الجمهوريـــة الجزائريـــة الديمقراطيـــة الشعبيـــة
The Peoples's Democratic Republic of Algeria
وزارة التعليم العالي و البحث العلمي
Ministry of Higher Education And Scientific Research

UNIVERSITY OF MUSTAPHA STAMBOULI - MASCARA
FACULTY OF ECONOMICS, BUSINESS AND MANAGEMENT SCIENCES
DEPARTMENT OF MANAGEMENT SCIENCES

جامعة مصطفى اسطمبولي معسكر
كلية العلوم الاقتصادية و العلوم التجارية وعلوم التسيير
قسم علوم التسيير

Lessons directed to Students of Third Year L.M.D , Management

Module :

Projects Management

Prepared by: Dr. Bouhelal Fatima

University Year : 2025/2026

Index of Contents

Index of Figures

Index of Tables

Introdution

Projects arise within the framework of what is known as meeting the needs of the environment with the possibility of developing them due to the fierce competition for survival and growth. What is known is that the project will not come out of nothing, but some conditions must be available to judge that this project, and among these conditions:

 The nature of the person, whether he is an initiator or not? (Through qualities that must be available in him)

 The relative advantage of the project idea (on the basis that the project begins with an idea, the latter must be distinguished from competitors by a set of characteristics) and thus, to achieve the success of the project, project management is one of the most important management philosophies adopted by contemporary organizations to achieve their specific goals. As well as, project management works to direct individuals and the necessity of cooperation among them to achieve the project goals and obtain the necessary resources for it. In contrast the project manager must possess project management skills to complete the project on time, according to the specified budget and according to the required specifications; it also prevents him from making mistakes resulting from negligence.

These skills are represented in: 1. Administrative skills: the ability to estimate costs, prepare timetables, and determine the project budget. 2. Human skills: the ability to persuade and communicate, as well as the ability to manage conflict and change. 3. Integration skills: the process of coordination between the different stages (planning, implementation, control). 4. Technical skills: This is an important element for the project team more than for the project manager (on the basis that the project is implemented by the team).

Project management is therefore a vital field that requires careful coordination of resources, time, and costs to achieve desired goals and address the challenges facing project teams, such as conflicts and risks, which can derail the project if not managed effectively. If conflict is managed wisely, it can become a motivation for creativity and development, while risk management contributes to enhancing preparedness and flexibility in the face of challenges. Integrating these two aspects into a project management methodology contributes to increased performance efficiency and ensuring that objectives are effectively achieved.

Through these chapters, we will attempt to achieve a set of objectives:

• Define the meaning of a project and project management;
• Understand the success factors of project management and define the project life cycle;
• Identify the various risks that will accompany a project throughout its life cycle;
• Define project selection methods and criteria;
• How to plan, schedule, and budget for a project;
• Identify the levels of conflict and risks that face a project and how to manage them.

In light of the above, and in order to acquire project management skills, it is necessary to know the meaning of each of the following: management, project, project management, project objectives (time, cost, specifications), project characteristics, project life cycle, project parties, project plan or commitment contract, project scheduling (among the most important methods we find Gantt charts and network programming (CPM, PERT)), the project budget, conflict management, and then risks management.

Chapter 01

I. The Project

Introduction

Project management is the process of organizing, planning, directing, and controlling resources to achieve specific project objectives. It aims to successfully complete the project within time, budget, and quality constraints. This is what we will attempt to address in this chapter.

1. What is a Project?

There are many definitions of the concept of a project, depending on the background of the thinker and the purpose for which the project will be implemented. Below we will discuss some definitions:

A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists. A project may also be terminated if the client wishes to terminate the project. Temporary does not necessarily mean the duration of the project is short. It refers to the project's engagement and its longevity. Temporary does not typically apply to the product, service, or result created by the project; most projects are undertaken to create a lasting outcome. For example, a project to build a national monument will create a result expected to last for centuries. Projects can also have social, economic, and environmental impacts that far outlive the projects themselves[1].

According to Quin (2024), a Project is "a temporary endeavour designed to produce a unique product, service or result with a defined beginning and end, undertaken to meet unique goals and objectives" . The essential features of a project are that it is innovative, time-constrained and resource-constrained. Different from the routine plans, the project tasks are often used as a preparation for future routine activities[2].

According to Lester (2014) 'A unique process, consisting of a set of co-ordinated and controlled activities with start and finish dates, undertaken to achieve an objectives conforming to specific requirements, including constraints of time, cost and resources'[3].

2. Are projects different from the other work?

Projects are different from the normal operation of the organisation in that they:

- have specific objectives to deliver new benefits to, the taxpayer, companies, the general public, government, the sponsoring organisation, stakeholders and/or delivery partners;
- may introduce significant changes to the way the business operates;
- create new outputs/deliverables that will enable benefits to be realised;

[1] Project Management Institute. A Guide to the Project Management Body of Knowledge (PMBOK III ® Guide). Fifth Edition. 2013. P3.

[2] Xia Qin, Project Management and Project Action Plan, Dialogue on innovative Higher Education Strategies, https://www.lpmu.upj.ac.id › userfiles › files ›.12/08/2024. 19 :18. Pp1-5

[3] Albert Lester. Project Management, Planning, and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards. Sixth Edition. 2014. Elsevier Publisher, Oxford, UK. P1.

- have a specific, temporary management organisation and governance arrangements set up for the duration of the project;
- are susceptible to risks not usually encountered in the day to day operational work of the organisation;
- involve a range of stakeholders from different parts of the organisation and beyond;
- may use methods and approaches that are new or unfamiliar[4].

2.1. The difference between a project and routine work

Project: A project is an effort that involves a series of activities and resources, aimed to achieve a certain output, considering constraints like time, quality and cost and which often introduces a change.
A temporary endeavor that is needed to produce a unique outcome or result at a prespecified time using predetermined resources.
Temporary – each project has a definite beginning and a definite end.
Unique Product – the outcome of a project must be unique product, service or result
Routine work/Operations: Routine work, often called Business As Usual (BAU) will continue on an ongoing basis and is required even after the project finishes.This is a good test as there are instances where a project team takes on BAU work to help move the project forward. For example, running the process to set-up new users on a system.
An operation is a function that performs ongoing tasks: It does not produce a unique product or it does not have a beginning and an end[5].

2.2. Project and operations characteristics:

Project and operations share some characteristics: Both require resources, including human resources (people). Both are managed – that is planned, executed and controlled.
Projects have a limited duration, projects have well defined start and end dates. When the goals and objectives of a project are accomplished, it is said to have been completed. Sometimes when it becomes evident that the goals and objectives cannot be accomplished the project is cancelled and it ends.
Operations involve continuous work without an ending date and often the same process is repeated.
A project is considered a success if it meets the expectations of the stakeholders.
The customer is also stakeholder like contractors and suppliers.
Project being objective oriented, if not achieved timely, it may have been terminated taking it as a failure project.
Whereas routine work consist ongoing tasks and rarely gets terminated since time is not the limited factor there[6].

---

[4] Department for Business Innovation & Skills (BIS). (2010). Guidelines for Managing Projects :How to organize, plan, and control projects, November. P3.
[5] Megh Bahadur KC . (2020). Project definition, Lifecycle and role of Project Managers. Research Gate. P2.
[6] Ibid. P2.

