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## COURSE DESIGN AND PREPARATION TEAM

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Prof. K. Ravi Sankar Director, School of Management Studies, IGNOU, New Delhi	Prof. H.P. Mishra National Institute of Financial Management, Faridabad	Prof. Sanjay Banerjee Management Development Institute, Gurgaon
Prof. R.K. Grover (Retd.) School of Management Studies, IGNOU, New Delhi	Prof. Rakesh Khurana (Retd.) School of Management Studies IGNOU, New Delhi	Prof. P.K. Bhaumik International Management Institute, New Delhi
Prof. A. Chakravarti Management Development Institute, Gurgaon	Prof. Abid Haleem Jamia Milia Islamia New Delhi	Prof. B. Koteswara Rao Naik* NITIE, Mumbai
Prof. S. Venkataramaniah Indian Institute of Management Lucknow, Greater Noida	Prof. G.V.R.K. Acharyulu School of Management Studies University of Hyderabad, Hyderabad	Dr. Ruchita Gupta* Associate Professor NITIE, Mumbai
Prof. R. Sampath Kumar* Department of Business Management Osmania University, Hyderabad	Dr. Vrushank Buch*, PMP Senior Project Manager ITT Corporation, Vadodara, Gujarat, India	Prof. U.V. Adinarayana GITAM School of Business GITAM (Deemed to be University), Visakhapatnam
Ms. Falguni Rolekar*, PMP Enterprise Agile Transformation Leader – IBM, Mumbai, India	Prof. T. Nambirajan Department of Management Studies Pondicherry University	<b>Course Coordinator and Editor</b> Dr. Venkataiah Chittipaka Associate Professor School of Management Studies IGNOU, New Delhi

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## PRINT PRODUCTION

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Mr. Tilak Raj  
Assistant Registrar  
MPDD, IGNOU, New Delhi

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# COURSE INTRODUCTION

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The contents of this course are practical, relevant, and current. All the topics discussed in this course are simple and intuitive. This course may help the learners to improve their knowledge and skills in project management. These course contents cover most of the topics prescribed by PMI's Project Management Body of Knowledge (PMBOK).

This course consists of four blocks spread over 14 units. **Block 1** is on **Project Initiation** consists of three units.

**Unit 1** discusses the importance and characteristics of a project. It also discusses the triple constraints of a project, the frameworks of project management and the roles and responsibilities of a project manager. While project management can be mastered while working on projects, a theoretical foundation and formal learning of project management course is essential to learn and execute projects successfully and quickly. In **Unit 2, Project Feasibility Analysis** is introduced. In this unit, the learners may realise the importance of project feasibility analysis. Primarily, the learners may learn how to conduct a project feasibility analysis. Any crucial matter which can render the progress unviable shall be known at the start of the project so that the organisation can judge the pros and cons of whether to proceed with a particular project. **Unit 3** is all about **project chartering**. A project charter is a document that formally authorises the existence of a project and provides the project manager with the authority to apply organisational resources to project activities. Therefore, a project charter creates a link between the project and the organisation's strategic objectives, the primary reason why the project was conceptualised in the first place. Project Charter will maintain the records of the senior management expectation right from the start of the project.

**Block 2** is on **Project Planning** consists of five units. In **Unit 4**, Project scope management is discussed. It is necessary to define the scope, priorities and breakdown structure. While defining the scope of the project, the project managers primarily focus on the end product/items of the project. It is essential to develop a priority list for every project to take meaningful decisions. **Project network analysis** is carried out in **Unit 5**. The network diagram of the project, critical path determination and total float calculation etc., are the focus points of this unit.

The use of resources and their availability are very difficult issues for project managers to deal with. In **Unit 6**, Project Scheduling discusses by paying attention to these things when making a project schedule, resource bottlenecks can be found before the project even starts. Project managers should know what will happen if they don't schedule their resources. **Unit 7** discusses the **Project Crashing**; there are many things that can make it necessary to shorten the length of a project, such as time-to-market concerns, incentive contracts, the need for key resources, high overhead costs, or just

delays that come up out of the blue. These are called cost-time trade-off decisions, and they happen all the time in real life.

In **Unit 8** discusses **Earned Value Analysis (EVA)**. Project managers use the Earned Value Management (EVM) approach to monitor how their projects are performing in comparison to project baselines. It's common to think of a project's progress as being ahead of schedule, behind schedule, or over budget. The project manager and the project team should make an effort to make sure that the realized value of their project is always more than the projected value and the actual cost booked on the project. Proper data collection and computation of the project's completion percentage are essential to the success of earned value analysis.

**Block 3** is on **Project Monitoring and Control** consists of four units. **Unit 9** gives an insight into the project implementation and control. An attempt has been made to explain the advantage of integrating MIS with planning, scheduling, reporting, reviewing and updating of projects. An effective cost control system is explained clearly, along with project monitoring and reporting. In **Unit 10**, the fundamentals and importance of **Project Monitoring and Control** is introduced. To deliver the project to its customers within the time frame and allocated budget with the requirements specified, it is critical for a project manager to monitor the progress throughout the lifecycle of the project.

All projects have risks. In **Unit 11, Project Risk Management** is discussed. To be successful, the organization should implement risk management proactively and consistently throughout the project. A deliberate attempt must be made at all levels to actively identify and pursue effective risk management during the project's life. Risk exists the moment a task is envisaged. Moving forward on a project without a proactive focus on risk can lead to failure. In **Unit 12** discusses the basic concepts of **Agile Project Management**. When the project is executed using Agile ways, it gives multiple benefits which the end-user is looking for in this competitive market. Agile prioritization practices yield the highest value to the customer first.

**Block 4** is on **Project Closure** consists of two units. **Unit 13** discusses the Project Contracts and Partnering. Contractors and subcontractors execute several large projects. A contract binds the seller to provide goods or services and the buyer to pay. Tender has multiple meanings in business, finance, and investing. In business, a tender is when governments invite vendors to bid on government projects or provide goods or services. Public-private partnerships can fund large government projects like roads, bridges, and hospitals. BOT contracts are used to finance large public-private infrastructure projects.

Lastly, in **Unit 14**, Project Audit and Closure is discussed. A company's income statement, cash flow statement, and balance sheet are just a few examples of the financial statements that are examined during an audit. Audits give authorities and investors assurance that a company's financial

reporting is accurate. Following completion, the auditor will express an opinion regarding whether the financial statements accurately reflect the corporation's financial status. The auditor's report is a written statement that includes the auditor's assessment of whether the financial statements of a company adhere to GAAP and are free of major misstatements.

### **Suggested Readings:**

1. Clifford F.Gray, Erik W. Larson, Gautam V.Desai, *Project Management: The Managerial Process*, 2010, Tata McGraw – Hill 6<sup>th</sup> Edition.
2. Jack R. Meredith & Samuel J.Mantel, 2022, *Project Management: A Strategic Managerial Approach*, 11<sup>th</sup> edition, Wiley India Adaptation.
3. Rory Burke, *Project Management: Planning and control Techniques*, 4<sup>th</sup> edition 2010, John Wiley & Sons.
4. Pinto Jeffrey K, *Project Management-Achieving Competitive Advantage*, Indian edition, Pearson
5. Jhon M.Nicholas, Herman Steyn. *Project Management for Business, engineering, and Technology*, 3<sup>rd</sup> edition, 2010, Elsevier.
6. Jack Gido, James P. Clements. *Project Management*, 2011, Cengage Learning India Private Limited.
7. The Project Management Institute. *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*. Upper Darby, Pa: PMI.
8. Harold Kerzner. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 7<sup>th</sup> edition. New York: John Wiley & Sons, 2010.
9. Chandra, Prasanna, *PROJECTS – Planning, Analysis, Selection, Financing, Implementation, and Review*, Tata McGraw – Hill 7<sup>th</sup> Edition.
10. Gary L. Richardson, *Project Management Theory and Practice*, 2011, Taylor & Francis Group.
11. R.B.Khanna, *Project Management*, 2011, PHI Learning.



# **BLOCK 1**

## **PROJECT INITIATION**

Unit 1 Introduction to Project Management

Unit 2 Project Feasibility Analysis

Unit 3 Project Chartering





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# UNIT 1 INTRODUCTION TO PROJECT MANAGEMENT

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## Objectives

After studying this chapter, you will be able to:

- Understand why project management is growing as a profession.
- Explain what a project is and differentiate it from others
- Characteristics of projects
- What is project management?
- Project constraints and characteristics
- Project management frameworks
- Project roles
- Business environment impacting projects

## Structure

- 1.0 Introduction
- 1.1 What is a Project
- 1.2 Project Characteristics
- 1.3 Project Constraints
- 1.4 Project Management
- 1.5 Who is a Project Stakeholder?
- 1.6 Project Management Frameworks and Standards
- 1.7 Project Management Body of Knowledge (PMBOK) Guide 6th Edition
- 1.8 Project Management Body of Knowledge (PMBOK) Guide 7th Edition
- 1.9 Project Roles
- 1.10 Business Environment
- 1.11 Let us Sum Up!
- 1.12 Answers
- 1.13 Self-Assessment Exercises
- 1.14 Further Readings

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## 1.1 INTRODUCTION

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The field of project management has attracted the interest of many individuals, groups, and organizations. Previously, project management was intended for management reporting of project status reports, schedules, and resource loading information. Besides, only a few industries, such as the military and construction industry, were utilizing project management. However, with the changing scenario, project management is being

implemented by many organizations as it has become a primary means to execute project management. This scenario also brings in new paradigms in any organization, such as new product development, distributed and virtual teams, talent pool availability, and involvement of various companies as sub-contractors.

Organizations employ project management to get the following benefits:

- Lower costs and higher margins
- Better reliability on processes and quality
- Effective utilization of financial and human resources
- Faster product to market
- Better relations with clients
- Improved productivity
- Better coordination and improved worker morale

While project management is fairly known in the industry, more and more organizations are now embracing program and portfolio management. The current chapter explains the difference between project, program, and portfolio management and discusses in detail what is project management and how it helps organizations achieve success.

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## 1.2 WHAT IS A PROJECT?

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A project is a temporary endeavor undertaken to create a unique product, service, or result. It is meant to have a definite beginning and end and is meant to deliver a purpose for which it is undertaken. On the other hand, operational work is done in organizations to continue business work as usual. Projects are therefore different from operations as they end when their purpose is achieved or the project has been discontinued at the discretion of the management.

Following are a few examples of projects. It is imperative to note how these align with the definition of projects are create a unique well-defined deliverable.

- Building a custom design house
- An automobile company creates a new assembly line to assembly its products
- A college campus replaces all overhead power cables with underground
- A school implements a new mobile app for all its students
- A pharmaceutical company creates a new drug to fight a particular disease
- A company creates a petroleum refining unit on a barren land
- A two-wheeler manufacturing company launches electric vehicles in the market.

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## 1.3 PROJECT CHARACTERISTICS

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As evident from the list given here, projects are of different sizes and purposes. To define a project more accurately, the following characteristics will be helpful:

- **Unique purpose** – Every project should have a predetermined objective that is defined properly. For example, though there are several companies that create medicines, not any two medicine is the same. They are different in one or the other way.
- **Temporality** – The nature of the project is temporary. If it goes on forever, then it is not a project. It can be qualified as operations that are ongoing. Therefore, a project should have a definitive end.
- **Progressive elaboration** – The projects are elicited as and when more information is made available. Projects are created with a rough idea and a close estimate when started. However, when more details about requirements are made clear the project is tuned and detailed as needed.
- **Role of resources** – Resources include manpower, machines, tools, or any other assets which are utilized to perform a particular task. For example, in the case of building a house, there are various types of tools like measuring tape, plumbob, plastering machine, etc. are involved. Besides, there is specialized manpower like fitter, mason, painter, and helper required to perform this task. These all are referred to as resources.
- **Customer or sponsor** – A project is executed with a purpose to achieve a result. That result can be for the organization's internal consumption or for a customer who will be paying for the result. The internal customer who sanctions the funding and decides on the requirement is called a sponsor.
- **Uncertainty** – Every project is unique not only in terms of the results but also in terms of the conditions in which it is executed. Therefore, it becomes difficult at times to define the project objectives clearly, estimate how long it will take to complete, or determine how much it will cost. External factors also cause uncertainty such as supplier delays in the delivery of input parts, failure of equipment during testing, etc. Uncertainty is one of the main reasons why project management is risky and therefore becomes challenging.

Projects should not be conceived just for the sake of it. It is important to work on projects which are relevant and which serve a particular purpose or goal. This is because the projects will consume resources and therefore money. So the organization must be clear about the role that the project is going to serve.

A good project manager contributes towards the achievement of project goals. Project managers work closely with the project team, sponsor, and

other stakeholders involved in the project to define, plan, execute and meet project goals.

### **Check Your Progress 1**

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

Read the following and identify which of these are the projects. Discuss why these can be considered as projects.

1. Constructing a statue of the size of ‘The Statue of Unity’ in another state

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2. Modifying an existing assembly line for new car model

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3. Commercial production of the newly designed computer.

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4. Production of petrol.

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5. Revamping a part of petroleum refinery

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## **1.4 PROJECTS CONSTRAINTS**

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A project has multiple dimensions which are interdependent to each other. These are called constraints. Any project will have elements of scope, time, and cost constraint. This is also referred to in project management terminology as the Iron Triangle of constraints. Any change in one element will affect another dimension. For example, if the scope is increased the time and cost will also increase. For a project to be successful, the project manager must balance these three competing goals. The following elements should be considered:

**Scope:** What is to be accomplished in terms of work. What deliverable does the customer or sponsor needs from the project?

**Time:** Within what time frame should the project be completed. When should the stage-wise deliverable be completed?

**Cost:** What cost will be incurred for the completion of the project. What is the project budget and how will it be financed?

Sometimes, quality is also added as a constraint.

**Quality:** How does the quality of the project or service need to be? What do we need to do to satisfy the customer's requirements?

Any project starts with project baselines which define the scope of work, the time allocated to complete the work, and the budget or funding that is set aside for consumption while performing this work. For example, a family wants to renovate their house and they start with an initial scope of painting and furniture and plan to spend 10 lac INR for the task. However, while the activity is being undertaken they get to know more about the leaking plumbing and faulty electric lines and then they revise the scope of work to incorporate these changes. With the added work effort comes additional cost and time. If the family decides to stick to the work content, they run the risk of getting the entire work effort wasted as in due course of time rectification of electric and plumbing lines will bring in patchwork which will compromise the original reason why the family decided to undertake renovation in the first place. Therefore, in a project scenario, the project team also encounters several situations where they will have to strike a balance on scope, time, and cost constraints.

Experienced project managers have over some time learned what is most critical for the project. If cost and time are most important, one must reduce the scope of work if some additional work has to be accommodated. If completing the new scope is important then the project manager has to increase the budget and extend the timeline. For projects involving multiple parallel tasks that can be done, and time is the most important criteria then the additional money has to be spent to employ people and get the work done simultaneously which ultimately costs more. When you don't want to reduce money or give more time to additional scope then the quality of work gets adversely impacted. Therefore, the project constraints are in a way interrelated and change of any particular parameter will imply at least one or more parameters. The project manager must communicate the changes in the situation from time to time to the project stakeholders and the sponsor so that a thorough assessment of the situation and appropriate decisions can be taken in the interest of the project and the organization. The project sponsor has a responsibility to provide realistic project baselines to the project team so that the initial set of constraints are well defined and the project team feels energetic while trying to achieve these constraints. The project manager should not get consumed only by these project constraints but also keep in

mind how important it is to meet customers' needs and expectations for continued business prospects and sustainability. Thus a systematic and disciplined approach is important on the part of the project manager to handle these situations.

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## **1.5 PROJECT MANAGEMENT**

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Project Management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. There are various frameworks as suggested by several project management institutions. One of the most sought-after project management frameworks is that of Project Management Institute ® called the Project Management Body of Knowledge (PMBOK) which involves 5 process groups and 10 knowledge areas. Spanning these knowledge areas and process groups are various project management processes that are interrelated to each other and form a logical sequence of processes. The PMBOK also lists out several project management-related tools and techniques for each of these processes.

Project managers must not only strive to meet specific scope, time, cost, and quality requirements of projects, they must also facilitate the process to meet the needs and expectations of the stakeholders who are involved in the project work. Therefore, it is extremely important to understand the project from the perspective of stakeholders.

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## **1.6 WHO IS A PROJECT STAKEHOLDER?**

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There are several definitions of stakeholder. However, the most regularly prescribed is the one where the stakeholder is any individual or group of individuals who affects or is affected by the project or perceives to be affected by the project. While this definition is very exhaustive and encompasses many individuals or groups the project is concerned only with the salient stakeholders. These include the project sponsor, project team, customers, users, suppliers, competitors. The project stakeholder can be internal as well as external to the project.

On a sculpture building project similar to the Statue of Unity, there can be several stakeholders which are discussed in further detail below: -

- The sponsor can be regarded as the government organizations who are in charge of this particular project as they will be responsible for the funding of the project. Besides the funding responsibility, the government organizations and their officials will also be responsible for making critical decisions about the scope of the project and those related to the approval and necessary inputs regarding the project. Regarding the funding and budget of the project, the government organization will be deciding on the tradeoff for any particular requirement against the available budget therefore the ultimate responsibility of what gets finalized and what will be the final output of the project will be defined by the project sponsor because for all such requirements the project

sponsor has to you agree to the funds that have to be paid to the contractor.

- For a project of this size and scale, there would mostly be a team of individuals who in turn is supportive of the project manager. For large projects, there are additional positions that resemble small and medium-sized projects. In this case, it would be termed as a project director. However, most often these leaders of the project are identified as project managers. The responsibility of the project manager will be to maintain integration and communication on the project among the several stakeholders. The project manager has to ensure that all the elements of the project are being addressed appropriately. For example, if there is any change in the dimensions of the sculpture then it needs to be communicated to other functions who you will be affected by this change like the civil engineering contractor, the design engineering contractor, and the seismic analysis contractor who will then revise their documents and technical specifications suitably.
- The project team is not only the primary group of people who works on the project but they also are a majority stakeholder of the project. The project team consists of Engineers, designers, civil construction workmen and various other individuals or groups who are directly working on the project. They will it necessary inputs to complete their work. They will also need to be apprised of whether those inputs such as raw material, tools, and equipment will be made available to them or they will have to arrange it by themselves. The project team will have to work in a coordinated fashion to complete the task. For example, the civil construction workers will have to work closely with the fabrication workers so that structure is erected as per the requirements. Further, the electrical engineering team will have to work ok with civil construction workers so that the light can be installed at predetermined locations.
- Generally, for any project, it will be counter-productive and impractical for the project team to make all the components and systems by themselves. The project team might not have the time, resources, or capabilities to execute the task by themselves. Therefore, in this situation, the role of suppliers/vendors becomes extremely important. For the suppliers, the activity would be a regular task for which they have already developed expertise. Rather than performing this task all by themselves, the project team can generate a suitable statement of work and procure these inputs from these suppliers. In doing so, the project team can limit their work effort up to creating the requirements, monitoring suppliers' progress, and quality control of the supplier's deliverables. Hence, the suppliers become important stakeholders on the project without being directly a part of a project team.
- Several other individuals and groups who are of importance to the project's progress are regarded as additional stakeholders. The local

authorities providing electric supplies, water supplies, and communication channels are also a stakeholder to the project as their performance impacts the project progress even when they are not directly working on the project tasks.

- While there are stakeholders who are benefited from the success of the project, there are other stakeholders who would benefit if the project fails or the project progress is stalled. Adversaries to those involved in the project such as the competitors of the participating organizations, individuals who want the project to prolong beyond the scheduled time so that their revenue is continued, etc. would have negative interest in the project and these are also regarded as stakeholders of the project. This is because they would try to exploit every opportunity to derail the project and so the project authorities will have to keep a watch on their actions as well.

As discussed here, there are several stakeholders on the project and it is extremely important to identify these stakeholders at the start and during the life of the project. Besides, the project manager will have to ensure that these stakeholders are engaged and their expectations are taken care of to have a good relationship with them and ensure their continued support on the project.

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## 1.7 PROJECT MANAGEMENT FRAMEWORKS AND STANDARDS

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There are various project management frameworks available in the extant literature. These frameworks are selected based on the kind of project and the industry. These frameworks are documented using standards or a body of knowledge. Prince2, PMBOK, Agile, Scrum, Kanban, XP are the different frameworks that are currently in practice. These frameworks are continuously updated based on feedback from industry professionals and academic research to keep these relevant. From a basic learning standpoint, students need to get familiarized with the PMBOK® (Project Management Body of Knowledge) offered by the Project Management Institute®. While several agile methodologies are being used in the IT industry, the PMBOK guides widely regarded as a gold standard of project management. Until PMBOK version 6, the project management methodologies were based on five process groups and ten knowledge areas. However, the PMBOK guide 7<sup>th</sup> edition has shifted from the principles-based standard to support effective project management to focus more on intended outcomes rather than deliverables. PMBOK 7 focuses on project management principles and project performance domains. While future developments are likely to happen on PMBOK guide 7<sup>th</sup> edition, project management learners and practitioners need to have an idea of PMBOK guide 6<sup>th</sup> edition as these are more prescriptive in nature and several industries will retain the principles, tools and techniques, and terminology given in PMBOK 6<sup>th</sup> edition.



## 1.8 PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK) GUIDE 6<sup>TH</sup> EDITION

As explained earlier, PMBOK 6<sup>th</sup> edition is based on **five process groups** and **ten knowledge areas** as given in the table. These process groups and knowledge areas are mapped into processes that need to be deployed appropriately for successful project management and achieving the project management baselines.

Five Process Groups	Ten Knowledge areas	
Initiating	Integration	Resource
Planning	Scope	Procurement
Execution	Time	Communication
Monitoring & Control	Cost	Risk
Closing	Stakeholder	Quality

### Process Groups:

- **Initiating** process group contains processes that are performed to define a new project or new phase of an existing project. It is related to securing necessary approvals towards chartering of a project.
- The **planning** process group establishes project scope, creates project management plans relevant for each knowledge area, defines objectives, and determines the course of action to attain these objectives.
- **Executing** process group contains processes to undertake the work as defined in the planning phase aimed at satisfying project objectives.
- **Monitoring and controlling** process groups are a set of processes that are undertaken to track the progress of the project work. Based on the feedback of the status it also regulates the progress and performance of the project. It serves as means to identify areas of changes required in any knowledge area and provides feedback to the planning phase to that necessary changes can be implemented.
- The **closing** process group contains processes required to formally complete the contracts and the project.

### Knowledge areas:

- **Project Integration Management** includes processes and activities to identify, combine and coordinate the various processes and tasks into a cohesive whole.
- **Project Scope management** contains processes to ensure that all the project work and only the project work is undertaken for successful

completion of a project

- **Project Time management** contains processes to ensure that work is completed within predetermined or scheduled timelines.
- **Project Cost management** contains processes and tasks towards planning, estimating, budgeting, financing, funding, managing, and controlling project costs so that the cost of the project does not exceed the allocated budget.
- **Project Quality management** contains processes that are undertaken to ensure that the project management process quality and the resulting product quality are in line with the requirements aimed at meeting the stakeholder's expectations.
- **Project Resource Management** is aimed towards identifying, acquiring, and managing the resources. For human resources, it is also concerned with training, team building, conducting appraisals, and demobilizing upon completion of the project.
- **Project Communication management** ensures that all project information is timely and accurately generated, stored, and disseminated to the intended recipients including but not limited to the project team and stakeholders.
- **Project risk management** is conducted to identify, categorize and analyze project risks. Further, it is also related to planning risk responses, implementing actions, and building contingencies for unplanned risks.
- **Project procurement management** is related to procuring necessary products and services outside the project team which serves as inputs to the project.
- **Project stakeholder management** contains the processes required to identify individuals or groups of individuals that could impact or be impacted by the project and devise strategies towards engagement and monitoring of these stakeholders.

### Check Your Progress 2

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

Read the Following Activities and Answer Which Knowledge Area Does They Belong to:

1. The resident, where the site is situated is upset about the heavy truckload on the road due to the project activities.

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.....

2. The project team needs to advance the project by 2 weeks due to requests from the end client.  
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3. The customer wants all communications to happen through hard copies and signed documents as they don't have email access at their location.  
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## 1.9 PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK) GUIDE 7<sup>TH</sup> EDITION

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PMBOK 7<sup>th</sup> edition is based on the concept of project management principles and project performance domains. The project management principles guide the behavior of people involved in projects. With these principles, being broad, it is easy for individuals and organizations to maintain alignment. The project management principles are elaborated in brief:

### 1. Be a Diligent, Respectful, and Caring Steward

The stewardship principle necessitates the individual to operate in alignment with the organization's interests, respectful engagement of project team members, and diligent approach to organizational resources such as finances, materials, and technology. Outside the organization, it includes responsibility towards the environment, external stakeholders, society, and operating regions.

### 2. Create a Collaborative Project Team Environment

A collaborative project team environment allows everyone to perform at their optimum, fosters a culture of partnership within the team members, and enhances team learning and development. As a result, the organization is benefited from the outcomes which are in alignment with its fundamental principles, values, and culture.

### 3. Effectively Engage with Stakeholder

Stakeholders who are supportive of the project should be taken care of appropriately so that they develop a sense of association with the project thereby increasing the chances of success on the project. Those stakeholders who possess a high degree of influence and hold a negative idea of the project should be effectively engaged so that their concerns and interests are taken care of in the project.

#### **4. Focus on Value**

Value is the primary reason why a project is undertaken. The project team should identify the value that the project will generate during, at the end of, or after the project is completed. Project teams should monitor project progress and work towards timely achieving and maximizing project value.

#### **5. Recognize, Evaluate, and Respond to System Interactions**

A project can be regarded as a system of interdependent and interacting domains of activity. To properly respond to the interactions of the system consistent attention to internal and external conditions is required.

#### **6. Demonstrate Leadership Behaviors**

Leadership does not mean authority and while any team member can demonstrate leadership behavior, an effective leader recognizes differences in motivation among the project team members. Further, effective leadership promotes project success and contributes to the positive project outcome.

#### **7. Tailor Based on Context**

The fundamental characteristic of any project is its uniqueness and hence context-specific appropriate methods of producing the desired outcomes are required. This process is continuous and happens throughout the life of the project.

#### **8. Build Quality into Processes and Deliverables**

Project quality needs to satisfy stakeholders' expectations and meet project and product requirements. It focuses on meeting the acceptance criteria and ensures that project processes are suitable and as effective as possible.

#### **9. Navigate Complexity**

Complexity is the result of human behavior, system interactions, uncertainty, and ambiguity. The project team needs to stay vigilant in identifying elements of complexity and use a variety of methods to reduce the probability or impact of the complexity.

#### **10. Optimize Risk Response**

The project team should take steps to minimize the negative risks and maximize positive risks. A disciplined approach towards risk by identifying, evaluating, planning a response, and proactive implementation safeguards the project from eventualities.

#### **11. Embrace Adaptability and Resiliency**

Adapting to changes and the ability to absorb impacts keeps the team focused on the desired outcome when external and internal factors change. It helps project teams to learn, improve and recover from setbacks thereby continue making progress.

## 12. Enable Change to Achieve the Envisioned Future State

Managing changes through a structured approach helps project teams to traverse from their current state to a future desired state. While change can be challenging as not very often do stakeholders embrace change, by employing a motivational approach and focused actions the project team can move steadily towards success.

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### 1.10 PROJECT ROLES

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**A typical project will generally have the following roles:**

- **The Project Manager** is accountable for managing the project to meet project objectives and deliver its intended value and benefits to the organization. This role involves gathering information to get the project initiated, ensuring the project is completed according to scope, schedule, and cost baselines including approved change orders that are undertaken to meet the project objectives. Having the right skills is very essential for being a successful project manager. Using interpersonal and team skills such as team building, enabling a safe and motivating environment as against using a commanding approach is essential for a project manager to get the tasks delivered from the project team. The project manager should be leadership-focused and should embrace components such as empowerment, communication, doing the right things, and a principles-based working methodology.
- **Project Sponsor / Initiator** provides financial resources for the project while also supporting the project and safeguarding it from any unnecessary or non-value-adding changes. The project sponsor also conveys the project status and updates on major risks activities to the senior management.
- **A project team** is a group of people including the project manager who will perform the work of the project. Team members can change throughout the project as people are added to and released from the project. It is the team's role to help plan the tasks and create the work breakdown structure (WBS) so that project tasks are monitored and controlled. Team members complete activities to produce the deliverables from the project management plan during project execution and also keep a watch on the deviations happening from the project management baseline.
- **Functional / Resource manager** provides physical and human resources such as engineering, quality, sales, IT, etc. to the project on an ongoing basis. They have a pool of resources who possess certain skills specific to their function and can thereby work on the project to deliver the output on the project.

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## 1.11 BUSINESS ENVIRONMENT

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It is understood for the project manager and the team to understand the business environment in which they operate as it helps them deliver the benefits and value for which the project was initiated. The term 'business environment' can be thought of as environmental factors and organizational culture.

### **Environmental factors**

Internal and external factors influence projects. These factors include customers, stakeholders, regulations, technology, and the marketplace. The business environment is always changing so it is important to consistently assess and adapt to changes in the business environment. In a predictive environment, the challenge is to consistently ensure that the forecasted/predicted benefits meet the plan envisaged during the initiating and planning stages. While small changes in the environmental factors require only reprioritization of the project work or re-assessment of scope, the larger changes may require altering the project scope entirely.

### **Organizational culture**

Projects are not unimpacted by the cultural norms, management policies, and procedures of the organizations in which they are conducted. These factors are increasingly important in global organizations in which the project resources are not collocated and operate across different countries, sometimes continents, cultures, and time zones. Organizations may have employees, suppliers, sub-contractors, and consultants who perform the project work but belong to different nationalities, cultures, and locations. A project manager is expected to devise methodologies to manage the project task within these constraints. It is important to consider organizational culture not only at the start but also during the life of the project. The project manager should be open to listening and understanding the perspective of these team members, align work accordingly, and seek support from the project team while executing the project work.

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## 1.12 LET US SUM UP!

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Project management has proven its value across industries. Not only do project management knowledge and skills help managers in taking the right decisions on the project, but it can also teach the art of communicating effectively, good interpersonal behavior, and building successful teams. It can be generally found in industries where individuals having good technical skills and soft skills are assigned the task of project management. While project management can be indeed mastered while working on projects, a theoretical foundation and formal learning of the subject of project management is very important to quickly learn and execute projects successfully.

## 1.13 ANSWERS

### Check Your Progress 1

Read the Following and Identify which of these are the Projects? Discuss Why These Can be Considered as Projects.

1. Constructing a statue of the size of 'Statue of Unity' in another state

**Answer:** This is a project. The site conditions and the requirements will not be the same as that of the Statue of Unity in Gujarat. Hence it is unique within its characteristics. It has a unique purpose and is temporary

2. Modifying an existing assembly line for new car model

**Answer:** This is a project. The change in the assembly line is unique and temporary as the modified assembly line will be handed over to the production plant.

3. Commercial production of the newly designed computer

**Answer:** This is NOT a project. There is a fixed product whose several instances have to be mass-produced. This endeavor is not temporary or unique.

4. Production of petrol

**Answer:** This is NOT a project. There is a fixed product that has to be mass-produced perpetually as per the established process. This endeavour is not temporary or unique.

5. Revamping a part of petroleum refinery

**Answer:** This is a project. The revamping of a part of the petroleum refinery is temporary and unique. Once the revamping is complete the plant will be handed over to operations for production.

### Check Your Progress 2

Read the Following Activities and Answer Which Knowledge Area Does They Belong to:

1. The residents where the site is situated is upset about the heavy truckload on the road due to the project activities

**Answer:** This belongs to the 'Stakeholder management' knowledge area. The residents are impacted by the project as it is creating a heavy truckload on their roads.

2. The project team needs to advance the project by 2 weeks due to requests from the end client.

**Answer:** This belongs to the 'Time Management' knowledge area. The project team needs to work out ways to advance the project through time management techniques.

3. The customer wants all communications to happen through hard copies and signed documents as they don't have email access at their location.

**Answer:** This belongs to the 'Communications Management' knowledge area. The project team should have a proper plan to ensure that all stakeholders get the project information in the form and manner that is appropriate to their situation.

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### 1.13 SELF-ASSESSMENT EXERCISE

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1. Read the following and identify which of these is the project? Discuss why these can be considered as projects.
  - a. Making a new television commercial advertisement
  - b. Rolling up a nationwide vaccination plan
  - c. Building an airplane
  - d. Manufacturing steel plates and rods
2. Read the following activities and answer which knowledge area does they belong to:
  - a. Customer requests a change in project requirements
  - b. The project sponsor wants the team to audit their existing processes
  - c. The project involves subcontracting a work package to external parties.

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### 1.14 FURTHER READINGS

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<https://www.manage.gov.in/studymaterial/PM.pdf>

<https://www.ongc.com.au/2019/06/24/an-introduction-to-it-project-management>

<https://www.edo.ca/downloads/project-management.pdf>

Buch, V., & Damle, P. (2017). Successful launch of 450MT girder for monorail bridge at Currey Road, Mumbai. *International Journal of Teaching and Case Studies*, 8(1), 59-65.



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## UNIT 2 PROJECT FEASIBILITY ANALYSIS

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### Objectives:

After studying this unit, you will be able to:

- Understand why project feasibility analysis is required
- What are the various dimensions of the project feasibility study
- Who are the stakeholders of a project feasibility analysis
- When, Why and How of project feasibility analysis
- What is a project feasibility report
- How to prepare a project feasibility report
- Calculate financial parameters such as Payback Period, Internal rate of return, Net present value, etc.
- What is a business case?

### Structure

- 2.0 Introduction
- 2.1 Why do we need to conduct project feasibility?
- 2.2 Dimensions of Project Feasibility
- 2.3 Stakeholders of project feasibility
- 2.4 Conducting a project feasibility analysis
- 2.5 Sample Project feasibility report
- 2.6 Business case
- 2.7 Let us Sum Up!
- 2.8 Answers
- 2.9 Self-Assessment Exercises.
- 2.10 Further Readings

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## 2.0 INTRODUCTION

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In **unit 1**, we learned what is a project and what is project management. But before we initiate a project and start consuming resources in terms of cash outflow and working hours of project staff we need to ascertain a few things. First and foremost, what is the probability that the project being undertaken will be completed successfully and deliver its intended output? And second, what benefits are going to be realized for the organization and the project stakeholders. To assess the possibility of successful completion and foresee any major challenges that may render the project unfeasible, a project feasibility analysis is conducted. This analysis takes a holistic view of what risks the project may see during the entire lifecycle of the project and its results or product after completion of the project. The project feasibility

analysis is thorough, if not detailed in most cases, in nature. It will be unfortunate and disastrous for the project to not make it up to the end successfully and fail to deliver the intended results. The project feasibility analysis should necessarily identify such foreseeable possibilities and events before the project takes off. Another element of project delivery, after successful completion of the project, is to deliver the intended outcomes. For profit-based organizations, this may mean delivering more revenue, improving market share, efficient operations, or new products. For non-profit and government-based organizations intended results can be the improvement in the living standard of the public, better infrastructure, or any other social parameter for which the project is undertaken. Based on project feasibility analysis and awareness of how the project outcome will be delivered, a business case is prepared. A business case is an important project management document that explains how the benefits of a project outweigh its cost and the reason why it should be undertaken.

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## **2.1 WHY DO WE NEED TO CONDUCT PROJECT FEASIBILITY ANALYSIS?**

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A project feasibility study is intended to conduct and determine whether a particular project can be completed given the various pertinent aspect including but not limited to social, economic, financial, legal, and technical studies. Before commencing any project, the project team must assess the possibilities of completion of the project and whether it is worth investing the kind of funds including cash, human effort, and energy of individuals in comparison with other revenue generating ideas. According to a PMI research survey, it is observed that more than 50% of projects are not successful. While it does not mean the project does not get delivered in terms of its commitments or the intended result it means that the participating organization did not find it useful at least immediately after the completion of the project and would have preferred to choose another better alternative. A good and thorough project feasibility study is the first step towards avoiding getting into this situation. Most projects see investments in terms of millions of dollars and therefore a failed project brings in huge liabilities for the organization and sometimes can be disastrous for the organization, especially in terms of megaprojects. The sooner is it identified that the project is going to be a failure, then it is easier for the organization to kill the project and thereby save the resources and money without expending this any further. Before the project is initiated a feasibility study will ensure that such a project, which may end up in failure costing huge sums of money for the organization, is not started in the first place. There are several dimensions through which a project feasibility study has to be conducted. Each of these dimensions indicates a particular area that can bring in significant risk for the project. These may not necessarily be the same for all types of projects. An IT project would have far more technical risks as compared to a construction project where there can be huge financial risk involved owing to its very nature of being capital intensive. A not-for-profit such as a government

initiative towards improving the social well-being of the people or a project of the kind of roll-out of a vaccine for a particular disease may not be financially viable but the primary goal of that project is not to generate revenues and therefore it might be difficult for the project team to assess the benefits of a project in financial terms. Projects which are executed for the sole purpose of generating revenues need to be assessed based on financial terms and parameters such as net present value, payback period, cash flow analysis, etc. This will help ensure and understand how the project is going to generate benefits over the period. All these rigor and assessments go into a feasibility study of a project. While a project feasibility study is entirely contextual, some standard templates and checklists can guide the team to perform a feasibility study that is robust and rigorous and successfully bring out challenges that need to be analyzed before initiating the project. We will see each of the dimensions of project feasibility in detail over the next sections.

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## 2.3 DIMENSIONS OF THE PROJECT FEASIBILITY STUDY

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Often, a project is first conceived and regarded as a fantastic idea by individuals or a group of individuals who think that the project will yield good results for the organization. Not only do they become the ambassadors of the project, but they also go on to claim that this project is the single best alternative that the organization has. While it can be accepted that the idea has a lot of potential, the organization must assess the associated impacts and the challenges that might come during or after the project is initiated and completed to judiciously analyze how the project can get into trouble at the time of execution. This can be done with the help of a project feasibility study. However, there are different ways and guidelines to conduct a project feasibility study a project can get into trouble in many possible ways. Based on the type of project, these dimensions can vary in rigor and impact.

Examination of a feasibility request case needs to be done by an individual having significant expertise. Technical consultancy organizations (TCOs) generally perform the feasibility analysis.

In this section, we will see which are these dimensions and how they impact the project in different ways.

### i. Market analysis

This is primarily concerned with the aggregate demand of the proposed product/service in the future and the market share expected to be captured. The success of the proposed project is dependent on support from the customers. Therefore, this involves detailed study and understanding of:

- Consumption trends of the product/alternate product in the market
- Existing suppliers and their current production capacity as well as plans

## **Project Initiation**

- Feasibility and constraints of production
- Patterns of varying demand across the year/seasons
- Demand elasticity
- Behaviour, intentions, motivations, attitudes, preferences, and requirements of consumers
- Imports and Exports scenario
- Competition and different players available in market
- The cost structure of the product being offered
- Administrative, technical, and legal constraints involved in product marketing

### **Financial analysis**

The objective of financial analysis is to ascertain whether the proposed project will be financially viable in terms of the ability to repay the debt and satisfy the return expectations of those who provided the capital. Financial analysis is key in project feasibility because the institution providing capital will be more interested in looking at financial feasibility than anything else. Financial analysis involves a thorough assessment of the following:

- Cost of the total project and lifecycle costs
- Projected profitability
- Cash flow position throughout the life of the project and the output associated with
- Investment worthiness is judged in terms of various criteria of merit
- Means of financing the project
- Projected financial position
- Internal rate of return (IRR)
- Breakeven point
- Net present value
- Payback period

Financial parameters involve mathematical calculations. We will see some of these in more detail here:

#### **A. Net Present Value**

The value of the same amount of money today is more than at a later period. This is due to two reasons, inflation, and opportunity cost. Inflation eats into the purchasing power of the number of funds available at discretion today than later. This is because of the ever-increasing prices of goods and services. Opportunity cost is the foregone benefit that would have been derived from an option not chosen. Hence if 100 ₹ received 1 year later is a loan to the debtors which would have otherwise fetched interest upon investing in alternate financial instruments.

Simply put, a 100 Rs. can fetch more value (i.e. products or services) than it will a year later. But what value can it fetch 1 year later? This can be calculated by the formula of Present value.

Present value = Future Value /  $(1 + (\text{cost of capital} / 100))^{\text{number of years}}$

Therefore, if the cost of capital is 10%,

The present value of 100 Rs. available today is 100 Rs.

The present value of 100 Rs. received after 1 year is 90.9 Rs.

The present value of 100 Rs. received after 2 years is 82.6 Rs.

The present value of 100 Rs. received after 3 years is 75.13 Rs.

However, it can be rightly argued that a project spanning 5 years will see various cash inflows and outflows at a different point in time. So how do we find whether the project has earned money or lost?

If we sum up the present value of all cash inflows in the project, then the resulting amount will be referred to as *Gross Present value* (GPV). Further, if we sum up the present value of all cash outflows in the project and then deduct this figure from GPV then the resulting amount will be the Net Present Value (NPV).

NPV = Present value of all cash inflows (GPV) - Present value of all cash outflows

Let us take a simple example to illustrate this. The list of cash inflows and outflows during the project operations, over 3 years, is given in the table below. The amount of cash inflow or outflow is adjusted to its present value and then summed up to get the Net Present Value.

(Amount in Thousand Rs.)				
Type	Value	Event	Date of Event	Present Value
Outflow	200	Payment against procurement of Raw material	01-Jan-22	-200.00
Inflow	150	Milestone payment 1 received from the client	01-Jan-23	136.36
Inflow	300	Milestone payment 2 received from the client	01-Jan-24	247.93
Outflow	200	Payment made to the contractor for construction services	01-Jan-25	-150.26
<b>Net Present Value</b>				34.03

It is interesting to note that while the total amount in absolute terms is:

Inflows = 300,000+150,000 = 450,000 and

Outflows = 200,000+200,000 = 400,000

→ Result = 50,000 Rs. Cash Surplus.

The value of the surplus cash in today's date is only 34,030 Rs.

In a nutshell, NPV recognizes the time value of money and evaluates the true and maximum profitability of the project proposal. However, there are practical challenges in using this method. These are:

- Difficult to understand and operate
- Difficult to predict dates and amounts of cash flow at the start of the project
- Assumption of discount rate
- Project with high NPV may still be unattractive if it needs very high initial capital

## **B. Payback Period**

It is the time that a project takes to generate money for itself. It is several years that are required to recover the cash outflow invested in the project. A project with a lower payback period is more likely to be accepted than one with a higher payback period. Not only that a lower payback period ensures that the project starts generating positive cash flow in a shorter time, but it also is prone to eventualities for a lesser period and so the management can focus on other important matters. The payback period can be calculated using the formula below:

**Payback period = Total cost of investment / average net cash flows**

Let's calculate the Payback Period for a hypothetical case. Assume a company has options for two projects, A and B. Project A requires an investment of Rs. 1 million and is expected to save the company Rs.250,000 every year. Therefore, the Payback period of Project A is 4 years.

Project B requires an investment of Rs. 200,000 and will generate incremental revenue of Rs. 100,000 every year. Therefore, the Payback period of Project B is 2 years. From a sole payback period standpoint, project B is better than A.

### **i. Technical analysis**

It deals with the technical aspects of the project which are specific to the domain or discipline involved. The issues can be categorized as inputs, throughputs, and outputs.

Input analysis is concerned with the identification, quantification, and evaluation of project inputs such as skilled manpower, machinery, and raw materials. It is very important to know what and how much is required. Also, it needs to be ensured that the right and quality inputs are available at the

right time. For example, in a refinery project, the erection of a distillation column is critical. Hence at the refinery site, timely availability of necessary cranes having the right capacity of loading, pre-planned erection procedure, and skilled manpower for that activity is required on the day of activity.

Throughput analysis involves various operations that need to be performed on the inputs to add value. The inputs will have to transform several stages of manufacturing to reach the final stage. From a technical feasibility perspective, the project team needs to have a thorough understanding of how to transform the inputs. For a highway project, the necessary input materials like stone, gravel, and cement will be transformed into roads that should meet the purpose. The feasibility analysis should assess if the team has the right set of people or whether there are agencies with the required expertise to achieve the outcome.

Output analysis refers to the product specifications in terms of physical features such as the geometry of the product, functional features, chemical properties as well as compliance to global standards applicable to the product.

## **ii. Economic analysis**

It is the study of costs vs. benefits. It is conducted to know whether the cost of the product is justifiable in comparison to the price at which it will be sold. Generally, FMCG products such as soaps and detergents have relatively less cost of manufacturing. But to take the product to the market and other marketing costs are high. Therefore, economic analysis deals with all the costs associated with the product and compares it with the budgeted selling price of the product.

## **iii. Ecological analysis**

Some projects may expect to cause a severe impact on the environment either during the execution of the project or the lifetime of the resulting product or service. Bulk drugs, chemicals, and petroleum industries pollute the environment. Hence these projects need prior clearances from several different government agencies who may reject the proposal or accept with special conditions. This would create a significant risk for the project in terms of its viability or expected financial benefits. Therefore, a thorough study needs to be conducted that answers the following questions:

- What is the likely damage caused to the environment
- What are the costs associated with restoration measures to counter the damage

## **iv. Legal and administrative**

There are several legal and administrative issues in any project such as registration and clearances and approvals from diverse authorities. These are related to land use, pollution control, factory rules, safety, and labor. The

project has to work in close coordination with these authorities and so the team should be aware of the provisions of the rules, acts, and procedures. As a result, the team can understand whether the project is feasible and practical given these requirements.

**v. Operational feasibility**

There are foreseeable problems and definite opportunities in any project. The operational feasibility is the measure of the fact in terms of the ability of the entity to solve the problems and exploit the opportunities successfully. For example, organizations conduct projects involving setting up a new Enterprise resource planning (ERP) platform in the organization to save the time of various business processes. An unsuccessful project may end up with huge projects costs, inefficient business processes, and system unavailability. Hence the project should be able to envisage any operational feasibility in advance and plan out actions beforehand.

**vi. Schedule feasibility**

A project has to be concluded within a feasible amount of time and cannot go perpetually without delivering the expected result for reasons whatsoever. There is a need to estimate the time required to execute the project. The project deadline and how much is it can be postponed needs to be agreed upon before the starting of the project. Given the various project factors, the teams need to assess whether it is feasible to complete the project within the given time frame or not.

**vii. Resource feasibility**

The project is always executed by the human resource. Hence the availability of the right kind and amount of skilled manpower is crucial for the project to be executed without any hassles.

**Check Your Progress 1**

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

Briefly discuss key points related to the project feasibility study dimensions (Any 4) for the Statue of Unity Project. (Answer in about 200 words).

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## **2.4 STAKEHOLDERS OF PROJECT FEASIBILITY**

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The team conducting the project feasibility study will generally receive crude inputs in form of the preliminary requirements or a broad outline of the project. During the project feasibility analysis, they will have to make several



assumptions and clarifications to verify that their assessment is reliable and relevant to the project. This additional detailing must be done in coordination and consultation with other individuals and groups who may have first-hand information, would be consuming the result, or are subject matter experts in this area. These are referred to as stakeholders of project feasibility analysis as they are going to be impacted or will be impacting the project once initiated. Consider the following headers:

- **Owner** – the individual whose strategic plan created the need of the project
- **Originator** – the individual who suggested the project as a means to achieve that particular strategic plan
- **Sponsor** – the representative of the organization (client) who will authorize the finances of the project
- **Project champion** – Also referred to as project director, is an individual who will oversee the project and ensure that it is executed
- **Users** – who will be using the product/services or operating the facility. For mega projects, users will be operating the facility on behalf of the owners
- **Customers** – individuals or groups who will be paying for the facility or the product.

For example, in a power plant project local electricity board authority is the owner, contractor personnel running the facility will be the user and household owners will be the customers of the output of the project.

- **Project team** – the group of people directly working on the project and will be planning, executing, monitoring, and controlling the tasks of the project to deliver the requirements within the constraints of quality, cost, and time.
- **Senior management** of the organization undertaking the project who are entrusted with the responsibility of ensuring the project is delivered
- **Functional managers** are the individuals who generally head a department or have at their discretion a pool of resources having a particular skill set. The functional managers will be allocating the resources to a project for a fixed period based on the need of the project. As multiple projects will require their involvement, their capability and availability are key for the project to be feasible.
- **External parties** – These are individuals or groups who do not participate directly in the project but are impacted or perceived to be impacted. For a greenfield project, the inhabitants in the vicinity of the location of the project, environmental protection groups, etc. are external parties. In addition, the banking institutions, government agencies, local authorities, etc. can be considered as stakeholders to the project feasibility as they would like to get involved in the project if they believe

that by doing so they will be able to align their goals and in turn meet the targets.

## Check Your Progress 2

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

List down the key stakeholders of the project feasibility study for the Statue of Unity Project. Briefly discuss how they are affected or perceived to be affected by the project (Answer in about 250 words).

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## 2.5 CONDUCTING A PROJECT FEASIBILITY STUDY

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A feasibility study involves performing a detailed analysis of an existing business problem or opportunity, identifying the various solutions alternatives available and the probability of each option meets the requirement. The resulting document, called as *Feasibility Study Report*, it contains:

- A complete description of the problem or opportunity at hand
- List of criteria that the solution should address
- List of all available alternatives by which the solution can be delivered
- Feasibility assessment of each of these alternatives
- List of threats and challenges associated with each of the alternatives
- Ranking of these alternatives
- The most preferred alternative preferred for implementation

The feasibility study report is presented by the senior leadership team to the business sponsor or client. A feasibility study may be conducted before concluding the business case but generally, they are conducted simultaneously to that the study is more thorough.

### Steps for conducting the project feasibility study:

#### 1. Examine the business problem/opportunity

##### a. Study the business environment

Before conducting a feasibility study it is recommended to have a full understanding o the business problem to be addressed. This can be achieved by studying the business environment through the following means:

- Identify market segment, competition, and relevant products and services available

- Identify short, near, and long term business vision and strategy
- Identify department and its location
- Identify the information which is relevant to the project. List the data repositories and databases
- List each technology relevant to the project with a description of its architecture and interfaces
- List each organizational process relevant to the project with clear flow diagrams

**b. Study the business problem**

- Identify the central business problem which needs to be addressed. Note the reasons with details of why the problem exists, its impact on business, and the time frame in which it needs to be solved
- These problems can be related to:
  - Business process – Efficiency, robustness, timeliness
  - Business unit – Lack of clarity, alignment, inadequate performance, data quality
  - Technology – Reliability, relevance, and scalability

**c. Study the business opportunity**

- List business opportunity identified with details of why and how the opportunity currently exists and the time frame until which it is likely to remain
- The examples can be:
  - Newmarket requirement
  - Lack of competitor to meet a demand or change
  - New product ideas
  - New technologies available to build products onto
  - Legal and regulatory changes

**2. Identify the requirements**

**a. Note the key business drivers**

- **These include examples such as:**
  - A certain objective that has to be achieved within a predetermined time frame
  - Alignment to a future change in legislation/regulation from a particular date
  - Ability to achieve competitive/first entry advantage available for a limited duration
  - Forthcoming changes in business or external marketplace will happen within a limited time frame

**b. Characterize the business requirements**

- For each, business problem or opportunity, list the requirement that needs to be satisfied for being qualified as an acceptable solution
- The examples can be:
- For a business problem of poor business efficiency, the business requirement should be a new process that improves efficiency.
- For a business opportunity involving a new product launch, the business requirement can be the establishment of a new business unit to deliver the product
- For a business problem of capacity constraint towards meeting market demand, the solution business requirement will be to build a new manufacturing facility that can ramp up production.

**3. Undertake a feasibility study**

Once the business environment, drivers, problems, and requirements are identified, a detailed feasibility study can be undertaken. Following is a step-by-step procedure for studying the feasibility of each of the problems/opportunities.

**a. Identify the potential solutions**

- Generate a complete list of potential solutions to the business problem or opportunity
- List the components of each of the potential solutions
- Describe the purpose of each of the potential solutions
- Assess how each of the components addresses the key business requirement for which the project needs to be undertaken

**b. Undertake the assessment**

- Assess the actual feasibility of each alternative solution through a range of methods few of which are as under:
  - **Prototype building** – Create a subset or a smaller version of the complete solution to prove what the solution/product will look like or the process by which it will be achieved. Prototyping is developed generally for the highest risk areas of the solution. Also, it is created when the end product or solution cannot be completely quantified in terms of requirements. For example, before building the Statue of Unity, the project team build 3 different sub-sized prototypes to seek inputs from all the stakeholders. Imagine if they did not build a prototype in the first place, how would they address the suggestions/criticism that would have been received after the actual statue is built.
  - **Survey studies** – For projects meant for internal consumption/development, surveying staff members is useful. This study can assess how likely are the end users going to use the solution or what features

are mandatory to get users' buy-in and agreement for implementation flawlessly. For projects, the result of which generates products for customers outside the organization, a market survey should be performed. It helps is an assessment of whether there exists a demand for a particular product and how much is the likely volume the market can absorb. Further, it also helps to identify what are the various segments within a particular market to create customizations of the product.

**c. Evaluate the results**

- Measure the overall result of each assessment through scoring in terms of how the actual values compare to those initially expected. For non-tangible or non-quantifiable considerations, the results need to be measured on a qualitative scale of perceptions of the survey respondents.

**d. Identify any risks**

- List the foreseeable risks associated with the deployment of each solution. Risks are defined as an event that may cause to reduce or deny the effectiveness of the solution after the conclusion of the delivery.
- Also, note the probability of encountering the risk and its likely impact should the risk occur. While it is advisable to have risk-mitigating actions for all the risks, at least those risks which are beyond a certain threshold should have robust risk mitigation actions. These actions should either avoid or reduce the effect of the risk.
- *For example:*
  - If a particular solution requires resources having a particular skill set that the organization does not possess, the solution can be to outsource the project task to a company having demonstrated capabilities and manpower with these skills.
  - If a particular technology solution may not be accepted by the staff as it is perceived as difficult then it is advisable to create a prototype of a software interface that the staff will be using to seek their inputs on how to make it more user-friendly.

