables is then distributed to the concerned parties.

In view of the above, there should be a proper project scope management plan that details how the project scope is defined, declares how the project scope should be controlled in order to prevent scope creep, and records how the project scope will be verified. It is desirable for the project developer organization to have a set process on how the scope will be verified. There may be any method of scope verification, but there should always be something formal in writing from the customers stating that they are satisfied with the final project deliverables. Hence, formal acceptance in writing is vital in the process of scope verification.

6.9 Scope Change Control

Even though the project has been defined carefully at the start, the scope of most projects is subject to considerable uncertainty. Generally, there are three basic causes for change in projects. Some changes result due to errors committed by the project planners in the initial assessment about achieving a given end or their choice of the proper goal for the project. For example, the foundation for a building must be changed because a preliminary geological study did not reveal a weakness in the ground structure on which the building will stand. Another example is project team becoming aware of a recent innovation that allows a faster and cheaper solution to the conformation of a new computer. A second source of changes may result because the customer or project team learns more about the nature of the project deliverable or about the setting in which it is to be used. That is, an increase in client or team knowledge or sophistication is the primary factor leading to such changes. For example, a computer program needs to be extended or rewritten because the customer thinks of new uses for the software. The third source of changes is the mandate or instruction from the concerned authority. This is linked to a change in the environment in which the project is being developed and which is not even under the control of the project manager. Examples include passage of new law, a new policy articulated by a government regulatory unit, a new standard set by a trade association, or application of new criteria laid down by the client organization for purchases.

Due to such changes. If the project scope needs to change, it is critical to have a sound change control process in place that records the change and keeps a log of all project changes. The log identifies the change, impact, and those responsible for accepting or rejecting a proposed change. Scope change control is the process of controlling the changes in the project scope that occur at various stages of the project life cycle. Scope change control involves: managing the factors that cause scope changes to see that changes are advantageous to the project; and identifying the changes in the scope.

Generally, the project managers should monitor scope changes very carefully. They should allow scope changes only if it is clear that the project will fail without the change or the project will be improved significantly with the change, or the customer wants it and will pay for it.

Scope change control must be integrated with other control processes (time control, cost control, etc.). Project managers use information collected from various documents to control scope change. They are outputs of Work Breakdown Structure (WBS), performance reports and change requests.

The Work Breakdown Structure (WBS) is a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project. Performance reports organize and summarize the information gathered and provide information on scope performances (e.g. which interim products have been completed and which have not).

Change requests occur in different ways. They may be external or internal to the project, oral or written, legally mandated or optional. These changes may expand or shrink the project scope. Changes in government regulations and new rulings (by the courts) are some of the external events that can change the scope of a project. Errors made in defining a project's product (functions, characteristics, etc.) and errors made in defining the project's scope (using a list of deliverables in place of WBS) constitute internal reasons that lead to changes in project scope.

Scope change also occurs when a new process that adds value to the project become available. For example, some new technology that could improve the execution of the project may become available after the project has been initiated. Naturally, the project manager would like to take advantage of the technological change to add value to the project.

The project manager uses a 'Scope change control system' to control changes to the scope of a project. The scope change control system defines the procedures by which the scope of a project can be changed. The scope change control system includes paper work, tracking systems, and levels of approval necessary for authorizing the changes.

Performance techniques like variance analysis, trend analysis, and earned value analysis help the project manager assess the magnitude of the variations that occur. The project manager then notes down all the causes of the variations and takes corrective action.

The scope changes made to the already approved plans (technical plans, financial plans etc.) are also updated. Then all project stakeholders are informed of the changes. The causes of variances and the corrective actions taken are documented for future reference.

Example: Sample Scope Change Request Form

Scope Change Number: An arbitrary numbering scheme, usually 1, 2, 3.... Also, some coding scheme for categorizing the scope change request.

Requested By: Who requested the scope change?

Date Reported: When was the change requested?

Contd…

Status: Usually Pending, On Hold, In Progress, Complete, Not Approved

Assigned To: Who is assigned to investigate the scope change?

Date Resolved: When was the request resolved?

Scope Change Description: Describe the change in sufficient detail so that others can understand the scope change request.

Business Benefit: Why is the request being made? What is the benefit from a business perspective?

Implications of not making the Change: Describe the consequences if the change is not made.

Impact Analysis to the Project: Describe how the change would be incorporated into the project, as well as the impact on the project in terms of cost, effort and duration.

Alternatives: If there are any alternatives, note them here, along with their impact on cost, effort and duration.

Final Resolution: Briefly describe how the scope change was resolved.

Approval from Sponsor for Final Resolution: Signifies that the Project Sponsor agrees to the resolution, including any budget, effort and / or duration implications.

Adapted from http://www.tenstep.com.

Check Your Progress - 5

29. _____ is a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project.
    a. Change requests
    b. Performance reports
    c. Work breakdown structure
    d. None of the above
30. Scope verification is
    a. The process of controlling the changes in the project scope that occur at various stages of the project life cycle.
    b. A process that formalizes the acceptance of the project scope by the project stakeholders.
    c. The process of developing a scope statement as a basis for all future decisions to be taken on the project.
    d. A process that involves decomposing the major deliverables into smaller, more manageable components to provide better control.

31. Identify the statement that is **not true** with regard to change requests.
    a. Change requests are always external to the organization.
    b. Change requests always expand the scope of the project.
    c. Changes in government regulations, errors in the project's product, etc. are some of the events that can change the scope of a project.
    d. Both (a) and (b)
32. Identify the statement that is **not true** regarding scope change control.
    a. Scope change control involves identifying the changes in scope.
    b. Scope change control controls the changes to the project schedule.
    c. Scope change control involves managing the factors that cause scope changes to see that the changes are advantageous to the project.
    d. Scope change control requires repeated execution with other control processes like time control, cost control, quality control, etc.
33. All the following documents provide information to the project manager to control scope change **except**:
    a. Contract files.
    b. Change requests.
    c. Performance reports.
    d. Outputs from work breakdown structure.
34. _____ is the process of controlling the changes in the project scope that occur at various stage of the project life cycle.
    a. Quality control
    b. Schedule control
    c. Scope change control
    d. Risk response control
35. Identify the techniques that help the project manager in assessing the magnitude of the variations that occur.
    i. Simulation analysis
    ii. Trend analysis
    iii. Variance analysis
    iv. Earned value analysis
    a. Only i, ii, and iii
    b. Only i, iii, and iv
    c. Only ii, iii, and iv
    d. i, ii, iii, and iv

36. Identify the reports that organize and summarize the information gathered and provide information on scope performances.
    a. Change requests
    b. Performance reports
    c. Work breakdown structure
    d. None of the above

6.10 Summary

- Projects are initiated only when an opportunity is recognized, when some need arises, or because of specific requirements.
- A project deliverable is any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or a part of a project.
- A list of project deliverables, known as the conditions of satisfaction, is jointly prepared by the project manager and the client. The list is developed in four steps: request, clarification, response, agreement.
- Scope planning involves development of the scope statement. The project manager uses tools like product analysis, cost/benefit analysis, and expert judgment to develop the scope of a project.
- The scope of a project is documented in the project overview statement (POS). After preparing the POS, the project manager sends it to top management for approval.
- The project definition statement is similar to the POS, but the people who are involved in the preparation of the statement are different. That is, the project manager discusses with the project team members, and not the project client.
- Scope verification is a process that formalizes the acceptance of the project scope by the project stakeholders. The project manager reviews the fully or partially completed deliverables to ensure that they have been completed as per the specifications.
- Scope change control is the process of controlling the changes in the project scope that occur at various stages of the project life cycle.
- Scope change control involves managing the factors that cause scope changes to see that changes are advantageous to the project; and identifying the changes in the scope.

6.11 Glossary

Conditions of satisfaction: A list of project deliverables, which is jointly prepared by the project manager and the client.

Cost Benefit Analysis: The economic and social justification for the proposed project.

Project Definition Statement: It is similar to a project overview statement, and it provides more detailed information about the project as it is used as a reference point by the project team for executing the project.

Project deliverable: Any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or a part of a project.

Project Overview Statement: A document that describes the scope of a project.

Scope Change Control: The process of controlling the changes in the project scope that occur at various stages of the project life cycle.

Scope Planning: The process of developing a scope statement as a basis for all future decisions to be taken on the project.

Scope Verification: A process that formalizes the acceptance of the project scope by the project stakeholders.

Scope: A brief and accurate description of the end products or deliverables to be expected from a project. It describes all the activities that have to be performed and identifies the resources that will be utilized for the successful completion of the project.

Work Breakdown Structure: A deliverable-oriented grouping of project activities that organizes and defines the total scope of the project.

6.12 Self-Assessment Exercises

1. The scope of a project is a brief and accurate description of the deliverables to be expected from a project. Define project deliverables. What are the steps involved the development of a list of project deliverables?
2. The project manager uses various tools like product analysis, and consults experts to determine the scope of a project. How can the project manager develop the project scope? What is a project overview statement (POS)? Describe the different parts of and attachments to a POS.
3. After preparing the POS, the project manager sends it for approval. Give the reasons as to why a POS needs to be approved. Who are all involved in the approval process of a POS?
4. More than the POS, a project definition statement (PDS) works as a very useful tool in project execution. What is a PDS? How is it different from a POS?
5. The project scope needs to be formally accepted by the project stakeholders and also controlled at various stages in the project life cycle. How is the acceptance process of the project scope taken up? Considering that changes may occur, how is the project scope change controlled by the project manager?

6.13 Suggested Readings/Reference Material

1. Prasanna Chandra, “Projects,” Mcgraw Hill, Seventh Edition, 2017
2. James Wood, Kory Kogon, and Suzette Blakemore, Project Management for the Unofficial Project Manager: A Franklin Covey Title, Goodreads, 2018

3. HEAGNEY, Fundamentals of Project Management Paperback, Amacom, September 2018
4. Na, Nagarajan, Project Management 8/Ed, New Age International Publications, 2019
5. IES Master Team, ESE 2020 - Basics of Project Management Paperback – 1 IES Master Publication, January 2019
6. Electronic Voting Machine Manual, Election Commission of India, July, 2018

6.14 Answers to Check Your Progress Questions

Following are the answers to the Check Your Progress questions given in the Unit.

1. (d) Agreement

The list of project deliverables is developed in four stages, namely request, clarification, response, and agreement. In the agreement stage, based on the project manager's response, both the parties (the client and the project manager) continue their discussions and arrive at an agreement. If both are still ready to go ahead with the project, they establish the project norms in this stage. Finally, both the parties examine each other's requests closely in order to determine how the project should be executed.

2. (d) Only the project goals determine the scope of the project.

Project scope is a brief and accurate description of the end products or deliverables to be expected from a project. It describes all the activities that have to be performed and identifies the resources that will be utilized for the successful completion of the project. It is concerned with target outcomes, prospective customers, outputs, and the financial and human resources required for completing the project. The client and the project manager prepare a project goal. They also identify a number of objectives that will help them reach that goal. The project goals, together with the objectives, determine the scope of the project.

3. (d) i, ii, and iii

Exchange of views between the project manager and the client regarding the objectives of the project will enable them to determine the purpose of the project. It will help the project manager understand the client's expectations and make the client aware of the project manager's method of executing the project.

4. (c) Request – Clarification – Response – Agreement

The list of project deliverables is developed in four stages, namely request, clarification, response, and agreement. In the request stage, the client requests the project manager to undertake a project as per his/her requirements. In the

clarification stage, the project manager explains what he/she has understood by the request made by the client. In the response stage, the project manager explains what he/she can do to fulfill the client's request. In the agreement stage, based on the project manager's response, both the parties continue their discussions and arrive at an agreement.

5. **(b) Project scope**

   Project scope describes all the activities that have to be performed for the successful completion of the project and identifies the resources that will be utilized for the purpose. A project phase is a collection of related project activities, which results in the production of one or more major project deliverables. Project control is the process of collecting information related to the performance of the project system, comparing it with the desired level of performance, and taking corrective action to decrease the gap between the actual and the desired performance levels. A project deliverable refers to any measurable, tangible, verifiable outcome or result that must be produced to complete a project.

6. **(c) Response**

   The list of project deliverables is developed in four stages, namely request, clarification, response, and agreement. In the response stage, the project manager explains what he/she can do to fulfill the client's request. He/she informs the client of his/her capabilities, his/her schedule, and fees for undertaking the project.

7. **(b) the list of project deliverables.**

   The project manager and the client jointly prepare a list of project deliverables. A project deliverable, as defined by the Project Management Body of Knowledge (PMBOK), is 'any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or a part of a project. This list of project deliverables is also called the 'Conditions of Satisfaction.' The other options are wrong.

8. **(d) project overview statement.**

   The list of project deliverables is developed in four stages, namely request, clarification, response, and agreement. In the agreement stage, both parties continue their discussions and arrive at an agreement. If both are still willing to go ahead with the project, they establish the project norms in this step. Finally, both the parties examine each other's requests closely in order to determine how the project should be executed. The final agreement is documented in the 'Project Overview Statement'. A project plan is a formal, approved document used to manage and control project execution. An aggregate project plan is a concise statement of all project activities. A project progress report is a formal statement that gives a comparison between the project progress, accomplishments, and the project plan.

9. (b) Clarification

The list of project deliverables is developed in four stages, namely request, clarification, response, and agreement. In the request stage, the client requests the project manager to undertake a project as per his/her requirements. In the clarification stage, the project manager explains what he/she has understood by the request made by the client. In the response stage, the project manager explains what he/she can do to fulfill the client's request. In the agreement stage, based on the project manager's response, both the parties continue their discussions and arrive at an agreement.

10. (c) The project goal statement should mention specific dates for starting or completing the project.

The project goal forms the purpose of the project and provides guidance to the entire project team. The project goal statement should be specific, measurable, assignable, realistic, and time-related. It should not mention specific dates for starting or completing the project. Time-related information about the project is mentioned in the project objectives of the project overview statement.

11. (d) Both (a) and (c)

The scope of the project is documented in the project overview statement. The project overview statement is also referred to as initial project definition, document of understanding, project scope statement, or statement of work.

12. (c) A POS is a static document that need not be changed, revised, or redefined.

The scope of a project is documented in the project overview statement (POS). A POS is not a static document. As the project progresses, it has to be revised or redefined. The reason behind this is that over time, the scenario may change, and the POS should be documented accordingly.

13. (d) i, ii, iii, and iv

In general, the project overview statement consists of five parts: project problem/opportunity; project goal; project objectives; success criteria; and assumptions, risks, and obstacles. The POS first identifies the reasons for undertaking the project, and then proceeds to identify the project's goal. The project goal is further broken down into a number of project objectives. The POS also mentions the criteria for the success of the project, and the various risks and obstacles involved in the execution of the project.

14. (b) Only i and iii

The first part of a project overview statement (POS) states the problem or opportunities that the project is going to address. This statement need not be defined rigidly. It should be written in such a way that all project stakeholders are able to understand it. Statements regarding the outcome and the time period

of the project are defined in the project objectives of the POS. Statements about the reason for taking up the project are explained in the success criteria of the POS.

15. (b) Only i, iii, and iv

The project manager uses tools like product analysis, cost/benefit analysis, and expert judgment to develop the scope of a project. Product analysis is a technique for understanding the features and functions of a product. Techniques like value analysis and quality function deployment help the project manager gain more information about the project. A cost/benefit analysis is necessary for studying the various tangible and intangible costs and benefits associated with the project. The project manager also consults experts to determine the scope of a project. This technique is called expert judgment. Black box is a technique used to develop creativity in individuals.

16. (a) Only i, ii, and iv

The scope of a project is documented in the project overview statement (POS). The POS should be very specific. A good scope statement would identify the goal of the project and describe how it can be achieved. It should be expressed clearly and precisely so that all the project stakeholders understand what the project is about. A POS is not a static document. As the project progresses, it has to be revised or redefined. POS should describe what the project is, why it is being taken up, and what value it brings to the firm. All future decisions pertaining to the execution of the project and allocation of necessary resources will be based on the POS.

17. (b) defining the project goal.

The project goal is defined on the basis of the problems/opportunities stated in the first part of the project overview statement. The other options are defined or carried out before drafting a project overview statement.

18. (a) Only i, ii, and iii

The scope of a project can be divided into ‘product scope’ and ‘project scope.’ Product scope details all the functions and features that are to be included in a product or service of a project. Project scope details the work to be done to deliver a required product with specific features. The tools and techniques for managing product scope vary with the nature of the project.

19. (c) Cost/benefit analysis

The cost/benefit analysis explains the economic and social justification for the proposed project. Feasibility analysis is conducted to ensure that the proposed project is financially viable. The return on investment is the revenue likely to be generated over the life period of the project against the investments made in it. Break-even analysis is used by the project manager to determine when the project will arrive at a ‘no profit-no loss’ situation.

20. (d) Break-even analysis

Break-even analysis is used by the project manager to determine when the project will arrive at a 'no profit-no loss' situation. Feasibility analysis is conducted to ensure that the proposed project is financially viable. The return on investment is the revenue likely to be generated over the life period of the project against the investments made in it. The cost/benefit analysis explains the economic and social justification for the proposed project.

21. (c) The risk analysis report does not include any mention of the formal procedures to deal with the risks in the project overview statement.

The risk analysis report describes the various risks associated with proposed project activities, their probability of occurrence, and their severity. This analysis also describes risk identification techniques, risk quantification, and other risk control measures. Formal procedures should also be mentioned to effectively deal with these risks in the POS.

22. (d) Assumptions, risks, and obstacles

The project overview statement consists of five parts: project problem/opportunity, project goal, project objectives, success criteria, and assumptions, risks, and obstacles. The assumptions, risks, and obstacles section mentions all the organizational or environmental factors that may affect the outcome of the project. Some of the aspects of projects that are risk prone are technological aspects, environmental aspects, interpersonal aspects, cultural aspects, causal relationships, etc.

23. (c) The revenue likely to be generated over the life period of the project against the investments made in it.

The return on investment is the revenue likely to be generated over the life period of the project against the investments made in it. The return on investment is numerically expressed, which makes it easy for the top management to identify the most profitable project. Actual cost of work performance is the total costs incurred (direct and indirect) in accomplishing work during a given time period. Budgeted cost of work performance is the sum of the approved cost estimates (including any overhead allocation) for activities completed during a given period. Any measurable, tangible, and verifiable outcome or result that must be produced to complete a project is called a project deliverable.

24. (b) iii-ii-vii-i-iv-vi-v

A feasibility analysis is conducted to ensure that the proposed project is financially viable. Following are the steps involved in conducting a feasibility analysis: define the problem/opportunity clearly; define the scope of the project, what it includes and what it does not; identify alternative solutions for the problems; rank the alternative solutions; state the expected

time and costs required; project the profits from the project; and list the recommendations.

25. (d) Both (a) and (b)

Risk analysis and financial analysis reports help managers assess the economic value of the project. The risk analysis report describes the various risks associated with the proposed project activities, their probability of occurrence, and their severity. Financial analysis includes a feasibility analysis, return on investment, a cost/benefit analysis, and a break-even analysis. The critical path method is used in schedule development. It is a network analysis technique used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility.

26. (d) The top management wants the estimates of time and cost to be provided by the project manager in the POS.

After preparing the POS, the project manager sends it to the top management for approval. The top management examines the proposed project to see if it adds any business value to the firm. Approval of the POS indicates that the top management is interested in undertaking the project, that the client feels that the project has been understood and a satisfactory solution offered, and that the top management feels that the project is well defined. Estimates of time and cost are provided later by the project manager during the detailed planning stage.

27. (b) While preparing the PDS, the project manager holds discussions with the project client.

The PDS is similar to the POS, but the people who are involved in the preparation of the statement are different. While preparing the PDS, the project manager holds discussions with the project team members and not the project client. The PDS provides more detailed information about the project as it is used as a reference point by the project team for executing the project.

28. (d) i, ii, iii, and iv

The role of the project manager is crucial. He/she should draft the POS in such a way that the top management can easily understand it. He/she should persuade the management to approve the project. He/she should direct the entire project team and close the project by satisfying the client.

29. (c) Work breakdown structure

The work breakdown structure (WBS) is a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project. Change requests are changes that may expand or shrink the project scope. Performance reports organize and summarize the information gathered and provide information on scope performances.

30. (b) a process that formalizes the acceptance of the project scope by the project stakeholders.

The Project Management Body of Knowledge (PMBOK) has defined scope verification as a process that formalizes the acceptance of the project scope by the project stakeholders. Scope change control is the process of controlling the changes in the project scope that occur at various stages in the project life cycle. Scope planning is the process of developing a scope statement as a basis for all future decisions to be taken on the project. Scope definition involves decomposing the major deliverables into smaller, more manageable components to provide better control.

31. (d) Both (a) and (b)

Change requests can be external as well as internal to the organization. They may contract or expand the scope of the project. Changes in government regulations and new rulings (by the courts) are some of the external events that can change the scope of a project. Errors made in defining a project's product (functions, characteristics, etc.) and errors made in defining the project's scope (using a list of deliverables in place of WBS) are the internal reasons that lead to changes in project scope.

32. (b) Scope change control controls the changes to the project schedule.

Scope change control is the process of controlling the changes in the project scope that occur at various stages of the project life cycle. Scope change control involves managing the factors that cause scope changes to see that the changes are advantageous to the project and identifying the changes in the scope. Scope change control must be integrated with other control processes like time control, cost control, quality control, etc. Schedule control controls the changes to the project schedule.

33. (a) contract files.

Project managers use information collected from various documents to control scope change. These documents include outputs of work breakdown structure, performance reports, and change requests. Contract files are a set of indexed documents developed to include the various documents in the final project records.

34. (c) Scope change control

Scope change control is the process of controlling the changes in the project scope that occur at various stages of the project life cycle. Schedule control has similar functions as scope change control except that it controls changes to the project schedule. Quality control is the process of scrutinizing specific project results in order to check their compliance with quality standards. Risk response control is the process of implementing a risk management plan to address the various risk factors associated with the project.

35. (c) Only ii, iii, and iv

Scope change control is the process of controlling the changes in the project scope that occur at various stages of the project life cycle. Performance techniques like variance analysis, trend analysis, and earned value analysis help the project manager in assessing the magnitude of the variations that occur. Simulation analysis is an advanced technique used for conducting risk analysis.

36. (b) Performance reports

Performance reports organize and summarize the information gathered and provide information on scope performances. Change requests are changes that may expand or shrink the project scope. The work breakdown structure (WBS) is a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project.

Unit 7

Identifying Project Activities

Structure

7.1 Introduction

In the previous unit, we have discussed the management of project scope. In this unit, we will discuss the identification of the project activities. Identifying project activities is an important step in the project planning phase after the project scope statement has been defined. The Work Breakdown Structure (WBS) is a useful tool for the project manager in identifying the project activities. It illustrates how each activity of the project contributes to the whole project in terms of budget, schedule and performance. It also lists the vendors/subcontractors associated with specific activities of the project. Software packages like Microsoft's Project 2000 can generate the WBS automatically.

A WBS is initially developed with the limited data available and subsequently revised when additional information is received. This gives the project manager a clear idea of what the end product of the project will be, and the overall process by which it will be created. Firms follow different approaches to developing work breakdown structures. The decomposition of the activities is continued till the lower activities satisfy some specified criteria. The planned WBS is then communicated to other project members and further modifications are done as and when required.

This unit will deal with the definition of an activity. We will discuss the WBS and its development. We shall then move on to discuss the various tests for completeness of decomposition of activities. Finally, we would be discussing the various approaches to defining deliverables in the WBS, and about representing the WBS.

7.2 Objectives

By the end of this unit, students should be able to:

- Define an activity.
- Explain a work breakdown structure (WBS), and
- Developing a WBS.
- Test for completeness of decomposition of activities.
- Approaches to defining deliverables in the WBS.
- Representing the WBS.

7.3 Activity Definition

An activity is an element of work performed during the course of a project. A project involves a number of interrelated activities. In general, activities share the following characteristics – each activity is of a definite duration; each activity uses resources such as people, materials or facilities; and each activity has a cost associated with it.

A project consists of a series of activities. Every activity of the project has an activity that goes before it, or one that goes after it, and sometimes both. An activity that must be completed immediately before the start of another activity is called a *predecessor activity*. An activity that immediately succeeds another activity and which cannot be started until the earlier one has been completed, is called a *successor activity*. Two activities which are taken up at the same time are called *concurrent activities*. Activity definition involves identification of specific activities that must be performed in order to produce project deliverables.

7.4 Work Breakdown Structure

The Project Management Body of Knowledge (PMBOK) defines work breakdown structure (WBS) as a deliverable-oriented grouping of project activities that organizes and defines the total scope of the project. A *deliverable* is any measurable, tangible, verifiable outcome or result that must be produced to complete a project or part of a project. The WBS helps the project manager to ensure that the project includes all the activities needed, and that the project includes no unnecessary activity.

The breaking down of work into hierarchy of activities and tasks is called *decomposition.* The project goal statement is shown at the top of the WBS as a Level 0 activity. This Level 0 activity is decomposed into Level 1 activities. The completion of all Level 1 activities means completion of Level 0 activity. Similarly an activity at level n is said to be completed when its decomposed activities at Level n+1 are completed.

The decomposition process makes it easy for the project manager to estimate the duration of the activity, the resources required, and the costs incurred. The

decomposition is done to such an extent that each lower activity should satisfy the test of completeness.

7.4.1 Factors Considered in Developing a WBS

The project manager must keep in mind the following issues while designing a WBS:

1. Every activity in the WBS should produce a single tangible deliverable.
2. Every activity at any level of the WBS is an aggregation of all its subordinate activities listed immediately below it.
3. Each activity should be unique and distinct from other activities of the project.
4. The activities should be decomposed logically from higher levels to lower levels.
5. There should be some flexibility in the WBS development process, as the WBS might be updated when the project scope changes.
6. The WBS must specify the important reporting points (e.g., review meetings, monthly reports, test reports etc.) The activities should be compatible with organizational and accounting structures.

Exhibit 7.1 shows the Work Breakdown Structure for a Business Process Modelling (BPM) project.

Exhibit 7.1: Business Process Modelling (BPM) WBS

It is organised by the phases in the BPM project:

Launch - selection of the processes, stakeholder analysis, preparation and planning for the project.

Design - modelling of the as-is processes, measure performance baseline, identify quick wins.

Innovate or Modelling - modelling of the to-be processes, updated business case, detailed plan for future phase, initial organisational change strategy.

Develop or Execution - identfication and configuration of hardware and software required for to-be processes, integration specifications and test scripts.

Implement phase - rollout out new business process model (bpm), marketing, staff training and user acceptance testing.

Realise Value & Monitor phase - Benefits delivery and tracking of progress against towards meeting to-be KPIs, communicate benefits.

Source: Business Process Modelling (BPM) WBS; https://www.stakeholdermap.com/plan-project/bpm-business-process-modelling-wbs.html

7.4.2 Uses of WBS

The uses of WBS are given below:

Thought process tool: The WBS improves the thought process of the project manager and his team by designing the entire project in a structured manner. It helps them to see how the project work can be defined and managed.

Architecture tool: The WBS provides a complete picture of the project and represents how various activities are related to one another.

Planning tool: The WBS provides a series of activities to be performed to complete the project. It helps the project manager estimate resources required and build a schedule for the whole project.

Project status reporting tool: The WBS can also be used as a tool to report the status of the project. Completion of lower level activities implies the completion of the corresponding activities at one level above. Completion of some higher level activities indicates completion of project milestone events and these are reported to the top management and the project client.

Check Your Progress - 1

1. All the given statements are **true** regarding work breakdown structure (WBS) **except**:
   a. WBS is a useful method of schedule development for the project manager.
   b. WBS lists the vendors/subcontractors associated with specific activities of the project.
   c. WBS illustrates how each activity of the project contributes to the whole project in terms of budget, schedule, and performance.
   d. WBS is initially developed with the limited data available and is subsequently revised when additional information is received.
2. _____ involves breaking down of work into a hierarchy of activities and tasks.
   a. Crashing
   b. Decomposition
   c. Fast tracking
   d. Solicitation
3. Identify the step in the project planning phase that immediately follows the defining of the project scope statement.
   a. Financial analysis
   b. Project selection
   c. Project screening
   d. Identifying project activities

4. Which of the following options acts as a planning tool and a project status reporting tool?
   a. Critical path method
   b. Work breakdown structure
   c. Program evaluation and review technique
   d. Graphical evaluation and review technique
5. _____ is an element of work performed during the course of a project.
   a. Event
   b. Node
   c. Slack
   d. Activity
6. Which of the following statements are **not true** with regard to an activity?
   i. An activity is an element of work performed during the course of a project.
   ii. A project involves a number of independent and unrelated activities.
   iii. An activity has a cost associated with it.
   iv. An activity does not have a definite duration.
   a. Only i and ii
   b. Only i and iii
   c. Only ii and iv
   d. Only iii and iv
7. An activity that must be completed immediately before the start of another activity is called
   a. a successor activity.
   b. a predecessor activity.
   c. a concurrent activity.
   d. Both (b) and (c)
8. The work breakdown structure (WBS) helps the project manager ensure that
   i. the project includes all the activities needed.
   ii. the interdependency relationships are identified and documented.
   iii. the project includes no unnecessary activity.
   iv. specific activities are identified that must be performed in order to produce project deliverables.
   a. Only i and ii
   b. Only i and iii
   c. Only ii and iii
   d. Only iii and iv

9. _____ involves identifying specific activities that must be performed in order to produce project deliverables.
    a. Scope planning
    b. Activity definition
    c. Scope definition
    d. Activity sequencing
10. An activity at level n is said to be completed when
    a. All activities are completed.
    b. Its decomposed activities at level n are completed.
    c. Its decomposed activities at level n+1 are completed.
    d. Its decomposed activities at level n-1 are completed.
11. Which of the following is **wrongly** stated as a factor to be considered for developing a work breakdown structure (WBS)?
    a. Each activity should be unique and distinct from other activities of the project.
    b. The activities should be decomposed from lower levels to higher levels.
    c. Every activity in the WBS should produce a single tangible deliverable.
    d. There should be some flexibility in the WBS development process.
12. A successor activity is
    a. An activity that must be completed immediately before the start of another activity.
    b. An activity that immediately follows another activity and which cannot be started until the earlier one has been completed.
    c. An activity taken up at the same time as another activity.
    d. None of the above
13. From the following options, identify the goals of decomposition.
    i. Developing the schedule
    ii. Estimating the duration of the activity
    iii. Estimating the resources required
    iv. Estimating the costs incurred
    a. Only i, ii, and iii
    b. Only i, ii, and iv
    c. Only i, iii, and iv
    d. Only ii, iii, and iv
14. Two activities that are taken up at the same time are called _____ activities.
    a. Predecessor
    b. Successor
    c. Concurrent
    d. None of the above

7.5 Developing a WBS

The process of developing a WBS can be top-down or bottom-up approach.

7.5.1 Top-down Approach

In this approach, the project goal level is decomposed to lower levels until the project manager and his team are satisfied that the work has been sufficiently well defined. The decomposition is continued till the activities of lower level satisfy the test of completeness.

Once all the activities are identified, the project manager ensures that each project activity is described in detail, with the time, cost, material, and labor requirements for each activity being estimated. This is because allocation of resources is easier at the activity level rather than at the project level. The sum of all resources allocated for all project activities provides the total resource requirements for the project.

After the activities are described, the project manager puts them in sequence, so that a schedule can be drawn up for the entire project. The project manager analyzes the dependencies among the various project activities to see how many of the activities can be taken up simultaneously. If some of the activities can be carried out simultaneously, it reduces the total project duration. There are two variations in the top-down approach. These are the team approach and subteam approach.

Team approach: In this approach, the entire project team works on all parts of the WBS. A suitably qualified person is given the responsibility of decomposing each Level 1 activity. As the entire team is involved in developing the WBS, members can take note of discrepancies as and when they occur and take corrective measures.

Subteam approach: In this approach, the planning team is divided into as many subteams as there are Level 1 activities. Each team is led by an expert who decomposes the Level 1 activity assigned to his team, taking into consideration the suggestions made by his team members. The process is continued till each lower level activity of WBS meets the test for completeness of decomposition.

7.5.2 Bottom-up Approach

Here, as in top-down approach, the entire planning team prepares the first level breakdown. Then the team is divided into as many groups as there are Level 1 activities. Each group makes a list of all the activities that must be completed to complete one Level 1 activity. This is done by getting group members to identify different activities and present these to the group. Every activity that the group thinks is appropriate, is put down on a slip of paper. Once all the ideas are exhausted, related activities are grouped together and the final list is submitted to the planning team. The planning team prepares the final work breakdown structure by removing redundant activities and adding missing activities. The drawback in this approach is that the activities are not defined properly.

Activity: The management of Power Oil Ltd., wanted to take up a project of constructing a refinery. The management appointed Surya Narayana as the project manager and asked him to develop the Work Breakdown Structure (WBS) of the project. Narayana, with his team members, prepared the project's goal statement. This project goal was broken down to lower level activities till the entire project work was defined. What kind of approach did Narayana follow to develop the WBS of the project? At what level can the breaking down of the activities be stopped?