3. Condition for the success of the project

To judge the success of the project, it is necessary to:

- deliver the outcomes and benefits required by the stakeholders
- create and implement deliverables that meet agreed requirements
- meet time targets
- stay within financial budgets
- involve all the right people
- make best use of resources in the organisation and elsewhere
- take account of changes in the way the organisation operates
- manage any risks that could jeopardise success
- take into account the needs of staff and other stakeholders who will be impacted by the changes brought about by the project[7].

4. Reasons for project failing are

- failure to take into account the needs and influences of stakeholder
- failure to communicate and keep the stakeholders informed of developments
- lack of attention to the impact of project work on the normal business of the organization
- failure to identify and deal with the many risks that can affect achievement of project objectives
- insufficient attention to planning, monitoring and control of the work of the project[8].

5. Constraints affecting project performance

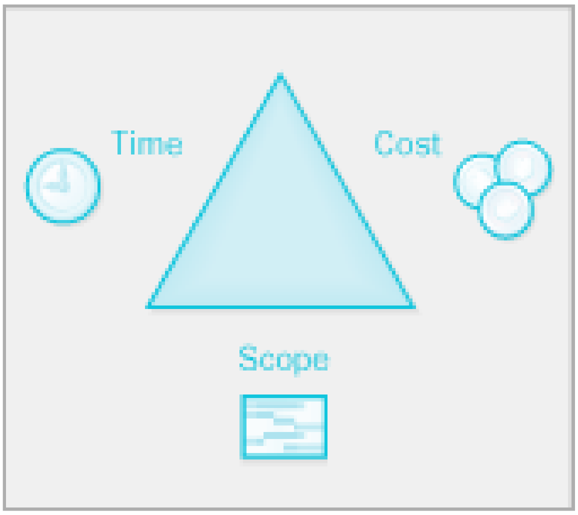
During the project management process, the project manager is constantly facing the challenges of balancing the scope1, cost and time, which is known as project triangle. These are the three competing constraints affecting the project performance: increased scope typically means increased time and cost, a tight time constraint could mean increased costs and reduced scope, and a tight budget could mean increased time and reduced scope. If the project must be done fast and good, then the cost will rise; vice versa, if the project must be done low-cost and fast, the quality or scope will not be satisfying[9].

[7] Xia Qin. (2024). Op cit. Pp1-5.
- Department for Business Innovation & Skills (BIS). (2010). Op cit.p3.

[8] Xia Qin. (2024). Op cit. P2.

[9]Ibid. P4.

Figure 01: The Project Triangle



Source: Xia Qin, Project Management and Project Action Plan, Dialogue on innovative Higher Education Strategies, https://www.lpmu.upj.ac.id › userfiles › files ›.12/08/2024. 19 :18. P6.

6. How to define SMART project objectives

Project objectives define what a project must achieve for it to be judged to be complete and successful and hence able to be closed. Benefits on the other hand may only just be starting to appear at the end of a project and may continue to be realised long after the project has finished. (NB If there are specific, measurable benefits that must be achieved within the life of the project they may be expressed as objectives as well as appearing in the project's Business Case). A well defined and agreed (set of) objective(s) is a necessary pre-cursor to detailed project planning. For the objectives to be useful as an aid to project management they must be:

6.1. Specific to the project, and within the project. For example the objective: 'To improve the efficiency of our interactions with customers.' is too vague. It is really a goal shared by a number of programmes, projects and business as usual activities. On the other hand 'To reduce the average turnaround times for enquiries from customers on subject X.' is a much clearer indication of what the project must do. However it is not yet very measurable.

6.2. Measurable. You need to define in as measurable and subjective terms as possible what must be achieved. Measurability will depend on the nature of the objective and may be in terms of such things as performance, cost, effort, % change, amount of time, deliverables, quality levels, numbers of events, agreements, approvals, commencement or termination of something, numbers of people/organisations, a benefit to be achieved within the life of the project etc. When setting a measurable target you must ensure that it is achievable.

6.3. Achievable. It must be possible to achieve the objective in practical terms and also within whatever time target has been set. You might need to consider constraints of technology, people and processes when assessing achievability. Other things that influence achievability include: the time needed to perform consultations, common commencement dates and the requirements of OJEU procurement process. You should be realistic without being too conservative - project objectives will often be challenging. Objectives must also be relevant to the bigger picture of the environment within which the project is running. Sometimes it is only as a result of detailed planning that it becomes clear that an objective is not achievable. If this happens during production of the Project Initiation Document then agreement must be reached on the revised objective. After the PID has been approved, change control must be applied so that the impact of any changes to a project's objectives are carefully assessed and managed.

6.4. Achievable. It must be possible to achieve the objective in practical terms and also within whatever time target has been set (see Time bound below). You might need to consider constraints of technology, people and processes when assessing achievability. Other things that influence achievability include: the time needed to perform consultations, common commencement dates and the requirements of OJEU procurement process. You should be realistic without being too conservative - project objectives will often be challenging. Objectives must also be relevant to the bigger picture of the environment within which the project is running. Sometimes it is only as a result of detailed planning that it becomes clear that an objective is not achievable. If this happens during production of the Project Initiation Document then agreement must be reached on the revised objective. After the PID has been approved, change control must be applied so that the impact of any changes to a project's objectives are carefully assessed and managed.

6.5. Relevant. Is the objective consistent with, and does it contribute towards, the goal/objective at the next level up (Programme, Departmental, PSA)? Make sure the project, or some part of it is not just there because of a whim or has been influenced by an agenda that is not aligned with the organisation's core purpose.

6.6. Time Bound (and, perhaps Trackable). It is useful to have a target date by which each objective should be achieved. Sometimes there will be one date that applies to most or all objectives. In other cases each project objective may require its own time frame. Setting interim time targets may also be useful for certain types of objective. This will make the objective trackable so that you can measure whether or not you are on course to achieve it and hence can take early action if not.

The SMART criteria described above should be used to check that your objectives are sufficiently rigorous. Non-SMART objectives can lead to one or more of the following:

- Insufficient information available to enable production of detailed plans as it is not clear what the project must achieve.
- Wasted effort producing multiple plans to cater for the range of possibilities allowed for in vague objectives.

 Shortage of project resources as the availability of people, skills, £, things is driven by supply rather than planned requirement.
 Project deliverables and outcomes rejected - 'That's not right! What I really need is....'
 Needs of external stakeholders and other interested parties not met leading to dissatisfaction and damage to reputations.
If you find it difficult or impossible to define your objectives in SMART terms, or it is difficult to gain agreement on them then you must be aware of the risk this poses and hence the additional effort the SRO and Project Manager must devote to controlling the project and to managing the expectations of stakeholders[10].

7. Project within Program Management and Portfolio Management

7.1. Program Management

Programme management may be defined as 'The co-ordinated management of a group of related projects to ensure the best use of resources in delivering the projects to the specified time, cost, and quality/performance criteria'.
A number of organizations and authorities have coined different definitions, but the operative word in any definition is related. Unless the various projects are related to a common objective, the collection of projects would be termed a 'portfolio' rather than a 'programme'.
A programme manager could therefore be defined as 'The individual to whom responsibility has been assigned for the overall management of the time, cost, and performance aspects of a group of related projects and the motivation of those involved'.
Again, different organizations have different definitions for the role of the programme manager or portfolio manager. In some companies he or she would be called manager of projects or operations manager or operations director, etc., but it is generally understood that the programme manager's role is to co-ordinate the individual projects that are linked to a common objective. Whatever the definition, it is the programme manager who has the overall picture of the organization's project commitments.