**e. Prioritize the issues**

- This step is to look for any issues that may be encountered while adopting any solution. Issues are different from risks in the sense they are certain while still adversely impacting the ability of the solution to produce the required output. The actions required to resolve a particular issue needs to be recorded and assigned appropriate priority rating so that while assessing the feasibility of a solution
- *For example:*
  - If the required funds are not budgeted, funding requests should be requisitioned with the right authority.
  - If the solution requires government approval which is a time-consuming task then the issue should be noted with actions and cut-off date by

which the approval has to be received.

**f. Record assumptions made on the study**

- List any assumptions that are considered as pre-requisite for adopting any solution.
- *For example:*
  - The study does not consider the possibility of change in any legislation or government policy or global events that will result in a particular situation
  - The study does not consider the price fluctuation of a particular commodity beyond forecasts.

**4. Rank the feasibility results**

**a. Define the criteria**

- Specify the criteria used to rank each solution option and describe the scoring and the weighing mechanism used to produce an overall result

**b. Give ranking scores**

- Score each option against the pre-identified criteria and present in a sorted form with the higher ones at the top and the lower ones at the bottom

**5. Identify the feasibility outcome**

Based on the total score, identify the most feasible option to be recommended for implementation.

Most often the project feasibility report will list out two to three best options as the senior management might have an alternate strategy that they want to explore and the project team should be prepared with multiple feasible options for their consideration.

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## **2.6 PROJECT FEASIBILITY REPORT TEMPLATE**

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A project feasibility template is shown below. This is a modified version of the feasibility report template available in the public domain. (Reference: Public Services and Procurement Canada; weblink - [www.tpsgc-pwgsc.gc.ca](http://www.tpsgc-pwgsc.gc.ca)) This template shall be added with more headings and details to tailor it with the actual study as needed.

**Executive Summary**

<Provide a brief overview of the most important and decision-relevant information about the project. Mention in a few words:

- Opportunity or problem being analyzed.
- Any special challenges or impacts needing the attention of the reviewers/stakeholders
- *List of recommended options with its key features>*

## Problem Statement

*<Briefly present the primary problem, opportunity, or issue that the proposed project is intending to solve>*

## Project Business Requirement

*<This section provides details related to the context for undertaking the proposed project. This information should align with the problem definition and requirement.*

*This section should contain information relevant to the initial analysis, such as the findings of an environmental scan (whether about technology or to what other organizations have done to support a similar business problem or opportunity), key parameters/constraints from relevant policy and legislation, etc.>*

## Assessment of Options

*<The purpose of this section is to list all the possible options to meet the business requirements and to document the results of the feasibility assessment of each of the options. A table format is most suitable for this however it should contain only concise details and figures. A detailed explanation can be supported through cross-reference notes. Subsequent documentation shall contain the justification in or against the proposal. Project constraints and budget limitations are among the various factors that will determine viability.>*

*< In the format given below, assess each option against common high-level criteria. There should be one table for each option.*

*An indicative evaluation criterion is provided here for reference purposes. Add or remove criteria to suit the specific option.>*

<b>Option 1</b> <i>&lt;Name &gt;</i>	<b>Notes / Comments</b>
<i>Description of Option</i>	
<b>Option Evaluation Criteria</b>	
<i>Alignment with Required Business Objectives</i>	
<i>Technical Fit to Target present architecture</i>	
<i>Costs</i>	
<i>Cost-Benefit</i>	
<i>Legal / Regulatory Fit</i>	
<i>Impact</i>	

<i>Potential Risks that impact the ability to Deliver Desired Business Outcomes</i>	
<i>Fit to Project Constraint 1</i>	
<i>Fit to Project Constraint 2</i>	
<i>etc</i>	
<b><i>The rationale for Rejection or for Recommending further Analysis</i></b>	
<b><i>Overall Viability</i></b>	<b>&lt;State Whether “Viable” or “Non-Viable”</b> Note: Viable Options are un-ranked at this stage

### **Risk Assessment of Viable Options**

*<List the top three to five risks for each of the viable options. Use a high-level, standard risk assessment process involving the qualitative breakup of probability and impact parameters over a 1 to 5 Likert scale i.e.*

*NOTE: For the feasibility report, identify the results of the preliminary risk assessment of each option in terms of scope, time, cost, or other considerations surrounding the problem/opportunity. These considerations can be related to the physical limitations of the size of the facility, infrastructure, technical, legal, organizational, or social dimensions>*

### **Recommended Options for Further Analysis**

*<Summarize the key findings of the options assessment. Identify which options will carry forward into the analysis phase and the business case.>*

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## **2.6 BUSINESS CASE**

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While a project feasibility report is a detailed assessment of undertaking a project, a business case is a document that justifies the startup of a project. The business case document is referred to regularly during the project to assess whether the costs, benefits, risks, and issues align with those originally documented before the start of the project. At the end of the project, a project review will be conducted to determine whether the project delivered the business benefits outlined in the business case. In this regard, the success of the project is measured against the ability of the project to meet the criteria outlined in the business case.

A typical business case (Reference: Public Services and Procurement Canada; weblink - [www.tpsgc-pwgsc.gc.ca](http://www.tpsgc-pwgsc.gc.ca)) shall contain the following details:



1	The Strategic Context
1.1	Organizational Overview
1.2	Problem/Opportunity Statement
1.3	Business Outcomes
1.4	Prioritized Requirements
1.5	Assumptions and Constraints
1.6	Dependencies
1.7	Scope Boundaries
2	Analysis and Recommendation
2.1	Preliminary Options Analysis
2.1.1	Evaluation Criteria
2.2	Viable Options Analysis
2.2.1	List and Describe the Possible Options
2.2.2	Strategic Alignment
2.2.3	Alignment with Desired Business Outcomes
2.2.4	Costs
2.2.5	Cost-Benefit Analysis
2.2.6	Impact
2.2.7	Risks
2.2.8	Advantages and Disadvantages
2.2.9	Scoring Summary Table
2.2.10	The Preferred Option
2.3	Managing the Project

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## **2.7 LET US SUM UP!**

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Unfortunately, it is observed that very less time is spent to assess the feasibility of a project which therefore results in challenges during execution. While it can be understood that at a feasibility study level, there can only be a high-level view of the project, and more facts and information will get unearthed during further detailing. However, any crucial matter which can render the progress unviable shall be known at the start of the project so that the organization can judge the pros and cons of whether to proceed with a particular project. Therefore, a thorough analysis of project feasibility is critical for the success of the project and the long-term returns envisaged as a result of the implementation of the project.

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## **2.8 ANSWERS**

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### **Check Your Progress 1**

Briefly discuss key points related to the project feasibility study dimensions (Any 4) for the ‘Statue of Unity’ Project.

**Answer:** Consider the following headers:

- i) **Market analysis** – While there is no direct product involved, the project will be useful to attract tourists across the globe to visit the place, thereby increasing the overall prosperity of the region where the statue is situated.
- ii) **Technical analysis** – The project team has demonstrated civil engineering capability to execute the project. The statue surface has to be manufactured from sheet metal which can withstand for several years in the site conditions. As there are no technical specifications available besides the overall height of the statue, the project team has to involve the larger stakeholder base to finalize the technical specifications of the outer surface of the structure.
- iii) **Resource feasibility** - There needs to be a resource pool of structural design consultants, geologists, and construction contractor who has to execute the task in close coordination
- iv) **Legal and administrative** – The primary contractor who is also in charge of the construction will have to integrate the project efforts with the client and in turn with the consultants working on the project. The primary contractor will have to also coordinate with local authorities and administration during the execution of the project.

### **Check Your Progress 2**

List down the key stakeholders of the project feasibility study for the Statue of Unity Project. Briefly discuss how they are affected or perceived to be affected by the project

**Answer:** The key stakeholders of the project feasibility study are:

- i) **Government & Local administration** - As there are several projects of similar nature executed in different parts of the world which were heavily delayed, government officials need to make sure that the project is completed on time otherwise, it will adversely impact the inhabitants of neighbouring villages and put pressure on the administrative system.
- ii) **Construction contractor, structural design consultants, and other suppliers** – This being a construction project, the project team involving the contractor, suppliers, and consultants must agree on the technical feasibility of making the structure given the difficult site conditions.
- iii) **Residents of that area** – It can be envisaged that post completion of the project there will be a multifold increase in the number of tourists and visitors. Hence the civic amenities such as road, electricity, and water supply have to be ramped up significantly to meet the increased needs and avoid disturbance to the residents of that area.

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## 2.9 SELF-ASSESSMENT EXERCISE

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1. Think of a project that you are/were a part of. Can you generate a project feasibility study report for that project?
2. Think of a project that failed to deliver its intended results, and you believe the project should not have been initiated in the first place. Can you think of what went wrong during the project feasibility study that made the organization decide to go ahead with the project? What element of the feasibility study was not properly conducted as a result of which the risks were not known before?

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## FURTHER READING

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Bryce, T. (2008). The elements of a good feasibility study. *Project Smart Online Project Management Resource*.

Del Cano, A. (1992). Continuous project feasibility study and continuous project risk assessment. *International Journal of Project Management*, 10(3), 165-170.

Goel, A., Ganesh, L. S., & Kaur, A. (2020). Social sustainability considerations in construction project feasibility study: a stakeholder salience perspective. *Engineering, construction, and architectural management*.

Mukherjee, M., & Roy, S. (2017). Feasibility studies and important aspects of project management. *International Journal of Advanced Engineering and Management*, 2(4), 98-100.

[https://courses.lumenlearning.com/alamo-technicalandbusinesswriting/chapter/unit-4-b\\_feasiblity-report\\_lecture-2/](https://courses.lumenlearning.com/alamo-technicalandbusinesswriting/chapter/unit-4-b_feasiblity-report_lecture-2/)

<https://shodhganga.inflibnet.ac.in/handle/10603/92555?mode=full>

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## UNIT 3 PROJECT CHARTERING

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### Objectives:

After studying this unit, you will be able to understand:

- What is project chartering?
- What are the inputs for preparing a Project Charter?
- Which tools & techniques are used to prepare a project charter?
- How to conduct a stakeholder analysis?
- What are the contents that form a project charter?
- How to create a sample project Charter?
- Which processes use Project charter as input?
- What is a Project Management Plan?

### Structure

- 3.1 Introduction
- 3.2 What is a Project Charter
- 3.3 Inputs to Project Charter
- 3.4 Tools & Techniques for Creating a Project Charter
- 3.5 Stakeholder Analysis
- 3.6 Contents of the Project Charter
- 3.7 Sample Project Charter
- 3.8 Processes Utilizing Project Charter as Input
- 3.9 Creating Project Management Plan
- 3.10 Let us Sum Up!
- 3.11 Answers
- 3.12 Self-Assessment Exercises
- 3.13 Further Readings

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### 3.1 INTRODUCTION

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In the previous **units 1 & 2**, we learned what is a project and what is project management. We also learned how do we conduct a feasibility study and what are the merits of conducting a feasibility study and the preparation of the business case. Until this stage, the project is not yet approved or started in most cases. Once the management reviews the feasibility study and business case and approves the project, work can be started. However, these documents are elaborate and contain a lot of information that might be important from a feasibility standpoint but not useful for the project team. Hence, the project team needs a basic document that contains a fair detail of inputs and understanding at the project concept stage which forms the

primary reference to execute the project. This purpose is served by creating a project charter.

At the conceptual stage of the project and before its initiation, there are requirements, conditions, and assumptions that form the boundary of the project. If the project is executed within this boundary then it will deliver the expected results. The project charter is the document that contains this information. Besides, the project manager can also utilize this document within the organization as a formal authorization of the project and as a result of this can legitimately claim the resources and funds from within the organization while executing the project.

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## **3.2 WHAT IS A PROJECT CHARTER?**

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Project Management Body of Knowledge PMBOK® from Project Management Institute defines a project charter as a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. Therefore, a project charter creates a link between the project and the strategic objectives of the organization, the primary reason why the project was conceptualized in the first place. It is also a formal document that is communicated to the supporting functions and departments of the organization such as procurement, finance, and human resources so that they can allocate the cost and resources to the project. In other words, it shows documentary evidence of an organization's commitment to undertaking a particular endeavor to achieve organizational objectives. The creation of the project charter is performed at least once at the start of the project and reviewed in predetermined situations as required.

For projects that are undertaken to produce output for customers as a part of a contract, the project charter establishes a partnership between the performing and requesting organization. These are also referred to as external projects and a formal contract is preferred to establish an agreement. But within the performing organization, a project charter may still be used to ensure the proper delivery of the contract.

An approved project charter served as a formal initiation of a project. It is important to identify and formally assign a project manager preferably as the project charter is taking shape but certainly before the planning is initiated. As a result, the project manager will be aware of the various discussions and deliberations on the project specifics while preparing of charter and will be able to make the right judgments during the project. The project charter can be created by the sponsor or the project manager in collaboration with the customer to have a better understanding of the project goals, purpose, and expected output. The project charter gives the authority to the project manager for planning, execute, and control the project.

A matured project-based organization will have formal identified roles and functions such as sponsor and project or program management office. The

project sponsor should be at a level that is appropriate to secure funding and arrange resources for the project. Projects, irrespective of their nature, internal business, or external influence, are meant to address a particular business case. Hence chartering a project confirms alignment between the strategy and ongoing work. A project charter, being an internal document to the organization, is not regarded as a contract as there is no consideration involved.

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### 3.3 INPUTS TO PROJECT CHARTER

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The project charter documents the need that the project must address and is within the constraints of the organizational environment. External projects, it is also under the influence of the agreements with the customer. These form the inputs to the project charter. Consider the following headers:

- **Business Case** - Is the most utilized document while creating a project charter. The business case contains the necessary information about the expected outcome of the project as well as the investment involved and so contains the justification for undertaking the project from a business standpoint. The document contains the assumptions and considerations within which the project is conceived and therefore provides a boundary within which the project has to be executed to ensure that it remains viable. As explained in an earlier chapter, the business case is created based on a feasibility study of one or more areas viz. market demand, customer needs, technological changes, legal requirements, environmental impacts, social needs, organizational needs, etc.
- **Agreements** – Such as MOUs (Memorandum of Understanding), service level agreements (SLA), and letter of intent (LOI) form the basis of the need of undertaking a project. In the case of an external contract, purchase order or contract is used.
- **Factors External**-To the organization serve as inputs to the project charter. These are government or industry standards, market conditions, regulatory constraints, stakeholders' expectations, etc.
- **Organizational Assets** - Such as internal standards, framework, policies, and procedures. Also, historical information and learned lessons repository of past projects.

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### 3.4 TOOL AND TECHNIQUES TO CREATE A PROJECT CHARTER

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A project charter is prepared at the initiation of the project and therefore very less details are known. Much of the content in the project charter is prepared through calculations and judgments based on available information and the team's capability of articulating the available data into logical assumptions. As a result, a robust project charter has a major bearing on the availability of data and the team's ability.

- **Data Gathering Techniques**

- Brainstorming is used to generate a list of several options in a limited time. It is conducted with a group of people and facilitated by a facilitator. This method not only helps create new ideas but also analyzes these ideas further. It helps in generating data from the experience of the group which can be further used in creating a few ideas and solutions for a thorough review later.
- Interviews are used to get relevant information on assumptions, constraints, risks, gross understanding of the requirements, acceptance criteria, and other such information from any stakeholder through a direct conversation.
- The focus groups technique is used when there are several stakeholders involved, most often from different areas, and a collective understanding is required. It is better than the interview technique as the resulting idea is obtained after reaching a consensus within the team. This is more likely to pass the test of constraints of all domains whose subject matter experts would have participated.

- **Interpersonal and Team Skills**

- Facilitation is the ability to effectively guide a group to converge ideas and reach out to a mutually agreed understanding in the form of a decision or solution. A facilitator is responsible to ensure that there is no bulldozing of ideas by a few, all individuals are heard and are motivated to contribute, the ideas are channelized towards the result, and the final output has a buy-in of all the parties participating in the process. The facilitator is also responsible to record the details of the discussion and generate an action item list with due dates and following up until closure.
- Conflict management is used to deal with situations that may arise during group events to direct the team into meaningful discussion and avoid situations that may end up in distrust, non-cooperation, and lack of participation among the participating members. It is useful to arrive at an alignment on important parameters such as project objectives, success criteria, major milestones, and other specifics of a project charter.

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## 3.5 STAKEHOLDER ANALYSIS

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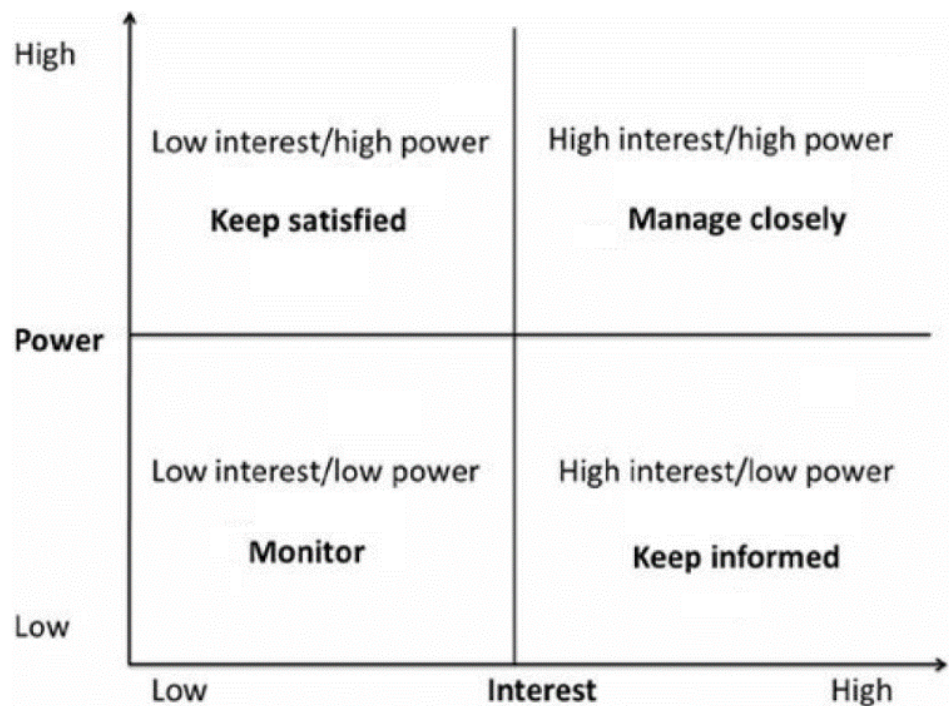
We studied the stakeholder in brief in the previous chapter. In the project chartering stage, it is important to identify the stakeholders. While a detailed list and analysis of stakeholders may not be required, or even feasible, key stakeholders should be identified and should feature in the stakeholder register. A stakeholder register is a term for the document which contains the name of stakeholders in addition to other details relevant to the project. A sample stakeholder register format is shown in the table below.

**Table 3.1: Stakeholder Register**

Name	Position	Internal / External	Project Roles	Organization	Contact
ABC	Project Procurement Manager – XYZ Corporation	External (Customer)	Customer Single point of contact	XYZ Corporation	abc@xyz.com

Once key stakeholders are identified, a thorough understanding of what is the position of these stakeholders vis-à-vis the project is studied. This technique is called stakeholder analysis.

A stakeholder analysis is a technique used for analysing information to determine which stakeholders' interests to focus on and how to increase stakeholder support throughout the project. There are several classification models to perform a stakeholder analysis. One such model is the power/interest grid. With this method, stakeholders can be grouped into categories based on their level of authority (power) and their level of interest in the project. These stakeholders can be plotted on a 2X2 map as shown below:

**Figure 3.2: Stakeholder Analysis - Power/Interest grid**

1. **Low Power, Low Interest** – These stakeholders might not be priority attention but should be monitored closely as they may enhance their level of interest or power.
2. **Low Power, High Interest** – These stakeholders should be kept abreast of the happenings on the project.



3. **High Power, Low Interest** – These stakeholders should be kept satisfied by brief project updates as while they have less interest in the project, owing to high power they can impact critical decisions of the project.
4. **High Power, High interest** – These stakeholders should be managed very closely to the point of developing working relationships and frequent communication. The team should identify ways and means to enhance their positive involvement in the project.

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### 3.6 CONTENTS OF PROJECT CHARTER

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The contents of a project charter will also vary to meet individual project needs. Typical information included in a project charter includes the following:

- **The Project's Name and Date of Approval** – The project name should be as brief as possible. It should contain keywords that will help the organization identify the project with ease. Most often the names of projects are given based on the name of the result or the customer who has given the order.
- **The Name of Project Key Personnel and Contact Details** – These include the name of the project sponsor, project director, project manager, and any other key personnel who are in charge of the project.
- **A High-Level Schedule with Planned Start and Finish Dates** – This may take the form of a milestone level schedule or the phase-gate detail as per the standard of the organization. It provides the project team with a preliminary outline of assumptions of what is expected duration of each phase or milestone envisaged before the start of the project. In other words, it conveys the expectation of the sponsor as to which milestones should complete by what date. The high-level schedule is based on a rough assessment of a similar project conducted earlier or a projection of a key parameter. Hence this high-level schedule also conveys the expected completion of each milestone which will be further associated with the event of cash outflow or inflow. Therefore, during the project, if there is any deviation in these dates, it can not only impact the entire project in terms of overall schedule but also affects the project financials and other commitments in terms of key deliverables getting due on completion of a particular milestone.
- **A Brief of the Project's Estimated Cost and Budget Allocation** – A project charter will contain a schedule of high-level cost headers with a breakup of costs. These headers should be mutually exclusive and collectively exhaustive so that during the project execution, the team should be able to figure out where to account for any particular cost event without any ambiguity.
- **A Brief Description of the Objectives, Business Needs, or Other Justification for Approval of the Project** – This part of the project

charter records what is the primary purpose of conceiving the project. It mentions what is the investment or effort involved in achieving the objectives of the project and how the result is going to benefit the organization in the near term and long term thereby justifying its purpose. This section of the project charter also makes a note of the feasibility of the project across the various dimensions so that during the execution of the project, the team knows what was envisaged at the time of chartering the project.

- **Project Success Criteria, Including Project Approval Requirements and Who Signs off on the Project** – This is one of the most important sections of the project charter. Generally, it is observed that as the project progresses, the project team members and stakeholders develop their perception of what they believe to be a successful project. This understanding might even sometimes be counterintuitive to the success criteria of the project agreed upon in the first place thereby adversely impacting the project. For example, meeting the cost baseline on the project is the most important of all the pre-identified success criteria. However, the project manager during the execution of the project gives a higher priority to 'Customer satisfaction and starts accepting the client's request for additional functionalities without any price escalation thereby seriously jeopardizing the cost baseline. This can cause irreparable harm to the project and therefore the charter should clearly define the project success criteria. Besides, the charter should also establish the level of approvals for key project purchases based on the parameters such as purchase order value, non-budgetary purchases, purchases involving foreign exchange, manpower enhancement, overtime, etc.
- **Summarized Plan for Managing the Project i.e., Brief of the Project Management Plan** – This describes the various project management plans that will be used to execute the project. It should contain what are the needs and expectations of the stakeholders of the project. Also, important assumptions and constraints that were considered in the feasibility study or the initiation stage should be detailed for the project team to have a thorough understanding.
- **A Roles and Responsibilities Matrix** – This matrix will delineate the major roles and responsibilities of each function participating in the project. The intent of this section is not to define responsibilities at a micro level but to provide a general idea on the mapping of the area of influence of each function. This guides the project team to understand which function or individual will be responsible for a particular work because of which unnecessary repetitions are avoided. It also helps different functions to later detail out key elements of interfacing activities for a smooth transition of work among these functions.
- **Signatures of Key Project Stakeholders**
- **The General Comments and Notes Section**-Includes information that could not have been added to the above sections.

- **Most Project Charters Will be Maximum of 2 Pages as These are Meant for an Executive level Review.** However, some project charters might run into several pages and can include team members' signatures also.

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### 3.7 SAMPLE PROJECT CHARTER

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A sample project charter for deployment of the Enterprise Resource Planning (ERP) system is shown here.

Project Title: ERP deployment project (Approved on 1-Oct-2021)

Project Start Date: 1-Jan-2022

Project Finish Date: 31-Dec-2022

Project Sponsor: Ms. Minaxi (minaxi@xyz.com)

Project Manager: Mr. Utkarsh (utkarsh@xyz.com)

High-Level Schedule:

Following are the key milestones of the project:

- Issue of Purchase and maintenance contract to the ERP software provider – 30-Mar-22
- Mapping of Accounting and Purchase sessions – 30-Apr-22
- Mapping of Production and Costing sessions – 30-May-22
- Test case simulation – Round 1 – 15-Jul-22
- Functional changes and deployment – 15-Aug-22
- Test case simulation – Round 2 – 15-Sep-22
- System ready for simultaneous data capturing in Old and New ERP – 30-Sep-22
- Functional verification on actual data – 15-Nov-22
- Rectification of system issues – 1-Dec-22
- System Go Live – 25-Dec-22

**Budget Information:** A total budget of INR 10 Cr is allocated for the project. Approximately half of these costs will be for software providers while the other half will be for outsourced labor and training programs.

**Project Objectives:** Deploy new ERP software that enhances the efficiency of operations in production, project management, and purchase department by reducing non-value adding activities. The new ERP software shall maintain the operational efficiency levels of all other functions using the tool. All the Management Information System (MIS) reports, as listed in the annexure, shall be available over a live dashboard having real-time synchronized information on the key drivers of the business.

**Success Criteria:** The project will be successful if it is completed as per schedule so that the new system is deployed on a full scale before the start of

the next financial year. The new system should meet all financial reporting and audit compliance requirements as per the audit procedure. The stakeholders of the new system will fill out a questionnaire on the effectiveness of this system. The new system shall demonstrate an improvement from present 4 to 7 (out of 10) on the overall rating.

Project approach :

- The project will be executed in 4 stages where the first one is implementation and the subsequent ones are testing and rectification.
- Over the last quarter of 2022, all the personnel utilizing the legacy system will have to maintain information in both the systems for smooth transitioning and loss of data. The software provider and version which has to be deployed are already finalized and therefore no effort in that direction is required.
- Communication between the team members and inter-function interfacing are key to the success of the project. Hence a cross-function team should be prepared. Each team lead will nominate 1 person for the role. The team point of contact will be responsible for coordination with team leads, developing procedures, and imparting training to the team members.

#### **Roles & Responsibilities:**

<b>Name</b>	<b>Role</b>	<b>Designation</b>	<b>Signature</b>
Vishal C.	Project Champion	Head – IT	
Savan B.	Project Sponsor	Head - Finance	
Mayur M.	Project Manager	Project Manager	
Bipin P.	Steering Committee member	Manager - Purchase	
Gopal P.	Team Member	Manager - IT	
Vivek S.	Team Member	Manager - Production	

#### **Comments:**

“A significant amount of time my team members are spending in creating manual reports for the management and attending status review meetings which should be otherwise be spent for purchase functions like negotiations and meetings with vendors” - Bipin

“Every time we get the raw material issued for the production; we get them incomplete. We cannot say precisely when this raw material will get transformed into finished goods as some of the other assembly is waiting for components which should have been received by now as per the latest forecast report which is 10 days old. We struggle to meet throughput and we know we can do better”. Vivek

**Check Your Progress 1:**

You are the project manager of a project which is already in execution and are required to review the project charter often. What, according to you, best describes when a project charter when the project work is being undertaken?

- a. So that project team member appraisals are done properly and there is a fair distribution of bonuses at the end of the year.

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- b. To help conclude if a project scope change should be approved

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- c. To assess whether the project plan can manage the changes requested by the customer

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- d. To make sure all project documentation is done as per the request.

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**Check Your Progress 2:**

Time and again the stakeholders are asking for new changes to the project charter. Who do you think is the right person to decide if these changes are to be undertaken or not?

- a. Project sponsor

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- b. Project manager

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- c. The team working on the project

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- d. The stakeholders of the project

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### **3.8 PROCESSES UTILIZATION PROJECT CHARTER AS INPUT**

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The project charter is one of the key documents of the project. It contains vital information that not only sets the course for the further processes on the project, it also is used as a reference to set project boundaries and validate whether a particular task should be undertaken or not. Several processes use project charter as input. These are described in brief here:

1. Create Project management Plans process utilizes a project charter as input for the planning of each knowledge area. We will describe this in detail in a subsequent section.
2. Collection of requirements is the process of determining, documenting, and managing stakeholder needs and requirements to meet objectives. This process provides the basis for defining project and product scope. It is important to identify and document all requirements and not just those related to the project or product as a missed requirement can be critical for the project.
3. Defining the project scope process utilizes a project charter document to elaborate the scope and identify tasks and activities which need to be performed to deliver the intended scope of work. This process is concerned with what and what does not needs to be done on the project. A well-laid-out project charter will facilitate the team to define the scope of work accurately and make realistic plans which will eventually lead to successful execution and output.
4. Identifying stakeholders in the process of identifying project stakeholders at regular intervals. It is related to the analysis and documentation of useful information regarding their interest, participation, interdependencies, level of influence, and potential impact on the success of the project. The project charter is the first input for the creation of a stakeholder register, the output of identifying the stakeholder process. The project charter not only lists the major stakeholders involved in the project it also contains vital information which can help identify relevant stakeholders well ahead at the start of the project.

5. Plan stakeholder engagement is the process of devising useful strategies to involve project stakeholders in line with their needs, expectations, interest, and potential impact on the project. It results in an actionable plan which can guide the project team to interact effectively with the stakeholders. The project charter contains information on the objectives of the project, purpose, and success criteria that can serve as first-hand input for the project team to create plans for engaging project stakeholders.
6. A close Project or phase is the process of finalizing all activities in a particular phase or project. It also ensures that the activities and actions necessary to satisfy completion requirements for the project are finished. This phase is also related to the completion of contractual agreements applicable to the project or phase. The project charter documents contain details such as project success criteria, approval requirements, and authorization matrix which serve as inputs to the close project process.

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### 3.9 CREATING PROJECT MANAGEMENT PLAN

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The Project Management plan integrates all individual management plans, for each knowledge area, into a comprehensive centralized document containing details of what is involved in the project. It also includes the finalized baselines for the project. This document is a repository of several sub-plans showing how the project will be executed, monitored and controlled, and closed. It integrates subsidiary management plans, baselines, and other information into a cohesive whole which is required to manage the project. The project requirements will determine which subsidiary management plan is required and with what rigor. The project management plans will deal with 'How' and not 'What' over each of these knowledge areas. The project manager is responsible to create the project management plan. However, a project manager may not necessarily be an expert on all the technical and functional areas involved in the project. Hence the project manager needs to be supported by the team members in creating the project management plan. The project team shall support the project manager with necessary details, technical inputs, and solutions so that the project manager can make a judicious decision about the project work.

A brief introduction to these plans is given here. To maintain the exact understanding, the content is taken from the Project Management Body of Knowledge® (PMBOK®) by the Project Management Institute.

#### [A] Subsidiary management plans

- **Scope Management Plan** – It establishes how to define, develop, monitor, control, and validate the scope of work for the project and result.
- **Requirements Management Plan** – It establishes how to analyze,

document, and manage the project and product requirements

- **Schedule Management Plan** – It establishes the criteria and activities for developing, monitoring, and controlling the project schedule
- **Cost Management Plan** – It establishes the means to plan, structure, and control the project cost.
- **Quality Management Plan** – Establishes how the project will inculcate the quality procedures, standards, and methodologies of the organization undertaking the project.
- **Resource Management Plan** – Guides how project resources should be categorized, allocated, managed, and released.
- **Communication Management Plan** – Establishes who, how, and when will the project information be administered and disseminated.
- **Risk Management Plan** – Established how to structure and perform risk management activities.
- **Procurement Management Plan** – Established how to acquire goods and services from outside the organization undertaking the project.
- **Stakeholder Management Plan** – Establishes how to engage stakeholders in the process of making project decisions and execution in line with their needs, interest, and impact.

#### **[B] Baselines**

- Scope baseline is an approved version of the scope statement, work breakdown structure along with its associated dictionary. It is used as a basis to compare the completed scope.
- A schedule baseline is an approved version of the project schedule containing the list of tasks and activities, duration, start and finish dates, and interdependencies within the task.
- A cost baseline is an approved version of a time-phased project budget that is used as a basis for comparing the actual results.

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### **3.10 LET US SUM UP!**

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Once project feasibility is studied, project work starts. The team is identified, and it is the responsibility of the management to robustly convey precise requirements to the project team who is assigned the task of undertaking the project work. While the senior management has a few mandatory expectations, the project team needs to be given some flexibility to work with the project requirements to avoid unnecessary complexities in the project. Most projects will run into months, if not years, and so the senior staff which conceived the project might not be able to remember exactly what the project needs to deliver. In this condition, a thorough and well-laid out Project Charter will serve the purpose of maintaining the records of the senior management expectation right from the start of the project. Further, it will



also help the project team to resolve any trade-offs arising during the project as they can refer to the project charter before reaching out to the project sponsor or senior staff for clarifications. The project management plans also help the project team to stay on course with the project requirements and pre-determined and agreed plans. Once the project contains these plans the project chartering is completed and the project is ready for execution.

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## 3.11 ANSWERS

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### Check Your Progress 1

You are the project manager of a project which is already in execution and are required to review the project charter often. What, according to you, best describes when a project charter when the project work is being undertaken?

- a. So that project team member appraisals are done properly and there is a fair distribution of bonuses at the end of the year.
- b. To help conclude if a project scope change should be approved
- c. To assess whether the project plan can manage the changes requested by the customer
- d. To make sure all project documentation is done as per the request

**Correct Answer:** (b) – The project charter contains relevant information on what needs to be achieved on the project. Hence the project charter should help conclude whether a change in scope should be approved or otherwise. The project charter does not help in making appraisal decisions or the capability of project plans. It also does not contain information on what project documentation is required to be maintained, as that is part of another knowledge area.

### Check Your Progress 2

Time and again the stakeholders are asking for new changes to the project charter. Who do you think is the right person to decide if these changes are to be undertaken or not?

- a. Project sponsor
- b. Project manager
- c. The team working on the project
- d. The stakeholders of the project

**Correct Answer:** (a). The project sponsor authorizes the project and approves the funding. Any work will have its associated commercial implications in terms of time and cost. Hence any change requested by a team member or stakeholder needs to be approved by the project sponsor. Further, the project sponsor will also validate if this change meets the initial business case and seeks top management intervention wherever required.

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### 3.12 SELF-ASSESSMENT EXERCISE

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1. Think of a project that you are/were a part of or else a hypothetical project of inviting 50 friends for a get-together and dinner party. Can you create a project charter for it?
2. Refer to the sample project charter given in section 3.7. Answer the following questions
  - a. Which project knowledge area is likely to demand the most amount of effort?
  - b. Can you identify the major assumptions given in the project charter?
  - c. List out the details that will serve as inputs to the processes: (i) collect requirements (ii) define project scope (iii) identify stakeholders
3. It is important to have a realistic project management plan so that the project is managed properly. Which of the following means best describes how a project management plan is created.
  - a. The sponsor and project manager together decide the project management plan so that the team can follow it.
  - b. Department heads join together in creating a project management plan so that all functional matters are taken care of in the plan
  - c. The project manager creates a project management plan based on inputs from the team
  - d. The sponsor creates a project management plan based on inputs from senior management

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### 3.13 FURTHER READINGS

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# **BLOCK 2**

## **PROJECT PLANNING**

- Unit 4     Project Scope Management
- Unit 5     Project Network Analysis (PERT and CPM)
- Unit 6     Project Scheduling
- Unit 7     Project Crashing
- Unit 8     Earned Value Analysis (EVA)



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## UNIT 4 PROJECT SCOPE MANAGEMENT

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### Objectives

After studying this unit, you will be able to:

- Define project scope
- Establishing project priorities
- What are the deliverables
- Work breakdown structure (WBS)
- Time estimation
- Resource estimation
- Responsibility Matrix (RM)

### Structure

- 4.1 Introduction
- 4.2 Defining Project Scope
  - 4.2.1 Example of a Project Scope Statement
  - 4.2.2 Priorities of a Project
- 4.3 Work Breakdown Structure (WBS)
  - 4.3.1 Hierarchical Composition of WBS
  - 4.3.2 Work Breakdown Structure of Motorcycle (Sample)
  - 4.3.3 Advantages of WBS
  - 4.3.4 Work Packages
  - 4.3.5 Responsibility Matrix (RM)
- 4.4 Let Us Sum Up
- 4.5 Self-Assessment Exercise
- 4.6 Further Readings

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## 4.1 INTRODUCTION

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A project is a unique activity in the sense that you can't compare one project with another as there is a change in time, cost and scope. Project managers are the custodians / in-charge of a single small project and are responsible for planning and scheduling the project. The scope is defined by the cost, time, and quality of the deliverable in project terms.

Project scope management (PSM) is a part of the project planning exercise; one needs to clearly draw a boundary with respect to all the aspects of the project, including all connected activities, resources requirement, timelines, and deliverables (with all the expected parameters which defines the final product/service quality). PSM is the guide for executing the project to its end, so defining the scope of the project is very much essential for successfully completing the project.

**PSM** also summarizes the key stakeholders, procedures, activities, hypotheses, and limitations, along with dos and don'ts too. Without a clear project scope statement, your project will end up beyond your team's ability to complete it due to delays (time overrun) and cost overrun.

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## 4.2 DEFINING PROJECT SCOPE

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For any project, one needs to define the objectives, needs and limitations. The project scope is a function of project objectives/goals, needs, limitations, deliverables, resources, and budget. The project manager needs to clearly document the project objectives, resource plan (if you have one) / planning resource, stating the budget requirement, time schedule (for completing the project), constraints and deliverables at the end. Make sure that all the project stakeholders have clearly understood the project boundaries.

**The Key Steps for Defining any Project's Scope are as Follows.**

- Clearly defining the objectives.
- Create a sound resource plan.
- Budget requirement (maybe stage-wise/phase-wise).
- Project time durations (for completion of the total project along with the time taken to complete each stage of the project).
- Identify and clearly state the project deliverables.
- Define the key milestones/stages of the project.
- Constraints, if any.
- Drafting the scope documents and getting them approved by all the stakeholders.

A project scope document is a powerful tool for the successful completion of the project, provided the plan has been communicated properly to all the stakeholders.

Sometimes due to changing requirements, specifications, and priorities, the project scope gets expanded over time is called *scope creep*.

### 4.2.1 Example of a Project Scope Statement

**Project:** Creating a website for the new venture which you're planning for. Following is the way the project scope might look like.

**Key Project Objectives:** To create a user-friendly and attractive website for the new venture with easy to browse smoothly.

**Resources:** Web designer team (two people), 30 hours of work a week for 3 weeks. Software manager (one person), 10 hours of work a week for 2 weeks and IT & Legal review as for the statutory compliances (two teams), 4 hours of ad-hoc work for 1 week.

**Budget:** Rs. 200,000/- (you may also give the break-up for each activity).

**Deliverables:** User-friendly, attractive website.

**Time Schedule:** Timelines/milestones of the project are as follows.

- Project initiation and identifying the stakeholders – 2 weeks.
- Work breakdown structure, resource estimation and budget estimation – 1 week
- Drafting the project scope – 1 week
- Project allocation – 1 week
- Designing the webpage – 4 weeks
- Final launch of the website – 5<sup>th</sup> week.

### **Check Your Progress**

#### **Exercise 1:**

You have been asked to lead an event for a marriage. The event is to organize an orchestra–dance concert on the marriage eve. You have reserved a hall that will accommodate 200 couples and have hired the orchestra troop. Develop a scope statement for this project that contains all the elements (project objectives, deliverables, milestones, schedule, technical requirements, resources, budget, limits & exclusions, and audiences). Assume that the event will occur in 3 weeks from now and provide your best guess estimate of the dates for milestones.

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### **4.2.2 Priorities of a Project**

The project objectives answer what, when and how much. It also defines the priorities of a project which include Time, Scope, and Cost. One will have three scenarios on which these priorities are viewed. These priorities will have constraints where no other option will be available because as the requirement is fixed with a parameter, accepting whatever is available and last, there is a chance for enhancement / optimizing over others. The reasons for project trade-off are due to the relative importance of criterion-related cost, time, and scope. For example, if the date is fixed, then the project is time -constrain, scope-accept and cost-enhance, meaning the project must be completed on a specific date, the scope re-worked to meet the objective of time and cost, and look for possibilities to reduce the cost. For the given priorities, one can have the following three scenarios.

**For the priority scenario– I: Time-constrain, Scope-accept, Cost-enhance**

**Examples:** 1. Corona Vaccine 2. Energy efficient engine

**For the priority scenario–II: Time-constrain, Scope-enhance, Cost-accept**

**Examples:** 1. Wedding Party in India 2. Birthday Celebration

**For the priority scenario– III: Time-accept, Scope-constrain, Cost-accept**

**Examples:** 1. Construction of a living colony on the moon

2. Hyperloop transport system

### **Check Your Progress**

#### **Exercise 2:**

Identify at least two real-life examples of a project that would fit in each of the priority scenarios (I, II & III) described above.

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## **4.3 WORK BREAKDOWN STRUCTURE (WBS)**

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Work breakdown structure (WBS) is a project management tool which establishes a step-by-step approach for completing any kind of project, which ranges from very small to complex one. WBS will help in planning various deliverables with timelines.

WBS is used to estimate the time, cost and scope which are required for a project. This is a top-down approach for making the work packages to an extent of the smallest assignment where there is a very slim scope for subjectivity. WBS is breaking down the project into possible levels where there is much scope for objectivity to estimate the appropriate requirement of time, cost and scope. The WBS levels depend on the size and complexity of the project. Smaller projects will have a maximum of two levels, and a complex project like the Mangalyaan mission may have multiple levels.

### **4.3.1 Hierarchical Composition of WBS**

**Level I** : Project (Complete Project)

**Level II** : Major Deliverables (main major parts ranging from minimum 2 to 10)

**Level III** : Sub-deliverables

**Level IV** : Sub-deliverables (Next lower level)

**Level V** : Cost / Resource Account (Summing of work packages for monitoring progress and responsibility)

**Level VI** : Work packages / Assignments (Identifying time, cost and scope)



### 4.3.2 Work Breakdown Structure of Motorcycle (Sample)

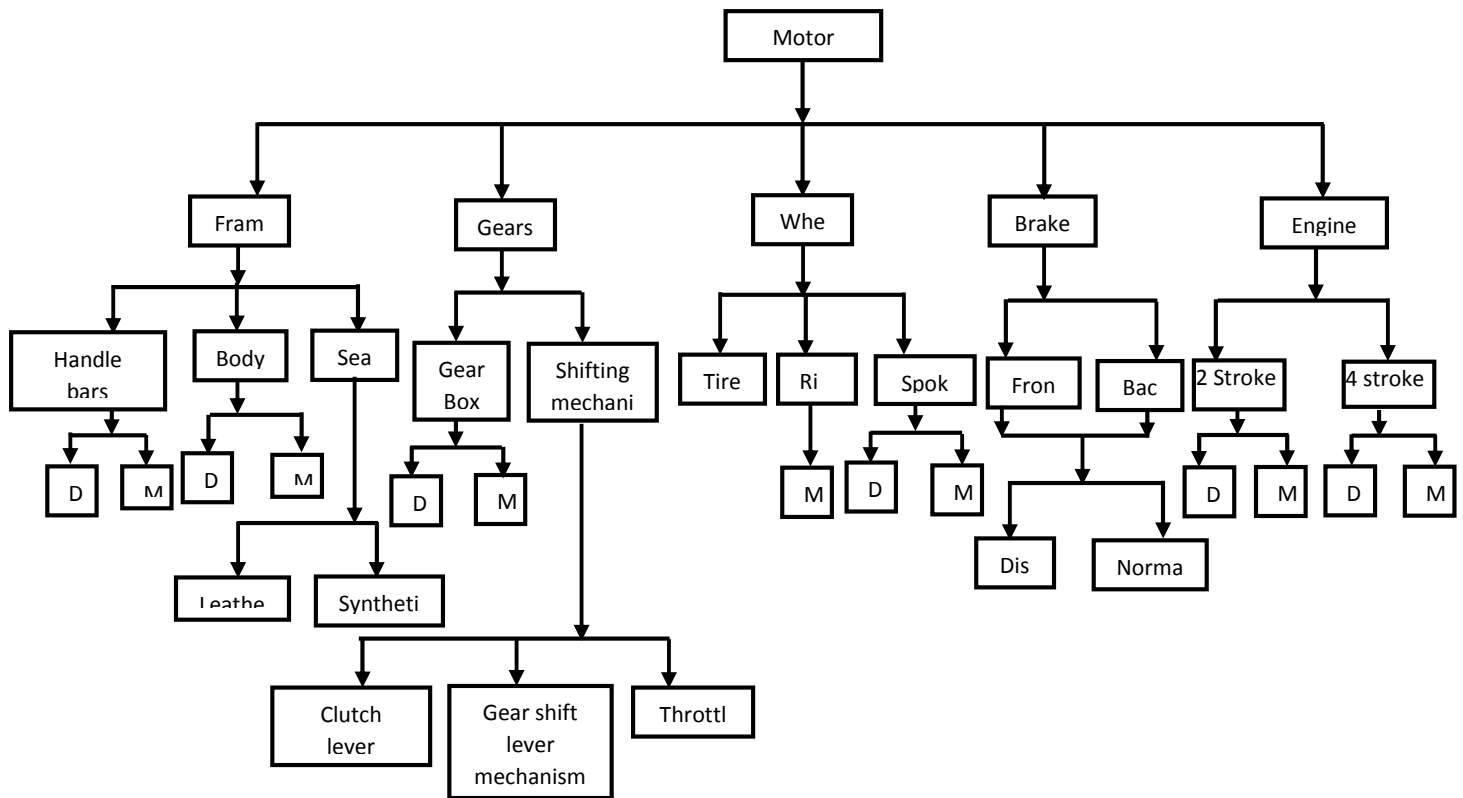


Figure 4.1

Source-D: Design, M: Material

### Check Your Progress

**Exercise 3:** Develop a WBS for Solar Car

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**Exercise 4:** Develop a WBS for Mobile Phone

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**Exercise 5:** Develop a WBS for Corona Vaccine Project

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### 4.3.3 Advantages of WBS.

- WBS is a widely used project management tool for decision-making.
- It allows evaluation of the cost, time and technical performance of a project along with the organization which is executing the project.

- It helps in project planning, time scheduling and budget estimation.
- It describes communication channels and helps in coordinating various project components and stakeholders.
- It enables management with the required information to various departments and functions in the organization.
- It assists in the development of an organization breakdown structure which helps in assigning project responsibilities to various departments, centres, units and individuals.

#### 4.3.4 Work Packages

The work package is the lowest/bottom level of the work breakdown structure, which gives quantifiable/subjective parameters.

- At the work package level, one can easily estimate how much work is there / how much work needs to be done.
- What are the resources required for completing the work can be easily assessed.
- Easy to estimate the time taken to complete the work.
- It identifies the number of manpower required to complete the work package.
- It determines milestones in the work package completion.

#### Check Your Progress

**Exercise 6:** Below is a software development project WBS with cost apportioned by percent. If the total project cost is estimated to be Rs. 1,000,000, what are the estimated costs for the following deliverables?

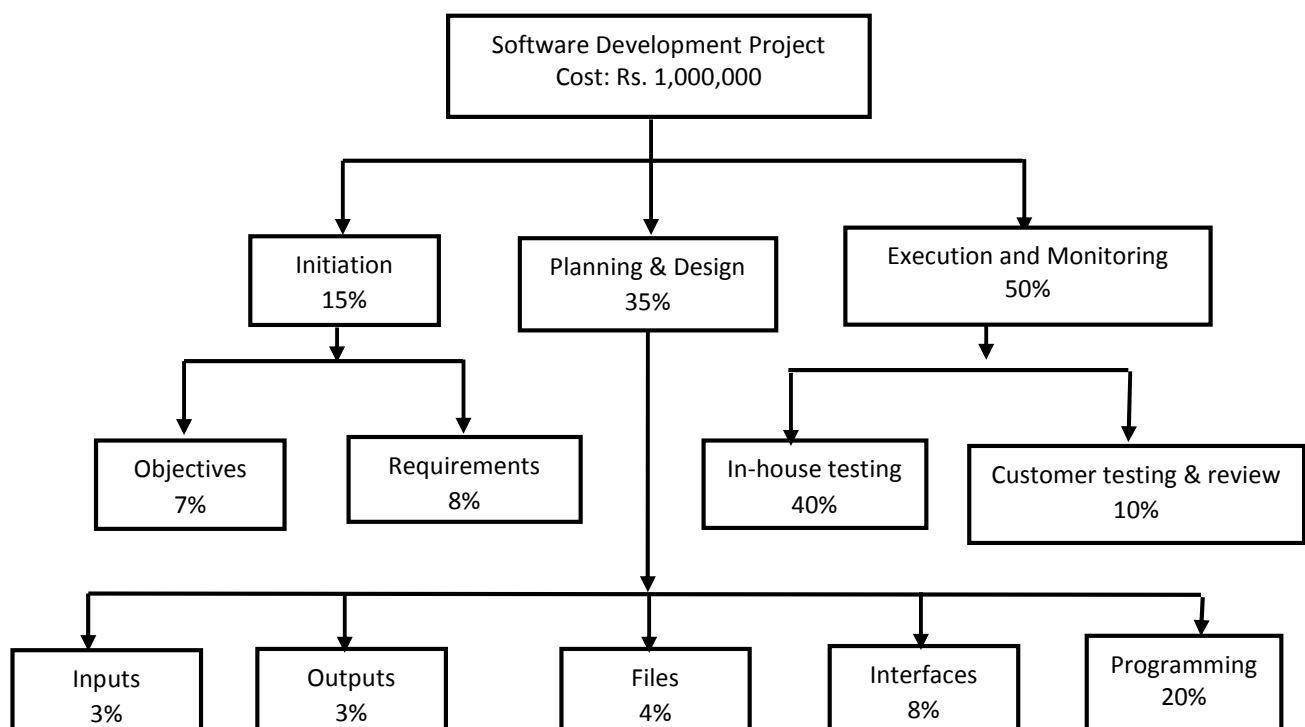


Figure 4.2

4.3.5 Responsibility Matrix (RM)

It is a simple matrix used by the project manager in assigning roles and responsibilities for individuals to complete the tasks/deliverables assigned to them.

RM is also called as linear responsibility chart, which clearly identifies the list of tasks to be accomplished and the responsibility of individuals w.r.to a particular task completion in the project.

**Example:** You are one of the four members (father, mother, son – 15 years and daughter, 13 – years) planning a weekend tour to a hill station. Develop a responsibility matrix for the work that needs to be done before starting your family trip to a hill station. The partial responsibility matrix is shown in table 4.1.

Table 4.1 The partial responsibility matrix

Task	Date	Father	Mother	Son	Daughter
Research sites		S	R	S	S
Decide on site		S	R	S	S
Reserve site		R	-	-	-
Shopping list		S	R	S	R
Packing for the trip		R	R	R	R
Travel arrangements		R	-	-	-
Boarding arrangements		R	S	-	-
Fill car with gas		R	-	-	-
Get cash		S	R	-	-

R: Responsible, S: Supervision

Check Your Progress

**Exercise 7:** Develop a Responsibility Matrix for your son’s marriage (in the family, you, your wife/husband, son – 25 years and daughter – 22 years).

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## 4.4 LET US SUM UP

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Prior to the commencement of any project, it is necessary to define the scope, priorities and breakdown structure. While defining the scope of the project, the project managers primarily focus on the end product/items of the project. It is essential to develop a priority list for every project to take meaningful decisions. In project management, the structure provides two views of the project—one on deliverables and one on organizational responsibility—helping to ensure that all of the project's duties are defined. The WBS prevents the project from being controlled by an organizational function or a financial system. The organizational design demands consideration of reasonable staffing, equipment, and financial needs.

Without a systematic, disciplined approach, it is impossible to design a project plan or control system that works properly. This discipline is offered by the cost account codes, WBS, and OBS. The project network, which sets the schedule of work, personnel, equipment, and costs, will be developed using the WBS as the database. Responsibilities matrices can be used in small projects to define individual responsibility.

Planning begins with defining your project precisely, which is the first and most significant stage. Project failures are most frequently attributed to a lack of a well-defined project plan. Using a WBS or a responsibility matrix will mostly depend on the scope and scale of your project.

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## 4.5 SELF-ASSESSMENT EXERCISE

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1. What are the elements of a project scope statement? Discuss.
2. What do you mean by project objective? What kind of questions does a project objective answer? Write an example of a good project objective.
3. What are the project priorities? What are the most relevant priorities of a project? Discuss some of the priorities, including *Time-constrain*, *Scope acceptance*, and *Cost-enhance*.
4. What is a work package? Discuss what kinds of information are included in a work package.
5. What do you mean by responsibility matrix? When do you use the responsibility matrix? Discuss with suitable examples.

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## 4.6 FURTHER READINGS

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## **UNIT 5 PROJECT NETWORK ANALYSIS (PERT & CPM)**

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### **Objectives**

After completion of this unit you should be able to:

- Develop a network diagram of projects
- Differentiate between various levels of networks
- Carry out time-analysis of networks
- Use time-analysis results for time management of projects
- Use probabilistic estimates of project activity durations to compute probability of completion in projects with high degree of uncertainty
- Develop time-scaled networks of projects A Schedule projects through an iterative process

### **Structure**

- 5.1 Introduction
- 5.2 Network Diagramming of Projects (AOA) Diagrams
- 5.3 Time-Analysis of Networks
- 5.4 Probabilistic Durations
- 5.5 Other Types of Diagrams
- 5.6 Project Scheduling
- 5.7 Let Us Sum Up!
- 5.8 Self-Assessment Exercises
- 5.9 Bibliography and Further Readings

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### **5.1 INTRODUCTION**

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Time is of great essence in all projects and one of the most important objectives of all project managers is to ensure completion of a project in time. In this unit we shall discuss the various tools and techniques as well as the concepts which are vital in effective planning, scheduling and control of projects.