Answer:

Exhibit 7.2 depicts project risk and work breakdown structure

Exhibit 7.2: Project Risk and WBS

For projects that are likely to be exposed to higher risks, the WBS should be very detailed. Each activity faces a different kind of risk and so the project manager must identify the nature and level of risk that is likely to arise for each project activity. Certain risks are specific to certain activities. For instance, breakdown risk is specific to machinery and equipment. An activity like the documentation of expenses does not face such a risk. Any negligence in dealing with these risks will have a detrimental effect on the project.

The WBS, by breaking down the project activities, helps identify and mitigate several risks. For instance, the risk involved in the activity of getting permits from the regulatory authorities is high. Since it affects several other WBS activities, the project manager has to analyze its impact on all the other WBS activities. To effectively deal with the risks involved in the project activities, the project manager defines a risk plan that describes the contingency activities that must succeed the risk affected activities.

Some of the questions that the project manager must answer while considering the project risk for each WBS activity are:

- Is the technology changing faster than the pace of the project? Can the project include the latest technological innovations?
- Will the quality of the project activities be evaluated through testing and inspection?
- Does the firm have enough manpower, facilities and resources to produce the required deliverables?
- Have the risks of social pressures, government approval, understanding among team members been identified?

.Source: ICFAI Research Center

7.6 Test for Completeness of Decomposition of Activities

Preparing an appropriate WBS is of critical importance in planning the project. The project manager should ensure that no unnecessary activity is included in the WBS and that all the activities that are necessary to meet the ultimate project goals are included.

The decomposition of the project activities should be continued till all the lower level project activities fulfill the following conditions.

1. The activity must be measurable
2. It must have clearly defined start/end events
3. It must have a clear deliverable
4. The time/cost of the activity must be measurable
5. The duration of the activity must be in acceptable limits
6. The activity must be independent

If any activity does not satisfy all the six conditions, it should be further decomposed. The criteria for completeness are discussed in greater detail below.

7.6.1 Measurable

The project manager can ask for the current status of an activity anytime during the project. So, the status of the activity should be easy to measure. Let us assume the transportation activity in a building construction project takes 15 days, if 5 trucks are engaged. Assuming that the trucks are at equal capacity, the extent of completion of the activity can be measured at any point of time. The measure of the activity's completion is the proportion of the work completed for a given time period.

7.6.2 Bounded

Each activity should have clearly distinguishable start and end events. Once the start event has occurred, the project manager assumes that the activity has begun. The deliverable should result once the last event occurs. For example, the printing activity of a book starts when papers are loaded into the printing machine and it is completed once all the printed papers are collected. If the activity is not properly bounded, then the activity has to be further decomposed.

7.6.3 Deliverable

Every activity, on completion, should produce a result or outcome. The deliverable is a visible proof of the completion of an activity. The outcome could be a document, or a physical product. The next activity can be started only when the predecessor activity produces the desired outcome.

7.6.4 Simplicity in Estimating Cost/Time

Every activity in a WBS should have an estimated time and cost of completion. By dividing the activities into lower level activities, a project manager can arrive at reasonably accurate cost and time estimates for all the activities listed in the

WBS. If it is difficult to estimate the cost/ time of an activity, it should be further broken down.

7.6.5 Acceptable Duration Limit

In general, the duration of an activity is kept less than two weeks. Even for big projects, the activities are decomposed further till each activity has an acceptable duration. In the case of repetitive operations, further decomposition of activities is not required. For example, if we want to produce 1000 units and it requires a time period of 10 weeks, the activity need not be further broken down into five activities with each activity producing 200 units. But long durations for activities is not recommended, as a delay in that activity can seriously disturb the entire project schedule.

7.6.6 Activity Independence

Each activity in the project should be independent. Once the work on an activity begins, it should be amenable to being continued till completion, without need for additional inputs and information. However, an activity can be scheduled in parts on the basis of resource availability.

The WBS is decomposed to such a level that the lower level activities should allow for the effective planning, control, and performance measurement. In order to plan for adequate resources, the project manager examines the following details:

- Is all the work planned for an activity capable of producing the required deliverable?
- Is it practically feasible to manage the individual work assignments with the WBS structure?
- What kind of an approach is to be adopted for identifying project activities: a top-down approach or a bottom-up approach?
- How will work be assigned to an individual and controlled to receive the required deliverables?
- How will the budgets be allocated for each project activity? How are the budgets proposed for the increments of work?
- How will the status of the project work activity be determined?

Check Your Progress - 2

15. Decomposition of the project activities should be continued till all the lower level project activities fulfill certain conditions. Some of these conditions are:
    i. The activity must be measurable.
    ii. The activity must be dependent on the other activities.
    iii. The activity must have a clear deliverable.
    iv. The duration of the activity must be within acceptable limits.

a. Only i, ii, and iii
b. Only i, iii, and iv
c. Only ii, iii, and iv
d. i, ii, iii, and iv

16. Which of the following statements is **true** regarding the top-down and bottom-up approaches of developing a work breakdown structure (WBS)?
    a. Activities are clearly defined in the bottom-up approach.
    b. In the top-down approach, the project goal level is decomposed to lower levels until the project manager and his/her team are satisfied that the work has been sufficiently well defined.
    c. Team approach and sub-team approach are variations in the bottom-up approach.
    d. All of the above

7.7 Approaches to Defining Deliverables in the WBS

There are several approaches to defining the deliverables and building the WBS for a project. The three main types of approaches are noun-type approaches, verb-type approaches and organizational approaches.

7.7.1 Noun-type Approaches

There are two types of noun type approaches used in developing a WBS. They are i) physical decomposition, and ii) functional decomposition.

Physical Decomposition

In this approach, the deliverables of the project work are defined in terms of physical components that make up the deliverable. For example, in a project for manufacturing a lathe machine, the project will involve the manufacture of physical components like gears, gear belts, motor, machine base, fixtures, supporting blocks, shafts, cutting tools and dimension scales. All these components are to be produced to make the end product and the WBS will represent the manufacture of all the above physical components. The project manager can use Gantt charts that depict the duration of each activity as rectangular bars. The length of the rectangular bar represents the duration of each project activity and these are arranged in proper sequence.

Functional Decomposition

In the functional noun-type approach, the same cutting machine project is built on the functional requirements of the machine like manufacturing of gear system, conveyor system, motor system, work piece rotating system and dimension checking system. The WBS lists the functions to be performed to produce the end product.

7.7.2 Verb-type Approaches

The verb-type approach defines the project deliverables in terms of the actions to be performed to produce them. The 'design-build-test-implement' approach and 'objectives' approach are the two types of verb- type approaches.

Design-Build-Test-Implement Approach

Assume a project that has to produce an innovative cutting machine. Here, all the features that are to be added to the current cutting machine are designed, built, tested and then implemented. Gantt charts are drawn that have lengths corresponding to the duration of each design, build, test and implement stage of the project.

Objectives Approach

The project manager reports completion of project activity on the basis of attainment of some project objectives. The objective approach is similar to the design-build-test-implementation approach and is used when progress reports are to be prepared at various stages of the project. Clear-cut objectives are set for each activity and the progress in meeting these objectives is measured. But setting objectives and measuring their completion levels is difficult.

7.7.3 Organizational Approaches

Organizational approaches define project deliverables in terms of organizational units. Geographical, departmental, and business functional approaches are the important organizational approaches.

Geographical Approach

If the project is dispersed geographically, then the project work is partitioned geographically. For example, a National Highway construction project requires construction activity at different locations simultaneously. So, the project is divided according to locations and any of the noun or verb- type approaches is used at each location.

Departmental Approach

In the departmental approach, the project work is first divided department wise. Any other approach can be used later in each department. Complex projects undertaken by a single firm usually follow the departmental approach at the earlier stages. Resource allocation becomes simpler this way, as each department will take care of the work assigned to it.

Business Functional Approach

According to this approach, the project work is divided based on business functional areas. The project work is divided into several business processes and an appropriate approach is followed for each process later. This approach has same uses that of departmental approach, but the difficulty in this process lies in integrating all the deliverables from various processes.

Activity: The management of Midwest Automobiles Ltd., decided to launch a bike with tubeless tyres and disk brakes on both front and rear wheels, which ensured more safety. The concept was developed by the firm's R&D department. The management appointed Gauri Prasad as the project manager. As part of his planning, Prasad wanted to define the deliverables of the project by developing the work breakdown structure of the project. What are the different types of approaches that Prasad can use to build a WBS?

Answer:

7.8 Representing the WBS

Work Breakdown Structures can be represented in different ways. Whatever the structure type, the project goal that states the purpose of the project has to be written at the top. Then it is divided into various activities, called Level 1 activities. The activities that do not satisfy the test for completeness are further divided into several activities again and they are called Level 2 activities. The process is continued till all the activities satisfy the six criteria for completion, described earlier.

Whatever is the type used for representation, the main issue in representing the WBS is to know whether the work required to achieve the desired outcome and meet the project objectives has been captured in enough detail to identify the resources, assign the responsibilities, and set the activities in sequence. Following Exhibit 7.3 shows the generic WBS for a telecom project.

Exhibit 7.3: WBS for a Telecom Project

1.0 CONCEPT/FEASIBILITY

1.1 Develop Concept/Marketing Plan

1.2 Conduct Market Analysis

1.3 Conduct Technical Analysis

1.4 Develop Prototype

1.5 Prepare Product Development Plan/ Cost/ Schedule

2.0 REQUIREMENTS

2.1 Develop End-User Requirements

2.2 Develop Application Requirements

2.3 Develop Infrastructure (Systems) Requirements

2.4 Develop Operations /Maintenance Requirements

2.5 Develop Service Requirements

Contd….

3.0 DECISION

3.1 Present Prototype

3.2 Present Financial Statements & Time Schedule

3.3 Present Technical Capabilities

3.4 Obtain Financial Commitment

3.5 Go/ No-Go Decision (Milestone)

4.0 DEVELOPMENT

4.1 Develop End-User Systems

4.2 Develop Application

4.3 Develop Infrastructure Systems and Network

4.4 Develop Operations/Maintenance Structure

4.5 Develop Service Plan

5.0 TEST

5.1 Develop Test Plans for Each Aspect/ Element

5.2 Conduct Tests

5.3 Validate Results

5.4 Perform Corrective Action (as necessary)

5.5 Conduct Retesting

5.6 Revalidate Results

6.0 DEPLOY

6.1 Conduct a Trial Test

6.2 Conduct First Live Test

6.3 Complete Deployment

7.0 LIFE CYCLE

7.1 Conduct Customer Training & Education

7.2 Obtain Customer Acceptance

7.3 Perform Support & Maintenance

Source: ICFAI Research Center

Check Your Progress - 3

17. Identify the approach which is **not** used to define the deliverables and build the work breakdown structure for a project.
    a. Noun-type approach
    b. Verb-type approach
    c. Dividend capitalization approach
    d. Organizational approach

18. From the following, identify the verb-type approaches that are used to define project deliverables.
    i. The objectives approach
    ii. The departmental approach
    iii. The business functional approach
    iv. The design-build-test-implement approach
    a. Only i and ii
    b. Only i and iv
    c. Only ii and iii
    d. Only iii and iv
19. Physical decomposition and functional decomposition are used to develop a work breakdown structure. These are
    a. Noun-type approaches
    b. Verb-type approaches
    c. Organizational approaches
    d. NONE of the above
20. All of these are organizational approaches used to define project deliverables **except**
    a. The business functional approach.
    b. The functional decomposition approach.
    c. The geographical approach.
    d. The departmental approach.
21. Identify the approach that is used to define the project deliverables in terms of the actions to be performed to produce them.
    a. Noun-type approach
    b. Verb-type approach
    c. Organizational approach
    d. Departmental approach
22. SafeQuip is a two-wheeler manufacturing company, specializing in the manufacture of environment-friendly vehicles. The company has taken up a project to manufacture an environment-friendly car. The project manager of the company has developed a work breakdown structure that represents the manufacture of components like internal combustion engine, braking system, battery, gear box, doors, tires, etc. All these components have to be manufactured in order to make the car. Which of the following approaches has the project manager used to define the project deliverable?
    a. The business functional approach
    b. The physical decomposition approach
    c. The functional decomposition approach
    d. The design-build-test-implement approach

23. In which of the following approaches are the deliverables of the project defined in terms of the components that make them up?
    a. The business functional approach
    b. The departmental approach
    c. The physical decomposition approach
    d. The functional decomposition approach

7.9 Summary

- An activity is an element of work performed during the course of a project. A project involves a number of interrelated activities.
- Activities generally, share the following characteristics – each activity is of a definite duration; each activity uses resources such as people, materials or facilities; and each activity has a cost associated with it.
- The Project Management Body of Knowledge defines work breakdown structure (WBS) as a deliverable-oriented grouping of project activities that organizes and defines the total scope of the project.
- A deliverable is any measurable, tangible, verifiable outcome or result that must be produced to complete a project or part of a project.
- The WBS helps the project manager to ensure that the project includes all the activities needed, and that the project includes no unnecessary activity. The process of developing a WBS can be top-down or bottom-up approach.
- The criteria for completeness of decomposition of activities are that an activity should be measurable, bounded, deliverable, simple in estimating cost and time, should have an acceptable duration limit, and be independent.
- There are several approaches to defining the deliverables and building the WBS for a project. The three main types of approaches are: noun-type approaches, verb-type approaches, and organizational approaches.
- WBSs can be represented in different ways. Whatever the type of representation, the main issue in representing the WBS is to know whether the work required to achieve the desired outcome and meet the project objectives has been captured in enough detail to identify the resources, assign the responsibilities, and set the activities in sequence.

7.10 Glossary

Activity Definition: Identifying the specific activities that must be performed in order to produce the various project deliverables.

Deliverable: Any measurable, tangible, verifiable outcome, or result that must be produced to complete a project.

Work Breakdown Structure: A deliverable-oriented grouping of project activities that organizes and defines the total scope of the project.

7.11 Self-Assessment Exercises

1. A project involves a number of interrelated activities. Define an activity.
2. Identifying project activities is an important step in the project planning phase, which can be done with the help of a work breakdown structure (WBS). Define a WBS. What factors should be considered while designing a WBS? How is a WBS useful for a project manager?
3. The process of developing a WBS can be top-down or bottom-up approach. Explain these approaches in detail. What are the various ways in which a WBS can be represented?
4. While preparing a WBS, it is important that the project manager should ensure that no unnecessary activity is included in the WBS, and that all the necessary ones are included. How can the project manager ensure that all the activities are decomposed completely?
5. There are several approaches to defining the deliverables and building the WBS for a project. What are these approaches? Describe them in detail.

7.12 Suggested Readings/Reference Material

1. Prasanna Chandra, “Projects,” Mcgraw Hill, Seventh Edition, 2017
2. James Wood, Kory Kogon, and Suzette Blakemore, Project Management for the Unofficial Project Manager: A Franklin Covey Title, Goodreads, 2018
3. HEAGNEY, Fundamentals of Project Management Paperback, Amacom, September 2018
4. Na, Nagarajan, Project Management 8/Ed, New Age International Publications, 2019
5. IES Master Team,,ESE 2020 - Basics of Project Management Paperback – 1 IES Master Publication, January 2019
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7.13 Answers to Check Your Progress Questions

Following are the answers to the Check Your Progress questions given in the Unit.

1. (a) WBS is a useful method of schedule development for the project manager

WBS is a useful tool for the project manager in identifying the project activities, and not for schedule development. It lists the vendors/subcontractors associated with specific activities of the project. It also illustrates how each activity of the project contributes to the whole project in terms of budget, schedule, and performance. A WBS is initially developed with the limited data available and is subsequently revised when additional information is received.

2. (b) Decomposition

The breaking down of work into a hierarchy of activities and tasks is called decomposition. Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. In fast tracking, the project manager attempts to reduce the project duration by doing project activities in parallel. Solicitation is the process of gathering information in the form of bids, quotations, and proposals from qualified vendors to satisfy the project needs.

3. (d) Identifying project activities

Identifying project activities is the step in the project planning phase that immediately follows the defining of the project scope statement. After a pool of project ideas has been generated, the project manager screens the ideas. Once the project ideas have been screened, they are evaluated for marketability and technical and financial feasibility. After all these stages, a project idea is chosen for implementation from the available alternative project ideas.

4. (b) Work breakdown structure

The work breakdown structure (WBS) acts as a planning tool. It provides a series of activities to be performed to complete the project. It helps the project manager to estimate the resources required and build a schedule for the whole project. The WBS can also be used as a tool to report the status of the project. Completion of lower level activities implies the completion of the corresponding activity at one level above. Completion of some higher level activities indicates completion of project milestone events and these are reported to the top management and the project client. The critical path method, program evaluation and review technique, and graphical evaluation and review technique are used by the project manager to develop schedules.

5. (d) Activity

An activity is an element of work performed during the course of a project. An event is a time-oriented reference point that signifies the start or end of an activity. It is also called a node. Slack is the difference between the latest event time and earliest event time.

6. (c) Only ii and iv

An activity is an element of work performed during the course of a project. A project involves a number of interrelated activities. Each activity is of a definite duration. Each activity uses resources such as people, materials, or facilities. Each activity has a cost associated with it.

7. **(b) A predecessor activity.**

   A project consists of a series of activities. An activity that must be completed immediately before the start of another activity is called a predecessor activity. An activity that immediately succeeds another activity and which cannot be started until the earlier one has been completed is called a successor activity. Two activities which are taken up at the same time are called concurrent activities.

8. **(b) Only i and iii**

   The work breakdown structure (WBS) is a deliverable-oriented grouping of project activities that organizes and defines the total scope of the project. It helps the project manager ensure that the project includes all the activities needed and excludes any unnecessary activity. Activity sequencing is the process of identifying and documenting interdependency relationships. Activity definition involves identifying specific activities that must be performed in order to produce project deliverables.

9. **(b) Activity definition**

   Activity definition involves identifying specific activities that must be performed in order to produce project deliverables. Scope planning is the process of developing a scope statement as a basis for all the future decisions to be taken on the project. Scope definition involves grouping all major project outputs into more manageable components so as to improve the accuracy of cost, time, and resource estimations; defining a standard for measuring performance; and controlling and assigning responsibilities. Activity sequencing is the process of identifying and documenting interdependency relationships.

10. **(c) Its decomposed activities at level n+1 are completed.**

    An activity at level n is said to be completed when its decomposed activities at level n+1 are completed. That is, an activity at level 0 is said to be completed only when an activity at level 1 is completed.

11. **(b) The activities should be decomposed from lower levels to higher levels.**

    The project manager should consider the following factors while designing a WBS – the WBS should produce a single tangible deliverable; each activity should be unique and distinct from other activities of the project; the activities should be decomposed logically from higher levels to lower levels; there should be some flexibility in the WBS development process, etc.

12. **(b) An activity that immediately follows another activity and which cannot be started until the earlier one has been completed.**

    A project consists of a series of activities. An activity that immediately succeeds another activity and which cannot be started until the earlier one has

been completed is called a successor activity. An activity that must be completed immediately before the start of another activity is called a predecessor activity. Two activities which are taken up at the same time are called concurrent activities.

13. (d) Only ii, iii, and iv

The decomposition process makes it easy for the project manager to estimate the duration of the activity, the resources required, and the costs likely to be incurred. Schedule development is concerned with determining a realistic start and finish time for project activities. Some of the methods used for schedule development are: critical path method, program evaluation and review technique, and graphical evaluation and review technique.

14. (c) Concurrent

A project consists of a series of activities. Two activities which are taken up at the same time are called concurrent activities. An activity that must be completed immediately before the start of another activity is called a predecessor activity. An activity that immediately succeeds another activity and which cannot be started until the earlier one has been completed is called a successor activity.

15. (b) Only i, iii, and iv

The decomposition of the project activities should be continued till all the lower level project activities fulfill the following conditions – the activity must be measurable; the activity should have a clearly defined start/end events; the activity must have a clear deliverable; the time/cost of the activity must be measurable; the duration of the activity must be in acceptable limits; and the activity must be independent.

16. (d) In the top-down approach, the project goal level is decomposed to lower levels until the project manager and his/her team are satisfied that the work has been sufficiently well defined.

In the top-down approach of developing a WBS, the project goal level is decomposed to lower levels until the project manager and his/her team are satisfied that the work has been sufficiently well defined. The decomposition is continued till the activities of the lower level satisfy the test of completeness. Activities are not properly defined in the bottom-up approach. The team approach and sub-team approach are variations in the bottom-up approach.

17. (c) Dividend capitalization approach

There are three main approaches that are used to define the deliverables and build the work breakdown structure for a project. These are the noun-type approach, the verb-type approach, and the organizational approach. The dividend capitalization approach is used for calculating the cost of external equity.

18. (b) Only i and iv

The verb-type approach defines the project deliverables in terms of the actions to be performed to produce them. The design-build-test-implement approach and the objectives approach are the two types of verb-type approaches. The departmental approach and business functional approach are types of organizational approaches.

19. (a) Noun-type approaches

Physical decomposition and functional decomposition are noun-type approaches used in developing a work breakdown structure. In the physical decomposition approach, the deliverables of the project work are defined in terms of the physical components that make them up. In functional decomposition, the deliverables of the project work are defined in terms of the functions that are required to be performed to produce the end product.

20. (b) The functional decomposition approach.

Organizational approaches define project deliverables in terms of organizational units. Geographical, departmental, and business functional approaches are organizational approaches. The functional decomposition approach is a noun-type approach.

21. (b) Verb-type approach

The verb-type approach defines the project deliverables in terms of the actions to be performed to produce them. The design-build-test-implement approach and the objectives approach are verb-type approaches. The departmental approach is a type of organizational approach. In this approach, the project work is first divided department-wise. Any other approach can be used later in each department. Complex projects undertaken by a single firm usually follow the departmental approach at the earlier stages. Resource allocation becomes simpler this way, as each department will take care of the work assigned to it.

22. (b) The physical decomposition approach

The project manager of SafeQuip has developed the work breakdown structure by defining the components used to create the deliverable. This approach of defining the deliverables of the project work in terms of physical components that make up the deliverable is called as the physical decomposition approach. According to the business functional approach, the project work is divided based on business functional areas. In functional decomposition, the deliverables of the project work are defined in terms of the functions that are required to be performed to produce the end product. In the design-build-test-implement approach, all the features that are to be added to the project deliverable are designed, built, tested, and then implemented.

23. (c) Physical decomposition approach

In the physical decomposition approach, the deliverables of the project work are defined in terms of the physical components that make them up. According to the business functional approach, the project work is divided based on business functional areas. In the departmental approach, the project work is first divided department-wise — later any other approach can be used in each department. In functional decomposition, the deliverables of the project work are defined in terms of the functions that are required to be performed to produce the end product.

Unit 8

Activities: Sequencing, Estimating Duration, and Scheduling

Structure

8.1 Introduction

In the previous unit, we have discussed how to identify the project activities. In this unit, we will discuss how to sequence activities, estimate their duration, and schedule them. After the project activities are identified, they are represented in a project network diagram. The project manager sequences the project activities, estimates the duration and then schedules the activities. The project manager sequences the project activities by understanding the dependencies among them. He prepares the duration estimates of each project activity with the help of duration estimates from other projects, historical information, expert advice, etc.

The project manager schedules the project activities to estimate the start and finish dates of each project activity, to arrive at the duration of the project. He can take help from two important techniques: Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) to schedule the project. Schedule control deals with the study of factors that influence and change the project schedules. It aims at managing changes to complete the project within the estimated schedule.

This unit will deal with the fundamentals of the project network diagram. We will discuss activity sequencing and activity duration. We shall then move on to discuss schedule development and the various techniques for schedule development. Finally, we would be discussing schedule control.

8.2 Objectives

By the end of this unit, students should be able to:

- Understand the fundamentals of project network diagram.
- Define activity sequencing and activity duration.
- Know about the techniques for schedule development.
- Define schedule control.

8.3 Fundamentals of Project Network Diagrams

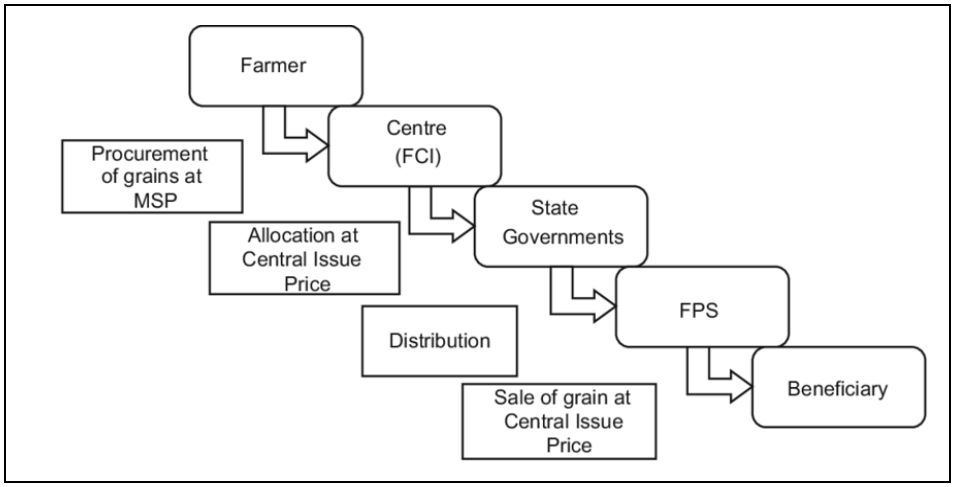
According to the Project Management Body of Knowledge (PMBOK), a project network diagram is a schematic representation of the project activities and the logical relationships (dependencies) among them. The diagram helps the project manager in sequencing, scheduling and controlling the project. It represents all the project activities, the sequence in which they have to be performed, the duration of each activity, the interdependencies among various activities and the criticality (significance) of each activity.

The project network diagram helps the project manager in project planning by detailing the project activities, estimating the required resources, and displaying the inter-relationships among activities. The diagram helps to determine the start and end dates of each activity during scheduling and it also provides insights into possible trade-offs while controlling the project. A good project network diagram should answer the following questions:

1. What is the estimated completion time of a project?
2. How does a delay in an activity affect the expected completion time?
3. How can the expected completion time of a project be reduced, if additional resources are available?

Exhibit 8.1 shows the network diagram for India's Public Distribution System

Exhibit 8.1: Network Diagram of Public Distribution System



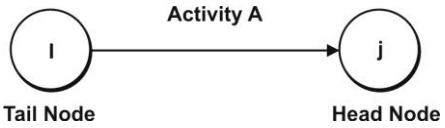
Source: ICFAI Research Center

8.3.1 Activity and Node

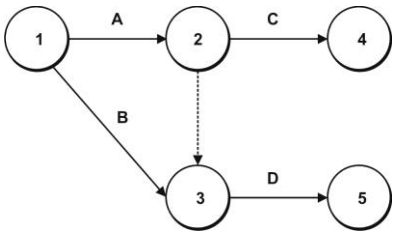
The project network diagram is represented by a series of activities and nodes. An activity is a specific task or operation required to do a project. It is depicted by an arrow. A node (also called an event), is a time oriented reference point that signifies the start or end of an activity. It is represented by a circle.

The difference between an activity and a node is that the activity represents the passage of time and the nodes are points in time that denote the starting or ending of a specific activity. In the diagram, activity A is represented with i and j as the starting and ending nodes. The activity can also be written as i –j. Event i is called the tail event and event j is called the head event.

Dummy activity: An activity of zero duration that is used to represent the logical relationship in the network diagram is called a dummy activity. Dummy activities do not consume any resources, but are used to maintain the proper precedence relationship between the activities that are not connected by the nodes. It is represented by a dashed line headed by an arrow.



For example, in a project, A and B are concurrent activities. Activity C is dependent on A and activity D is dependent on both A and B. Then the project manager uses a dummy activity X to represent the relationship between activity A and activity D.



8.3.2 Dependencies in the Project Network Diagram

A dependency is a relationship that exists between a pair of activities. There are four types of activity dependencies that describe the relationship between any pair of activities. They are finish to start, start to start, start to finish and finish to finish.

Finish to Start

Finish to start dependency states that activity A must be completed before activity B can begin. If activity A is obtaining raw material and activity B is inspecting the raw material, then activity B can be performed only after the completion of activity A. Therefore, the dependency is finish to start.

Start to Start

Start to start dependency states that activity B can be started only if activity A has begun. This can be explained with the help of the previous example – that is the inspection activity can be started and continued once the raw materials start coming. Subsequently, both activities go on in parallel.

Start to Finish

Start to finish dependency states that activity B must start before activity A can finish. For example, if a firm wants to develop a new information system to replace the existing one, the firm has to confirm that the new system is well operating. When the new system starts to work (activity B), the existing system can be discontinued (activity A).

Finish to Finish

Finish to finish dependency states that activity A must finish before activity B finishes. For example, data feed operation (activity B) cannot be finished until the collection of data (activity A) is completed.

Activity: John Robertson, the project manager-in-charge of construction of a hospital, identified the following project activities: selecting the administrative staff, selecting the site, selecting the equipment, designing a layout, bringing them to the site, recruiting the medical staff and other support staff, purchasing medical equipment, constructing the hospital, installing the equipment, developing an information system and training the support staff to use it. To construct a project network diagram, Robertson needs to know the dependencies among various activities of the project. What is a dependency? What are the different types of dependencies? Explain the dependencies among various activities of the project.

Answer:

Check Your Progress - 1

1. In a certain project, collection of data is an activity and the entry of data into an information system is another activity. The activity of data entry cannot end until the collection of data is completed. This is an example of
   a. Finish to start dependency.
   b. Start to finish dependency.
   c. Finish to finish dependency.
   d. Start to start.

2. A dummy activity in a project network diagram represents the _____ in the network diagram.
   a. Necessary time delays
   b. Logical relationship
   c. Allocation of resources
   d. Crashing of an activity
3. Given here is a list of activities that have to be carried out after the project activities have been identified. Identify the **correct** sequence of these activities.
   i. The project manager schedules the project activities to estimate the start and finish dates of each project activity to arrive at the duration of the project.
   ii. The project manager prepares duration estimates of each project activity with the help of duration estimates from other projects, historical information, expert advice, etc.
   iii. The project manager sequences the project activities by understanding the dependencies among them.
   a. ii-i-iii
   b. i-iii-ii
   c. iii-ii-i
   d. iii-i-ii
4. Which of the following is a schematic representation of project activities and the logical relationships or dependencies among them?
   a. Control chart
   b. Project network diagram
   c. Work breakdown structure
   d. None of the above
5. _____ is a specific task or operation required to do a project.
   a. Event
   b. Node
   c. Slack
   d. Activity
6. An activity can also be represented as ‘i-j’. ‘i’ is called the _____ and ‘j’ is called as the _____.
   a. Tail event, head event
   b. Head event, tail event
   c. Head event, dummy activity
   d. Dummy activity, tail event

7. A dummy activity is one that has
   a. Zero duration.
   b. The lowest duration.
   c. The highest duration.
   d. None of the above
8. In a project network diagram, j denotes
   a. The starting node.
   b. An activity.
   c. The ending node.
   d. BOTH (a) and (c)
9. In a project network diagram, a node is
   a. A time-oriented reference point that signifies the start or end of an Activity.
   b. Represented by an arrow.
   c. A specific task or operation required to do a project.
   d. Also called as a float.
10. Which of the following statements **correctly** differentiates between an activity and a node?
    a. An activity is represented by a circle while a node is represented by an arrow.
    b. An activity represents the passage of time while the nodes are points in time that denote the starting or ending of a specific activity.
    c. An activity is a time-oriented reference point that signifies the start and end of a node while a node is an element of work performed during the course of a project.
    d. All of the above
11. Consider two activities – A and B. Start to start dependency between these two activities states that
    a. Activity B must start before activity A can finish.
    b. Activity A must finish before activity B finishes.
    c. Activity B can be started only if activity A has begun.
    d. Activity A should be completed before activity B can begin.
12. Activity B must start before activity A can finish. This is called
    a. Start to start dependency
    b. Start to finish dependency
    c. Finish to finish dependency
    d. Finish to start dependency

13. Identify the statements that are **true** regarding a dummy activity.

    i. A dummy activity is an activity of zero duration that is used to represent the logical relationship in the network diagram.

    ii. Dummy activities do not consume any resources.

    iii. Dummy activities are used to maintain the proper precedence relationship between the activities that are not connected by the nodes.

    iv. Dummy activities are represented by circles in a project network diagram.

    a. Only i, ii, and iii

    b. Only i, iii, and iv

    c. Only ii, iii, and iv

    d. i, ii, iii, and iv

14. Identify the statement that is **not true** regarding a project network diagram.

    a. A project network diagram is a schematic representation of the project activities and the logical relationships among them.

    b. The project network diagram helps the project manager in sequencing, scheduling, and controlling the project, but does not explain how a delay in an activity affects the expected completion time.

    c. The project network diagram represents all the project activities, the sequence in which they have to be performed, the duration of each activity, the interdependencies among various activities, and the criticality of each activity.

    d. The project network diagram helps to determine the start and end dates of each activity during scheduling, but does not provide insights into the possible trade-offs while controlling the project.

15. In a project, activity A should be completed before activity B can begin. This is called

    a. Finish to start dependency.

    b. Start to finish dependency.

    c. Finish to finish dependency.

    d. Start to start.