7.2. Portfolio Management

Portfolio management, which can be regarded as a subset of corporate management, is very similar to programme management, but the projects in the programme manager's portfolio, though not necessarily related, are still required to meet an organization's objectives. Furthermore, portfolios (unlike projects or programmes) do not necessarily have a defined start and finish date. Indeed portfolios can be regarded as a rolling set of programmes that are monitored in a continuous life cycle from the strategic planning stage to the delivery of the programme. In a large organization a portfolio manager may be in charge of several programme managers, while in a smaller company, he or she may be in direct control of a number of project managers[11].

[10] Department for Business Innovation & Skills (BIS). (2010). Op cit. Pp13-14.
[11] Albert Lester. (2014). Op cit. Pp11-13.

8. Project Life Cycle

A project life cycle is the series of phases that a project passes through from its initiation to its closure. The phases are generally sequential, and their names and numbers are determined by the management and control needs of the organization or organizations involved in the project, the nature of the project itself, and its area of application. The phases can be broken down by functional or partial objectives, intermediate results or deliverables, specific milestones within the overall scope of work, or financial availability. Phases are generally time bounded, with a start and ending or control point. The particulars of the company, sector, or technology used might influence or define the project life cycle. Although each project has a clear beginning and end, the particular deliverables and activities that occur during those times will differ greatly depending on the project. The life cycle offers the fundamental structure for project management, irrespective of the particular tasks required[12].

Understanding the normal project lifecycle and how it relates to your particular project is helpful for efficient management. You must determine exactly who will be involved and how the management activities of the lifecycle steps will be accomplished. You need to be aware of your responsibility to ensure that these things occur in the proper manner and at the appropriate moment. The project manager and the owner/sponsor, also referred to as the Senior Responsible Owner (SRO), will be responsible for a large portion of the project management work throughout the lifetime. They will most likely need to use the expertise and abilities of numerous people from the company, its partners, and its suppliers in order to succeed[13].

8.1. Project Life Cycle Characteristics

Projects vary in size and complexity. All projects can be associated with the general life cycle structure.

The generic life cycle structure generally displays the following characteristics:

• Cost and staffing levels are low at the start, peak as the work is carried out, and drop rapidly as the project draws to a close

• A project may require significant expenditures to secure needed resources early in its life cycle, for instance, or be fully staffed from a point very early in its life cycle.

• Risk and uncertainty are greatest at the start of the project. These factors decrease over the life of the project as decisions are reached and as deliverables are accepted.

• The ability to influence the final characteristics of the project’s product, without significantly impacting cost, is highest at the start of the project and decreases as the project progresses towards completion.

The cost of making changes and correcting errors typically increases substantially as the project approaches completion[14].

---

[12] Project Management Institute. A Guide to the Project Management Body of Knowledge (PMBOK III ® Guide) – Fifth Edition. 2013. P38.

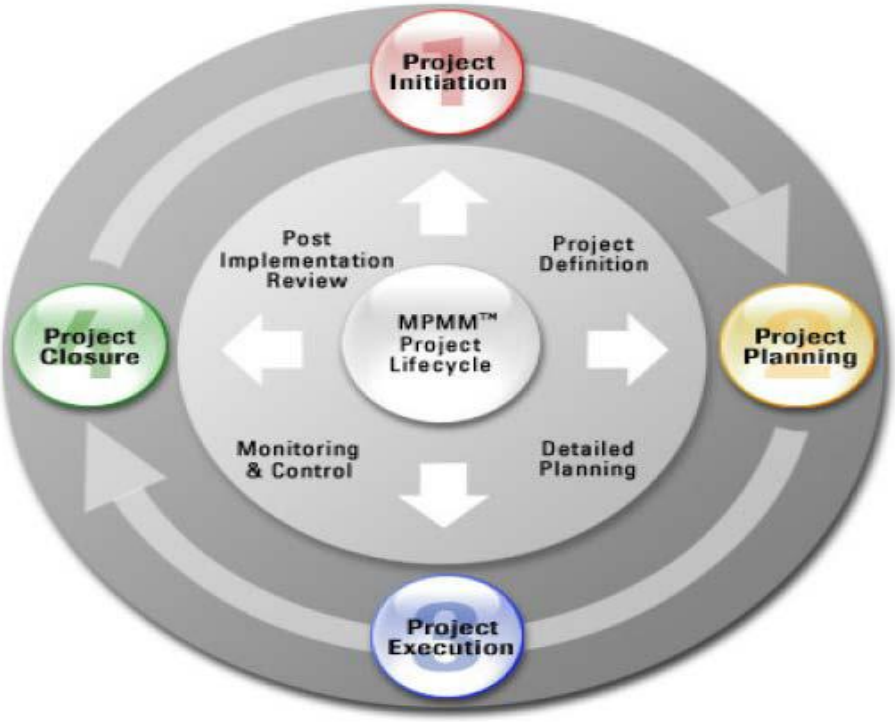
[13] Department for Business Innovation & Skills (BIS). (2010). Op cit P5.

[14] Project Management Institute. (2013). Op cit. P39.

8.2.Project life cycle stages

The traditional project cycle includes project initiation, project planning, project execution and project closure (see Figure 02):

Figure 02: Project life cycle stages



Source: Xia Qin, Project Management and Project Action Plan, Dialogue on innovative Higher Education Strategies, https://www.lpmu.upj.ac.id › userfiles › files ›.12/08/2024. 19 :18. P2.

8.2.1. Project Initiation is often regarded as the project start-up. It is the very important preparation stage of project work. In this phase, the problems or case studies are defined and analysed. A project initiative is then put forward for consideration. After a feasibility study, if the higher management or the responsible party decides for setting up a project to tackle the problems or test the solutions, project work will start. In this case, a project manager will be officially appointed.
At the end of the first phase, the project outline will be agreed by all the parties involved. The project manager begins to recruit his team. A detailed phase of planning follows.

8.2.2. Project Planning is the phase of detailed planning. The project manager needs to fulfil the tasks of recruiting the right people, outline the activities and timeframe. In addition, financial plan and resource distribution need to be specified.

8.2.3. Project Execution is the third phase in the project lifecycle. The main goal at this stage is to implement the planned activities in order to achieve the deliverables within the given time and resource frame.

However, no matter how precisely the project has been planned, in practice, it might take another route. This would not mean the failing of the project. Control at this stage is the one of the most challenging tasks for the project manager in order to manage changes and adjust the project plan accordingly.

8.2.3. Project Closure marks formally completion of a project. In this stage, the deliverables will be presented to the stakeholders. A successful project will meet the defined objectives. Besides the project report to the stakeholders, a project review report will be drafted for the documentation and evaluation of the project[15].

[15] Xia Qin, (2024). Op cit. Pp3-5.

II. Project Management

Introduction

The project management has changed significantly over the past years, and these changes are expected to continue to what some people call "modern project management." and the survival of any firm may very well rest upon how well project management is implemented, and how quickly. Project management became a necessity for many companies as they expanded into multiple product lines, many of which were dissimilar, and organizational complexities grew. This growth can be attributed to:

- Technology increasing at an astounding rate
- More money invested in R&D
- More information available
- Shortening of project life cycles

1. What is Project Management?

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. The 47 logically grouped project management processes, which are divided into five Process Groups, must be applied and integrated appropriately to complete a project. The following are the five Process Groups

- Initiating,
- Planning,
- Executing,
- Monitoring and Controlling, and
- Closing[16].