As projects are unique, one-time endeavours, the normal planning and control tools are not very effective in the planning and scheduling of projects. Network diagrams provide a framework which can be used to develop project schedules and also for updating and control of projects. We begin our discussion by developing the concepts required to draw project networks and go on to use the same for scheduling of projects.

## 5.2 NETWORK DIAGRAMMING OF PROJECTS (AOA) DIAGRAMS

Network diagrams provide a mechanism to depict the interdependencies of various activities that constitute a project. We will first describe AOA (Activities on Arrows) diagrams which are the simplest and later, in section 6.5, we shall introduce some other types of diagrams.

### 5.2.1 Concept of Activity and Event

For effective monitoring and control, it is necessary to break-up a project into smaller activities. The basic idea is that if individual project activities are completed in time, the project itself should also be completed in time.

#### *Activity*

An activity is a homogenous element of work consuming some resources and requiring some definite amount of time for its completion. An activity is the smallest unit of productive effort to be planned, scheduled and controlled in a project and is represented by an arrow in a network diagram. The arrows are usually labelled by the activity codes and the estimated duration of the activity.

#### *Event*

The starting of an activity or the ending of an activity is called an event.

Activities are completed over a period of time (for example 2 weeks) while events take place at an instant of time. In AOA networks events are represented by small circles. Thus each activity has a head event as well as a tail event. For example, activity A in Figure 5.1 below has event 7 as the head event and event 6 as the tail event:

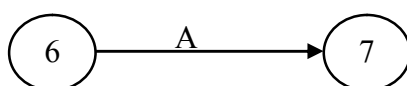


Figure 5.1: Head event (7) and tail event (6) of activity A

#### *Completion of a Project*

A project is completed only when all its activities have been completed. However, as many activities may be going on simultaneously, it is difficult to compute the project completion time even if the estimated duration of each activity is known. Except in a very rare case, the project activities are not all sequential in nature. Thus it becomes important for us to identify which activity may be going on simultaneously, and which others have to be done one after the other. The different types of events described in the next sub-section helps in this regard.

### 5.2.2 Simple, Merge and Burst Events

To get a clear understanding regarding the nature of activity interdependencies, it is important to understand different types of events.

**Simple Event**

A simple event is one which has only one preceding activity and only one succeeding activity. Thus in Figure 5.2 below, event 2 is a simple event and activity B can begin only after activity A has been completed.

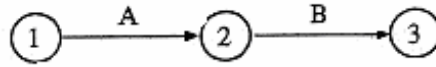


Figure 5.2: Event 2 is a simple event

**Merge Event**

A merge event is one which has more than one preceding activities and only one succeeding activity. For example, in Figure 5.3 below, event 4 is a merge event with C as the succeeding activity and A and B as two preceding activities. This shows that activity C can begin only after both the activities A and B have been completed.

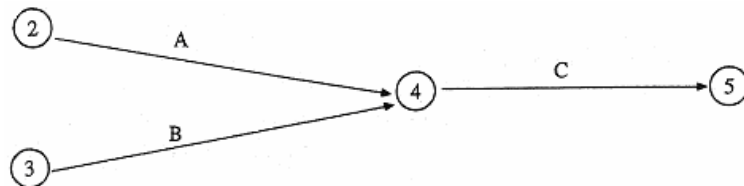


Figure 5.3: Event 4 is a merge event

**Burst Event**

A burst event is one which has only one preceding activity and more than one succeeding activities. For example in Figure 5.4 below, activities B and C are the succeeding activities for the burst event 4, whereas A is the only preceding activity. This shows that activity B and activity C both of them can start only after activity A has been completed.

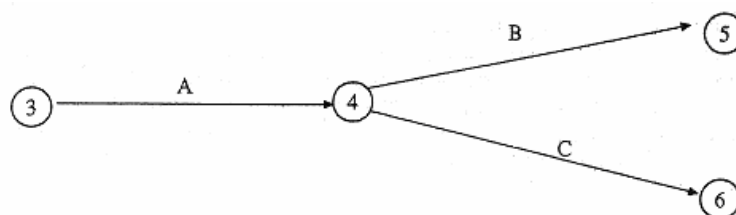
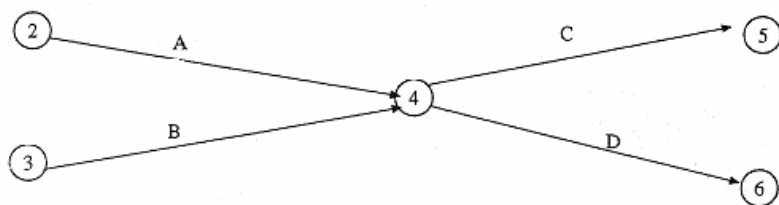


Figure 5.4: Event 4 is a burst event

**Combined merge and burst event**

An event having more than one preceding activities as well as more than one succeeding activities is a combined merge and burst event. For example, in Figure 5.5 below, event 4 is a combined burst and merge event, having C and D as succeeding activities and A and B as preceding activities. This shows that activities C and D can begin only after both activities A and B have been completed.

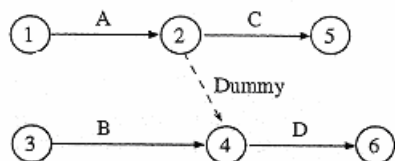




**Figure 5.5: Event 4 is a combined merge and burst event**

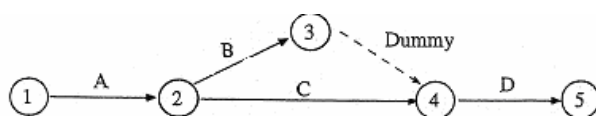
There are certain situations where the interdependency cannot be shown clearly using the above conventions. As an example, suppose activity D can start only after both A and B have been completed, whereas activity C can start only after the completion of

A. This relationship cannot be shown using the simple conventions developed above. To show the activity interdependency explicitly, we need to introduce dummy activities in our networks. A dummy activity is one which does not consume any resource and does not require any amount of time for its completion. Dummy activities are required only for the purpose of explicitly depicting certain activity interdependencies which cannot be shown otherwise. Dummy activities are represented by dotted arrows in network diagrams. After a dummy activity has once been introduced in a network, it is treated exactly like any other activity for any further analysis. Figure 5.6 below uses a dummy activity connecting events 2 and 4 to resolve the difficulty in showing the activity interdependencies encountered above.



**Figure 5.6: Dummy activity is needed for explicitly representation of interdependencies of activities C and D**

If two or more activities have common tail and head events, then again dummy activities may be needed to diagram the network elegantly – e.g. in Figure 5.7 below, activities B and C have the same dependency relationships and a dummy activity has been used to have an elegant representation of the same.



**Figure 5.7: Need for dummy activity when activities B and C both have common predecessors and successors**

### Conventions while drawing network diagrams

A network diagram is a set of activities and events represented by arrows and circles, respectively. The length of an arrow does not represent anything, nor does its direction. Events are numbered as 1, 2, 3, etc., while activities are

labelled using activity codes as A;-B, C, etc. By convention, the head event number for any activity is always larger than the corresponding tail event number. The orientation of the arrows is usually kept from left to right, signifying the flow of time from left to right in a general way. Criss-crossing of arrows are avoided as much as possible. It is a good practice to represent both the start of the project and its completion as single events. Similarly, one should use as few dummy activities as possible.

### **Information Required for Drawing of Networks**

The basic information required for drawing of networks has two components, viz. a list of individual activities, and activity interdependencies. In order to be able to carry out time analysis, time estimates for individual activities are also typically collected at this stage.

#### ***Project Activities***

A project has to be broken up into its constituent activities for detailed planning and scheduling. Each activity is homogeneous, requires specific amount of resources and is the responsibility of a specific individual. Work breakdown structure is usually employed to break a large project into its constituent activities,

#### ***Activity Interdependencies***

The immediate predecessors of each activity are typically listed. When this listing is completed for all project activities, the relationship between any pair of activities can be known. If activity A is an immediate predecessors for activity B, this implies that activity B can begin only after activity A has been completed. The beginning activities do not have any predecessors, whereas the finishing activities are not the predecessors of any project activity. The precedence relationships are decided based on technological constraints (e.g. roof can be cast only after the walls have been built), management policy constraints and legal constraints. Precedence relationships are sometimes used where the activities use a common critically scarce resources-e.g. equipment or money. However, this is not a good practice and it is better to look at resource constraints separately and explicitly.

#### ***Time Estimates***

The time required for completion, of each of these activities can be estimated by a person or a group of persons who are familiar with the activity and its details. These estimates can vary in terms of their reliability, depending on the nature of the activity as well as the relevance of prior experience in execution of the activity. While estimating the activity duration, an implicit assumption about some "normal" amount of resources is also made. It is possible to complete some activities quicker by employing a greater amount of resources and *vice-versa*. Similarly, the estimated duration of some activities (e.g. leveling a road) may be expressed in working time (e.g. 5 working days) while some other activities (e.g. curing of concrete) may be expressed in elapsed time (e.g. 15 days).

## Levels of Networks

Large projects consume a huge amount of resources and have to be planned, monitored and controlled at various levels. The top management may not be interested in the details, but would still be interested in knowing if the project is proceeding according to the schedule or not. On the other hand, the supervisor responsible for one activity is interested in all the details for that activity. This is achieved by drawing different levels of project network incorporating different levels of details. At the highest (say L1) level, the project may have 20 to 30 different major activities and it may be reviewed once every quarter at the top management level. At the lowest (say L3) level, the project may have 200 to 300 detailed activities - each activity may be the responsibilities of a specific supervisor. For the senior management, an intermediate level of detail (L2 say having 60 to 90 activities) may be adequate and this may be reviewed once every month for taking corrective actions. An activity in an L1 level network is actually a sub-project in an L2 level network and so on.

## An Example

Let us consider a comprehensive example to highlight the concepts discussed in this unit so far. A company manufacturing and selling consumer products has recently developed a new brand of soap and has prepared a project for launching the new brand. An activity analysis is first carried out to break up the project into homogeneous activities. From a careful analysis of the activities, the immediate predecessors for each activity is also determined. Finally, the duration of each activity is estimated based on previous experience of similar in the past. This information is presented as Table 6.1 below.

**Table 5.1 Details of Activities for New Product Launch Project**

Activity Code	Activity Description	Immediate Predecessor Activity	Estimated Duration (Weeks)
A	Finalise package design	—	2
B	Set up packaging equipment and procure raw materials	A	8
C	Produce the first batch	—	12
D	Package the first batch	B, C	4
E	Set up the sales office	—	4
F	Recruit salesmen	E	4
G	Train salesmen	F	6
H	Select retailers	E	8
I	Sell to retailers	G, H	3
J	Despatch to retailers	D, J	5
K	Select advertising agency	E	4
L	Plan advertisement campaign	K	9
M	Release pre-launch advertisements	L	1
N	Conduct advertisement campaign	J, M	4

From the information contained in Table 5.1, we can easily see that activities A, C and E do not have any predecessors and so all of them are starting activities. Activity B is the only one with activity A as its predecessor and so it is a simple event connecting activities A and B. Activity D has two predecessors - B and C and so it is a merge event connecting activities B and C to activity D. Again, activities F, H and K all have activity E as their predecessor and so the completion of activity E and the starting of activities F, H and K is a burst event. Working step by step in this manner, we build up the project network for this project. In this case it is possible to develop the project network without using any dummy activity as shown in Figure 5.8.

## 5.3 TIME ANALYSIS OF NETWORKS

One of the key questions a project manager has to ask herself is "In how much time can I complete the project?" Time analysis helps us to answer such questions. Once the project network and the activity durations are known, time analysis is a relatively straight-forward exercise. In fact, at the end of time analysis we have much more insight into the project and its activities than merely the answer to the question asked earlier regarding the project completion. In this section, we shall describe the steps involved in performing a forward pass and, a backward pass -- which together comprise time analysis. We shall again take the new product launch project as an example for this purpose.

### 5.3.1 Forward Pass

Each project has a zero date- the date when the project clock starts ticking. All references to time for any activity or event are made relative to the zero date of the project. As suggested by

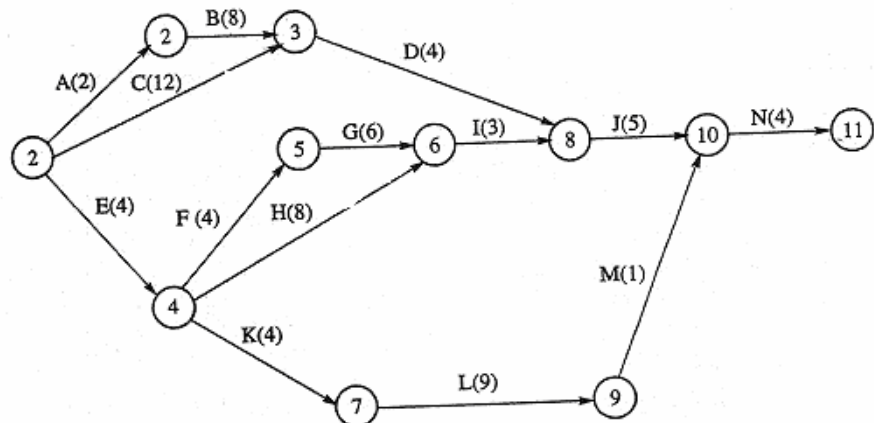


Figure 5.8 Network diagram for the New Product Launch Projects

Its name itself, in forward pass we begin with the starting activity or the starting activities of the project and gradually move to their respective succeeding activities - i.e., move forward in time. Assuming our activity interdependencies and time estimates are correct, we ask two questions for each activity:

1) What is the earliest time at which we can start the activity?

2) What is the earliest time at which we can finish the activity?

In other words, for each activity, we shall be working out its Early Start (ES) time and its Early Finish (EF) time, relative to the zero date of the project.

For the new product launch project of Figure 5.8 we can easily see that ES for activity A is 0 as A is a starting activity with no predecessor. EF for activity A can then be computed as 2 weeks as it is not possible to finish A before this time. When we move to activity B, which is the successor to activity A, we find that ES for B is 2 weeks and its EF is 10 weeks, since activity B requires 8 weeks for its completion after its start. Similarly ES and EF for activity C can be easily seen to be 0 and 12 weeks respectively. Now, activities B and C have a common successor - viz. activity

D. Since activity D can start only after both B and C have been completed, ES for D will be 12 weeks and not 10 weeks because C cannot be finished before 12 weeks (its EF is 12 weeks). In a similar manner, this process can be continued till we have covered all the project activities.

For activity 1, we can say that

$$ES_i = \max \{EF_f, EF_g, EF_h, \dots\}$$

where  $f, g, h, \dots$  are the immediate predecessors of activity  $i$ ; and  $EF_i = ES_i + t_i$

where  $t_i$  is the estimated duration of activity  $i$ .

As the EF for activity N is 26 weeks, we can say that the earliest completion time for the new product launch project is 26 weeks. Table 5.2 lists the results of the forward pass for this project.

**Table 5.2: ES and EF for all activities of new product launch project.**

Activity (i)	Estimated Duration ( $t_i$ ) (Weeks)	$ES_i$	$EF_i$
A	2	0	2
B	8	2	10
C	12	0	12
D	4	12	16
E	4	0	4
F	4	4	8
G	6	8	14
H	8	4	12
I	3	14	17
J	5	17	22
K	4	4	8
L	9	8	17
M	1	17	18
N	4	22	26

### 5.3.1 Backward Pass

If the project has to be completed by a given date, then we can again ask two questions for each activity:

- 1) What is the latest time by which the activity has to be finished?
- 2) What is the latest time by which the activity has to start?

In other words, for each activity we can work out its Late Finish (LF) time and its Late Start (LS) time, given that the completion of the project must be achieved by a certain date.

After the LF and LS times for any activity have been worked out, the same can be done for its immediate predecessors. The process thus begins with the finishing activities of the project and continues through their predecessors till we reach the start of the project. Since we are moving backwards in time, the exercise is referred to as the backward pass.

For the new product launch project, we can conduct the backward pass assuming that the project has to be finished in 26 weeks - its earliest completion time. Thus, LF for N is 26 weeks and consequently its LS must be 22 weeks since it takes 4 weeks for N to be completed. For both activities J and M, LF is 22 weeks as N cannot start at 22 unless and until J and M are completed. The LS for J can then be worked out as  $(22 - 5)$  i.e. 17 weeks, where 5 weeks is the duration of J. Moving one further step backwards, the LF for D and I have to be 17 weeks. This process can be continued in a similar manner till we have covered all the project activities.

**Table 5.3: LF and LS for all activities of New Product Launch Project**

Activity (i)	Estimated Duration ( $t_i$ ) (Weeks)	$LF_i$	$LS_i$
A	2	5	3
B	8	13	5
C	12	13	1
D	4	17	13
E	4	4	0
F	4	8	4
G	6	14	8
H	8	14	6
I	3	17	14
J	5	22	17
K	4	12	8
L	9	21	12
M	1	22	21
N	4	26	22

For activity i, we can say that

$$LF_i = \min \{LS_j, LS_k, LK_l, \dots\}$$

where j, k, l, ..... are the immediate successors of activity i;

$$\text{and } LS_i = LF_i - t_i$$

where  $t_i$  is the estimated duration of activity i. Table 5.3 above lists the results of the backward pass for this project.

### 5.3.3 Total, Free and Independent Slack

If we look at the results of the forward and the backward pass together, as in Table 5.4 below, we observe some interesting facts. For activity A, although the ES is 0 weeks, its LS is 3 weeks showing that due to some reason if this activity is not started at 0 weeks but say at 1, 2 or 3 weeks, even then the completion of the project is not delayed. On the other hand, for activity E both its ES and its LS is 0 weeks showing that any delay in its start will immediately affect the completion of the project. In other words, some activities have some looseness or cushion and some others do not. This property is referred to as activity slack and in this sub-section we shall try to develop a deeper understanding of the same. Activity slacks are very useful when preparing project schedules.

**Table 5.4: Activity Slacks for all activities of New Product Launch Project**

Activity (i)	Estimated Duration (Weeks)	$ES_i$	$EF_i$	$LS_i$	$LF_i$	Total Slack <sub>i</sub>	Free Slack <sub>i</sub>	Independent Slack <sub>i</sub>
A	2	0	2	3	5	3	0	0
B	8	2	10	5	13	3	2	0
C	12	0	12	1	13	1	0	0
D	4	12	16	13	17	1	1	0
E	4	0	4	0	4	0	0	0
F	4	4	8	4	8	0	0	0
G	6	8	14	8	14	0	0	0
H	8	4	12	6	14	2	2	2
I	3	14	17	14	17	0	0	0
J	5	17	22	17	22	0	0	0
K	4	4	8	8	12	4	0	0
L	9	8	17	12	21	4	0	0
M	1	17	18	21	22	4	4	0
N	4	22	26	22	26	0	0	0

#### Total Slack

Total slack for an activity is the difference between its LF and EF or that between its LS and ES. If the total slack for activity K is 4 weeks, then there can be a maximum delay of 4 weeks in the completion of activity K from its EF or a maximum delay of 4 weeks in its start from its ES, without affecting the timely completion of the project in 26 weeks.

On careful observation of Table 5.4 together with the network diagram of Figure 5.8, we find that activities K, L and M - all have a total slack of 4 weeks. However, this does not mean that each of the activities K, L and M can be delayed by 4 weeks without delaying the completion of the project. In fact, the total slack of 4 weeks is shared by activities K, L and M and that is why the total slack of an activity is sometimes referred to as its path slack as it is shared with other activities on the same path or sub-path. Another way to view total slack for an activity is that if all other activities take exactly the same time for their completion as given by their respective estimated durations, then the maximum delay possible in the execution of this activity from its estimated duration is its total slack.

The computation of total slack for activity  $i$  can be done as follows:  $[\text{Total Slack}]_i = EF_i - ES_i$

### ***Free Slack***

Consider activities B, C and D in the network diagram of new product launch project shown in Figure 5.8 and its time analysis shown in Table 6.4. Activity B has a total slack of 3 weeks, whereas both C and D have a total slack of 1 week each. In other words, out of a total slack of 3 weeks for activity C, only 1 week is shared with its successor and other 2 weeks of total slack are not shared with its successor. We say that activity B has a free slack of 2 weeks, which it does not share with its successor(s). Free slack can occur for only those activities whose head events are merge events (or combined merge and burst events) and this slack is available only to the activity concerned and not to its successor. If the activity concerned cannot make use of the free slack, it is no longer available to any of its succeeding activities:

The computation of free slack can be done as shown below:  $[\text{Free Slack}]_i = ES_j - EF_i$ ,

where  $j$  is a succeeding activity of activity  $i$ .

e.g.  $[\text{Free slack of activity B}] = (\text{ES of activity D}) - [\text{EF of activity B}] = 12 - 10 = 2 \text{ weeks}$

### ***Independent Slack***

Some activities may have some slack which they do not share with any of their predecessors or any of their successors. This slack is referred to as the independent slack of the activity concerned.

If we take a closer look at activity H in the project network of Figure 6.8, we find that H does not share any of its total slack of 2 weeks with its predecessor E which does not have any total slack - nor does it share it with its successor I which again has a total slack of 0 weeks. Thus, the total slack of 2 weeks available to activity H is independent of any of its predecessor(s) or its successor(s). Independent slack can occur only for those activities where there is at least one more sub-path between the tail event and the head event of the activity concerned. The tail event for activity H is 4 and the head event is 6 and the activity H provides a direct path between these two events. However, there is another sub-path between these two events - viz, via activities F and G and the difference between the two sub-path lengths i.e. between F and G on one side and H on the other is the independent slack of H. Activity H does not share its independent slack-with either its predecessor or its successor. Even if all its predecessors finish at their latest possible times (i.e. at their LF) and even if we want all its successors to begin at their earliest possible times (i.e. at their ES), even then activity H has its independent slack of 2 weeks.

The computation of independent slack for activity  $i$  can be done as follows :  $[\text{Independent Slack}]_i = ES_j - LF_h - t_i$



where j is a succeeding activity and h is a preceding activity of activity i.

e.g. [Independent Slack of activity H] = [ES of activity I] - [LF of activity E]

(Estimated duration of activity H)

=14-4-8=2 weeks

### 5.3.4 Critical Path

If the project has to be finished at its earliest completion then some activities cannot be delayed at all. These *are* the activities with zero slack and they are called critical activities as their timely completion is critically important for the timely completion of the project. From Table 5.4 we can see that activities E, F, G, I, J and N are all critical activities for the new product launch project. The path obtained by joining the critical activities is called the critical path of the project. Thus the path E-F-G-I-J-N is the critical path for the new product launch project as shown in Figure 5.9 below.

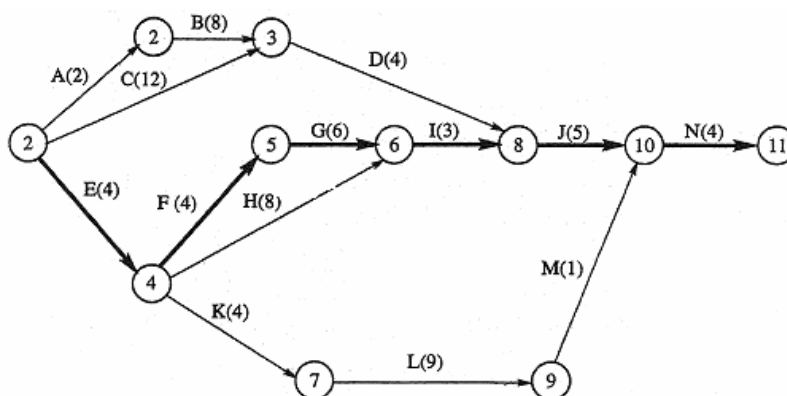


Figure 5.9: Critical Path for the New Product Launch Project

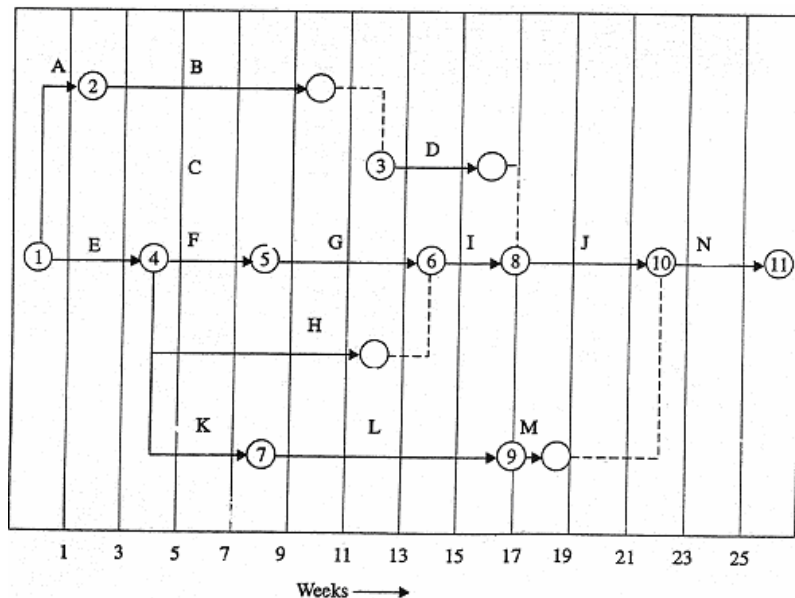
The critical path is also the longest path from the start of the project to its finish. However, a project may have more than one critical path. While a project is under execution, critical activities need to be monitored very closely as any delay in their completion is immediately reflected as a delay in the project completion:

### 5.3.5 Time-scaled Networks

As the network diagram are not drawn on time scale, they do not communicate much visually except showing the activity interdependencies. On the other hand, managers have always found it more convenient to interact with bar charts when it comes to monitoring and controlling the actual performance vis-à-vis the scheduled performance.

This anomaly can be removed by drawing time-scaled networks. In these networks, all activities are drawn horizontal arrows and the length of the arrows represent their durations. The critical path is first drawn as the longest path and then the other paths and sub-paths are drawn.

The time-scaled network diagram for the new product launch project is shown in Figure 5.10 below.



**Figure 5.10: Time-scaled Network for the New Products Launch Project**

For easy reference, the event numbers used are exactly the same as used in Figure 5.8 earlier. The time-scaled networks show not only the activity interdependencies but also their durations and their slacks - dotted horizontal lines show the activity slacks and it is quite clear that activities K, L and M, each has a total slack of 4 weeks which they share among themselves. It is also clear that if there is any delay in the completion of activity K, the total slacks of activities L and M automatically get reduced to the same extent and hence the appropriateness of the term path slack. Free slack and independent slack for different activities can also be seen in the time-scaled network. In Figure 5.10, all the activities are shown at their respective earliest start and finish and so the ES, EF times can be seen directly. The LF and the LS times can also be interpreted from the figure.

### *Activity 1*

What are the benefits to manager for determining the critical path of a project?

.....

.....

.....

.....

## **5.4 PROBABILISTIC DURATION**

In many projects there are activities whose time durations cannot be estimated very precisely because of the high degree of uncertainty associated with them. In fact, it may become impossible to get satisfactory time estimates for some activities because of the uncertainty in their durations. In Programme Evaluation and Review Technique (PERT), one of the early network approaches to project management, a special mechanism has been developed to handle these uncertainties. We shall first develop the concepts

in section 5.4.1, use the same in section 5.4.2 to answer questions regarding the probability of completion of a project in a given amount of time and finally in section 5.4.3 discuss some limitations of this approach.

### 5.4.1 Three Time Estimates

For some activities where the degree of uncertainty is high, it may be easier and more appropriate to get three different estimates for each activity duration rather than trying to get the best estimate. We can thus try to find an optimistic estimate, a pessimistic estimate and a most likely estimate of the activity duration.

#### *Optimistic Time*

If all conditions are favourable, then the minimum time in which an activity can be finished is called the optimistic time of the activity concerned. Of course the probability of all the conditions being favourable is very low and so the probability that the activity will actually be finished in its optimistic time is very low. In fact, we can say that it is impossible to finish an activity in less than its optimistic time.  $a$

#### *Pessimistic Time*

This is the reverse of optimistic time. If all conditions are unfavourable, then the maximum time in which an activity will be finished is called its pessimistic time. Using the same logic as earlier, we can say that the probability that an activity will require as much time as its pessimistic time for finishing is very low and that it is impossible for an activity to take longer than its pessimistic time for finishing.

#### *Most Likely Time*

In reality, some factors may be favourable and some others unfavourable for the timely finishing of an activity and so in almost all cases the actual time to finish an activity will be somewhere between the optimistic and the pessimistic times. The most likely time is that duration of the activity which has the highest probability of occurrence among all possible values of the activity duration.

Once the optimistic, pessimistic and the most likely times of an activity are estimated, one has a reasonable idea about the degree of uncertainty in the duration of that activity. It is also known empirically that the probability density function of activity duration closely follows a beta distribution as shown in Figure 6.11 below. The expected duration (or the mean duration) of the activity and its standard deviation are easily calculated as shown below:

$$\text{expected duration of an activity, } t_e = \frac{a + 4m + b}{6}$$

$$\text{standard deviation of activity duration, } \sigma = \frac{b - a}{6}$$

where,  $a$  = optimistic time of the activity  $m$  = most likely time of the activity

and  $h$  = pessimistic time of the activity

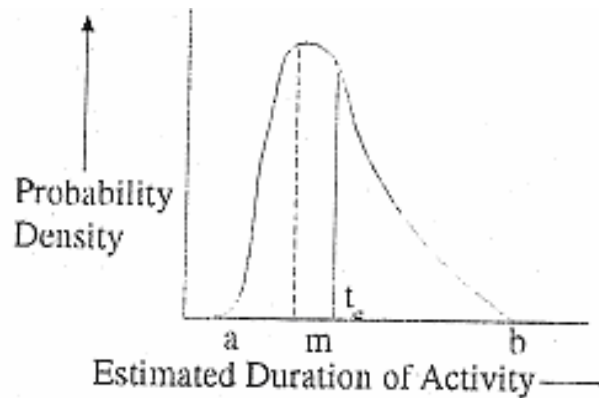


Figure 5.11: Probability Distribution of Activity Duration

Thus, it can be seen from the above expressions as well as from the Figure 5.11 above that if  $m$  is equidistant from both  $a$  and  $h$ , then the probability density function becomes a symmetrical curve with  $t_e = m$ . Also that the interval  $(b - a)$  governs the variability of the activity duration as measured by its standard deviation or its variance which is nothing but the square of the standard deviation.

#### 5.4.2 Probability of Completion of a Project

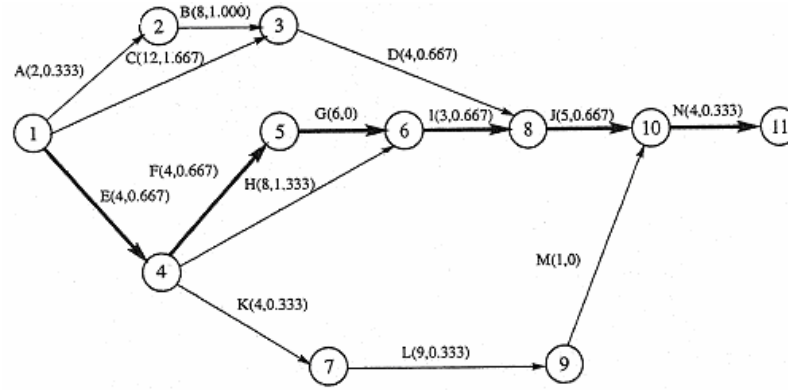
A path on a project network diagram is simply a sequence of activities and the path length (or duration) is nothing but the sum of the durations of all the activities on the path. If the various activity durations are independent of each other, then the expected duration of a path is the sum of the expected durations of all the activities on the path and the variance of the path duration is the sum of the variances of all the activity durations on the path. Moreover, the general version of the *central limit theorem* assures us that the sum of a large number of independent random variables will be approximately normally distributed regardless of the distribution of the individual random variables. We can, therefore, not only find the expected duration of any path but also its variance and the shape of the distribution.

Earlier, we had defined the longest path in a project network diagram as the critical path. However, if the individual activity durations are uncertain, the longest path in the network may also not be known with certainty. If we now define the path with the longest expected duration as the critical path, we can find the expected time of completion of a project as well as its variance. Also, we can find the probability that the critical path will be completed within a given duration and this may be taken as the probability that the project itself will be completed within the specified duration. We now propose to show how all this can be done by taking the new product launch project as our example.

**Table 5.5 Three time estimates of Activity durations for New Product Launch Project**

Activity Code	Activity Description	Immediate Predecessor Activity	Estimated duration (Weeks)				Standard deviation of duration ( $\sigma$ )
			Optimistic (a)	Most likely (m)	Pessimistic (b)	Expected duration (Weeks) ( $t_e$ )	
A	Finalise package design	-	1	2	3	2	0.333
B	Set up packaging equipment and procure raw materials	A	6	8	10	8	0.667
C	Produce the first batch	-	9	11	19	12	1.667
D	Package the first batch	B, C	2	4	6	4	0.667
E	Set up the sales office	-	3	3.5	7	4	0.667
F	Recruit salesmen	E	3.5	4	4.5	4	0.167
G	Train salesmen	F	6	6	6	6	0
H	Select retailers	E	2	9	10	8	1.333
I	Sell to retailers	G, H	2	3		3	0.667
J	Despatch to retailers	D, I	4	5	6	5	0.667
K	Select advertising agency	E	3	4	5	4	0.333
L	Plan advertisement campaign	K	8	9	10	9	0.333
M	Release pre-launch advts.	L	1	1	1	1	0
N	Conduct advt. campaign	I, M	3	4	5	4	0.333

Table 5.5 above shows the three time estimates for each activity of the new product launch project. As can be seen from the table, some activities like G and M have no uncertainty (e.g. for activity G, optimistic, most likely and pessimistic times are all estimated as 6 weeks), whereas some other like activity C have a relatively high degree of uncertainty in their activity durations (this can be seen from the low optimistic time of 9 weeks and the high pessimistic time of 19 weeks for activity C). We can also see that some activities like B have a longer left tail, whereas some others like E have a longer right tail and many other activities like A, D, F etc. have both their tails of equal length. The last two columns in Table 5.5 above show the computed values of the expected duration and the standard deviation of each activity. Figure 5.12 below shows the network diagram of the new product launch project where the expected value and the standard deviation of each activity duration is shown by the side of the respective activity code. The path with the longest expected duration is also identified as the critical path on this network diagram. As the expected duration of each activity has remained unchanged as compared to the earlier estimated single time estimate for each activity, the critical path is also unchanged.



**Figure 5.12 Critical Path for the New Product Launch Project with Expected Value and Standard Deviation of each Activity Duration**

The expected duration of the critical path,

$$\begin{aligned}\mu &= \sum_{i=1}^n t_i \\ &= [t_e \text{ of E} + t_e \text{ of F} + t_e \text{ of G} + t_e \text{ of I} + t_e \text{ of J} + t_e \text{ of N}] \\ &= [4 + 4 + 6 + 3 + 5 + 4] \\ &= 26 \text{ weeks}\end{aligned}$$

The variance of duration of the critical path,

$$\begin{aligned}\sigma^2 &= \sum_{i=1}^n \sigma_i^2 \\ &= [\sigma^2 \text{ of E} + \sigma^2 \text{ of F} + \sigma^2 \text{ of G} + \sigma^2 \text{ of I} + \sigma^2 \text{ of J} + \sigma^2 \text{ of N}] \\ &= [(0.667)^2 + (0.167)^2 + (0)^2 + (0.667)^2 + (0.667)^2 + (0.333)^2] \\ &= 1.472 \text{ weeks}^2\end{aligned}$$

Let  $t$  be the length of the critical path EFGIJN for this project. So, we know that  $t$  has a normal distribution with mean  $\mu = 26$  weeks and variance  $\sigma^2 = 1.472$  weeks.

Obviously, the probability that the critical path will be completed in 26 weeks is 0.50. As the critical path is the path with the longest expected duration, this may be taken as the probability of completing the project in 26 weeks as well. What is the probability that the project will be completed in 28 weeks?

$$\begin{aligned}\Pr[t \leq 28] &= \Pr\left[\frac{t - \mu}{\sigma} \leq \frac{28 - 26}{\sqrt{1.472}}\right] \\ &= \Pr\left[Z \leq \frac{2}{1.213}\right] \\ &= \Pr[z \leq 1.65] \\ &= 0.9505\end{aligned}$$

[ From Tables of Area under the Standard Normal Curve ]

This is shown in Figure 5.13 below as the shaded area under the standard normal curve. We can therefore say that the probability of completing the project in 28 weeks is 95.05%.

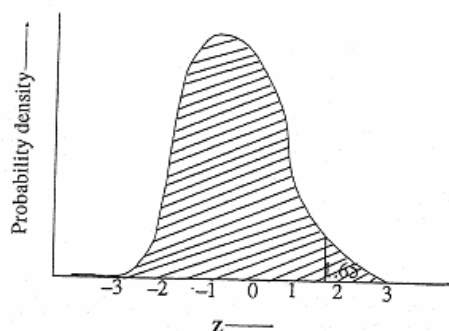


Figure 5.13: Area under the Standard Normal Curve for  $z \leq 1.65$

### 5.4.3 Interpreting the Probability of Completion of a Project

We must keep in mind that what we computed as the probability of completion of the project is actually the probability of completing the critical path in the given time and the two may not be the same. In case there is another path which is near critical in terms of the expected duration but with a higher variability, then the probability of completing that near-critical path may be smaller than the probability of completing the critical path. It may be better to demonstrate this with an example and for this we go back to Figure 5.12. The path CDJN has an expected duration of 25 weeks and a much higher variability than that of the critical path EFGIJN. For the near-critical path CDJN, we can compute the probability of completion in 28 weeks following the same steps as used earlier.

The expected duration of the critical path, CDJN,

$$\begin{aligned}\mu &= \sum_{i=1}^n t_{ei} \\ &= [t_e \text{ of C} + t_e \text{ of D} + t_e \text{ of J} + t_e \text{ of N}] \\ &= [12 + 4 + 5 + 4] \\ &= 25 \text{ weeks}\end{aligned}$$

The variance of duration of the path CDJN,

$$\begin{aligned}\sigma^2 &= \sum_{i=1}^n \sigma_i^2 \\ &= [\sigma^2 \text{ of C} + \sigma^2 \text{ of D} + \sigma^2 \text{ of J} + \sigma^2 \text{ of N}] \\ &= [(1.667)^2 + (0.667)^2 + (0.667)^2 + (0.333)^2] \\ &= 3.778 \text{ weeks}^2\end{aligned}$$

Again, if  $t$  be the length of the path CDJN, then

$$\begin{aligned}\Pr[t \leq 28] &= \Pr\left[\frac{t - \mu}{\sigma} \leq \frac{28 - 25}{\sqrt{3.778}}\right] \\ &= \Pr\left[Z \leq \frac{3}{1.944}\right] \\ &= \Pr[z \leq 1.54]\end{aligned}$$

= 0.9382 [From Tables of Area under the Standard Normal Curve]

We therefore conclude that the probability of completing the project in 28 weeks cannot exceed 93.82% which is lower than 95.05% which was obtained by considering the critical path EFGIJN.

In such cases the Project Manager may get false assurance of a relatively

higher probability of completion of a project than is actually the case. In fact, one way of getting a valid probability distribution of project completion time is to perform a computer simulation of the project. In such a simulation, the project is run many times - say 100 times or 1000 times on the computer and by studying the project completion times in these runs, a probability distribution can be constructed. For each run, the computer first picks up one value randomly for each activity - representing the duration of the activity. These values are picked up such that for each activity, these values follow the probability distribution of the activity duration as known from its optimistic, most likely and pessimistic times. For each set of such values, (i.e. each run), the project is analysed to find the project completion time as well as the critical activities.

The distribution of project completion time can be used directly to answer questions like, "what is the probability of completing the project in  $n$  weeks?" One can also find out how frequently a particular activity became critical and interpret the same as the probability that the particular activity is critical. This is referred to as the criticality index of the activity when activity durations are uncertain and is a number between 0 and 1. For example, in the new product launch project of Figure 5.12, the criticality index of activity N would be 1.0 since activity N would always be critical, the criticality index of activity J is expected to be very high (close to 1.0) as activity J would be critical as long as any one of the paths ABDJN, CDJN, EFGIJN and EHIJN is critical, whereas the criticality index of activity M is expected to be low (close to 0.0) as activity M would be critical only when path EKLMN happens to be the longest path in the project network. In this analysis, the focus is on critical activities (more specifically the criticality index of activities) rather than on critical paths.

### *Activity 2*

What is the probability of achieving the project duration computed on the basis of average or mean values of activity duration? How can we enhance the probability of achieving project completion within the deadlines agreed?

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## **5.5 OTHER TYPES OF DIAGRAMS**

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We have so far been using Activities-On-Arrows (AOA) diagrams to represent activity interdependencies. Although these are still the most commonly used network diagrams, some other network diagrams are also used. In this section we present two of these - the first one is an Activity-On-Node (AON) diagram and the other one is the Precedence Network (PN) diagram which is an extension of both AOA and AON diagrams.



## 5.5.1 AON Diagrams

AON diagrams are similar to the AOA diagrams or the arrow diagrams that we introduced in section 5.2 earlier. In these diagrams also, we use circles and arrows, but the circles (or nodes) now represent activities. The arrows do not represent any entity but only show the precedence relationships between the nodes. The arrowhead points to the succeeding activity. The precedence relationship "activity B can start only after activity A has been completed", will have an AON diagram as shown in Figure 5.14 (a) below. The corresponding AOA diagram for the same precedence relationship is also shown as Figure 5.14(b).

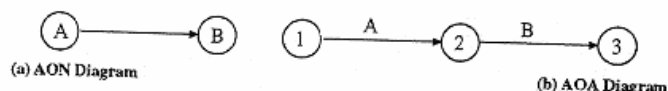


Figure 5.14: Activity B can start only after activity A has been completed

In an AON diagram, each arrow represents a precedence relationship and so the number of arrows is simply the number of precedence relationship in the project. Also, in this case there is no need to use dummy activities as any complex set of precedence relationships can be explicitly represented without using any dummy.

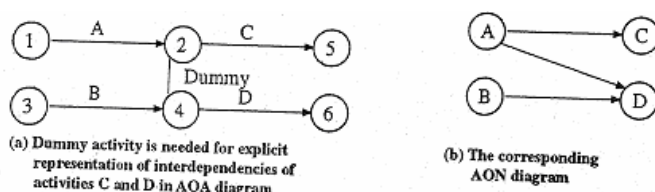


Figure 5.15: No need for Dummy activities in AON Diagrams

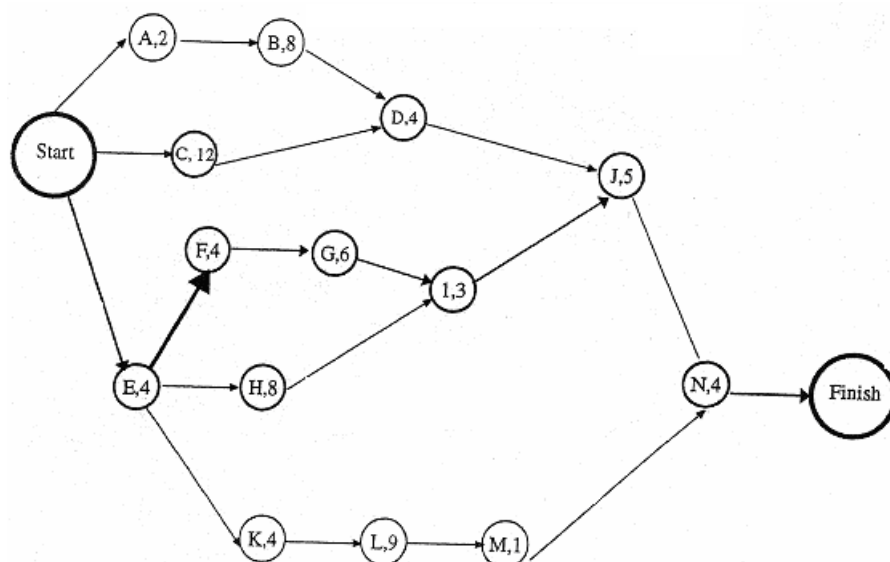


Figure 5.16: AON Diagram of the New Product Launch Project with the data given in Table 5.1

For example, the situation described earlier in Figure 5.6 to justify the use of dummy activities in AOA diagrams (and shown again as Figure 5.15a) can be easily represented by its AON diagram shown as Figure 5.15b above:

It should also be noted that there is no concept of an event in an AON diagram. However, if required, special events or milestones can also be represented as additional nodes in AON diagrams. However, they are not used as extensively as the AOA diagrams. This is largely due to historical reasons as PERT was based on an event-oriented approach. AON diagrams are now getting popular as some popular Project Management software use this form of diagramming as also because the Precedence Network (PN) diagrams, which are more versatile and which we describe in the next section, are based on AON diagrams.

The AON diagrams for the new product launch project, based on the data given in Table 5.1, is shown in Figure 5.16 above. As is generally done in AON diagrams, we have also added two fictitious nodes called Start and Finish in our diagram to identify the starting and the finishing activities clearly.

### 5.5.2 Precedence Network Diagrams

Both AOA and AON diagrams can represent only one type of interdependency between two activities - that of complete precedence. The successor activity can start only after the predecessor activity is completed. However, there may be partial precedence between two activities in the sense that one of them can start only after the other one has started or can be finished only after the other one has finished and so on. Precedence Networking (PN) or Precedence Diagramming Method (PDM) allows explicit representation of four types of precedence relationships and these are shown in Figure 5.17 below. In these diagrams, activities are represented as square or rectangular nodes. This allows easier depiction of the "start" (the left side of the rectangle) or the "finish" (the right side of the rectangle) of activities. The flow of time is again assumed to be from left to right. Arrows represent precedence relationships and they also have a symbolic representation with a precedence symbol (e.g. FS) and a lead-lag factor (e.g. n weeks).

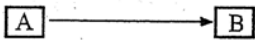
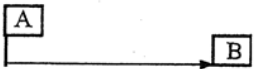
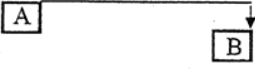

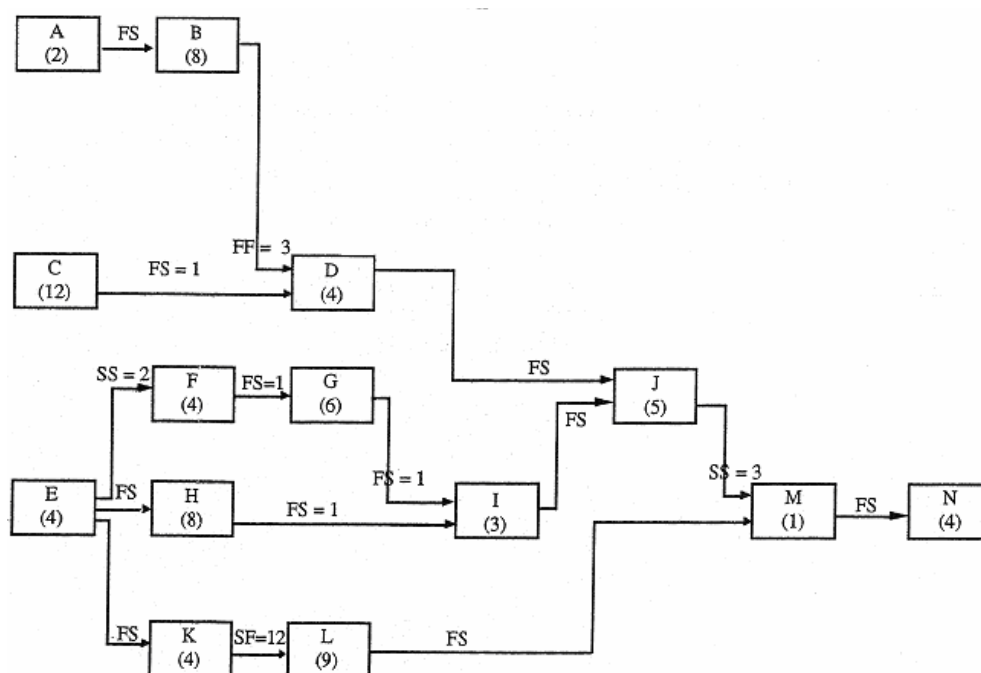
<i>Precedence Relationship</i>	<i>Symbolic Representation</i>	<i>Description</i>
	FS = n	Finish to Start : Activity B cannot start until n weeks after activity A is finished.
	SS = n	Start to Start : Activity B cannot start until n weeks after activity A is started.
	FF = n	Finish to Finish : Activity B cannot finish until n weeks after activity A is finished.
	SF = n	Start to Finish : Activity B cannot finish until n weeks after activity A is started.

Figure 5.17: Four types of Precedence Relationships in PN Diagrams

**Table 5.6: Details of Activities for Drawing Precedence Network of New Product Launch Project**

Activity Code	Activity Description	Precedence Relationship (Lead Lag Factor)	Estimated Duration (Weeks)
A	Finalise package design	—	2
B	Set up packaging equipment and procure raw materials	$F_A S_B = 0$	8
C	Produce the first batch	—	12
D	Package the first batch	$F_B S_D = 3$ $F_C S_D = 1$	4
E	Set up the sales office	—	4
F	Recruit salesmen	$S_E S_F = 2$	4
G	Train salesmen	$F_F S_G = 1$	6
H	Select retailers	$F_E S_H = 0$	8
I	Sell to retailers	$F_G S_I = 1$ $F_H S_I = 1$	3
J	Despatch to retailers	$F_D S_J = 0$ $F_I S_J = 0$	5
K	Select advertising agency	$F_E S_K = 0$	4
L	Plan advertisement campaign	$S_K F_L = 12$	9
M	Release pre-launch advertisements	$F_L S_M = 0$ $S_J S_M = 3$	1
N	Conduct advertisement campaign	$F_M S_N = 0$	4



**Figure 5.18 Precedence Network (PN) Diagram for the New Product Launch Project**

### ***FS Relationship***

The first precedence relationship is an FS relationship.  $F_G S_I = 1$  means that there is a finish. to start relationship between the activities G and I with a lead-lag factor of 1, More specifically, activity I can start only 1 week after the finish of activity G and not before that. FS relationships are very common

and are the only relationships which can be shown on AOA or AON diagrams (with a lead-lag factor of zero).

### ***SS Relationship***

This is a start-to-start relationship.  $S_E S_F = 2$  would mean that activity F can start only 2 weeks after the start of activity E and not before that. After activity F has started, it is possible for both activities E and F to continue simultaneously till one of them is finished.

### ***FF Relationship***

Two activities may have an FF relationship if one of them cannot be finished before the finish of the other. For example,  $F_B F_D = 3$  would imply that activity D can finish only 3 weeks after the finish of activity B and not before that.

### ***SF Relationship***

The fourth and the least common precedence relationship between two activities is the start-to-finish relationships.  $S_A F_B = 7$  would mean that activity B can finish only 7 weeks after the start of activity A and not before that.

It is perhaps possible to split some activities in two or more parts to represent some of these precedence relationships or introduce fictitious activities to represent lead-lag factors, but these are only crude approximations and not complete representations and may result in undesirable interruptions while working on some activities. PN algorithms are available to compute the ES and EF times of activities in the forward pass and LS and LF times in the backward pass and thus to compute activity slacks and identify critical paths. However, because of the variety of precedence relationships, the interpretation of slack and critical path is not as straight forward as we developed in the AOA (or AON) diagrams and has to be done with great care.

If we go back to the new product launch project as an example and look at the data of Table 5.1, we may find that some of the precedence relationships may not have been of the type  $FS = 0$ . By questioning the Project Manager about each precedence relationship, suppose we find the precedence relationships as listed in Table 5.6 above. Activity B is related to activity A through the relationship  $F_A S_B = 0$ , which is the same as listed in Table 5.1 earlier while drawing the AOA diagram. On the other hand, earlier we had stated that activity D follows activities B and C. On closer scrutiny, the Project Manager finds that there has to be a minimum gap of 1 week between the finish of C (produce the first hatch) and the start of D (package the first hatch). This is represented as  $F_C S_D = 1$ . Similarly, activity D can start before activity B (set up packaging equipment and procure raw materials) is completely finished - as soon as some raw materials are procured, but activity D can be finished only 3 weeks after the finish of activity B and not before that. This can now be represented as  $F_B F_D = 3$ . We can also agree with the

Project Manager's view that the recruitment of salesman (activity F) may not wait till the setting up of the sales office (activity E) is finished but that we can start F 2 weeks after the start of E. This has been shown as  $S_E S_F = 2$ .

Figure 5.18 above shows the precedence network diagram (PN diagram) of the new product. launch project based on the information contained in Table 5.6. Since the symbolic representations are associated with the arrows, no subscripts are used to identify the activities associated with a preceding relationship. Also, lead-lag factors of zero are not mentioned separately and are implicit.

### Activity 3

By and large, we launch the project based on Earliest Start Time (EST) schedule for all activities. Is there any justification?

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## 5.6 PROJECT SCHEDULING

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In this unit, we have so far looked at time analysis of projects and worked out Early Start, Early Finish and Late Start, Late Finish times of different activities. In activities with a high degree of uncertainty in their durations, we have also seen the role of three time estimates - which allow us to compute the probability of completion of the project in a given amount of time. However, we still have not discussed how to obtain a project schedule in terms of setting dates for the start and finish of each activity and each milestone. In this section we propose to discuss project scheduling and while doing so - to introduce concepts of project resources and project costs.