16. In a project network diagram, a node is also called a/an _____.

    a. Activity

    b. Event

    c. Slack

    d. None of the above

8.4 Activity Sequencing

Once the project activities are identified using the work breakdown structure, the project manager prepares an activity list of the project. He puts all the activities down in a logical sequence to arrive at the project end-product. Several project management software packages like Project 2000 provide sequencing of activities to achieve the project end product. While sequencing the activities, the project manager has to study various aspects such as the description of the end product, mandatory and discretionary dependencies among the activities, external dependencies, other constraints and assumptions of the project.

While analyzing the product description, the project manager has to consider the physical characteristics of the product and the logical sequencing of the activities to achieve the end product. The product description is generally less detailed in early phases of the project and it is progressively elaborated later.

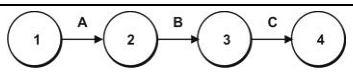
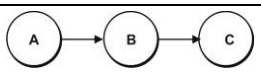
The project manager analyzes the mandatory and discretionary dependencies among the various project activities. Mandatory dependencies are those that are inherent in the nature of project. Here, the dependency between activities is certain. For example, new machinery is erected only when the layout has been finalized. Mandatory dependency is also called as 'hard logic'. Therefore the dependency among the activities is mandatory. Discretionary dependencies are those dependencies of the project that are defined by the project team. Discretionary dependencies are defined by the knowledge of the best practices and the standard procedures followed for certain activities in the project. This dependency is also called as 'soft logic' or 'preferred logic.'

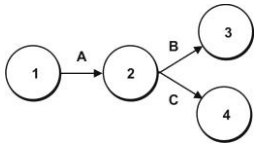
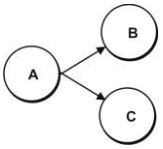
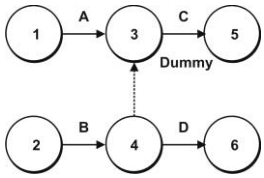
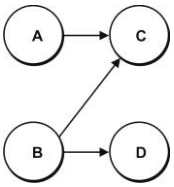
The project manager also has to analyze the dependencies among project activities with external activities. For example, voter identity cards should be distributed before the elections. Therefore, the activity of holding elections is dependent on the distribution activity. The sequencing of activities is also affected by several other constraints and assumptions made by the project manager regarding the project.

8.4.1 Methods of Activity Sequencing

The project manager considers all the above issues to sequence the project activities. The project manager sequences all the project activities in an appropriate manner and represents them in the project network diagram. Some of the methods of activity sequencing are given below. Figure 8.1 represents the various activity relationships in ADM and PDM methods.

Figure 8.1: Activity Relationships in ADM and PDM Methods

ADM	PDM	Activity Relationship
		A precedes B which precedes C

		B and C cannot begin until A has been completed
		C cannot begin until both A and B have been completed. D cannot begin until B has been completed

Arrow Diagram Method (ADM)

In this method, the network diagram is constructed using arrows to represent the activities and connecting them at nodes to show the dependencies. This method uses finish-to-start dependencies only to explain the logical relationships. This method is also called as Activity-On-Arrow (AOA) method.

Precedence Diagram Method (PDM)

In this method, the network diagram is constructed using nodes to represent the activities and connecting them with arrows to represent the dependencies. This method uses all four types of dependencies. This method is also called as Activity-On-Node (AON) method.

Conditional Diagramming Methods

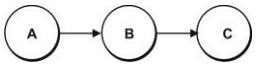
The project manager also uses conditional diagramming methods like GERT (Graphical Evaluation and Review Technique) and system dynamics that represent non-sequential activities like loops (where activities are repeated again and again) or conditional branches (e.g. a design update is required only when errors are found in the inspection). PDM and ADM cannot represent loops and conditional branches.

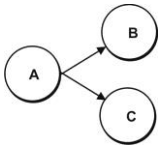
Activity: The project of installing milling machines involves activities A, B, C and D. Raghavendra, the project manager, identifies the relationship among the activities: activities B and C cannot begin until activity A has been completed; activity D cannot begin until activities B and C have been completed. How can he represent these relationships in a project network diagram using the Arrow Diagram Method (ADM) and Precedence Diagram Method (PDM)?

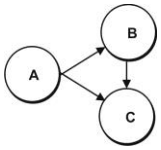
Answer:

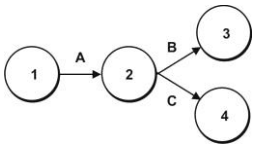
Check Your Progress - 2

17. In a certain project, activity B and activity C cannot begin until activity A has been completed. How is this activity relationship represented using the activity-on-arrow method of activity sequencing?

a. 

b. 

c. 

d. 

18. Discretionary dependencies are
    i. Those dependencies among project activities that are inherent in the nature of the project.
    ii. Those dependencies among project activities that are defined by the project team.
    iii. Those dependencies among project activities that are certain or mandatory.
    iv. Also called preferred logic.
    a. Only i and ii
    b. Only i and iii
    c. Only ii and iv
    d. Only iii and iv
19. Which of the following aspects should the project manager consider while analyzing the product description?
    i. The physical characteristics of the product
    ii. The dependencies among the various project activities
    iii. The logical sequencing of the activities to achieve the end product
    iv. The dependencies among the project activities with external activities
    a. Only i and iii
    b. Only i and iv
    c. Only ii and iii
    d. Only iii and iv

20. Which conditional diagramming method represents non-sequential activities like loops and conditional branches to sequence project activities?
    a. The Arrow Diagram Method (ADM)
    b. The Precedence Diagram Method (PDM)
    c. The Graphical Evaluation and Review Technique (GERT)
    d. All of the above
21. The arrow diagram method
    a. Is also called activity-on-node method.
    b. Makes use of all the four types of dependencies.
    c. Involves constructing the network diagram using arrows to represent Activities and connecting them at nodes to show the dependencies.
    d. Involves constructing the network diagram using nodes to represent the activities and connecting them with arrows to represent the dependencies.
22. _____ are dependencies that are inherent in the nature of the project.
    a. Preferred logic
    b. Mandatory dependencies
    c. Discretionary dependencies
    d. Both (a) and (b)
23. Which of the following statements are **true** regarding the precedence diagram method used to sequence activities?
    i. The precedence diagram method is also called activity-on-arrow method.
    ii. The network diagram is constructed using nodes to represent the activities and connecting them with arrows to represent the dependencies.
    iii. All the four types of dependencies – start to start, start to finish, finish to start, and finish to finish, are used.
    a. Only i and ii
    b. Only i and iii
    c. Only ii and iii
    d. i, ii, and iii
24. From the following options, identify the methods/techniques used for activity sequencing.
    i. Arrow diagram method
    ii. Critical path method
    iii. Precedence diagram method
    iv. Program evaluation and review technique
    a. Only i and ii
    b. Only i and iii
    c. Only ii and iv
    d. Only iii and iv

25. Which of the following aspects should the project manager keep in mind while sequencing the activities to achieve the project's end product?
    i. Description of the end product
    ii. Mandatory and discretionary dependencies among the activities
    iii. External dependencies
    iv. Constraints and assumptions of the project
    a. Only i and ii
    b. Only i, iii, and iv
    c. Only ii, iii, and iv
    d. i, ii, iii, and iv

8.5 Activity Duration

After the project activities are sequenced, the project manager estimates the duration of each activity to calculate the duration of the entire project. The duration of an activity is the time period required to complete the activity. As it is not possible for a person to work continuously, the project manager may include some time allowance while estimating activity duration. He assigns these allowances based on his experience, the difficulty involved in the activity, the ability of the workman to execute it, etc. It is assumed that an average performer completes an activity in the estimated duration with his normal performance.

The activity duration is not synonymous with work effort. Suppose an activity takes 30 days to complete, we cannot assume that the effort is made for 30 days, even though the activity duration is 30 days. For example, if the activity is to consult an external expert for the given problem, the actual consultation time is only about 3 hours, but the duration assigned for the activity will be about 30 days considering the time required to find the expert, discuss the matter and solve the problem.

Activity duration could also be influenced by the amount of resources allocated. Generally speaking, more the resources, the shorter the duration of the activity. For example, if more number of people are included to work on a project, then the project can be completed on or before time. However, it cannot be assumed that the relationship between activity duration and resources allocated is completely proportional. Thus, the project manager has to allocate more resources till the *crash point* is arrived at. Beyond this point, it is not possible to reduce the duration of an activity.

The actual duration of activities may vary from the estimates. Therefore, the project manager has to see to it that there is as little deviation as possible. The different skill levels of manpower employed, unexpected events like acts of nature, vendor delays, power failures, or misunderstanding the nature of work are some of the causes for variations of actual activity durations from the estimates.

8.5.1 Methods of Estimating Activity Duration

The project manager uses the techniques given below to estimate the appropriate duration of the project activities.

Similarity to Other Activities

Some project activities may be similar to activities in other projects. In such cases, the estimates of activity duration can be taken from those activities. This is normally followed in case of administration activities that are common for all projects.

Historical Data

The actual durations of successful projects in the past can be used to estimate the duration of the activity. Larger firms maintain an extensive database of activity duration history that records the estimated time, actual time, reasons for time overrun (if there was one), characteristics of the activity, the skill levels of the people, etc. Whenever firms wish to assign duration estimations, they refer to historical data and find the duration estimate and actual time.

Expert Advice

In case of highly technical activities, the project manager can consult a technical expert to estimate the activity duration. He can also consider the advice of vendors and other non-competing firms to assign the duration estimates.

Delphi Method

In this method, the project manager forms a group of people and asks them to estimate the duration of an activity, after describing the nature and characteristics of the activity. The estimates of each participant are then collected. Those participants whose estimations are very high or very low are asked to explain the reasons for their estimates.

The project manager then discusses with all the group members to know why their estimates are higher or lower than estimates of the other participants. He then asks the participants to write down new estimates of duration after the discussion. This process continues until the entire group arrives at a particular estimate. In general, this method is followed when expert advice is not available.

Three- Point Method

The duration of an activity may vary even when the same activity is repeated in similar conditions. Therefore the project manager considers three types of estimates in this method.

They are:

1. Optimistic time
2. Pessimistic time
3. Most Likely time

Optimistic time (t_0)

Optimistic time is the minimum amount of time within which an activity can be completed. It is possible to complete an activity within the optimistic time only when the external environment is extremely favorable.

Pessimistic time (t_p)

Pessimistic time is the maximum amount of time required to complete an activity. This happens when the external environment is unfavorable.

Most Likely time(t_m)

It is the time that is the best guess for an activity completion – neither optimistic nor pessimistic.

Expected time (t_e)

The project manager arrives at the 'expected time' based on the above estimates. The project manager calculates the estimate of duration of an activity as,

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

The expected time of an activity cannot be more than the pessimistic time of that activity. However, it can be more than the optimistic time. The expected time of an activity is more than, less than, or equal to the most likely time of that activity.

Wide Band Delphi Method

A combination of the Delphi method and the three point method is referred to as the Wide Band Delphi method. In this method, the members are asked to give an optimistic time, a pessimistic time, and the most probable time, instead of a single estimate. Then the project manager follows the Delphi method and determines the duration estimate.

Check Your Progress - 3

26. Which of the following time is **not** included in calculating the variance of a project?
    a. Optimistic time
    b. Pessimistic time
    c. Most likely time
    d. None of the above
27. The _____ refers to a point beyond which it is not possible to reduce the duration of an activity.
    a. node
    b. slack

c. free float

d. crash point

28. If a, b, c are the optimistic, pessimistic, and most likely times of an activity, then the variance of the activity is calculated as

a. $\frac{(c-a)^2}{36}$

b. $\frac{(a-c)^2}{36}$

c. $\frac{(b-c)^2}{36}$

d. $\frac{(b-a)^2}{36}$

29. The duration of a project activity can be estimated by:

i. Taking estimates of duration of similar activities in other projects.

ii. Taking the actual durations of successful projects in the past.

iii. Consulting a technical expert to estimate activity duration.

iv. Forming a group of people and asking them to estimate the duration of the activity after describing the nature and characteristics of the activity.

a. Only i, ii, and iii

b. Only i, iii, and iv

c. Only ii, iii, and iv

d. i, ii, iii, and iv

30. Identify the method of estimating the duration of an activity in which the members are asked to give an optimistic time, a pessimistic time, and the most probable time, instead a single estimate.

a. Expert advice

b. Delphi method

c. Three-point method

d. Wide Band Delphi method

31. Match the following types of estimates with their descriptions.

i. Optimistic time

ii. Pessimistic time

iii. Most likely time

p. The maximum amount of time required to complete an activity

q. The time that is the best guess for an activity completion

r. The minimum amount of time within which an activity can be completed

a. i/q, ii/r, iii/p

b. i/r, ii/p, iii/q

c. i/q, ii/p, iii/r

d. i/r, ii/q, iii/p

32. If a, b, and c represent optimistic time, most likely time and pessimistic time of an activity respectively, then the expected time of an activity is calculated as

a. $\frac{a+b+c}{6}$

b. $\frac{a+4b+c}{6}$

c. $\frac{4a+b+c}{6}$

d. $\frac{a+b+4c}{6}$

33. Which of the following statements is **not true** about the expected time of an activity?

a. It can be more than the optimistic time of that activity.

b. It can be less than the most likely time of that activity.

c. It can be more than the pessimistic time of that activity.

d. It can be more than the most likely time of that activity.

Exercise

A. The optimistic, pessimistic, and most likely times of an activity are 5 days, 12 days, and 7 days, respectively. Calculate the expected time of an activity.

8.6 Schedule Development

Schedule development is concerned with determining a realistic start and finish time for project activities. It aims to match project resources like machinery, materials and labor with project activities over time. Good scheduling eliminates production problems, facilitates timely procurement of raw materials, and ensures project completion on time. Otherwise, it may lead to delays in project activity, loss of inventory and cost overruns.

The project manager should be aware of the resources and the quantity of these resources needed at every stage of the project. He has to prepare a 'resource pool description' that contains details of all the project resources and their allocation to project activities.

The project manager prepares two types of calendars; project calendars and resource calendars to schedule the project. Project calendars emphasize the

completion time of the project activities. Suppose it is estimated that the project is to be completed in 7,200 hours in normal working conditions. Then schedules are prepared based on the time estimates. The project manager assumes that 60% of the project is accomplished, if 4,320 hours are spent on the project. Most of the projects are scheduled based on project calendars.

Resource calendars schedule the project on the basis of the resources used. The focus here is on scheduling and utilizing specific resources effectively. For example, a construction project requires 1200 bags of cement. If 360 bags have been used, the project manager can assume that 30% of the work has been done. Here, the project manager concentrates on whether the specific resources are being used effectively or not. Project calendars are concerned with how various project resources are consumed over a period of time. Resource calendars deal with how a specific resource or specific category of resources is spent over a period of time.

8.7 Techniques for Schedule Development

The project manager can use some of the following methods for schedule development:

1. Critical Path Method (CPM)
2. Program Evaluation and Review Technique (PERT)
3. Graphical Evaluation and Review Technique

These methods are used:

1. To estimate the completion time of the project
2. To find out if the project is behind, ahead of or on schedule.
3. To compare the actual resources spent with the planned resources at any stage of the project.
4. To study activities that are critical for project completion and activities that can be delayed without delaying project completion.
5. The project network diagram is used in schedule development.

8.7.1 Construction of a Network Diagram

Before assigning the duration estimates, the project manager sequences all the activities and then gives numbers to all nodes.

Numbering Nodes

Step 1: Assign the starting event as '0'.

Step 2: Assign the next number to any unnumbered event whose predecessor events are already numbered.

Repeat *Step 2* until all events are numbered.

The basic scheduling computations of a project can be grouped under three heads: Forward pass, backward pass, and calculation of floats.

Forward Pass

The forward pass computation finds the earliest start and earliest finish times for each activity; or the earliest expected occurrence time for each node. The computation starts with an assumed earliest occurrence time of zero for the initial project event.

The earliest starting time for activity (i,j) is the earliest event time of the tail event. i.e. $ES_{ij} = E_i$.

The earliest finish time for activity (i,j) is the earliest starting time plus the activity duration, t_{ij}

i.e, $EF_{ij} = ES_{ij} + t_{ij}$

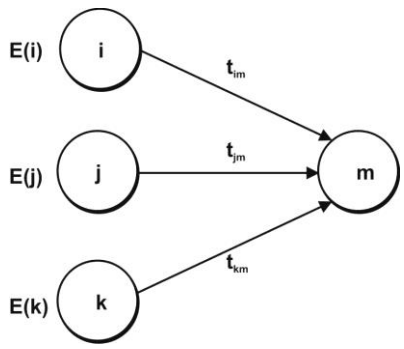
Event is just a time oriented reference point. Events will have only the earliest time and latest time. The earliest time is obtained in the forward pass, and the latest time is obtained in the backward pass. But every activity will have earliest start time, earliest completion time in forward pass and latest start time and latest finish time in backward pass.

Suppose an activity A is connected between two events i and j, and duration of the activity is 5 units of time. Then the earliest start time of activity A is 0 and the earliest completion time is 5. Also, the earliest time of event i is 0, and the earliest time of event j is 5.

Earliest event time for event j is the maximum of earliest finish time of all activities leading into that activity.

E_j= Maximum $\{E_i + t_{ij}\}$.

Consider the network diagram, where three activities are leading into event 'm.'



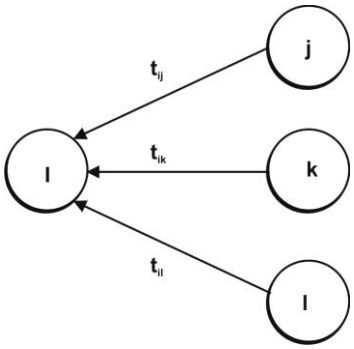
Here, the earliest event time at 'm', is the maximum of the earliest finish times of all the activities ending into that activity.

Thus, E_m is the maximum of

$\{(ES_{im} + t_{im}), (ES_{jm} + t_{jm}),$ and $(ES_{km} + t_{km})\}$

Backward Pass

The backward computation finds the latest start and completion times of each activity without affecting the total project duration. Here the calculation starts at the 'end' node and ends with the 'first' node. The total project duration is taken as the latest time of the end node.



Latest finish time for activity (i,j) is the latest event time of event j. i.e., $LF_{ij} = L_j$

Latest starting time for activity (i,j) is the difference between the latest completion time of (i,j) and the activity duration. i.e., $LS_{ij} = LF_{ij} - t_{ij}$

Latest event time for event i is the minimum of the latest start time of all activities starting from that the event i.

L_i = Minimum $\{LF_{ij} - t_{ij}\}$.

Consider the network diagram, where three activities are beginning at the event i.

The latest event time of event i is calculated as:

Minimum of $\{(LF_{ij} - t_{ij}), (LF_{im} - t_{im}), (LF_{il} - t_{il})\}$

Calculation of Floats

There are three types of floats. They are:

1. Total float
2. Free float
3. Independent float

Total Float

This is the amount of time by which the completion of an activity can be delayed beyond its expected earliest completion time without affecting the overall project duration. It is calculated as the difference between the latest start time and the earliest start time of a project activity.

Total float= $LS_{ij} - ES_{ij}$

$= (L_j - t_{ij}) - ES_{ij}$

$= (L_j - E_i) - t_{ij}$

Free Float

This is the amount of time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.

Free float= Earliest event time of event j – Earliest event time for event i – activity time (i,j)

$$= (E_j - E_i) - t_{ij}$$

Independent Float

This is the amount of time by which the start of an activity can be delayed without affecting the earliest start of any activities following immediately.

Independent float= $(E_j - L_i) - t_{ij}$

Event Slacks

For an event, slack is the difference between the latest event time and earliest event time. For an event i, slack = $L_i - E_i$

For an activity (i, j), the slack of event j is called head slack, and the slack of event i is called tail slack.

Head slack = $L_j - E_j$

Tail slack = $L_i - E_i$

The values of free float and independent float can be expressed in terms of head and tail slacks.

Free float = $E_j - E_i - t_{ij}$

$= L_j - E_i - t_{ij} - (L_j - E_j)$

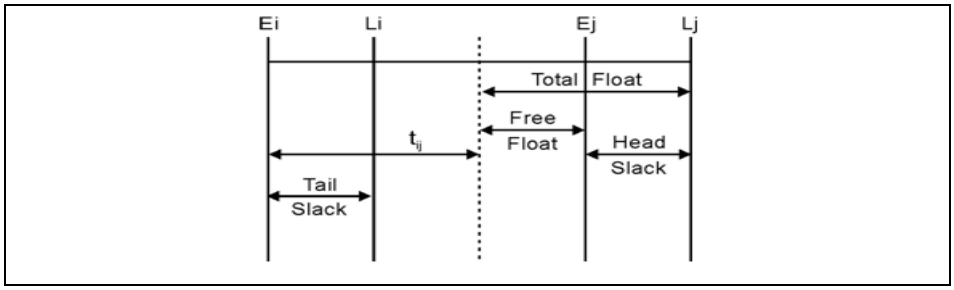
= Total float – Head slack

Independent float = $(E_j - L_i) - t_{ij}$

$= E_j - E_i - t_{ij} - (L_i - E_i)$

= Free float – Tail slack

The Various floats and slacks of an activity (i,j) can be represented in the following manner:



Example 8.1

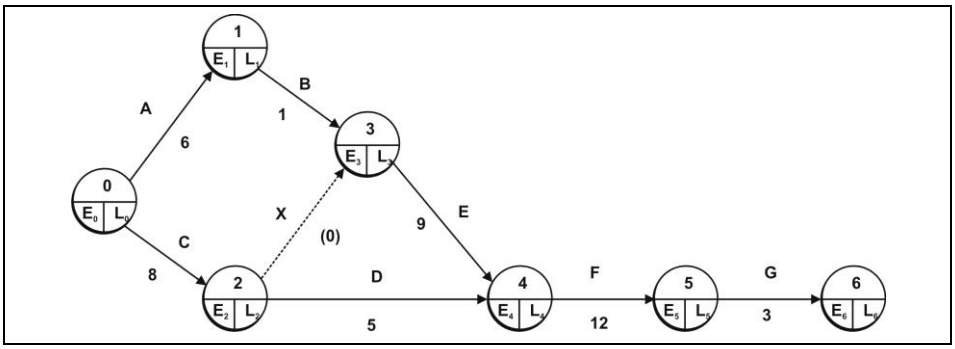
Suppose a project has seven activities A, B, C, D, E, F, and G. The predecessor activity (ies) of a particular activity and duration estimates of all project activities are given in Table 8.1.

Table 8.1: Project Activities and Duration Estimates

	Predecessor Activity	Duration
A	---	6
B	A	1
C	---	8
D	C	5
E	B, C	9
F	D, E	12
G	F	3

The network diagram for the given project activities is shown in Figure 8.2 (a). Here, activity X is a dummy activity. Each node is assigned a certain number that is written on the top half of the circle. The earliest completion time is represented on the bottom left and the latest completion time on the bottom right of the circle.

Figure 8.2 (a): Project Network Diagram



Note: ----------→ *X is a dummy activity*

The network is depicted using the Activity-On-Arrow method.

The earliest and latest event times are to be calculated now, in order to complete the project network diagram and fill in the Earliest Time (E_i) and Latest Time (L_i) (for each node) in Table 8.2 (a).

Let us assume that the unit of time is 'days'.

Forward Pass Computation: To determine the Earliest Time (E_i) of each event (node) from 0 to 6.

For Event 0, Earliest Time, $E_0 = 0$.

Since Event 0 simply signifies the start of the project, E_0 will always be 0.

("The computation starts with an assumed earliest occurrence time of zero for the initial project event.")

For Event 1, $E_1 = 0 + 6 = 6$.

Event 1 can occur as soon as Activity A is completed. Activity A starts at Event 0 and takes 6 days for completion [Refer to Table 8.1 or Figure 8.2(a)].

So, earliest occurrence of Event 1

= Earliest occurrence of Event 0 + Duration of Activity A

$= E_0 + 6 = 0 + 6 = 6$ days.

("Earliest event time for event j is the maximum of earliest finish time of all activities leading into that event.")

Using formula, this is represented as, $E_1 = E_0 + t_A = 0 + 6 = 6$ days.

Similarly, $E_2 = E_0 + t_C = 0 + 8 = 8$ days, as Event 2 can occur as soon as Activity C is completed.

Event 3 denotes the situation that Activity E can start. For this, predecessor activities B and C should be over (Refer Table 8.1). From the project network diagram, this can also be viewed as the condition that activity B and dummy activity X (which follows Activity C) should be over.

Earliest completion of Activity B = E_1 + Time taken by Activity B = 6 + 1 = 7 days.

Earliest completion of Activity C = E_0 + Time taken by Activity C = 0 + 8 = 8 days.

(From the project network diagram, earliest completion of dummy activity X = $E_2 + 0 = 8 + 0 = 8$ days.)

So, earliest event time of Event 3 = E_3 = Max (7, 8) = 8 days.

("Earliest event time for event j is the maximum of earliest finish time of all activities leading into that event.")

Using formula, the above calculation is represented as;

$E_3 = \text{Max}\ [(E_1 + t_B), (E_2 + t_X)] = \text{Max}\ [(6 + 1), (8 + 0)] = 8$ days.

Similarly, $E_4 = \text{Max}\ [(E_3 + t_E), (E_2 + t_D)] = \text{Max}\ [(8 + 9), (8 + 5)] = 17$ days.

$E_5 = E_4 + t_F = 17 + 12 = 29$ days.

$E_6 = E_5 + t_G = 29 + 3 = 32$ days.

Table 8.2 (a): Earliest and Latest Times

Node	Earliest Time	Latest Time
0	0	0
1	6	7
2	8	8
3	8	8
4	17	17
5	29	29
6	32	32

Backward Pass Computation: To determine the Latest Time (L_i) of each event (node) from 0 to 6. Here, Node 6 represents project completion. The backward pass is done, "without affecting the total project duration." That is, the earliest occurrence of the last node in the network is also taken as the latest occurrence of that node. Therefore,

$L_6 = E_6 = 32$ days.

Now, we work backwards from Event 6, following the two rules given below:

When a node is the starting point (tail) for only one activity (e.g., nodes 1, 3, 4, 5), the latest time for the node is the latest start time of the activity starting from that event. This is computed as the difference between the latest event time of the head node and the activity duration.

That is,

$L_5 = L_6 – t_G = 32 – 3 = 29$

$L_4 = L_5 – t_F = 29 – 12 = 17$

$L_3 = L_4 – t_E = 17 – 9 = 8$

When an event (node) is the starting point of two (or more) activities, as in node 0 or node 2; the latest time for the node is the minimum of the latest start times of the activities starting from the event. This is mathematically represented below.

$L_2 = \text{Min } [(L_3 – t_X), (L_4 - t_D)] = \text{Min } [(8 - 0), (17 - 5)] = 8$ days.

$L_1 = L_3 – t_B = 8 – 1 = 7$ days.

$L_0 = \text{Min } [(L_1 – t_A), (L – t_C)] = \text{Min } [(7 - 6), (8 - 8)] = 0$ days.

Calculation of Floats:

Total float:

For activity A, the total float is,

$(L_i – E_j) – t_{ij} = (7 – 0) – 6 = 1.$

For activity B, the total float is = (8– 6) – 1= 1.

For activity C, the total float is = (8– 0) – 8 = 0.

Similarly, total float values can be determined for all the activities.

Free float:

For activity A, the free float is,

Total float – Head slack = 1 – (7 – 6) = 0.

For activity B, the free float is, 1 – (8 – 7) = 0.

For activity C, the free float is, 0 – (8 – 8) = 0.

Similarly, free float values can be determined for all the activities.

Independent float:

For activity A, the independent float is,

Free float – Tail slack = 0 – (0 – 0) = 0.

For activity B, the free float is, 1 – (7 – 6) = 0.

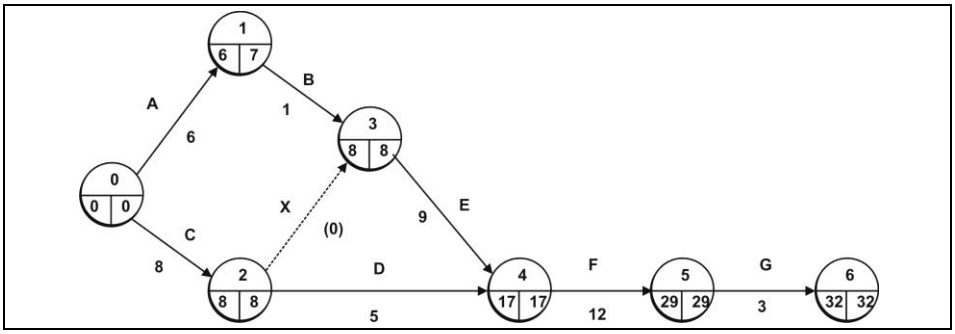
For activity C, the free float is, 0 – (0 – 0) = 0.

Similarly, independent float values can be determined for all activities.

Table 8.3 (a): Floats of the Project Activities

Activity	Duration	Total Float $(L_i - E_j) - t_{ij}$	Free Float (Total Float – Head Slack)	Independent Float (Free Float – Tail Slack)
A	6	1	0	0
B	1	1	0	0
C	**8**	**0**	**0**	**0**
X	**-**	**0**	**0**	**0**
D	5	4	4	4
E	**9**	**0**	**0**	**0**
F	**12**	**0**	**0**	**0**
G	**3**	**0**	**0**	**0**

Figure 8.2 (b): Project Network Diagram



The critical path of the project is the longest path through the network. The length of the critical path gives the shortest allowable time for the completion of the project. This helps the project manager to concentrate and prioritize critical activities while allocating project resources.

From Figure 8.2 (b) and Table 8.2 (b), the critical path is C – X – E – F – G (indicated in the figure by thick arrows). Therefore, the project takes at least 32 time units (8+0+9+12+3=32) for completion.

Table 8.3: Floats of the Project Activities

Activity	Duration	Total Float $(L_j - E_i) - t_{ij}$	Free Float (Total Float – Head Slack)	Independent Float (Free Float – Tail Slack)
A	6	1	0	0
B	1	1	1	0
C	8	0	0	0
D	5	4	4	4
E	9	0	0	0
F	12	0	0	0
G	3	0	0	0
X	-	0	0	0

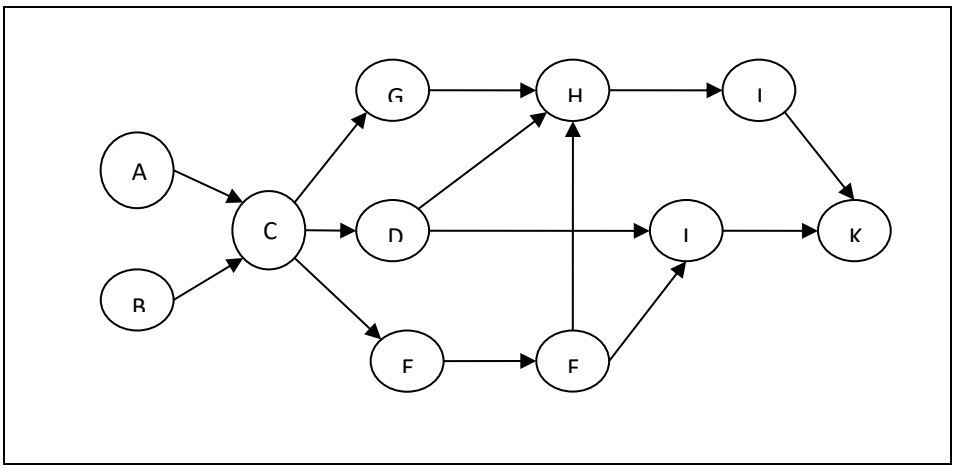
Exhibit 8.2

Suppose a project has eleven activities A, B, C, D, E, F, G, H, I, J and K. The immediate predecessor activities of a particular activity and duration estimates of all project activities are given in Table 8.1.

Activity	Immediate Predecessor	Duration (in weeks)
A	---	3
B	---	5
C	A, B	2
D	C	6
E	C	5
F	E	3
G	C	4
H	D, G, F	3
I	D, F	4
J	H	2
K	I, J	2

The network diagram for the given project activities is shown in Figure 8.3 (a). Here, each node is assigned activity that is written in centre of the circle. The earliest completion time is represented on the bottom left and the latest completion time on the bottom right of the circle.

Figure 8.3 (a): Project Network Diagram



The network is depicted using the Activity-on-Node method.

The earliest start and latest finish times are to be calculated now, in order to complete the project network diagram and fill in the Earliest Start Time (EST) and Latest Start Time (LST) (for each node/Activity) in Table 8.3 (a).

Given unit of time is 'weeks'.

Forward Pass Computation: It is the process of tracing the network from start to end. It provides earliest start time and earlier finish times. To determine the Earliest Start Time (EST) of each activity (node) from A to K.

For Activity A, Earliest Start Time (EST) = 0.

Since Activity A simply signifies the start of the project, EST will always be 0.

("The computation starts with an assumed earliest occurrence time of zero for the initial project event.")

For Activity A, Earliest Start Time is 0.

Activity B can occur as soon as Activity A is completed. Activity A starts at 0 and takes 3 weeks for completion [Refer to Table 8.1 or Figure 8.3 (a)].