Project management, according to Harold Kerzner, is the process of organizing, planning, directing, and regulating business resources in order to accomplish particular goals and objectives[17].

Project management, as defined by Lister (2014), is the act of organizing, observing, and managing every facet of a project as well as the motivation of all participants in order to accomplish the project's goals within predetermined parameters of time, cost, and performance[18].

Although the core criteria of time, cost, and performance are included in this definition, motivation is the key term from a managerial perspective. If the majority of the participants are not just skilled but also driven to create an acceptable result, the project will fail. This has been accomplished through the development of various methodologies, procedures, and techniques that, when combined with general management and people skills, allow the project manager to satisfy time, cost, and performance/quality goals in the most efficient manner.

Project management[19] is "the application of knowledge, skills, tools and techniques to project activities to meet project requirements". Its immediate goal is to assure the successful

[16] Project Management Institute. (2013). Op cit P5.
[17] Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P4.
[18] Albert Lester. (2014). Op cit. P7.
[19] Xia Qin. (2024). Op cit. Pp1-5.

completion of the project. In its practice, this management process is frequently connected with risk management due to its complexity and unpredictability of future happenings. In this regard, the project manager, who serves as the intermediate between project board (project sponsor) and project team, often manages the risks of the project. That means that the project manager should be able to recognize potential risks or resistance in good times, to communicate them and to set up measures which will allow him to intervene when such risks or resistance arise. In addition, project managers are more and more challenged with a great deal of social competence.

2. Project Management Factors (Elements)

Managing a project typically includes[20]**:**

• Identifying requirements;

• Addressing the various needs, concerns, and expectations of the stakeholders in planning and executing the project;

• Setting up, maintaining, and carrying out communications among stakeholders that are active, effective, and collaborative in nature;

• Managing stakeholders towards meeting project requirements and creating project deliverables;

• Balancing the competing project constraints, which include:

 Scope,

 Quality,

 Schedule,

 Budget,

 Resources, and

 Risks.

The relationship among these factors is such that if any one factor changes, at least one other factor is likely to be affected. For example, if the schedule is shortened, often the budget needs to be increased to add additional resources to complete the same amount of work in less time. If a budget increase is not possible, the scope or targeted quality may be reduced to deliver the project's end result in less time within the same budget amount. Project stakeholders may have differing ideas as to which factors are the most important, creating an even greater challenge. Changing the project requirements or objectives may create additional risks. The project team needs to be able to assess the situation, balance the demands, and maintain proactive communication with stakeholders in order to deliver a successful project.

3. The difference between project management and management of any other business or enterprise[21]:

Project management is essentially management of change, while running a functional or ongoing business is managing a continuum or 'business-as-usual'.

It is immediately apparent therefore that there is a fundamental difference between project management and functional or line management where the purpose of management is to

---

[20] Project Management Institute. (2013). Op cit P6.

[21] Albert Lester. (2014).Op cit. P1.

continue the ongoing operation with as little disruption (or change) as possible. This is reflected in the characteristics of the two types of managers. While the project manager thrives on and is proactive to change, the line manager is reactive to change and hates disruption. In practice this often creates friction and organizational problems when a change has to be introduced.

4. Characteristics of Project management[22]:

• Objectives- oriented
• Change- oriented
• Single responsibility center
• Requires functional coordination along functional lines (chain of command)
• Requires integrated planning and Control systems.
• Achieves results within the constraints of time, cost and quality.

5. Benefits of Project Management[23]:

• Project management allows us to accomplish more work in less time, with fewer people.
• Profitability will increase.
• Project management will provide better control of scope changes.
• Project management makes the organization more efficient and effective through better organizational behavior principles.
• Project management will allow us to work more closely with our customers.
• Project management provides a means for solving problems.
• All projects will benefit from project management.
• Project management increases quality.
• Project management will reduce power struggles.
• Project management allows people to make good company decisions.
• Project management delivers solutions.
• Project management will increase our business.

6. Organization Structures[24]:

To manage a project, a company or authority has to set up a project organization, which can supply the resources for the project and service it during its life cycle. There are three main types of project organizations:
1. Functional
2. Matrix
3. Project or taskforce

[22] Megh Bahadur KC . (2020). Project definition, Lifecycle and role of Project Managers. Research Gate. P4.
[23] Harold Kerzner. (2009). Op cit. P49.
[24] Albert Lester. (2014). Op cit. P41.

6.1. Functional Organization

This type of organization consists of specialist or functional departments, each with their own departmental manager responsible to one or more directors. Such an organization is ideal for routine operations where there is little variation of the end product. Functional organizations are usually found where items are mass produced, whether they are motor cars or sausages. Each department is expert at its function and the interrelationship between them is well established. In this sense a functional organization is not a project- type organization at all and is only included because when small, individual, one-off projects have to be carried out, they may be given to a particular department to manage. For projects of any reasonable size or complexity, it will be necessary to set up one of the other two types of organizations.

6.2.Matrix Organization

This is probably the most common type of project organization, since it utilizes an existing functional organization to provide the human resources without disrupting the day-to-day operation of the department. The personnel allocated to a particular project are responsible to a project manager for meeting the three basic project criteria: time, cost, and quality. The departmental manager is, however, still responsible for their ‘pay and rations’ and their compliance with the department’s standards and procedures, including technical competence and conformity to company quality standards. The members of this project team will still be working at their desks in their department, but will be booking their time to the project. Where the project does not warrant a full-time contribution, only those hours actually expended on the project will be allocated to it.

6.2.1. The advantages of a matrix organization are[25]:

1. Resources are employed efficiently, since staff can switch to different projects if held up on any one of them;
2. The expertise built up by the department is utilized and the latest state-of-the-art techniques are immediately incorporated;
3. Special facilities do not have to be provided and disrupting staff movements are avoided;
4. The career prospects of team members are left intact;
5. The organization can respond quickly to changes of scope; and
6. The project manager does not have to concern himself with staff problems.

6.2.2. The disadvantages are:

1. There may be a conflict of priorities between different projects;
2. There may be split loyalties between the project manager and the departmental manager due to the dual reporting requirements;
3. Communications between team members can be affected if the locations of the departments are far apart; and
4. Executive management may have to spend more time to ensure a fair balance of power between the project manager and the department manager.