### 5.6.1 ES and LS Schedules as Limits

Assuming that the activity durations estimated are correct, we can view the two schedules obtained - viz. the ES schedule and the LS schedule as the limits between which the actual schedule must lie - else the project completion will get delayed. This is because the ES time of an activity is the earliest time at which the activity can begin or the earliest time at which all its predecessors can be completed and so no feasible schedule can have a planned start time for an activity earlier than its ES time. Similarly, the LS time for an activity is the latest time by which the activity must start if the project has to be completed by a given date and if the planned start time is later than its LS time then again it will lead to an infeasible schedule since the project cannot be completed by the given date. For the critical activities- the ES and the LS times are the same and for these activities their planned start should also be the same as their ES or LS times. On the other hand, for those activities which have a slack, the LS times are later than their ES times and any feasible schedule must have the planned start times not earlier than

the respective ES and not later than the LS times. While deciding the planned start time some other considerations like resource availability, unevenness of employment of workers, cost optimisation, etc. also need to be looked into. It may also be true that because of these considerations the planned start of some activity is scheduled after its LS time.

### 5.6.2 Resource Scheduling

Earlier in section 5.2.1 we defined an activity as a homogeneous element of work consuming some resources and requiring some definite amount of time for-its completion. Each activity will require some resources - which could be manpower, equipment, money, space or any other thing which is available in a limited quantity. The cost incurred on an activity is largely due to the cost of the resources consumed and a better resource scheduling may be able to lower project costs or make the project more cost-effective.

Time analysis by itself may not produce a feasible schedule because resource availability constraints have not been considered. If we review the process of project planning discussed so far we find that we started with breaking up the project into its constituent activities, listed the activity interdependencies based on technological constraints, management policy constraints and legal constraints and finally estimated the activity durations based on an implicit assumption about some "normal" amount of resources available. With the data so generated we proceeded to carry out time analysis. Stated differently; we have not yet ensured that the resources required for an activity are actually available in the period when the activity is scheduled. For example, if activities A and B both require a crew of a mechanic and a helper and we have only one such crew assigned to the project, then A and B cannot be done simultaneously, even though the ES or the LS schedule calls for their parallel execution. This is because resource availability constraints have not yet been considered. If, however, the schedule is changed and the parallel activities A and B are made sequential - i.e. one after the other- then it becomes a feasible schedule although the project duration may get extended due to this change. This is the heart of resource scheduling.

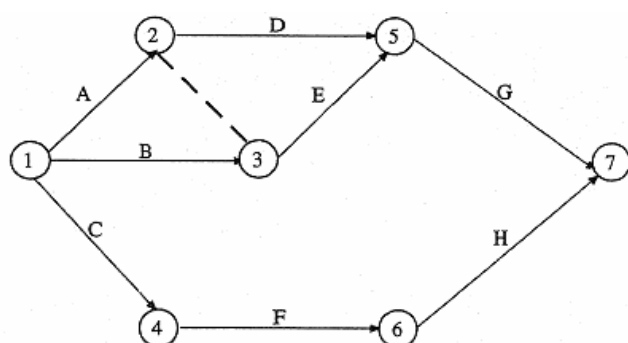
In resource scheduling, we first identify resource conflicts--i.e. periods where the current schedule requires more resources than are available and then we try to remove the resource conflicts to get a feasible schedule. However, the problem is not as simple as it sounds here because the number of resources used in a project is very large and any of these could give rise to a resource conflict. Secondly, even if a resource conflict is identified, its removal may have many consequences: it may increase the project duration, it may lead to uneven resource use rate and it may affect the resource utilisation; This, in turn, might complicate the process of removal of resource conflict because the alternative which minimises the increase in project duration may make the resource use more uneven and so on.

While manpower is usually a resource for most activities - in a large number of projects there are various skills of manpower required and each skill and

each level of personnel is a separate resource. Not only that, when these people are grouped into sections and departments - each skill or level of workman in each section is a separate resource. It is therefore not unusual to have 100 or 200 different resources in large projects and a feasible schedule cannot have a resource conflict for any of its resources. Further, a resource may not be required for the complete activity duration (e.g. the activity "build a wall" may be estimated to take 3 weeks whereas the resource "painter" may be required only for the last three days of its estimated duration) or may not be required for the complete day (e.g. 8 working hours) even for those days when it may be required: There maybe alternate resources which could be used - perhaps at a higher cost - e.g. an Electrician Grade I may also do the work of an Electrician Grade 11 but not *vice versa*. All these factors make the resolution of resource conflicts a very difficult problem and that is why computers are very helpful at this stage. There are very good software packages available in the market which carry out resource scheduling using their own individual procedures. Basically, these try to remove resource conflicts by first trying to change the use of the resource within the duration of the activity, then delaying some activities having a slack and finally by delaying the start of critical activities.

### 5.6.3 An Example

We shall try to understand this process by taking a small project whose details are shown in Figure 5.19. Here we make a simplifying assumption that the resource requirement is uniform and for the complete' 4uration of the activity.



Activity	A	B	C	D	E	F	G	H
Duration (Days)	5	2	4	3	4	2	4	2
No. of men Required	6	2	2	5	3	3	4	3

Fig. 5.19 A small project with eight activities, their interdependencies estimated duration and resource requirements.

We can easily carrying out a time analysis of this project and identify AEG as the critical path having a length of 13 days. If each activity is scheduled at its earliest, we can get the ES schedule which is shown in the form of a time-scaled network in Figure 5.20(a). By summing up the number of men required to perform each activity, the resource requirement for the whole

project can be easily computed. Figure 5.20(b) shows the resource requirement for the ES schedule of this project. For example, on day 1 - activities A, B and C are scheduled and this would require  $(6+2+2=)$  10 men. We find that the peak resource requirement is of 11 men required on days 6, 7 and 8. However-, if only 8 men are available on this project, then this schedule is not feasible - for feasibility, the resource requirement on any day cannot exceed 8 men.

Suppose we use the following heuristic to remove resource conflicts:

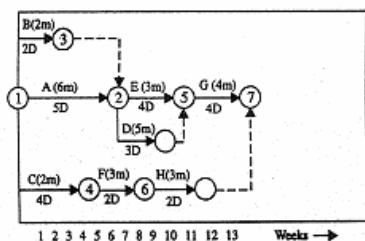
**Step 1** On the project schedule, locate the first period with a resource conflict as one move forward in time from the start of the project to its finish. If there is no such period, stop as the schedule is resource feasible - else go to step 2.

**Step 2** Among all the activities scheduled to start at this period, pick up the one with the largest total slack (where Total Slack = Late Start - Planned Start for the activity) and delay its start. This activity cannot be performed alongwith the other conflicting activities - i.e. the remaining activities scheduled to start at this period and the ones continuing from a previous period. Schedule the start of this activity immediately after the first of the other conflicting activities is finished.

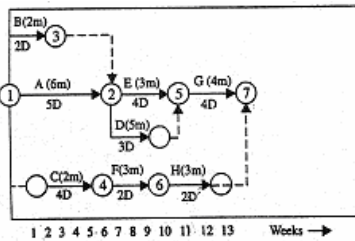
**Step 3** If there is no resource conflict in this period go to step 1, else go to step 2.

Let us apply this heuristic to the small project of Figure 5.19. We begin with the ES schedule and the corresponding resource profile of Figure 5.20. At step 1, we find that day 1 is the first period with a resource conflict since the schedule requires 10 persons on that day whereas we have only 8. At step 2, we find from Figure 5.20(a) that three activities viz. A, B and C are scheduled to start on that day. Their total slacks are 0, 3 and 5 days respectively and so we pick up activity C and delay its start. The other conflicting activities are A and B and the first of these to get finished is B. So, we schedule the start of C immediately after the start of B. This schedule is shown in Figure 5.21. As there is no resource conflict on day 1 we go to step 1. The first period with a resource conflict is now day 6 and D and E are two activities scheduled to start on this day. As D has a total slack of 1 day whereas E does not have any slack, we pick up D at step 2 and delay its start. The other conflicting activities are E - the other activity scheduled to start at this period - and C - continuing from a pervious period. Of these C is the one scheduled to finish first and so we schedule the start of D immediately after the finish of C. This schedule is shown in Figure 5.22. As there is no resource conflict on day 6, we go to step 1.

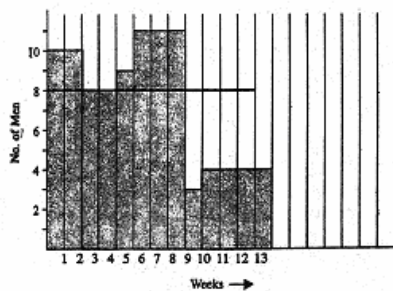




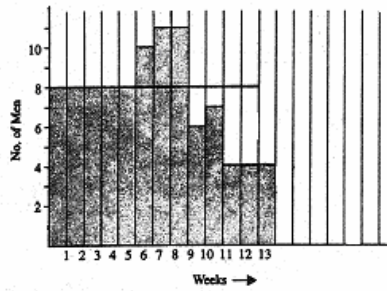
(a) ES schedule for the project Figure 5.19



(a) Schedule with delayed start of C by 2 days

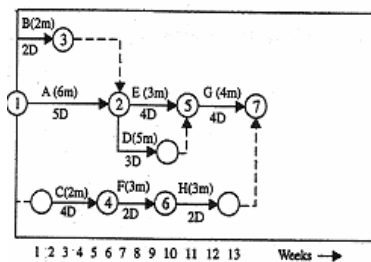


(b) Corresponding Resource Profile Figure 5.20

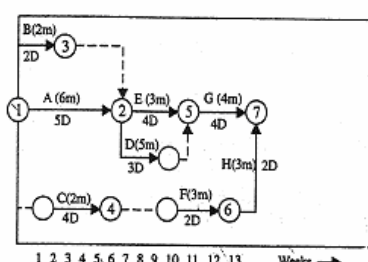


(b) Corresponding Resource Profile Figure 5.21

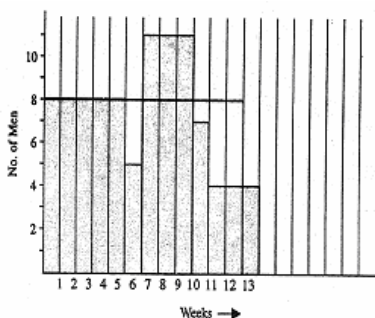
Day 7 is now the first period with a resource conflict and between D and F which are scheduled to start on this day, we delay the start of F as it has a total slack of 3 days whereas D has zero slack. As both the other conflicting activities D and E are scheduled to finish on day 9. We schedule the start of activity F immediately after this- i.e. on day 10. This schedule is shown in Figure 5.23. As there is no resource conflict on day 7, we go back to step 1 and as there is no resource conflict in any period, we stop as we have reached a resource feasible schedule. The heuristic seems to have worked very well since we could get a resource feasible schedule without any delay in the project completion from its earliest completion of 13 days.



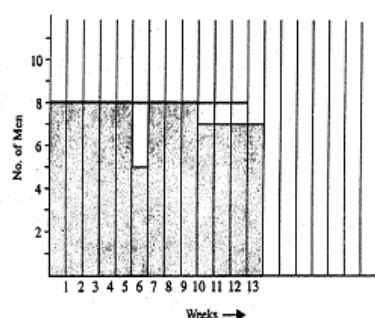
(a) Schedule with delayed start of activity D



(a) Schedule with start of F and H delayed



(b) Corresponding Resource Profile  
Figure 5.23



(b) Corresponding Resource Profile  
Figure 5.23

Now suppose that we had only six men available to work on this project. Figure 5.24(a) through (e) show the schedule as it evolves on application of the heuristic. We finally get a resource feasible schedule which shows that the project can be completed in 22 days with not more than men required on any day. Obviously, this is not the best as Figure 5.25 gives us a resource feasible schedule with 20 days as the project duration. The same heuristic which worked well with a resource constraint of 8 men does not work well when the constraint is 6 - men. This is a general problem with all resource scheduling heuristics.

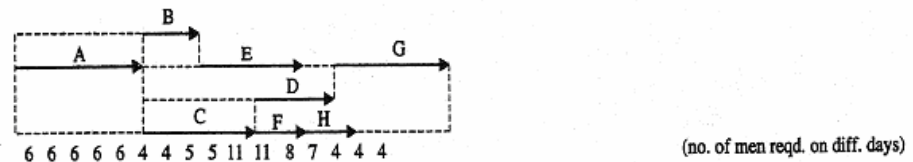
**5(a) ES Schedule. Project duration -13 days:**



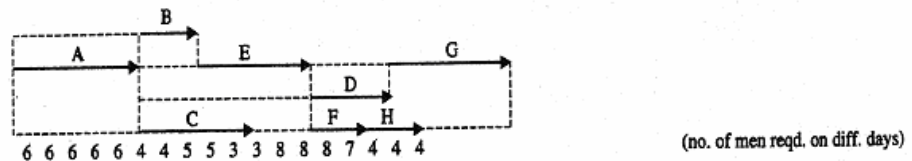
**(b) Delay C by 2 days, B by 5 days and C by 3 days, Project duration - 15 days:**



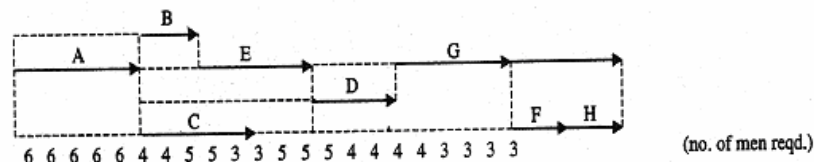
**(c) Delay D by 2 days and again D by 2 days. Project duration - 16 days:**



**(d) Delay F by 2 days and D by 2 days. Project duration - 18 days:**



**(e) Delay F by 3 days and again F by 4 days. Project duration - 22 days:**



**Figure 5.24 Resource scheduling with only 6 men available**

Imagine the complexities involved in a large project with hundreds of activities and scores of resources. The resource scheduling in such cases can be handled efficiently, only by computers. However, the heuristics or rules

used by different project management software are proprietary and also none of them claim to give the optimal solution - but they do give good schedules. They all try to minimise the delay in project completion by altering good schedules. They all try to minimize the delay in project completion by altering the intensiveness of resource use (e.g. where the resource is not used for all 8 hours in a shift) altering the allocation of resource within an activity (e.g. where a resource is required only for a part of the activity duration and making use of different types of activity slack.

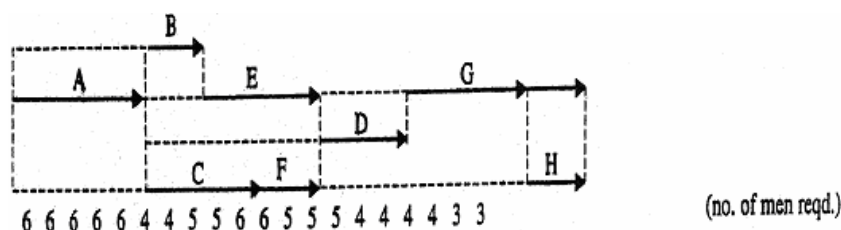


Figure 5.25: Resource feasible schedule with 6 men and project duration of 20 days

#### Activity 4

If resources for meeting the Earliest Start Time (EST) Schedule are available, is there any valid justification for undertaking resources planning?

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#### 5.6.4 Time/Cost Trade-off

In most projects, many activities may be expedited - i.e. completed in a shorter duration by changing the intensiveness of resource use, changing the method or procedure, changing the resources, changing the material and so on. However, all such reductions in activity durations are accompanied by rise in activity costs and so all such activity duration reduction may not be desirable. This trade-off between the activity duration and the associated cost is the subject of interest in this sub-section.

The reduction in activity duration by any change in its resources, resource use, method, procedure or material is referred to as the crashing of the activity. There are activities (e.g. curing of concrete) which cannot be crashed, some others which can be crashed very 'marginally' and still others which can be crashed by a significant amount of time. If we take a look at the details of activities for New Product Launch Project in Table 5.1, we may find that it is not possible to crash activity A "finalise package design" - from its "normal" duration of 2 weeks whereas activity B - "set up packaging equipment and procure raw materials" - having a "normal" duration of 8 weeks may be crashed to a "crash" duration of only 6 weeks. This is because, overtime may be used while setting up the packaging equipment and local purchase may be used while procuring raw materials. However, there is an

overtime premium and local purchase is at a higher price resulting in an increase in the activity cost from a "normal" cost of Rs.10,00,000 to a "crash" cost of Rs 12,00,000. Table 5.7 lists all the normal and crash times and costs for all fourteen activities of the new product launch project.

From Table 5.7 we can easily see that the cost of the project will be Rs 46,98,000 if all the activities are executed as per their "normal" durations. We know from the earlier time analysis that the earliest project completion in such a case is in 26 weeks. However, if the project has to be finished sooner then we have to crash some activities. Let us now determine an efficient method of crashing the project duration.

**Table 5.7: Normal and Crash Durations and Costs for New Product Launch Project**

Activity Code	Activity Description	Immediate Predecessor Activity	Normal		Crash		Cost Slope Rs ('000) Week
			Duration (Weeks)	cost Rs. ('000)	Duration (Weeks)	cost Rs ('000)	
A	Finalise package design	—	2	10	2	10	—
B	Set up packaging equipment and procure raw materials	A	8	1000	6	1200	100
C	Produce the first batch	—	12	720	9	900	60
D	Package the first batch	B, C	4	35	3	50	15
E	Set up the sales office	—	4	16	3	24	8
F	Recruit salesmen	E	4	52	3	63	21
G	Train salesmen	F	6	108	6	108	—
H	Select retailers	E	8	144	6	152	4
I	Sell to retailers	G, H	3	60	3	60	—
J	Despatch to retailers	D, I	5	45	4	72	27
K	Select advertising agency	E	4	8	4	8	—
L	Plan advertisement campaign	K	9	20	9	20	—
M	Release pre-launch advertisements	L	1	500	1	500	—
N	Conduct advertisement campaign	J, M	4	2000	4	2000	—
		Total			4698		5167

If the project duration has to be reduced, then the length of the critical path has got to be reduced. Obviously, there is no advantage in crashing a non-critical activity as that would not reduce the length of the critical path. On the other hand, if any of the critical activities is crashed, it would immediately result in a reduction in the length of the critical path and consequently the project duration.

The question then is, which critical activity should be crashed? The answer to this should be simple - the one which is the cheapest to crash i.e. where the increase in cost is the minimum.

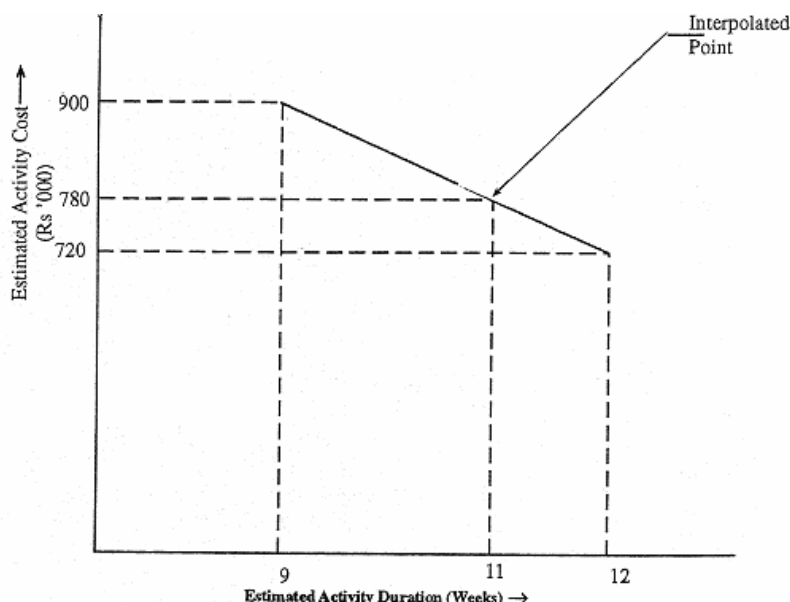


Figure 5.25: Linear interpolation of Cost for Activity C

We assume that for activities whose durations could be crashed by 2 or more weeks, partial crashing is also possible and the cost increase can be estimated by linear interpolation of the activity cost curve as shown in Figure 5.25 for activity C. Thus, if the activity C is crashed to 11 weeks, the activity cost would increase to Rs 780,000. It is easier to capture the same information through computation of the cost slope for each activity as shown below:

**Cost slope for an activity = Crash Cost - Normal Cost**

**Normal Duration - Crash Duration**

The cost slope for each activity is also shown in Table 5.7 and it captures the increase in activity cost per week of crashing. However, no activity can be crashed beyond its crash duration which is an absolute minimum.

We know from Figure 5.9 that E, F, G, I, J and N are six critical activities. Of these G, I and N cannot be crashed and E, F and J can each be crashed by one week only at a cost of Rs. 8,000, Rs. 21,000 and Rs. 27,000 respectively. Hence the cheapest way of reducing the project duration from 26 to 25 weeks is by crashing activity E to its crash duration of 3 weeks. The project cost would rise to (Rs. 4698,000 + Rs. 8,000 i.e.) Rs. 4706,000.

If we want to reduce the project duration by one more week, we have to crash some critical activity again. However, now there are two critical paths viz. EFGJN and CDJN and the project duration will reduce only if both the critical path lengths can be reduced. Of these critical activities only F can be crashed by 1 week at a cost of Rs. 21,000, J by 1 week at a cost of Rs. 27,000, C by 3 weeks at a cost of Rs. 60,000 per week and D by 1 week at a cost of Rs. 15,000. One way of reducing the project duration to 24 weeks is by crashing both D and F by 1 week each costing (Rs. 15,000 + Rs. 21,000 i.e.) Rs. 36,000. The other way is by crashing J by 1 week costing only Rs. 27,000. As J is an activity lying on both the critical paths - crashing it by 1 week will reduce the project duration by 1 week. This is the cheapest way of

completing the project in 24 weeks and the project cost would rise to (Rs. 4706,000 + Rs. 27,000 i.e.) Rs. 4733,000.

We still have only two critical paths - viz. EFGIJN and CDJN and the only critical activities which can be crashed are - F which can be crashed by 1 week at a cost of Rs. 21,000, C which can be crashed by 3 weeks at a cost of Rs. 60,000 per week and D which can be crashed by 1 week at a cost of Rs. 15,000. The only way in which the project duration can be reduced from 24 to 23 weeks is by crashing both F and D by 1 week each costing (Rs. 21,000 - Rs. 15,000 i.e.) Rs. 36,000. The project cost will now increase to (Rs. 4733,000 + Rs. 36,000 i.e.) Rs. 4769,000.

At this stage no activity on the critical path EFGIJN can be crashed any further and so it is not possible to reduce the project duration beyond 23 weeks. Although it is possible to crash the project duration from 26 to 23 weeks, it may not be economically justified. Suppose the economic benefit of launching the new product earlier is Rs. 30,000 per week of early launch. Then we will crash the project duration by only 2 weeks as the incremental cost of crashing by one more week (i.e. the third week) is Rs. 36,000 whereas the incremental benefit is only Rs. 30,000.

Some projects carry an incentive for early completion or a penalty for late completion and these can also be treated in the same way for determining the optimum project duration. The guiding principle in all crashing decisions is the same - the cost of crashing by 1 week (or 1 month or any other period) goes on increasing with each successive round of crashing and we should crash only as far as it is economically beneficial and not beyond that.

### **5.6.5 Project Scheduling as an Iterative Process**

As described in the previous sections, the steps involved in project planning and scheduling could be summarised as follows

- Establishing the Project goals and objectives
- Defining the work - i.e. breaking up the project into its constituent activities
- Estimating the activity duration and defining activity interdependencies
- Carrying out time analysis of the project
- Establishing the resource availability and requirements

Developing a resource feasible schedule  
Analysing activities to find feasibility of crashing  
Optimising the baseline plan and schedule  
Freezing the baseline plan and schedule  
a simple single-pass sequence of steps to be followed one after the other. As the objective is to get an optimised project schedule and baseline plan some of these steps may have to be repeated in an iterative way to get closer to the baseline plan. After going through the time/cost trade off analysis once, one may realise that it is better to Modify the resource allocated to a particular activity - say from 10 to 8. With this change, resource scheduling may have to be repeated with consequent

changes in crashing of activities. Similarly, after one round one may realise that the resources available to the project must be increased to complete the project in time. This in turn calls for another iteration. The final outcome after this whole exercise is a project schedule and baseline plan which is feasible, meets the projects goals and has been optimised on cost. The baseline plan then becomes the basic document against which the project progress is monitored and controlled.

### **Activity 5**

Project delays can be very costly and can impact adversely on the fiscal health of the company,. If we are engaged in crashing the overall project duration because of its high profitability, are there any other cost factors that must be taken into account?

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## **5.7 LET US SUM UP!**

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Project Scheduling is quite a complicated exercise - especially for large projects. In this unit we have brought out the issues relevant to project scheduling and time analysis of projects and also tried to discuss some procedures for carrying out the same.

As projects are unique one-time endeavours having their own goals, we found that project network diagrams could provide the basic framework to carry out time analysis of projects. We described how project network diagrams could be drawn and then used for time analysis of projects. We did this through AOA network diagrams wherein activities are represented by arrows and events by small circles or nodes.

The time analysis could give us Early Start and Early Finish times of different activities during the forward pass and Late Finish and Late Start times during the backward pass. We used these to define total slack, free slack and independent slack of different activities. We interpreted those activities having no total slack as critical activities as any delay in their execution would be immediately reflected in project delay and the path (or paths) formed by joining the critical activities together on the network diagram as the critical path. Finally, we combined the project network diagram and the time analysis results to draw the time-scaled network of projects - which can visually depict both the activity interdependencies and their durations and slacks.

We then took a look at those activities having a high degree of uncertainty in their estimated durations and discussed the role of three time estimates - viz. optimistic time, pessimistic time and most likely time in capturing this uncertainty

We used the three time estimated optimistic compute activity expected duration and variance and then using the central limit theorem the project expected duration and variance. This information, once generated, can be used to answer question regarding the probability of completion of the project in a given amount of time.

We also introduced AON (Activity on Node) network diagrams in which activities are, represented as nodes and there is never a need to use dummy activities.

Precedence Network (PN) diagrams are then introduced and these network diagrams allow us to represent dependency relationships between a pair of activities other than the Finish - to Start (FS) which is used in AOA and AON networks. In PN networks, we discussed how to use Start-to-Start (SS), Finish-to-Finish (FF) and also the less commonly used Start-to-Finish (SF) relationships. Each of these precedence relationships can also have their respective lag times.

Time analysis alone does not give us a feasible schedule as we have not get ensured that resources required for different activities will actually be made available. This is done in resource scheduling where we first identify resource conflicts and then try to remove the same through the use of heuristics. We showed the use of one simple heuristic which worked well with a resource availability of 8 men but did not work well when the resource availability was changed to 6 men. This is true of all heuristics including the ones used *in* computer packages to remove conflicts.

We also analysed time/cost trade off in project scheduling. We found that the estimated duration of some activities can be crashed (i.e. reduced) from their normal durations. This can be achieved only by incurring a higher cost on the activity e.g. on overtime, local purchase, changed methods or procedures, etc. Project crashing can be used in situations where the incremental benefit for crashing is more than the incremental cost of crashing. It is true that the greater the crashing, the higher the incremental crashing per period and so beyond a point it may not be economical to resort to crashing.

The various steps involved in project scheduling may have to be used more than once in an iterative manner to get the project schedule which uses the right amount of resources. is estimated to be completed at the right time and at an optimised cost.

Such a schedule called the baseline schedule is used for monitoring and control of the project.

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## 5.8 SELF-ASSESSMENT EXERCISES

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1. Compare and Activity-on-Arrow (AOA) networks with Activity-on-Node (AON) networks and justify why AOA networks are preferred internationally.



2. Time-scaled networks are significant improvements over traditional networks and bar charts and their usage will grow in the next century.' Justify with examples of their advantages.
3. What is the concept of "Free Float" (Primary slackness) and "Total Float"(secondary slackness)? Bring out their significance in project management.
4. A network comprises of the following activities:

Activity	Duration(Weeks)	Activity	Duration(Weeks)
1-2	6	2-7	4
1-4	6	5-7	Dummy
1-3	2	4-8	6
3-5	4	6-8	8
2-4	Dummy	7-8	8
5-6	2		

- a) Draw an AOA network
  - b) Compute forward pass calculations (Earliest possible occurrences of nodes), Backward Pass calculations (Latest possible) occurrences of nodes); Free Float, Total Float of all activities and determine the critical path. Mark the critical path in the network.
  - c) Prepare a time-scaled network and mark the critical path in the network.
5. Draw an AOA network of the following activities:

	Activity	Precedes	Duration(days)
Start	A	D	2
Start	B	E,H	3
Start	C	F,K	4
	D	G	7
	E	G	6
	F	E,H	5
Finish	G	-	8
	H	-	9
	K	-	10

- a) Carry out all the calculations on the network, determine and mark the critical path. What is the total project duration?
  - b) Calculate the amount by which the duration of activity 'A' may increase without changing the total project duration.
  - c) Draw the time-scale network and reconfirm the answer to (b) above.
6. A network has following activities their normal duration and costs as well as their minimal (crash) duration and costs are also indicated in the tabulation below:

Job	Predecessor	Normal		Minimal (crash)	
		Time (days)	Cost (Rs.)	Time (days)	Cost (Rs.)
A	—	10	5,000	10	5,000
B	A	8	4,000	8	4,000
C	A	8	4,500	8	4,500
D	C	4	6,000	4	6,000
E	B	7	5,500	5	6,500
F	B	9	3,750	4	13,750
G	D	8	2,000	1	4,800
H	E,F,G	15	6,500	12	14,900
I	H	10	5,000	10	5,000

- Draw the time-scales network.
  - For the activities and their corresponding time and cost information, determine how and at what additional cost; a deadline of completing the project in 48 days can be met.
7. A project comprising of eight tasks (A to H) has the following characteristics:

Tasks	Preceding Tasks	Time Duration in Weeks		
		Optimistic	Most Likely	Pessimistic
A	None	2	4	12
B	None	10	12	26
C	A	8	9	10
D	A	10	15	20
E	A	7	7.5	11
F	B,C	9	9	9
G	D	3	3.5	7
H	E,F,G	5	5	5

- Draw an AOA network. Carry out all the calculations, determine the critical path and mark it in the network. What is the total project duration.
- What is the probability of achieving the project within the deadline of 30 weeks?

## 5.9 BIBLIOGRAPHY AND FURTHER READINGS

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## UNIT 6 PROJECT SCHEDULING

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### Objectives

- Describe the types of project constraints.
- Understand the nature of resource constraints.
- To understand the time constraint situations.
- Explain the steps and issues involved in scheduling resources in a project environment.
- To understand the heuristics for scheduling resources.
- Explain the benefits of resource scheduling.

### Structure

- 6.1 Introduction
- 6.2 Defining the Schedule
- 6.3 Resource Scheduling Problem
  - 6.3.1 Classification of a Scheduling Problem
  - 6.3.2 Resource Allocation Methods
- 6.4 Time Constrained Projects: Smoothing Resource Demand
  - 6.4.1 Steps Involved in Resource Smoothing
- 6.5 Resource – Constrained Projects
- 6.6 Let Us Sum Up
- 6.7 Self-Assessment Exercise
- 6.8 Further Readings

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## 6.1 INTRODUCTION

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Project scheduling is a process required to ensure the timely completion of a project. Till now, we learned about activity on arrow (AOA) and activity on node (AON) network representation, also calculated the cost and time required for each activity. A real-life project involves hundreds of activities for which it is important to evaluate early and late times at which the activities start and finish. In addition, identifying the group of critical activities so that they can be focused to reduce the cause for delay. All these can be done by scheduling a project, which basically adds a time dimension to the planning process. Project scheduling includes all the tools require to ensure timely completion of the project. The project scheduling is sued for;

- Knowing the activities timing and the project completion time.
- Having resources available on site in the current time.
- Making corrective actions if schedule shows that the plan will result in late completion.

- Assessing the value of penalties on project late completion.
- Determining the project cash flow.
- Evaluating the effect of change orders on the project completion time.
- Determining the value of project delay and the parties responsible for the same.

But before creating a project schedule, one should typically have a work breakdown structure (WBS), the time estimate for each task, and a resource list with availabilities for each resource. A Schedule is created using a consensus-driven estimation method, the reason for this is that a schedule itself is an estimate, each date in the schedule is estimated, and if those dates do not have the buy-in of the people (resource) who are going to do the work, the schedule will be inaccurate. Setting overall completion dates must be done by the project team and key stakeholders. The project manager assists by assimilating information about scope, budget, resources, and estimating times for completion of project tasks. Once an overall schedule is set, the project manager is responsible for monitoring the progress of the project and revising the schedule if needed. This must be done in consultation with project team members who are doing the work. There will be typically give-and-take as a project proceeds among budget, scope and schedule. It is essential for the project manager to keep all participants informed as to current schedule status.

The schedule development process should generate a project schedule that meets the following criteria.

- **Complete** - the schedule must represent all the work to be done, therefore, the quality and completeness of the WBS is very important.
- **Realistic** - the schedule must be realistic with respect to time expectations and the availability of beneficiaries to participate.
- **Accepted** - the schedule must have 'buy-in' from team members and stakeholders, especially the beneficiaries.

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## 6.2 DEFINING THE SCHEDULE

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The creation of the project schedule requires the team to define the conditions that will lead to the development of the schedule. The first piece of information needed for this step comes from the WBS that has all the activities identified for the project. The quality and completeness of the WBS will determine the quality of the schedule, and this is a good time for the project team to review if all the project activities are accounted for. Building the schedule is actually an easy part but once a project is published and issues and changes start to creep, the schedule becomes difficult to manage since it's the resources with the less flexibility. The goal of defining the schedule is for the project team to have a complete understanding of all the work that needs they must accomplish, by defining the schedule the project also develops an understanding of the constraints, dependencies and sequence of the activities.

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## 6.3 RESOURCE SCHEDULING PROBLEM

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After the assigning of staff and other resources have been taken place, a project manager still needs to answer the following questions:

1. Will the assigned resource be adequate or available to deal with my project?
2. Will there be need of outside contractors?
3. Do unforeseen resource dependencies exist? Is there a new critical path
4. The rate of flexibility available for using the resources
5. How realistic is the deadline?

Any project scheduling system should tend to facilitate easy answers to these questions.

As of now, the start and sequence of activities were solely based on technical or logical considerations. For, example, a project network for constructing a home might show 3 activities in sequence: 1) Pour foundation, 2) Build frame 3) Cover roof. In other words, you cannot perform activity 2 without completing activity 1 and so on. The project network assumes that the resources are available to perform the required work. But this is not often the case! The absence of abundant amount resources can drastically affect the timeline of a project.

The internal relationships and interactions among the time and resource constraints are often complex for even smaller projects. Some efforts to examine these interactions prior to starting the project frequently uncovers surprising problems. Project managers who do not look out for resource availability in moderately complex projects usually learn when it's too late recover.

### 6.3.1 Classification of a Scheduling Problem

The scheduling of projects can be classified into either time constraint type or resource constraint type. It is necessary for a project manager to consult their priority matrix to determine which case fits their projects. One simple test to check whether the project is time or resource constrained is to check, when the critical path is delayed, will resource be added to get back to schedule? If the answer is yes, the project is time constrained, of no, then the project is resource constrained.

**Time- Constrained:** It means the project must be completed within the given time period. It required, more resources can be added to make the process faster and complete it on the given specific time zone. Although time is the crucial factor, resources usage should be no more than is necessary and sufficient.

**Resource Constrained:** It happens when the resources available are limited. In such situation, it will be acceptable to delay the project, but as little as possible.

### 6.3.2 Resource Allocation Methods

Before demonstrating the allocation methods, there are certain assumptions that must be followed through-out the procedure. The assumptions are as follows:

1. Splitting activities is not allowed. i.e., if one activity is placed with the schedule, it can't be removed unfinished.
2. The level of resources used for an activity cannot be changed.

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## 6.4 TIME CONSTRAINED PROJECTS: SMOOTHING RESOURCE DEMAND

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Time Constrained projects are scheduled based on resource utilization. When the demand for specific resource is erratic, it is difficult to manage and the utilization of the resource is poor. Many practitioners defend such problems using resource leveling techniques that balance the demand for resources. But, leveling techniques delay noncritical activities by using positive slack to reduce peak demand and fill in the valleys for the resources.

If the duration of completion of project is the constraint, then resources smoothing is applied without changing total project duration. The period of minimum demand for resources are located and the activities are shifted according to float availability and requirement of resources. Thus, intelligent utilization of float can smoothen the demand of resources to the maximum possible extent. This type of resources allocation is called as "Resource Smoothing."

### 6.4.1 Steps Involved in Resource Smoothing

1. List out the resources which will be required for execution of the various activities and identify the ones which are considered important.
2. Resource profiles are prepared by carrying out the resource aggregation exercise and cumulative resource requirement for each unit are plotted in the form of histogram.
3. The periods of peak and low demands are identified and an attempt is made to lower the peaks and fill up the troughs.
4. If there is no constraint on the availability of resources, make the demand as uniform as possible. This can be achieved by altering the times of start and finish of non-critical activities, to start with. These activities can have certain amount of float. Therefore, available float can be used for making adjustments in the start in start and finish of the activities concerned and thus, lowering the peak demand by staggering of resource requirements without delaying the project duration.

Now, let us look at an example and try to understand how resource smoothing works in a project.

Consider a project with seven activities as shown in the table below. The predecessors of each activity and the duration of the activities are given. The number of compressors (consider it as a resource) required by each activity is also listed. The organization has only 6 compressors available with them. Look at the table 6.1

Table 6.1

Activity	Predecessors	Duration (Days)	No. of Compressors Needed
A	-	3	6
B	A	2	1
C	B	5	5
D	B	4	2
E	C	9	4
F	C, D	2	4
G	E, F	1	1

Solution:

Step 1: Draw the schedule network diagram and determine the critical path.

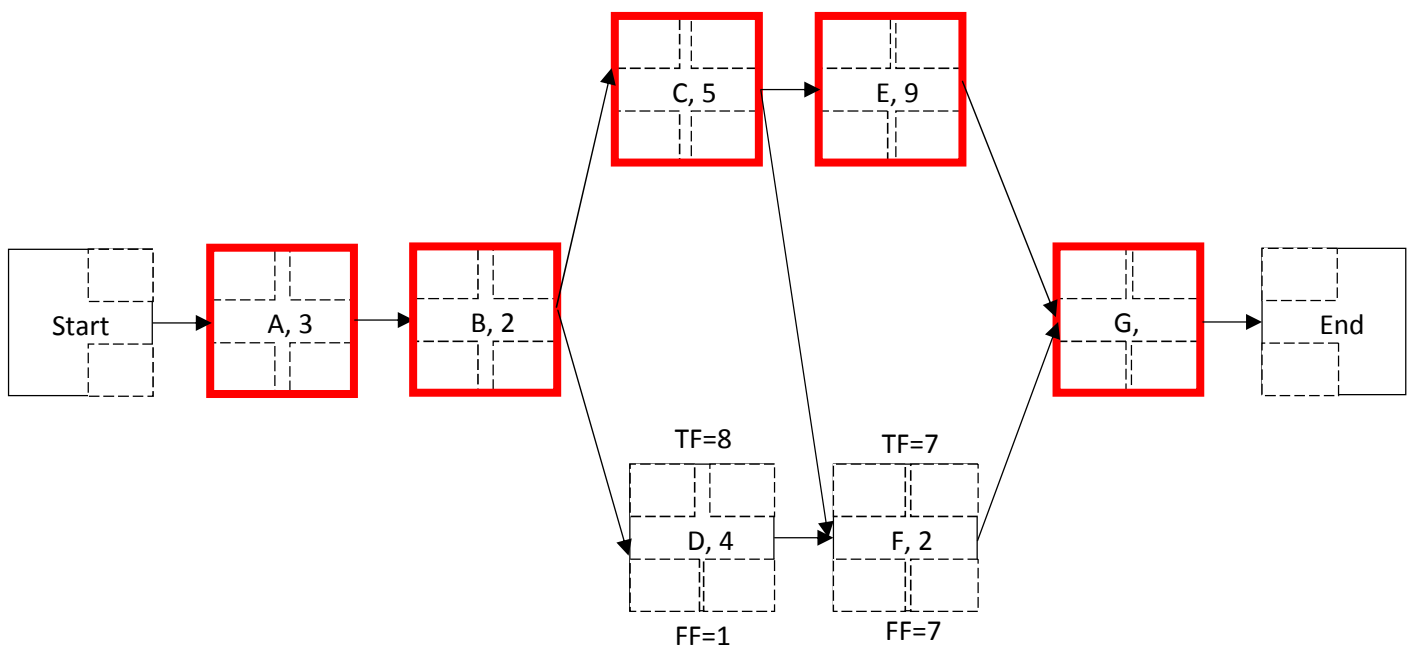


Fig. 6.1: Show the schedule network and critical path

From the schedule network diagram, you can understand the critical path is A-B-C-E-G and the total duration of the project is 20 days. The problem with the critical path method is it does not consider the availability of resources. So, now we need to check whether there are any resource conflicts in the schedule created by the critical path method. It will be easier if we present the schedule in the Gantt chart/ bar chart format to understand the resource usage over time periods.



Chart. 6.1: Gant chart or bar chart

ACT	DUR	RES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	3	6	■	■	■																			
B	2	1				■	■																	
C	5	5						■	■	■	■	■												
E	4	4											■	■	■	■	■	■	■	■	■			
G	9	6																			■			
D	2	2						■	■	■	■													
F	1	1											■	■										

ACT: Activity    DUR: Duration (Days)    RES: Resources (No. of Compressors Needed)

With the bar chart representation, it is easier for us to calculate the compressors needed on each day. For example, we know that from day 1 to 3, only activity A is in progress; so, we need 6 compressors on each of these days. However, from day 6 to 9, activity C and activity D are running in parallel. So, you need 7 compressors (5 for activity C and 2 for activity D) on each of these days.

Let us plot the resources required as a histogram in fig. 6.2 below.

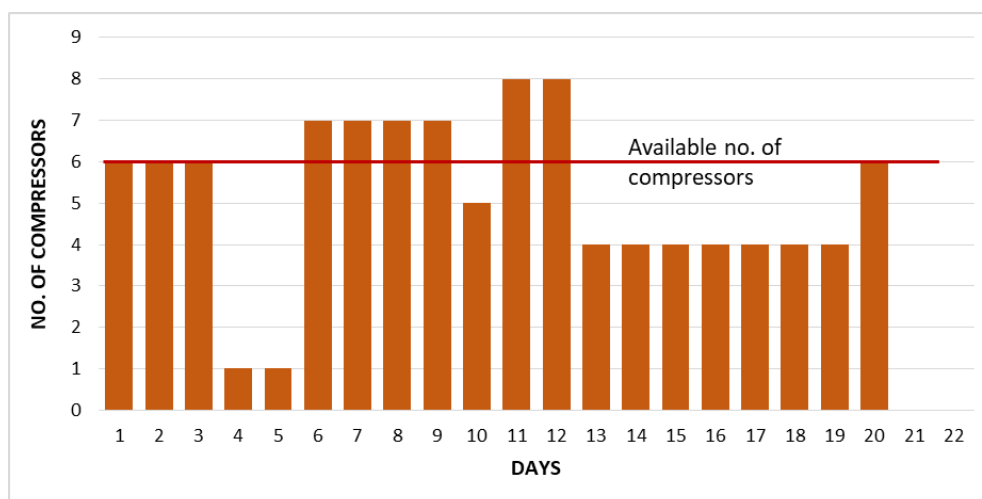


Fig. 6.2:

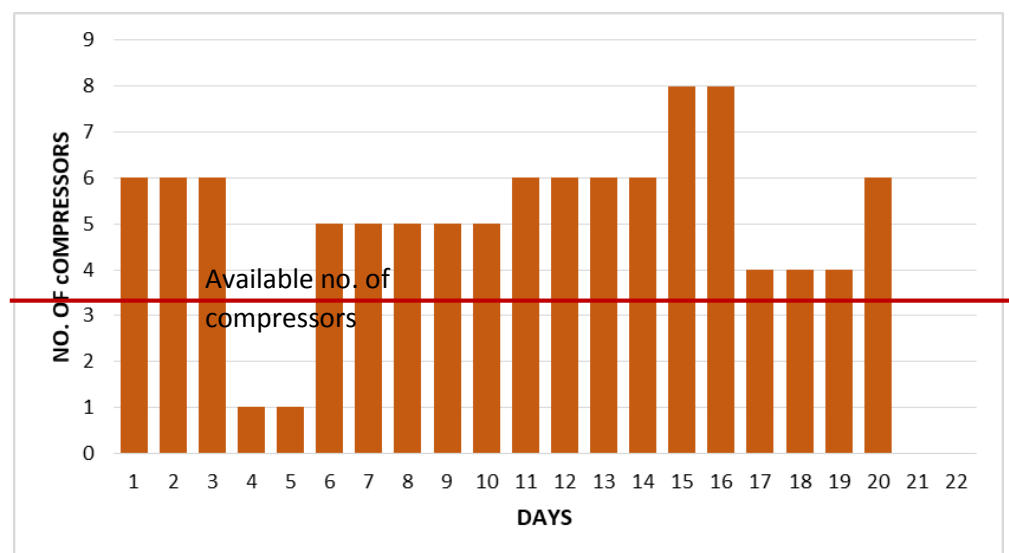
By drawing a line to show the resource limit, we can clearly see the days on which the resource conflict occurs. You can see that the schedule requires more compressors than available on six days; Day 6, 7, 8, 9, 11 and 12.

Now, let us see how the application of resource smoothing helps to remove the resource conflicts on these six days. Resource smoothing looks at removing as much resource conflicts as possible without delaying the total project duration.

Let us again start to adjust the original CPM schedule to avoid resource peaks.

**Chart. 6.2**

ACT	DUR	RES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	3	6	■	■	■																			
B	2	1				■	■																	
C	5	5					■	■	■	■	■													
E	4	4										■	■	■	■	■	■	■	■	■	■			
G	9	6																			■			
D	2	2					■	■	■	■		■	■	■	■									
F	1	1										■	■				■	■						



**Fig. 6.3:**

Activity D is shifted from day 6 to day 11. This removes the resource peaks from day 6 to 9. However, there is still resource conflicts on day 15 and day 16. This conflict cannot be removed without delaying the total project duration. So, resource smoothing will stop here. Out of the six days of

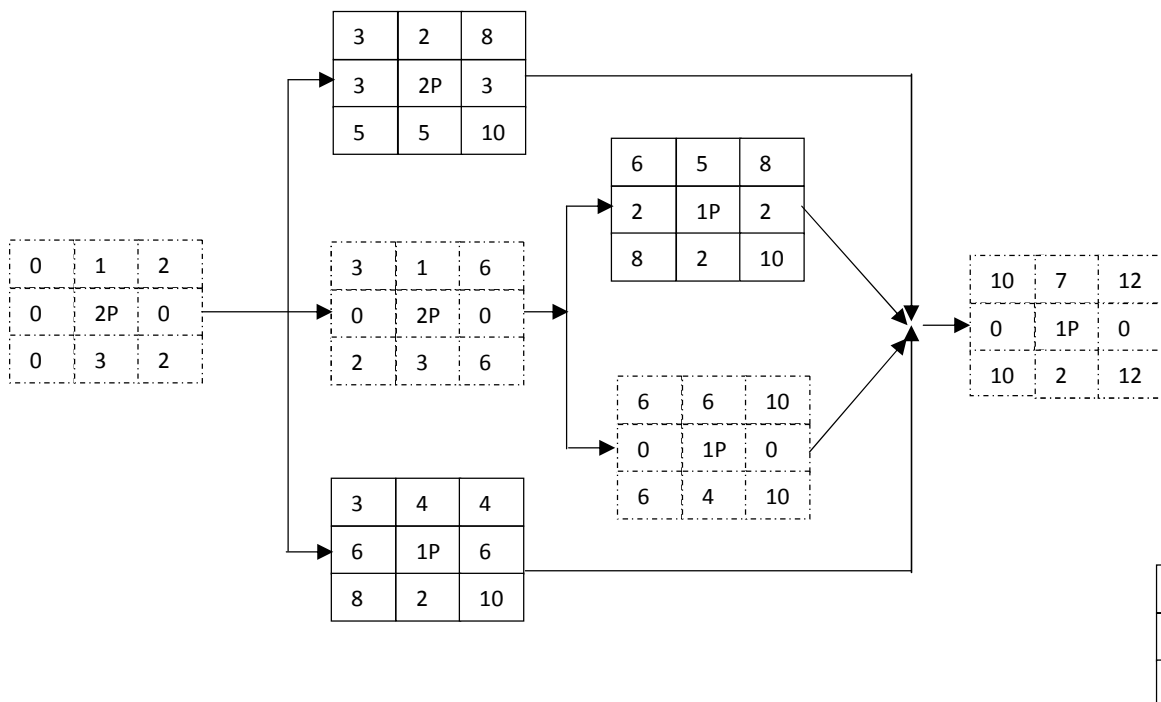
conflict, resource smoothing managed to remove 4 days of conflict. However, if the organization wants to stick to the original schedule, they should bring additional resources on day 15 & day 16.

## 6.5 RESOURCE – CONSTRAINED PROJECTS

Solving the resource scheduling problem for optimal solutions is extremely complex, particularly for large project networks with many different resource types. However, several heuristics are available to solve such problems. These heuristics allocate resources to activities to minimize project delay based on certain priority rules. The two most commonly used heuristics are the serial and the parallel methods. In the serial method of resource allocation, activities are sorted into a list and resources are allocated to each of these activities one at a time until resources are allocated to all activities. In the parallel method, however, resources are allocated on a period-by-period basis rather than each activity. In this method only those activities whose preceding activities have been completed will be considered. If two or more activities compete for the same resources, then allocation of resources is based on certain prescribed priority rules. Compared to the serial method, the parallel method has been the most widely used heuristic. The following priority rules, in the order presented, have been found to be the most effective in minimizing project delay.

- Minimum slack
- Smallest duration
- Lowest activity identification number

The Parallel method



Regardless of the scheduling heuristic used, the primary impact of resource constrained scheduling is the loss of flexibility due to the reduction in slack. Furthermore, the reduction in slack also increases the number of critical or near-critical activities.

ID	RES	DUR	ES	LF	SL	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2P	3	0	2	0	2	2	2											
2	2P	5	3	10	3				2	2	2	2	2						
3	2P	3	3	6	0				2	2	2								
4	1P	2	3	10	6				1	1									
5	1P	2	6	10	2							1	1						
6	1P	4	6	10	0							1	1	1	1				
7	1P	2	10	12	0											1	1		

Fig.6.4:

Period	Action
0-1	Only activity 1 is eligible. It required 2 programmers.
1-2	No activities are eligible to be scheduled
2-3	No activities are eligible to be scheduled
3-4	Activities 2, 3, 4 are eligible to be scheduled. Activity 3 has least slack (0) – apply rule 1. Load Activity 3 into schedule. Activity 2 is next with the slack of 2 but activity 2 requires 2 programmers and only 1 is available. Delay activity 2. Update: ES = 3, Slack = 2. The next eligible activity is activity 4, since it only requires 1 programmer. Load activity 4 into schedule.

Resource-constrained schedule through period 2-3

Chart. 6.3:

id	RES	DUR	ES	LF	SL	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2P	3	0	2	0	2	2	2											
2	2P	5	3	10	3				x										
3	2P	3	3	6	0				2	2	2								
4	1P	2	3	10	6				1	1									
5	1P	2	6	10	2														
6	1P	4	6	10	0														
7	1P	2	10	12	0														
Total resource load						2P	2P	2P	3P	3P	2P								
Resource available						3P	3P	3P	3P	3P	3P	3P	3P	3P	3P	3P	3P		

Period	Action
4-5	Activity 2 is eligible but exceeds limit of 3 programmers in the pool. Delay activity 2. Update: ES = 4, slack = 1.
5-6	Activity 2 is eligible but exceeds limit of 3 programmers in the pool. Delay activity 2. Update: ES = 5, slack = 0.
6-7	Activities 2, 5 and 6 are eligible with slack of 0, 2 and 0 respectively. Activity 2 and 6 have slack (0) – rule 1 becomes inactive. But since, Activity 6 requires 1 programmer and activity 2 requires 2 programmers, both are loaded at the same time. Delay activity 5. Update: ES = 6, slack = 1.
7-8	Activity 5 is eligible but exceeds limit of 3 programmers in the pool. Delay activity 5. Update: ES = 6, slack = 0.
8-9	Activity 5 is eligible but exceeds limit of 3 programmers in the pool. Delay activity 5. Update: ES = 6, slack = -1.
9-10	Activity 5 is eligible but exceeds limit of 3 programmers in the pool. Delay activity 5. Update: ES = 6, slack = -2.
10-11	Activities 5 and 7 are eligible with slack of -2 and 0 respectively. Activity 5 with slack (-2) and activity 6 have slack (0) – rule 1 Load Activity 5 into schedule. Delay activity 7. Update: ES = 10, slack = -1.