So, earliest finish time for activity A

= Earliest occurrence of Activity A + Duration of Activity A (Time)

= EST + 3 = 0 + 3 = 3 weeks.

("Earliest event time for event j is the maximum of earliest finish time of all activities leading into that event.")

Using formula, this is represented as, EST for Activity B = EST + t_B = 0 + 5 = 5 weeks.

Similarly, EST for Activity C = EST (Largest time from previous predecessor) + t_C (Duration) = 5 + 2 = 7 weeks, as Activity D can occur as soon as Activity C is completed.

Activity C denotes the situation that Activity C can start. For this, predecessor activities A and B should be over (Refer Table 8.1). From the project network diagram, this can also be viewed as the condition that activity A and activity B (which follows Activity C) should be over.

Earliest finish Time of Activity B = EST + Time taken by Activity B = 0 + 5 = 5 weeks.

Earliest finish Time of Activity C = EST + Time taken by Activity C = 5 + 2= 7 weeks.

So, earliest finish time of Activity C = EST = Max (3, 5) = 5 weeks.

("Earliest event time for event j is the maximum of earliest finish time of all activities leading into that event.")

Using formula, the above calculation is represented as;

Table 8.3 (b): Earliest Start and Earliest Finish Times

Activity/Node	Earliest Start Time	Earliest Finish Time
A	0	3
B	0	5
C	5	7

D	7	13
E	7	12
F	12	15
G	7	11
H	15	18
I	15	19
J	18	20
K	20	22

EST for activity C = Max [(EST for Activity A + t_A), (EST for Activity B + t_B)] = Max [(0 + 3), (0 + 5)] = 5 weeks.

EST for Activity D = 7 weeks

EST for Activity E = 7 weeks

Similar calculation is required for Activity D to K.

Backward Pass Computation: To determine the Latest Finish Time (L_i) of each activity (node) from A to K. Here, Activity K represents project completion. The backward pass is done, "without affecting the total project duration." That is, the earliest occurrence of the last activity in the network is also taken as the latest occurrence of that Activity. Therefore,

Latest Finish Time (LFT) for Activity K = 22 weeks.

Now, we work backwards from activity K, following the two rules given below:

When a node is the starting point (tail) for only one activity (e.g., nodes A, B, G, E, I, J), the latest time for the node is the latest start time of the activity starting from that activity. This is computed as the difference between the latest event time of the head node and the activity duration.

That is, Latest Start Time (LST) for Activity J = LFT – Activity Task Time (t_K)

Latest Start Time (LST) for Activity J = 22-2= 20 weeks

Latest Start Time (LST) for Activity I = 22-2= 20 weeks

When an activity (node) is the starting point of two (or more) activities, as in node F or node D or node C; the latest time for the node is the minimum of the latest start times of the activities starting from the event. This is mathematically represented below.

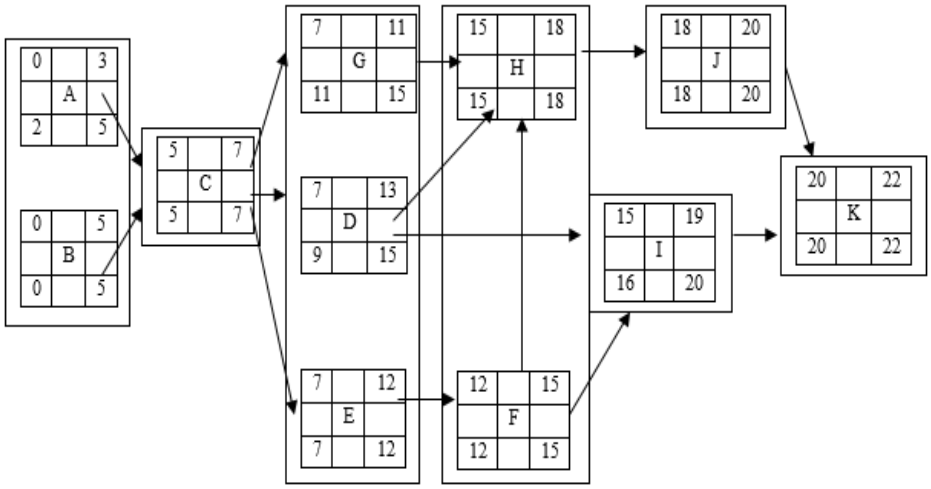
Latest Finish Time (LST) for Activity F= Min [(LFT for activity I – t_I), (LFT for activity H – t_H)]

Latest Finish Time (LST) for Activity F= Min [(20 - 4), (18 - 3)] = 15 weeks.

Latest Finish Time (LST) for Activity D= Min [(20 - 4), (18 - 3)] = 15 weeks.

Latest Finish Time (LST) for Activity C= Min [(15 - 4), (15 - 6), (12 – 7)] = 7 weeks.

Figure 8.3 (b): Project Network Diagram



Source: ICFAI Research Center

The critical path of the project is the longest path through the network. The length of the critical path gives the shortest allowable time for the completion of the project. This helps the project manager to concentrate and prioritize critical activities while allocating project resources.

From Figure 8.3 (b) and Table 8.4 (a), the critical path is B – C – E – F – H –J – K. Therefore, the project completion time is 22 weeks (5+2+5+3+3+2+2=22)

Table 8.4 (a): CPM with all Activities

Activity/Node	Duration	Earliest Start Time (EST)	Earliest Finish Time (EFT)	Latest Start Time (LST)	Latest Finish Time (LFT)	Slack (LST-EST)	Critical Path
A	3	0	3	2	5	2	-------
B	5	0	5	0	5	0	Yes
C	2	5	7	5	7	0	Yes
D	6	7	13	9	15	2	-----
E	5	7	12	7	12	0	Yes
F	3	12	15	12	15	0	Yes
G	4	7	11	11	15	4	-----
H	3	15	18	15	18	0	Yes
I	4	15	19	16	20	1	-----
J	2	18	20	18	20	0	Yes
K	2	20	22	20	22	0	Yes

Check Your Progress - 4

34. The project manager develops the project schedule on the basis of the raw materials consumed in a project. What type of schedule development calendar is this?

    a. Project calendar
    b. Resource calendar
    c. Resource pool description
    d. None of the above

35. Methods like the critical path method, the program evaluation and review technique, and the graphical evaluation and review technique are used to:

    i. Estimate the completion time of the project
    ii. Find out if the project is behind, ahead of, or on schedule.
    iii. Compare the actual resources spent with the planned resources at any stage of the project.
    iv. Study activities that are critical for project completion and activities that can be delayed without delaying project completion.

    a. Only i, ii, and iii
    b. Only i, iii, and iv
    c. Only ii, iii, and iv
    d. i, ii, iii, and iv

36. Match the following types of floats with their descriptions.

    i. Total float
    ii. Free float
    iii. Independent float

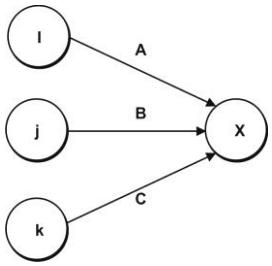
    p. The amount of time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.
    q. The amount of time by which the start of an activity can be delayed without affecting the earliest start of any activities following immediately.
    r. The amount of time by which the completion of an activity can be delayed beyond its expected earliest completion time without affecting the overall project duration.

    a. i/p, ii/r, iii/q
    b. i/r, ii/p, iii/q
    c. i/q, ii/r, iii/p
    d. i/r, ii/q, iii/p

37. Which of the following statements is **not correct** for an activity in a project network diagram?
    a. Total float is the difference between the latest start time and the earliest start time of a project activity.
    b. Slack is the difference between the latest event time and earliest event time.
    c. Free float is the difference between total float and head slack.
    d. Independent float is the difference between total float and tail slack.
38. Which of the following methods is **not** used for developing schedules?
    a. The Critical Path Method
    b. The Work Breakdown Structure
    c. The Program Evaluation and Review Technique
    d. The Graphical Evaluation and Review Technique
39. For an activity (i, j), the difference between the latest finish time and the earliest finish time represents
    a. Head slack.
    b. Tail slack.
    c. Activity duration.
    d. Total float.
40. Identify the techniques used for scheduling the project.
    i. Black box
    ii. Critical path method
    iii. Realized yield method
    iv. Program evaluation and review technique
    a. Only i and ii
    b. Only i and iii
    c. Only ii and iv
    d. Only iii and iv

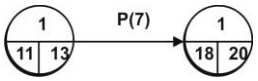
Exercises

B. A project network diagram has three activities – A, B, and C. All these activities lead into event ‘x’.



The earliest start times of activities A, B and C are 3 days, 5 days, and 7 days, respectively. The duration estimates of these activities are 5 days, 7 days, and 11 days, respectively. What would be the earliest event time at X?

C. The earliest start, earliest finish, latest start and latest finish times of an activity P are given below: The duration of activity P is 7 units. What is the total float, free float and independent float of activity P?



D. The earliest start, earliest finish, latest start and latest finish times of an activity A are given below: The duration of activity A is 8 units. What is the total float of activity A?

8.7.2 Critical Path Method (CPM)

Critical Path Method is a network analysis technique used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility. In this method, the project manager identifies the critical activities of the project that constitute the critical path of the project.

Critical activities are those activities whose total float value is '0'. This means, any delay in the critical activity results in a delay in the entire project to the same extent. The project manager identifies a series of critical activities from the beginning of the project to its completion. The series of critical activities is called the '*critical path*' of the project.

The critical path of the project is the longest path through the network. The length of the critical path gives the shortest allowable time for the completion of the project. This helps the project manager to concentrate and prioritize critical activities while allocating project resources.

8.7.3 Program Evaluation and Review Technique (PERT)

The duration estimates in this technique are probabilistic. The project manager considers optimistic, pessimistic and the most likely completion time of each activity rather than a single estimate as in the Critical Path Method.

The project manager calculates the expected time (t_e) for each activity as,

$$t_e = \frac{t_o + 4t_m + t_p}{6},$$

Where, t_o, t_p , and t_m are the optimistic, pessimistic and most likely completion times of a project activity.

The methodology of PERT is explained below:

Step 1: Develop a list of project activities, and identify all their immediate predecessors.

Step 2: Calculate time estimates for each activity as $t_e = \frac{t_o + 4t_m + t_p}{6}$

Step 3: Calculate the earliest start time and earliest finish time for each activity, based on the expected time.

Step 4: Identify the critical path of the network taking into consideration those activities whose total float value is '0' and determine the expected project duration.

Step 5: Calculate the standard deviation of the project. The standard deviation is a square root value of project variance. The variance of a project activity is calculated as $(t_p - t_o)^2 / 36$, and the project variance is the sum of variances of all project activities.

Step 6: The square root value of project variance gives the standard deviation of the project. Calculate the value of z as,

z = (Due date – Expected date of completion) / (Standard deviation of the project).

Where, 'z' is the number of standard deviations the due date lies from the mean or expected date.

Step 7: Using the standardized normal distribution table, determine the probability of meeting a specific completion date for the obtained z value.

Step 8: Crash or compress the project to the extent possible.

Example 8.2

The pessimistic, most likely, and optimistic times (in number of days) of the activities in a particular project are given below, along with the predecessor activities. Find the probability of completing the project in 26 days.

Figure 8.4 (a): Project Network Diagram

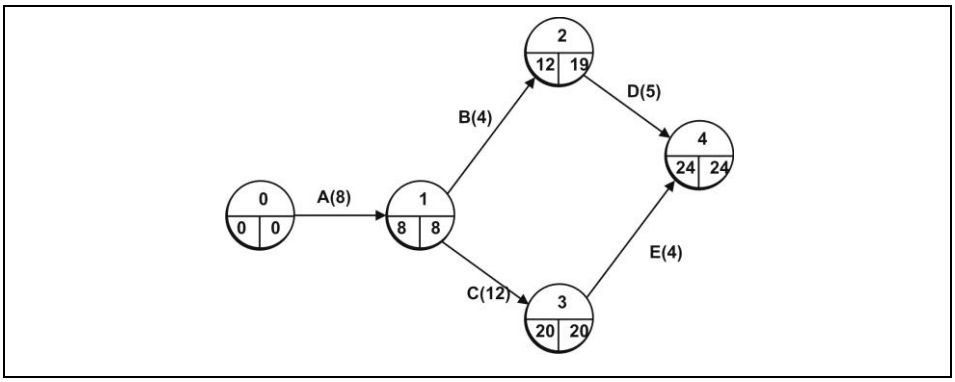


Figure 8.4 (a) is the network diagram for the given project. The critical path of the project is A-C-E and the expected project completion time is 24 days.

Activity	Predecessor(s)	t_o	t_m	t_p
A	-	6	8	10
B	A	2	3	10
C	A	10	11	18
D	A, B	3	4	11
E	A, C	4	4	4

The expected completion time of an activity is calculated as: $t_e = \frac{t_o + 4t_m + t_p}{6}$

The variance of an activity is calculated as: $\frac{(t_p - t_o)^2}{36}$

The expected completion time of all project activities, and their variances are given below.

Activity	Expected Time	Variance
A*	**8**	**0.44**
B	4	1.78
C*	**12**	**1.78**
D	5	1.78
E*	**4**	**0**

* *denotes critical activity.*

As the critical path is A-C-E, the expected project completion time (expected time) for A-C-E = 8 + 12 + 4 = 24 days.

Therefore, expected project completion time μ = 24 days.

The total variance of the project (considering all activities) =

0.44 + 1.78 + 1.78 + 1.78 + 0 = 5.78

Therefore, standard deviation (σ) of the project $\Rightarrow \sqrt{5.78} = 2.4$

The probability of completing the project by 26 days is the probability of completing the project in less than or equal to 26 days.

For x = 26, the corresponding value of the standard normal variate 'z' is

z = (Due date – Expected date of completion) / (Standard deviation of the project)

= (26-24)/2.4 = 0.83

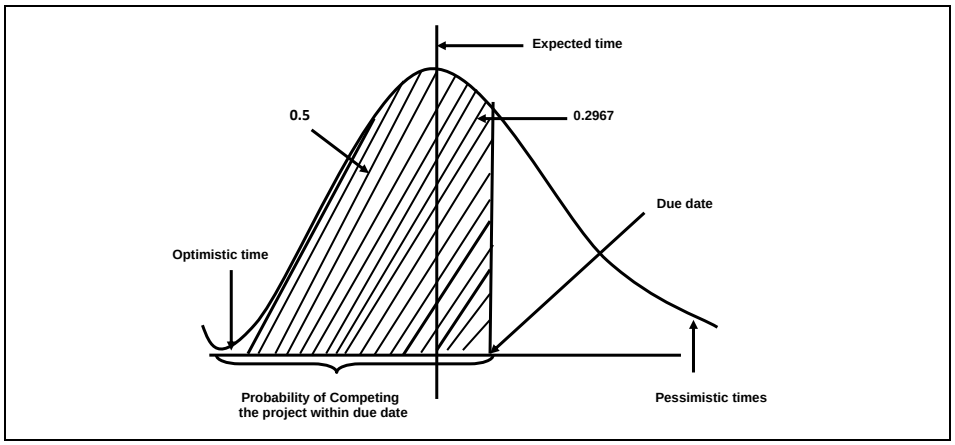
$$P(x \leq 26) \Rightarrow P\left(z \leq \frac{26-24}{2.4}\right)$$

$$\Rightarrow P(z \leq 0.83)$$

$$\Rightarrow P(-\alpha \leq z \leq 0) + P(0 \leq z \leq 0.83)$$

(From the standardized normal distribution function, F(z) table, the area under the normal curve corresponding to z = 0.83 is 0.2967.) Refer to Figure 8.4 (b).

Figure 8.4 (b): Calculation of Probability



$\Rightarrow$ 0.5 + 0.2967

$\Rightarrow$ 0.7967

Hence, the probability of completing the project in 26 days is 0.7967.

Note: *In standard normal distribution, probability of completing the project in expected time (μ) will always be 0.5. As due date (26 days) is more than μ (24 days), probability of completion will definitely be greater than 0.5.*

Check Your Progress - 5

41. Which of the following statements is **not true** regarding the critical path method?
    a. It is used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility.
    b. The critical path of the project is the shortest path through the network.
    c. The length of the critical path gives the shortest allowable time for the completion of the project.
    d. Both (b) and (c)
42. _____ is a network analysis technique used to predict the project duration by finding out which sequence of activities has the least amount of scheduling flexibility.
    a. Crashing
    b. Fast tracking
    c. Decomposition
    d. Critical path method

Exercises

(Questions E-G)

Nishant International has taken up an overseas project. The optimistic, most likely, and pessimistic times of the activities in the project are given here.

Activity	Optimistic time	Most likely time	Pessimistic time
A	2	8	12
B	3	5	10
C	4	7	18
D	3	9	16
E	5	8	14

E. Calculate the expected time of completion of the project.

F. Calculate the total variance of the project.

G. Find out the probability of completing the project in 27 days.

H. Saharsh is the project manager of a company currently working on a software project. The expected project completion time is 28 days and the standard deviation of the project is 2.56. What is the probability of Saharsh finishing the project in 30 days?

I. The variances of the critical activities of a project are 0.2, 0.6, 0.5, and 0.7. What is the standard deviation of the project?

J. The optimistic, pessimistic, and most likely times of an activity are 3, 10, and 7 days, respectively. Calculate the variance of the activity.

8.7.4 Graphical Evaluation and Review Technique (GERT)

Graphical Evaluation and Review Technique is similar to PERT, except that it allows multiple project activities by the way of looping and branching project activities. Suppose an activity fails due to some unavoidable reasons, then the project manager has to look for alternative ways to obtain the end result.

Similarly, some of the activities may not be carried out at all, some may be partially carried out and some that may be repeated. PERT cannot show alternative plans in a single network diagram. GERT overcomes these problems as it shows alternative ways to continue the project.

8.7.5 Duration Compression Techniques

When the project manager finds that the expected completion time of the project is more than the desired time, he attempts to reduce the project duration using some duration compression techniques like crashing, fast tracking, etc.

Crashing

Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. Here, the project manager reduces the project duration by allotting

more resources, subcontracting some activities, using more labor, etc. The project manager considers the time-cost trade-offs for all project activities. These trade offs reveal how the duration of a project activity is reduced with additional costs. Normally, the project manager focuses on time-cost trade offs for the critical activities of the project as they play a major role in deciding the project completion time.

Some people argue that crashing may decrease the quality of a project. As all project activities cannot be completed just by adding more resources, the project manager should ensure that the quality of the project end product does not suffer as a result of crashing. Activities like planning and inspection are not crashed, in general, because they have an effect on the quality of the project output.

The following are the types of activities that are considered for crashing:

1. A critical activity of the project.
2. An activity of longer duration.
3. An activity that has low per unit crash cost.
4. An activity that does not cause any quality problems, if crashed
5. An activity that is labor intensive.

The crashing procedure is explained below:

8.7.6 Constraints

- The maximum extent of crashing of an activity is given as part of the problem statement. (For instance, in Example 8.3, activity 1—2 can be crashed by a maximum of 2 weeks, from 8 to 6 weeks).
- Activities of the critical path(s) are to be crashed, in order to reduce the total project time.

8.7.7 Steps

1. Identify the sequence of activities and prepare a network diagram. Each activity should list the details of normal cost, normal time, crash cost and crash time.
2. Compute the critical path of the project network.
3. Calculate the crashing cost for all project activities using the formula:

$$\text{Crash slope} = \frac{\left(\text{Crash cost} - \text{Normal cost}\right)}{\left(\text{Normal time} - \text{Crash time}\right)}$$

4. The most effective way of crashing, is to start with the activity in the critical path having minimum crash slope, that is, minimum additional cost per unit of reduction in time. If possible, the other critical path activities can also be crashed in the ascending order (lowest to highest) of the crash slope. At each step of crashing, an activity can be crashed to the extent possible, such that the relevant path continues to be a critical path.

5. While crashing a project, if we get new critical paths in addition to the original critical path, subsequent crashing should be done in such a way that there is reduction of time along all these parallel critical paths so that the total project duration decreases.
6. The crashing process is continued till further crashing is not possible, or it does not result in the reduction of project duration.
7. For different project durations, the total cost of the project is calculated, including both critical and non-critical activities, and including both direct (normal, crashing) and indirect costs.

This will be clearer in the explanation of Example 8.3.

Example 8.3

The normal costs and crash costs, and the normal times and crash times of all project activities in a particular project are given below. Assume that indirect costs of the project are Rs. 40 per week. Find out the optimum project duration and the minimum cost of the project.

Activity	Immediate Predecessor	Normal		Crash	
		Cost	Time	Cost	Time
1--2	--	1500	8	2000	6
1--4	--	2000	10	3000	7
2--3	1--2	1100	6	1500	4
2--5	1--2	900	8	1500	5
4--6	1-4 and 2-3	300	12	400	8
5--6	2--5	500	5	800	4

The per unit crash cost (also called crash slope) for each activity is calculated as:

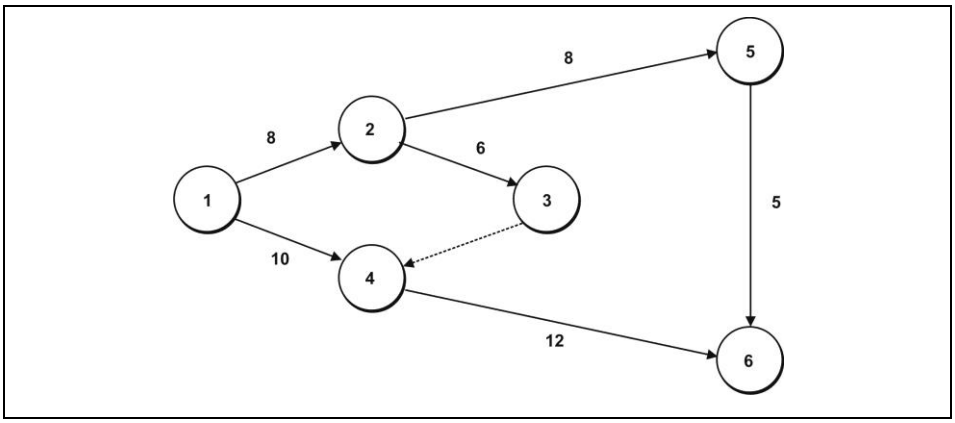
$$\text{Crash slope} = \frac{(\text{Crash cost} - \text{Normal cost})}{(\text{Normal time} - \text{Crash time})}$$

For each activity, the crash slope and the maximum possible reduction in time are tabulated as shown below.

Activity	Crash Slope (Crashing Cost per Week)	Maximum Reduction in Time
1 - 2	250	2
1 - 4	333.3	3
2 - 3	200	2
2 - 5	200	3
4 - 6	25	4
5 - 6	300	1

For clarity of understanding, we use a simplified network diagram without start time and finish time.

Figure 8.5 (a): Network Diagram – Before Crashing



From network diagram 8.5 (a) we can identify three paths (activity 3-4 is a dummy activity and does not consume any resource).

Path A: 1-2-3-4-6 = 8+6+12 = 26 weeks

Path B: 1-4-6 = 10+12 = 22 weeks

Path C: 1-2-5-6 = 8+8+5 = 21 weeks

∴ Critical path = Path A = 26 weeks

Total cost = Direct Cost + Indirect Cost

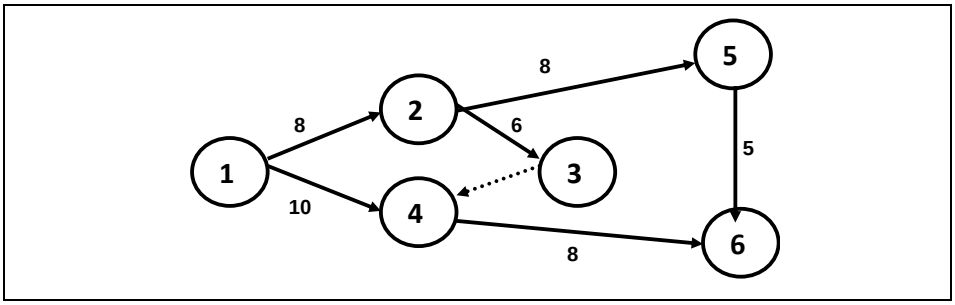
= Rs. (1500 + 2000 + 1100 + 900 + 300 + 500) + (Rs. 40 × 26)

= Rs. 6300 +Rs. 1040

= Rs. 7340

Among the critical path activities (1- 2, 2 – 3, and 4 – 6), crash slope is minimum for activity 4-6 i.e. Rs. 25 per week. So we will first crash activity 4-6. We can crash it to the maximum extent of four weeks [Refer to network diagram 8.5 (b)].

Figure 8.5 (b): Network Diagram – After Crashing



Path A: 1-2-3-4-6 = 8+6+8 = 22 weeks

Path B: 1-4-6 = 10+8 = 18 weeks

Path C: 1-2-5-6 = 8+8+5 = 21 weeks

∴ Path A continues to be the (only) critical path.

Crashing cost at this stage, for 4 weeks = Rs. 25 × 4 = Rs. 100

Total Cost = Direct cost (before crashing) + Crashing Cost + Indirect cost

= Rs. 6300 + Rs. 100 + (Rs. 40 × 22)

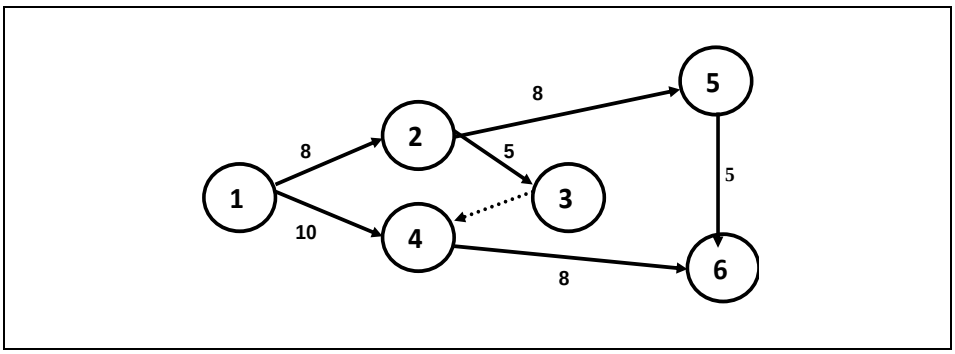
= Rs. 6300 + Rs. 100 + Rs. 880

= Rs. 6400 + Rs. 880

= Rs. 7280

Among the critical path activities (1- 2, 2 – 3, and 4 – 6), 4 – 6 cannot be crashed further. Among the remaining critical activities 1 – 2 and 2 – 3, crash slope is minimum for activity 2-3 at Rs. 200 per week. So we can next crash activity 2-3, by a maximum of 2 weeks. [Refer to network diagram 8.5 (c)]

Figure 8.5 (c): Network Diagram – After Crashing



Path A: 1-2-3-4-6 = 8+4+8 = 20 weeks

Path B: 1-4-6 = 10+8 = 18 weeks

Path C: 1-2-5-6 = 8+8+5 = 21 weeks

But then Path A 1-2-3-4-6 will no longer be a critical path; the critical path will change to path C 1-2-5-6, i.e., 21 weeks.

To ensure that Path A also continues to be one of the critical paths, we should crash 2-3 by only 1 week (and not 2 weeks). Again refer network diagram 8.5 (c).

Path A: 1-2-3-4-6 = 8+5+8 = 21 weeks

Path B: 1-4-6 = 10+8 = 18 weeks

Path C: 1-2-5-6 = 8+8+5 = 21 weeks

∴ Both path A & path C become parallel critical paths.

Crashing cost at this stage, for 4 weeks of 4-6 and 1 week of 2-3

= Rs. (25 × 4) + (200 × 1)

= Rs. 300

Total Cost = Direct cost (before crashing) + Crashing Cost + Indirect cost

= Rs. 6300 + Rs. 300 + (Rs. 40 × 21)

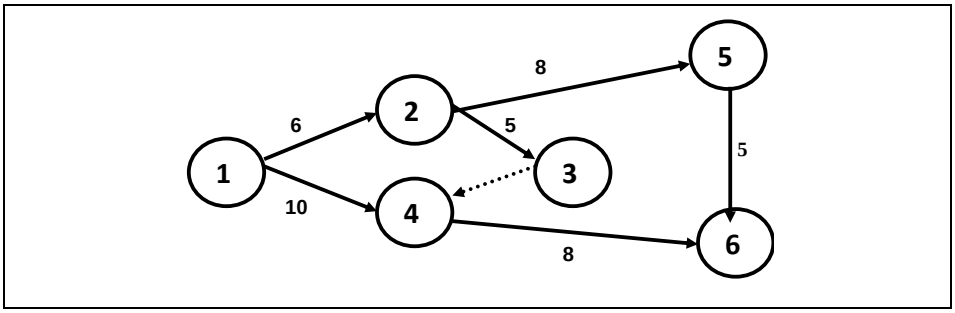
= Rs. 6300 + Rs. 300 +Rs. 840

= Rs. 6600 + Rs. 840

= Rs. 7440

Now activity 1-2 is common to both the critical paths (1-2-3-4-6 and 1-2-5-.6) and this activity can be crashed to the maximum extent of 2 weeks [Refer to network diagram 8.5 (d)].

Figure 8.5 (d): Network Diagram – After Crashing



Path A: 1-2-3-4-6 = 6+5+8 = 19 weeks

Path B: 1-4-6 = 10+8 = 18 weeks

Path C: 1-2-5-6 = 6+8+5 = 19 weeks

∴ Both path A & path C continue to be the parallel critical paths.

Crashing cost at this stage, for 4 weeks of 4-6, and 1 week of 2-3, and 2 weeks of 1-2

= Rs. (25 × 4) + (200 × 1) + (250 × 2)

= Rs. 800

Total Cost = Direct cost (before crashing) + Crashing Cost + Indirect cost

= Rs. 6300 + Rs. 800 + (Rs. 40 × 19)

= Rs. 6300 + Rs. 800 +Rs. 760

= Rs. 7100 + Rs. 760

= Rs. 7860

In Path A (1-2-3-4-6), the only critical activity that has further potential for crashing is 2-3, to an extent of 1 week. In addition to this, as path C is also critical, we should crash some activity of path C (1-2-5-6) also by 1 week, to reduce the project duration by 1 week. Of the two activities 2-5 and 5-6 that have scope for crashing, the crash slope is minimum for activity 2-5 (Rs. 200/week) when compared to 5-6 (Rs. 300/week). So we will crash 2-5 by 1 week.

Path A: 1-2-3-4-6 = 6+4+8 = 18 weeks

Path B: 1-4-6 = 10+8 = 18 weeks

Path C: 1-2-5-6 = 6+7+5 = 18 weeks

∴ Now all the three paths are parallel critical paths.

Crashing cost at this stage, for 4 weeks of 4-6, and (1+1) week of 2-3, and 2 weeks of 1-2, and 1 week of 2-5

= Rs. (25 × 4) + (200 × 2) + (250 × 2) + (200 × 1)

= Rs. 1200

Total Cost = Direct cost (before crashing) + Crashing Cost + Indirect cost

= Rs. 6300 + Rs. 1200 + (Rs. 40 × 18)

= Rs. 6300 + Rs. 1200 +Rs. 720

= Rs. 7500 + Rs. 720

= Rs. 8220

As all the three paths are critical and there is no further scope for crashing in Path A (1-2-3-4-6), there is no further scope for reduction in project duration.

Project Duration	**Direct Costs**		**Indirect Costs**	**Total Costs**
	Before crashing	*Crashing costs*		
26	6300	-	1040	7340
22	**6300**	**100**	**880**	**7280**
21	6300	300	840	7440
19	6300	800	760	7860
18	6300	1200	720	8220

Therefore, optimum project duration is 22 weeks, when the total cost incurred is minimum, i.e., Rs. 7280.

Fast Tracking

In this technique, the project manager attempts to reduce the project duration by doing project activities in parallel. Suppose activity B can be started only after the completion of activity A in normal conditions. But the project manager can start both activities at the same time, but makes modifications to activity B as per the changes in activity A. This ultimately reduces the duration of the entire project.

For example, the software code is normally written only after the design is approved. But both the activities are started at the same time and the final code is written only after the software design is approved by the top management. However, this technique requires modifications, reworking, etc.

8.7.8 Resource Leveling

CPM and PERT techniques assume that the project has unlimited resources, and they can be assigned for project activities. However, in reality, project resources are usually limited. Sometimes activities may be delayed because of the non-availability of resources.

So, the project manager sequences the project keeping in mind the availability of resources, which forces him to recalculate the activity schedules. Normally, the project manager assigns the available resources to the critical activities first as they play a major role in determining the total completion time of a project.