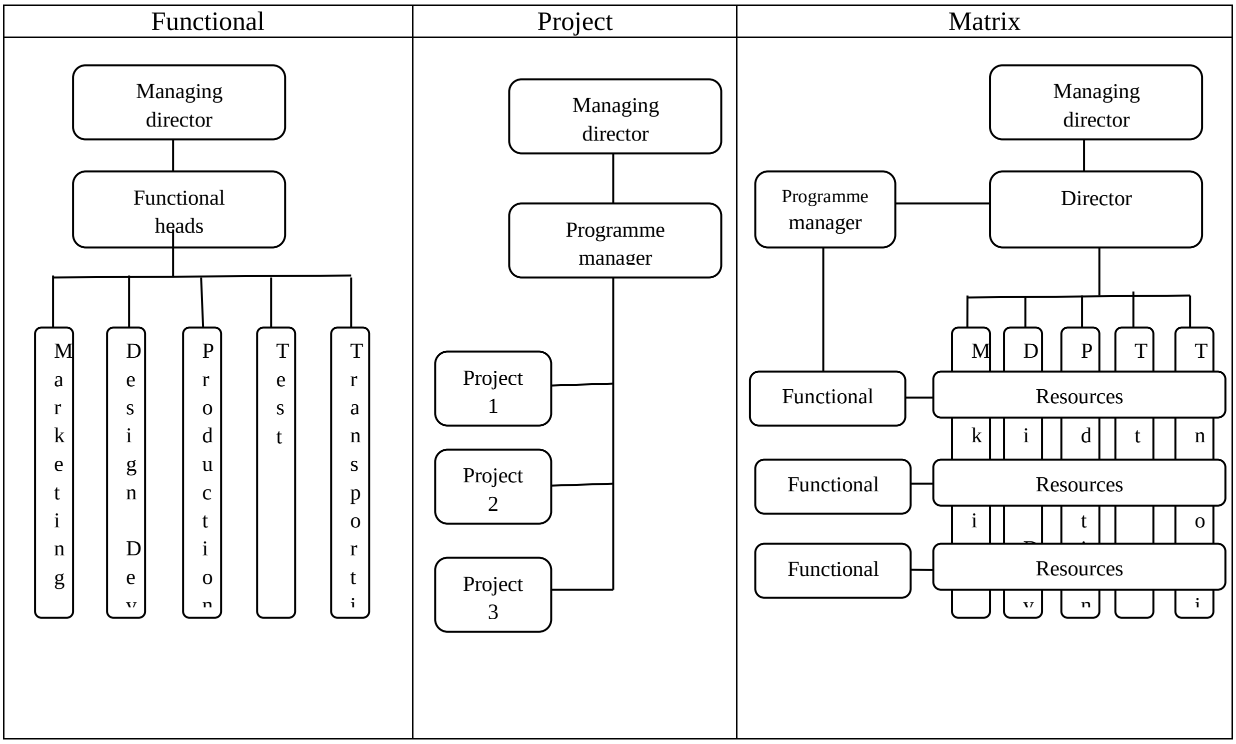
[25] Albert Lester. (2014). Op cit. P42.

Matrix organizations can sometimes be categorized as strong or weak, depending on the degree of dominance or authority of the project manager or department managers respectively. This can of course create friction as both sides will try to assert themselves. However, all the above problems can be resolved if senior management ensures (and indeed insists) that there is a good working relationship between the project manager and the department heads. At times both sides may have to compromise on the interests of the project and the organization as a whole.

6.3.Project Organization (Taskforce)

From a project manager’s point of view, this is the ideal type of project organization, since with such a setup he or she has complete control over every aspect of the project. The project team will usually be located in one area, which can be a room for a small project or a complete building for a very large one.

Figure 03: Types of organization



Source: Albert Lester. Project Management, Planning, and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards. Sixth Edition. 2014. Elsevier Publisher, Oxford, UK. P43.

Chapter 02

I. Project Selection Model

Introduction

Every organization has it goals and objectives. To achieving these objectives, it is imperative for the organization to develop a strategy under many activities that should be undertaken. This ranges from routine activities to unique activities bounded by time, cost and scope (project). An organization can have several ongoing projects geared towards achieving it stated goals and objectives. The organization is challenged with how to select among the various projects, those projects that are in line with management strategy and those ones that can augment organizational performance. The selection process can be daunting and exhaustive, depending on the criteria used by the project selection team. There are numeric as well as nonnumeric models that can be used to select project. These are useful models that can help management in selecting the most appropriate project for the benefits of the organization. Meredith & Mantel (2009) defines project selection as the method of assessing anticipated projects or groups of projects, and then selecting to implement some set of them to accomplish organizational objectives.

Project selection models are not absolute but they help project managers in making decisions. Each model has its merits and demerits that plays valuable role in the selection process. The appropriateness of a model depends on its ability to meet organizational goals from the project manager’s viewpoint. However, these models have the following limitations:

- No single model has it all. A particular model can be appropriate for project A and yet not applicable for another similar project. This is because project selection depends on several factors including organizational goal, project objectives, resources needed to achieve the project and the organizational competence.
- The soundness of a model depends on the input (data). Insufficient or distorted input can lead to misleading results and hence influence the model selection process. Thus, reinforcing the need to properly verify every model before using it to make organizational decisions. A misleading model can be detrimental to the organization and to a great extent damage the credibility of the organization to its clients.
- Biasness on the part of the selection team. This team like any other team comprises of individuals that do favour the use of a particular model in project selection because of several reasons ranging from model simplicity to previous project selection model that worked. However, should biases should be mitigated especially when individual managers are doing so for their own interest. Organizational interest should supersede personal interest thus, the need for managers to abide by the set selection models of the organization during the selection process.

1. Criteria For Choosing Project Selection Model[1]

In project selection, each project idea is evaluated and chosen based on organizational preference. Every organization will choose a project in consideration of the potential benefits of that project to the objectives of the organization. In cases, where there are several interesting projects to select from in an organization, it becomes necessary for the organization to choose the project that best fit its strategy and has the highest possibility of success. Selection models should help management in accomplishing the overall goal of the organization. the most important criteria required for choosing a project are:

- **Realism:** This criterion looks at the practicality of choosing project selection model. It considers organizational objectives and capacity in making such decisions; knowing fully well that without such models it becomes impossible for the organization to make adequate projects comparisons. It takes cognizance of the prevailing situations in the organization in terms of its capability to provide the resources needed for the chosen project selection model.
- **Capability:** The model should be robust enough to address both present and future challenges such as the internal and external factors militating against the project and these includes; strikes, wages, interest rate changes, staff attritions etc. The model should be robust enough to survive difficult periods.
- **Flexibility:** The model should be adequate enough to provide reliable results that the organization can rely on for decision making purposes. In addition, it should be relatively easy for effective modification purposes especially in response to changing circumstances in the project environments such as technological changes, political changes, economic changes, changes to organizational goals and potential risks situation that might erupts. Such model is preferred in the selection process of complex and high-risk prone projects.
- **Ease of use:** The model should be appropriate and easy to use. Should not be difficult to execute and understand. In fact, there should not be any special clarification or additional explanation to aid one in understanding its operations rather, its data and equipments should be easy to access and acquire. It should not bring unwarranted pressure on the organization in terms of recruitment of additional personnel.
- **Cost:** The model cost should not exceed that of the project cost and its intending benefits to the organization. However, the organization must consider the cost of data collection and the effective implementation of the chosen model. Both costs should be less than the implementing cost.
- **Computerization:** Data from this model should be easy and suitable to store and manipulate by computer systems. Because of the advancement of technology, it becomes imperative for a model that uses computer systems to be preferred in the selection process than models that are not. Computer friendly models give managers the edge in decision making.

[1] Crispin George. (2020). An Understanding of the Different Selection Models used to Select Projects in an Organization. International Journal of Innovative Science and Research Technology. Volume 5, Issue 3, March – 2020. Pp132-133.

2. Types of Project Selection Models

Project selection methods usually focus on the benefits of projects to the organization. It particularly expresses senior management's concerns on whether the project will be able to achieve organizational objectives. However, the project is expected to improve the following in the organization; return on investment, competitive advantage, customer base, organizational perception especially to potential customers, organizational profitability and sustainability. In essence, the project should march the strategic goals of the organization. In most cases, if the project is unable to meet such goals, it becomes imperative for management to put it aside. Management will always support projects that are seemed helping the organization in accomplishing its strategic goals.

Meredith & Mantel (2009) put forward two types of project selection models and these are; numeric and nonnumeric models.