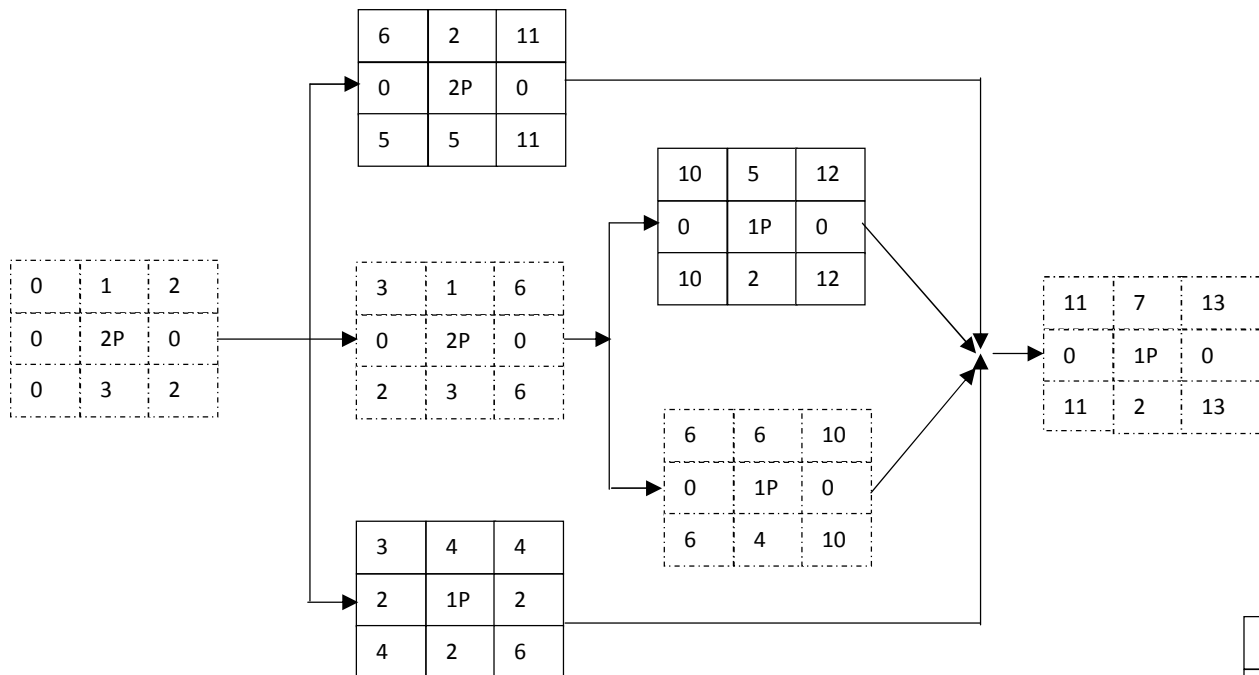
Chart. 6.4:

i	RE	DU	ES	L	SL	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2P	3	0	2	0	2	2	2											
2	2P	5	3	1	0				x	x	x	2	2	2	2	2			
3	2P	3	3	6	0				2	2	2								
4	1P	2	3	0	6				1	1									
5	1P	2	6	1	2							x	x	x	x				
6	1P	4	6	0	0							1	1	1	1				
7	1P	2	10	1	2														
Total resource load						2P	2P	2P	3P	3P	2P	3P	3P	3P	3P				
Resource available						3P	3P	3P	3P	3P	3P	3P	3P	3P	3P	3P			

Chart. 6.4:

ID	RES	DUR	ES	LF	SL	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2P	3	0	2	0	2	2	2											
2	2P	5	<del>3</del> 6	10	<del>3</del> 0				x	x	x	2	2	2	2	2			
3	2P	3	3	6	0				2	2	2								
4	1P	2	3	10	<del>6</del> 2				1	1	S L								
5	1P	2	6	10	2							x	x	x	x	1	1		
6	1P	4	6	10	0							1	1	1	1				
7	1P	2	1 0	12	<del>0</del> -1											x	1	1	
Total resource load						2 P	2 P	2 P	3 P	3 P	2 P	3 P	3 P	3 P	3 P	3 P	2 P	1 P	
Resource available						3 P	3 P	3 P	3 P	3 P	3 P	3 P	3 P	3 P	3 P	3 P	3 P		

New network schedule network;



ES	ID	EF
SL	RES	SL
LS	DUR	LF

Fig.6.5

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## 6.6 LET US SUM UP

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The use of resources and their availability are very difficult issues for project managers to deal with. By paying attention to these things when making a project schedule, resource bottlenecks can be found before the project even starts. Project managers should know what will happen if they don't schedule their resources.

When you schedule resources, the results are often very different from what you'd get with the standard CPM method. With how quickly technology changes and how important it is to get products to market quickly, catching problems with resource use and availability before a project starts can save the cost of crashing project activities later. Any resource changes that don't conform to the plan and schedule can be quickly recorded, and their effects can be noted as the project is being carried out. If there was no quick way to receive updates, the true negative effects of a change might not be known until they occurred.

Connecting the availability of resources to a system with multiple projects and multiple resources helps a project priority process that chooses projects based on how much they contribute to the organization's goals and strategic plan. Some people may need to be a better fit for the projects given to them by computer software routines. The best course of action in these circumstances is almost always to find a workaround that suits each person's individual needs and abilities. The project resource schedule is important because it gives you a time baseline that you can use to figure out how much time is different between what you planned and what actually happened. Your time-phased project cost budget baseline will be built around the resource schedule.

The baseline (planned value, or PV) is the total of the cost accounts, and the total of the work packages in each cost account is the total of that cost account. Remember that if your budgeted costs aren't spread out over time, you don't have a good way to measure how well things are going. The cost baseline typically only includes the direct costs that the project manager can control, such as labor, materials, and equipment, despite the fact that there are many different types of project costs. Other indirect costs can be added to the project costs separately.

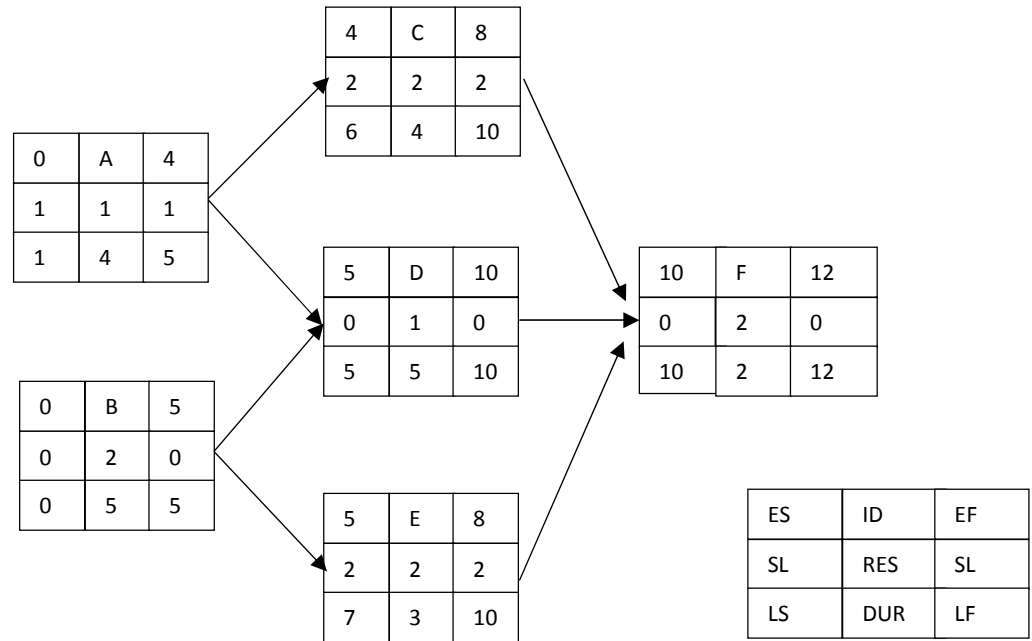
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## 6.7 SELF ASSESSMENT EXERCISES

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1. How does resource scheduling tie to project priority?
2. How does resource scheduling reduce flexibility in managing projects?
3. Present six reasons scheduling resources is an important task.
4. Why is it critical to develop a time-phased baseline?
5. You have prepared the following schedule for a project in which the key resources is a tractor. There are three tractors available to the project.

Activities A and D require 1 tractor to complete while activities B, C, E and F require 2 tractors.



## 6.8 FURTHER READINGS

1. Clifford F.Gray, Erik W. Larson, Gautam V.Desai, *Project Management: The Managerial Process*, 2010, Tata McGraw – Hill 6<sup>th</sup> Edition.
2. Jack R. Meredith & Samuel J.Mantel, 2010, *Project Management: A Managerial Approach*, 7<sup>th</sup> edition, Wiley India Edition.
3. Rory Burke, *Project Management: Planning and control Techniques*, 4<sup>th</sup> edition 2010, John Wiley & Sons.
4. Pinto Jeffrey K, *Project Management-Achieving Competitive Advantage*, Indian edition, Pearson
5. Jhon M.Nicholas, Herman Steyn. *Project Management for Business, engineering, and Technology*, 3<sup>rd</sup> edition, 2010, Elsevier



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## UNIT 7 PROJECT CRASHING

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### Objectives:

- How to reduce the project timelines when you're forced to complete the project before time?
- How to optimize the time and resources when there is time constraint?
- To find out the optimum time and resources required in case of reducing the project timeline / crashing the project timelines.

### Structure

- 7.1 Introduction
- 7.2 What is Project Crashing?
- 7.3 Time-Cost Relationship
- 7.4 Project Crashing Example
- 7.5 Let Us Sum Up
- 7.6 Self-Assessment Exercise
- 7.7 Further Readings

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## 7.1 INTRODUCTION

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Time is a very precious resource when it comes to project management. Schedules for each job or activity must be very carefully developed to ensure on-time completion of a project. But under certain circumstances and challenges, which may occur along a new project, it is necessary to adopt certain methods to overcome these challenges. As a project manager, you need to reassess and adjust a plan in response to arising needs. For this, there are several methods such as critical thinking, risk analysis and project crashing are used.

Crashing in project management relates to cost-evaluation of reducing those activities which are on the critical path. After which, the activities that correspond to the lowest cost for crashing should worked on. In this chapter, the underlying premise behind project crashing is explained and typical risks involved in a schedule crashing effort are described. Combined, the project crashing assessment and the risks can be brought to executive management when you advise them about how best to proceed with your project.

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## 7.2 WHAT IS PROJECT CRASHING?

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Crashing is a method used in project management that assists in boosting up the project timeline by employing additional resources in cases where the scope and deadline of the project cannot be changed instead, you're force to complete the project before time without compromising the scope. Although it will increase the cost of the project but in some cases, it is a good project

strategy to be exercised when you're forced to complete the project before time. There are several situations where one can think of crashing the project timelines, for example;

- When there is an emergency to complete the project before time
- When project is delayed due to unforeseen circumstances
- To avoid a delay in an upcoming phase of another project which is lined-up
- Availability of free resources

Since crashing a project entails a large budget increase for employing additional resources, it should only be used as a last resort when;

- It's impossible to delay the project deadline.
- It's impossible to reduce the scope of the project.
- When the cost of missing the deadline is greater than the cost of crashing the project.

That said, the best, and most effective time to begin crashing a project is as soon as the need for it is identified. But to be successful, project crashing should be calibrated, decided upon, and applied at the very start of a project for effective results.

Let's consider this simple project crashing example. Your team is tasked with launching a magazine to celebrate your company's 50th anniversary, but delays in approving the lead feature have caused the project to fall behind. In order to ensure the magazine is in hand by the anniversary party, an element of the project's scope that can't be changed, you choose to pay a rush fee for the printer. This project crashing step helped you meet the immovable deadline, but it also increased your project budget.

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## **7.3 TIME-COST RELATIONSHIP**

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Estimation of time required for the performance of an activity depends upon the quantity of resources. Except some fixed duration activities such as a gestation, crop duration etc. for which it is possible to manage the duration of an activity by varying the quantity of resources. For an instance, if cost is not a constraint, adding more resources to the project might reduce the time duration i.e., time is inversely proportional to cost. The relation can be better understood from the figure below. The time for the activity at minimum cost is called normal time and the minimum time for the activity is called crash time. The costs associated with these times are called respectively the normal cost and the crash cost. Although it is possible to estimate the time and cost associated with the normal and crash conditions for each activity it is difficult to estimate the time and cost at any intermediate stage between these two points. To overcome this difficulty, it is assumed that the relationship between the time and cost as linear in the range between normal and crash situations.

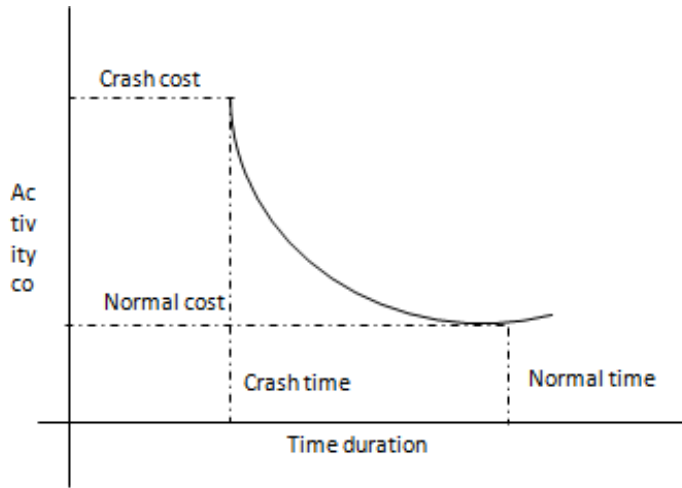


Figure 7.1: Time cost relationship

There is a possibility that when a project is crashed another non-critical activity may become critical and in next iteration this has to be considered for further crashing.

Steps involved in project crashing as follows;

1. Identify critical path and critical activity
2. Compute crash cost slope i.e.  $[(\text{Crash cost} - \text{Normal cost}) / (\text{Normal Time} - \text{Crash Time})]$
3. Select the activity with the least cost slope i.e., minimum crash cost per unit time.
4. Check for the critical path.

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

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## 7.4 PROJECT CRASHING EXAMPLE

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**Example 1:** The network and durations given in the following figure shows the normal schedule for a project. You can crash (decrease) the durations at an additional cost. The Table 7.1 given below summarizes the time-cost information for the activities. The owner wants you to complete the project in 110 days. Find the minimum possible cost for the project if you want to complete it in 110 days. Assume that for each activity there is a single linear, continuous function between the crash duration and normal duration points. Cost is given in dollars (\$) and time duration in days.

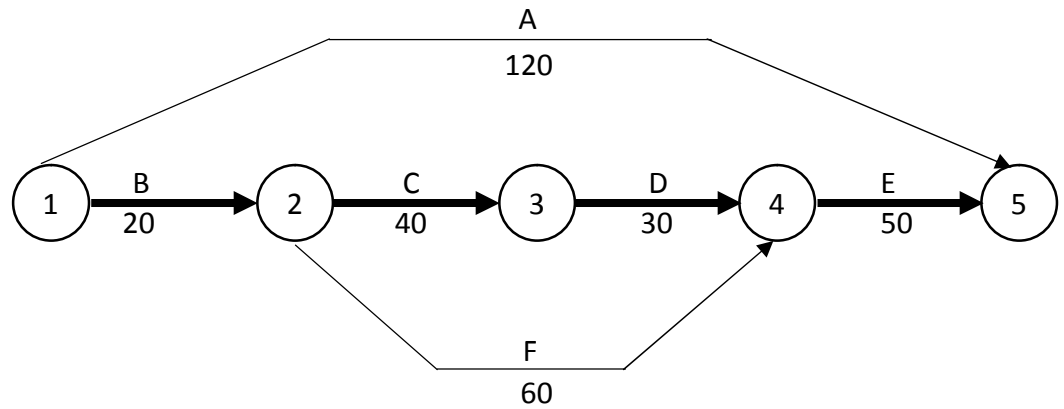


Figure. 7.2:

Table 7.1:

Activity	Normal Duration	Crash Duration	Normal Cost	Crash Cost
A	120	100	13000	15000
B	20	15	1500	2500
C	40	30	18000	22500
D	30	20	1300	2000
E	50	40	3200	4200
F	60	55	12000	13050

**Solution:**

Assume that the duration-cost relationship for each activity is a single linear, continuous function between the crash duration and normal duration points. Using the normal duration (ND), crash duration (CD), normal cost (NC), and crash cost (CC), the crash cost slope for each activity can be determined as follows;

$$S_A = \frac{CC - NC}{ND - CD}$$

$$S_A = \frac{15000 - 13000}{120 - 100} = \$ 100/\text{day}$$

$$S_B = \$200/\text{day}$$

$$S_C = \$450/\text{day}$$

$$S_D = \$70/\text{day}$$

$$S_E = \$100/\text{day}$$

$$S_F = \$250/\text{day}$$

The normal cost for the project is the sum of a normal cost for each activity. The normal cost for the project is \$49000 and the normal duration is 320 days. The activity which should be crashed is the one on the critical path which will add the least amount to the overall project cost. This will be the

activity with the flattest or least-cost slope. The duration can be reduced as long as the critical path is not changed, or a new critical path is created. In addition, the activity duration cannot be less than the crash duration.

$S_D = \$70/\text{day}$  (least-cost slope) Maximum of 10 days can be cut from this schedule by reducing the duration of activity D to the crash duration of 20 days.

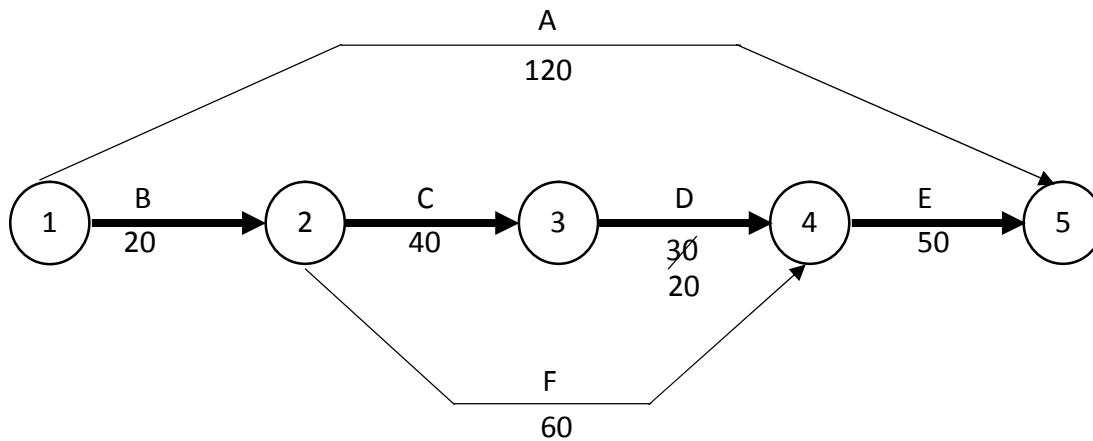


Figure.7.3

Overall duration is 130 days and there are multiple critical paths (B-F-E and B-C-D-E). Total project cost at this duration is the normal cost of \$49000 plus the cost of crashing the activity D by 10 days ( $70 * 10 = \$700$ ) for a total of \$49700.

The next activity to be crashed would be the activity E, since it has the least-cost slope (\$100 per day) of any of the activities on the critical path. Activity E can be crashed by a total of 10 days. Crashing the activity E by 10 days will cost an additional \$100 per day or \$1000.

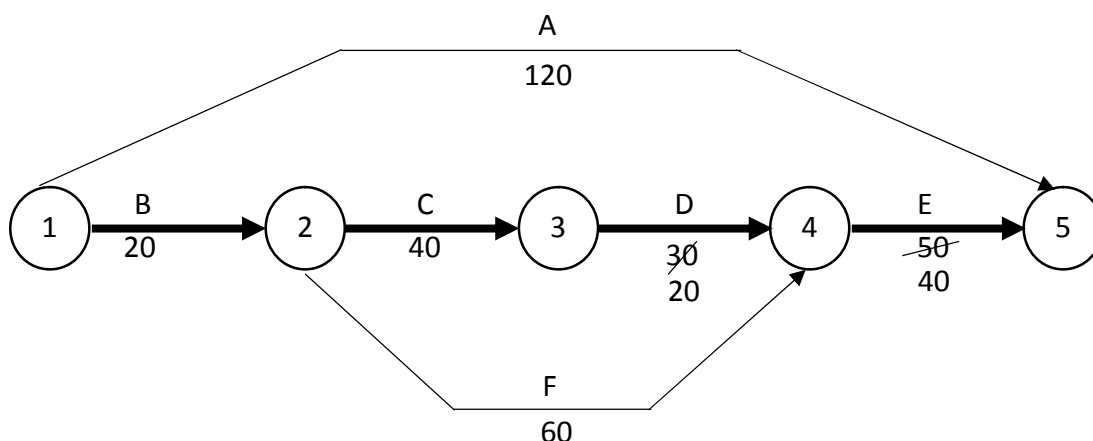


Figure. 7.4

The project duration is now 120 days and the total project cost is \$50700. There are now three critical paths (A, B-C-D-E, and B-F-E). The next stage of crashing requires a more thorough analysis since it is impossible to crash one activity alone and achieve a reduction in the overall project duration.

Activity A is paired with each of the other activities to determine which has the least overall cost slope for those activities which have remaining days to be crashed. Activity A (\$100) + activity B (\$200)

Activity A (\$100) + activity C (\$450) + activity F (\$250)

The least-cost slope will be activity A + activity B for a cost increase of \$300 per day. Reducing the project duration by 5 days will add  $5 \times 300 = \$1500$  dollar crashing cost and the total project cost would be \$52200. Activity B cannot be crashed any more.

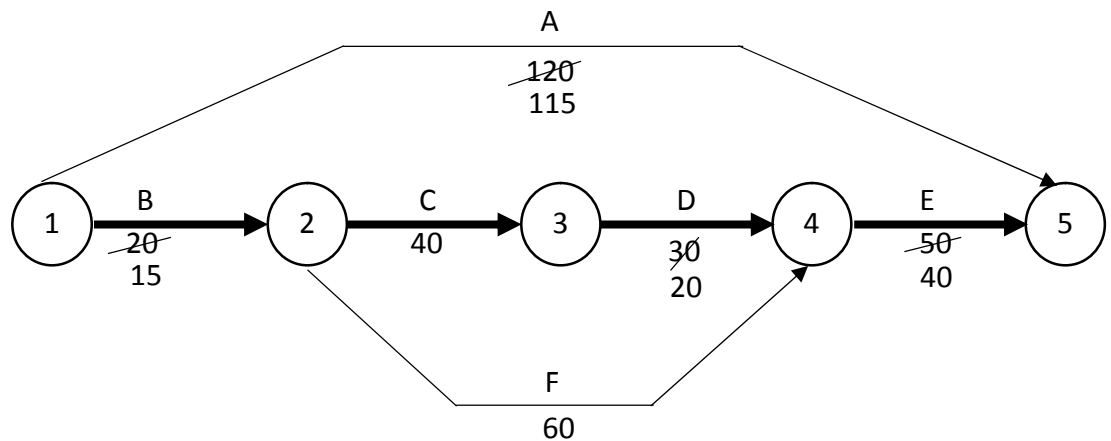


Figure. 7.5

Final step in crashing the project to 110 days would be accomplished by reducing the duration of activity A by 5 days to 110 days, reducing activity C by 5 days to 35 days, and reducing activity F by 5 days to 55 days. The combined cost slope for the simultaneous reduction of activity A, activity C, and activity F would be \$800 per day. For 5 days of reduction this would be an additional \$4000 in total project cost. The total project cost for the crashed schedule to 110 days of duration would be \$56200.

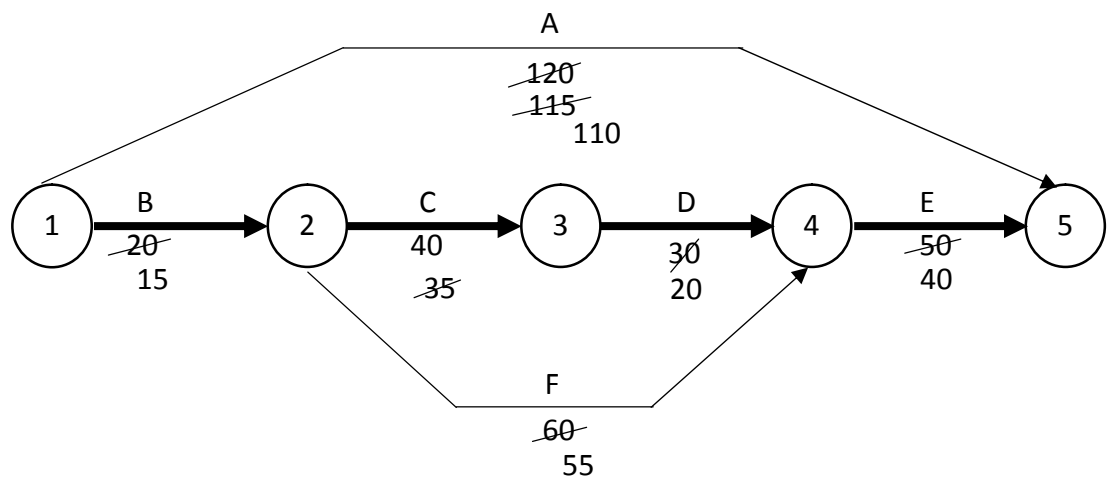


Figure. 7.6

## 7.5 LET US SUM UP

There are many things that can make it necessary to shorten the length of a project, such as time-to-market concerns, incentive contracts, the need for key resources, high overhead costs, or just delays that come up out of the blue. These are called cost-time trade-off decisions, and they happen all the time in real life.

This unit showed a formal, step-by-step way to figure out what will happen if the project is finished earlier than planned. Rushing through a project makes it more likely that it will run late. Depending on how sensitive the project network is, the amount of time that needs to be cut from the normal time to the best time varies. If a network has several critical or nearly-critical paths, it is considered sensitive.

When shortening sensitive networks, it is important to be careful so that project risks don't go up. On the other hand, insensitive networks offer the chance to save a lot of money on a project by getting rid of some overhead costs without much risk.

## 7.6 SELF ASSESSMENT EXERCISE

1. How often do projects crash, and what are the top five causes?
2. What are the benefits and drawbacks of decreasing a project's scope in order to move it along more quickly?
3. Why is putting projects on overtime a common strategy for rescheduling work? What potential drawbacks could this choice have?
4. How can a project manager use a cost-duration graph? Explain.
5. Shortening the project's duration raises the possibility of being late. Explain.
6. The critical path can be shortened in order to save money. Describe how
7. A project has activities with the following normal and crash times and cost in dollars (\$).

**Table 7.2:**

Activity	Predecessor Activity	Normal Duration (Weeks)	Crash Duration (Weeks)	Normal Cost	Crash Cost
A	-	6	4	18000	30000
B	A	7	5	14000	1000
C	A	4	3	19000	15000
D	B	8	6	34000	30000
E	C	2	1	3000	1500
F	D	7	5	12000	10000
G	E	4	2	15000	12000

Determine a crashing scheme for the above project so that the total project time is reduced by 3 weeks.

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## **7.7 FURTHER READINGS**

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1. Clifford F.Gray, Erik W. Larson, Gautam V.Desai, *Project Management: The Managerial Process*, 2010, Tata McGraw – Hill 6<sup>th</sup> Edition.
2. Jack R. Meredith & Samuel J.Mantel, 2010, *Project Management: A Managerial Approach*, 7<sup>th</sup> edition, Wiley India Edition.
3. Rory Burke, *Project Management: Planning and control Techniques*, 4<sup>th</sup> edition 2010, John Wiley & Sons.
4. Pinto Jeffrey K, *Project Management-Achieving Competitive Advantage*, Indian edition, Pearson
5. Jhon M.Nicholas, Herman Steyn. *Project Management for Business, engineering, and Technology*, 3<sup>rd</sup> edition, 2010, Elsevier.



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## UNIT 8 EARNED VALUE ANALYSIS

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### Objectives

After studying this unit, you will be able to:

- Define Earned value analysis.
- Able to measure and control the performance and progress of a project

### Structure

- 8.1 Introduction
- 8.2 Define Earned Value Analysis
- 8.3 Earned value Analysis Terms
- 8.4 Earned value – Performance metrics
- 8.5 Let Us Sum Up
- 8.6 Key Words
- 8.7 Self-Assessment Exercise
- 8.8 Further Readings

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### 8.1 INTRODUCTION

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In 1966, the United States Air Force mandated earned value management (USAF EVMS) in addition to the other planning and controlling requirements on Air Force programs, turning the idea of earned value management into a basic approach to program management (EVM project management). The Cost/Schedule Planning Control Specification (C/SPCS) was the name of the demand. The idea and the necessary conditions have essentially not altered over the years. Cost/Schedule Control System Criteria (C/SCSC), Earned Value Management Systems Criteria (EVMSC), and the present 32 guidelines in the EIA-748 Standard for Earned Value Management Systems have all undergone frequent modifications (EVMS).

Project managers use the Earned Value Management (EVM) approach to monitor how their projects are performing in comparison to project baselines. It's common to think of a project's progress as being ahead of schedule, behind schedule, or over budget. In this global era of highly competitive conditions, all the business practices operating in the public, as well as private sectors are made to operate faster than ever before. As a result, it is observed that industries are working on multiple projects simultaneously. To make these projects work, regardless of the scope, companies need skilled project managers. Project control is the activities conducted by the project managers within the horizon of monitoring and updating the project, which examines the current situation of the project and differentiates it from the initial project plan to develop a current plan suiting the actual situation. If there is a further delay in the project after updating, the manager may take

necessary steps to prevent the delay. Deviations happening in a project can be minimised by making a healthy decision using the proper tools. In addition to that, with the moving time, sustainable measures related to quality and cost should also need to be monitored. In this context, Earned Value Analysis (EVA) is a very much useful and efficient tool used widely. For the management of successful projects, project management presents several tools and techniques, of which, Earned Value Analysis is the most regarded one. It is a method used for measuring the performance project at any given point in time. A technique, that uses “work in progress” status to predict the future performance of the project.

To understand it better, let us consider you are a project manager working for a client that contracted with your firm to produce 5 software. You developed a plan to produce the five software during this year. In fact, the plan calls for 100 hours to be spent on each software. Finally, the ear ended, and five software were produced. At year-end, you check with the finance department to inquire about the total number of hours spent while developing the software. The finance team informs you that 400 total hours were expended to create the five software. At first, you are filled with a sense of accomplishment, in fact, dazzling accomplishment as you finished the planned five-hundred-hour production of software in 400 hundred hours, saving the company 100 hours that may be applied to other projects in need. Then, a sense of less-than-great feeling is recognized from deep within; why? What’s wrong with this picture?

Maybe it is the fear of the unknown that gives Earned Value a less-than-stellar review by many in the field. Information, which is power, can help hold project fear at bay. Therefore, this unit sets out with the fundamental expectation of providing the learner with basic information about Earned Value Management.

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## **8.2 DEFINE EARNED VALUE ANALYSIS**

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Earned Value Analysis is a method that allows measuring the amount of work actually carried out on a project rather than the basic review of cost and schedule reports. EVA provides a method that combines a project’s domain, and schedule, under a bound together situated metrics to monitor and forecast the project’s performance. The project manager is then able to use the progress measured, to forecast a project’s total cost and date of completion, based on trend analysis or application of the project’s “burn rate”. This method relies on a key measure known as the project’s earned value. Often, earned value is defined as the budgeted cost of worked performed. This basically, enables the project manager to compute performance indices or burn rates for cost and schedule performance, providing information on how well the project is doing or performing relative to its original plans. These parameters, when applied to future work, forecast how the project will do in the future, assuming the burn rates will not fluctuate, which oftentimes is a large assumption.



Figure 8.1: Risk management using EVA

## 8.3 EARNED VALUE ANALYSIS TERMS

As already discussed, Earned Value Analysis allows the project manager to answer the following three questions, as they relate to the project:

1. Where have we been?
2. Where are we now?
3. Where are we going?

In Earned Value Analysis, unlike in traditional management, there are three data sources:

- The budget (or planned) value of work scheduled (PV)
- The actual cost/value of work completed (AC)
- The earned value of the physical work completed (EV)

**Planned Value (PV):** It is the planned cost that has been estimated for the following project. PV explains how much the project work is supposed to be at any given point in the project schedule and cost estimate. Cost and Schedule baseline refers to the physical work scheduled and the approved budget to accomplish the scheduled work. PV can be looked at in two ways: cumulative and current. Cumulative PV is the sum of the approved budget for activities scheduled to be performed to date. Current PV is the approved budget for activities scheduled to be performed during a given period. This period could represent days, weeks, months, etc. PV, also known as Budget Cost of Work Scheduled (BCWS).

**Actual Cost (AC):** It is the total cost incurred directly or indirectly in completing a work on a particular project during a given period. This numbers tells what amount has been spent and, as with Planned Value, can be looked at in terms of cumulative and current. Cumulative AC is the sum of the actual cost for activities performed to date. Current AC is the actual costs of activities performed during a given period. This period could represent days, weeks, months, etc. AC is also called Actual Cost of Work Performed (ACWP).

**Earned Value (EV):** It is the estimated value of the work that has been actually completed. To understand the accomplishments of the project, EV is applied to the numbers and calculations in the project. EV basically quantifies the worth of the work done to date. EV can be presented in a Cumulative and Current fashion as well. Cumulative EV is the sum of the budget for the activities accomplished to date. Current EV is the sum of the budget for the activities accomplished in a given period. Earned Value is also called Budgeted Cost of Work Performed (BCWP).

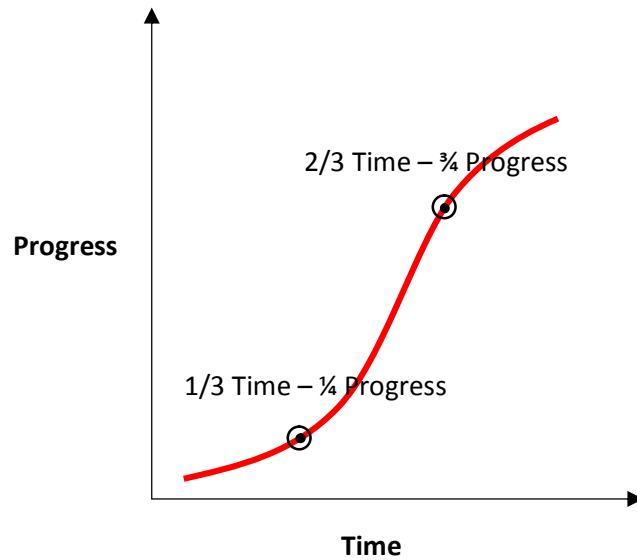


Figure 8.2: Earned value – The standard Curve

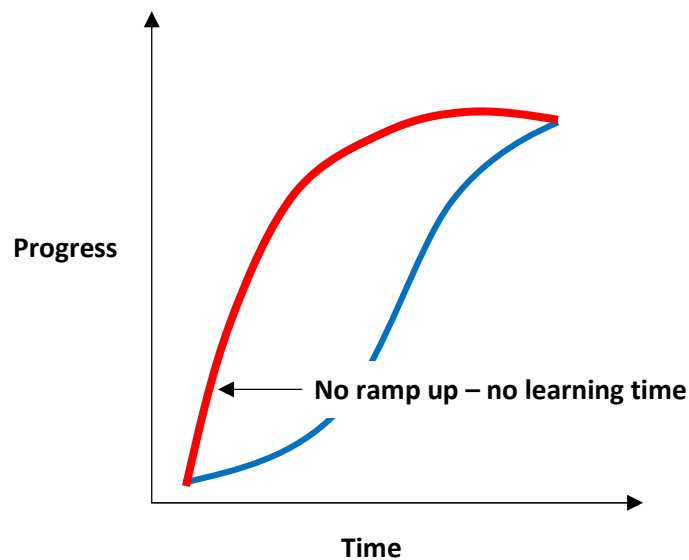


Figure 8.3: Earned value – The Aggressive Curve

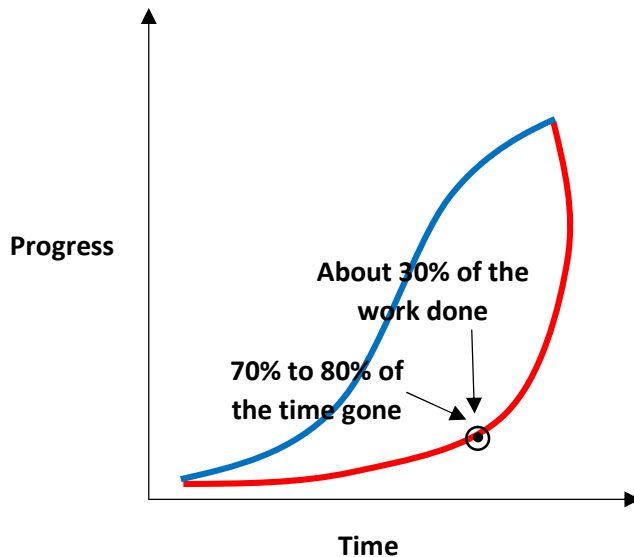


Figure 8.4: Earned value – The Curve to avoid

## 8.4 EARNED VALUE- PERFORMANCE METRICS

**Cost Variance (CV):** It is the difference between earned value and actual costs. ( $CV = EV - AC$ ). Sometimes it is also expressed as the difference between budgeted cost of work performed and actual cost work performed. If the variance is equal to 0, the project is on budget. If a negative variance is determined, the project is over budget and if the variance is positive the project is under budget.

**Schedule Variance (SV):** It expresses the difference between work that is ahead or behind the plan and reflects a given measurement method. The formula utilized to express schedule variance is project earned value minus the project planned value as of the date of examination. ( $SV = EV - PV$ ) If the variance is equal to 0, the project is on schedule. If a negative variance is determined, the project is behind schedule and if the variance is positive the project is ahead of schedule.

**Schedule Performance Index (SPI):** It is the measure of schedule efficiency on a project. It is the ratio of earned value (EV) to planned value (PV). The SPI is equal to earned value divided by planned value, ( $SPI = EV/PV$ ). An SPI equal to or greater than one indicates a favourable condition and a value of less than one indicates an unfavourable condition.

**Example:** Calculation show a SPI of 1.4, that means project recognizing Rs. 1.40 for every Rs.1.00 spent to date on project. Assuming SPI efficiency remains throughout the remainder of work, project will finish ahead of schedule.

**Cost Performance Index (CPI):** It is as a measure of cost efficiency on a project. It is the ratio of earned value (EV) to actual costs (AC). The CPI is equal to the earned value divided by the actual costs, ( $CPI = EV - AC$ ). A CPI equal to or greater than one indicates a favourable condition and a value of less than one indicates an unfavourable condition.

**Example:** Calculation show a CPI of Rs. 0.50, that means project recognizing Rs. 0.50 for every ₹ 1.00 spent to date on project. Assuming CPI efficiency remains the same throughout the reminder of work, project will be over budget.

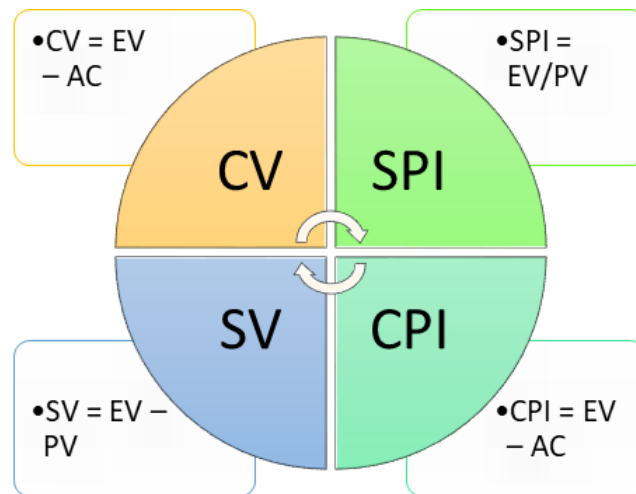


Figure 8.5: Earned value performance metrics

### Index values

<1: Over budget or behind schedule

>1: Under budget or ahead of schedule

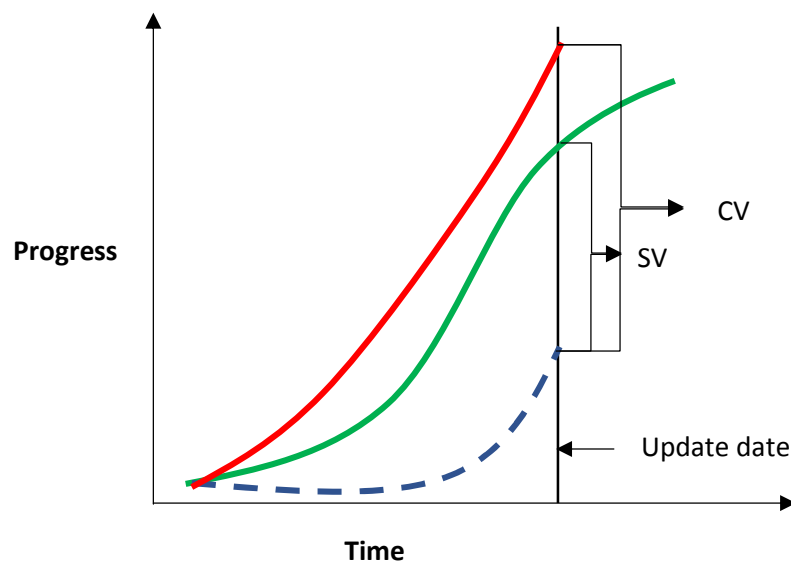


Figure 8.6: Earned value analysis curve

### Example 1:

1. You are the project manager on a project that has Rs. 900,000 in the product development effort. There are two teams of workers that will work for six months for a total of 12,000 hours. According to the project schedule, your team should be done with 34% of the work. As of today, the project is 37% complete, while 48% budget has been used. Calculate and share your conclusion.

**Solution:**

Budget at Completion (BAC) = Rs. 900,000 (given)

AC = Rs. 432,000 (48% budget used)

PV = BAC × Planned % Complete

$$= 900,000 \times 0.34 = \text{Rs. } 306,000$$

EV = BAC × Actual % Complete

$$= 900,000 \times 0.37 = \text{Rs. } 333,000$$

CV = EV – AC

$$= 333,000 - 432,000 = -99,000$$

CPI = EV / AC

$$= 333,000 / 432,000 = 0.77$$

SV = EV – PV

$$= 333,000 - 306,000 = 27,000$$

SPI = EV / PV

$$= 333,000 / 306,000 = 1.08$$

Since CPI is less than 1, the project is over budget

And since SPI is more than 1, the project is ahead of schedule.

**Check Your Progress 1:**

For the following project, calculate SV, CV, SPI and CPI at the end of the second month.

Month	1	2	3	4
Planned Value	Rs. 11,10,000	Rs. 6,00,000	Rs. 25,00,000	Rs. 8,00,000
Earned Value	Rs. 10,00,000	Rs. 7,50,000		
Actual Cost	Rs. 12,50,000	Rs. 5,00,000		

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**Check Your Progress 2:**

You are managing a software project which is into eight months of its execution. You are now reviewing the project status, and you have ascertained that the project is behind schedule. The actual cost of Activity A is Rs. 4,00,000 and that of Activity B is Rs. 2,00,000. The planned value of these activities is Rs. 2,80,000 and Rs. 80,000, respectively. The Activity A is 100% complete. However, Activity B is only 82% complete. Calculate the schedule performance index and cost performance index of the project on the review date.

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## 8.5 LET US SUM UP

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In short, the project manager and the project team should make an effort to make sure that the realized value of their project is always more than the projected value and the actual cost booked on the project. Proper data collection and computation of the project’s completion percentage are essential to the success of earned value analysis. Each person interprets the percentage of work completed in their own unique way. Because of this, The Practice Standard on Earned Value Management outlines the procedures to be used for calculating the percent of work completed for various project activity types and scenarios.

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## 8.6 KEYWORDS

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**Planned Value (PV):** The budgeted cost for the planned work is the planned value (BCWS). PV fluctuates depending on the size of the project under consideration and where you are in the overall timetable.

**Actual Cost (AC):** The cost expended for carrying out work on a project is known as the actual cost (AC), also known as actual expenditures.

**Earned Value (EV):** EV measures the “value” of the job completed so far. In other words, EV explains the project’s accomplishments in concrete terms. EV can be expressed in a Cumulative and Current manner, just as PV and AC.

**Cost Variance (CV):** It is defined as the discrepancy between the actual cost incurred while carrying out the scheduled activity and the anticipated cost of work accomplished (earned value).

**Schedule Variance (SV):** It is a measure of the schedule performance of the project. It can be expressed as the difference between the budgeted cost of work scheduled (planned value) and work performed (earned value).

**Schedule Performance Index (SPI):** SPI is a measure of the schedule efficiency of the project and indices if the project is ahead of the baseline schedule. SPI can be expressed mathematically as Earned Value divided by Planned Value. **Schedule Performance Index (SPI) = Earned Value (EV) / Planned Value (PV)**

**Cost Performance Index (CPI):** CPI is the measure of how efficiently the budgeted resources are being utilized on a project. It is mathematically expressed as Earned Value divided by Actual Cost. **Cost Performance Index (CPI) = Earned Value (EV) / Actual Cost (AC).**



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## 8.7 SELF-ASSESSMENT EXERCISE

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1. What do you mean by the term 'earned value'? Explain.
2. What is Earned Value Management (EVM)? Discuss the roles of EVM in Project Management.
3. What are the top three EVM performance measures? Discuss.

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## 8.8 FURTHER READINGS

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Project Management Institute. (2004) A Guide to the Project Management Body of Knowledge (PMBOK® Guide). (Third ed.) Newtown Square, PA: Project Management Institute

Project Management Institute. (2005) Practice standard for earned value management (PMI Global Standard) (2005 ed.) Newtown Square, PA: Project Management Institute

Government Electronics and Information Association. (2002) Earned value management systems Approved: May 19, 1998. Reaffirmed: August 28, 2002. ANSI/EIA-748-A-1998

United States Department of Energy (2005) Earned value management application guide, version 1.6. January 1, 2005. Office of Engineering and Construction Management.

Reichel, C. W. (2006). Earned value management systems (EVMS): "you too can do earned value management" Paper presented at PMI® Global Congress 2006—North America, Seattle, WA. Newtown Square, PA: Project Management Institute.



## **BLOCK 3**

# **PROJECT MONITORING AND CONTROL**

Unit 9 Project Management Information System

Unit 10 Project Monitoring and Control

Unit 11 Project Risk Management

Unit 12 Agile Project Management



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## **UNIT 9 PROJECT MANAGEMENT INFORMATION SYSTEM**

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### **Structure**

- 9.0 Objectives
- 9.1 Introduction
- 9.2 Objectives of Project Management Information System
- 9.3 Planning by Network Analysis
- 9.4 Cost Control Systems
- 9.5 Integrated Project Management Information System
- 9.6 Project Monitoring and Reporting
- 9.7 System Automation and Computerization
- 9.8 Let Us Sum Up
- 9.9 Self-Assessment Exercises
- 9.10 Further Readings

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### **9.0 OBJECTIVES**

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After studying, this unit you will be able to understanding:

- Role of management information system (MIS) in implementation and control of projects
- Vital role of feedback from events generated by project implementation for all the phases of project management
- Advantages of integrating MIS with planning, scheduling, reporting, reviewing and updating of projects
- Productive role of MIS in evaluating impact of delays on future events and triggering of corrective remedial measures
- Appreciation of different types of reports and their frequency
- Role of computers in accelerating compilation and transmission of reports to aid decision making at all levels and in dispersed locations.

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### **9.1 INTRODUCTION**

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A project is typically an assignment that has identifiable start and finish and consists of a series of discrete, finite tasks. Setting up an industry, building a house, publishing a book or introducing a new product are all example of projects. All of them have identifiable beginnings, endings and are comprised of a series of finite tasks. In contrast, maintaining a clean office, using a product or understanding a book are not projects - they are continual and repeating processes with no predictable starts or finishes. Project Management offers methods and techniques for planning and controlling projects. A good Project on time and at cost closest to the one originally

envisaged. Any delay in the implementation, delays the anticipated benefits which were planned from the establishment of the project. In certain cases minor delays can often result in major losses. Similarly, any increase in the project cost adversely affects economic viability of the project. In the cases of large cost overruns, it may not be possible to arrange sufficient funds to complete the project in time causing unplanned delays in the project implementation.

The three primary phases of project management are :

- a. **Planning:** In this phase, you identify the general requirements of a project, break it down into discrete activities, determine the sequence and interdependence of these activities, estimate resource requirements and find the "Critical Path".
- b. **Scheduling:** This phase overlaps with the planning phase. You give actual calendar dates to the activities and determine the overall project dates. Calculate the early and late start and finish times for each activity of the project.
- c. **Implementation and Control:** The implementation phase which is also the control phase begins once the project is underway. Here you employ a variety of techniques to achieve optimisation of resources usage, monitor progress and cost, forecast completion dates and overall project cost and ensure that critical activities are completed on time.

A major project encompasses numerous areas and disciplines. Each operates as a separate autonomous unit. Integration is the approach of bringing them together. It is the key to effective project management. Project success is completely dependent on adequate planning, direction, scheduling, monitoring and control. These project functions must be closely bound together by an adequate information and control system if project performance is to be adequately measured and controlled. For efficient project operation, a single information and control system should be used, not separate project and functional department cost control systems. The integrated information and control system should be compatible with the needs of the project and the functional managers.

The success of timely implementation of projects depends on the availability of essential information at appropriate time. Normally, the information needed at different levels would depend on the hierarchical structure in a project. In large projects, there could be three distinct levels, viz., the top or corporate level, the general or executive management level and the functional or operating management level. The information needs of all these three levels are not the same. Therefore, the information system has to be designed in such a way that the needs of all these three levels are adequately taken care of. In a project, the information reports are basically used for project monitoring and control with the idea to ensure that the projects are executed as per schedule and at minimum cost. The social cost of delay can be of a very high order and, therefore, the need for timely completion of the projects is of paramount importance.

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## 9.2 OBJECTIVES OF PROJECT MANAGEMENT INFORMATION SYSTEM

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The project information/monitoring system would have to have the following objectives:

- Record and report relevant information and the status of various components of the project in such a manner as to bring the most critical activities directly to the attention of concerned managers at appropriate level.
- Highlight deviations from the plan, if any, in respect of every component of the project and also to indicate the effects of such deviations on the overall status and completion of the project as a whole.
- Form the basis of updating of project schedule wherever necessary.
- Identify and report on critical areas which are relevant to different levels of management and to highlight the corrective action that needs to be taken.
- Sift the information and report on an exception basis. In other words, emphasis is focused on those activities that are not going according to the plan.
- Provide a basis for the evaluation of the performance of the functions of various managers and departments by regular comparisons with budgets/plans/schedules.

Mere physical progress reporting and monitoring does not ensure timely completion of the project at the minimum cost. Along with monitoring on physical status, another parameter namely, value of work done and cost implication of delays in commissioning the project should also be monitored. For this purpose, the physical progress of each activity has to be converted into monetary terms, using unit rates established by apportioning the cost over all the activities.

In designing project management information system, the following have to be spelt out clearly:

- The objective of each format or report in brief.
- The distribution chart.
- The periodicity of the reports.
- The persons responsible for preparation of the reports.
- The timing of the reports.
- The sources from which information has to be gathered in the preparation of reports.

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## 9.3 PLANNING BY NETWORK ANALYSIS

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The basic premise of the project network planning method is that a network can be used to reasonably represent performance sequence of a project. Complexities of modern projects have made network scheduling mandatory for adequate project control. Experience shows that total project duration derived by breaking project down into discrete activities and basing each activity estimate on the planner's experience and historical data is valid and useful.

### A. Resource Allocation

By using positive float available on non-critical path through the project, the project planner can arrange a schedule of work that accomplishes the result in the same time while smoothing or levelling the peaks and valleys in the resources to be consumed.

### B. Work Breakdown Structure (WBS)

Project WBS breaks the total task into a logical series of smaller tasks, each of which is chosen for size and scope to fit in with the management structure of the project so that it can be subject to efficient planning and execution. The WBS of a large construction project is depicted in figure-1 (a) and 1 (b). It may be observed that work package is a logical chosen to suit the requirement of engineering, planning, contract administration and cost control. Each 'work package carries a duration and cost control.

The essentials of WBS are:

- Work packages are related to organizational break down for effective control and performance measurement.
- Cost. estimates are built up by aggregating the cost of work packages following a logical WBS of the project.
- Work packages must be related logically to the code of account applicable to the project to enable exercise of effective cost control function.

### Activity 1

Time is one of the most critical accesses variables in projects. List down the advantages of monitoring and controlling 'time duration' of projects.

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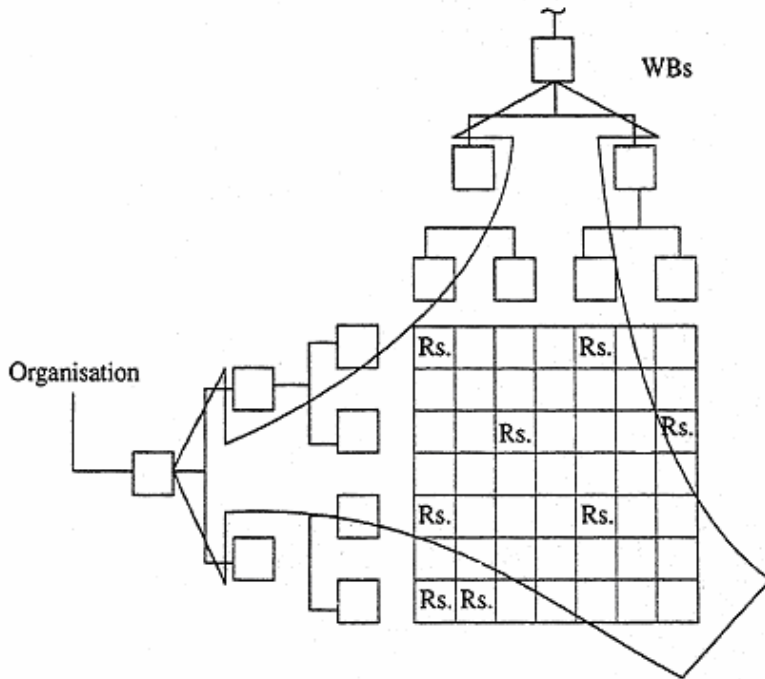


Fig 9.1: Work breakdown structure

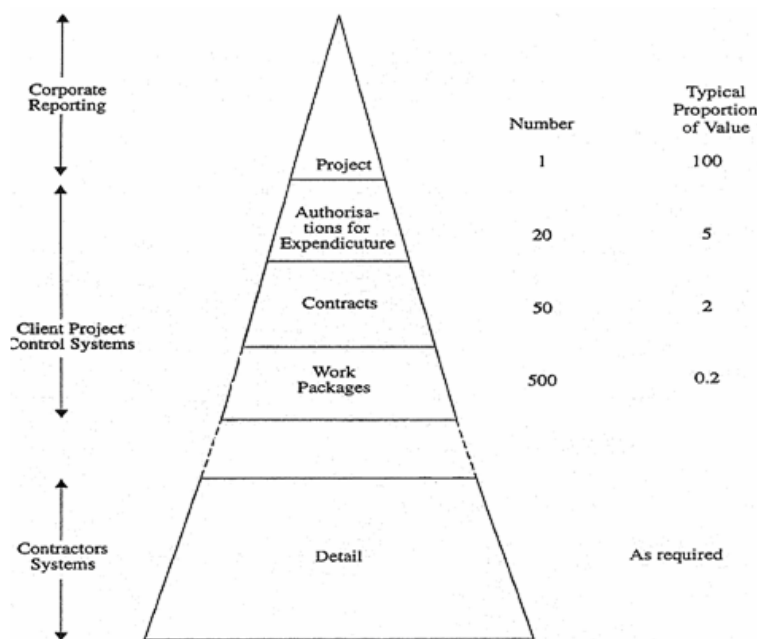


Fig. 9.2: Work break down structure for large civil engineering or construction project

## 9.4 COST CONTROL SYSTEM

Effectiveness of the project cost control system<sup>1</sup> is largely dependent upon the following:

- Realistic estimation of cost at initial stages.
- Adequate provisions for contingencies at initial stages.
- Effective cost reporting system.