Check Your Progress - 6

43. Which of the following options are called duration compression techniques in project management?
    i. Crashing
    ii. Fast tracking
    iii. Critical path method
    iv. Program evaluation and review technique
    a. Only i and ii
    b. Only i and iv
    c. Only ii and iii
    d. Only iii and iv
44. _____ refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost.
    a. Fast tracking
    b. Crashing
    c. Decomposition
    d. None of the above
45. Identify the correct formula to calculate the crash slope in project crashing.
    a. $\frac{\text{Normal cost} - \text{Crash cost}}{\text{Normal time} - \text{Crash time}}$
    b. $\frac{\text{Crash time} - \text{Normal time}}{\text{Crash cost} - \text{Normal cost}}$
    c. $\frac{\text{Normal cost} - \text{Crash cost}}{\text{Crash time} - \text{Normal time}}$
    d. $\frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

46. Which of the following statements is **not true** regarding the graphical evaluation and review technique?
    a. It is similar to the program evaluation and review technique.
    b. It allows multiple project activities by the way of looping and branching project activities.
    c. It does not show alternative plans in a single network diagram.
    d. Both (a) and (b
47. Identify the activities that should **not** be considered for crashing.
    a. Activities that are labor intensive.
    b. Activities that are of longer duration
    c. Activities that have a high per unit crash cost
    d. Activities that do not cause any quality problems, when crashed

Exercise

K. If the normal cost and crash cost of an activity A are Rs. 2,500 and Rs. 3,000 and the normal time and crash time are 9 and 7 days respectively, then what is the crash slope of activity A?

8.8 Schedule Control

The project manager has to ensure that all the project activities are being carried out as per the schedules. Schedule control studies all the factors that affect project schedules. Schedule control determines the schedule changes and manages to complete them within the desired duration. Based on the changes, the project manager updates the project schedules.

The project manager has to consider the project schedule, performance reports, and change requests while controlling the schedule. The project schedule represents the planned start and expected finish dates for each project activity. It provides a basis for the project manager to measure the schedule performance. Performance reports provide information about schedule performance and point out whether the activities are proceeding as per the planned schedule or not. The project manager initiates controls to complete all the activities within the desired time. He considers the change requests made by the project stakeholders, which may be verbal or written. These change requests may be for extension or acceleration of project schedules.

The project manager uses techniques like schedule change control system, and performance measurement in controlling the project schedule. The schedule change control system describes the procedures by which project schedules can be modified. The methods include redrawing the project network diagrams, and understanding the proposed changes. Performance measurement systems assess the effective completion of the project activity in the normal duration. They calculate the magnitude of variation that may occur for each project activity.

Software packages like Project 2000 also help the project manager in controlling the project schedules by continuously studying the planned and actual time periods of each project activity. Sometimes additional planning is required when the project manager thinks that it is important to incorporate certain changes in the project. The project manager then revises the duration estimates, modifies the sequence of activities and analyzes alternative schedules.

Check Your Progress - 7

48. _____ deals with the study of factors that influence and change the project schedules and aims at managing changes to complete the project within the estimated schedule.

    a. Crashing
    b. Fast tracking
    c. Schedule control
    d. Schedule development

8.9 Summary

- According to the Project Management Body of Knowledge, a project network diagram is a schematic representation of the project activities and the logical relationships (dependencies) among them.
- The project network diagram helps the project manager in sequencing, scheduling, and controlling the project. It represents all the project activities, the sequence in which they have to be performed, the duration of each activity, the interdependencies among various activities and the criticality (significance) of each activity.
- Once the project activities are identified using the work breakdown structure, the project manager prepares an activity list of the project. He puts all the activities down in a logical sequence to arrive at the project end-product. This is known as activity sequencing.
- The project manager sequences all the project activities in an appropriate manner and represents them in the project network diagram. Some of the methods of activity sequencing are arrow diagram method, precedence diagram method, and conditional diagramming method.
- After activity sequencing, the project manager estimates the duration of each activity to calculate the duration of the entire project. The duration of an activity is the time period required to complete the activity.
- Schedule development is concerned with determining a realistic start and finish time for project activities. It aims to match project resources like machinery, materials, and labor with project activities over time.

- Some of the methods used by project managers for schedule development are: Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and Graphical Evaluation and Review Technique.
- Through schedule control, the project manager ensures that all the project activities are being carried out as per schedule. It determines the schedule changes and manages to complete them within the desired duration.

8.10 Glossary

Activity Sequencing: It is the process of identifying and documenting interdependency relationships.

Activity: An activity is an element of work performed during the course of a project.

Arrow Diagram Method: A network diagram constructed using arrows to represent the activities and connecting them at nodes to show the dependencies. This method is also called as activity-on-arrow (AOA) method.

Crashing: It refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost.

Critical Path Method: It is a network analysis technique used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility.

Dummy Activity: An activity of zero duration that is used to represent the logical relationship in the network diagram is called a dummy activity.

Fast Tracking: Compressing the project schedule by overlapping activities that would normally be done in sequence.

Finish to Finish: Finish to finish dependency states that activity A must finish before activity B finishes.

Finish to Start: Finish to start dependency states that activity A must be completed before activity B can begin.

Free Float: This is the amount of time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.

Independent Float: This is the amount of time by which the start of an activity can be delayed without affecting the earliest start of any activities following immediately.

Most Likely Time: It is the time that is the best guess for an activity completion – either optimistic or pessimistic.

Node: It is a time-oriented reference point that signifies the start or end of an activity. It is represented by a circle.

Optimistic Time: Optimistic time is the minimum amount of time within which an activity can be completed. It is possible to complete an activity within the optimistic time only when the external environment is extremely favorable.

Pessimistic Time: Pessimistic time is the maximum amount of time required to complete an activity. This happens when the external environment is unfavorable.

Precedence Diagram Method (PDM): In this method, the network diagram is constructed using nodes to represent the activities and connecting them with arrows to represent the dependencies. This method is also called as activity-on-node (AON) method.

Project Network Diagram: It is a schematic representation of the project activities and the logical relationships (dependencies) among them.

Schedule Development: Evaluating activity sequences, activity durations, and resource requirements to develop a project schedule.

Slack: Slack is the difference between the latest event time and earliest event time.

Start to Finish: Start to finish dependency states that activity B must start before activity A can finish.

Start to Start: Start to start dependency states that activity B can be started only if activity A has begun.

Total Float: This is the amount of time by which the completion of an activity can be delayed beyond its expected earliest completion time without affecting the overall project duration.

8.11 Self-Assessment Exercises

1. After the project activities are identified, they are represented in a project network diagram. What is a project network diagram? Explain the fundamental concepts involved in a project network diagram.
2. The project manager sequences the project activities by understanding the dependencies among them. How are the activities of a project sequenced? What are the various methods of sequencing the project activities?
3. After the project activities are sequenced, the project manager estimates the duration of each activity to calculate the entire project duration. Explain in detail the methods involved in the estimation of the activity duration.
4. Scheduling eliminate production problems, facilitates timely procurement of raw materials, and ensures project completion on time. How is a schedule developed? Explain briefly the techniques involved in schedule development. How can the schedule be controlled?

8.12 Suggested Readings/Reference Material

1 Prasanna Chandra, "Projects," Mcgraw Hill, Seventh Edition, 2017

2 James Wood, Kory Kogon, and Suzette Blakemore, Project Management for the Unofficial Project Manager: A Franklin Covey Title, Goodreads, 2018

3 HEAGNEY, Fundamentals of Project Management Paperback, Amacom, September 2018

4 Na, Nagarajan, Project Management 8/Ed, New Age International Publications, 2019

5 IES Master Team,, ESE 2020 - Basics of Project Management Paperback – 1 IES Master Publication, January 2019

6 Electronic Voting Machine Manual, Election Commission of India, July, 2018

8.13 Answers to Check Your Progress Questions

Following are the answers to the Check Your Progress questions given in the Unit.

1. (c) finish to finish dependency

Finish to finish dependency states that activity A must finish before activity B finishes. In the given example, collection of data is an activity and entry of data into an information system is another activity. The activity of data entry cannot end until the collection of data is completed. Therefore, it is an example of finish to finish dependency.

2. (b) logical relationship

An activity of zero duration that is used to represent the logical relationship in the network diagram is called a dummy activity. Dummy activities do not consume any resources, but are used to maintain the proper precedence relationship between the activities that are not connected by the nodes. They are represented by a dashed line headed by an arrow.

3. (c) iii-ii-i

After the project activities have been identified, they are represented in a project network diagram. The project manager sequences the project activities, estimates the duration, and then schedules the activities. The project manager sequences the project activities by understanding the dependencies among them. He/she then prepares the duration estimates of each project activity with the help of duration estimates from other projects, historical information, expert advice, etc. Finally, the project manager schedules the project activities in order to estimate the start and the finish dates of each project activity. This scheduling helps him/her in arriving at the duration of the project.

4. (b) Project network diagram

A project network diagram is a schematic representation of the project activities and the logical relationships (dependencies) among them. The diagram helps the project manager in sequencing, scheduling, and controlling the project. It represents all the project activities, the sequence in which they have to be performed, the duration of each activity, the interdependencies among various activities, and the criticality (significance) of each activity. A control chart is a graphical representation of the results of a process over a period of time. A work breakdown structure is a deliverable-oriented grouping of project activities that organizes and defines the total scope of the project.

5. (d) Activity

An activity is an element of work performed during the course of a project. It is depicted by an arrow. An event is a time-oriented reference point that signifies the start or end of an activity. It is also called a node and is represented by a circle. Slack is the difference between the latest event time and earliest event time.

6. (a) tail event, head event

The project network diagram is represented by a series of activities and nodes. An activity is a specific task or operation required to do a project. A node is a time-oriented reference point that signifies the start or end of an activity. An activity can be represented with 'i' and 'j' as the starting and ending nodes, respectively. The activity can also be written as 'i–j'. Event 'i' is called the tail event and event 'j' is called the head event.

7. (a) zero duration.

An activity of zero duration that is used to represent the logical relationship in the network diagram is called a dummy activity. Dummy activities do not consume resources, but are used to maintain proper precedence relationship (start to start, start to finish, finish to start, or finish to finish) between the activities that are not connected by the nodes. They are represented by a dashed line headed by an arrow.

8. (c) the ending node.

In a project network diagram, an activity can be represented with i and j as the starting and ending nodes, respectively. The activity can also be written as i –j. Event i is called the tail event and event j is called the head event.

9. (a) a time-oriented reference point that signifies the start and end of an activity.

A node, also known as an event, is a time-oriented reference point that signifies the start or end of an activity. It is represented by a circle. An activity is a specific task or operation required to do a project.

10. (b) An activity represents the passage of time while the nodes are points in time that denote the starting or ending of a specific activity.

An activity is an element of work performed during the course of a project while a node is a time-oriented reference point that signifies the start and end of an activity. An activity represents the passage of time and the nodes are points in time that denote the starting or ending of a specific activity. An activity is depicted by an arrow while a node is represented by a circle.

11. (c) activity B can be started only if activity A has begun.

Start to start dependency states that activity B can be started only if activity A has begun. This can be explained with the help of the previous example – that is, the inspection activity can be started and continued once the raw materials start coming. Subsequently, both activities go on in parallel.

12. (b) start to finish dependency

Start to finish dependency states that activity B must start before activity A can finish. For instance, if a firm wants to develop a new information system to replace the existing one, the firm has to confirm that the new system is operating well. When the new system starts working (activity B), the existing system can be discontinued (activity A).

13. (a) Only i, ii, and iii

An activity of zero duration that is used to represent the logical relationship in the network diagram is called a dummy activity. Dummy activities do not consume any resources, but are used to maintain the proper precedence relationship between the activities that are not connected by the nodes. They are represented by a dashed line headed by an arrow.

14. (d) The project network diagram helps to determine the start and end dates of each activity during scheduling, but does not provide insights into the possible trade-offs while controlling the project.

A project network diagram is a schematic representation of the project activities and the logical relationships (dependencies) among them. The diagram helps the project manager in sequencing, scheduling, and controlling the project. It represents all the project activities, the sequence in which they have to be performed, the duration of each activity, the interdependencies among various activities, and the criticality (significance) of each activity. It helps to determine the start and end dates of each activity during scheduling. It also provides insights into the possible trade-offs while controlling the project.

15. (a) finish to start dependency.

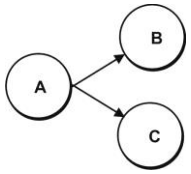
Finish to start dependency states that activity A must be completed before activity B can begin. If activity A involves obtaining raw material and activity

B involves inspecting the raw material, then activity B can be performed only after the completion of activity A. Therefore, the dependency is finish to start.

16. (b) event

An event is a time-oriented reference point that signifies the start or end of an activity. It is represented by a circle and is also called as a node. An activity is an element of work performed during the course of a project. It is depicted by an arrow. Slack is the difference between the latest event time and earliest event time.

17. (b)



In the given project, activities B and C cannot begin until activity A has been completed. Option (b) correctly represents this activity relationship if the arrow diagram or activity-on-arrow method is used. Option (d) is also correct if the activity relationship is represented using the precedence diagram or activity-on-node method.

18. (c) Only ii and iv

While sequencing the activities, the project manager analyzes the mandatory and discretionary dependencies among the various project activities. Mandatory dependencies are those that are inherent in the nature of project. In these, the dependency between the activities is certain or mandatory. Discretionary dependencies are those dependencies of the project that are defined by the project team. Using certain best practices or standard procedures in the project are examples of discretionary dependencies. This dependency is also called as soft logic or preferred logic.

19. (a) Only i and iii

While analyzing the product description, the project manager has to consider the physical characteristics of the product and the logical sequencing of the activities to achieve the end product. The product description is generally less detailed in the early phases of the project and is progressively elaborated on later.

20. (c) Graphical Evaluation and Review Technique (GERT)

Conditional diagramming methods like the Graphical Evaluation and Review Technique (GERT) and system dynamics represent non-sequential activities like loops (where activities are repeated again and again) or conditional branches (e.g., a design update is required only when errors are found in the inspection). PDM and ADM cannot represent loops and conditional branches.

21. (c) involves constructing the network diagram using arrows to represent activities and connecting them at nodes to show the dependencies.

In the arrow diagram method, the network diagram is constructed using arrows to represent the activities and connecting them at nodes to show the dependencies. This method uses finish-to-start dependencies only to explain the logical relationships. This method is also called Activity-On-Arrow (AOA) method. Options (a), (b), and (d) pertain to the precedence diagram method.

22. (b) Mandatory dependencies

While sequencing the activities, the project manager analyzes the mandatory and discretionary dependencies among the various project activities. Mandatory dependencies are those that are inherent in the nature of project. For instance, in order to install a new machine, it is necessary for the plant layout to be finalized. Therefore, in this case, the dependency among the activities is certain or mandatory. Mandatory dependency is also called as hard logic. Discretionary dependencies are those dependencies of the project that are defined by the project team. This kind of dependency is also called preferred logic.

23. (c) Only ii and iii

In the precedence diagram method, the network diagram is constructed using nodes to represent the activities and connecting them with arrows to represent the dependencies. This method uses all four types of dependencies and is also called the activity-on-node method. The arrow diagram method is also called the activity-on-arrow method.

24. (b) Only i and iii

The project manager sequences all the project activities in an appropriate manner and represents them in the project network diagram. Methods like the arrow diagram method and the precedence diagram method are used for activity sequencing. In the arrow diagram method, the network diagram is constructed using arrows to represent the activities and connecting them at nodes to show the dependencies. In the precedence diagram method, the network diagram is constructed using nodes to represent the activities and connecting them with arrows to represent the dependencies. The critical path method and the program evaluation and review technique are methods that the project manager uses to develop schedules.

25. (d) i, ii, iii, and iv

After identifying the project activities using the work breakdown structure, the project manager prepares an activity list of the project. The activities are sequenced in order to obtain the project end product. While sequencing the activities, the project manager has to study various aspects such as the

description of the end product, mandatory and discretionary dependencies among the activities, external dependencies and other constraints and assumptions of the project.

26. (c) Most likely time

Optimistic time (t_0) is the minimum amount of time within which an activity can be completed. Pessimistic time (t_p) is the maximum amount of time required to complete the activity. The variance of an activity is calculated as

$$\frac{(t_p - t_o)^2}{36},$$

where, t_p = pessimistic time and t_o = optimistic time. Most likely time (t_m) is the time that is the best guess for the completion of an activity (neither optimistic nor pessimistic). It is not included in the calculation of the variance.

27. (d) crash point

The crash point is a point beyond which it is not possible to reduce the duration of an activity. The project manager has to allocate more resources till the crash point is arrived at. A node is a time-oriented reference point that signifies the start or end of an activity. Slack is the difference between the latest event time and earliest event time. Free float is the amount of time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.

28. (d) $\frac{(b-a)^2}{36}$

The variance of an activity is calculated as $\frac{(t_p - t_o)^2}{36}$

where t_p = pessimistic time and t_o = optimistic time. In the given question, for a certain activity, the pessimistic time (t_p) is given as b and the optimistic time (t_o) is given as a. So, the variance of the activity would be

$$\frac{(b-a)^2}{36}.$$

29. (d) i, ii, iii, and iv

The project manager can use various techniques to estimate the appropriate duration of the project activities. The duration of an activity can be estimated by: taking estimates of the duration of similar activities in other projects;

taking the actual durations of successful projects in the past; consulting a technical expert to estimate the activity duration; and forming a group of people and asking them to estimate the duration of the activity after describing the nature and characteristics of the activity. Some of methods used for this purpose are the Delphi method, expert advice, the three-point method, and the wide band Delphi method.

30. (d) Wide Band Delphi method

In the expert advice method, the project manager consults a technical expert to estimate the activity duration. In the Delphi method, the project manager forms a group of people and asks them to estimate the duration of an activity after describing the nature and characteristics of the activity. In the three-point method, the project manager estimates the activity duration by considering three estimates – optimistic, pessimistic, and most likely times, and then calculates the expected time of completion of an activity. The Wide Band Delphi method is a combination of the Delphi method and the three-point method. In this method, the members are asked to give an optimistic time, a pessimistic time, and the most probable time, instead of a single estimate. Then, the project manager follows the Delphi method and determines the duration estimate.

31. (b) i/r, ii/p, iii/q

According to the three-point method of estimating the duration of project activities, the project manager considers three types of estimates – optimistic time, pessimistic time, and most likely time — in order to calculate the duration of an activity. Optimistic time (t_0) is the minimum amount of time within which an activity can be completed. Pessimistic time (t_p) is the maximum amount of time required to complete an activity. Most likely time (t_m) is the time that is the best guess for the completion of an activity (neither optimistic nor pessimistic). Expected time,

$$t = \frac{t_0 + 4t_m + t_p}{6}.$$

32. (b) $\frac{a + 4b + c}{6}$

According to the three-point method of estimating the duration of project activities, the project manager considers three types of estimates – optimistic time, pessimistic time, and most likely time — in order to calculate the duration of an activity. Optimistic time (t_0) is the minimum amount of time within which an activity can be completed. Pessimistic time (t_p) is the maximum amount of time required to complete an activity. Most likely time

(t_m) is the time that is the best guess for the completion of an activity (neither optimistic nor pessimistic). Expected time,

$t = \frac{t_0 + 4t_m + t_p}{6}$. In the given question, $t_0 = a$, $t_m = b$, and $t_p = c$.

Therefore, expected time, $t = \frac{a + 4b + c}{6}$.

33. (c) It can be more than the pessimistic time of that activity.

Optimistic time (t_0) is the minimum amount of time within which an activity can be completed. Pessimistic time (t_p) is the maximum amount of time required to complete an activity. Most likely time (t_m) is the time that is the best guess for the completion of an activity (neither optimistic nor pessimistic).

Expected time, $t = \frac{t_0 + 4t_m + t_p}{6}$.

The expected time of an activity cannot be more than the pessimistic time of that activity. However, it can be more than the optimistic time. The expected time of an activity is more than, less than, or equal to the most likely time of that activity.

34. (b) Resource calendar

The project manager prepares two types of calendars – resource calendars and project calendars to schedule the project. Resource calendars schedule the project on the basis of the resources used. The focus is on scheduling and utilizing specific resources effectively. Resource calendars deal with how a specific resource or specific category of resources is spent over a period of time. Project calendars emphasize the completion time of the project activities. They are concerned with how various project resources are consumed over a period of time. A resource pool description contains details of all the project resources and their allocation to project activities.

35. (d) i, ii, iii, and iv

The project manager can use methods like the critical path method, the program evaluation and review technique, and the graphical evaluation and review technique for schedule development. These methods are used to: estimate the completion time of the project; find out if the project is behind, ahead of, or on schedule; compare the actual resources spent with the planned resources at any stage of the project; and study activities that are critical for project completion and activities that can be delayed without delaying project completion.

36. (b) i/r, ii/p, iii/q

There are three types of floats – total float, free float, and independent float. Total float is the amount of time by which the completion of an activity can be delayed beyond its expected earliest completion time without affecting the overall project duration. Free float is the amount of time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity. Independent float is the amount of time by which the start of an activity can be delayed without affecting the earliest start of any activities following immediately.

37. (d) Independent float is the difference between total float and tail slack.

Total float is the difference between the latest start time and the earliest start time of a project activity. Slack is the difference between the latest event time and earliest event time. Free float is the difference between total float and head slack. Independent float is the amount of time by which the start of an activity can be delayed without affecting the earliest start of any activities following immediately. It is the difference between free float and tail slack.

38. (b) The Work Breakdown Structure

Methods like the critical path method, the program evaluation and review technique, and the graphical evaluation and review technique are used for schedule development. The work breakdown structure is a deliverable-oriented grouping of project activities that organizes and defines the total scope of the project.

39. (a) Head slack

In an event, slack is the difference between the latest event time and earliest event time. For an event 'i', slack = $L_i - E_i$. For an activity (i, j), the slack of event 'j' is called head slack, while the slack of event 'i' is called tail slack. Head slack = $L_j - E_j$, and Tail slack = $L_i - E_i$.

40. (c) Only ii and iv

The critical path method, the program evaluation and review technique, and the graphical evaluation and review technique are the various methods used for scheduling a project. Black box is a technique used to enhance creativity in individuals. The realized yield approach is a method used for estimating the rate of return required by the equity shareholders.

41. (b) The critical path of the project is the shortest path through the network.

Critical path method is a network analysis technique used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility. In this method, the project manager identifies the critical activities of the project that constitute the

critical path of the project. The critical path of the project is the longest path through the network. The length of the critical path gives the shortest allowable time for the completion of the project. This helps the project manager to concentrate and prioritize critical activities while allocating project resources.

42. (d) Critical path method

Critical path method is a network analysis technique used to predict the project duration by finding out which sequence of activities (the critical path) has the least amount of scheduling flexibility. In this method, the project manager identifies the critical activities of the project that constitute the critical path of the project. Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. Fast tracking refers to compressing the project schedule by overlapping activities that would normally be done in sequence. Decomposition refers to the breaking down of work into hierarchy of activities and tasks.

43. (a) Only i and ii

When the expected completion time of the project is more than the desired time, the project manager tries to reduce the project duration using some duration compression techniques like crashing and fast tracking. Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. Fast tracking refers to compressing the project schedule by overlapping activities that would normally be done in a sequence. The critical path method and program evaluation and review technique are techniques used by the project manager to develop schedules.

44. (b) Crashing

Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. In crashing, the project manager reduces the project duration by allotting more resources, subcontracting some activities, using more labor, etc. Fast tracking refers to compressing the project schedule by overlapping activities that would normally be done in sequence. Decomposition refers to the breaking down of work into a hierarchy of activities and tasks.

45. (d) $\dfrac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$

Crash slope is the per unit crash cost for each activity involved in a project.

It is calculated as, $\dfrac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$.

46. (c) It does not show alternative plans in a single network diagram.

The graphical evaluation and review technique is similar to the project evaluation and review technique. It allows multiple project activities by the way of looping and branching project activities. The program evaluation and review technique cannot show alternative plans in a single network diagram. This problem is overcome in the graphical evaluation and review technique as it shows alternative ways to continue the project.

47. (c) Activities that have a high per unit crash cost

Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. Following are the type of activities that are considered for crashing: activities that are of longer duration; activities that are labor intensive; activities that are critical; activities that have a low per unit crash cost; and activities that do not cause any quality problems, if crashed.

48. (c) Schedule control

Schedule control studies all the factors that affect project schedules. It determines the schedule changes and manages to complete them within the desired time. Based on the changes, the project manager updates the project schedules. Crashing refers to decreasing the total project duration after analyzing a number of alternatives to determine how to get the maximum duration compression for the least cost. In this technique, the project manager attempts to reduce the project duration by carrying out project activities in parallel. Schedule development is concerned with determining a realistic start and finish time for project activities.

Unit 9

Project Review

Structure

9.1 Introduction

In the previous unit, we have discussed activity sequencing, estimation of duration and scheduling. In this unit, we will discuss project review. Once a project is organized, in terms of building the project team and drawing up the operating rules, it is time for the project manager to design and develop an effective tool to check whether the activities are proceeding as per the plan. This task requires a mechanism to review the performance of various project aspects such as project status, product design and process.

This unit will explain the importance of the project review process. We will discuss the various types of project reviews and the different stages involved in the project review. We shall then move on to discuss project status review meetings and the advantages of conducting them. Finally, we would be explaining the various types of project status meetings.

9.2 Objectives

By the end of this unit, the students should be able to:

- Understand the importance of project review.
- Classify the various types of project reviews.
- Define project review stages.
- Discuss project status review meetings.
- Identify the advantages of a project status review meeting.
- Recognize the types of project status meetings.

9.3 Importance of Project Review

Once the project enters the implementation phase, the project manager should take up the responsibility of reviewing the status of the project in a timely and phased manner. Project reviews conducted at various stages of project implementation play a major role in the success of a project. The project manager conducts reviews to find out;

- If the project can accomplish the business goals.
- Whether the rules of the organization are understood properly and implemented
- If it is worthwhile to take up the project at all before entering into major contracts
- Whether the project is managed effectively and the team members are sure of completing the project, by following the guidelines.

Reviews give the project manager and the organization a chance to solve problems before they get out of hand, or to improve the way in which the projects are being handled. To derive the maximum benefit out of the reviews the project manager has to take follow-up action with an open mind. Reviews ensure that the project utilizes the available funds to gain business advantage. On the whole, a review helps the project manager;

- Keep in mind the purpose of carrying out a project
- Determine the appropriateness of the project activities from time to time
- Gauge the way in which the objectives are being accomplished
- Verify the completion of the project
- Evaluate the cost of the project
- Understand the project requirements.

Check Your Progress - 1

1. Which of the following is/are the purpose/s of a project review?
   i. To determine whether the project can accomplish the business goals.
   ii. To check whether the project is exceeding the budget limits set by the management.
   iii. To determine whether it is worthwhile taking up the project at all before entering into major contracts.
   iv. To see whether the project is being managed effectively and whether the team members can complete the project by following the guidelines.
   a. i, ii, iii, and iv
   b. Only i and ii
   c. Only i, iii, and iv
   d. Only i, ii, and iii

2. In which of the following ways does the review help the project manager?
   i. To remember the purpose of carrying out the project.
   ii. To verify the completion of the project.
   iii. To evaluate the cost of the project.
   iv. To understand the project requirements.
   a. Only i
   b. Only ii and iii
   c. Only iii and iv
   d. i, ii, iii, and iv

9.4 Types of Project Reviews

A project manager has to conduct various reviews throughout the life of a project to ensure that it is progressing towards achieving the planned objectives. The manner in which these reviews are conducted decides the success of current and future projects. In general, a project manager conducts three types of reviews -- status reviews, design reviews, and process reviews.

9.4.1 Status Reviews

Status review is the most common and frequently conducted review in organizations taking up projects. These reviews are conducted at fixed intervals to review the present position of the project. A status review is usually conducted at two levels: cursory review and comprehensive review.

Though deciding the frequency of project reviews is largely a matter of judgment, a weekly cursory and a monthly comprehensive review are conducted for projects of one year duration. The frequency with which project reviews are conducted also depends on the frequency with which problems occur. Project reviews are conducted frequently whenever problems arise. Care should be taken to avoid conducting too many project reviews. The project manager should take care that team members give status reports that are substantiated by meaningful numerical figures on cost, performance, time and scope. The project manager should also be aware of the possibility of mis-reporting. In many cases, team members report that they are on schedule even if they are not, in the hope that they will be back on schedule by the next reporting period. The project manager should design a reporting system that can detect deviations which are greater than the permissible variance limits.

It is always advantageous to have an organizational structure that focuses on correcting problems, rather than punishing those held responsible for these problems. Therefore, project reviews must be conducted with the aim of solving the problem rather than with the objective of giving out punishment to person responsible for the problem. A problem-solving project review has three steps: (i) Identification of existing problems, (ii) Identification of factors that cause

problems, and (iii) Exploring solutions that can solve the problem. An effective problem-solving approach is one that can get to the root cause of the problem, rather than trying to tackle the symptoms.

9.4.2 Design Reviews

Generally, a project is subjected to a design review, usually at the major milestones. The primary objective of conducting a design review is to check whether the design of the product or service being produced is of the desired performance quality. Thus a design review is more a tool for reviewing the performance factor than the cost, time and scope of a project.

The performance of the product determines the project's success or failure. The design of the product plays a major role in the effective performance of the product. Many projects fail due to improper product design. While deviations from the schedule with regard to the cost, time and scope of a project can be corrected, a deviation in design would result in an underperforming product that would be rejected by the client. Therefore, the design review plays an important role in ensuring the performance quality of the project deliverable.

A design review should cover aspects like:

- Conditions of manufacturability, serviceability, tooling, economics of special machinery and processes to ensure better integration of design with manufacturing to ensure overall optimization.
- Safety of operators and maintenance personnel and precautions taken to minimize damages.
- Scope statement along with technical specifications based on which the performance of end products can be evaluated.

Informal reviews are also done by implementing Management By Walking Around (MBWA) where the project manager personally goes around all the departments to make sure that the work is progressing as planned in terms of design. In order to make sure that a design is reviewed properly, ANSI (American National Standards Institute) has developed some design review criteria. These criteria can be used for any program involving design.

Elements of Design Review

Elements of design review as recommended by ANSI are as follows:

- Were the inputs rightly chosen and put into the design?
- Are assumptions required to conduct the design review complete and reasonable?
- Are the assumptions identified for re-verification, if needed, on completion of detailed design activities?
- Are the quality and quality assurance standards specified?
- Are the codes, standards and regulations pertaining to design and its approval identified and met?

- Is the construction and operating experience considered, if applicable?
- Is the design interface requirement satisfactory?
- Was the design method relevant?
- Is the output justified in comparison with inputs?
- Does the parts, equipment and processes suit the application?
- Is there compatibility between the specified materials and the design environment in which the material will be put to use?
- Are there sufficient maintenance features and requirements?
- Are there enough accessibility and design provisions to carry on maintenance and repairs?
- Is there sufficient provision for accessibility to conduct in-service inspection that can be needed during the plant life?
- Has the impact of the design on the public and the plant personnel been considered?
- Is the acceptance criterion in the design document sufficient to verify the satisfactory accomplishment of design requirements?
- Are sufficient pre-operational and follow-up periodic test requirements given?
- Are the given handling, storing, cleaning and shipping specifications adequate?
- Are there enough identification requirements?
- Are adequate requirements for documenting records, acceptance, storing, etc. specified?

9.4.3 Process Reviews

The primary objective of conducting a process review is to determine whether the processes are going on as planned and whether any improvements are possible. A process review is conducted either once in three months or at major milestones in the project, whichever comes first. Process reviews can be conducted once a month if the project is of shorter duration. The two objectives of process reviews are: (i) To preserve the performance of project processes those are going on well, and (ii) To improve the processes those are below standard. Even if there is nothing wrong with the processes, there may be some scope for improvement and process reviews suggest how improvements can be made.

Process reviews are conducted by the project manager or an external facilitator. Both of them have their own limitations. Leadership is one of the processes crucial for the success of a project. A process review conducted by the project manager will not get the desired feedback as the team members will not feel free to be critical about the leadership skills of their project manager. An external facilitator can gather better information in such situations. Sometimes, relations between the project manager and his team may deteriorate if the team gives a negative feedback on the leadership skills of the project manager.

Activity: Perfect Pte. is a Singapore-based white goods manufacturing company. To develop an ultra modern future-ready washing machine, the company started a project (codename WM-800). It produced an initial batch of washing machines and brought in an external consultant to review the machine design. And after thorough inspection, the consultant found that the temperature of the dryer was damaging the clothes. The company also found that the project manager was not technically sound and so he did not review the design properly. What do you think the project manager should have done to conduct a design review? And what are the parameters to be taken into consideration while conducting a design review?