2.1.The Nonnumeric Models[2],[3], [4]

The nonnumeric models are relatively simple and easy to use and some of its subtypes are thus:

- **Sacred cow:** This is a situation where the project is selected by an individual who is powerful in the organization (boss). This boss thinks management must look into the initiation of this project as it will be of immense benefits to the organization in his own eyes. Such project, when selected becomes "sacred". Everyone is working hard to ensure that the project succeeds because it emanates from the boss. Even if the project is not doing well, no one dares say something because of fear of the boss, until the boss, personally realizes that the project is a failure and terminates it.
- **Operating necessity:** This model is used to select projects that are of need to the very existence of the organization. For instance, when the location of the organization is seriously threatened by natural disaster, it becomes incumbent on management to initiate a project for the relocation of the organization. In some other cases, the very product that enables the organization to have competitive advantage over its rivals becomes threatened and something must be done by management to either change the product or upgrade it in order to maintain its market leadership. In essence, this project is selected to remedy the operations of the organization and therefore requires management support.
- **Competitive necessity:** In this model, projects are selected primarily to enhance the competitive position of the organization. The project is selected either to gain competitive advantage or to maintain the competitive edge the organization has over its rivals in the market. It is worth noting, that the operating necessity takes preeminence over the competitive necessity but both models usually bypass the rigorous numeric analysis used for projects considered not too important for the existence of the organization.
- **Product extension[5]:** This model is used in cases where management sees the need to differentiate its products in order to strengthen a weak link or extends the product line in a new way. This is usually devoid of numeric calculations and in most cases, management

[2] Crispin George. (2020). Op cit. P134.

[3] موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص ص52-53.

[4] عبد الستار محمد العلي، إدارة المشروعات العامة، دار المسيرة، عمان، الأردن، ص ص 212-213.

[5] Crispin George. (2020).Op cit. P134.

makes such decision on the premise that the project will cause significant impact on the performance of the organization.

 Comparative benefit: Usually applied when a company has to decide between many initiatives that will significantly benefit the company. When the projects are simple to compare, this selection process is significantly easier. Making such a choice becomes difficult for projects that cannot be compared. The business relies on management to identify the best initiatives that will benefit the organization; there is no set process for doing so.

2.2. The Numeric Models

The numeric models use quantitative techniques in establishing whether a project is worth selection. It can be divided into two; profitability and scoring models. In most organizations, profitability is used as the only means of project acceptance.

2.2.1. Weighted Scoring Model (The scoring model)

The selection committee establishes the criteria by which a given project is graded in the scoring model. The most appropriate project—the one that speaks to the organization's strategic focus—will be chosen from among the numerous projects that can be graded. Weighted and unweighted scoring models are two more subcategories of this approach. The weighted scoring approach assigns numerical weights to the committee-established factors, which are then totaled to determine the project's preferred option. The unweighted scoring methodology, on the other hand, allows the committee to rate the project on each component according to each individual criterion after management identifies all the factors. There are advantages and disadvantages to scoring models.

a. Advantages:

 This model uses a variety of factors to help managers make decisions.
 It is easy to use and offers a great deal of versatility.
 There is so much flexibility in using this model.
 Some factors that are extremely important to the organization are given greater weights than others in the weighted scoring methodology.).

b. Disadvantages:

 Scoring model is relative in nature.
 The unweighted scoring model assumes that all criteria are of the same importance.
 This model usually captures profitability as a criterion.
 Scoring models are direct in form and the factors are assumed to be independent.

It is a simple and easy-to-use quantitative model, as some users consider it a qualitative model despite the use of numbers in the process of comparing projects. This model is used by following the following steps:

 Determine the relative weight for each of the comparison criteria. The sum of the relative weights must be = 1.

$$\sum_{i=1}^{n} \text{Weights} = 1$$

 Determine the points obtained by each of the comparison criteria for each project using one of the known and appropriate data collection tools.
 The relative weight of each criterion is multiplied by the points it obtained to determine the weighted points for each of the comparison criteria in the project.
 The weighted points for all the criteria of the single project are added together to determine the total weighted marks for each project.
 The project that obtained the highest total weighted points is selected.

Example: A company decided to compare three projects to choose one of them to develop a product. If the selection criteria were the relative weights and marks for the three projects as shown in the following table:

Table 01 : Weighted Scoring Model

The standard	Relative weight	Project A	Project B	Project C
profit margin	0.5	5	5	3
Ease of marketing	0.3	4	3	4
Ease of production	0.1	4	3	2
Raw material availability	0.1	4	4	2

Source: موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص55

Required: Choose one of these projects to implement using weighted points?

Solution:
1. We multiply the relative weight of each criterion by the criterion score for each project.
For example: Weighted points for the profit margin of the project
A = 0.5 x 5 = 2.5
2. We add the weighted points for all the criteria for each project as shown in the following table:

Table 02: Weighted score results

The standard	Project A	Project B	Project C
profit margin	2.5	2.5	1.5
Ease of marketing	1.2	0.9	1.2
Ease of production	0.4	0.3	0.2
Raw material availability	0.4	0.4	0.2
Total	4.5	4.1	3.1

Source : Prepared by the researcher based on previous data

Decision: Project A is chosen because it has the highest weighted score among the three projects.

2.2.2. Profitability Models

Project selection models that fall within the profitability category are thus:

2.2.2.1. Simple Payback Period (SPbP)[6]

Everyone investing in a business wants a situation where he/she will be able to recoup his investment within a period of time. However, the payback period establishes how an investor or an organization can regain its initial investment in a business or project within a stipulated time frame. It is the time required to recoup one's invested money in a project. The shorter the time required to recover the invested money in the project, the better the project. A project with longer payback period is not considered favourable. Payback period is estimated by dividing the investment cost by the cash inflow. However, the payback period overlooks the time value for money. This method is based on the stability of the value of money over time, meaning that the value of money does not change in the future.

Payback period method is defined as the number of years required to recover the value of the original investment, and is calculated as follows:

a. The case of equal cash flows:

$$SPbP = \frac{I_0}{CFN} \qquad \text{Where: CFN = CIF - COF}$$

I_0: Initial Investment

CFN: Cash-Flow Net

CIF: Cash in Flow

COF: Cash out Flow

Investment decision: The project that has the lowest payback period compared to other projects is accepted.

Example 1

A company owns three mutually exclusive investment projects in order to evaluate them financially. Their information is shown in the following table:

Table 03: Projects data

Project	I_0	CFN
A	30000	5000
B	30000	7000
C	30000	10000

Source : Prepared by the researcher.

The solution:

Calculating the payback period for projects:

For project A:

[6] موسى أحمد خير الدين، 2014، مرجع سابق، ص ص 56-57.

$$SPbP_A = \frac{I_0}{CFN} \Rightarrow SPbP_A = \frac{30000}{5000} = 6$$

The payback period for Project A is 6 years.

For project B:

$$SPbP_B = \frac{I_0}{CFN} \Rightarrow SPbP_B = \frac{30000}{7000} = 4{,}28$$

The payback period for Project B is 4 years, 3 months, and 10 days.

1 year............... 12 months

0,28...............X

X=(12*0,28)/1=3,36

Month.............. 30 days1

0,36.............X

X=(30*0,36)/1=10,8

For project C:

$$SPbP_C = \frac{I_0}{CFN} \Rightarrow PbP_C = \frac{30000}{10000} = 3$$

The payback period for Project C is 3 years.