- d. Timely identification and implementation of effective cost control measures.

Realistic estimation of cost at initial stages practically' forms the back-bone of any effective cost control system. Typical elements that affect estimate accuracy are generally known and well documented in technical publications and elsewhere, although their effect may be difficult to quantify.

There will be an element of risk in a cost estimate for there is no such thing as an "Accurate cost estimate". What exactly contingencies are intended to cover should be made perfectly clear.

The efficacy of the project cost control system. is largely dependent upon the cost reporting system. Effective cost reporting system should not only incorporate information on actual cash flows but also full information on commitments being made or likely to be made by various responsible executives for the activities under their control.

Periodic review of estimated cost to completion (ECTC) is an essential feature of an effective cost control system. ECTC for each package or activities according to responsibility centres, should be compiled on the basis of actual commitments entered into, likely commitment under, processing as well as anticipated commitments to completion of the package/activity during every reporting cycle, The ECTC for all the packages/activities comprising the total project scope will give the latest estimated cost to completion for the project.

Adoption of best possible methods for realistic estimation of cost, making adequate provisions for contingencies at initial stages as well as' having appropriate cost reporting system alone is not enough for controlling the project cost, Identification of problem areas and timely implementation of effective remedial measures only can help in keeping the project cost in check.

Periodicity of project cost review should be established on the basis of the ability of the organization to furnish h information required for the cost reporting system as well as the extent of delays that can be tolerated by the management in the identification and implementation of cost control measures. In case it is practical to install effective cost reporting system for weekly cost reporting, the same would be ideal.' However, for a large organization, collection and compilation of reliable information related to project cost for various package/activities for all on going projects and forwarding the same to the Corporate Head-quarters becomes an problem in the absence of effective channels of communications. In such cases at least a monthly review should be undertaken. Periodicity should certainly not be less than once a quarter to be able to exercise any meaningful control on project cost.

## Activity 2

Think of a procedure of cost monitoring of projects which aims to support cost- efficient design and engineering.

## 9.5 INTEGRATED PROJECT MANAGEMENT - INFORMATION SYSTEM

Structure of a typical integrated project management information system is depicted in figure-9.3: It allows total project information to be structured into a number of data sets which are integrated by the software. Some of the relevant datasets for a large project are:

- Drawing dataset
- Network dataset
- Cost dataset
- Material dataset
- Vendor dataset
- Job card dataset
- Rates dataset
- Resources dataset
- History dataset, etc

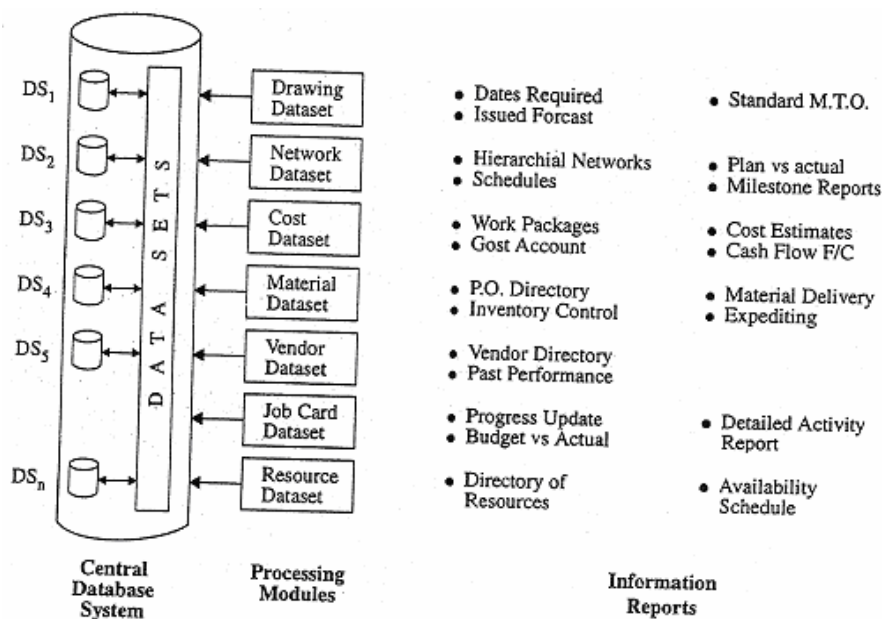


Fig. 9.3: Integrated Project Management System

Integration of these independent datasets through various processing modules enables high control of projects. It permits:

- Horizontal integration between disciplines, e.g., cost/schedule integration, or, cost estimates, cost accounts and project schedule integration via Work Breakdown Structure:

As illustrated in figure 9.3 availability of integrated performance reports to higher management is thus possible.

- Vertical integration. Data can be aggregated ('rolled up') to any required level to produce desired summary reports.

Standard processing modules are available for all important project management methods plus other modules for special requirement.

a. Drawing Dataset it contains information on

- Drawing number
- Drawing description or title
- Date drawn
- Date first issued
- Subsequent revision numbers and issue dates
- Draughtsman's name and his department
- Schedule of quantities (standard material take off), etc.

Management control is exercised through queries such as :

- Identify all drawings which are not yet approved.
- Drawings which are due for issue in the next four weeks.
- Listing of drawing for a specific area of the project.

By linking the Drawing Dataset with Network Dataset, anticipated drawing issue dates can be compared with on-site required dates for various activities. Efficient retention and easy access of information are the key to several record management applications.

- b. **Network Dataset:** Vertical integration enables a project to be structured into hierarchical networks, where a top-level network may contain about 15Q to 200 activities and this is driven by a second or third level network having many more activities.

Progress information on lower-level networks can be 'rolled up' and summarized to the management level network.

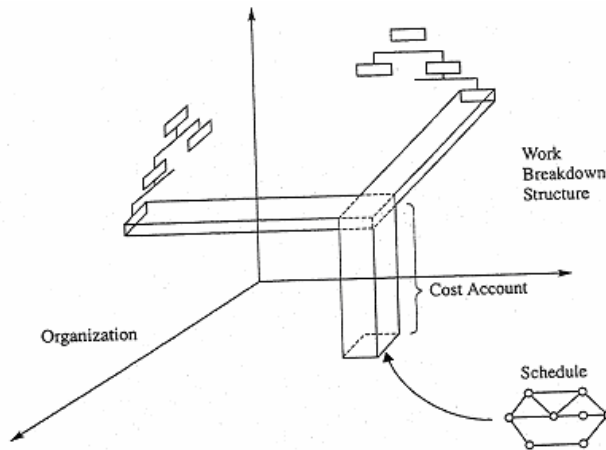


Fig. 9.4: Project and Schedule Integration

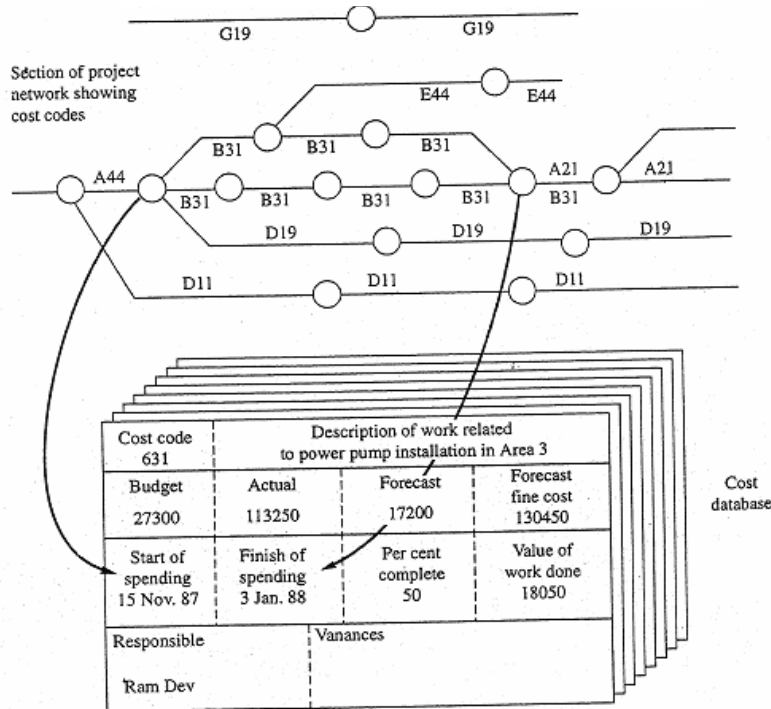


Fig. 9.5: Linking the project network to the cost database

Key events or milestones reports highlight the deadlines:

- c. **Cost Dataset:** This dataset contains details of each project cost account. This is based on a defined work package with an identified manager and reflects the logical WBS of the project discussed earlier. A large project could contain several thousand records, usually structured so that the cost can be 'rolled up' to show the position on each section of the project and the overall position. The fields of information usually include.

- Account code or cost code
- Description of the work package
- Person responsible
- Budgeted provision
- Actual cost of date of work completed
- Cost forecast of residual works taking into account 'change orders', etc.

As a result of integration of cost data set with project schedule; effective cost control is now possible. As shown in figure-9.5, dynamics of time/cost trade-off can be examined in a more scientific manner after-assessing overall implications before a final decision is made. Cost dataset in conjunction with current schedule can be used for cost forecasting.

- d. **Material Dataset:** It contains all the information on the materials required, the dates when they are required, and the manufacturing location for each item. A typical material management system begins with material take-off(MTO) from the drawings, covers the entire bidding, procurement, expediting and shipping process, and extends through to site inventory control. Examples of specific functions served by a material control system include

- Material Register
- Inventory Control
- Delivery Analysis
- Bulk order discounts
- Purchase order
- Material Quality Assurances

Typical management queries from such a system relating to a specific area, such as "expediting" would include :

- Materials required at the site in the next 4 weeks.
- Late materials only, grouped by vendor or manufacturer.
- All materials expected ex-works this week.

- e. **Vendor Dataset:** This provides a record for each supplier, his name, address, telephone and telex numbers, the name of the usual person to contact and line of business. The details of past performance will be included for use in vendor rating and initial choice of vendor. The terms and conditions of contract, 'progress, payment schedule, history of delivery and many other pieces of information about vendor can all be stored, related and accessed. Because information relationship can be identified to properly linked multiple datasets, data duplication is reduced in the project data base. For example, the vendor's code is identified on the material package record in the material dataset that is also linked to the vendor dataset which contains names, addresses and other pertinent information.

- f. **Job Card Dataset** Job Card carries details of each job performed on the project. "Typically, the job card level is directly below network planning in the project hierarchy and facilitates day to day planning.

- Job Description
- Budgeted amount

- Planned start and finish dates
- Resources required for executing the job

It includes procedures for progress control and effectively provides the mechanism for allocating Work, collecting project information and (via the relational data base) updating the rest of the project systems.

A large organisation engaged in a large number of power projects has evolved a system of information reporting, covering the project as a whole and construction activities separately. A last of a model reporting and monitoring system in line with the system of the above company is indicated later in this chapter.

This very comprehensive and detailed system has been given only as a model as it covers every area of Project Implementation. Each project has to, on the basis of nature of the project requirements and its management set up, design its own information/ monitoring system. The underlined idea is that the information required for corrective action should be available at the appropriate time. In addition to these reports, it would be more appropriate, to deliberate and take stock of the situation periodically by having meetings with all the functional heads wherein critical analysis of the performance in all areas of the project management can be made and decision on the course of action taken.

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## **9.6 PROJECT MONITORING AND REPORTING**

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In order to keep track of the project's status and head off problems before they occur, it is important to regularly report activity progress.

You report progress along the dimensions applicable to the activity. For example, certain activities involving creative work can not be accurately assessed in terms of physical percent completion. However, for certain: other activities you can easily gauge duration complete and remaining duration. By regularly reporting progress you can anticipate the shifts in float and criticality that inevitably occur. An activity not previously on the critical path might become critical if the start of its predecessor is delayed. By the same token if an activity finishes sooner than expected, it may create some float for a previously critical activity. Thus reporting progress allows you to anticipate resources shortages and schedule delays and with luck, to work around them. After reporting progress against each date, you should create a new schedule. This schedule reflecting actual performance is referred to as a Current Schedule. You compare your first set of current schedules to your target schedules. Then as the project proceeds, establish new targets to compare to current schedules. In this way you can always identify where the project is deviating from the goals you have established.

### **A. Project Monitoring Reports**

#### **i. Overall Status Report**

- Monthly project status report
- Delay report assessment
- Township progress report

**ii. Value Reports**

- Format for contract cost allocation
- Activity cost breakup
- Record for compilation of value of work done
- Value of work done (project)
- Summary of value of work done (site)
- Report on value of work done (site)
- Contract progress report
- Project value report

**iii. Contracts**

- Schedule for contract activities
- Schedule for mile-stones activities
- Contract package-wise activities
- Contract progress summary
- Departmental performance summary
- Contract progress summary
- Delay report – contracts

**iv. Contractor's Works**

- Activities schedule - contractor's works
- Physical progress summary - contractor's works
- Bulk material procurement progress
- Delay report - contractor's works
- Schedule activities
- Physical progress targets
- Delay report-site
- Physical progress report
- Report on construction machinery deployed
- Contractor's manpower status report
- Bulk material procurement progress
- Daily critical activities progress report
- Daily progress record
- Daily progress report



**v. Infrastructure**

- Schedule for site contracts
- Site contracts progress summary
- Infra-structure progress report
- Infra-structure progress summary

**b. Management Report**

The fundamental principle on which the management reporting, structure is to be built up is the "Exception basis of reporting". The system must provide for comparison of actual performance and expenditure with plans and budgets and an analysis of deviations from plans reason-wise. To a large extent the reports should highlight information for effective control on quantity, time and cost of activities within a function. In certain areas like rejection of incoming material which are not planned, the reporting would not be against budget or targets but in absolute terms:

The reporting system assumes a comprehensive system of performance budgeting and activity planning. In designing the reporting systems the activities of the undertaking have to be broken up functionally according to the current and planned organisation structure and further into sub-functions depending on the nature. As far- as possible the system should cover each such sub-function. Each report could cover one of the sub- function and analyse the performance

The forms should be designed to print the actual results (for the period and cumulative for the year) and comparisons with previous periods and with what was planned (for the current period and cumulative for the year). All forms can provide a remarks column for explanatory notes, overall remarks, and notes on extraordinary events which have a bearing on the period performance.

**i. Technical Services**

- Status on project engineering report
- Contracts status report
- Achievement of objectives report

**ii. Materials**

- Inventory status report
- Inward rejection report
- Material issued to contractors report
- Delays in procurements report
- Delays in supplies report
- Demurrage paid report

**iii. Construction Facilities**

- Construction equipment control report
- Construction utilities control report
- Maintenance report
- Auto base control report

**iv. Personnel**

- Manpower and recruitment Report
- Staffing report
- Training and development report
- Manpower cost report
- Divisional manpower cost report

**v. Finance**

- Funds report
- Loans utilisation report
- Payments to contractors report
- Cash flow report
- Cash flow analysis report
- Divisional cash flow report
- Indirect expenses report
- Indirect expenses analysis report
- Divisional indirect expenses report
- Divisional indirect expenses analysis report
- Expenses control report.

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## **9.7 SYSTEM AUTOMATION AND COMPUTERIZATION**

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Modern project control methods are most successful when automated, as has been found necessary to handle today's very complex and large projects. Considerable thought has to be given in the development of appropriate system to take care of collections of reliable information, its compilation, analysis and presentation of the same to various levels of management according to their own requirement and spans of control. The system will generally comprise of an extensive electronic data bank, development of detailed reports for various users and identification of effective control measures at appropriate levels which percolate down in time to be able to achieve their envisaged objectives.

***Activity 3***

Computerization enjoys: quantification. List down some aspects of reporting on vendors management which cannot be quantified but are rather important

feedbacks for project management.

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## 9.8 LET US SUM UP

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MIS forms the nervous system of the entire project. It can be clustered as the monitoring of a patient in an intensive care centre of a hospital. The various components and levels of MIS should be so designed as to aid decision-making as we proceed with project implementation. Projects involve very large matrix of organisation. MIS design and administration should be able to provide the vital link of communication and foster healthy competition. In projects, techniques of information is extremely important- if information is 24 hours late, we call it a 'stale' information, if it is 48 hours late, we call it a 'ruined' information and if it is seven days late, we call it ancient history'.

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## 9.9 SELF-ASSESSMENT EXERCISES

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1. Draw of an MIS for a 4-storeyed brick and residential building assuming that there is a magnificent component of marbling, tiling and sanitary work.
2. Design a simple reporting format 'which monitors conversion of purchase indents with orders. Assuming that no purchase indent shared be delayed more than eight weeks, how would you incorporate it in the above report.
3. Comment on, "MIS is not new but computerisation of MIS has added new dimension to it."
4. MIS is a 'feedforward' rather than a 'feedback' system in project management. Justify.
5. List down specific areas at a construction site where computers can be used for effective project management.

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## 9.10 FURTHER READING

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1. Davis GB & Olson M.H., *Management Information Systems*, McGraw-Hill International Editors
2. McRae. TW, *Management Information Systems- Selected Readings*, Penguin.
3. Basandara, S.K., *Computers for Management*, Global Press, New Delhi.
4. Kanter. J, *Managing with Information*, Prentice Hall of India, New Delhi.

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## UNIT 10 PROJECT MONITORING AND CONTROL

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### Objectives

After studying this unit, you should be able to:

- Understand the meaning of project monitoring and control.
- Understand the importance of monitoring and control process.
- Apply appropriate control measures for project success.

### Structure:

- 10.1 Introduction
- 10.2 Types of Project Control Systems
- 10.3 Project Monitoring and Control Plan
- 10.4 Gantt Chart
- 10.5 Earned Value
- 10.6 Technical Performance Measurement
- 10.7 Let Us Sum Up
- 10.8 Key Words
- 10.9 Self-Assessment Exercise
- 10.10 Further readings

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### 10.1 INTRODUCTION

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Today, in organizations, managing projects successfully have become one of the most critical aspect. Competition, becoming fierce daily, and completing projects on time, within budget and of good quality requires controlling and monitoring the project activities. Project monitoring and control aim at minimizing the deviations from the project plans by comparing them with the plan, analysing the deviations, and implementing the appropriate corrective actions.

**Monitoring** is about collecting sufficient data to measure progress and making sure that the project team implements the plan correctly, whereas **Control** is the process of ensuring that the project delivers everything as intended according to schedule, cost and quality by taking corrective actions. Control is based on a comparison of baseline plans with actual events and then selecting the action plans to control those deviations. The question arises of what needs to be controlled. Table 1 presents the key elements which need to be controlled during the project life cycle.

**Table 10.1: Key elements of Project Control (What to Control)**

Scope and Performance:	Costs	Time	Quality	Risk	Team
<ul style="list-style-type: none"> <li>• Unexpected technical problems</li> <li>• Specifications Changes</li> <li>• Inter-functional complications</li> </ul>	<ul style="list-style-type: none"> <li>• Initial estimates</li> <li>• Budgeting</li> </ul>	<ul style="list-style-type: none"> <li>• Initial time estimates</li> <li>• task sequencing</li> </ul>	<ul style="list-style-type: none"> <li>• Technical quality</li> <li>• External Quality requirements</li> <li>• Internal Quality Standards</li> <li>• Customer Expectations</li> </ul>	<ul style="list-style-type: none"> <li>• Internal</li> <li>• External</li> </ul>	<ul style="list-style-type: none"> <li>• Motivation</li> <li>• Enthusiasm</li> </ul>

## 10.2 TYPES OF PROJECT CONTROL SYSTEMS

One of the challenges in projects is that the project managers face multiple objectives/goals to be accomplished, and monitoring their progress becomes therefore critical. For every goal/objective, at least one performance measure is needed. It is well established that the project is desired to be on time, within budget, and should meet performance standards as set or needed by the customer. Thus, the project control systems can be classified as:

- i) One-dimensional control systems, and
- ii) Multidimensional control systems.

One-dimensional control systems are used mainly to control specific issues, dealt with as a single dimension, and thus, the objectives are not integrated. Whereas multidimensional control systems integrate several project control objectives. Integrated cost and scheduled control systems were introduced in the USA during the sixties and were mainly used in defence projects.

## 10.3 PROJECT MONITORING AND CONTROL PLAN

The project monitoring and control plan is developed during the planning phase and includes basically three steps:

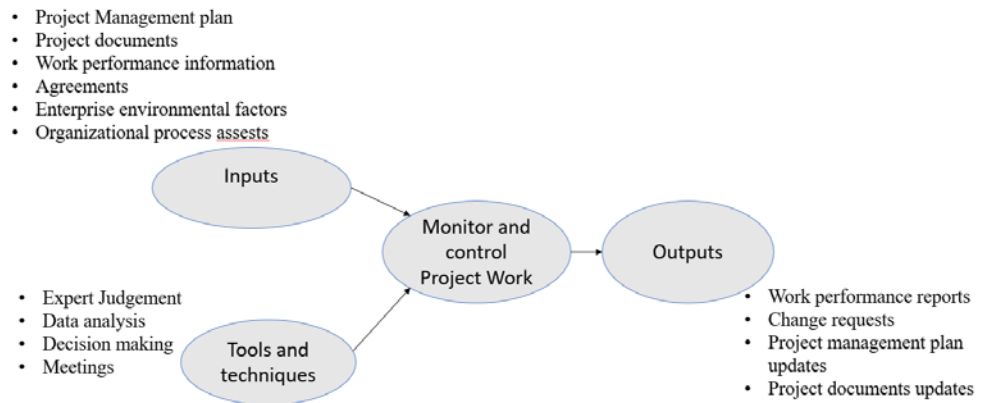
- i) **Outline the Project.** Establishing scope, schedule, and budget baselines and defining milestones.
- ii) **Creating a Breakdown Structure** – Creating a clear picture of tasks, subtasks and deliverables to manage work.
- iii) **Executing the Project Plan, Reporting and Analysing the Variances.** Determining the variances and their acceptability and taking corrective actions for unacceptable variances.

There are many ways in which information about the project's progress may be gathered, such as:

- ☞ Team meetings
- ☞ regular progress reports
- ☞ specific technical meetings

It is critical to note that information required by the project manager must be timely, clear, appropriate, and correct, and the problems should be spotted as early as possible.

Figure 10.1 shows the inputs, tools and techniques, and outputs of the Monitor and Control Project Work process



**Figure 10.1: Process of Project Monitoring and Control**

**Frequency of Reporting:** Reporting of the events can be Event-based (at the end of a particular stage or task) or time-based (at the end of a particular time period), or deviation based (when there has been a deviation from the plan outside the agreed tolerances) or problem-based (when there has been a significant unplanned event or occurrence of a known or unknown project risk).

**Type of Data to be Reported:** Data such as effort utilization (man hours), costs, elapsed time by tasks; work package completed; tasks completed; milestones achieved; equipment usage and changes considered should be collected for monitoring purposes. Schedule and cost forecasts are normally presented as the reflecting status of the project (on track, ahead, or behind), typically expressed as schedule variance (SV) and cost variance (CV), which are discussed in a later section.

**Frequency of Data Collection-**The question comes to how frequently the data should be collected. It is suggested to assess the work progress every week. For small projects, with work packages lasting for only 2 to 3 weeks, progress should be monitored at least twice. For projects with work packages lasting for several months, assessment every 2-3 weeks might be adequate.

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## 10.4 GANTT CHART

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During the execution of any given project, the project manager seeks for following answers.

- 1) Is the project going ahead or behind schedule?
- 2) What is the present status of the project in terms of costs and schedule performance?
- 3) How are the cost performance and schedule performance of the project?
- 4) Based on the current performance, when would the project be finished?
- 5) What is the overall cost of completing the project?

The Gantt chart and Earned Value management provides the answers to above.

The Gantt chart is named after Henry Gantt who explained its use in project management in the early 20th century. It is one of the most used planning and controlling tools in projects today depicting the work scheduled to be done on specific days with start dates, end dates and milestones of a project. Project tasks are presented on a vertical axis and timelines that represent task duration are presented on a horizontal axis. Mostly Gantt diagrams are created in Excel or with project management software.

The questions presented in table 2 assist project managers in reflecting on the appropriateness of the Gantt chart for their specific project (Geraldi and Lechter, 2012). If many of the questions below are answered with yes, the project manager should consider the use of Gantt charts to manage the project's implementation. However, in situations of high ambiguity and low objective, the Gantt chart can act as an instrument to negotiate consensus and understand different perspectives of time/duration across different groups of stakeholders instead of imposing "a reality" to the project (Geraldi and Lechter, 2012). An illustration of the Gantt chart is presented in Figure 5 in a later section.

**Table 10.2: When to use Gantt Chart (Source: Geraldi and Lechter, 2012)**

Principles	Questions
Time-focused	Is the project mainly time driven, e.g. The focus on time precedes other performance areas of a project?
Objective	Can the tasks of the project and its duration be described precisely, unequivocally, and incontestably?
Deterministic	Is the project mainly a routine project, and uncertainties are not really expected?
Analytical	Can the project be easily broken down into parts, and the interfaces and interdependencies can be clearly defined and coordinated? Does the performance of the project equal the sum of the performance of its parts?
Accountable	Can one establish clear accountability to different parts of the system?

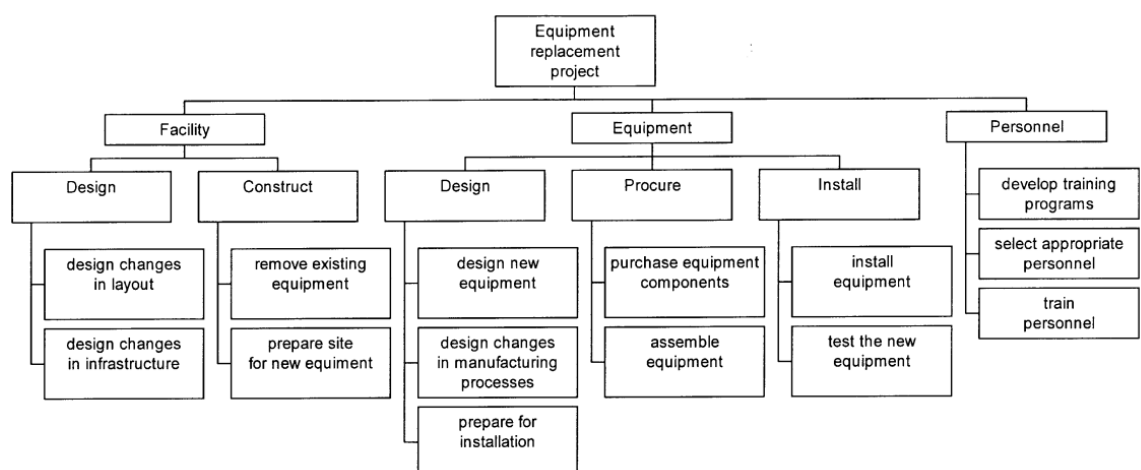
Sequential	Do the activities have a natural linear sequence? Is it expected to get each task right the first time without the need to revisit it?
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## 10.5 EARNED VALUE ANALYSIS (EVA)

The Department of Defence introduced “earned value” (EV) in the U.S Government as the main instrument of schedule and cost-control systems. Earned Value (EV) is the classical multidimensional project control method used for monitoring two dimensions: time and cost. It compares the “planned” work with “accomplished” work in terms of the monetary value assigned to the work. Here, when an activity is completed, then the value of the activity will be considered as earned. Given a baseline, project managers and their teams can determine how well the project is meeting scope, time, and cost goals by entering actual information and then comparing it to the baseline. The baseline information includes:

- Scope data (Work breakdown structure (WBS) tasks)
- Time data (start and finish estimates for each task)
- Cost data (cost estimates for each task)

Work breakdown structure (WBS) is a deliverable-oriented grouping of project elements (hierarchic structuring) defining the total scope of the project. A work package is the lowest level of a WBS and includes a set of tasks to be carried out and are used as the basic elements in the planning and control phases of a project. A sample of WBS is presented in Figure 2 for an equipment replacement project.



**Figure 10.2: Sample of WBS**

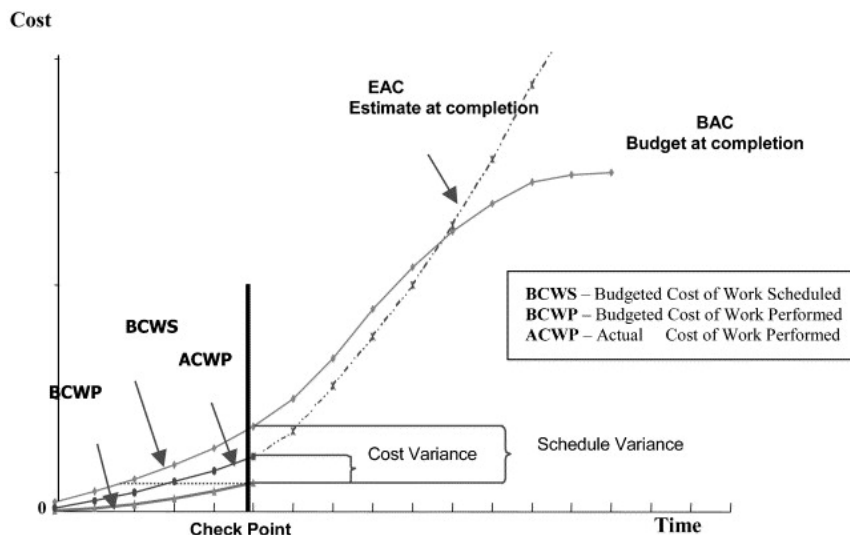
Let us understand the key terminologies of Variances as presented in Table 10.3. Figure 10.3 presents the different variances graphically.



**Table 10.3: Variance Terminologies of Earned Value**

Cost Variance (CV)	CV determines whether costs are higher or lower than budgeted. A negative CV means the project is over budget; a positive CV means the project is under budget
Schedule Variance (SV)	SV determines whether the work is ahead of or behind the planned schedule. A positive SV means the project is ahead of schedule; a negative SV means the project is behind schedule.
Planned Value (PV)	The PV is the budgeted cost of work that has been authorized for a scheduled activity or WBS component during a given time period or phase. These budgets are established during the Planning processes. All PVs add up to the budget at completion (BAC). PV is also known as the budgeted cost of work scheduled (BCWS).
Actual Cost (AC)	AC is the cost of completing the work component in a given time period. AC measures the costs (direct, indirect, or other) that were used to calculate the planned value. It is also known as the actual cost of work performed (ACWP)
Earned Value (EV)	EV is measured as budgeted dollars for the work performed. EV is typically expressed as a percentage of the work completed compared to the budget. It is also known as the budgeted cost of work performed (BCWP).

- Cost Variance (CV) =  $BCWP - ACWP$
- Cost Variance % (CVP) =  $CV / BCWP$
- Cost Performance Index (CPI) =  $BCWP / ACWP$
- Schedule Variance (SV) =  $BCWP - BCWS$
- Schedule Variance % (SVP) =  $SV / BCWS$
- Schedule Performance Index (SPI) =  $BCWP / BCWS$



**Figure 10.3. Cost and Schedule Variances**

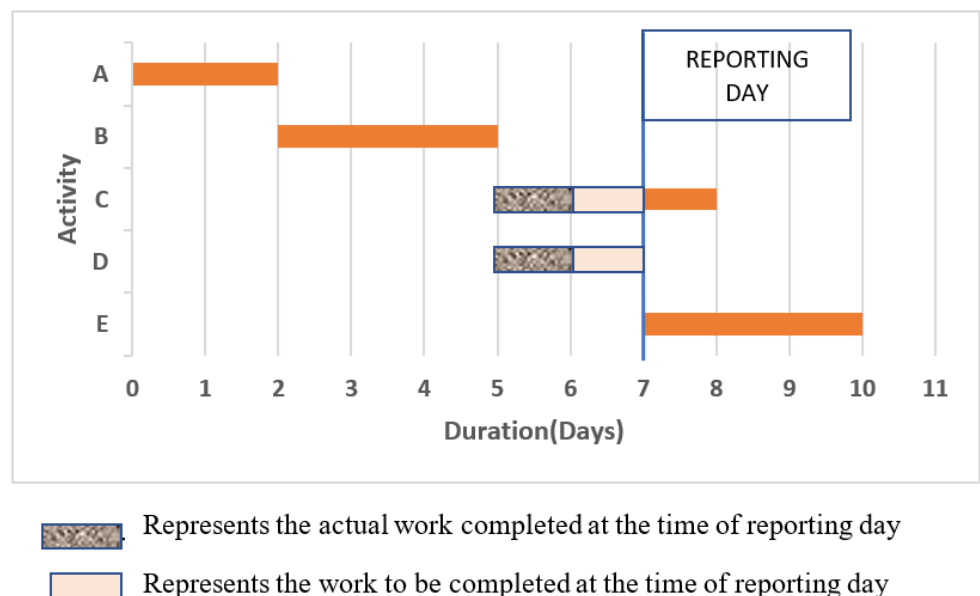
**Example:**

The project has 5 activities. Its cost per day for each activity and the total cost of each activity, along with the duration, is presented in table 10.4 below.

**Table 10.4: Project Activities**

Activity	Predecessor	Duration	Cost/Day	Total cost
A	-	2	300	600
B	A	3	400	1200
C	B	3	400	1200
D	B	2	200	400
E	D	3	100	300

The Gantt chart for different activities in the project is shown in Figure 4. Activity A starts on the first day and ends on the second day. Activity B's predecessor is activity A, and so activity B starts only on the 2<sup>nd</sup> day. It gets completed on the 5<sup>th</sup> day. Activity C's predecessor is activity A, so activity C starts only when activity B ends i.e., It starts on the 5<sup>th</sup> day. Its duration is 3 days & so it gets completed on the 8<sup>th</sup> day. Similarly, activities D & E start on the end of the 5<sup>th</sup> day & 7<sup>th</sup> day, respectively end on the 8<sup>th</sup> & 10<sup>th</sup> day, respectively.



**Figure 10.4: Gantt Chart**

Suppose the reporting time is 7<sup>th</sup> Day; from the Gantt chart, it is observed that

- 100% of activity A must have been completed
- 100% of activity B must have been completed
- 66% of activity C must have been completed
- 100% of activity D must have been completed
- Activity C is yet to be started

However, the data provided by the manager on the 7<sup>th</sup> day on the actual completion of the project at the end of day 7 presents a different scenario as presented in Table 10. 5.

**Table 10.5: Actual work done and cost incurred on the 7<sup>th</sup> day of reporting**

Activity	% Completed	Incurred Cost
A	100	600
B	100	1400
C	33	500
D	50	200
E	0	0

Activity B has incurred an additional cost of 200 than the planned total cost of activity B. Activity C & D have not been completed as per the plan of the project, and an additional cost has been incurred (than the planned cost) for activity C at the end of day 7.

Let us see the calculations of Variances w.r.t 7<sup>th</sup> day of reporting.

**For activity A**

- ACWP = 600 (from Table 4)
- BCWP = Fraction of work completed x Total cost (from Table 3)  
BCWP =  $2/2 \times 600 = 600$
- BCWS = Fraction of work budgeted (planned) to be completed x Total cost  
BCWS =  $2/2 \times 600$   
BCWS = 600

**For activity C**

- Incurred cost = 500, So ACWP = 500
- BCWP = Fraction of work completed x Total cost (from Table 3)  
BCWP =  $1/3 \times 1200$  (i.e., out of 3 days, only 1-day work has been completed)  
BCWP = 400
- BCWS = Fraction of planned work to be completed x Total cost  
BCWS =  $(2/3) \times 1200$  (i.e., out of 3 days, 2-day work was planned to be completed at the time of reporting day)  
BCWS = 800

Similarly, for all other activities, the calculations are presented in Table 6.

**Table 10.6: Earned Value calculations**

ACTIVITY	ACWP	BCWP	BCWS	CV	SV
A	600	600	600	0	0
B	1400	1200	1200	-200	0
C	500	400	800	-100	-400
D	200	200	400	0	-200
E	0	0	0	0	0
Total at Project Level	2700	2400	3000	-300	-600

Let's calculate the cost and schedule variance and index at the project level.

- $CPI = BCWP/ACWP = 2400 / 2700 = 0.889$   
If CPI is less than 1, then the project is over budget.
- $CV = BCWP - ACWP = 2400 - 3000 = -300$   
A negative value for CV indicates the project is over budget.

As CPI and CV says only about the budget, to know whether a project is behind schedule or ahead of schedule, SPI and SV are calculated.

- $SPI = BCWP/BCWS = 2400/3000 = 0.8$   
If SPI is less than 1, the project is behind schedule.
- $SV = BCWP - BCWS = 2400 - 3000 = -600$   
If SV is negative the project is behind the schedule.

It is important to consider the variances both at the project level as well as work package /activity level. The project manager should check both levels to assess the project status. If only project level is considered, good performance of some activities may hide the low performance of others. If only a work package is considered, the cumulative effect of slightly poor performance in many activities can be overlooked. Once deviations are identified, then corrective action, if required, is taken, such as

- No action is taken if the variances are small.
- Revising the original plan and replanning activities in light of the current situation.
- Terminating the project.

EVM provides several advantages, such as

- It integrates time and cost aspects of the project
- It works as an early warning signal that can help project manager in making decisions and corrective actions
- It provides a better view of scope and procurement management.

- iv) It can predict the trend of delay in the projects.
- v) The performance of the EVM encourages people to implement the process of project control.

EVA presents a multidimensional view of project control; however, it also presents limitations such as:

- i) Critical and noncritical activities are not differentiated.
- ii) Activities are assumed to be independent.
- iii) Behavioural aspects of management are not considered.
- iv) Only considers two dimensions: **time** and **cost**.

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## 10.6 OBJECTIVES TECHNICAL PERFORMANCE MEASUREMENT

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- vi) TPMs are critical technical parameters that a project monitors to ensure that the technical
- vii) objectives of a product will be realized. Typically, TPMs have planned values at defined time
- viii) increments, against which the actual values are plotted. Monitoring TPMs allows trend detection
- ix) and correction, and helps identify possible performance problems prior to incurring significant
- x) cost or schedule overruns
- xi) TPMs are critical technical parameters that a project monitors to ensure that the technical
- xii) objectives of a product will be realized. Typically, TPMs have planned values at defined time
- xiii) increments, against which the actual values are plotted. Monitoring TPMs allows trend detection
- xiv) and correction, and helps identify possible performance problems prior to incurring significant
- xv) cost or schedule overruns

Technical performance measurement (TPM) shows how well a project is meeting its technical requirements of a product/process through design, implementation, and testing. TPMs have planned values at definite time increments, against which the actual values are plotted. Monitoring TPMs (i) provides visibility of actual versus planned performance and (ii) provides early detection of problems requiring management attention.

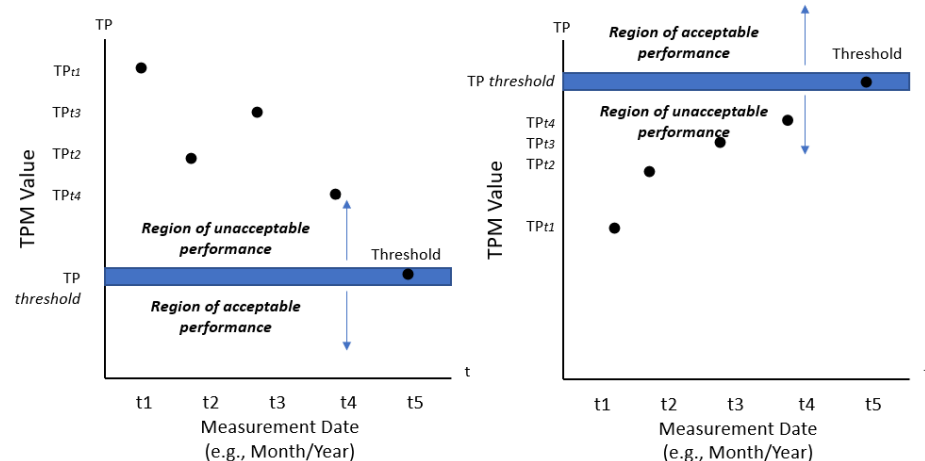
They are considered the most basic form of technical measures and if not achieved, may introduce cost, schedule, or performance risk. Example of performance measures includes Reliability, Power required, Weight, Throughput, human factors, Response time, Complexity, Speed, Set up Time,

Idle time, Trip time, Flexibility, Maintainability, Cycle time, Capacity, Signal to noise ratio, Speed, Size/Space etc.

TPM is created for projects with the following characteristics:

- High-priority requirements that impact mission accomplishment and customer satisfaction.
- High-risk requirements that have a high probability and consequence of failure
- Requirements where the desired performance is not currently being met because of new technology, new constraints have been added (e.g. a drastic increase in the number of users), or the performance target has been increased.
- Requirements where the performance is expected to improve with time, where progress toward a goal is expected.
- Requirements where the performance can be controlled.

It is to be noted that technical performance measures, when evaluated over time, must either decrease or increase to meet performance requirements, as shown in Figure 5. For example, Figure 5(a) TPMs are those whose values must decrease to achieve threshold performance requirements, whereas Figure 5(b) TPMs are those whose values must increase to achieve a threshold performance requirements. A sample example of the design target weights of two components of a spacecraft navigation system and actual value are presented in Figure 6. (Nicololas and Steyn, 2015)



10. 5 (a)

10. 5 (b)

*Note: TP is technical performance measure*

**Figure 10.5: TPM chart demonstration**

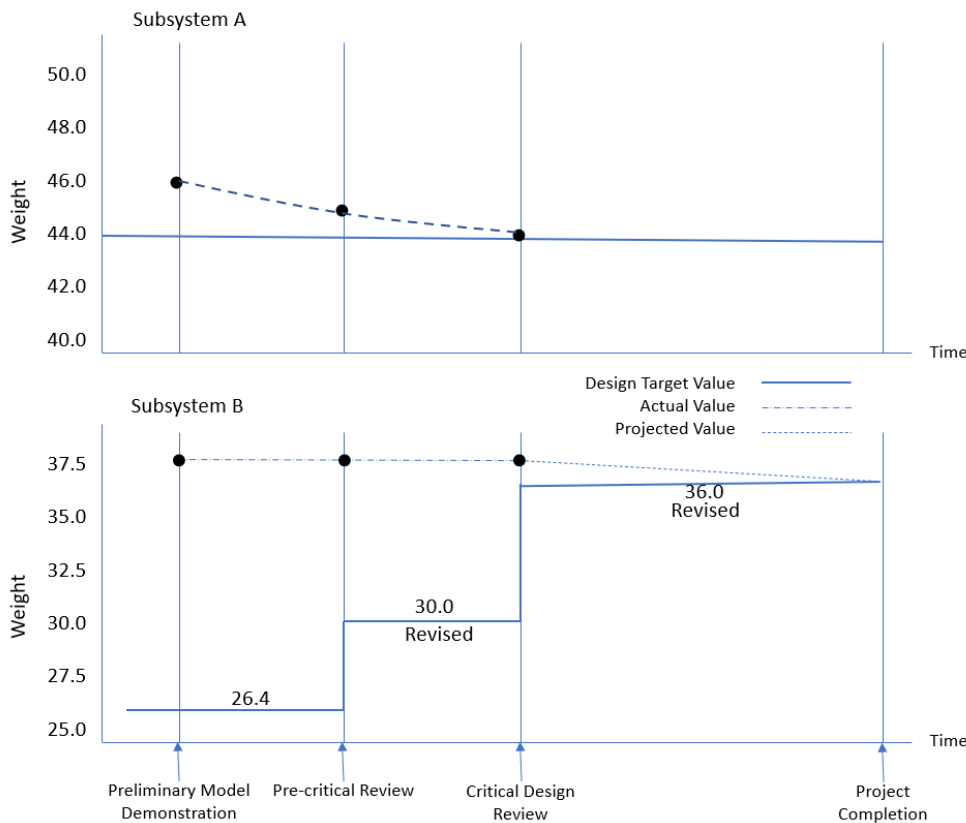


Figure 10.6: Time-phased TPM chart for 2 components of the spacecraft navigation system (Source: Nicholas and Steyn, 2015)

## 10.7 LET US SUM UP

This unit provided the fundamentals and importance of project monitoring and control. To deliver the project to its customers within the time frame and allocated budget with the requirements specified, it is critical for a project manager to monitor the progress throughout the lifecycle of the project. The most widely used tool to view progress is the Gantt Chart. To get an understanding of project cost and schedule, earned value analysis should be conducted, which presents a multidimensional view of control. Further, other than time and cost, to cater to quality requirements, technical performance measurement should be used especially when a new technology in the project are being used.

## 10.8 KEYWORDS

**Project Monitor:** The process of maintaining a careful check on the whole project management life cycle and ensuring project activities are on track is referred to as project monitoring.

**Project Control:** Project Control is a process that includes the resources, methods, and instruments for planning, monitoring, and controlling all aspects of the capital project lifecycle.

**Earned Value:** Earned value (EV) is a method of measuring and monitoring

the amount of work accomplished on a project in comparison to the plan.

**Gantt Chart:** It is a type of bar chart that indicates the progress and assigns responsibility for each job in a project. It is a visual representation of a project plan through time.

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## **10.9 SELF-ASSESSMENT EXERCISE**

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- 1) Why Monitoring and control of projects is important?
- 2) How many types of project control mechanisms are there?
- 3) What kind of information Gantt charts provide to project managers?
- 4) What is earned value?
- 5) When should project manager use TPM?

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## **10.11 FURTHER READINGS**

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Project Management Institute (PMI). (2013). A guide to the project management body of knowledge, PMBOK guide (5th ed.).

John M. Nicholas, J Herman Steyn, H (2015). Project Management for Engineering, Business, and Technology, A Butterworth-Heinemann.

Geraldi, J and Lechter, T (2012) Gantt charts revisited. A critical analysis of its roots and implications to the management of projects today. International Journal of Managing Projects in Business, Vol 5(4).

Raby, M (2000). Project management via earned value. Work Study, Vol. 49 (1), 6–10, 2000.



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# UNIT 11 PROJECT RISK MANAGEMENT

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## Objective

After studying this unit, you should be able to:

- Understand the meaning of project risk, its importance in the current scenario
- Identify the various risks in the projects
- Assess and prioritize various risks in the given project for resource allocation and decision making
- Design the mitigation or control measures to reduce the effects of risks

## Structure

- 11.1 Introduction
- 11.2 Definition of Uncertainty and Project Risks
- 11.3 Risk Management Process
- 11.4 Risk Identification
- 11.5 Risk Categorization and Risk Breakdown Structure
- 11.6 Risk Assessment Methods
- 11.7 Risk Response Planning
- 11.8 Risk Control Measures
- 11.9 Let Us Sum UP
- 11.10 Self-Assessment Exercise
- 11.11 Further Readings

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## 11.1 INTRODUCTION

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Globalization, hyper-competition along with shorter technology and product life cycles are forcing organizations to undergo changes. The current volatile (Changes are frequent and unpredictable- example-fast technological changes), uncertain (impact of future events not known- example- pandemic-COVID 19; climate changes), complex (Many inter-connections and levels- multiple stakeholders involvement, interdependencies example-cyber physical systems ), and ambiguous (lack of knowledge, unclear what to expect; example-fake news) environment is putting pressure on companies to innovate at a faster pace. Organizations increasingly use projects (whether construction, product development or service development) as a vehicle for transformation and implementation of strategic proposals with the aim of staying competitive. A project is a series of tasks that need to be completed to reach to specific goal /outcome. It can also be said as a set of inputs and outputs needed to achieve a specific goal. Some important characteristics of the project are:

- 1) It has a purpose, and results normally in terms of cost, performance requirements and schedule.
- 2) Projects are temporary activities, i.e., they have a fixed time frame.
- 3) Every project is unique; some of the activities need to be modified due to changes in laws, location, time, people etc.
- 4) The project possesses a significant element of uncertainties and risk due to changes in circumstances and technology developments.
- 5) Projects pass through several distinct phases called Project Life Cycle.

Thus, the role of the project manager is considered to be highly critical while defining and shaping the desired targets of project execution. A project is considered successful only if it achieves the specified project objectives. It is important to remember that not only –within time and within budget are the measures of project success, but measures such as -efficiency, impact on the customer, impact on the team, business success, and future aspects that projects create are critical to be considered. Project success is a multi-dimensional construct that embraces long-term achievement, i.e. desired effectiveness and impact of project results; and short-term success in terms of project efficiency.

The Project Management Institute (PMI) Pulse of the Profession (2021) reports that still only 55% of the projects are completed on time, with 12% of the projects deemed failures. One of the recent example of the construction of Qatar stadium for the FIFA World Cup 2020, a ground-breaking architectural achievement, revealed unethical practices and mistreatment of migrant workers on the part of contractors responsible for the various sites and developments. This attracted severe criticism from human rights groups. Can it be classified as a successful project?. Think about it.

The specificity of the project–more frequent changes, pressure to meet the project deadline, and budget, and meeting customer expectations with limited resources, makes project teams more challenging as compared to leading teams in traditional organizations.

**Activity:** List any 4 projects from the world (2 successful and 2 failed)

Project Name	Success/ Failed	Measures of Success /Failure
1.		
2.		
3.		
4.		

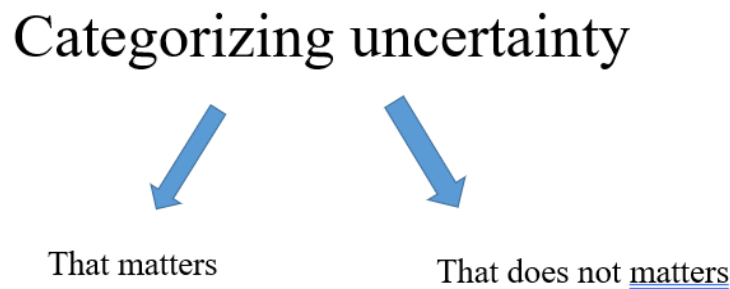
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## 11.2 DEFINITIONATION OF UNCERTAIN AND PROJECT RISKS

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The world and the environment in which the projects operate are not deterministic in nature, and many uncertainties are faced. Let us understand

what do we mean by saying- uncertainty. Uncertainty is a state of mind characterized by a conscious lack of knowledge about the outcomes of an event. Uncertainty is a situation in which it is not possible to specify numerical probabilities.



**“Risk is uncertainty that matters”**

**Fig.11.1: ‘Risk in uncertain that matters’**

Uncertainty in the project may be associated with estimating, project parties and stages of the project life cycle.

***“Risk is an uncertain event that matters, that if it occurs, has a positive or negative effect on a project's objective.”*** In other words, risk in the project is one which creates a situation impacting the project team’s ability to achieve the outcome of the project exactly as planned. It is *an event likely to occur in future during the project life cycle*. The key element in this definition is uncertainty, which refers to situations under which either the outcomes and/or their probabilities of occurrences are unknown to the decision-maker.

However, none of the projects are risk-free. In general, the level of risk depends upon two factors, one is the uniqueness of the project, and the other is the experience of the project team. Uniqueness is usually linked with uncertainties and unknowns. Risks are present in all projects, whether big or small. One of the other risk will always be present from concept to completion and operation of the project. For the success of the project, it becomes important to eliminate or reduce the effect of risk and therefore it requires attention and action at the earliest. Sooner the better, that is before it leaves the project manager and other stakeholders in a state to suffer with its negative impact on project objectives.

Thus, the purpose of risk management is to enable project progress towards organisational goals and project objectives in an efficient and effective path through maximising the use of available resources and deliver targets consistently in a sustainable manner. Thus, the discipline of project risk management has been recognised as critical for the success of every project. Project risk management seeks to increase the probability and impact of positive events and to decrease the probability and impact of negative one’s.

Project risks varies with project type, industry, experience in managing similar projects, as well as scope and size of the project.

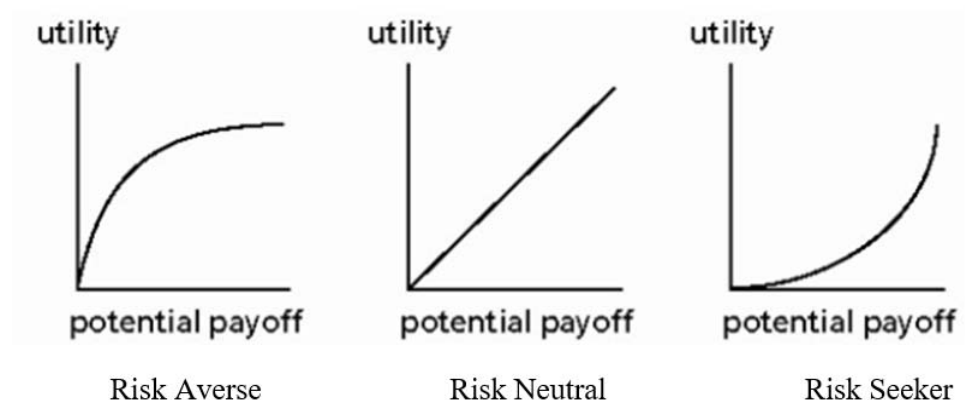
The risk management plan depends on your organization and stakeholders risk attitude, which is to what extent the project manager and stakeholders are willing to take risks. There are different kinds of organizations outlook towards risk.