Answer:

Check Your Progress - 2

3. Expand ANSI.
   a. Australian National Standards Institute
   b. American National Symbols Institute
   c. American National Standards Institute
   d. American National Serial Institute
4. Project reviews conducted at fixed intervals to analyze the present position of the projects are called
   a. Design reviews.
   b. Status reviews.
   c. Process reviews.
   d. None of the above
5. Of the following reviews, pick the one that is done mostly during major milestones of the project implementation and whose objective is to know whether the design or service being produced is of the desired performance quality.
   a. Comprehensive review
   b. Status review
   c. Process review
   d. Design review

6. Which of the project reviews is generally conducted by an external facilitator rather than the project manager?

   a. Status reviews
   b. Cursory reviews
   c. Process reviews
   d. Comprehensive reviews

7. Project reviews must be conducted with the aim of solving the problem rather than punishing those who are responsible for the problem. Which of the following is the correct sequence of steps in problem solving?

   i. Exploring the solutions that can solve problems.
   ii. Identifying the factors that cause problems.
   iii. Identifying the existing problems.

   a. i-ii-iii
   b. iii-ii-i
   c. ii-iii-i
   d. ii-i-iii

8. The review that is done on a weekly basis as part of the status review of the projects is called

   a. Comprehensive review.
   b. Cursory review.
   c. Design review.
   d. Process review

9. Which of the following are the two objectives of process reviews?

   i. To review the financial performance of the project.
   ii. To preserve the performance of project processes that are going well.
   iii. To improve the processes that are below standard.
   iv. To ensure the safety of operators and maintenance personnel and take precautions to minimize damage.

   a. Only i and ii
   b. Only i and iv
   c. Only ii and iii
   d. Only iii and iv

10. Which of the following aspects is **not** covered by design review?

    a. Conditions of manufacturability
    b. Serviceability
    c. Control of costs in project implementation
    d. Safety of operators and maintenance and personnel

9.5 Project Review Stages

A review should always be conducted before taking any major decisions that can affect the future of the project. Some of the important points or stages at which a review is conducted are as follows;

- In the initial stages of the project life cycle, i.e., after the project proposal has been submitted.
- At the stage when an in-depth evaluation is conducted i.e., after the primary business case has been accepted.
- During the implementation of the project, i.e., while the activities of the project are being carried out, particularly at the following points – before entering into major contracts; when the major output of the project is to be delivered; at points where the risk is substantially high; and at points where major problems occur.
- When the project is completed.
- When auditing has to be conducted.

9.5.1 Review after Submission of Project Proposal

A review at this point would help the project manger to know whether – the proposal is worth the resources on undertaking an initial investigation; the proposal is in keeping with the existing business strategy; and the proposal is flexible, in case it does not comply with the existing business strategy.

9.5.2 Review in the Implementation Phase

There are different types of reviewing techniques to monitor the project in the implementation phase. Status reviews, design reviews, and process reviews are carried out during this phase of the project.

9.5.3 Review at the Time of Completion of Project

A project is closed either when it accomplishes its objectives (successful project) or when it fails to do so. Closing a project is a formal activity aimed at discharging all the assets belonging to the project in a proper manner. The project manager conducts a review at this stage to

- Evaluate the project efficiency by comparing the delivered output with the planned one, in terms of time, cost and performance standards.
- Ensure that the benefits are well documented for use in future projects.
- Document the lessons learnt as these may be helpful in the management of future projects.

9.5.4 Review in the Post-implementation Stage

This kind of review is usually conducted any time between three to six months after the completion of the project. The project manager undertakes the review to

judge whether the project was successful in meeting its goals or not. These reviews should;

- Evaluate the benefits of the project and compare them with the benefits envisaged in the initial plan
- Judge the effectiveness and efficiency of the delivered output of the project when it is put to use in real-life situations
- Suggest corrective measures, if necessary
- Document the lessons, as these may prove helpful in managing future projects
- Be conducted keeping in mind the information requirements of the various stakeholders, like the sponsor of the project, the functional departments, the end-users and the clients.

Post project reviews have a special significance in project management as shown through the following Exhibit 9.1

Exhibit 9.1: Significance of Post Project Review

Project review is probably the most effective tool for improving project results and project management practices. An effective and thorough review of project performance can help the project manager find out what was right and what was wrong about the conduct of the project. Project reviews should be target oriented and realistic i.e., they should be conducted efficiently and lay emphasis on overall project goals and objectives. To sum up, post project reviews should analyze the performance of the project so as to build on the project achievements and avoid problems in the future. Post project reviews help evaluate the performance of the project from various perspectives:

1. Was the project a total success?
2. Was it a well defined project?
3. Did the project deliver the expected results?
4. Was the project implemented according to established project management policies and procedures?
5. Was the progress of the project monitored and controlled properly?
6. Was the project a success from the stakeholder's point of view?
7. Is the project team happy with the performance of the project?

Every project has some valuable lessons for improving future projects and developing professional skills. Post project reviews help uncover those valuable lessons.

Adapted from www.ittoolkit.com/pmreview_intro.htm.

Check Your Progress - 3

11. Projects are reviewed at the post-implementation stage usually between three and six months after the completion of the project. Which of the following stages of project review falls under the post-implementation stage of the project?
    a. When auditing is to be conducted
    b. When the major output of the project is to be delivered
    c. At the point where major problems occur
    d. None of the above
12. At which of the following points in the implementation stage is the project review **not** taken up?
    a. Before entering into major contracts.
    b. At points where the risk is substantially high.
    c. At points where major problems occur.
    d. When there are any minor difficulties in the project implementation.
13. Which of the following are the stages at which project review is to be conducted?
    i. During the initial stages, after the project proposal has been submitted.
    ii. At the stage when in-depth evaluation is conducted.
    iii. During the implementation of the project.
    iv. When auditing has to be conducted.
    a. Only i and ii
    b. Only iii and iv
    c. i, ii, and iii
    d. i, ii, iii, and iv

9.6 Project Status Review Meetings

Meetings are an effective and essential means of conducting project reviews in an organization. These meetings are aimed at reviewing the project status and have a specific agenda. At these meetings, decisions are made, different aspects of the project are discussed and the work is planned and scheduled. Project managers usually use a top-down approach for conducting a project status review meeting. The sequence of events at a review meeting is generally as follows;

1) The project leader presents the changes in the project scope that may have an impact on its future
2) The client presents the changes in the project that may have an impact on its future
3) The project manager presents the status of the project, with a note on the impact of changes that were considered or approved earlier

4) Activity managers present the progress since the last status meeting
5) Activity managers of future activities present the changes having an impact on the project status since the last meeting
6) The project manager checks the status of the problems that remained unresolved at the previous meetings
7) Members present in the meeting explore new problem areas and assign responsibility for solving these problems.
8) Closing comments are made by the project leader, the client or the project manager
9) The project manager closes the meeting after announcing the venue, date and time of the next review meeting.

The following aspects have to be decided upon before holding a review meeting -- frequency of meetings, preparing agenda, meeting coordinator, and recording and distributing minutes.

9.6.1 Frequency of Meetings

If the activity manager submits his report to the project manager on a weekly basis, and the project manager in turn submits his report to senior management on a biweekly basis, project status review meetings may be conducted once in two weeks. But there is no hard and fast rule about the frequency of meeting. The frequency is usually based on the length and duration of the project. Meetings must not be held too frequently as this leads to waste of time. At the same time if the review meetings are infrequent, the project manager may lose control over the project. The project manager must therefore exercise his judgment while deciding the frequency of meetings.

9.6.2 Preparing Agenda

The agenda lists the issues that are to be discussed at the meeting. It helps the project manager to ensure that every one participates in the discussion. The agenda should not have many topics for discussion. If the agenda provides background information for each topic that is listed, participants can come better prepared for the meeting. Depending on the importance of a topic, the agenda specifies a time limit for discussing the topic.

9.6.3 Meeting Coordinator

The meeting coordinator fixes the place and time for the meeting and arranges for the required equipment. While deciding the time and the arrangements for the meeting, the coordinator must consider the following;

- Is the room big enough to accommodate all the participants? The room should neither be too small nor too large.
- The convenience of the place.
- Are the seating arrangements comfortable? Can additional seats be provided if required?

- Does the room have proper light and ventilation?
- Are the visual aids working properly?
- Is additional stationery available?
- Are name plates required?
- Handling of messages.

Once these aspects have been taken care of, the preparation for the meeting are over. Let us now see how a review meeting should be conducted.

Before starting a review meeting it is the responsibility of the project manager to respect the protocol. The following measures/precautions have to be taken to avoid the problems arising out of breach of protocol.

- Participants must be given enough notice and the agenda given to them must contain background information about the topics that are to be discussed
- The heads of the relevant departments must be informed about the requirement of expert subordinates
- New comers must be introduced to the other members before the meeting starts
- Participants must be listed in alphabetical order
- Significant contributions made by persons inside and outside the group must be acknowledged
- Participants must be informed well in advance if the meeting is being postponed or being canceled.

Once the meeting gets underway, it is the responsibility of the project manager to encourage discussion, seek the opinions of all the participants and before concluding the meeting, to summarize what was discussed at the meeting. The project manager must ensure;

- That all the participants have a clear understanding of the objectives of the meeting.
- That a time limit for the entire meeting has been set in the agenda and that this time limit is made known before the meeting begins.

The meeting will be a success if all the participants agree upon the objectives from the same point of view. The leadership skills of the project manager and cooperation among the participants determine the success of the review meetings. The project manager and the participants should;

- Get acquainted with other participants before the meeting starts
- Allow other participants to come out with their ideas and recommendations
- Carefully listen to the views of other participants
- Welcome new ideas that support the objectives of the meeting
- Help in arriving at a consensus
- Be flexible enough.

Even if all efforts are made to make sure the meeting goes on smoothly, a number of problems may arise. Participant's inability to reach a consensus on the objectives of the meeting is a major problem. Another key problem is the difficulty participants face in communicating effectively with one another, due to differences in age, rank, status etc. Sometimes participants tend to spend too much time trying to solve a single problem. If this happens, the project manager should intervene in the discussion and make sure that things go according to schedule. When participants fail to arrive at a decision, the project manager must help them sort out their differences and encourage them to reach a decision before the meeting concludes. While closing the meeting, the project manager should present a summary of the discussions and thank all those who made significant contributions to the meeting. A follow up should be done to make sure the decisions taken at the meeting are implemented.

9.6.4 Recording and Distributing Minutes

The minutes of a meeting form an important part of the project documentation. They provide proof that certain problems were discussed and certain decisions were arrived at. Therefore, recording and distributing the minutes is as important as preparing the agenda.

Check Your Progress - 4

14. Which of the following will be the **correct** sequence of a typical project status review meeting?
    i. The project leader outlines the changes in the project that may have an impact on its future.
    ii. Activity managers present a report of the progress since the last status meeting.
    iii. The project manager checks the status of the problems that remained unsolved at the previous meetings.
    iv. Members present at the meeting explore new problem areas and assign responsibility for solving these problems.
    a. i-ii-iii-iv
    b. ii-i-iii-iv
    c. ii-i-iv-iii
    d. i-iv-iii-ii
15. Based on which of the following factors is the frequency of holding the project review meetings decided?
    a. Length and duration of the project
    b. Budget allotted for the project
    c. Availability of venue for holding the meetings
    d. None of the above

16. Which of the following are specified by the agenda of the meeting?
    a. Duration of the meeting.
    b. Time limit for discussing each of the topics.
    c. The scope of discussion of the topics.
    d. None of the above
17. Who among the following decides on the time of the meeting and makes the arrangements for it like fixing the place and arranging the required equipment?
    a. Project manager
    b. Meeting coordinator
    c. Project member
    d. External facilitator
18. Which of the following aspects have to be decided upon before a review meeting is held?
    v. Quorum for the meeting
    vi. Frequency of the meeting
    vii. Location of the meeting
    viii. Recording and distributing minutes
    a. Only i and iii
    b. Only i, ii and iv
    c. Only ii and iv
    d. i, ii, iii and iv
19. Which of the following involves the recording of the proceedings of the project status review meetings and forms an important part of the project documentation?
    a. Preparing agenda
    b. Recording and distributing minutes
    c. Status reviews
    d. Design reviews
20. Reviewing the _____ is the purpose of holding the project review meeting.
    a. Project budget
    b. Project status
    c. Project design
    d. Project duration

21. The _____ lists the issues that are to be discussed at the meeting.
    a. Minutes
    b. Agenda
    c. Duration of the meeting
    d. Time
22. Which of the following aspects need **not** be considered by the meeting coordinator when deciding on the time and arrangements for the meeting?
    a. The convenience of the place.
    b. Whether the seating arrangements are comfortable.
    c. Whether the visual aids are working properly.
    d. The proximity of the meeting place to the project site.

9.7 Advantages of a Project Status Review Meeting

Apart from allowing participants to share information and make decisions, a project status review meeting also gives the project manager a chance to – make the team more cohesive; keep the team informed about project's progress; identify potential problems; make sure the team has a clear idea of where the project is going; and ensure that the entire team is willing to put in their efforts to meet the project objectives.

Activity: Ganesh Ahuja joined a software development firm as assistant project manager. He is assigned to work under the senior project manager Shreenivas Raju, on a telecommunication software project. The project was half-way through when Raju called for a review meeting. And unexpectedly Raju was sent to New Jersey to handle another project (on which he was the project manager). So, the responsibility of conducting the review meeting was handed over to Ahuja, who had no previous experience in conducting review meetings. Think yourself as a senior project manager in the firm and advice Ahuja on how to conduct a review meeting. Explain to him the advantages of conducting review meetings.

Answer:

9.8 Types of Project Status Meetings

Project status meetings keep the participants informed about the project's progress. These meetings are usually attended by the representatives of senior management, the project manager, the client and the key members of the project team. These are the people who should be kept informed of the project progress. In the case of projects that are geographically dispersed, or projects in which different activities are being taken up in two different locations, it may not be possible for the project manager to bring all the parties involved under one roof to hold the traditional project review meeting. In such situations modern communication technology can be used to conduct meetings. Such meetings could either be long distance status meetings, which allow two-way communication or meetings conducted through a "visibility web-site" which allows only one-way communication.

9.8.1 Long Distance Status Meetings

These meetings enable two-way communication between the parties involved through audio conferencing or video conferencing. These meetings need a high amount of formality to ensure that all the topics in agenda are addressed. To make sure that all the topics in the agenda are discussed at these meetings and to keep track of all the parties involved, a structure called 'Open Job Report' is prepared.

9.8.2 Visibility Websites

A visibility website allows one-way communication between the project manager and the parties involved. This is the best way to keep people informed about the project developments. This information is available across the globe through a Uniform Resource Locator (URL). The most significant aspect of visibility website is its ability to link team members spread across different geographical locations.

Exhibit 9.2 gives a glimpse of PM's status review meeting on COVID

Exhibit 9.2: PM Modi Chairs High-Level Meeting to Review Covid Situation

- The meeting reviewed the Covid-19 situation and vaccination status across the country on 11th September, 2021.
- It was held a day after Union Health Secretary said India is still going through the second wave of Covid-19 and it is not over yet.
- He had said 35 districts are still reporting a weekly Covid positivity rate of over 10% while it is between five to 10% in 30 districts.
- The active cases comprise 1.18% of the total infections, while the national Covid-19 recovery rate was recorded at 97.49%.

Contd….

- The number of people who have recuperated from the disease surged to 3,23,42,299, while the case fatality rate was recorded at 1.33%.
- The cumulative anti-Covid doses administered in the country under the nationwide vaccination drive has exceeded 72.37 crore.
- Cumulatively, 28,57,04,140 people in the age group 18-44 years across the country have received their first dose and 3,85,99,523 their second dose since the start of phase-3 of the vaccination drive.
- The next phase of Covid-19 vaccination commenced from 1 March for people over 60 years of age and those aged 45 and above with specified co-morbid conditions.
- The country launched vaccination for all people aged more than 45 years from 1 April.
- The government then decided to expand its vaccination drive by allowing everyone above 18 to be vaccinated from 1 May.

Source: https://www.livemint.com/news/india/pm-modi-chairs-high-level-meeting-to-review-covid-situation-vaccination-status-in-country-11631272749327.html

Check Your Progress - 5

23. Which of the following allows a one-way communication between the project manager and parties who are geographically dispersed?
    a. Long distance status meetings
    b. Project review
    c. Visibility website
    d. None of the above
24. _____ is prepared to ensure that all the topics on the agenda are discussed and to keep track of all the parties involved.
    a. Open Job Report
    b. Visibility web site
    c. Agenda
    d. Process review
25. Which of the following enable/s two-way communication between the parties involved in the project through audio and video conferencing?
    a. Visibility website
    b. Long distance status meetings
    c. Project status review meetings
    d. None of the above

9.9 Summary

- Once the project enters the implementation phase, the project manager should review the status of the project in a timely and phased manner. Project reviews conducted at various stages of project implementation play a major role in the success of a project.
- Reviews are conducted to find out if the project can accomplish the business goals; whether the rules of the organization are understood properly and implemented; if it is worthwhile to take up the project at all before entering into major contracts; and whether the project is managed effectively, and the team members are sure of completing the project by following the guidelines.
- A project manager has to conduct various reviews throughout the life of a project to ensure that it is progressing towards achieving the planned objectives. Generally, a project manager conducts three types of reviews – status reviews, design reviews, and process reviews.
- A review should always be conducted before taking any major decisions that can affect the future of the project. Reviews can be conducted during the various stages of the project life cycle such as initial stage, implementation stage, and closing stage.
- Meetings are an effective and essential means of conducting project reviews in an organization. Project status review meetings are aimed at reviewing the project status and have a specific agenda. At these meetings, decisions are made, different aspects of the project are discussed, and the work is planned and scheduled.
- Project status meetings keep the participants informed about the project's progress. These meetings are usually attended by the representatives of senior management, the project manager, the client and the key members of the project team.
- Project status meetings could either be long distance status meetings, which allow two-way communication or meetings conducted through a "visibility web-site" which allows only one-way communication.

9.10 Glossary

Agenda: Lists the issues that are to be discussed at the meeting and process reviews are used to determine whether the processes are going as planned.

Comprehensive reviews: These are conducted monthly basis as part of the status reviews. Status reviews and process reviews are not done at any fixed milestones, but are conducted frequently to know the status and process of the project.

Cursory reviews: These are conducted as a part of the status review on a weekly basis.

Design review: The review conducted at the major milestones of project implementation to ensure the performance quality of the project deliverable.

Long distance status meetings: Enable/s two-way communication between the parties involved in the project through audio and video conferencing.

Open job report: A structure prepared to ensure that all the topics on the agenda are discussed at these meetings and to keep track of all the parties involved.

Visibility websites: One-way tools that help the project manager communicate with parties situated at distant places.

9.11 Self-Assessment Exercises

1. As the project enters the implementation phase, the project manager should review the status of the project in a timely and phased manner. Explain the importance of conducting a project review.
2. A project manager has to conduct various reviews throughout the life of a project to ensure that it is progressing towards achieving the planned objectives. What are the different types of project reviews conducted by a project manager?
3. A project review should be conducted before taking any major decisions that can affect the future of the project. What are the different stages in the project life cycle at which a project manager can conduct project reviews?
4. Meetings are an effective and essential means of conducting project reviews in an organization. What are these meetings? Describe the advantages of conducting these meetings. What are the various ways in which these meetings can be conducted?

9.12 Suggested Readings/Reference Material

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2. James Wood, Kory Kogon, and Suzette Blakemore, Project Management for the Unofficial Project Manager: A Franklin Covey Title, Goodreads, 2018
3. Heagney, Fundamentals of Project Management Paperback, Amacom, September 2018
4. Na, Nagarajan, Project Management 8/Ed, New Age International Publications, 2019
5. IES Master Team,, ESE 2020 - Basics of Project Management Paperback – 1 IES Master Publication, January 2019
6. Electronic Voting Machine Manual, Election Commission of India, July, 2018

9.13 Answers to Check Your Progress Questions

Following are the answers to the Check Your Progress questions given in the Unit.

1. **(c) Only i, iii, and iv**

   The purpose of the project review is to know whether the project can accomplish the business goals, whether the rules of the organization have been understood and will be implemented properly, whether it is worthwhile taking up the project at all before entering into major contracts, whether the project is being managed effectively, and whether the team members are sure of completing the project by following the guidelines laid out. It is not one of the purposes of the project review to determine whether the project is exceeding the budget limits set by the manager. But the results of the review will help the management to evaluate the cost of the project.

2. **(d) i, ii, iii, and iv**

   The project review helps the manager in keeping in mind the purpose of carrying out the project, determining the appropriateness of the project activities from time to time, gauging the way in which the objectives are being accomplished, verifying the completion of the project, evaluating the cost of the project, and understanding the project requirements.

3. **(c) American National Standards Institute**

   The design review criteria developed by the American National Standards Institute help in the design review of the projects.

4. **(b) status reviews.**

   Status reviews are conducted at fixed intervals to review the present position of the project. Generally, a cursory review is done every week and a comprehensive one every month to review the status of the project. But the frequency with which the reviews are conducted may vary depending on the frequency with which problems occur. Design reviews are conducted to check whether the design of the product or service being produced is of expected quality and the process reviews are conducted to determine whether the processes are going as planned and whether any improvements are possible.

5. **(d)Design review**

   Design review refers to the review conducted at the major milestones of project implementation to ensure the performance quality of the project deliverable. Design review is the tool to review the performance factor of the project. Comprehensive review is done on a monthly basis as part of the status reviews. Status reviews and process reviews are not done at any fixed milestones, but are conducted frequently to know the status and process of the project.

6. (c) Process reviews

Process reviews are sometimes conducted by external facilitators rather than the project manager himself/herself. This is because the team members may not feel free to be critical about the leadership skills of their project manager, leadership being one of the processes crucial for the success of the project. Cursory reviews and comprehensive reviews, which are part of status reviews, are generally conducted by the manager himself/herself.

7. (b) iii-ii-i

The steps in the problem-solving process are: Identifying the existing problems, identifying the factors that cause problems, and exploring solutions that can solve the problems.

8. (b) cursory review.

Cursory reviews are done as a part of the status review on a weekly basis. Comprehensive reviews, also a part of the status reviews, are done on a monthly basis. Design reviews are conducted to check whether the design of the product or service being produced is of the expected quality and process reviews are conducted to determine whether the processes are going as planned and whether any improvements are possible.

9. (c) Only ii and iii

The main objective of conducting a project review is to determine whether the processes are going on as planned and whether any improvements are possible. The two objectives of process reviews are: To preserve the performance of project processes that are going well and to improve the processes that are below standard. Reviewing the financial performance of the project and the safety of the operators and maintenance personnel are not the objectives of process reviews.

10. (c) Control of costs in project implementation

The design review covers only the performance aspects of the project implementation like manufacturability, serviceability, tooling, economics of special machinery, safety of operators and maintenance personnel, precautions taken to minimize damages, etc. It doesn’t cover the cost, time, and scope of the project.

11. (a) When auditing is to be conducted

The projects are reviewed at the post-implementation stage three to six months after the completion of the project and during the conduct of audit of the project. The other two options: when the major output of the project is to be delivered and at the point where major problems occur do not fall under the post-implementation stage of the project.

12. (d) When there are any minor difficulties in the project implementation.

The project review is conducted at the implementation stage of the projects at the following points: Before entering into major contracts, when the major output of the project is to be delivered, when the risk is substantially high, and when major problems occur.

13. (d) i, ii, iii, and iv

The important points or stages at which a review is conducted are as follows: In the initial stages of the project life cycle, at the stage when an in-depth evaluation is conducted, during the implementation of the project, when the project is completed, and when auditing has to be conducted.

14. (a) i-ii-iii-iv

The sequence of events at a review meeting are: The project leader presents the changes in the project that may have an impact on its future, the client presents the changes in the project that may have an impact on its future, the project manager presents the status of the project accompanied by a note on the impact of changes considered earlier, activity managers present a report of the progress since the last status meeting, activity managers of future activities outline the changes that have had an impact on the project status since the last meeting, the project manager checks the status of the problems that remained unresolved at the previous meetings, members present at the meeting explore new problem areas and assign responsibility for solving these problems, the project leader, the client, or the project manager makes closing comments and the project manager closes the meeting after announcing the venue, date, and time of the next review meeting. The activity manager presents the progress since the last status meeting to the members present at the meeting exploring new problem areas and assigning responsibility for solving these problems.

15. (a) Length and duration of the project

The frequency of holding meetings is decided based on the length and duration of the project. This is because meetings held more often than necessary lead to wastage of time. The budget allotted and the availability of venue for holding the meetings are not factors which determine the frequency of holding project review meetings.

16. (b) Time limit for discussing each of the topics.

The agenda of the meeting specifies the time limit for discussing each of the topics, depending upon the importance of the topics. The duration of the meeting and the scope of discussion of the topics at the meetings are not specified by the agenda of the meeting.

17. (b) Meeting coordinator

The meeting coordinator fixes the place and time for the meeting and arranges for the required equipment. The project manager and project member do not decide upon the time and arrangements of the meeting. The external facilitator is used in the process reviews of the project.

18. (c) ii and iv

The aspects that are to be decided upon before a review meeting is held are: Frequency of meetings, preparing the agenda, meeting the coordinator, and recording and distributing minutes. It is not necessary to decide upon the quorum for the meeting and the location before holding the review meeting.

19. (b) Recording and distributing minutes

Recording and distributing minutes forms an important part of project documentation and provides evidence regarding the problems which were discussed and the decisions arrived at in the review meeting.

20. (b) project status

Organizing meetings is an effective way of conducting project reviews in the organization. The meetings will have a specific agenda of reviewing the status of the implementation of the projects. Reviewing the project budget, project design, and project duration are not the purposes for which a project review meeting is held.

21. (b) agenda

The agenda of the meeting lists out various issues that are to be discussed at the meeting. The minutes of the meeting are prepared after the meeting has been conducted.

22. (d) The proximity of the meeting place to the project site.

The coordinator must consider the following while deciding on the place and time of the meeting: Whether the room is big enough to accommodate all the participants of the meeting, the convenience of the place, whether the seating arrangements are comfortable, whether the room in which the meeting is to be held has proper light and ventilation, whether the visual aids are working properly, whether additional stationery and name plates are required, and how messages are to be handled in the meeting.

23. (c) Visibility website

The visibility website is a tool which enables a one-way communication between the project manager and the parties involved.

24. (a) Open Job Report

Open job report is the structure prepared to ensure that all the topics on the agenda are discussed at these meetings and to keep track of all the parties involved. Visibility websites are one-way tools that help the project manager

communicate with parties situated at distant places. The agenda lists the issues that are to be discussed at the meeting and process reviews are used to determine whether the processes are going as planned.

25. (b) Long distance status meetings

Long distance status meetings enable two-way communication between the parties situated at distant places through audio and video conferencing. The visibility website only allows one way communication between the project manager and the parties involved. Project status review meetings are held if the participants have geographical proximity.

Unit 10

Project Control

Structure

10.1 Introduction

In the previous unit, we have discussed about project review. In this unit, we will discuss about project control. Project control is the process of collecting information related to the performance of the project system, comparing it with the desired level of performance and taking corrective action to decrease the gap between the actual and the desired performance levels. The basic purpose of project control is to control and manage change. Project control is not a separate phase in itself but it goes hand in hand with the project implementation phase.

As the project progresses, the project manager gathers all the information pertaining to project status from its team members and the clients. The information gathered has to contain the progress made, percentage of work completed and predictions indicating the possible date of completion. This is the right period for getting inputs on changes in activity dependencies and to decide on the inclusion or exclusion of activities from the plan. The information gathered can be analyzed to find out variances, to examine the total performance of the

project and to prepare monthly sales reports. The significant areas to look out for variances are scope of the project, project schedule and resource utilization.

An effective project management system is one which puts in place a well organized control system at the time of project planning. Once the project enters the execution phase, it is the responsibility of the project manager to check whether the actual output matches with scheduled/desired level of output. The parameters to be used are performance, time and cost. A project control system helps in fixing problems in time and in putting the system back in shape. The idea behind implementing a project control system is "A stitch in time saves nine". A project control system is a corrective, evaluating tool to minimize the risk and cost of project deviations that may lead to project failure.

This unit will deal with the fundamentals of project control. We will discuss the objectives of control, control as a function of management, and the difference between control and risk. We will also discuss the reasons for measuring duration and cost deviations, and understand the ways to balance the control system, and control change and scope creep. We shall then move on to discuss progress reporting system and describe the various types of project status reports. We will also discuss about the graphical reporting tools and project status review meetings. Finally, we would be discussing the different ways to manage risk and quality.

10.2 Objectives

By the end of this unit, students should be able to:

- Explain the fundamentals of project control.
- Define the objectives of control.
- Discuss the reasons for measuring duration and cost deviations.
- Recognize control as a function of management.
- Differentiate between control and risk.
- Identify ways to balance the control system.
- Determine ways to control change and scope creep.
- Define progress reporting system.
- Recognize the various types of project status reports.
- List the graphical reporting tools.
- Discuss project status review meetings.
- Find out different ways to manage risk and manage quality.

10.3 The Fundamentals of Project Control

Project controls are tools developed to diagnose the system for deviations from the actual plan and reset them back with the actual plans/schedule. Project controls are required to check whether the project is progressing in accordance with the plans and standards set during the planning phase. In fact, the project

controls are measures taken by the project manager in order to minimize the gap between the planned output and the delivered output.

Answering the following questions will help us in designing an effective control system:

- Who sets the standards?
- How realistic are the set standards?
- How clear are the standards?
- Do these standards achieve the project's goals?
- What are the outputs and behaviour that need to be monitored?
- Is monitoring of people required?
- What kind of sensors are to be used?
- Where should the sensors be placed?
- How frequently should the monitoring be done?
- What should be the tolerable gap between the actual and the planned output before taking the corrective measures?
- What are the corrective measures available to take corrective action if needed?
- How ethical are these corrective measures?
- What rewards and penalties can be used to get the desired results?
- What kinds of actions are to be taken and by whom?

An effective control system is one that appears sensible and acceptable to those who use it and those who are controlled by it.

A project control system aims to minimize the gap between project planning and project execution in order to achieve project aims, i.e., cost, time, and scope. Planning, measuring, monitoring, and taking corrective action are all usually included in the control cycle. Typically, projects utilize a control system, which monitors the difference or gap between the planning variables and the actual results.

During the past decade, leading projects in many industries were enterprise resource planning (ERP) implementation projects. It was found that the recommended actions needed to bring troubled ERP projects under control are as follows:

(a) Redefining or subdividing the project;

(b) Improving project management through the use of formal tools and techniques; and

(c) Using a team-based approach to solve specific project problems.

The key element is to somehow link these factors to the project control system.

A useful control tool applied in the software industry to reduce project failure is the identification and analysis of threats to success. This control process was developed in USA, Finland, and Hong Kong using the Delphi methodology for the analysis and presentation of all possible resource requirements and outcomes. The successful completion of a project within budgeted time, cost, and perceived parameters depends to a great extent on the early identification and control of immediate risks to the project

There is a need for a holistic approach to multidimensional project control. For instance, the 9/11 incident, the rejection of the EU constitution treaty in the French national poll, growing U.S. China trade conflicts, the currency crisis in East Asia, and the recent upsurge of international oil prices were least expected, even by experts. These incidents, whose frequency has seemingly increased in the post-Cold War period, have influenced and will continue to influence project implementation, since such risks cannot be internalized in project management. Project managers must deal with such risks in a most flexible and economic manner so as to minimize losses of project profitability.

Project control systems can be classified as: (1) one-dimensional control systems, and (2) multidimensional control systems.

Both one-dimensional and multidimensional control systems execute one or more predefined project control objectives. In one-dimensional control systems, such objectives are not integrated in any way, whereas multidimensional control systems integrate several project control objectives.

The earned value (EV) methodology is probably the most commonly used multidimensional project control method, integrating time and cost. Variations of multidimensional control systems exist that are associated with risk management, theory of constraint, statistical process control, and so on.

Another important factor in both project control systems is the ability to determine when to perform the control activity for determining the optimal timing of project control points throughout the life cycle of the project.

Project management researchers and practitioners state that existing project control systems have several deficiencies. An important conclusion was that matching project objectives with the appropriate methodology is an important goal that remains to be explored. In the U.K., performance evaluation of new product developments was surveyed. Without exception, all companies wished to improve their use of performance measures. This implies that the methodologies used by these companies were not satisfactory.

Organizations need to use performance measurements in project management. Earned Value management is a popular technique to measure the progress of the project in terms of time and money.

Multidimensional project control systems integrate several dimensions within the control system. Integrated cost and schedule control systems were introduced in

the U.S. during the 1960s and were used mainly in defense projects. These systems created standards that were supported by official guidelines (e.g., U.S. DoD, 1997). The project control system, also called EV, was implemented in large projects budgeted by the DoD. This classical project control method was used to monitor two dimensions: time and cost. The EV methodology is based on the work breakdown structure (WBS) planning tool. The second edition of the PMBOK® Guide (2000) defines WBS as "a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project." Using a WBS to plan a project means the hierarchic structuring of a project using its components and subcomponents. A work package, usually at the lowest level of a WBS, includes a set of tasks to be carried out in a predefined organizational unit. In general, work packages are used as the basic elements in the planning and control phases of a project. The project manager should have flexibility to design the WBS and the lowest level in the WBS may be connected with dependency links in a dependency diagram.

The U.S. Air Force uses a methodology that uses EV principles to examine work-performed cost versus budgeted cost. EV is recognized as a very common methodology for project control.

Currently, project control systems employ similar principles. The Hong Kong construction industry uses integrated cost/schedule control. The software services industry uses Effort Variance, Schedule variance and risk to measure and control the progress of the project. Using a single performance measuring system would not advance the project's performance.

Additional variations of multidimensional project control systems exist. These variations logically lead to a new approach called multidimensional project control systems (MPCS), which attempts to integrate all factors identified as being important.

An enrichment EV system is one where quality breakdown structure (QBS) is integrated that indicates the overall quality objectives. This dimension enables the project manager to assess, at any time, the overall quality simply by comparing its earned quality with the planned quality. Assessing ongoing quality enables the project manager to identify activities that were not performed successfully. The assessment of such activities initiates corrective actions as quality deviations are detected.