The decision: Since the projects are mutually exclusive, the company accepts Project C and rejects the rest of the projects.

b. The case of unequal cash flows:

The cumulative cash flow is calculated until the initial cost of the project is reached.

$$SPbP = N_{(\sum CFN \leq I_0)} + \frac{I_0 - (\sum CFN)}{CFN_{T+1}}$$

Example 2

We have the following investment project:

Table 04: Project data

t	0	1	2	3	4
CFNt	-100000	30000	50000	30000	20000

Source : Prepared by the researcher.

Required: Evaluate the investment project using the payback period method.

The solution:

Table 05: Project data

t	0	1	2	3
CFNt	30000	50000	30000	20000
ΣCFNt	30000	80000	110000	130000

Source : Prepared by the researcher.

$$SPbP = N_{(\sum CFN \leq I_0)} + \frac{I_0-(\sum CFN)}{CFN_{T+1}} \Rightarrow SPbP = 2 + \frac{100000-80000}{30000} = 2,66$$

1 year................12 months

0,66.................X

X=(12*0.66)/1=7.92≈8

The decision: The payback period for the project is 2 years and 8 months.

Advantages and Disadvantages of the Simple Payback Period Standard[7]

a. Advantages:

 Simplicity and ease of calculation;

 The payback period indicator provides a degree of safety for projects whose work is affected by economic fluctuations.

b. Disadvantages:

 The payback period criterion does not take into account the time value of money;

 The payback period indicator encourages investment in projects with a small payback period.

 It does not take into account the project’s profitability achieved after the payback period, which weakens its credibility, especially since many projects become profitable after years of operation.

 It does not cover the productive life of the project and is limited to the period from its operation to the period of recovery of its funds, which weakens its accuracy.

[7] موسى أحمد خير الدين، 2014، مرجع سابق، ص ص56-57.

2.2.2.2.Discounted Payback Period (DPbP)[8]

This standard discounts the values of the project's future cash flows.

This model addresses the shortcomings of the previous model by taking the time value of money into consideration, by calculating its present value by subjecting it to the discount rate, by following the following steps:

- The present value (PV) of future cash flows is calculated based on the discount rate (r) and after (n) periods using the following mathematical law:

$$PV = \frac{\text{FV}}{(1+r)^n} = \text{FV} \times \left\{\frac{1}{(1+r)^n}\right\} \ldots\ldots\ldots\ldots 1$$

- To facilitate the solution of the equation, we first calculate the Discount Index, which is part of Equation 1 and depends on knowing both (r) and (n), and is calculated using the following law:

$$\text{PVIF(r, n)} = \left\{\frac{1}{(1+r)^n}\right\} \ldots\ldots\ldots\ldots 2$$

Therefore, equation 1 can be rewritten in the following form:

$$PV = \frac{\text{FV}}{(1+r)^n} = \text{FV} \times \left\{\frac{1}{(1+r)^n}\right\} = \text{FV} \times \text{PVIF(r, n)}$$

This coefficient is calculated either by using a calculator to solve Equation 2 or by using the financial table to extract the Present Value Index (PVIF) after determining each of (r, n).

- After calculating the discount factor and calculating the present value (PV) of future cash flows calculated on the basis of the discount rate, the payback period is extracted in the same way as in the simple payback period model.

Example: The initial investment is $100,000 and the annual cash flow is $25,000, but taking into account that the discount rate is 10% and the project life is 6 years.

Required: Calculate the payback period for the initial amount paid?

Solution: Calculate the discount factor (PVIF):

Discount factor for the first year:

---

[8] موسى أحمد خير الدين، 2014، مرجع سابق، ص ص58-62.

$$\text{PVIF(r, n)} = \left\{\frac{1}{(1+r)^n}\right\} = \left\{\frac{1}{(1+0{,}1)^1}\right\} = 0{,}909$$

Discount factor for the second year:

$$\text{PVIF(r, n)} = \left\{\frac{1}{(1+0{,}1)^2}\right\} = 0{,}826$$

Discount factor for the third year:

$$\text{PVIF(r, n)} = \left\{\frac{1}{(1+0{,}1)^3}\right\} = 0{,}751$$

Thus, we find the rest of the results in the following table.

2- Calculate the present value of future cash flows (PV) using the following equation:

$$PV = \text{FV} \times \left\{\frac{1}{(1+r)^n}\right\} = \text{FV} \times \text{PVIF(r, n)}$$

Therefore, the present value (PV) of the cash payment received at the end of the first year is:

$PV_{(1)}$ = 25000 x 0.909 = 22725 thousand $

$PV_{(2)}$ = 25000 x 0.826 = 20650 thousand $

$PV_{(3)}$ = 25000 x 0.751 = 18775 thousand $

And so on with the rest of the results:

Table 06: Project data

Time period (year)	**Cash flow $ at the end of the year (FV)**	**Discount rate (r)**	**Discount factor $PVIF_{(r,n)}$**	**Present value of annual cash flow $ (PV)**	**Total cash flows $ $\sum_{i=1}^{n} PV$**
1	25000	10 %	0.909	22725	22725
2	25000	10 %	0.826	20650	43375
3	25000	10 %	0.751	18775	62150
4	25000	10 %	0.683	17075	79225
5	25000	10 %	0.621	15525	94750
6	25000	10 %	0.564	14100	108850

Source : Prepared by the researcher based on previous data

• To calculate the payback period at the discount rate, we take the sum of the accumulated cash flows $\sum_{i=1}^{n}$ PV until we reach the value of the original investment, which is $100,000.

This amount, as is clear in the table, falls between the fifth year ($94,750) and the sixth year ($108,850).
• To know the exact time period, we subtract the cumulative flow $\sum_{i=1}^{n}$ PV for the fifth year from the investment amount:
100000-94750 = 5250 $
- Then we divide this amount by the discounted cash flow for the following year, $14,100, to find out exactly in what part of year 6 the amount is recovered.

$$DPbP = N_{(\sum PV \leq I_0)} + \frac{I_0 - (\sum PV)}{PV_{T+1}}$$

$$DPbP = 5 + \frac{1000-94750}{14100} = 5 + \frac{5250}{14100} = 5{,}372$$

So the payback period with the discount rate is equal to 5.372 years. It is noted here that subjecting the incoming cash flows to the time value of money has extended the payback period of the original investment amount.

Advantages and disadvantages of the updated payback period standard

a. Advantages

 Takes into account the time value of money;
 The investor is allowed to choose the project that recovers its costs in the shortest time.
 It is appropriate to use this criterion in comparing high-risk projects.

b. Disadvantages

 Does not take into account the project profitability achieved after the payback period;
 It does not give the useful life of the project and is limited to the period from its operation to the period of recovering its funds.
 It does not take into account the risk and uncertainty of achieving returns.

2.2.2.3. Net present value (NPV) [9]

The net present value criterion (It is also known as the discounted cash flow) is defined as the difference between the present value of the cash flows that will be achieved over the life of the project and the initial investment cost of the project, or it is the difference between the present value of net cash inflows and the present value of net cash outflows during the operating period.
The net present value criterion involves time-revamping all cash flows by means of a discount factor using the required rate of return from investment projects (financing cost).
The NPV is a financial technique used to evaluate the profitability of an expected project and it is simply value minus cost. A positive cash flow implies a favorable project that is, a project worth undertaking by an organization and a negative cash flow points to a project that is

[9] Crispin George. (2020). Op cit. Pp134-135.

unfavorable. Management usually accepts the project if the sum of the net present values of all estimated cash flows over the life of the project is positive.