**Risk Averse-** The organizations who are cautious in situations of large losses, they are reluctant from project decisions even if such project decisions might also offer a possibility of large gains associated with success. This behaviour is called “risk-averse.” For this organization, the fear of losing \$1 million far overweighs the benefit of gaining \$1 million. They prefer lower returns instead of higher ones, because the lower return investments have known risks . The risk averse organization will not do a project if the chances are 50 – 50 between the two outcomes.

**Risk Neutral** – Such organizations keep a balance towards the utility and payoff. Such organizations weigh all pros and cons before deciding to take risk or not.

**Risk Seeker-**They enjoy and find it challenging to deal with risks and accept risk as a normal feature of the project and business. However, this excessive optimism may sometimes lead to losses due to giving less importance to the potential effect of the risk on achievement of objectives. As it is understood as a normal feature of the project, it means that risk are underestimated (both in terms of probability and impact) and not managed appropriately.

Figure 1 depicts the 3 types of attitude towards risk



**Figure 11.2: Risk Attitude**

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## **11.3 RISK MANAGEMENT PROCESS**

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Risk management is a "*formally structured process for systemic risk identification, analysis and response throughout the life span of the project in order to achieve an optimum level of risk elimination or control*". The process of how to conduct /do risk management activities is called risk management process. The process has the following phases:

- 1) Identifying as many risks as possible
- 2) Analysing risks in terms of impact on project goals and it's likelihood of occurrence
- 3) Responding to each potential risk if and when it occurs
- 4) Changes in project plan to acceptable (by stakeholders) levels to account for certain risks
- 5) Monitoring and reviewing to have a check on risk control actions.



**Fig. 11.3: Risk management process. (Source: Cooper, 2005)**

Collective decision-making is very vital in project management that can make or break this part of the project. Almost all risk management activities will involve meetings between the project manager, the team and other stakeholders in order to make decisions about various activities, risks and associated estimates. Table 1 presents the responsibility of various stakeholders involved in the project. Make a note that, it is not only the responsibility of a project manager towards risk management.

**Table 11.1: Risk responsibility**

Risk Activity	Responsibility
Risk Identification	All project stakeholders
Risk Registry	Project Manager
Risk Assessment	All project stakeholders
Risk Statements	Project Manager's, team communication
Risk Response options identification	All project stakeholders
Risk Response approval	Team Communication (recommendations); project Directors
Risk Contingency Planning	Project Manager
Risk Response Management	Project Manager
Risk Reporting	Project Manager

When dealing with the project and looking at uncertainties and risk, following questions about a project should be looked at along with their answers.

1. Who are the parties ultimately involved?
2. What do the parties want to achieve?
3. What is it that each party is interested in?
4. Which way (how) is each party's work to be done?
5. What resources are required?
6. When does it have to be done?

Use of the six questions mentioned above from the earliest stages of the project life cycle can provide information on development of project design and logistics by clarifying key sources of uncertainty

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## **11.4 RISK IDENTIFICATION**

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*“A stitch in time saves nine”* is a proverb which means a prospective bigger harm can be avoided by taking proactive remedial action in the initial stage of the problem. Thus the risk identification needs to be done at the earliest. For this the project manager has to understand the project objectives and understand specific priorities of the key stakeholders. To obtain such understanding it is a good practice to have discussions between the project manager and project stakeholder's right from the early stages of the project life cycle. It is important to uncover the maximum number of risks early before they occur and leave their negative impact on the project objectives

There are a different risk identification techniques available based on following distinct criterion (1) identification conducted solely by the risk analyst, (2) identification by the analyst interviewing a member of the project team, and (3) the analyst leading a working group. Based on them, the most commonly used techniques for risk identification are – Documentation reviews, brainstorming, the nominal group technique and delphi technique.

**Documentation Reviews-** These are structured reviews of all project documentation up to this point in time including plans, assumptions, previous project files, contracts, and other information.

**Brainstorming:** Originated by Alex Osborn in the early 1950s, brainstorming was proposed as a problem solving method which would produce a much larger quantity of ideas in less time. Conducting a brainstorming session requires following set up-

- **Prepare the Group:** Make sure of tools, resources, and refreshments- Recorders, white boards, Tea/coffee, Post it
- **Small Group of Stakeholders-** Full-time members of the project team, have key responsibilities, cover critical technologies and any commercial considerations

- **Optimum Brainstorming Group Size** – 7-12 members- leader, an associate leader, about five regular or 'core' members and about five guests. Panel should be composed of people of the same rank
- **Define the Problem** and the objective of the session; Give people plenty of quiet time at the start of the session
- **Reverse the Problem** or challenge by asking, "How could I possibly cause the problem?" or "How could I possibly achieve the opposite effect?"

Example: "How do we improve patient satisfaction?"

*Reverse problem statement:*

"How do we make patients more dissatisfied?"

However, during conducting the brainstorming session, always remember that- the purpose of this session is to get large number of risks i.e., Quantity is wanted. Evaluation of ideas must be withheld until later. One of the drawbacks is that the some of the participants may be extrovert and dominate others in terms of sharing opinions.

**Nominal Group Technique (NGT)**- NGT was developed by Delbecq in 1968 is a method as initiating with the group members (between 7-10) without discussion, writing ideas related to the problem down on a pad of paper. Conducting a NGT requires:

- Silent generation of ideas in writing
- Round-robin feedback from group members to record each idea in a short succinct phrase on a flipchart
- Discussion of each recorded idea for clarification and evaluation
- Individual voting on priority ideas with the group. Any suitable scale could be used by participants for voting. For example- Using a scale of (Least important) 1 → 5 (Most important)
- Decision being mathematically derived through rank-ordering or rating as mentioned in Table 2.

**Table 11.2: Template of NGT**

	RANKS BY PARTICIPANT OF THE NGT SESSION				
	Participant 1	Participant 2	Participant 3	Participant 4	TOTAL
Risk 1					
Risk 2					
Risk 3					
.					
.					
Risk n					

**Delphi Technique:** Delphi developed at the RAND Corporation by Dalkey, Helmer and others primarily for technology forecasting, is a method for the systematic collection and collation of judgements from isolated anonymous respondents on a particular topic, through a set of sequential questionnaires combined with summarised information and feedback of opinions, derived from earlier responses. Setting up of Delphi method involves following

- Selection of panel experts representing broad spectrum of opinion on the issue being examined. There is no rule of thumb for the number of the panel members however it depends on the complexity of the project. It is observed that the panel could range from the 5-30 members. Exhibiting knowledge, considerable experience, readiness to contribute to process along with good communication skills are essential elements required in the Delphi panellist.
- Participants are usually kept anonymous
- The moderator or researcher (or the project manager) construct a series of structured questionnaire and feedback reports for the panel over the course of Delphi
- Usually, 3 to 4 iterations are involved till the consensus is achieved

The main advantage of Delphi is that the opinions are individually based and not biased as the members are kept anonymous and therefore interpersonal conflicts and communication problems do not exist. Further the problem of bringing people to the same location does not exist with travel cost reduced to minimal.

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## **11.5 RISK CATEGORIZATION AND RISK BREAKDOWN STRUCTURE**

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The purpose of risk identification is to create a long list of risks, but this list is many times hard to understand or manage. The best way to deal with this list of risks is to structure them for better comprehension and visual representation. Once the risks are identified, it is critical to categorize those risks for better understanding. There are many ways to categorise risks. Some are given below.

i) By considering when it occurs in the **Project Life Cycle**

The risks are categorised according to the phase of the project life cycle in which they are likely to occur. Such phases can be initiation, design, execution, closure

ii) By considering which **project objective**

By considering which project objective is impacted, that is, cost, scope, schedule or quality.

iii) Based on the **Source of the Risk (External or Internal)**

**Internal:** They originate from inside the project and thus the project



manager may have a control over them , for example, market risk, technical risk and so on.

**External:** These risks are generated from sources outside the project. Project manager has little or no control over them, for example, competitors action , Government regulations, acts of God –(floods, rain, earthquake etc.)

iv) By **What is Known and \What is Not Known** about the risk.

**Known- knowns :** That is we know the risk will happen and we know the time and its nature of happening. Therefore we can have a plan and manage it with certainty and thus the risk is not a risk.

**Known- unknowns:** That is we know the event will occur but its level/degree is unknown, for example, rain will occur but when and for how long and its degree is not known.

**Unknown- unknowns:** These are fully uncertain events and can't be thought in advance. No mitigation strategy can be planned , for example -acts of God.

**For example:** Some of the risk categories located in International projects are:

*Financial and economic:* due to situations like sudden and drastic fluctuations in exchange rate, inflation, financial shortage due to cost overrun and schedule overrun, financial failure of the contractor or subcontractor, increments in tax payments due to reforms in taxation policies, Changing market conditions

*Contractual and legal:* due to ambiguity in different regulations in different countries

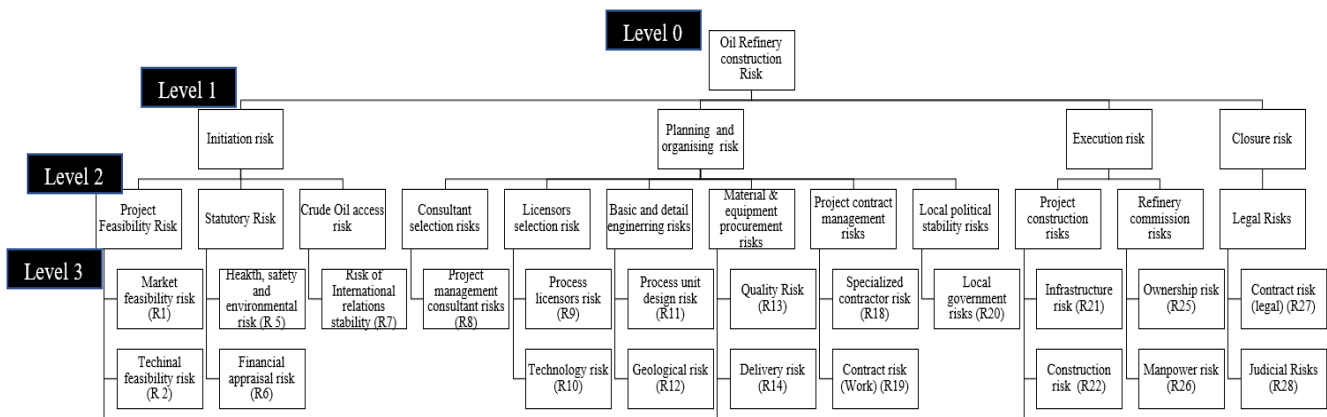
*Design-related:* due to unclear scope of project, unfamiliarity with the design standards used in the host country

**Political:** due to political instability, different foreign policies of the government

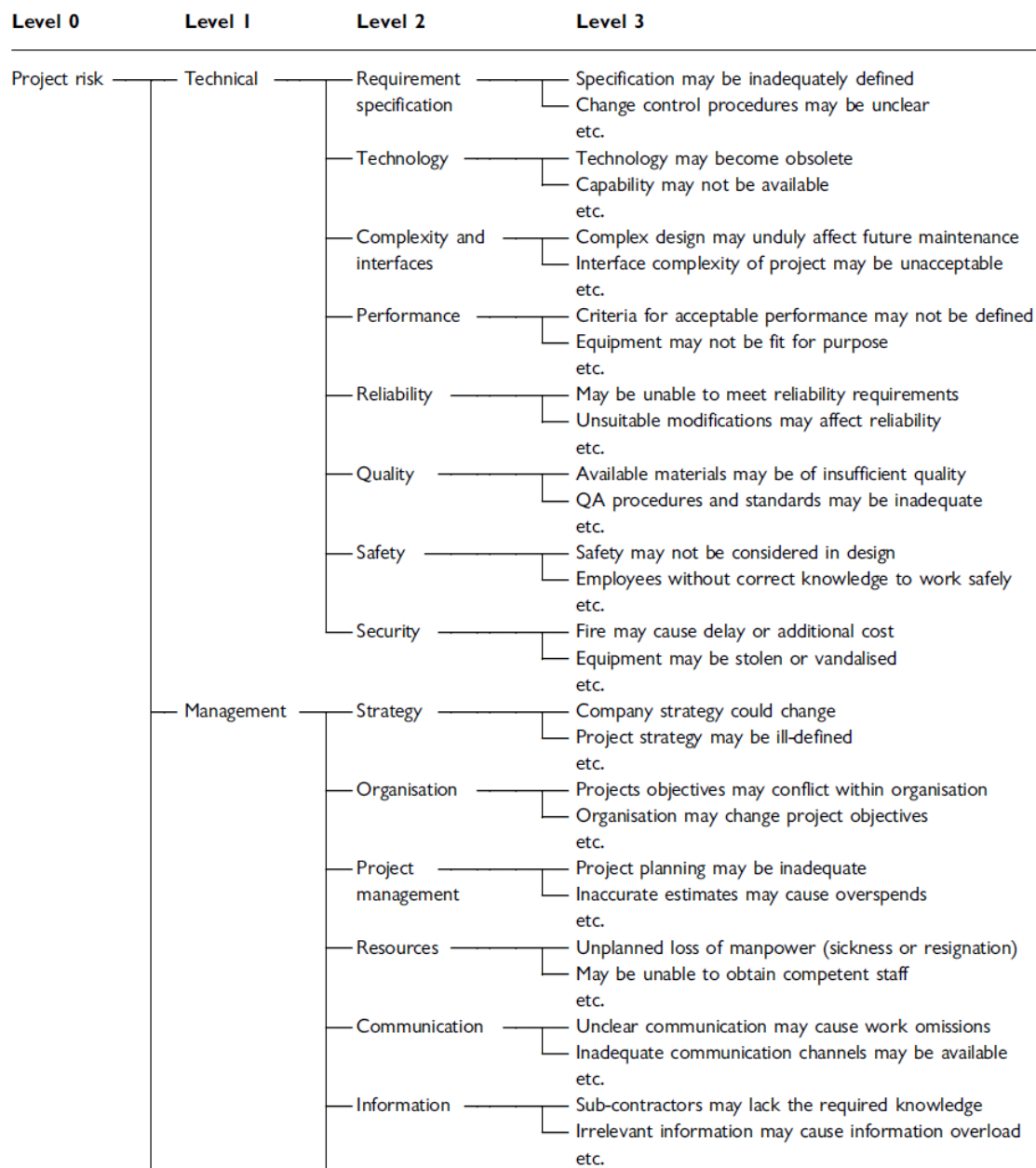
**Cultural:** due to different cultures, and communication languages of communication

**Technical:** due to different technology maturity and understanding levels, inadequate user documentation, poor production system performance based on the risk categorization, a Risk Breakdown Structure (RBS) —a hierarchical structuring of risks on the project can be drawn. It defines the total risk exposure of the project. RBS structures differ with respect to sources of risk, type of projects, the environment as well as industry sectors. It is therefore necessary for any organisation wishing to use the RBS as an aid to its risk management to develop its own tailored RBS.

The Figure 11.4 3a, 3b, 3c showcase the RBS of different projects (oil refinery construction, Vaccine development, Mining)



**Fig. 11.4: Snapshot of RBS of a oil refinery construction project (Source: Gupta et al, 2021)**



**Fig. 11.5 Snapshot of RBS of a Vaccine development project (Source: Hillson, 2003)**

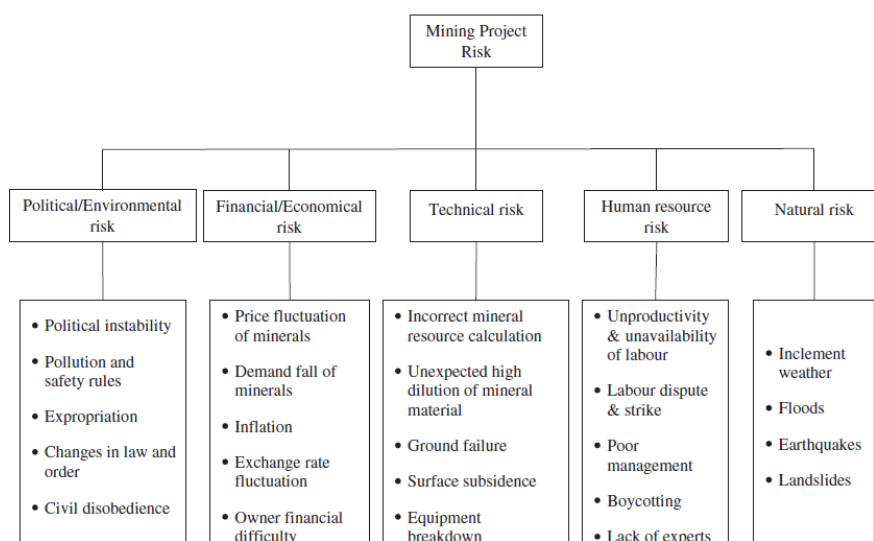


Fig. 11.6: Snapshot of RBS of a Mining project (Source: Banda, 2019)

## 11.6 RISK ASSESSMENT METHOD

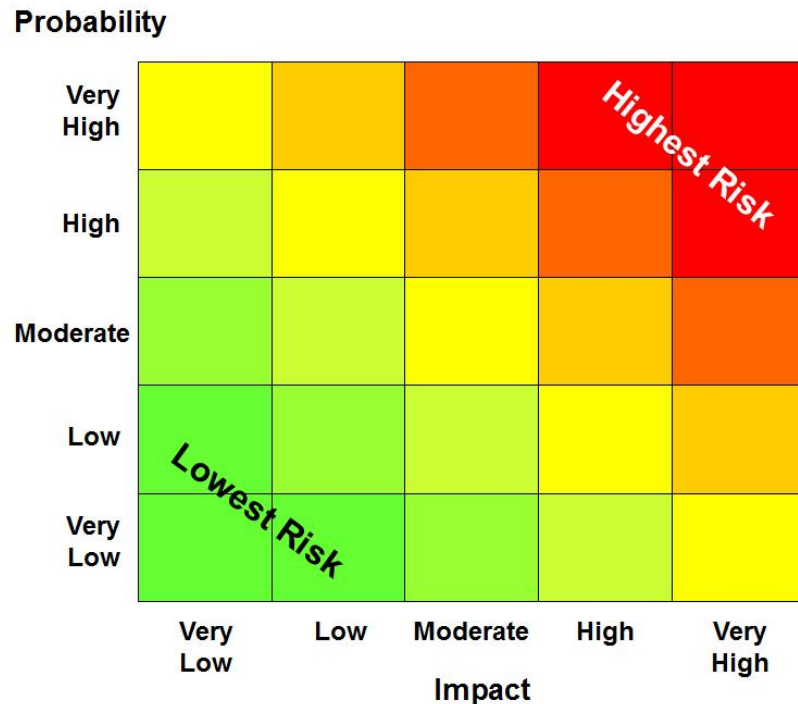
Risk assessment is the process of estimating the likelihood of the occurrence of an event (desirable or undesirable) and its impact on project objectives.

There are two ways of analysing the risk- qualitative approach and quantitative approach. The qualitative risk analysis is generally performed on all risks, for all projects, whereas quantitative risk analysis is based on the type of project, the project risks, and the availability of data to use to conduct the quantitative analysis.

**Qualitative Techniques:** A qualitative risk analysis prioritizes the identified project risks using a pre-defined rating scale. Risks will be scored based on their probability or likelihood of occurring and the impact on project objectives should they occur. The impact scale is defined by the organization (for example, a one to five scale, with five being the highest impact on project objectives - such as budget, schedule, or quality). As the impact of risks encountered in past projects are imprinted in the psyche of the project manager and will be remembered in future projects, experts are requested to give their judgement on probability (P) of occurrence and the degree of impact (I) for all the identified risks on the identified project objectives-such as cost, time, quality, scope, team performance, efficiency etc. The experts provide their inputs on probability of occurrence of risks using the words: very high, high, medium, low and very low as well as inputs on degree of impact of risks using words - critical, major, cautionary, minor, and negligible as shown in Figure 11.7. The risks are then plotted in the probability -Impact matrix to understand which risks are most critical to be looked at on priority as shown in Figure 11.8. Further, a Risk Score can be calculated as  $RS = P \times I$ .

<i>Impact</i>		<i>Probability</i>	
Critical	>8–10	Very High	>80–100%
Major	>6–8	High	>60–80%
Cautionary	>4–6	Medium	>40–60%
Minor	>2–4	low	>20–40%
Negligible	0–2	Improbable	0–20%

**Fig. 11.7: Probability Impact scale**



**Fig. 11.8: Probability Impact matrix**

**Quantitative Technique:** A quantitative risk analysis is a further analysis of the highest priority risks during which a numerical or quantitative rating is assigned in order to develop a probabilistic analysis of the project. Quantitative analysis allows to

- Quantify the possible outcomes for the project and assesses the probability of achieving specific project objectives
- Provides a quantitative approach to making decisions when there is uncertainty
- Creates realistic and achievable cost, schedule or scope targets

Some of the quantitative techniques are:

**Monte Carlo Simulation-** Monte Carlo simulation which involves the random sampling of uncertain variables based on defined probability distribution functions. Through this random sampling a probability distribution of the output variable can be determined, and the probability of failure calculated. The main criterion for selecting the appropriate probability distribution for input variables is the knowledge of characteristics of risk factors. One critical step in Monte-Carlo simulation is to develop a model of

relationship between dependent variable (example-objective/performance of project- in terms of cost or budget or schedule or quality etc.) and independent variables (risk factors). However, Monte Carlo simulation does not determine the impact of risks and presents a limitation in assessing political and social risks.

**Sensitivity Analysis** – It is used to determine which risks have the most potential impact on the project. It aids in understanding the extent to which variation of a project element affects a project objective when all other uncertain elements are held at their baseline values.

**Expected Monetary Value (EMV)** – EMV is used to calculate the contingency reserve. It calculates the costs of all the paths the project manager might take during the project.

**Expected Monetary Value (EMV) = Probability \* Impact**

The impact is the amount spent if a given identified risk occurs. The classical way to calculate the EMV of a project is as follows:

- Take the cost estimate or the Net Present Value for the project as a Base value (BV);
- Calculate the sum of EMV of all threats ( $\sum EMV_T$ ) and opportunities ( $\sum EMV_o$ );
- If cost as a base value is considered, sum the EMV of the threats and subtract the EMV of the opportunities;
- If revenue as a base value is considered, remove the EMV of the threats and sum the EMV of the opportunities.

$$EMV = BV \pm \sum EMV_T \pm \sum EMV_o$$

After calculation of the expected monetary value of the project, it is added to the work costs estimate and generate the cost baseline. This amount is called the contingency reserve.

For example -The project's total cost is 10,00,000 for a software project, and certain risks have been identified as shown in table 3.

**Table 11.3: EMV calculation**

<b>Risk</b>	<b>Probability</b>	<b>Impact (Rs)</b>	<b>EMV (Rs)</b>
Negative Risk 1 (Threat 1)	30%	30,00,00	90,000
Negative Risk 2 (Threat 2)	10%	20,00,00	20,000
Positive Risk 1 (Opportunity 1)	20%	20,00,00	40,000
Positive Risk 2 (Opportunity 2)	50%	10,00,00	50,000

$$\text{EMV} = \text{Rs } 10,00,000 + (30\% \times \text{Rs } 30,00,00 + 10\% \times \text{Rs } 20,00,00) - (20\% \times \text{Rs } 20,00,00 + 50\% \times \text{Rs } 10,00,00) = \text{Rs } 10,20,000.$$

One of the ways to calculate and represent EMV is through decision trees which are explained below.

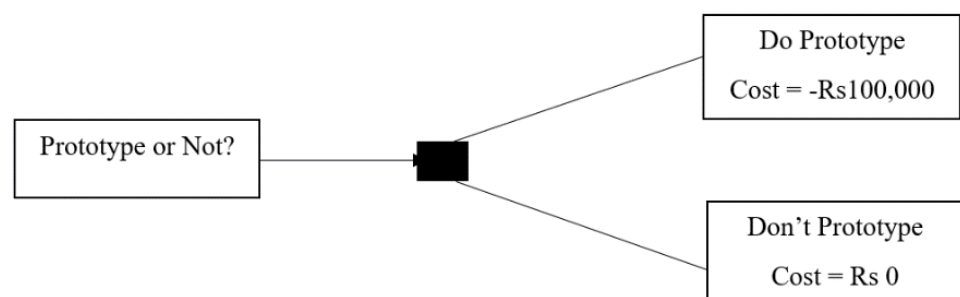
**Decision Tree Analysis (DTA)**— Decision tree analysis uses EMV analysis internally. As the name suggests, a decision tree is about making decisions when facing multiple options. DTA takes future uncertain events into account. The event names are inside rectangles, from which option lines are drawn. There will be decision points (or “decision nodes”) and multiple chance points (or “chance nodes”) when you draw the decision tree. The probability value will typically be mentioned on the node or a branch, whereas the cost value (impact) is at the end.

For calculations, move from right to left on the tree. The cost value can be on the end of the branch or the node. The best decision is the option that gives the highest positive value or lowest negative value, depending on the scenario.

**For Example:**

The project Manager is into a new product development project and wants to develop a prototype. If he does the prototype, it will cost Rs. 100,000; if he and the team do not make it, there will be no cost. If he goes for the prototype, there is a 30 percent chance that the prototype might fail, and the cost impact will be Rs. 50,000. However, if the prototype succeeds, the project will make Rs. 500,000. If he does not do any prototype, he is already taking a risk, the chance of which is 80 percent, with a failure impact of Rs 250,000. But, again, without a prototype, should he succeed, the project will make the same money as mentioned before. What should he do?

An example using a decision tree is demonstrated in Figure 11.9.



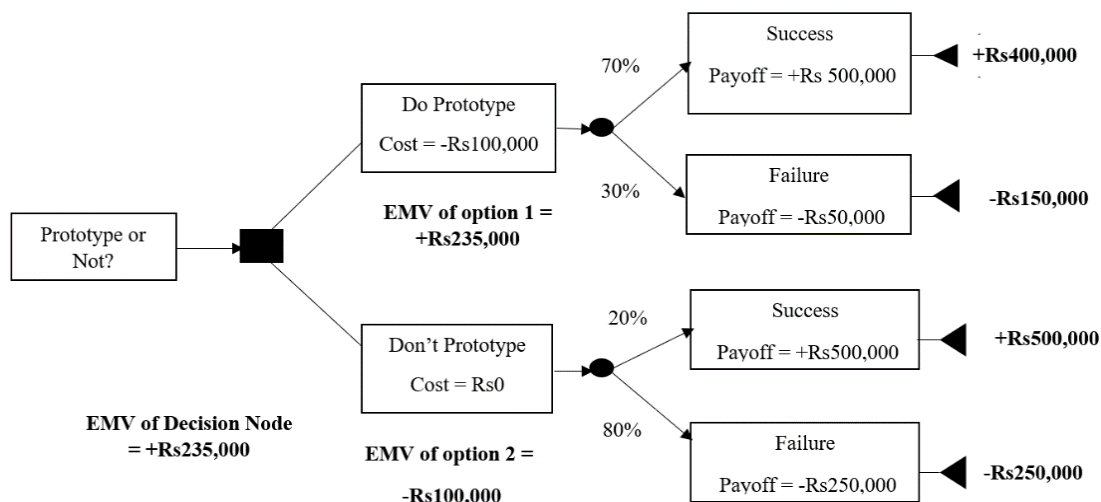


Fig. 11.9: Decision tree analysis using EMV

The net path value for the prototype with 70 percent success = Payoff – Cost:  
 $= +Rs. 500,000 - Rs. 100,000 = +Rs. 400,000$

The net path value for the prototype with a 30 percent failure = Payoff – Cost:  
 $= -Rs. 50,000 - Rs. 100,000 = -Rs. 150,000$

EMV of **option 1** =  $[70\% \times (+Rs 400,000)] + (30\% \times (-Rs150,000)) = +Rs 235,000$  On similar lines, the EMV of option 2 is also calculated

Looking at the EMV of the decision node will aid in decision-making. EMV of option 1 is +Rs 235,000, whereas with the other option — no prototyping — you're losing money. Hence, the project manager should go for the prototype development.

## 11.7 RISK RESPONSE PLANNING

Risk response planning involves developing responses to the identified risks that are appropriate, achievable, and affordable. Owners are also allocated to each risk response and are to be held responsible for its implementation and for monitoring its effectiveness. There are four risk response strategies as shown in Figure 11.10. Depending upon the severity of the risk, the strategy can be adopted

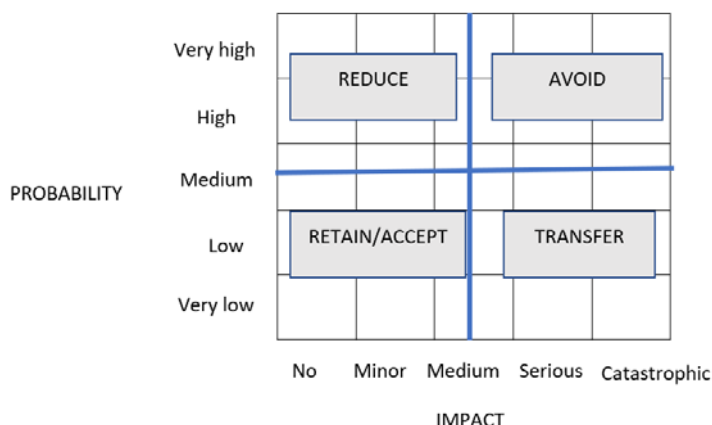


Fig. 11.10: Risk management strategies

**Avoid** – seeking to eliminate the uncertainty by making it impossible for the risk to occur (i.e., reduce the probability to zero) or by executing the project in a different way which will achieve the same objectives but which insulate the project from the effect of the risk (i.e., reduce impact to zero). Some examples of avoidance strategies are:

- Changing the PM plan;*
- Changing the project scope;*
- Adopting proven technology*
- Shutting down the project*
- Dependence on national suppliers*

**Transfer** –identifying another stakeholder better able to manage the risk, to whom the liability and responsibility for an action can be passed. Some examples of transfer strategies are:

- *Establish JV with renowned local partners*
- *Obtain local government guarantee to adjust tariff or extend concession period*
- *Obtain payment and performance bonds from local and international banks*
- *Outsourcing*

*There are multiple models available catering to this strategy*

*BOOT- (Build-Own-Operate-Transfer)- grants to a private sector party the right to finance, design, construct, own and operate a project for a specified number of years until the project is completed and capabilities are proven.*

*BOO (Build-Own-Operate)*

*PPP(Public-Private Partnership)*

**Reduce/Mitigate**—reduce the risk size to make it more acceptable to the project or organization by reducing the probability or the impact. Some examples of mitigation strategies are:

- Provide training to the member*
- Testing and Prototyping*
- Restructuring the contracts to include incentives for on-time delivery*
- Choosing high-quality materials and equipment*
- Adopting a less complex process*

**Accept** –recognizing that residual risks must be taken and responding either actively by allocating appropriate contingency or passively doing nothing except monitoring the status of the risk.

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## **11.8 RISK CONTROL MEASURES**

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The final phase of the risk management process aims to monitor the status of identified risks, identify new risks, ensure the proper implementation of



agreed responses, review their effectiveness, and monitor changes in overall project risk exposure as the project progresses. This section focuses on assessing project risk management performance and identifying whether a project is on track or straying from the original plan. Once the risks have been identified, assessed, and possibly analyzed, they are placed into the Risk Register. The risk register serves the purpose of helping the project team review project risks regularly throughout the project. Risk Register should contain the following information in the form of a table (as shown in Figure 11.11), an excel sheet, or any form of database convenient to the organization.

1. The area of the project in which the risk may materialize
2. Risk Identification Number.
3. Brief description of the risk.
4. The probability or likelihood of the risk occurring is determined within the risk assessment phase.
5. Impact value (impact of the risk, often in separate terms of time, cost, quality or other related project objectives framed)
6. Total impact value
7. Risk Score (combination of the probability and total impact values).
8. Ranking of the risk within the project (ranked risks are those with a high severity and are active within the project).
9. Track of the risk (i.e., has the risk increased, remained the same or decreased in severity since the previous month).
10. Risk Response strategy
11. Risk owner.
12. Whether the risk is active on the register.
13. Whether the risk has been solved

<p>➤ <b>Project title:</b></p> <p>➤ <b>Documented by:</b></p> <p>➤ <b>Revised date:</b></p>														
Risk Identification					Risk analysis				Risk resolution					
ID	Reported by	Date of report (D/M/Y)	Description of risk	Risk type	Description of risk impact	Severity rating	Occurrence rating	Risk rating	Preventive action	Action taken by	Risk priority no.	Date of action taken	Date of action completed	Note

**Fig. 11.11: Sample template of risk register**

Risk review meetings may be held to assess the current status of risks to the project, and project review meetings should include status reports from the project team on critical risks and agreed on responses.

Further, it is also essential to identify the residual and secondary risks after implementing the risk management strategies. The residual risks remain after all of the response strategies have been implemented whereas secondary risks are a direct result of implementing a risk response.

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## **11.9 LET US SUM UP**

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All projects have risks. To be successful, the organization should implement risk management proactively and consistently throughout the project. A deliberate attempt must be made at all levels to actively identify and pursue effective risk management during the project's life. Risk exists the moment a task is envisaged. Moving forward on a project without a proactive focus on risk can lead to failure.

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### **11.10 SELF-ASSESSMENT EXERCISE**

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1. Why do the majority of the projects fail? And what needs to be done to avoid those failures?
2. How risk is different with respect to uncertainty? Think about some uncertain events which turned to be risk for your project and some which did not converted to risk.
3. What is Risk management?
4. What is the difference between a brainstorming session and a nominal group technique?
5. When should the brainstorming session be used, and what are the rules of the session?
6. What is a Risk Score? And what does it indicate?
7. What are different risk management strategies? What will be your course of action as a project manager if the risk score is minimal?

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### **11.11 FURTHER READINGS**

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David Hillson, (2003) 'Using a Risk Breakdown Structure in project management, *Journal of Facilities Management*, Vol. 2 Issue: 1, pp.85-97.

Gupta, R., Das, B. and Jain, K. (2021) 'Risk management of oil refinery construction project:

an Indian case study', *Int. J. Project Organisation and Management*, Vol. 13, No. 3, pp.218–244.

Webby Banda (2019) 'An integrated framework comprising of AHP, expert questionnaire survey and sensitivity analysis for risk assessment in mining projects, *International Journal of Management Science and Engineering Management*, 14:3, 180-192.

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## UNIT 12 AGILE PROJECT MANAGEMENT

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### Objectives:

After studying this unit, you should be able to:

- Understand what is ‘Agility in Project Management’.
- Know the differences between Waterfall and Agile Project management.
- The challenges associated with the Agile Project Management.
- Role of stakeholder involvement in Agile Projects.
- Understand why People Over Process in Agile.

### Structure

- 12.1 Introduction
- 12.2 Manifesto for Agile Software Development
  - 12.2.1 Agile Values
  - 12.2.2 Guiding Principles
  - 12.2.3 Benefits for Agile
  - 12.2.4 Challenges with Agile Project Management
  - 12.2.5 Comparison Between Waterfall and Agile Project Management
  - 12.2.6 Why Agile Project Management, Getting Popular
  - 12.2.7 Agile Project Management Principles
- 12.3 Value-Driven Delivery
- 12.4 Stake Holder Involvement
- 12.5 Why People Over Process in Agile?
  - 12.5.1 Key Roles of Agile Project
  - 12.5.2 High Performing Agile Team
  - 12.5.3 Tracking Team Performance
    - 12.5.3.1 Burn Chart
    - 12.5.3.2 Velocity
  - 12.5.4 Problem Detection
  - 12.5.5 Technical Debt
  - 12.5.6 Lead Time
  - 12.5.7 Cycle Time
  - 12.5.8 Continuous Improvement
  - 12.5.9 System Thinking
  - 12.5.10 Retrospective
- 12.6 Let Us Sum Up
- 12.7 Self-Assessment Exercise
- 12.8 Further Readings

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### 12.1 INTRODUCTION

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Today’s fast pace moving technological world with a complex environment demands faster time to market with innovative and better quality

deliverables. Project work ranges from definite to highly uncertain work. The definite project work is characterized by clear procedures and can be done successfully using traditional project management.

The highly uncertain work requires experts to collaborate to create new designs, solve problems and build the solution. This project has high rates of change, complexity and risk. These characteristics can create problems for the traditional project management approach that aim to determine complete requirement upfront and control changes through the change request process.

Instead, the Agile approach explores flexibility in short cycles and quickly adapts based on feedback. Agile is a new approach to project management. Agile is an iterative approach to managing a project that helps the team deliver value to their customers faster and with effective handling of roadblocks. Instead of working on all requirements in one go, the agile team delivers work in small but consumable increments.

Requirements, plans, and deliverables are evaluated continuously so teams have great visibility for responding to end users' needs quickly. It works by breaking projects down into little bits of user functionality called user stories, prioritizing them and then continuously delivering them in short few week cycles called iterations.

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## **12.2 MANIFESTO FOR AGILE SOFTWARE DEVELOPMENT**

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In support of the agile way of working, IT industry thought leaders & experts agreed on a set of values that defined a culture. They *uncover a better way of developing software with the* Manifesto for Agile.

### **12.2.1 Agile Values**

**Individuals and Interactions:** Over processes and tools

**Working Software:** Over comprehensive documentation

**Customer Collaboration:** Over contract negotiation

**Responding to Change:** Over following a plan

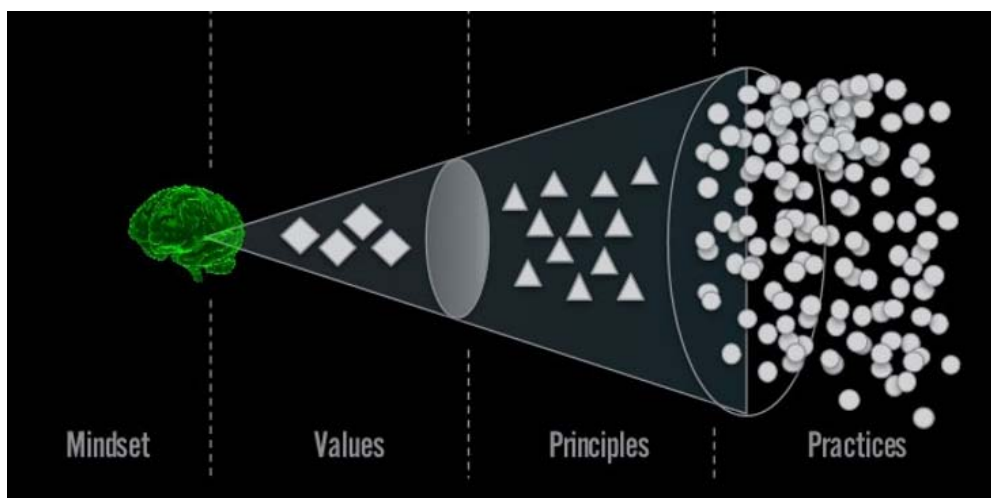
These values are very simple, but it helps to understand the application of the Agile approach to any kind of project work. A few years back everyone has the mindset that these Agile values and principles are applicable to only software development projects. However, that is no longer true. We are seeing Agile adoption across the sectors and domains. Even oil and gas or Infrastructures projects, do look forward to Agile ways of working.

The agile approach is all about the mindset and not specific to any framework or tool. That gives organizations the freedom to incorporate Agile ways of working everywhere including in personal life.

### 12.2.2 Guiding Principles of an Agile Project

Along with the four Agile values, the author defined twelve guiding principles.

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.



**Fig.12.1: Agile Mindset**

As shown in the figure 12.1 above Agile is a mindset that is described by four values, defined by twelve principles and enabled by various practices.

Managing a project using an agile approach requires that the project team adopt to an agile mindset.

The Agile values and principles are helping the team to incorporate new ways of working in their behaviour as well as the way we are delivering our work.

### **12.2.3 Benefits of Agile**

The new ways of working have proven over a period of time that our team is able to achieve high customer satisfaction.

Following are the core benefits of Agile:

1. **Highly Satisfied Customers:** Stakeholders are engaged throughout the project life cycle so they can offer feedback and ensure that the final product will be suited to their needs. These deliverables will improve the overall customer experience.
2. **Superior Quality:** Iterative approach helps to improve deliverables with each iteration. After a few iterations team is in a better position to manage the work.
3. **Faster Time to Market:** The prioritization approach in Agile is supporting the team as well as their customer in identifying high priority critical functionalities to be delivered first and building the rest of the features on top of it in future iterations.
4. **Adaptability:** Agile teams have the ability to respond to change, even at the last minute, and can adapt to it without much disruption. Being adaptable means teams can deliver consistently and manage clients' changing requirements effectively.
5. **Visibility & Transparency:** Agile team works in iteration. This fixed duration makes it easier to predict costs for shorter time periods than for a long-term project.
6. **Risk Reduction:** Regular iteration cadence help everyone is on the same page about where the project is going. This gives an opportunity to stakeholders to evaluate and make decisions based on business value and implementation cost. At any given point in time, customers can decide to discontinue if business demands.
7. **Improved Communication:** Stakeholders are engaged from the start hence it is easy for everyone to understand what we are focusing on and what are the challenges.
8. **Innovative Solution:** Team can experiment and spend time to build the innovative solution.
9. **Fewer Escalations:** The team is self-organizing and high-performing cross-functional. They deliver value to the customer in a short span of time with better quality.

### 12.2.4 Challenges with Agile

Even though Agile offers a host of potential benefits to organizations, it does come with multiple challenges.

People do not like to change. It is human behavior. Hence, we see a lot of resistance from the team to adapt to new ways of working when the organization announces Agile transformation. No matter, how many tools and processes you will provide, ultimately employees have to change the way they are working.

With this new way of working, team members will be afraid of losing their job. This means leaders need to be proactive about demonstrating the benefits of the new ways of working and their benefits to individuals.

Organizational processes become the biggest hurdle in implementing new ways of working.

Leaders need to lead by example by executing agile practices themselves. They cannot delegate to the team to adapt to new ways of working.

### 12.2.5 Comparison between Waterfall and Agile Project Management

In traditional project management practice, we start with gathering all requirements which are part of the project followed by an analysis of a few weeks followed by design again a few weeks, then coding and finally testing for the entire product. These sequential steps take a lot of time for customers to experience actual products or deliverables.

In Agile practice, the team works with the customer closely from day one and identifies which requirements are critical and important. Team focus on only those high priority requirements and finishes all the work related to those requirements and delivered to the customer for their feedback. The team continues to deliver small requirements quickly and frequently. The small iterations support customers to introduce any change they would like the team to work.

**Table 12.1 Comparison between waterfall and Agile project**

	<b>Waterfall / Traditional Project Management</b>	<b>Agile Project Management</b>
<b>Working Culture</b>	Command and Control	Servant leadership
<b>Roles</b>	Rigid – Function specific	Cross-functional
<b>Delivery Time</b>	Very long	Short duration – Few weeks
<b>Stakeholder involvement</b>	minimal	Very high
<b>Risk</b>	Very high	Addressed early in the cycle

<b>Expectation of customer</b>	May OR May not meet	Meets expectation
<b>Value Delivery</b>	Project Completion	Meet customer needs

### **12.2.6 Why Agile Project Management Getting Popular?**

Agile methodology overcomes the challenges encountered in executing the project using traditional methodology.

To meet highly competitive market demand, customers cannot continue with long delivery periods and fixed requirements.

Team members should be able to manage their workload effectively and have a better work-life balance.

Leadership and team build confidence about value delivery. Customers can change requirements at any time during the execution of the project. The team can deliver quickly to customers to get feedback on delivery. This in turn helps them to enhance performance and improve the quality of the delivery.

This new way of working builds a trusted environment with collaborative team culture. Everyone is ready to support each other as performance gets measured at the team level and not at the individual level.

### **12.2.7 Agile Project Management Principles**

- Higher Customer Satisfaction through fast and continuous delivery
- Short delivery cycle from initiation to the final delivery leads to the effectiveness of work
- Key stakeholders work together throughout the project from start gives a better understanding and productive work
- Team can accept customer requests even late in the cycle
- Effective coordination among team members works towards a common goal
- Evaluate the progress and effectiveness at the end of each iteration to identify improvement areas
- Trust and support to the team by the leadership team
- Co-location team is effective in conveying to and within a development team
- Start simple and clear requirements to maximize value delivery
- Practice simple & standardization – removing technical debt

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## **12.3 VALUE-DRIVEN DELIVERY**

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Agile project management focuses on delivering maximum value against business priorities in a shorter period with a given budget, especially when the drive to deliver is greater than the risk.



One of the key ways agile teams try to maximize value is by delivering value early. This means the team aims to deliver the highest value requirements of the project as soon as possible. To maximize success team have to try to deliver as many high-level requirements as soon as before it gets changed.

This means value-driven delivery means making decisions that prioritize the value-adding activities and risk-reducing efforts for the project and then executing based on these priorities.

To maximize value, agile teams need to consider risks and technical dependencies. Team need to consider risks and non functional requirements and let the customer know how those elements will Impact the project.

Risk management may seem like a traditional process-driven project management effort that would not work well in an agile environment. However agile practices are actually very well suited for rapidly identifying and reducing risks.

Prioritization is a fundamental agile process. During prioritization, the customer has an opportunity to insert new requirements at the appropriate place in the backlog and the lowest priority requirements drop off the team's worklist to accommodate that change.

Agile teams also use prioritization to confirm that they are delivering value. Different agile methodologies use different tools for customer-valued prioritization. Prioritization is an ongoing process throughout the project.

Incremental delivery is another way agile methods optimize the delivery of value. Team focus on the minimum functionality that is complete enough to be useful to the users or the market, which is called Minimum Viable Product.

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## 12.4 STAKEHOLDERS INVOLVEMENT

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Projects are undertaken for people and by people. Agile ways of working emphasize incorporating the sponsor's and user's prioritize into the project's priorities and execution. Incorporating stakeholder values means making team do not plan or initiate any work that does not add value to business.

Every stakeholder needs to be engaged based on his need and project impact. Follow the below principles for stakeholder engagement:

***Get the Right Stakeholders:*** Project won't be successful without the right stakeholders. The team has to identify the all the stakeholder's who can most effectively help the team understand the project requirements and make the necessary decisions to move things forward.

***Cement Stakeholder Involvement:*** It is essential for stakeholders to stay engaged with the project. Team needs to do all they can do to make stakeholder involved throughout the project.

***Actively Manage Stakeholder Interest:*** Team needs to take actions to recognize and reward stakeholder involvement, for example project accomplishment celebration with stakeholder or making sure project related feedback becomes part of their performance reviews.

***Frequently Discuss What “Does” Looks Like:*** It is critical to identify the gap created between what the customer wants and describe and what the development team hears and interprets. Regular discussion on what “done” looks like are essential.

***Show Progress and Capabilities:*** The iteration demos or presentations not only allow us to check that we are building the right thing before we get too far into the project. In turn stakeholders stay engaged and informed about when things will be completed.

The recommended way for agile stakeholders to communicate is through face-to-face communication. This method of communication transfers the most information in a given period of time.

Also, knowledge sharing is a key component of agile methods. When information is shared throughout the team, it greatly reduces the risk of impacting productivity.

Agile practices promote knowledge sharing at many levels.

**Team to customer:** Team expresses their understanding and presents what they build to customer to get early feedback.

**Customer to Team:** Customer expresses their acknowledgement about the product built and if changes required, they share with the team.

Agile methods also emphasize knowledge sharing by using low-tech, high-touch tools like cards on wall to plan and schedule the project.

To promote knowledge sharing, the organizational culture should instead encourage and reward the discovery, innovation and transfer of information.

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## **12.5 WHY PEOPLE OVER PROCESSES IN AGILE?**

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Agile first value talks about individuals and interactions, means we need to give importance to people are engaged on the project instead of tools and techniques. This does not mean we are getting rid of tools and techniques, we need them but not ignoring team members. Tools are not going to work on their own. We need right skilled individual to apply the tools and process it.

### **12.5.1 Key Roles of Agile Project**

Agile project has below three key roles from a methodology agnostic perspective.

**Development Team/Delivery Team:** This group includes everyone needed to build and test a complete increment of the product. Agile teams rely on

generalizing specialists means people should be able to perform multiple roles. They should be willing to switch roles based on demand. This group focus on product increments using agile practices and processes. This team is self-organized and self-directed to manage their work. Test and revise the product increments until they are accepted by the product owner. Demonstrate the completed product increment to the customer in the iteration review meeting. Team conducts a retrospective meeting to reflect on their continuous improvement.

**Product Owner/Client Representative:** This person represents a client or customer, who maximizes the value of the product by choosing and prioritizing the product features. He manages the product backlog and owns it. Make sure that it has accurate, up to date and prioritized by business value. Provides acceptance criteria that the delivery team will use to prepare the acceptance test. Determines each completed increment is working as intended and either accept it or requests change. Provides due dates for the project and releases.

**Scrum Master/Agile Team Lead:** This person act as a servant leader, coach and a mentor to the delivery team. Help team to improve and remove barriers from their work. Makes delivery team self-govern and self-organize team. Serves as a facilitator and supports communication with various stakeholder. Guides team to follow agile values and principles. Helps product owner communicate the project vision, goals and backlog items to the delivery team. Facilitates various meetings and follow up on issues raised in stand up meeting to remove impediments so that team can stay on track.

### 12.5.2 High Performing Agile team

Agile project delivery teams are developed into high-performing team. This team makes faster decisions and builds trust.

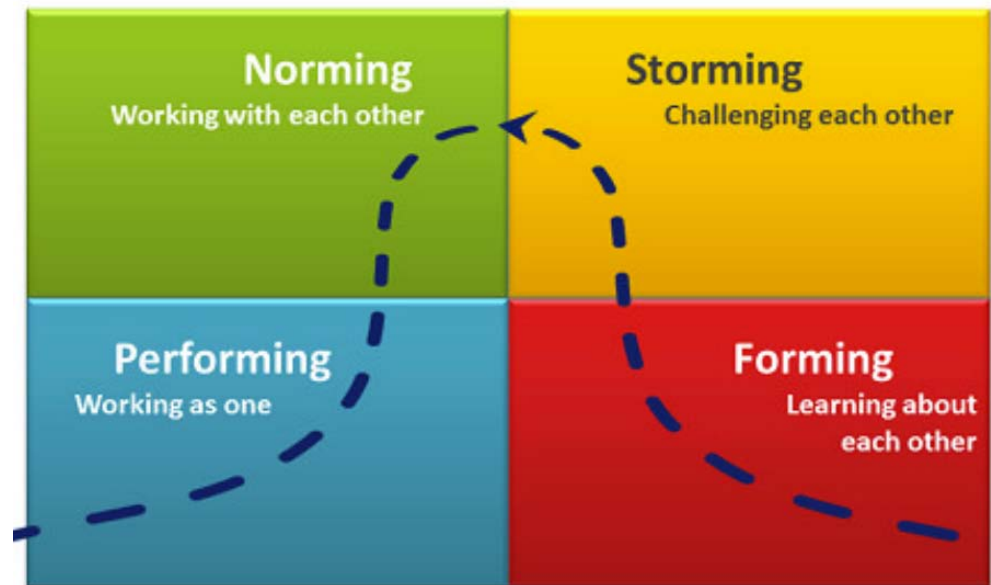
According to Lyss Adkins, high performing team has the following characteristics:

1. They are self organizing, rather than specialists based on role.
2. They are empowered to make local decisions.
3. They are truly believe that as a team they can solve any problem.
4. They are committed to team success and not focus on individual success.
5. The team owns its decisions and commitments.
6. The members are motivated by trust without any fear.
7. They are consensus-driven, with full divergence and then convergence.
8. They are in constant constructive disagreement.

Empowered teams aim to create an emergent leadership model where different people set up to lead different initiatives. These leadership roles are self selected and not assigned. This harness people's passions for trying new ideas and making improvements.

Agile methods use an approach called adaptive leadership in which leaders modify how they interact with team members based on the team's level of maturity. Throughout the project team goes through various team formation stages.

The four primary stages of Tuckman's model are called Forming, Storming, Norming and Performing. These are followed by a disengagement phase called Adjourning.



**Fig. 12.2: Four stages of Tuckman's model**

At the start of the project team is in Forming stage, where people come together as a team. Next phase is Storming, some turmoil as people learn to work together. In the third stage team becoming comfortable in their roles and relationships. Eventually they become a highly functional or performing team who works effectively together.

During the project execution, team may go through storming, Norming and Performing multiple times. This occurs whenever there are changes to the project team.

From the model it seems so simple and clean to define the stages of team formation like this. Does that mean all teams go through these phases in a predictable way? No, each team is unique and different.

The next question comes to mind is, do teams progress as a team through the stages? Not really. People and teams are complex and messy. As a leader need to observe and identify signs that the team is in a particular phase and then act accordingly. To support team in various stages, Agile leader has to adapt to different leadership style. When team starts in Forming stage, team members are new to project and each other. In this case leaders use directing style.

As the team enters into Storming phase, the leader needs to assume coaching style to help team members to resolve conflicts without damaging relationships.

When team reaches the Norming phase, the members help each others and create team norms. This does not mean leader can leave team independently. The leader needs to play a supporting role.

When team is in final stage ie Performing stage, leader use delegating style. However very few team reaches this stage. Most of the team go back and forth in the Storming and Norming phase over and over again. Performing teams are autonomous, empowered, self managing and selfdirecting.

In Agile, instead of motivating individuals. we need to use the approach which can help to motivate entire team.

### 12.5.3 Tracking Team Performance

Agile teams monitor their progress and performance using various tools – Burn Charts and the metric – Velocity.

#### 12.5.3.1 Burn Charts

Agile teams rely on low-tech, high-touch tools that are displayed on highly visible information radiators.

There are two types on burn charts – burndown and burnup. Burndown charts show the estimated effort remaining on the project and burnup charts show the work that have been delivered already.

**Burndown:** A burndown chart tracks the work that remains to be done on the project. As work is completed, the progress line on the chart will move downward, reflecting the smaller amount of work that still needs to be complete. This chart is used for measuring the team's progress in completing the project work.