10.3.1 Characteristics of an Effective Control System

For a control system to be effective and efficient, it should fulfill the following requirements:

Comprehensiveness: The control system should give a detailed overview of the work to be performed. It has to estimate the time, labor, and costs required to finish the project.

Communicability: The system should communicate the scope of the project.

Authenticity: The system should reflect budgetary discipline and authentic expense tracking by accounting tangible progress and cost expenditure in time.

Timeliness: The control system should be able to frequently re-analyze the cost and time required for the completion of the remaining work. This is done by comparing the delivered output with the actual/scheduled output in terms of performance, cost and time thereby rendering the system cost effective.

Simplicity: The system should be simple to operate.

Flexibility: The system should be open to extensions and alterations and it should also be easy to maintain.

Morally sound: The system should conform to all the ethical standards.

Check Your Progress - 1

1. Which of the following characteristics of an effective project control system refers to budgetary discipline and expense tracking by accounting tangible progress and cost expenditure in time?
   a. Comprehensiveness
   b. Simplicity
   c. Authenticity
   d. Moral soundness
2. It is the duty of the project manager to ensure that the actual output matches the desired output. Which of the following parameters should be used to ensure that this is monitored properly?
   i. Performance
   ii. Time
   iii. Price
   iv. Cost
   a. Only i
   b. Only i, ii, and iv
   c. Only ii, iii, and iv
   d. i, ii, iii, and iv
3. Which of the following options involves the process of collecting information related to the performance of a project, comparing the performance with the desired levels of performance, and taking corrective action if there is any gap between the actual and desired levels?
   a. Project review
   b. Project control
   c. Project risk management
   d. None of the above

4. Project controls are required to check whether the project is progressing in accordance with the standards set during the planning phase. Which of the following is a characteristic of an effective project control system?
   i. Comprehensiveness
   ii. Authenticity
   iii. Timeliness
   iv. Moral soundness
   a. Only i
   b. Only i, iii and iv
   c. i, ii, iii, and iv
   d. Only ii, iii, and iv
5. Which of the following characteristics of project control means that the system is open to extensions and alterations and is easy to operate?
   a. Comprehensiveness
   b. Flexibility
   c. Simplicity
   d. Moral soundness

10.4 The Objectives of Control

The primary objective of control is regulation. The purpose is to monitor the delivered output by comparing it with the actual/scheduled output suggested in the planning phase. The regulatory function of control helps in – translating the objectives into performance standards that are represented by program activities and events; and formulating budgets in order to compare the delivered output with the actual/scheduled output.

The secondary objective of control is conservation of resources. The project manager is entrusted the responsibility of protecting the physical, human and financial resources of the organization. The process of guarding each of these three assets is different. Resource control involves evaluating the utilization factor of resources. Human resource control tries to determine whether the individuals are capable of the efforts required to finish the task on time. It is hardly possible to dedicate the resources totally to a specific project. When the human resources are shared between the projects, some projects may not be able to achieve its objectives due to mismanagement or misallocation of their personnel.

Physical asset control is the process of controlling the use of physical assets. It includes the preventive or corrective maintenance of the assets. A project manager has to schedule the maintenance/ replacement plan in a way as to minimize interruption to the work in progress and without overlooking the quality

aspect. Controlling the inventory is also a key aspect that involves receiving, inspecting, storing and recording to ensure genuine payment to vendors. This also involves proper material handling techniques.

Human resource control is the process of controlling and maintaining the growth and development of the human capital of the organization. Unique projects enable people gain rich experience within a short period of time. Conserving human resource is therefore a significant aspect of the control system.

Financial resource control is a combination of regulatory and conservatory functions. The conservatory function of control on capital investments requires the meeting of certain conditions before investments are made. The same conditions also regulate capital flows for a higher return on investment. The regulatory and conservatory techniques of financial resource control consist of a control on current assets and project budgets along with capital investments. These controls are implemented through a series of analysis and audits by the controller or the project manager.

The tertiary objective of project control is to facilitate decision-making. Effective decision-making by the management requires the following reports:

- A report comprising the plan, schedule and budget made during the planning phase.
- Data consisting of the comparison between the resources spent in order to achieve the delivered output and the scheduled output. This report should also include an estimation of the remaining work.
- An estimate of the resources required for the completion of the project.

These reports that are submitted to the project managers and team members are useful in the following manner:

- They provide feedback to the management, planners and team members.
- They identify the deviations from the scheduled plan.
- They implement a contingency plan at an early stage in order to protect the project from higher losses due to cost, performance and time overruns.

10.4.1 Need to Control Performance, Time, and Cost

Talking of control always brings three parameters into the discussion: the performance, the cost and the time of a project. These three aspects are of utmost importance to any project manager because he is answerable to the client. This makes the project manager to check whether the project is progressing as per the expectations and if it is operating within the time frame and budget. The need to control the performance, cost and time arises from this.

Controlling Performance

It is necessary to control performance because technical problems may spring up any moment; resources may become scarce; complicated technical snags may

develop; quality problems may arise; the client may request for changes in the system specifications; inter functional complications may arise; and technological breakthroughs can also affect the project.

Controlling Costs

Some of the reasons that necessitate cost control are – more resources are required to solve the technical problems; cost of the project increases proportionately with the scope of the project; low estimations were given initially; poor reporting structures; inappropriate budgeting; failure to put a corrective measure in place in time; and change in the prices of inputs.

Controlling Time

Some of the reasons that necessitate time control are – solving a technical snag may require more time than estimated; time estimations that were done initially were very optimistic; tasks were inappropriately sequenced; shortage of material, personnel or equipment when required; incomplete preliminary tasks that were necessary to complete a series of activities; and changing government regulations.

Check Your Progress - 2

6. The project manager is entrusted with the responsibility of protecting the physical, human, and financial resources of the organization. _____ is the objective of project control which deals with the protection of these resources.
   a. Conserving the resources
   b. Regulation
   c. Facilitating decision making
   d. None the above
7. Which of the following options reflect the primary, secondary, and tertiary objectives of a control system in an order?
   a. Facilitating decision making, conserving resources, and regulation
   b. Conserving resources, facilitating decision making, and regulation
   c. Regulation, conserving resources, and facilitating decision making
   d. None of the above

10.5 Reasons for Measuring Duration and Cost Deviations

Before going into the reasons behind measuring duration and cost deviations, it is necessary to talk about variances and kinds of variances. Variances are deviations from the actual plan. Based on the parameters of time and cost, variances can be classified into Positive variances and Negative variances.

A positive variance is one in which the delivered output is ahead of the planned schedule or the cost incurred is less than the planned cost. Though positive variances are good news for the project managers, they can be as threatening as negative variances. Positive variances are capable of advancing the project completion date and allocating lesser resources than estimated. However, these variances can also occur as a result of missing an activity that was supposed to be completed during the reporting period. It needs to be examined thoroughly before reporting a positive variance.

A negative variance is one in which the delivered output is behind schedule or the cost incurred is more than the planned cost. The project manager would want a detailed report on the schedule accomplished and the costs incurred, along with the reasons for the delay.

It is important to measure duration and cost deviations because they play a significant role in the project management life cycle. Though all the parameters of project management have their own levels of significance, time and cost share a special place.

10.5.1 Identifying Deviations from the Curve Early

When the project manager plots the actual performance or cost curve against the planned performance or cost curve, he may observe some deviation between the curves. This deviation between the curves cautions the project manager about cost and performance overruns. This enables the project manager to initiate timely corrective measures to minimize the deviations.

10.5.2 Dampen Oscillation

A constant, continuous and identical pattern should be displayed by curves representing the actual and the planned performance over time. Projects with high fluctuations over time result in many bottlenecks in the project life cycle like running behind schedule, overspending during one phase and going out of control in the next phase. Measuring deviations would help the project manager in taking timely corrective measures that would nip problems in the bud.

10.5.3 Facilitate Early Corrective Action

A schedule or a cost problem is better reported to the project manager at an early stage of its development. The project manager has more opportunities for a corrective action plan when the problem is detected early.

10.5.4 Estimating Weekly Schedule Variance

Weekly reports on the work in progress have to be made, to give the project manager enough time to take corrective measures before the situation gets out of control.

10.5.5 Determining Weekly Effort (Person Hrs/Day) Variance

The variance between the planned/scheduled effort and the delivered effort has a direct impact on the planned cumulative cost and schedule. A lower delivered effort than the scheduled effort indicates that the potential has not been optimized

i.e., a person failing to enhance his/her effort in the following phases of the project. However, if the delivered effort is more than the scheduled effort, where progress is not in proportion with the effort put in, may result in a cost over run. It is very important to detect the out of control situations early. The longer one takes to detect a problem, the harder it will be to put the project back on track.

Exhibit 10.1 outlines the reasons for cost overruns in projects.

Exhibit 10.1: Reasons for Cost Overruns

During the proposal submission phase

1. Lack of understanding of the client's requirements.
2. Unrealistic evaluation of internal strengths.
3. Misjudging time requirements for project completion.

During the planning phase

1. Neglecting importance of planning
2. Incorrect work breakdown structure
3. Distortion of Information.
4. Using inappropriate reviewing techniques.
5. Inability to find and focus on the key parameters of the cost
6. Inability to analyze risk

During the negotiation phase

1. Demanding a faster settlement.
2. Settling for a higher cost

During the contractual phase

1. Conflicting clauses in the contract.
2. Different teams for projects and proposals

During the design phase

1. Entertaining change requests from the client without the top management's approval.
2. Difficulty in the communicating with the client.
3. Difficulty in conducting meetings on design review.

During the production phase

1. Higher inventory costs
2. Inappropriate specifications of the deliverables
3. Lack of compatibility between the production and engineering functions.

Source: ICFAI Research Center

Check Your Progress - 3

8. Which of the following options refers to the project manager taking timely corrective action to nip problems in the bud?
    a. Facilitating early corrective action
    b. Estimating weekly schedule variance
    c. Identifying deviations from the curve early
    d. Dampening oscillation
9. Among the following options, what is the type of variance in which the delivered output is behind the project schedule or the cost incurred is more than the scheduled cost?
    a. Coefficient of variation
    b. Positive variance
    c. Negative variance
    d. None of the above
10. _____ is the deviation from the actual project plan.
    a. Range
    b. Variance
    c. Coefficient of variation
    d. None of the above

10.6 Control as a Function of Management

Project control is generally implemented through people. Any form of control has a significant impact on human behavior. Because of this, it becomes necessary to study project control with special reference to people and their behavior.

10.6.1 The Governance Model in an Organization

The purpose of establishing governance and control across the organizational hierarchy is to minimize the gap between the delivered schedule, budget and output of the project and the planned schedule, budget and output. Though the fundamental purpose of control remains constant - to minimize the deviation between the actual and planned output- the management function of control involves developing and implementing control systems to observe people's response to various controls.

The various techniques for enhancing creativity and problem-solving through team work such as Total Quality Management (TQM) and Employee Involvement (EI) give the team a sense of direction and motivation to achieve a

goal. All these techniques signify control. Control is an inherent part of every organization. Control helps in achieving and preserving the ethical goal directed behavior. It is the project manager's responsibility to implement controls that instigate only those behaviors that are desirable. It is presumed that the control system motivates individuals and also affects the levels of motivation.

Individuals may respond to the goal directedness of control systems in the following manner – through active and passive participation and goal oriented behavior; through passive involvement to minimize loss; and through active but negative involvement and resistance.

10.6.2 Types of Control Processes

The process of controlling a project is a highly complex task. The complexity is more than fixing the problem after waiting for something to go wrong. Control starts from identifying the points in the project to exert control, knowing what should be controlled and how to measure it, what should be the tolerable limit of deviation and how to identify and correct these deviations as they happen. Project control is used to check the four key parameters time, cost, scope and performance. There are three basic control mechanisms – cybernetic control, go/no-go control, and post control.

Cybernetic Control

Cybernetic controls, also known as steering controls, are very common control systems. Automatic operation is its chief characteristic. A cybernetic control is like a steering in an automobile that enables the controller to keep the project on track. Cybernetic controls are generally used to monitor and control tasks that are carried out more or less continuously, for example, software projects. The designing of cybernetic controls requires identifying mechanical tasks, based on the Work Breakdown Structure (WBS).

The operation begins with an input that gets processed into an output. The sensing unit that monitors the output of the process (that we wish to control) sends the input to the comparison unit which then compares it with the standards that are already set. The comparison unit after measuring the variation between the input and the standard set, sends the output to the decision maker to decide on the requirement of a corrective action depending on the size of variation. If the variation is large enough to implement a corrective measure, the decision maker acts on the processing unit or the input to get it in close congruence with the set standards.

A cybernetic control system that minimizes the variation from the set standards is known as a negative feedback loop. The control mechanism in a cybernetic control system acts in a direction that is opposite to the one in which the variation moves away from the standard. Also the speed of action of a control is directly proportionate to the size of variation from the standard.

Cybernetic controls can be classified into three types, depending on the sophistication of the standards set. A first order control system is a goal-seeking device. It is a rigid system that seldom allows altering the set standards. The standards once set can be altered only by an external intervention. For example, once a standard temperature is set in a thermostat, the air-conditioning systems operate to maintain it. A second order control system can alter the standards that are set only in accordance with predetermined rules and regulations. A third order control system is a flexible goal seeking device. These systems are flexible enough to alter their standards from time to time, based on the evaluation of the past performances. These systems can deal with contingencies better than the rest.

Information Requirements of a Cybernetic Control System

Every output needs an input that has to be processed. If output here is an effective cybernetic control system, the inputs required by the project manager would be information. The information that is required for developing cybernetic controls is as follows:

- Defining the characteristics of the output that are to be controlled.
- Setting the standards for the defined characteristics.
- Acquiring the sensors that measure the characteristics at a particular level of precision.
- Transforming the measurements into signals that are to be compared with the set standards.
- Detecting the difference between the output and the standard set. If the variation is large enough, the decision maker should act on the processing unit in such a way that it tries to bring the output in close congruence with the set standards.

A cybernetic control system is most effective in keeping track of a system and in notifying the project manager automatically when the output starts deviating from the set standards.

Activity: George Erix, the COO of a project management firm, wants to revise the firm's control mechanisms for a new project – erecting a manufacturing facility at a new steel plant. Freddy Fernandez, a senior project manager, is asked to develop control mechanisms right from scratch. Identify and describe the control mechanisms that Fernandez can incorporate in the project. What type of information do these mechanisms require?

Answer:

Check Your Progress - 4

11. From the following options, identify the type of control whose chief characteristic is automatic operation.
    a. Go/No-go control
    b. Post control
    c. Cybernetic control
    d. None of the above
12. In the negative feedback loop cybernetic control system, the speed of action of control is _____ proportionate to the size of variation from the standard.
    a. Inversely
    b. Directly
    c. Conversely
    d. NONE of the above
13. Cybernetic controls can be classified into various types depending upon the sophistication of the standards set. Which of the following control system is a flexible goal-seeking device?
    a. First order controls
    b. Second order controls
    c. Third order controls
    d. Fourth order controls
14. Individuals can respond to the goal directedness of control systems in various ways. Which among the following is/are the ways through which individuals respond to goal directedness of the control system?
    i. Through active and passive participation and goal-oriented behaviour.
    ii. Through passive involvement to minimize loss.
    iii. Through active but negative involvement and resistance.
    a. Only i
    b. Only ii and iii
    c. i, ii, and iii
    d. Only i and ii
15. The setting up of the cybernetic controls requires various types of information. Of the following, which type of information is **not** needed for setting up the cybernetic controls?
    a. Setting the standards for the defined characteristics.
    b. Defining the characteristics of the output that is to be controlled.
    c. Milestones achieved in project implementation.
    d. Transforming the measurements into signals that are to be compared with the set standards.

16. A cybernetic control system that minimizes the variation from the set standards is known as a _____.
    a. Negative feedback loop
    b. Go/no-go controls
    c. Post controls
    d. None of the above

10.6.3 Go/No-Go Controls

As cost and time overruns may require the organization to pay penalties to the customer, Go/No-go controls are instituted to check whether the output meets the preset cost and time standards. These control systems are flexible and apply to all the aspects of project management. The project plan, budget and schedule are the control documents that contain preset milestones that act as verification points.

Controls are usually done at the level of detail as mentioned in the project plan, budget and schedule. The periodicities with which Go/no-go controls are operated are regular and preset. Preset intervals are decided upon with the help of calendars or the operating cycles. Because project milestones do not happen as planned in the calendar, it is advantageous to link these controls to the actual plans and the happening of real events. But a judicious use of these controls is advisable. While some parameters of output have to meet a particular standard range, others may or may not meet the standards precisely.

The major difference between the cybernetic and the Go/No -go control system is that a cybernetic system functions automatically and continuously, while a go/no-go system functions only when it is put into application by the controller, and is periodic.

10.6.4 Information Requirements for Go/No-Go Controls

Setting up an effective Go/no-go control system requires the following documents:

Project proposal: This document specifies the expected business value (i.e., return on investment) along with the cost and time estimates of the project. It describes what is to be done, who's going to do it, when is it going to be done and how. It gives a detailed map of the project. The project proposal describes the project background, states the objective of the project, and specifies the approach, the time and the cost requirements of the project.

Project plan: This document gives the ends and means to a particular action or objective. It describes the ways in which a project can be executed. It is a decision making tool that enables the project manager choose the best alternative from different approaches, schedules and resource requirements. A project plan is an effective tool in the hands of the project manager. An effective project plan reduces uncertainty and enhances clarity and efficiency of the delivered output.

Project specifications: These are the set of rules and regulations under which the objectives of the project are met. This document lays down standards that are to be met by the output of all the processes contained in the project lifecycle.

Project schedule: This document specifies a time frame for each activity.

Project budgets: Cost of the project being a key parameter in the project management, it needs to be monitored very carefully. Capital is a very scarce and valuable resource in project management that needs to be monitored closely. This document gives the estimation of the cost required to finish the project.

Milestones: These are the key parameters that highlight the control activity. Milestones, which are in the form of output, are delivered by the project. If the project is able to meet the milestones on time and budget and at a desired quality level, the project manager can be sure that the project is proceeding smoothly.

10.6.5 Post Controls

These are the control systems that are applied after the completion of the project. These are also called post project controls or reviews. As George Santayana said "Those who cannot remember the past are condemned to repeat it". Thus, while cybernetic and go/no-go controls help a firm to accomplish the goals of current projects, post control tries to enhance the firm's chances of meeting future project goals, on the basis of lessons learnt in the past projects. A post control report has the following sections:

The Objectives of the Project

The post control report explains the objectives of the project. It also includes the effect of change requisitions and their approvals on the project scope. Though the actual output of the project depends partially on uncontrollable external factors such as strikes, vendor delays, climatic conditions etc., the assumptions made while planning the budget and schedule should also be mentioned. Enough care has to be taken while giving assumptions so that they do not seem to be excuses to cover failures in the later projects.

Milestones, Checkpoints, and Budgets

This part of the post control report compares the actual project performance with the plans and points out deviations. This section includes the different status reports prepared during the project life cycle.

The Final Project Result Report

In this final project result report no distinction is made between positive or negative deviations while reporting the deviation of actual performance from the planned performance. The report is focused on the "How" aspect of the deviation rather than the "What" aspect. This part of the post control report describes the techniques that were used to plan and direct the project, review the communication networks and monitoring and control systems used during the project life cycle and examines the interactions between different work groups.

Recommendations for Performance and Process Improvement

This final section of the post control report contains recommendations for future projects. Though most of the reasons for deviation are one time events, some of the reasons are likely to recur and these are the areas that need attention. The predictability of such events can be improved by psroviding a slot for them in the project plan. Organizational systems and management techniques that proved effective in the current project can be used for future projects. Thus post control has a significant impact on the way future projects are handled. The control mechanisms are aimed at minimizing the amount of risk involved in managing projects. However, risk cannot be eliminated totally.

Check Your Progress - 5

17. Which type of project control mechanisms deal with the 'How' aspect of the deviation rather than the 'What' aspect?
    a. Cybernetic controls
    b. Go/No-go controls
    c. Post controls
    d. None of the above
18. The setting up of the Go/No-go controls requires various documents. Of the following, identify the document which is **not** necessary for setting up the Go/No-go controls.
    a. Project schedule
    b. Project plan
    c. Project definition statement
    d. Project proposal
19. The control systems that are applied after the completion of the project are called
    a. Cybernetic controls.
    b. Go/no-go controls.
    c. Post controls.
    d. Negative feedback loop.
20. Post control systems are applied after the completion of the project. From the options given, identify the sections present in the post control report.
    i. Objectives of the project
    ii. Milestones, checkpoints, and budgets
    iii. The final project result report
    iv. Recommendations for performance and process improvement
    a. Only i, ii, and iii
    b. Only i, iii, and iv

c. Only ii, iii, and iv

d. i, ii, iii, and iv

21. The document which specifies the time frame for each activity in the project is called

    a. Project proposal.

    b. Project plan.

    c. Project schedule.

    d. Project budgets.

22. The set of rules and regulations under which the objectives of the project are met is called

    a. Project proposal.

    b. Project plan.

    c. Project budgets.

    d. Project specifications.

23. Out of the following control mechanisms, identify the ones applied periodically.

    a. Cybernetic controls

    b. Go/No-go controls

    c. Post controls

    d. None of the above

10.7 Control vs. Risk

Once the project is in the implementation phase, the project manager would like to make sure that the project is moving ahead according to the plan. A number of reports are developed that show how closely the project is following the plan. This makes it easier for the firm to identify and correct deviations. The project plan being a system may go out of balance any time and hence as a precautionary measure we require a corrective plan that can bring the system back to equilibrium. Control systems are designed in such a way that they enable early detection of problems and a faster implementation of corrective measures.

10.7.1 High Control – Low Risk

Putting in more controls can reduce the risk of the project. But there is a balance between the amount of control that is achieved by seeking reports and enhancing their frequency and the protection bought against the out-of-balance situations that affect the risk unfavorably.

10.7.2 Low Control – High Risk

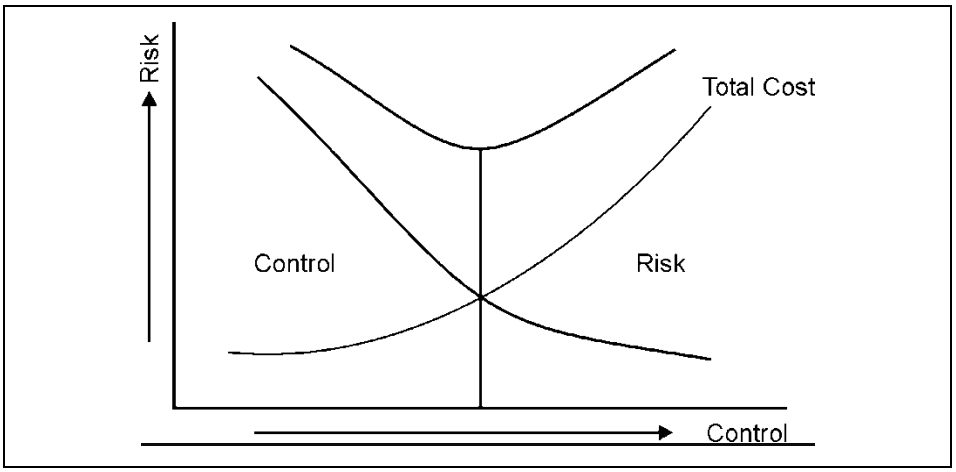
The project is unlikely to move ahead according to the plan, without proper control measures in place. Timely detection of problem situations in a project and

the design and implementation of a control plan is critical to a project's success. Without control plans, a project runs the risk of being completely derailed whenever problems occur. In studying the relationship between control and risk it becomes necessary to know the tools that enable us to strike a balance between control and risk.

10.8 Balancing the Control System

The greater the control exercised over a project, the less likelihood there is of project getting into trouble. However, enhancing the frequency of carrying out the project controls leads to wastage of time in reporting. In order to respond to the controls exerted, the team members would have to spend time in preparing reports and answering queries - thereby minimizing the time spent on project work. Controls do not come without a cost. Exercising greater control pushes up the cost of the project and leads to micromanaging events. The project manager has to decide as to what extent the project has to be controlled. Excessive control induces rigidity and tends to block creativity. The project manager should encourage creativity. The cost of control should be measured against its effect on the team members. Figure 10.1 gives the total cost of control and risk. It depicts the relationship between risk and control. Conceptually, the balance point reduces the overall cost liability for choosing a specific degree of control.

Figure 10.1: Total Cost of Control and Risk



A balanced control system has the following characteristics:

- The fact that investment in control and returns are inversely proportional to each other is to be kept in mind before designing a balanced control system. A linear increment in the degree of control results in an exponential hike in the cost.
- A balanced control system acknowledges that exerting control beyond a point would dampen creativity.
- A balanced control system focuses on correcting errors, rather than punishments.
- A balanced control system exercises only the minimum control that is required to achieve the project goals.

On the whole, a balanced control system is one that is cost effective and well equipped to seek the end results. For example treating everyone equally appeals to a sense of equity, but treating everyone individually would achieve better results.

10.8.1 Causes of Imbalance

It is important to know the factors that cause imbalances in a control system. such imbalances could be due to the following reasons:

- Focusing on easy to measure factors, while ignoring intangible factors that are difficult to measure.
- Laying greater emphasis on short-term results rather than on long-range objectives.
- Ignoring the organizational goals and structural changes brought about by time and the circumstances in which the firm operates.
- Exercising too much control.
- When organizations adopt management by objectives employees may ignore activities that are not considered for measurement.

Implementing a balanced control system is difficult. An important principle that is often overlooked is the need to relate the controls directly to the project goals. Also controls should be related to particular performance outputs. The process of relating controls to the project goals starts by describing the desired outputs as precisely as possible. Then the potential reasons for deviations are examined, after which proper controls are developed for these reasons starting with the one that can cause the highest intensity of deviation.

Striking a balance between the long-term and short-term controls is a difficult task because project managers are often more concerned with achieving the short-term objectives rather than long-term goals.

Check Your Progress - 6

24. Which of the following options represents the correct relationships between risk and control while balancing risk and control in the control process?

    i. Low Control-High Risk

    ii. Low Control-Low Risk

    iii. High Control-Low Risk

    iv. High Control-High Risk

    a. Only i and iii

    b. Only ii and iii

    c. Only iii and iv

    d. i, ii, iii and iv

25. Various factors cause imbalances in the control system. Which of the following is **not** a cause for such imbalances?
    a. Focusing on the easy to measure factors while ignoring the intangible factors that are difficult to measure.
    b. Laying too much emphasis on long-range objectives rather than short-term results.
    c. Exercising too much control.
    d. Ignoring the organizational changes and structural changes brought about by the time and the circumstances in which the firm operates.
26. Exercising greater control pushes up the cost of the project. _____ reduces the overall cost liability for choosing a specific degree of control.
    a. Balance point
    b. Balance control system
    c. Post controls
    d. None of the above

10.9 Control of Change and Scope Creep

Controlling the scope of a project involves attempts to include changes in the project scope when they occur and manage these changes simultaneously. In situations where these scope changes are inevitable, the project manager has to find out their impact on the project plan and seek the approval for the same from the client. Also the changes have to be communicated to the team members and the stakeholders, after they \ are approved by the client. There are many factors that have the potential to make a good application obsolete, such as changes in technology, changes in the competitive environment, or the reactions of customers. The three basic causes that can lead to changes in the project are;

- Uncertainty regarding the technology that is to be used in the project
- An increase in the level of sophistication of customers, leading to scope creep
- Modification of rules and regulations under which a process has to be carried out to convert the input into a desired output.

Any change can hamper progress, especially if it is introduced in the implementation phase. But changes cannot be avoided, as they are usually caused by factors that are beyond the control of the project manager. An effective project management system must have an effective change management method. Most changes are a result of efforts made by the client and the team members to improve the product. Incorporating changes when the project has already reached an advanced stage is difficult and expensive.

The absence of a proper control system to qualify a change for an implementation would result in a continuous piling up of all the small changes, which will have a negative impact on the cost and schedule of a project. Practices like Total Quality

Management (TQM) and Employee Involvement (EI) have proved helpful in conducting a detailed study on the outputs and processes of control systems. This detailed study is conducted by a team that represents the interests of all the stakeholders such as the clients, the management, the project team and the community.

A formal change control system that can minimize the risk associated with a change, is usually a part of the configuration management system that integrates and coordinates changes across the project development life cycle. The tasks of this system are;

- Examining the changes that are requested by the stakeholders of the project
- Determining the impact of these changes on the cost, schedule and performance of the project
- Exploring alternate changes that could yield the same or better output
- Accepting or rejecting the changes that are proposed
- Communicating the changes to all the parties involved
- Incorporating the changes properly as per the plan
- Developing monthly reports detailing all the changes and their impact on the project.

The following guidelines are useful in designing an effective change control system:

- All project agreements should include a detailed report on how requests for a change in the plan, budget, schedule or the output of a project should be introduced and processed.
- A "change order" that describes every change in the project should be prepared. This must include a description of the changes that are agreed upon, along with corresponding changes in the plan, budget, schedule and output.
- An approval letter must be obtained, both from the client's agent and senior management's representative, on the changes to be implemented. The project manager should be consulted before the change order is finalized. However, the approval of the project manager is not mandatory.
- Once the "change order" is approved, a master plan of the project should be made reflecting the changes and the change order is now a part of the master plan.

An effective change management process contains two documents:

- Requisition for change in a project and
- A project impact statement

Requisition for change in a project: It is important to document every change requested by the client. This can be done in the form of a simple memo or in the format prescribed by the project team. This will help the team to evaluate the

impact of the change on the project and to determine whether the change can be incorporated.

Project impact statement: Once a requisition for a change is made, a project impact statement is prepared. This statement identifies various alternative actions along with the pros and cons of each. The client then chooses the best alternative.

The following are the possible responses to a requisition for a change:

- Accommodating the change within the allocated resources and time schedule of the project.
- Accommodating the change with an extension in the delivery schedule of the project.
- Accommodating the change with additional resources and/or extension in delivery schedule.
- Implementing the change in a phased manner by the way of prioritizing the output needed.

Controlling Scope Creep

The most important reason for deviations from the budget is scope creep. One factor that causes scope creep is the absence of a detailed definition of scope. Repeated attempts by the project team and the client to improve the product/service is another. It is important to design an effective control mechanism to handle scope creep. The project manager must ensure that no expenditure is incurred until the scope change is approved. With changes being introduced during the implementation of the project, there is bound to be a discrepancy between the actual output and the planned one. An effective reporting system should be in place that periodically submits reports on the progress of the project and gives details about all the changes and their impact on the original project objectives and schedules, to all the parties involved in the project.

Activity: Go Stop Inc. (GSI) is a Munich-based automobile braking systems manufacturing company. It is an OEM (Original Equipment Manufacturer) for more than 75 models of cars and bikes across Europe. The company bagged an order from a motorbike manufacturing firm for its ventilated disc braking systems. After the design was approved and the project was set to start, the project organization received a requisition for change in the size of the disc brakes. What should the project organization do to control the changes and ultimately the scope of the project?

Answer:

Check Your Progress - 7

27. A change management process requires two documents. _____ identifies the various alternative actions along with the pros and cons of each alternative.
    a. Project impact statement
    b. Requisition for change in a project
    c. Project proposal
    d. Project plan
28. Which of the following options describes all changes in the project?
    a. Change order
    b. Scope creep
    c. Current period reports
    d. None of the above

10.10 Progress Reporting System

Once the project enters the implementation phase, the project manager has to be kept informed about how the project is progressing. This can be done through an effective reporting system. To design an effective reporting system, one must first decide the following:

i) What information is to be reported? And how is it to be reported?

ii) How frequently are the reports to be submitted?

iii) What level of detail is to be reported?

10.10.1 Information to be Reported

To design a progress reporting system one must first determine various information requirements of people involved in the project across the organizational structure. This involves deciding what kind of information is required and by whom, and at which hierarchy level, along with the timing and duration of the reporting.

Determining a specific day of the week and a period of time: The updated information has to be submitted by the project team on a particular day of the week and for a specified duration of time as scheduled. It is the responsibility of the project administrator to see that all the updated information is made available in time.

Reporting the actual work done during the period: There is sometimes a lot of difference between what was planned and what is actually accomplished. Activity managers usually report that they have achieved what was planned, even if they

are behind schedule, hoping to catch up by the next reporting time. It is the responsibility of the project manager to check the accuracy of information provided in the report.

Recording the historical information and re-estimating the work that is to be completed: Reporting all the finished work till the deadline along with the analysis of deviations that occurred. A proper re-estimating is done on the work to be completed in terms of cost and duration.

The start and finish dates have to be reported: The actual start and finish dates of the tasks that are started or finished during the time of reporting.

Recording the number of days spent and the number of days required for the completion of the task: The first parameter to be reported is the number of days spent on doing the task. The other aspect to be reported is the number of days required for completing the remainder of the task.

Recording the number of hours spent per day to finish the task: The man hours already spent on a task and also an estimate of the man hours required to accomplish the remainder of the task.

10.10.2 Frequency of Reporting Progress

Progress reports are usually submitted once in a week. However, this varies from project to project. As the complexity of the project changes the frequency of reporting also changes.