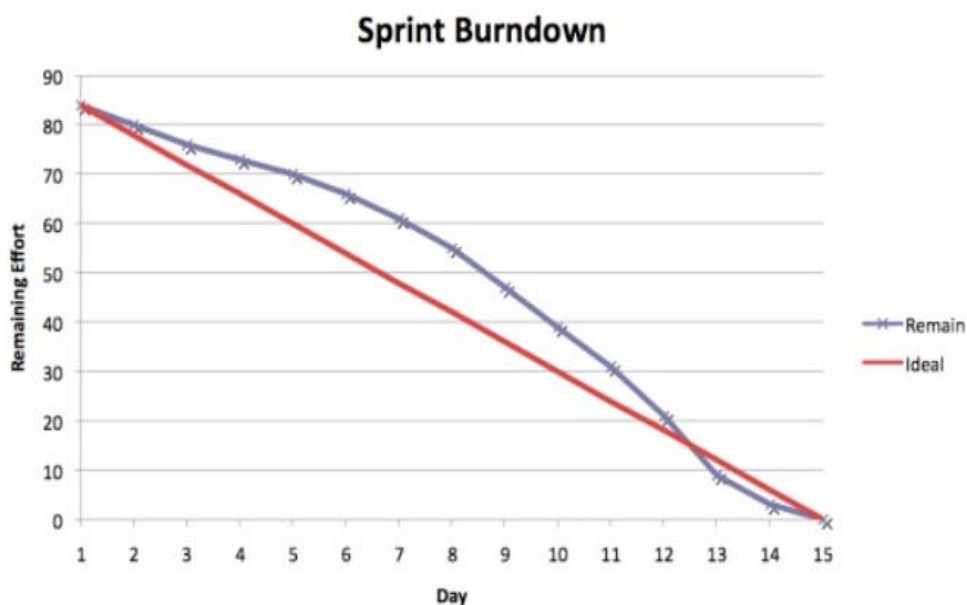
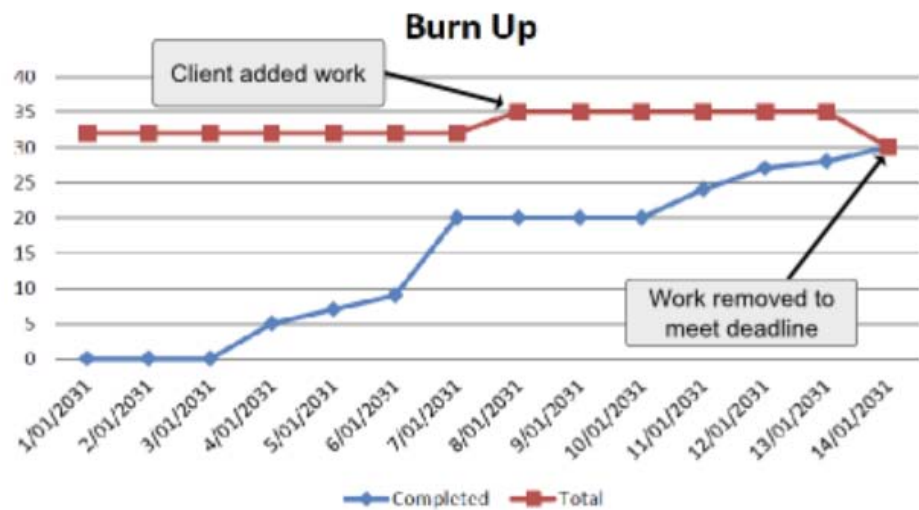


Fig. 12.3: Sprint burn down

**Burnup:** This chart tracks the work that has been completed. Therefore, during the project execution, the progress line will move upward indicating

the increasing amount of work that has been completed. This chart also helps to represent any changes in scope and its impact on the project progress.

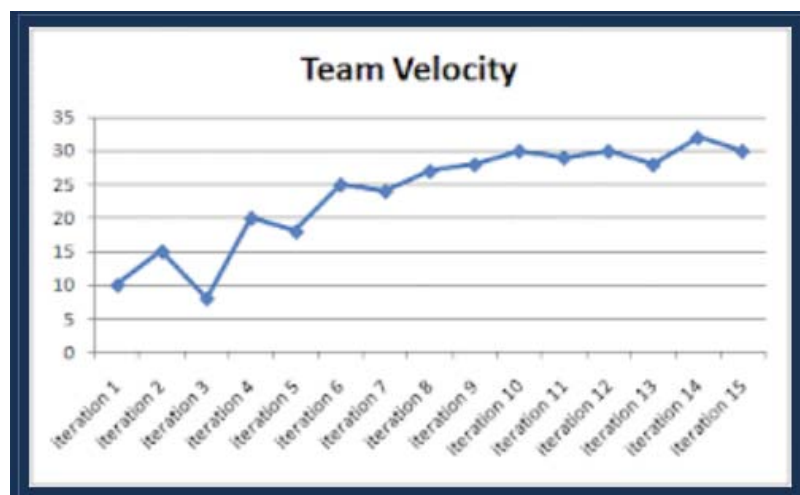


**Fig.12.4: Burn Up chart**

### 12.5.3.2 Velocity

Velocity is defined as the amount of work completed per iteration. This metric allows the team to understand how much work they can complete in future iterations. This provides a way to track and communicate how much the team has accomplished, anticipate what team will be able to accomplish in the future and forecast when the project is likely to be completed.

Velocity is measured in terms of story points. The fact that velocity tends to stabilize over few iterations making it more powerful tool for planning and estimating.



**Fig.12.5: Team velocity graph**

### 12.5.4 Problem Detection

During project execution, it is important that we identify problems early in the cycle to reduce the impact. The cost of fixing the problem over time as more work is done on top of the error or problem, so that more work will

need to be undone to fix the problem. At the same time, more stakeholders will be impacted by the defect making it more expensive to fix.

### 12.5.5 Technical Debt

Technical debt is identified as cleanup, maintenance and standardization work while the product is being built. Technical debt increases the cost of development hence it is recommended that the team needs to include regular work in their backlog to support technical debt regularly. In software development project the solution to technical debt is refactoring. Refactoring is the process to simplify and standardize the code to make it easier for the team to work on the product in the future.

Whenever a team is estimating the work, always ask them to include time for refactoring, as this should be part of their regular work routine.

Managing Technical Debt Over Time

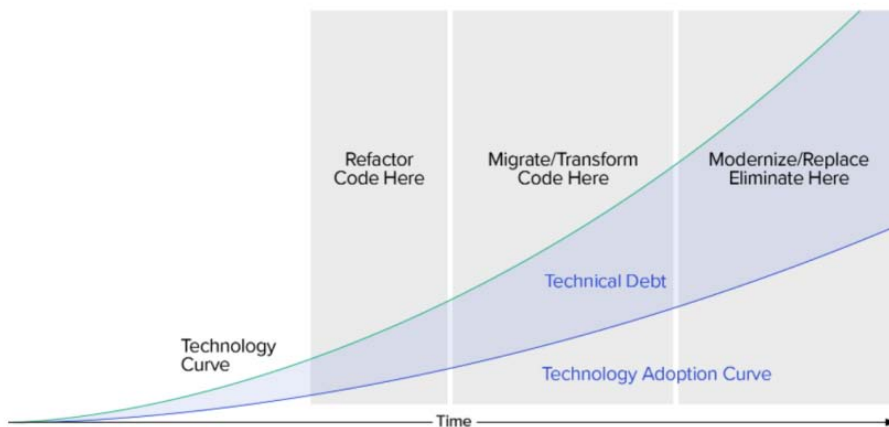


Fig.12.6: Technical debt over time

Reducing technical debt involves keeping the work environment organized and product streamlined and standardized.

In Agile, we create open and safe environment for the team to work collaboratively and protect their feelings.

Alistar Cockburn describes some failure and success modes, that can help to understand team member's side of performance. There are five failure modes that Cockburn describes in his book – Agile Software Development: The Cooperative Game.

1. **We make mistakes:** We are all human beings and we tend to make mistakes. Hence iterative ways of working help to identify mistakes early.
2. **We prefer to fail conservatively:** When team members face uncertainty they tend to go for what they know, even if they know it is not the optimal solution.
3. **We prefer to invent rather than research:** Many times team members go for inventing new ways of doing things rather than looking at already existing solutions created by another team member.

4. **We are a creature of habit:** People are creatures of habit hence it is difficult to get change.
5. **We are inconsistent:** Most people are very inconsistent at following the process. The challenge is not finding a better way of doing things, it is getting people to accept the new way and make them apply a new approach.

### **12.5.6 Lead Time**

Lead Time measures how long work takes to go through the end-to-end process. That means from requirements gathering through development to production deployment.

### **12.5.7 Cycle Time**

Cycle time is part of the lead time. That means the time any activity takes to complete that process. For example, cycle time for creating design begins with when team starts working on it and ends when design is ready for those requirements.

Cycle Time, WIP and Throughput are important parameters to measure performance.

Cycle time is a function of WIP (work in progress) and throughput. It can be calculated using below formula:

$$\text{Cycle Time} = \frac{\text{WIP}}{\text{Throughput}}$$

**WIP:** The amount of work which is not finished. If WIP is high then, it takes lot of time and creates delay in completing work.

### **12.5.8 Continuous Improvement**

Continuous improvement is the key practice in the Agile ways of working. It offers improvement at multiple levels. For example, In software development project, continuous improvement starts at the code level with pair programming. While one person is coding, the other person reviews it and suggests real time improvements. On a daily basis the team members share any impediments during stand up meetings, so that scrum master can quickly remove them. Finally, at the end of each iteration, team conducts review meeting with the customer and retrospective meeting for the team.

### **12.5.9 System Thinking**

System thinking is helpful to understand the systems-level environment for the project. This approach involves classifying projects in terms of their complexity in two areas – the project requirements and the technology.

Agile works best for the complex project where project have uncertainty around the requirements and technology.



### 12.5.10 Retrospective

The retrospective meeting team conducts at the end of the iterations only for the team, to identify

- What is going well?
- What areas team can improve?
- What should team do differently?

The lessons and improvements that results from the retrospective meeting are highly applicable and pertinent to future iteration work. The upcoming iterations will have same business domain, technical domain and team dynamics. The retrospective offers immediate value to the current project, instead just documenting learnings for the future project with similar business requirements and team dynamics.

Retrospective offers multiple benefits:

1. **Improved productivity:** By applying immediate actions to reduce rework, the team can get more productive work done.
2. **Improved capability:** This meeting provides platform to the team for spreading scarce knowledge within the team.
3. **Improved quality:** By identifying the circumstances that have led to defects and removing the cause.
4. **Improved capacity:** This meeting focuses on finding process efficiency improvement which can improve the team's capacity to do work.

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## 12.6 LET US SUM UP

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When the project is executed using Agile ways, it gives multiple benefits which the end-user is looking for in this competitive market. Team will be highly motivated and always willing to innovate without any fear of failure. Agile team members are not only empowered to make decisions but also lead the complex delivery with innovations. They identify risk and technical dependencies early enough to maximize the value. Agile prioritization practices yield the highest value to the customer first. With increment delivery, the team regularly delivers working increments of the product. This gives an opportunity to the customer to provide feedback early as well as they can make the decision to stop the project work, if they are comfortable with the product.

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## 12.7 SELF-ASSESSMENT EXERCISE

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1. What is agility in project management? Explain.
2. What are Agile Values? Discuss.
3. What are the guiding principles of an agile project?
4. What are the benefits of Agility in Project management? Discuss.

5. Discuss the challenges associated with Agile Project Management.
6. Compare and contrast between Waterfall and Agile Project Management.
7. Why Agile Project Management is getting more popular in the industry? Discuss.
8. What are the Agile Project Management Principles? Elaborate.
9. What are the key roles of Agile Project? Discuss.
10. What are the various tools used by Agile teams monitor their progress and performance? Discuss.

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## **12.8 FURTHER READINGS**

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## **BLOCK 4**

# **PROJECT CLOSURE**

Unit 13 Project Contracts and Partnering

Unit 14 Project Audit and Closure



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## UNIT13 PROJECT CONTRACTS AND PARTNERING

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### Objectives:

After studying this unit, you will be able to:

- Define Contracts, Tenders, Project Partnering and Public-Private Partnerships.
- Trace the features and scope of contracts, Tenders and Public-Private Partnerships.
- Identify different types of Contracts, Tenders, project partners, and public-private partnerships.
- Understand tendering process and steps involved in project partnering.
- Recognize various terminology and guidelines used on a national and international level.

### Structure:

- 13.1 Introduction
- 13.2 Contracts
- 13.3 Tenders
- 13.4 Project Partnering
- 13.5 Public-Private Partnership
- 13.6 Let Us Sum Up
- 13.7 Self-Assessment Exercises
- 13.8 Further Readings

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### 13.1 INTRODUCTION

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The fundamentals of contracts, tenders, project partnering, and public-private partnerships will be covered in this unit. We'll go over the nature, parameters, categories, and various definitions and meanings of contracts, tenders, and public-private partnerships in this section. Additionally, you will learn the purposes, processes, and procedures for contracts, bids, and public-private partnerships.

We will define the terms contracts, tenders, project partnering, and public-private partnership from a variety of angles in this unit. Your ability to generalize the applicability of contracts, tenders, and public-private partnerships and put it in the context of your personal experiences will be enhanced by this.

The distinctions between BOT and BOOT have also been attempted to explain. The overall goal of this unit is to offer a variety of conceptual

contributions, both western and Indian, to make project contracts and partnering applicable to the context of developing nations. Additionally, an effort is made to use examples from India to explain concepts like contracts, tenders, and public-private partnerships.

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## **13.2 CONTRACTS**

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### **13.2.1 What is a Contract?**

A contract is a legally binding agreement that requires both parties to fulfil their end of the bargain—the seller providing the goods or services in exchange for payment. It includes all agreements that, barring express written authorization to the contrary, require the Government to use appropriated funds for a specific purpose.

The phrase "contract type" is used to convey a variety of meanings. It denotes a variety of different compensation plans, of which there are many. Most compensation arrangements, however, fall into one of two categories: cost reimbursement or fixed price. In another sense, the phrase "contract type" refers to variations in contract form or structure. A letter contract, purchase order, performance-based, completion, or term contract, for instance, are a few examples of this structure. In order to specify an intended end result, the term "contract type" is used. Contracts for supply, supply chain management, and research and development are a few examples of this.

### **13.2.2 Categories of Contract Types**

In general, fixed-price and cost-reimbursement contracts fall under the two main categories of compensation. A firm fixed price is at one end of these categories, and a cost-plus fixed fee is at the other. Depending on the level of uncertainty associated with contract performance, there are a variety of compensation/profit structures between those two that allow for varying degrees of contractor responsibility.

The following lists these two main types of compensation, fixed price and cost reimbursement, along with the various types of contracts that fall under each. A list of additional contracts is also provided, some of which fall under the definition of contract structure or form but do not fall under the categories of fixed price or cost reimbursement contracts.

The most preferred type of contract is typically one with a firm fixed price, while cost-reimbursement contracts are the least preferred. With the exception of sealed bidding, the contract chosen should be specific to the facts of each individual case. Firm fixed prices for sealed bids or fixed prices with reasonable price adjustments are both required.

Government contracts are agreements made by the government for a variety of tasks such as building management, maintenance, repairs, hiring of labour, IT-related projects, etc. A contract qualifies as a government contract if it involves the federal government, a state government, or another government

entity. A contractor is a person or company that carries out a contract on behalf of the government. For instance, Larsen and Turbo may carry out a flyover construction project for the Tamil Nadu government. In a government contract, opened bids are typically floated through sealed bids, and requests for proposals may be issued. The supplier would need to be GST registered and meet the requirements specified in the contract document in order to participate in a government contract. Let's examine the various categories of public contracts now:

### **13.2.2.1 Fixed-Price Contracts**

A fixed-price contract is one in which the cost is determined without taking into account the time and resources used, which suggests that such a contract is entered into if the project's cost is already known. The agreement may also contain clauses relating to contract changes, reasonable pricing, or inaccurate pricing. It can benefit or harm either of the parties. To give an example, if prices suddenly rise, the seller will lose some of his profit margins, whereas the buyer will benefit because he got a good deal. The same is true for the buyer.

In a fixed-price contract, the contractor is required to provide the good or perform the service for the agreed-upon, fixed price. This type of contract gives the contractor the greatest amount of risk, complete accountability for all expenses and any resulting profit or loss, the greatest amount of incentive to manage costs and perform well, and the least amount of administrative work for the contracting parties.

### **13.2.2.2 Cost Reimbursement Contracts**

A cost reimbursement contract, in contrast to a fixed-price contract, enables the contractor to claim all of his expenses, as well as additional payments to make for a profit. The government might suffer losses as a result of rising costs or the obligation to pay even when the task isn't completed, though we might argue that this would be an uncommon occurrence. When estimating costs is challenging, this type of contract is used. The contractor might offer an estimated price in some circumstances. Government approval is required if the actual cost turns out to be higher than expected; otherwise, the contractor will lose money due to the overrun.

### **13.2.2.3 Indefinite-Delivery Contracts**

When the length of the contract is known but the precise time of delivery is not, the situation is called a "indefinite delivery contract." It is a contract that ensures the delivery of an unspecified number of services within a specific time frame. This is usually done when the government is unsure of the number of services needed to finish the job. The typical time it takes to complete a contract of this type is four years. Indefinite delivery contracts come in three different flavors:

- Definite quantity contract

- Requirements contract
- Indefinite quantity contract

**13.2.2.4 Other Categories of Contracts:**

There are different basis for classifying the contracts, some of the categories include the following:

**13.2.2.4.1 Incentive Contracts**

The introduction of incentive contracts served to encourage contractors to complete their work by providing them with financial incentives. Any of the following agreements could be considered an incentive contract:

- Fixed price incentive contracts
- Cost plus incentive contracts
- Cost plus award fee contracts
- Performance incentive
- Delivery incentive
- Multiple incentive contracts

**13.2.2.4.2 Time and Materials Contract:**

Only when a thorough understanding of the timeframe or the cost to be incurred is lacking is a time and materials contract used. To assess the effectiveness of the work process under this kind of contract, government oversight is necessary. This contract is only entered into if none of the other contracts can be implemented. Similar to fixed-price agreements, time and materials agreements have a ceiling price that the contractor may only exceed at his own risk.

**Check Your Progress 1**

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

1. Define the term contract, and list different types of contracts studied in the unit (Answer in about 50 words each).

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**13.3 TENDERS**

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There is a great deal of trading and dealing of goods and services when it comes to the business sectors. The companies involved in these agreements must submit a formal offer to other organizations in exchange for the



exchange of goods and services. This proposal for an offer or bid is made in the form of a tender. Let's look at the definition of a tender in more detail and examine how it functions to comprehend its significance in the business world.

### 13.3.1 What is a Tender?

An official offer, such as a takeover bid, or an invitation to submit a bid for a project are both examples of tenders. The term "tender" typically refers to the procedure by which the government and financial institutions submit invitation bids for significant projects. There is a deadline by which these bids must be submitted. The expression "tender" or "tendering" can also refer to the act of shareholders submitting their shares or securities in response to a takeover offer.

The shareholders also receive a tender offer, which is regarded as a public solicitation to all shareholders and asks them to tender their shares for sale at a specific price during a specific time frame.

A request for tender, or RFT, on the other hand, is a formal request or invitation to suppliers that asks them to submit aggressive bids to supply goods, services, and raw materials. In the private sector, the request for proposals, also known as an RFP, or request for tenders, is more frequently used.

In contrast to the request for tender, or RFT, a tender is a document that the supplier submits in response to the RFT. Due to this, a tender is essentially an offer to the buyer to supply goods and services in accordance with their needs.

### 13.3.2 Different Types of Tenders

To ensure that the work to be done for the government or a specific client is done reasonably and effectively, India now has an e-tender process that is well structured. For these reasons, the majority of institutions have a specific procurement that is conducted according to a set procedure and have set policies that instruct the institutions on how to decide and which tender to accept. This method involves a fair and transparent process for carefully examining, evaluating, and choosing the vendors.

- i) **Open Tender:** The open tender method, which is the main tender method, is accepted by both the private and public sectors. This is regarded as the primary type of tender in which the client or customer invites potential contractors and suppliers by publishing the tender publicly in a newspaper or on an e-tender platform along with some key details about the proposed works.
- ii) **Selective Tender:** To address the shortcomings of the open tender process, the selective tender method was created. The purpose of this tender is to increase the calibre of bids received while also making sure

that the contractors with the necessary experience are given the proper opportunities to submit the necessary bids on time.

- iii) **Serial Tender:**Serial tendering is a more sophisticated or hybrid tendering process that combines a competitive bid with negotiation. There may be one stage or two stages to this competitive tender. For clients who have several phases of similar work, this type of tendering is frequently used.
- iv) **Negotiated Tender:**In the engineering and construction sectors, negotiated tenders are frequently used. Because pre- and post-contract negotiations are common in these industries, this is true.
- v) **Term Tender:**Large projects with high maintenance requirements frequently use this type of tender. The contractor is being asked to take care of particular structures or buildings spread across various locations through this tender. Term tenders are limited in time and can specify specific criteria that must be met by the supplier while adhering to the needs of the client.

### 13.3.3 Tendering Process

The majority of institutions have procedures in place to control the opening, assessment, and final selection of vendors for projects or procurements. By doing this, the fairness and transparency of the hiring process is ensured. A request for tender (RFT) is a formal and structured invitation to suppliers to submit competitive bids to supply raw materials, products, or services. Due to the fact that this is a public and open process, laws were made to regulate it and ensure that bidders compete fairly.

For instance, nepotism and bribery may flourish in the absence of laws. Potential bidders have access to a variety of tenders from both public and private sources through tender services. As part of these services, bids that are appropriate are created, the process is coordinated to meet deadlines, and any applicable laws are followed.

**Special Considerations:** An open call for stock tenders at a set price and time is known as a tender offer, and it is made to all shareholders. The offer typically exceeds the current market value of the shares in order to entice shareholders to release a specific number of shares. Tender offers are closely scrutinized and heavily regulated in the United States.

- a) **Advertising the Requirement:** The opportunity may be promoted in a variety of ways, but it will at the very least contain the following:
  - E-tendering portal
  - E-tendering portal
  - Other websites (for example, Supply to Surrey)
  - Other websites (for example, Supply to Surrey)

**b) Selection Stage / Pre-Qualification Questionnaire (PQQ):** The selection stage may be carried out independently of the full tender process, in which case it is known as a Pre-Qualification (PQQ). It can also be completed in a single stage alongside the collection of tender information. It assesses:

- Capacity
- Capability
- Experience

**c) Evaluation of Selection Stage / PQQ:** The evaluation of submissions determines which suppliers advance to the evaluation of their complete tender submission (in the case of a single stage or open tender) or shortlists and chooses those suppliers who are best able to meet the requirements to be invited to the ITT (Invitation To Tender) stage in the case of a two-stage or restricted tender process.

**d) Invitation to Tender (ITT):** Depending on the process used, the ITT might be open to all suppliers (open or single-stage process), where selection and tender information are combined, or it might be restricted to those who have advanced past the selection/PQQ stage.

All tender documents are available for download on the portal and will include all or some of the following:

- Rendering instructions
- Specification
- Rendering instructions
- Specification
- Pricing schedule
- Contract conditions - defining the relationship between the government body and the supplier/contractor
- Tender evaluation model - how we plan to evaluate the submission

**e) Evaluation of the Tender Submissions:** This is completed by an evaluation panel.

**f) Award of Contract:** The portal will be used to notify each tender-submitting supplier of the selection of the winning bid. The successful supplier(s) and the grade received during the evaluation of tender submissions should be specified in the decision letters.

## Check Your Progress 2

**Notes:** a) Space is given below for your answer.

b) Check your answer with the one given at the end of this unit.

What do you mean by tendering? List the ways that investors can purchase government securities.

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## 13.4 PROJECT PARTNERING

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### 13.4.1 Partnership

A partnership is a company that is owned jointly by a number of people. The partners may be active participants in the operation of the business or passive investors. In the partnership agreement, it is made clear how the partners relate to one another, how much and what kind of ownership each partner has, and what their responsibilities are.

### 13.4.2 Types of Partners

The two partner categories, general partners and limited partners, are the best place to start when discussing a partnership business. Both invest in the business, but their activity within the business differs.

#### i) General Partnership

An association that only has general partners is called a general partnership. Any general partner may sign a contract on the partnership's behalf, and each general partner is required to actively participate in the company's management. As a corporate board of directors, the partners must agree on major decisions.

- **Benefit:** Each partner can act independently and invest in various types of capital. The startup costs and formalities for this type of partnership are also minimal.
- **Disadvantage:** A general partnership operates as a sole proprietorship, with no separation between the partners and the business. General partners' liability is not limited because they actively participate, as described above.

#### ii) Limited Partnership

A limited partnership has both general and limited partners. In many cases, the business is managed by one general partner and a number of limited partners. An investment in the company is the extent of a limited partner's liability; they are not involved in the day-to-day management of the partnership.

#### iii) Limited Liability Partnerships

Limited liability partnerships (LLPs) are similar to limited liability companies but differ from limited partnerships and general partnerships

(LLC). All partners have limited liability in an LLP. LLPs are frequently established by teams of experts who want to share resources and cut costs.

- **Benefit:** Unlike a limited partnership, general partners in an LLP are not personally liable.
- **Drawback:** Due to limited liability for all partners, some companies or people might be hesitant to work with the partnership.

### **13.4.3 Partnering**

The idea of partnering offers a framework for the development of shared goals among the construction team in an effort to arrive at a mutually acceptable dispute resolution process and to support the idea of continuous improvement.

#### **Goals of Partnering**

The main purposes of partnering are to prevent disputes from escalating into expensive and disruptive claim situations and to make it easier to complete profitable, on-time, and high-quality projects.

### **13.4.4 Project Partnering**

The traditional competitive dynamic between owner and contractor might be overcome by project partnering. By partnering, both parties can establish mutually beneficial goals and objectives and build a relationship based on trust and productivity.

**Advantages of Project Partnering:** Typical benefits from Project partnering would be

- Reduced exposure to litigation
- Project outcomes improved in terms of cost, time, and quality.
- Reduced administrative and legal expenses.
- Greater scope for innovation and value engineering.
- Improved financial success prospects.
- Consistent cost reductions
- Customized service delivery
- Client satisfaction
- Increased turnover and profitability

**Drawbacks of Project Partnering:** Due to the nature of change, partnering can also elicit criticism from professionals and academics. Senior management identified the following criticisms.

- When businesses must compete fiercely to win other projects, they face serious difficulties in establishing a culture of partnering for those projects.

- As decisions made in one department are overturned in another, contemporary decentralized decision-making models undermine partnering.
- Establishing long-term partnering relationships is hampered by commercial realities that force businesses to have multiple suppliers and customers.
- When one partner collaborates with the rivals of the other, open communication between partners is hindered.
- Partnering arrangements prevent companies from creating more lucrative new ventures.

### Guidelines for Success in Project Partnering

To adopt a win-win mentality, all parties involved should develop a set of shared objectives. This will motivate everyone to concentrate on achieving their goals and creating value for each other. That is, all parties will profit more and the client will pay less.

- Value for money
- Guaranteed Profits
- Reliable
- Costs within the agreed budget
- Handover on time
- Cost reduction
- Shared risks
- Improved efficiency for users
- No claims
- Effective meetings
- Shared use of computer systems
- Value for money

To maintain successful partnering across multiple projects, it's a good idea to hold workshops throughout the project and a final workshop that identifies problems and lessons learned from the previous project.

### 13.4.5 Steps in Project Partnering

Partnering Step by Step is a response to the demand from people working on local-level partnerships for sustainable development in many parts of the world.

- Scoping:** Government, business, or non-profit organisations can all propose the idea of forming a partnership for sustainable development. Whatever the specific situation, the initial energy for a partnership comes from one organisation or sector. Some partnerships are created from the "top down" while others are "grass roots" in nature. There is no value in

partnering merely for the sake of partnering, so be methodical in your exploration of other options.

- ii) **Identifying:** Finding suitable partners can be done in many different ways. In order to discuss the problems, consider the possibility of a collaborative approach, or simply make contact with as many potential partners as possible, one option is to call an open meeting for a significant number of key organisations from all sectors. A different choice is to pick the most likely partners and meet with each one of them separately to present the idea and gauge their interest.
- iii) **Building:** Once partners have been found, it is a good idea to devote some time to strengthening relationships and understanding among the various partners, both between the key players and between the cultures of the organisations involved. It is crucial to go beyond this and develop real engagement and understanding of the motivations, priorities, and values of each of the partner organisations and individuals involved.
- iv) **Planning:** It may surprise you that we advise doing so much planning before signing an agreement because this is the most important step in the pre-agreement phase. According to experience, the best partnerships are those that outline most aspects of a plan and work through them to ensure that the right people are involved and that the expectations are reasonable. This is significant because it will serve as the foundation for the partnership once it enters the project implementation phase.
- v) **Structuring:** The infrastructure for creating and carrying out the agreed-upon work programme of work must be put in place after an agreement is signed. Since transitioning from planning to managing mode is always difficult, it is not uncommon for partnerships to falter at this point. The goal is to develop a delivery mechanism that will be effective while maintaining the active engagement of all partners that was so carefully established in Phase 1.
- vi) **Mobilizing:** It occasionally turns out that a partner overstated what their company could provide out of enthusiasm for the partnership. In order to fulfil their commitment and convince their organisation that the contribution is appropriate and will have positive effects on the organisation, they might need assistance. Sometimes a partner has underperformed, but as the project progresses, that organisation is able to contribute more or in new ways.
- vii) **Delivering:** In a partnership, the delivery stage is in and of itself a perpetual cycle of activity that can last for years! Some partners will find this stage simple and familiar since they have previously delivered development projects, and in many ways it is comparable to any type of project delivery cycle.
- viii) **Measuring:** It can be tempting to put off asking some of the more

difficult questions, like, "Is the partnership productive?" when things are going well and the relationships between the partners appear to be generally satisfactory. Does everyone contribute what they can? Is it meeting targets and objectives? These are all important questions, and in the end, each partner organisation will want to know the answers to them to support their participation.

- ix) Reviewing:** In a partnership, it is important to distinguish between measuring project outputs and impacts and reviewing the partnership's added value and effectiveness.
- x) Revising:** Any review is likely to generate suggestions for changes to the partnership. Small but significant procedures to more radical changes can be included (for example, deciding to radically restructure the partnership). This process can be difficult, and some partners might interpret it as an implicit criticism of what has come before.
- xi) Scaling:** Many partnership projects begin as "pilots," evaluating the partnering strategy to see if it is effective in producing the desired outcomes. Some joint venture initiatives stay modest in scope and perfectly meet expectations. Usually, if a programme is a success, partners start thinking about how to expand it to increase reach, impact, and influence.

**Check Your Progress 3**

- Notes:** a) Space is given below for your answer.  
b) Check your answer with the one given at the end of this unit.

What is project partnering? List its advantages

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**13.5 PUBLIC – PRIVATE PARTNERSHIP**

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**13.5.1 Public-Private Partnerships**

Public-private partnerships involve collaboration between a government organisation and a company from the private sector, and they can be used to finance, build, and manage projects like public transportation systems, parks, and convention centre. By receiving funding from a public-private partnership, a project may be completed sooner or even become financially feasible. Giving up tax or other operating revenue, liability protection, or a percentage of ownership rights over things that are ostensibly public are frequent components of public-private partnerships.



## How Public-Private Partnerships Work

Public-private partnerships typically have contract terms of 25 to 30 years or longer. Users and/or the public sector must make payments throughout the project even though some of the funding is coming from the private sector. While the private partner participates in the project's planning, implementation, and funding, the public partner focuses on defining and ensuring that the objectives are being met. Risks are allocated to public and private partners through a negotiation process, ideally but not always in accordance with each party's capacity to evaluate, manage, and deal with them.

### Advantages of Public-Private Partnerships

Governments and private businesses benefit equally from partnerships. For instance, private sector innovation and technology can help boost the operational effectiveness of delivering public services.

### Disadvantages of Public-Private Partnerships

As a result of joining a public-private partnership, the private partner may experience unique risks. Construction risks exist with regards to physical infrastructure like roads and railroads. The private partner usually pays the price if the product isn't delivered on time, costs more than expected, or has technical flaws.

### Examples

Schools, jails, dorms for students, and sports or entertainment venues are examples of public service accommodations.

### 13.5.2 Build – Operate – Transfer(BOT) or Build – Own – Operate-Transfer(BOOT):

Build-operate-transfer (BOT) or build-own-operate-transfer (BOOT) is a type of project delivery method, typically used for large-scale infrastructure projects, in which a private entity receives a concession from the public sector to finance, design, construct, own, and operate a facility specified in the concession contract. For a specific period of time, the private entity will have the right to run it. This enables the project's promoter to recoup its investment as well as operating and maintenance costs.

**Examples:** A power plant in the Philippines, a highway in Pakistan, and a facility for treating sewage in China.

BOT contractors, in general, are special-purpose businesses established especially for a particular project.

A common example of this arrangement is a power purchase agreement, in which a public utility serves as the off taker and buys electricity from a privately owned plant. In a conventional concession, the business would sell

to consumers directly, without a government intermediary. Commonly, minimum prices that the offtake must pay are outlined in BOT agreements.

### **BOT Framework**

Public-private partnerships and infrastructure projects both make extensive use of BOT. In the BOT framework, a third party, such as the public administration, assigns to a private sector entity the responsibility of planning, designing, and constructing infrastructure as well as for the temporary operation and maintenance of these facilities. During this time, the private party is in charge of raising the necessary funds for the project, has the right to keep all profits made by it, and is the owner of the facilities in question. Once the concession agreement is over, the facility will be handed over to the public administration without payment to the private party involved.

In contrast to developing an entire network, a BOT project typically focuses on developing a single discrete asset. In a BOT project, the project company or operator typically gets its money from a fee it charges to the utility or the government rather than tariffs it imposes on customers. Concessions refer to a variety of new construction projects like toll road projects, which share many characteristics with BOTs.

### **Variations on the BOT**

The fundamental BOT model is subject to numerous modifications. The contractor owns the project during the build-own-operate-transfer (BOOT) contract period. Design-build-operate-transfer (DBOT) agreements are one illustration. The Build Own Operate Transfer (BOOT) funding model for project financing entails a single organisation or consortium (the "BOOT provider") that designs, finances, owns, and operates the project for a predetermined amount of time before transferring ownership to a designated party. Governments can use BOOT projects as a way to package and contract out the design, building, financing, operations, maintenance, and possibly marketing and customer interface aspects of a project to a single private sector service provider. Following the concession period, the asset is inexpensively or completely returned to the government.

### **The Components of Build Own Operate Transfer (BOOT) Model:**

- **Build:** The concession gives the promoter the freedom to plan, build, and fund the project. Between the promoter and a contractor, a construction contract will be necessary. Due to the conflict that frequently develops between the promoter, the contractor in charge of building the facility, and those providing the financing for its construction, the contract is frequently one of the most challenging to negotiate in a BOOT project.
- **Own:** The state grants the concessionaire the right to own, or at least possess, the assets that are to be built and to operate them for the duration of the concession. The concession agreement between the state

and the concessionaire will specify how much control and possession of the assets belong to the concessionaire, as well as the associated ownership rights.

- **Operate:** On behalf of the concessionaire, an operator is in charge of maintaining the facility's assets and managing them so as to maximise profit or minimize cost. Like a contractor carrying out construction, an operator is also a shareholder in the project company. Through the promoter company, the operator is frequently an independent.
- **Transfer:** When the concession period comes to an end and the assets revert to the government grantor, there is a change in ownership of the assets. In the event that the concessionaire fails, the transfer may take place earlier and be at book value or have no value.

#### **Check Your Progress 4**

**Notes: a) Space is given below for your answer.**

**b) Check your answer with the one given at the end of this unit.**

What do you mean by Build–operate–transfer (BOT) or build–own–operate–transfer (BOOT)? List the variations on the BOT?

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### **13.6 LET US SUM UP**

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A contract is a legally binding agreement in which the seller agrees to provide supplies or services, and the buyer agrees to pay for them. Contract compensation is divided into two types: fixed-price and cost reimbursement. Within these categories, there is a firm fixed price on one end and a cost-plus fixed fee on the other. Depending on the level of uncertainty associated with contract performance, there are a variety of compensation/profit structures between those two that allow for varying degrees of contractor responsibility. When referring to two distinct procedures governments use to sell government securities, the terms competitive tender and non-competitive tender are used. A different definition of a tender applies when buying government securities like U.S. Treasury bills, bonds, and notes. It alludes to the auction-style process by which investors buy these securities. An offer to repurchase stock from shareholders is referred to as a tender offer in the context of a stock buyback. Short tender and hedged tender are two other terms for the same thing. Public-private partnerships have many benefits, but they are frequently criticized for blurring the lines between acceptable private for-profit activity and legitimate public purposes.

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### **13.7 SELF – ASSESSMENT EXERCISES**

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- 1) What is a contract? List various categories of contracts
- 2) Define the term tender? List the various types of tenders.
- 3) Discuss the various steps involved in the tendering process?
- 4) What are special considerations to be considered in tendering process?
- 5) What is Project partnering? List the advantages and limitations.
- 6) State the various steps involved in project partnering?
- 7) Critically examine the role of Public Private Partnering in today's ever changing environment.
- 8) Elaborate on the concept of BOT and BOOT?

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### **13.8 REFERENCES AND FURTHER READING**

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## UNIT14 PROJECT AUDIT AND CLOSURE

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### Objectives

After studying this unit, you will be able to:

- Describe what the terms "project closure," "auditing," and "auditing" mean.
- Examine the characteristics and complexities of the audit, the audit report, and project closure.
- Name the different kinds of audits, project closures, performance evaluations, and
- To understand concepts like regular project closure, premature project closure, perpetual projects, unsuccessful projects, and
- Recognize that there are different words and instructions at the national and global levels.

### Structure

- 14.1 Introduction
- 14.2 What is a Project Audit?
- 14.3 When to Audit?
- 14.4 How to Audit
- 14.5 Who should Audit?
- 14.6 Audit Report
- 14.7 Project Closure
- 14.8 Types of Project Closure
- 14.9 Project Closure Process
- 14.10 Performance Evaluation
- 14.11 Let Us Sum Up
- 14.12 Self-Assessment Exercises
- 14.13 Further Readings

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### 14.1 INTRODUCTION

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In this unit, the foundations of auditing, auditing, and project conclusion will be covered. Here, we will discuss the characteristics, categories, definitions, and meanings of audit, auditing, and project completion. You will also learn the goals, procedures, and steps of auditing and how to close a project.

This unit will explain what audit, auditing, and project closure mean from different points of view. As a result, you can apply your experiences to the relevant audit, auditing, and project closing. In addition, distinctions have

been made between successful and unsuccessful initiatives and between normal and premature project conclusions. The overall objective of this unit is to offer several conceptual inputs, both western and Indian, to make project audit and closure appropriate to the context of developing countries. Also, words like audit, auditing, and projects are tried to be explained. Describe the process of performance evaluation, team evaluation, and project conclusion using examples from India.

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## **14.2 WHAT IS A PROJECT AUDIT?**

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A formal project management audit aims to assess a project considering predetermined standards. Project performance, quality, and conformity to the statement of work are a few examples.

Audits differ from conventional project reviews in that they are undertaken by a party external to the project team and command structure. A designated audit department, steering committee, or external auditor typically performs the project audit.

The Chartered Institute of Internal Auditors defines auditing as "an independent, impartial assurance and consulting activity meant to provide value and improve an organization's operations." It assists an organization in achieving its goals by bringing a systematic, disciplined approach to evaluating and improving the efficacy of risk management, control, and governance systems. In any audit, the auditor(s) see and understand the claims that need to be looked at, collect evidence, evaluate it, and use this information to form an opinion about how well the controls work in the activity being audited.

In this unit, we use the word "project" to mean "a unique, temporary effort undertaken to achieve planned goals", according to the Association for Project Management (APM) Body of Knowledge, 6th edition. Different techniques will be needed to audit programmes and portfolios. The auditing of a project should be seen in the context of how the APM Body of Knowledge defines the project, program, and portfolio (P3) assurance. P3 Assurance is the process of giving stakeholders Assurance that projects, programmes, and portfolios will meet their scope, time, cost, and quality objectives and realize their benefits.

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## **14.3 WHEN TO AUDIT?**

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A process or quality system is audited to ensure that it complies with requirements through on-site verification activities like inspection or examination. A function, process, or step in the production process may be the focus of an audit, which may also apply to the entire organization. Some audits have specific administrative objectives, such as document, risk, or performance audits, or they may follow up on corrective actions that have been taken and are complete.

ISO 19011:2018 defines an audit as a "systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled." There are three main types of audits:

- **Process Audit:** The purpose of this kind of audit is to confirm that processes are operating within predetermined parameters. In order to assess compliance with these standards and the efficiency of the instructions, it compares an operation or method to predetermined guidelines or requirements.
- **Product Audit:** In this kind of audit, a specific good or service, such as hardware, processed goods, or software, is examined to determine whether it complies with the standards.
- **System audit:** A management system audit that is performed. It can be characterized as a documented activity carried out to confirm, through the examination and assessment of objective evidence, that pertinent system elements are appropriate and effective and have been developed, documented, and put into place in accordance and in conjunction with specified requirements.

**Project Audit Components:** Review of the selection criteria for the project. The project's place in the organization's priorities is being reevaluated by Checking the organizational culture to see if it supports the kind of project being carried out, a review of the project team's performance and the number of staff members needed to meet its needs. A review of outside factors that might alter the project's direction or level of importance. A review of all elements important to the project and project management in the future.

#### **Types of Project Audits:**

- **In-Process Project Audits:** Allow for corrective changes if conditions have changed and for concentration on project progress and performance.
- **Post-Project Audits:** Take a broader and longer-term view of the project's role in the organization and emphasize improving the management of future projects.

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## **14.4 HOW TO AUDIT?**

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Although there are many different kinds of audits, when discussing them in the context of corporate finance, we typically refer to those that are carried out on public or private corporations. Governmental institutions like the Securities and Exchange Commission (SEC) Securities and Exchange Commission (SEC). Implementing federal securities laws and putting forth proposed securities regulations fall under the purview of the US Securities and Exchange Commission, or SEC, an independent agency of the US federal government. In order to maintain the stock and options markets and the

securities industry, it mandates that publicly traded companies carry out an independent audit to confirm their yearly financial reporting.

Although audits are not legally necessary for privately held businesses, they are still carried out to give banks, investors, and other stakeholders assurances about the company's financial standing. Various financial statements are examined during an audit, including the income statement and the cash flow statement. Statement of Cash Flows. A company's balance sheet and cash flow statement both include data on how much cash was generated and used during a specific period.

Information about how money is earned and spent during the course of the fiscal year is provided to stakeholders and regulatory organizations by the audit. An audit may take anywhere from a few months to a year, depending on the size of the business. At the conclusion of the engagement, the auditor offers a qualified opinion regarding the accuracy of the financial reporting completed.

### **Stages of an Audit**

- Depending on the complexity of the case and the size of the corporation, different auditing procedures may be used. An audit typically has four main stages, though:
- The first stage is the planning stage. This engagement stage, in which a corporation works with an auditing firm to establish details such as the level of engagement, procedures, and objectives.
- The second stage is the internal controls stage. Auditors gather financial records and any other information required to conduct audits at this stage. To assess whether the financial statements are accurate, information is required.
- Testing is done in the third stage. Using a variety of tests, auditors evaluate the accuracy of the financial statements at this stage. It could entail examining records of transactions, monitoring processes, or making inquiries for more data.
- The fourth stage is the reporting stage. The auditors prepare a report that expresses an opinion on the accuracy of the financial statements after finishing all the tests.

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## **14.5 WHO SHOULD AUDIT?**

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The Project Management Office, an authorized management committee, a specially designated audit department, or an external auditor typically conduct audits. The person in charge of the designated authority and the person conducting the audit must make recommendations in relation to that authority.



The objective of a project management audit is to establish the actual status of work accomplished on a project and its conformity with the project's statement of work, including time and cost limits. It is a methodical, unbiased evaluation of the condition of affairs undertaken by a qualified examiner (Ruskin & Estes, 1984).

The allocated team should have a diverse set of abilities, including audit, project management, and controls, as well as industry and subject area experience. Audits cannot be completed by a single person since they require assessment and permission. Even if that manager or supervisor is far away, the oversight must be done. A good audit team will make a report with useful suggestions while causing the project and business as little trouble as possible.

To ensure that all departments are using a documented system of recording transactions, an audit is an examination or inspection of numerous books of accounts by an auditor, followed by a physical check of inventory. It is carried out in order to validate the veracity of the organization's financial statements. An audit may be conducted both internally by staff members or the department head in question and externally by a third party or independent auditor. The goal is to have an independent authority review and validate the accounts to make sure that all books of accounts are completed fairly, and that no misrepresentation or fraud is taking place.

The auditor's sole responsibility is to assist a company in compiling its financial data into readable financial statements in a notice to readers' engagement. No additional investigations are conducted, and no viewpoints are offered regarding the reliability of the financial reporting. Small businesses without any responsibilities to external stakeholders are the only ones that typically use notice-to-reader engagements.

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## **14.6 AUDIT REPORT**

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An impartial external auditor typically performs the auditing of a company's financial statements. A letter from a company's auditor that summarizes the findings of the audit process is known as an audit report. It expresses the auditor's judgement regarding whether the company's financial statements, including the balance sheet, are in accordance with generally accepted accounting principles (GAAP) and whether they are free from material misstatement.

In most cases, the audit report is accompanied by the annual report of the company. Banks, financial institutions, investors, creditors, and regulators all require an audit report. If the auditor issues a clean report, it means that the financial statements of the company have been determined to be completely compliant with accounting standards.

## Types of Audit Reports

An auditor publishes an audit report in which they express their assessment of the company's financial statements. There are four typical formats for auditor reports:

- i) **Clean or Unqualified Report:** The best report an auditor can give a company is this one. A clean report certifies that there are no material omissions and that the company's financial statements fully conform to GAAP. It shows that the company's financial reporting meets the auditors' standards and that they adhere to all applicable laws and governing principles. A clean audit report or one without significant findings is the norm.
- ii) **Qualified Opinion:** There are two circumstances in which the auditor would issue a qualified report. If the financial statements contain materially false information, but they are not widely apparent, if there is insufficient evidence to base the audit opinion on, but the potential consequences of any material misstatements are not widespread, the audit opinion should be rejected.
- iii) **Adverse Opinion:** An adverse opinion on an audit report is the worst possible report. When the financial statements contain material and pervasive errors, the opinion is negative. Unless the problems are fixed, a negative opinion can harm a company's reputation and even have legal repercussions.
- iv) **Disclaimer of Opinion:** If an auditor: Could not obtain sufficient audit evidence upon which to base an opinion; Did not receive satisfactory responses to their inquiries; Undiscovered inaccuracies might have significant and widespread effects. This may occur if the auditor was prohibited from accessing specific financial data or if the auditor is unable to act impartially. When an opinion is disclaimed, it means that the company's financial situation could not be determined.

**Table 14.1 Format or Content of an Audit Report**

Section/Heading	Description
<b>Title</b>	Report of the Independent Auditor. Simple and the word "independent" should appear in the audit report's title. This suggests that an impartial, impartial, and external third party conducted the audit.
<b>Addressee</b>	The report will state clearly to whom it is addressed. Example: To the Company Name's Shareholders or Directors
<b>Introduction</b>	This would be a declaration that lists the name of the organization undergoing the audit as well as the dates of the financial period—typically the fiscal year—that the audit will cover.

<b>Responsibilities of directors and auditors</b>	Both the auditor and the board of directors of the company being audited have their responsibilities stated in this section. It states that the company's management and directors have agreed to fulfil their obligation to give the auditor all necessary financial records for the audit. To the best of the director's knowledge, it also affirms that the supporting documentation is true and accurate. According to the statement, the auditor's duty is to examine the company's financial statements. Additionally, it states that the auditor's judgement must be based on the data presented.
<b>Opinion</b>	This section clearly states the auditor's opinion.
<b>Basis of opinion</b>	The audit was carried out in accordance with the standards, and the section outlines the resources and audit process. This section might be a little longer than the others.
<b>Other reporting responsibility</b>	If there are any additional reporting obligations, such as statutory or regulatory requirements, they are listed here.
<b>Signature of the auditor</b>	Signed by the auditor
<b>Date and place</b>	The date and city where the report was signed by the auditor.

### Check Your Progress 1

What are the Guidelines for Effective Auditing?

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## 14.7 PROJECT CLOSURE

The final stage of the project management lifecycle is project closing. At the end of a project, the team looks over the deliverables and compares and tests their quality against what the project was supposed to accomplish. Then, the deliverables are shared with the project's client.

**What will happen if a project is not closed properly?** When a project is not properly closed, the opportunity to learn from its process and outcomes is lost. The likelihood of encountering the same challenges and maybe less motivated teams increases the next time we begin a project. When we fail to properly end a project, no lessons are learnt, and team efforts are not

recognized and honoured. Whether the project is intended for an internal audience or an external organization, it is likely that our customers may be less pleased with the results. This is true regardless of how well it meets project criteria or how quickly our client receives our deliverables.

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## 14.8 TYPES OF PROJECT CLOSURE

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A project manager will close a project for many reasons. Those include completing a project on time and finishing it early. Projects can also get cancelled, continue perpetually, or fail completely. There are four types of project closures.

- i) **Normal Closure:** When a project is completed according to plan, that is the usual condition of project closure. At this point, the client accepts the project, the project's goals are met, and the regular process of project closure starts.
- ii) **Premature Closure:** Numerous projects either aren't given a chance or don't manage to complete all of their deliverables. Instead, by removing project components that were initially identified in the project scope, they are closed before they are finished. This may be due to expenses, such as when the client allocates less money to the project or when the budget has already been used up. Premature closure can also happen when a project is crucial from a strategic standpoint and needs to be completed sooner than anticipated, like a new product launch. The client may miss an opportunity if the product is delayed past the initial completion date.
- iii) **Perpetual Projects:** Others, on the other hand, seem to go on forever. These are initiatives that have experienced numerous snags, hiccups, and issues. Infinite scope creep, add-ons, and changes plague perpetual projects as well. Due to constant changes and scope screeching, these projects have the problem of never accomplishing their goals or objectives. The project manager and the team find this to be extremely frustrating. The client will also find it extremely frustrating because they do not see the project's goals being met despite repeated requests for changes. The project manager needs to fix the scope at some point and create a plan for completion.
- iv) **Failed Projects:** Far too often, projects fail. Project failure can have many different reasons. The project may be permanently killed if the client runs out of money, which happens frequently.

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## 14.9 PROJECT CLOSURE PROCESS

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The project closing process consists of technical, learning, and human components. During the technical phase, tie up any loose ends. Assess what worked and what didn't, as well as how to improve, for the learning phase. During the people phase, express gratitude to the team. Follow these

procedures when a project nears completion. To ensure a stronger future, one must do the steps outlined below.

- i) **Technical Phase:** While the technical phase is rather bureaucratic, it produces a genuine sense of completion (and achievement) among the team and the company.
- ii) **Learning Phase:** The project closing learning phase is time allocated to team reflection on what you've done, how you've done it, and what you've learned now that the project is finished. There are several approaches to project closing that emphasize learning and growth for both the company as a whole and individual team members.
- iii) **People Phase:** The people phase makes you feel things. The project deliverables were made possible by the team. Recognizing their work and the need for emotional closure will make everyone feel good and ready for whatever comes next.

Each project closing step contributes to the development of an appreciation, gratitude, and accomplishment-centred workplace culture. If you take the time to accomplish this correctly, according to your unique set of circumstances, you'll have created the conditions for not only moving on but also moving forward.

## Check Your Progress 2

List a few best practices involved in Project closure.

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## 14.10 PERFORMANCE EVALUATION

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Performance reviews are done regularly to see how well employees are doing their jobs for the company. In addition to a full performance review once a year, managers usually check in with employees on a regular basis throughout the year. Performance reviews help employers set clear expectations and measure how well employees and the organization are doing. The information gathered during a performance review can affect both the strategic decisions an organization makes about growth, retrenchment, and downsizing, as well as the decisions each employee makes about pay raises, promotions, and layoffs.

Performance reviews often include both the employee's own assessment of their own success and the manager's assessment of the performance of the organization, the team, and the employee. Performance reviews need to be measured against clear goals and clear metrics.

### Check Your Progress 3

Define the term Performance Appraisal. List the objectives of the Performance Appraisal.

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## 14.11 LET US SUM UP

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An audit includes a review of a company's income statement, cash flow statement, and balance sheet. Regulators and investors can be certain that a company is accurately presenting its financial status thanks to audits. A team member's performance and the corporate culture are both improved by various goals served by individual team member assessment. Following completion, the auditor will express an opinion on whether the financial statements fairly depict the corporation's financial situation.

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## 14.12 SELF-ASSESSMENT EXERCISES

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- 1) What is a project audit? Why do organization go for it?
- 2) What are the essential factors to be considered while auditing?
- 3) Who Should Audit? What are the guidelines for effective auditing?
- 4) What is a Project Closure? Discuss the importance of project closure.
- 5) Describe various types of Project Closure with suitable examples.
- 6) What do you mean by Performance Evaluation?

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## 14.13 FURTHER READING

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1. R.B. Khanna, *Project Management*, 2011, PHI Learning.
2. Rajeev M. Gupta, *Project Management*, 2014, PHI Learning.
3. SitangshuKhatua, *Project Management and Appraisal*, 2012, Oxford University Press.
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6. *A Guide to Project Auditing* by Association for Project Management 2018
7. Ruskin, A. M., & Estes, W. E. (1984). *The project management audit: Its role and conduct*. *Engineering Management International*, 2(4), 279–286. [https://doi.org/10.1016/0167-5419\(84\)90049-8](https://doi.org/10.1016/0167-5419(84)90049-8)