10.10.3 Level of Detail to be Reported

It is very difficult to decide the exact level of detail that is to be included in a project status report. The information needs of the person controlling the project vary depending on his or her position in the management hierarchy. The following are the information requirements for different people across the organizational hierarchy:

The activity manager requires a detailed report, because he is the person directly responsible for getting the work done. As he has to manage the resources required for completing the project, he would like to know the what, why and how of all the resources and activities under his control.

The project manager requires the status information of all the tasks that are in progress during the reporting period. Reports submitted to the project manager contain information related to scheduling. They are infact documents for adjusting the schedules and for preparing the overall project status. The level of detail of this report is very high and the report is generally meant for reviews internal to the project teams.

Senior management usually prefers to get information in the form of graphs and pictorial representations. As they have a very limited time for reviewing project reports, a report submitted to them is best limited to a single page with the milestones of the project highlighted. In case the project is out of balance, it is

advisable to attach a get-well plan narrating the problem involved, alternative solutions, the actions recommended and some estimate of when the situation will be rectified.

10.10.4 Characteristics of an Effective Progress Reporting System

The information gathered for a progress reporting system must have the following characteristics:

- Information must be complete, accurate and timely.
- It should not add over head time to the planned time of completion.
- It must be acceptable to senior management and the project team.
- It should indicate the potential problems to the controller, in order to take timely and proper action.
- It should be understood easily and clearly by the people who need it.

It is difficult to arrive at a generic reporting structure for all projects because each and every project is unique and the information requirements of different projects vary. Therefore, it is advisable to use project management software packages to develop customized reports that meet the needs of different types of projects.

10.10.5 Project Monitoring and use of IT

Project monitoring assumed importance because a large number of projects are examples of time and cost overruns. While adequate attention is given to project planning, necessary attention is not being paid towards execution. This is due to lack of effective monitoring mechanisms. In many projects which are locally executed but centrally controlled, personal monitoring is difficult and therefore efficient IT enabled project monitoring systems are being used. It is now a part of overall project management. On-line monitoring is necessitated by tight schedules and huge penalties for delays. Major organizations implement software project management tools for effective monitoring and timely midcourse corrections to ensure that the costs and schedules are under control. This will also enable on-line reviews, feedback, corrective and preventive actions.

Many software tools have been developed for use by various project environments. They are categorized as

- Standalone tools
- Mid Range tools
- High end Enterprise Management tools
- Software as a Service (SaaS) model and
- Open Source Project Management tools

For example, GanttProject is a simple project management tool to track tasks and resources. The tool enables identification of hierarchical task dependencies,

define milestones, create work breakdown structure, create resource load chart, view critical path in network, create PERT chart and generation of project status reports.

Thus the use of IT in project monitoring, an integral part of project management is increasingly dependent upon IT for on line information and speedy corrective actions.

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29. The project should be comprehensive to provide proper information that meets the requirements of the people who use it. Which of the following options represent this feature of the progress reporting system?
    a. Frequency of the reporting progress
    b. Information to be reported
    c. Level of detail to be reported
    d. None of the above
30. A good reporting system is needed for the project manager to be kept informed about the progress of the project. Which of the following are the characteristics of an effective progress reporting system?
    a. Information should be complete, accurate, and timely.
    b. It must be acceptable to the senior management of the firm.
    c. It should be understood easily and clearly by the people who need it.
    d. All of the above

10.11 Types of Project Status Reports

Depending on the degree of detail and the frequency of reporting, project status reports can be classified into five categories – current period reports, cumulative reports, exception reports, spotlight reports, and variance reports.

10.11.1 Current Period Reports

These reports describe the project activities that have recently been completed. They indicate the progress of only those tasks that have been scheduled for a specific period. These reports can also focus on the deviations between the planned and the actual completion dates. The reasons for these deviations should be explained and a plan to correct the deviations from schedule should be recommended in the report.

10.11.2 Cumulative Reports

These reports present the history of the project, from its inception to the ending of the current reporting period. Because these reports indicate trends in project progress, they are considered to be more informative than current period reports.

10.11.3 Exception Reports

These reports show variances from the plan. Since senior managers do not have much time to spare, the information in these reports is presented in a way that is easy to read and interpret. Such reports have a one page executive summary that highlights the main points of the status of the project and its deviations from the plan. Senior managers who wish to learn about the reasons for these deviations can read the detailed report.

10.11.4 Spotlight Reports

These reports are alterations to be used along with all the reports discussed above. A green color sticker is placed on the top right hand corner of the first page of the project status report, to indicate to senior management that the project is progressing smoothly. A yellow sticker is placed on the top right hand corner of the first page of the project status report, to indicate that though there have been some problems in the execution of the project, a plan is in place to deal with these problems. An additional sheet attached to the report, describes the problems in a detailed manner along with the measures that have been taken to correct these problems and gives an estimate of the time needed to complete this rectification. A red sticker is placed on the top right hand corner of the first page of the project status report, to indicate that there is a serious problem in the project for which no corrective measures have been developed. The conditions in the red sticker reports are beyond the control of the project manager.

10.11.5 Variance Reports

These reports show how the delivered output/activity deviates from the plan. The report is divided into three columns, having the planned number, the delivered number and the variance (between the two) as the column heading. A variance report can have a numeric or a graphic format. In a graphic representation, the variance need not be represented because it is just the difference between the two curves at a particular point in time. Variance reports follow a format that is consistent across all the activities and tasks within a project, to make the senior management feel more comfortable while using it.

Activity: Gautam Gupta is a senior project manager at a software consulting firm. The firm bagged a project to develop an information system package for an upcoming retail chain in India. Gupta is made the project leader for this new project. The top management asked Gupta to design a separate progress reporting system for the project so that the senior authorities could monitor the project closely. What are the factors that Gupta should consider to develop a progress reporting system? What are the different types of project status reports he can consider?

Answer:

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31. A _____ is a type of report which shows how the delivered output/activity deviates from the project plan.
    a. variance report
    b. spotlight report
    c. exception report
    d. cumulative report
32. The project reports are classified into various categories depending upon the degree of detail and frequency of reporting. Identify the kind of report that describes the project activities that have recently been completed.
    a. Cumulative reports
    b. Current period reports
    c. Exception reports
    d. None of the above
33. Which of the following are the alterations that are used to attract the attention of the senior management to the status of the project?
    a. Variance reports
    b. Spotlight reports
    c. Exception reports
    d. None of the above

10.12 Graphical Reporting Tools

In addition to the reporting tools mentioned above that use numerical and theoretical data, the following are the types of reporting techniques that use graphs as their reporting tools. Graphical reporting tools are of three types – Gantt charts, milestone trend charts, and cost schedule control. Given the time constraints of the senior management, the project manager has to use reporting tools that effectively convey the meaning of a 15-page document in a single graphical representation.

10.12.1 Gantt Charts

Gantt charts depict the activities of a project in an easy-to-grasp manner. A Gantt chart can be used for different applications in project management, starting from planning, resource scheduling and status reporting. A Gantt chart represents the schedule of a project in a two dimensional manner. Activities are plotted on the Y-axis and time on the X-axis. The inability to show dependency relationships is a shortcoming of a Gantt chart.

10.12.2 Milestone Trend Charts

Milestones are key events/activities in the project life cycle that need to be tracked. These key events/activities represent the existence of certain conditions in the project. Milestones are planned in a fashion similar to activity planning. These charts plot the gap between the scheduled and the estimated dates of a milestone of a particular period. Each reporting period shows an extra slippage since the last reporting period. Project managers should take corrective action if such a slippage occurs four times continuously, irrespective of the size of slippage. Sometimes the milestone trend charts show drastic change between two successive reporting periods. Such radical change patterns may be a result of unrealistic time estimates at the planning stage or due to some data error occurring while preparing the trend chart. Hence a project manager has to conduct further enquiry to find out the reasons for such changes.

10.12.3 Cost Schedule Control

This tool uses rupee value of work performed to measure project performance. Manhours/day can also be used to measure project performance if the project budget is not being managed by the project manager. The measures "Manhours/day" and the "Rupee value" of work are helpful for determining the plan and cost variances in the current period and cumulative variances till date. The planned work is compared to the actual work performed. These parameters are required to give the total project history and it is not sufficient to have either the planned work or the actual work accomplished. These parameters are primarily used to monitor a project's health, which must be restored by the project manager as required.

A cost schedule control measures the budgeted cost of work scheduled, the budgeted cost of work performed, and the actual cost of work performed. Schedule variance and cost variance are the two-variance values resulting from the above measurements.

A cost schedule control tool can be used not only to measure the health of a project and report its history but also to predict the future status of the project. Measuring the budgeted cost of work scheduled, budgeted cost of work performed and the actual cost of work performed results in knowing the two variance values that are schedule and cost variances. Apart from measuring and reporting history, cost schedule control can also be used to predict the future status of the project.

Inspite of designing and implementing various tools for reporting the progress of the project there are some unanswered queries and doubts that can be solved only by conducting project status review meetings that add a personal touch to the mechanical processes involved.

Check Your Progress - 10

34. Graphical tools are used to report the progress of the project along with the numerical and theoretical data. Which of the following types of graphical representations represents the schedule of the project in a two dimensional manner?
    a. Milestone trend charts
    b. Gantt charts
    c. Cost schedule control
    d. None of the above
35. _____ is a type of graphical reporting tool that not only measures the current status of the project but also the future status of the project.
    a. Gantt charts
    b. Milestone trend charts
    c. Cost schedule control
    d. None of the above
36. From the following options, identify the graphical reporting tool that tracks the key events in the project life cycle.
    a. Gantt charts
    b. Milestone trend charts
    c. Cost schedule control
    d. None of the above

10.13 Project Status Review Meetings

Project status review meetings are used to review the status of projects. They are not general discussions or meetings trying to solve a generic problem, but focus on a single project with specifically timed agendas. Various kinds of reviews are conducted throughout the project life cycle. For a project to be called a successful one, the timing of reviews is important. A project undergoes the following reviews during its life-cycle – status review (reviews the status of cost, performance, schedule and scope), design review (reviews the design of the product or service to ensure that it meets client requirements), and process review (reviews the processes and checks for the possibility of any improvements).

10.13.1 Status Review

The most frequently conducted review is the status review. A status review can be comprehensive or cursory. Generally, a cursory review is conducted on a weekly basis while a comprehensive review is conducted on a monthly basis. Generally, for a project of one-year duration, a weekly cursory review and a monthly comprehensive review will suffice. When the project runs into

difficulties, the frequency of reviews increases until the problem is solved. To avoid micromanagement, the frequency of status reviews should be limited. A status review should, ideally solve problems, not punish people. It is always advantageous to know the kinds of problems existing in a system, the factors causing these problems and the corrective measures required to solve them.

10.13.2 Design Review

A design review ensures that the product or service being developed matches customer requirements. Generally, such reviews are conducted when a milestone has been reached. If a product is poorly designed, it will not meet customer expectations. Therefore, the design review focuses on the performance component rather than on cost, time and scope of the project.

The project manager has to keep in mind some guidelines while conducting design reviews. It is necessary to include the conditions for manufacturing and servicing in the design review. Ensuring optimization by integrating design with manufacturing specifics like tooling and economics of process and specialty machines, is also the responsibility of a design review. A design review also considers the specifications of the working conditions such as storage of inventory, ease of accessing the materials and tools, safety in operating and maintaining and damage protection.

10.13.3 Process Review

The process review is focused on reviewing the "how" aspect of an activity. This review tries to find out how an activity can be carried out in a better manner. Process reviews typically take place at the milestones or once every two or three months. This type of review tries to improve those activities that are not being carried out well.

It is important to discuss the outcome of the different types of reviews with all the parties involved in the project.

The activity manager reports the status of the project on a weekly basis to the project manager, who in turn reports to senior management on a biweekly basis. Thus it becomes appropriate to conduct project status review meetings once in every two weeks. Though the duration of the status review meeting depends on the size of the project, it is usually limited to one hour. The list of people attending the review meeting varies across the project life cycle, depending on the need of the person and the situation. Though status review meetings have a flexible format as influenced by the need of the project, the top-down approach is commonly used. The minutes of the meeting are circulated, revised for errors and follow ups and filed in the project notebook.

Till now we have seen all the aspects of project control that are highly vulnerable to change at any stage in a project life cycle. We have examined all the dimensions of control, starting from the types of controls to be exercised, their impact and the measures to be taken under various situations. We have also described the

reasons behind using controls to keep the project in equilibrium. Now we are in a position to discuss the two most important aspects of project control, without which the purpose of control is not achieved. They are Risk Management and Quality Management. Exhibit 10.2 shows a format of top down approach in review meetings.

Exhibit 10.2: Format of Top Down Approach used in Review Meetings

Participants in the Review Meeting	Specific Task	Common Task
Project champions and customers	Reporting the changes that have a bearing on the future of the project.	Closing comments of the meeting
Project manager	Describing the health of the project along with the impact of problems, changes and corrective measures.	Identifying new problems and assigning the responsibility to solve the same
Activity manager of the present activity	Reporting the status of the tasks scheduled for work between the previous and the current review meeting.	Identifying new problems and assigning the responsibility to solve the same
Activity manager of future activities	Reporting alterations since previous meeting that have a potential bearing an impact on the project status.	Identifying new problems and assigning the responsibility to solve the same
Project manager	Reporting the status of problems since the previous meeting. Meeting is adjourned after announcing the venue and timing of the next meeting.	Giving closing comments of the meeting and/or identifying new problems and assigning the responsibility to solve the same

Source: ICFAI Resource Center

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37. Identify the type of review which deals with the 'How' aspect of the project activities.
    a. Process review
    b. Status review
    c. Design review
    d. None of the above

38. Which of the following types of project review assesses the design of the product or service to ensure that it meets the requirements of the clients?
    a. Design review
    b. Status review
    c. Process review
    d. None of the above
39. Which of the following project review meetings are conducted to measure the position of cost, performance, schedule, and scope of the project?
    a. Process review
    b. Design review
    c. Status review
    d. None of the above

10.14 Managing Risk

Since control and risk are indirectly related to each other, it is important to examine their impact on each other. The higher the level of control, the lower the risk of project failure. Risk can be defined as the probability of not meeting a pre-defined project goal. While considering risk, the consequences associated with failure should also be considered. Risk consists of three fundamental components -- an event, the probability that the event happens, and the impact of probability on happening of event.

Risk arises because of the lack of knowledge of future events. "Opportunities" can be considered as favorable future events, while "risks" can be regarded as the unfavorable future events. Effective project management is one that is able to recognize the traps and allow the development of safeguards to overcome these traps. With the required number of safeguards, risk is minimized. Since risk is an activity that is based on the future, there are no tools that can totally prevent risk. The project manager can only attempt to minimize risk, using proper judgment.

Risk management as defined by the Project Management Institute Body of Knowledge (PMBOK) is a *formal process by which risk factors are systematically identified, assessed and provided for.* Though risk is minimized to a certain extent by exerting control, there is also a need for a proper risk management system. Effective risk control can be achieved by combining both control and risk management systems. In order to control risk throughout the project's life cycle, a risk management strategy is necessary. Risk management involves identifying, quantifying, responding to and controlling the risk.

10.15 Managing Quality

Quality as defined by BS4778 is the totality of features and characteristics of a product or service which bear on its ability to satisfy a stated or implied need. Developing and managing a control system to test the quality of the final product

or service is high priority in project management. Developing control systems, reporting systems, and risk management systems would be futile if no proper quality control system is in place.

The main elements of a quality system are the policy behind maintaining quality and description and procedures for maintaining quality, preferably in the same order. The basic objective of a quality control system is to ensure a continuous meeting of customer needs or system objectives.

For acquiring new businesses in new markets it is necessary to have a quality control system. Having a quality control system also helps in protecting the firm from product and legal claims (for faulty products) .

The PMBOK also refers to quality control as the technical aspect of quality management. The project team members play an active role in project management to make sure that every project process delivers a quality output. The output at the end of each stage in the project must meet the overall quality standards. This ensures that the desired quality is achieved. The following are the characteristics of an effective quality control system:

- Capability in identifying what to control.
- Setting standards in order to provide the basis for taking decisions on corrective measures.
- Developing quality measurement tools.
- Comparing the delivered output with the quality standards that have been set.
- Incorporating measures that can put the processes and outputs back to standard if it fails to meet the quality standards.
- Monitoring and calibrating the devices used to measure quality.
- Detailed documentation of the process.

Exhibit 10.3 narrates the IT based quality management in Apollo Hospitals.

Exhibit 10.3: IT Drives Quality Management in Apollo Hospitals

Information Technology (IT) has transformed the way healthcare is being delivered today. The revolutionary impact that IT has made, has greatly improved the quality and access to healthcare. Quality improvement and clinical decision support is being powered through Healthcare IT and is not just enabling patient monitoring but also specific and targeted recommendations for improving patients' health. Dr. Sangita Reddy, Joint Managing Director, Apollo Hospitals Group said, "Digital technologies have the potential to radically improve healthcare delivery. Technology can add value to every moment the patient spends in the system, putting the patient on a faster course towards effective treatment. While the use of AI along with Big Data can guide physicians in reaching a diagnosis or arriving at the best treatment method, it can also be a game changer in preventive healthcare.

Contd….

This in turn leads to optimisation of healthcare resources with reduced cost of healthcare. The 2020 CHIME Digital Health Most Wired recognition as a certified level 8 is a recognition of our efforts to harness digital technology to enhance access to care for patients and streamline their experience with improved outcomes. Technology enabled us to ensure continuity of care through the pandemic through telemedicine and remote healthcare and we share continue to use technology to transform every point of interaction with the patient and community."

Source: https://www.apollohospitals.com/patient-care/clinical-quality-and-outcomes/it-excellence/

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40. Which of the following are the fundamental components of risk?
    i. An event
    ii. The probability of the event happening
    iii. The outcome of the event
    a. Only i
    b. Only i and ii
    c. i, ii and iii
    d. Only ii and iii
41. Which of the following are the characteristics of an effective quality control system?
    i. Capability in identifying what to control
    ii. Developing quality measurement tools
    iii. Detailed documentation of the process
    iv. Monitoring and calibrating the devices used to measure quality
    a. Only ii
    b. Only i and iv
    c. i, ii, iii, and iv
    d. Only iii and iv
42. The probability of not meeting a pre-defined project goal is called _____.
    a. quality
    b. risk
    c. control
    d. None of the above

10.16 Summary

- Project controls are tools developed to diagnose the system for deviations from the actual plan and reset them back with the actual plans/schedule.
- Project controls are required to check whether the project is progressing in accordance with the plans and standards set during the planning phase.
- For a control system to be effective and efficient, it should have the following characteristics – comprehensiveness, communicability, authenticity, timeliness, simplicity, flexibility, and morally sound.
- The primary objective of control is regulation, while the secondary objective of control is conservation of resources.
- It is important to measure duration and cost deviations because they play a significant role in the project management life cycle. Though all the parameters of project management have their own levels of significance, time and cost share a special place.
- Project control is generally implemented through people. Any form of control has a significant impact on human behavior. Because of this, it becomes necessary to study project control with special reference to people and their behavior.
- The process of controlling a project is a highly complex task. Project control is used to check the four key parameters time, cost, scope and performance.
- There are three basic control mechanisms – cybernetic control, go/no-go control, and post control.
- The project plan may go out of balance any time and hence as a precautionary measure, we require a corrective plan that can bring the system back to equilibrium. Control systems are designed in such a way that they enable early detection of problems and a faster implementation of corrective measures.
- The greater the control exercised over a project, the less likelihood there is of project getting into trouble. The project manager has to decide as to what extent the project has to be controlled as controls are costly. The balance point reduces the overall cost liability for choosing a specific degree of control.
- Controlling the scope of a project involves attempts to include changes in the project scope when they occur and manage these changes simultaneously.
- Once the project enters the implementation phase, the project manager has to be kept informed about how the project is progressing. This can be done through an effective reporting system.
- Depending on the degree of detail and the frequency of reporting, project status reports can be classified into five categories -- current period reports, cumulative reports, exception reports, spotlight reports, and variance reports.
- Gantt charts, milestone trend charts, and cost schedule control are the various techniques that use graphs as their reporting tools.

- Project status review meetings are used to review the status of projects. They focus on a single project with specifically timed agendas.
- Various kinds of reviews are conducted throughout the project life cycle. A project undergoes the following reviews during its life-cycle – status review, design review, and process review.
- Control and risk are indirectly related to each other. The higher the level of control, the lower the risk of project failure.
- Quality can be defined as the totality of features and characteristics of a product or service which bear on its ability to satisfy a stated or implied need. Developing and managing a control system to test the quality of the final product or service is high priority in project management.

10.17 Glossary

Cybernetic Controls (or steering controls): These are used to monitor and control tasks that are carried out more or less continuously, for example, software projects.

Progress Reporting System: A mechanism that keeps the project organization updated on the performance of the vendor, i.e., the way in which he is achieving the objectives of the contract.

Project Control: The process of collecting information related to the performance of the project system, comparing it with the desired level of performance and taking corrective action to decrease the gap between the actual and the desired performance levels.

Project Plan: A formal, approved document used to manage and control project execution.

Project Proposal: An initial document that converts an idea or policy into details of a potential project, including the outcomes, outputs, major risks, costs, stakeholders and an estimate of the resources and time required.

Project Status Report: A report mentioning the status of achievements and deviations from the resources that are spent and the plans that are scheduled.

Quality: The totality of features and characteristics of a product or service, which influence its ability to satisfy a stated or implied need.

Risk Management: A process by which risk factors are systematically identified, assessed, and provided for.

10.18 Self-Assessment Exercises

1 Project control is not a separate phase in itself but it goes hand in hand with the project implementation phase. Discuss the fundamental purpose of project controls. Explain the characteristics of an effective control system.

2 Measurement of duration and cost deviations is very important as they play a vital role in the project management life cycle. What are the reasons for measuring duration and cost deviations.

3 Any form of control has a significant impact on human behavior. Explain the objectives of controls, and the role played by controls as a function of management. What are the control mechanisms? What do you think is the relationship between control and risk?

4 The project plan being a system may go out of balance any time and hence as a precautionary measure we require a corrective plan that can bring the system back to equilibrium. How does the project manager balance a control system? What are the factors that cause an imbalance in a control system?

5 Controlling the scope of a project involves attempts to include changes in the project scope when they occur and manage these changes simultaneously. What are the various ways in which the project manager can control the change and the scope creep?

6 Once the project enters the implementation phase, the project manager has to be kept informed about how the project is progressing. What are the factors to be kept inmind while designing an effective reporting system? Explain the characteristics of an effective progress reporting system.

7 Project status reports can be classified into various categories depending on the degree of detail and the frequency of reporting. What are the various types of project status reports?

8 The project manager has to use various reporting tools to convey the details regarding the project status. What are the different graphical reporting tools that can be used by a project manager?

9 Project status review meetings are used to review the status of projects. Various kinds of reviews are conducted throughout the project life cycle. Discuss the different types of reviews conducted by the project manager during the life cycle of a project.

10 Control and risk are indirectly related to each other. Also, a proper control system should be in place. How can the project manager manage the risk involved and the quality of a project? Explain the characteristics of an effective quality control system.

10.19 Suggested Readings/Reference Material

1. Prasanna Chandra, “Projects,” Mcgraw Hill, Seventh Edition, 2017
2. James Wood, Kory Kogon, and Suzette Blakemore, Project Management for the Unofficial Project Manager: A Franklin Covey Title, Goodreads, 2018
3. Heagney, Fundamentals of Project Management Paperback, Amacom, September 2018
4. N.A., Nagarajan, Project Management 8th Edition, New Age International Publications, 2019

5. IES Master Team, ESE 2020 - Basics of Project Management Paperback – 1 IES Master Publication, January 2019

6. Patrice Spath, Introduction to Healthcare Quality Management, Third Edition (Gateway to Healthcare Management), Health Administration Press, Paperback, 30 March 2018

10.20 Answers to Check Your Progress Questions

Following are the answers to the Check Your Progress questions given in the Unit.

1. (c) Authenticity

Authenticity refers to budgetary discipline and expense tracking by accounting tangible progress and cost expenditure in time. Comprehensiveness refers to the detailed overview of the work performed. Simplicity and being morally sound refer to the system being simple to operate and conforming to all the ethical standards, respectively.

2. (b) Only i, ii, and iv

It is the responsibility of the project manager to ensure that the actual performance matches the desired level of output. The parameters to be used for this are performance, time, and cost.

3. (b) Project control

Project control is one of the most important parts in project implementation. It is used to monitor the activities of the project and to take corrective action if there is any deviation from the desired level of performance. The main purpose of project control is to control and manage change in a project.

4. (c) i, ii, iii, and iv

The following are the characteristics of an effective project control system – comprehensiveness, communicability, authenticity, timeliness, simplicity, flexibility, and moral soundness.

5. (b) Flexibility

Flexibility refers to the system being open to extensions and alternations and being easy to maintain. Comprehensiveness refers to the detailed overview of the work performed. Simplicity and being morally sound refer to the system being simple to operate and conforming to all the ethical standards.

6. (a) Conserving the resources

Conserving the resources is the secondary objective of project control. This entails the protection of the physical, human, and financial resources of the organization. Regulation and facilitation of decision-making are the primary and territory functions respectively of project control.

7. (c) Regulation, conserving resources, and facilitating decision making

The primary objective of control is regulation, the secondary objective is conserving resources, and the tertiary objective is facilitating decision making.

8. (d) Dampening oscillation

Measuring the deviations helps the project manager in taking corrective actions. This will reduce the oscillation of the curves representing the actual and planned performance over time. The other options given are not correct as they refer to the possibility of taking corrective action. Facilitating early corrective action through weekly schedule variance will facilitate the project manager to take action at an early stage of the project.

9. (c) Negative variance

Negative variance refers to the case in which the delivered output is behind schedule or the cost incurred is more than the scheduled cost. Positive variance is the opposite of negative variance where the delivered output is ahead of the planned schedule or the cost incurred is less than the planned cost.

10. (b) Variance

Variance is the deviation from the actual project plan. Based on the parameters of time and cost, the variances may either be positive variances (when the resulting output exceeds the expectations) and negative variances (when the resulting output falls below the expectations).

11. (c) Cybernetic control

Cybernetic controls are used to monitor and control tasks that are carried out more or less continuously. They are designed by identifying mechanical tasks based on the work breakdown structure. Go/No-go and post controls are not carried out automatically.

12. (b) directly

The cybernetic control system that minimizes the variation from the set of standards is known as a negative feedback loop. The speed of action in a negative feedback loop is directly proportional to the size of the variation from the standard in that loop.

13. (c) Third order controls

Cybernetic controls can be classified into three types: The first order control system, which is a goal-seeking device; the second order control system, which can alter the standards that are set only in accordance with predetermined rules and regulations; and the third order control system which is a flexible goal-seeking device.

14. (c) i, ii, and iii

Individuals respond to the goal directedness of control systems in all the three ways given i.e. through active and passive participation and goal oriented behaviour, through passive involvement to minimize loss, and through active but negative involvement and resistance.

15. (c) Milestones achieved in the project implementation.

The information required for developing the cybernetic controls is as follows: defining the characteristics of the output that are to be controlled, setting the standards for the defined characteristics, acquiring the sensors that measure the characteristics at a particular level of precision, transforming the measurements into signals that are to be compared with the set standards, and detecting the difference between the output and the standard set. The information regarding milestones achieved in the project implementation is required in the setting up of Go/No-go controls.

16. (a) Negative feedback loop

The cybernetic control system that minimizes variation from the set standards is known as a negative feedback loop. Go/No-go and post controls are different types of controls as compared to the cybernetic controls.

17. (c) Post controls

Post controls deal with the 'How' aspect of deviation rather than the 'Why' aspect. Post control systems are applied after the completion of the project. Post control has a significant role to play in the way future projects are handled.

18. (c) Project definition statement

The documents needed for setting up the Go/No-go control mechanism are project proposal, project plan, project specifications, project schedule, project budgets, and milestones. The project definition statement provides more detailed information about the project and is not used in setting up the Go/No-go controls.

19. (c) post controls

Post controls are the control mechanisms that are applied after the completion of the project. The cybernetic and Go/No-go controls are applied at the time of project implementation itself. The negative feedback loop is a part of the cybernetic controls.

20. (d) i, ii, iii, and iv

The post control report has the following sections: objectives of the project, milestones, checkpoints, and budgets, final project report, and recommendations for performance and process improvement.

21. (c) project schedule.

The project schedule is one of the important documents for setting up a Go/No-go control mechanism. The document specifies the time frame for each activity in the project.

22. (d) project specifications.

Project specifications are the set of rules and regulations under which the objectives of the project are met. The other given options in the question are wrong because the project proposal specifies the expected business value along with the cost and time estimates of the project. The project plan gives the ends and means of a particular action or objective. Project budgets are the documents with estimation of the costs required to complete the project.

23. (b) Go/No-go controls

The Go/No-go control system functions only when it is put into application by the controller. It is applied periodically. Cybernetic control functions continuously and automatically. Post controls are applied only after the completion of the project.

24. (a) Only i and iii

In the control process, the project manager has to strike a balance between risk and control. The available options in the control process are high risk with low control and high control with low risk as risk and control have an inverse relationship with each other.

25. (b) Laying too much emphasis on long-range objectives rather than short-term results.

Laying too much emphasis on the short-term results rather than the long-term objectives is one of the causes for imbalances in the control system. The other options given in the question are the causes for imbalance in the control system.

26. (a) Balance point

As greater control is exercised on the project, the likelihood of the project getting into trouble goes down. However, exercising greater control increases the cost of the project. The balance point reduces the overall cost liability for choosing a specific degree of control by achieving a balance between the risk and control associated with the project.

27. (a) Project impact statement

The two documents in the change management process are: requisition for change in a project and project impact statement. The requisition for change documents all changes requested by the client. The project impact statement identifies the various pros and cons of the various identified alternatives. The

project proposal and the project plan describe the expected business value along with the cost and time estimates of the project and the ends and means for particular action or objective.

28. (a) Change order

A change order depicts all the changes in the project. Current period reports describe the activities that have recently been completed. Scope creep refers to the changes in the project's scope which cannot be controlled. Scope creep occurs when the scope of a project is not properly defined and controlled.

29. (c) Level of detail to be reported

The information needs of the people controlling the project vary depending upon the people who use it. The information provided in the report should be detailed enough to suit the information needs of people who use it.

30. (d) All of the above

The characteristics of an effective progress reporting system are: Information should be complete, accurate, and timely; it should not add overhead time to the planned time of completion; it must be acceptable to the senior management and the project team; it should indicate potential problems to the controller; and it should be understood easily and clearly by the people who need it.

31. (a) variance report

Variance reports show how the delivered output deviates from the plan. The report consists of three columns, viz., planned number, delivered number, and the variance. Spotlight reports are the reports which are used along with other reports. Exception reports show variances from the plan. Cumulative reports present the history of the project from its inception to the end of the current reporting period.

32. (b) Current period reports

Current period reports depict the project activities that have recently been completed. They indicate the progress of the tasks that have been scheduled for a specific period. Cumulative reports present the progress of the project from its inception to the current reporting period. Exception reports show the variances from the plan.

33. (b) Spotlight reports

Spotlight reports are the alterations that are used with other types of project status reports. Stickers of various colours like green, yellow, and red are used to indicate the status of the project. Exception reports show the variances from the plan and variance reports show how the delivered output/activity deviates from the plan.

34. (b) Gantt charts

Gantt charts depict the activities of the project in an easily understandable manner. They represent the schedule of a project in a two-dimensional manner. Activities of the project are depicted on the Y-axis, and time is represented on the X-axis. Milestone trend charts track the key activities that need to be tracked. Cost schedule uses the rupee value of the work performed to measure project performance.

35. (c) Cost schedule control

Cost schedule control can be used to predict the future status of the project apart from measuring and reporting the history of the project. Gantt charts and milestone trend charts are not used to predict the future of the project.

36. (b) Milestone trend charts

Milestone trend charts track the milestones or key events/activities in the project life cycle. Gantt charts depict the activities of the project in a way which is easy to grasp. Cost schedule control uses the rupee value of the work performed.

37. (a) Process review

The process review tries to find out how an activity can be carried out better.

38. (a) Design review

Design review assesses the design of the product to ensure that it meets the requirements of the client. Status review assesses the status of the cost, performance, schedule, and scope of the project. Process review assesses the process of the project.

39. (c) Status review

Status reviews are conducted on a periodic basis to review the position of the project. They may be cursory or comprehensive reviews. Design and process reviews are meant to review the design and process of the project.

40. (b) Only i and ii

The three fundamental components of risk are: an event, the probability of the event happening, and the impact of the probability on the happening of the event.

41. (c) i, ii, iii, and iv

The characteristics of an effective quality control system are: being capable of identifying what to control, setting standards in order to provide the basis for taking decisions on corrective measures, developing quality measurement tools, comparing the delivered output with the quality standards that have been set, incorporating measures that can put the processes and outputs back to standard if they fail to meet the quality standards, monitoring and calibrating the devices used to measure quality, and including detailed documentation of the process.

42. (b) risk

The probability of not meeting a pre-defined project goal is called risk. Quality is the essential or distinctive characteristic of any value which is under measure. Control refers to ensuring that all project activities are going as per the plan and the steps that need to be taken to mitigate any deviations from the plan.

Project & Operations Management

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