The investment decision based on this criterion is as follows:

• NPV>0 The project is accepted
• NPV <0 The project is rejected
• NPV=0 is a marginal proposal from the institution for acceptance or rejection in light of non-financial considerations (for example, strategy.......)

The net present value is calculated according to the following law:

a. In the case of equal annual cash flows

$$NPV = -I_0 + CFN\frac{1-(1+k)^{-n}}{k}$$

I_0: initial investement
CFN: cash-flow net
K: discount rate
n: project lifespan

Example:

It is expected that the project will achieve cash flows during the first three years as follows: 1,000, 1,000, and 1,000 monetary units, as the initial investment cost is estimated at 1,500.
Required: Calculate the net present value of the project, knowing that the cost of capital k = 10%.

The solution:

Since the project's cash flows are equal, the net present value is calculated as follows:

$$NPV = -1500 + 1000\frac{1-(1,1)^{-3}}{0,1} = 986,852 > 0$$

Decision:

b. In case of unequal annual cash flows

$$NPV = -I_0 + \sum_{T=1}^{n} \mathrm{CFN_T}(1+\mathrm{k})^{-\mathrm{t}}$$

I_0: initial investement
CFN: cash-flow net
K: discount rate
n: project lifespan
t : year

Example: We have the following project:

Table 07: Projects data

t	0	1	2	3	4
CF_T	-1000	300	300	300	400

Source : Prepared by the researcher.

Required: Calculate NPV for the project, knowing that the cost of capital k=10%?

The solution:

$$NPV = -I_0 + \sum_{T=1}^{n} \mathrm{CFN_T}(1+\mathrm{k})^{-\mathrm{t}}$$

$$NPV = -1000 + \frac{300}{(1,1)^1} + \frac{300}{(1,1)^2} + \frac{300}{(1,1)^3} + \frac{400}{(1,1)^4}$$

$$NPV = 19 > 0$$

The realization of the project leads to an increase in the market value of the organization and thus the wealth of shareholders increases.

Advantages and disadvantages of the net present value criterion

a. Advantages

- Takes into account the time value of money;
- Takes into account the cash flows generated by the project during its economic life;
- It shows the profitability and return of the investment project.

b. Disadvantages

- It does not take into account projects with different useful lives and varying initial investment value.
- It does not give clear information about the return of one monetary unit on the investment cost.
- It does not take into account the risk and uncertainty of achieving returns.

2.2.2.4. Benefit cost ratio: Known as Profitability Index(PI) [10]

It is estimated using the net present value of expected cash flows divided by the initial cash invested in the project. The project is deemed acceptable when it has a ratio greater than 1. A profitability index less than 1, shows that the present value of the project is less than the initial investment capital; and that is not favorable for the project. On the other hand, a profitability index greater than 1, is favorable for a project and such project can be accepted by management.

Profitability Index = Present value of expected cash flows / Initial investment in the project.

$$PI = \frac{\sum_{i=1}^{n} \text{PV}}{\text{Initial Investment } (I_0)}$$

OR

$$PI = \frac{NPV}{I_0} + 1$$

The project selection process is as follows:

1. Selecting the individual project: The profitability index value is one of three expected cases.

• PI>1 The project is accepted
• PI <1 The project is rejected
• PI=1 Break-even point

Decision: We choose the project if the profitability index is higher than 1 (PI > 1).

2. Choosing a project from a projects program: In the event of choosing one or more projects from among a group of projects, we choose the project that has the highest (PI) value, because it is the most profitable project.

Example: The initial investment is $100000, the annual cash flow is $25000, the discount rate is 10%, the project life is 6 years, calculate the profitability index, and do you choose the project for implementation or not?

Solution:

1. Calculate the sum of the present value flows of future cash flows at the discount rate.

$$\sum_{i=1}^{n} \text{PV} = 108850 \, \$$$

2. Determine:

Initial Investment = 100000 $

3. Calculate PI according to the following equation:

$$PI = \frac{\sum_{i=1}^{n} \text{PV}}{\text{Initial Investment}} = \frac{108850}{100000} = 1{,}0885$$

[10] موسى أحمد خير الدين، 2014، مرجع سابق ، ص ص65-67.

Decision: The project is chosen for implementation because its profitability is greater than 1.

2.2.2.5. Return on Investment Rate Model (ROI) [11]

This model is characterized by its simplicity, and is expressed mathematically by the following equation:

$$ROI = \frac{\text{Returned Amount } (\sum_{t=1}^{n} \text{CFN}) - \text{Invested Amount}(I_0)}{\text{Invested Amount } (I_0)}$$

Where:

ROI: Rate of return on investment.
Returned Amount: The value of the investment returned.
Invested Amount: The value invested.

The process of evaluating and selecting projects is as follows:

1. Evaluation of a single project: After calculating the ROI of the project, this return is compared to similar projects in the same company or in the same market sector, and this benchmark comparison helps in selecting the project if its rate of return on investment (ROI) is higher than the rate of return for similar projects.
2. Evaluation and selection of a group of projects: The project that achieves a higher rate of return is selected.

Example: If the expected average investment amount in a project is $4 million, and the expected return on investment is $5 million, what is the return on investment (ROI) rate for this project?

Solution:

Invested amount = 4 millions $
Returned Amount = 5 millions $

$$ROI = \frac{\text{Returned Amount} - \text{Invested Amount}}{\text{Invested Amount}} = \frac{5-4}{4} = \frac{1}{4} = 25\%$$

There are several models used to determine profitability depending on the nature of the project, available resources and the priority of the parent organization. Nevertheless, the profitability models have several benefits and challenges.

[11] موسى أحمد خير الدين، 2014، مرجع سابق ، ص ص67-68.

Benefits and Challenges of the Profitability Models[12]

a. The Benefits are:

Some of the Benefits of the profitability models are:

 Easy to understand and apply.

 Most stakeholders are conversant with their use.

 Required data to estimate cash flows, payback period, rate of return etc. are readily available.

 Project risks can be estimated using some of these models.

 These models can serve as the scientific basis for decision making.

b. The challenges are thus:

 These models tend to ignore the non-financial factors affecting project with the exception of risk.

 Estimation of cash flow and time value for money is a serious challenge with some of these models. For instance, the payback method does not account for cash flows beyond the payback period.

 These models are highly prone to errors especially during the early stages of data input.

 These models are biased towards short term goals.

In a nutshell,

Profitability models are aiming at the monetary or financial aspect of project selection with the exception of project risks. The scoring models are relative measure that allows several criteria to be used for estimation and decision-making. It is flexible enough to accommodate changes in management's decisions.

Numeric and nonnumeric selection models are used by organizations to select projects for implementation. When an organization is faced with natural occurrences like flooding, wildfires etc. that threatens it very existence, it becomes imperative to act. Since this is an emergency situation, it does not require much formal evaluation and hence, nonnumeric parameters can be used for the selection process. Numeric models require detail analysis that are not too appropriate for emergency situation. Rather, numeric models are more convenient in cases where cost is estimated.

[12] Crispin George. (2020). Op cit. Pp135-136.

A Set of Exercises

Exercise 01

The investment cost for two public projects is estimated at 10000000 monetary units. The annual net cash flows for the first project are estimated at 2500000 monetary units, while the annual net cash flows for the second project are estimated at 2000000 monetary units.

Required: Choose the appropriate public project between the two alternatives according to the simple payback period?

Solution

The appropriate public project according to the payback period criteria:

$$SPbP = \frac{I_0}{CFN}$$

For Project A :

$$SPbP_A = \frac{10000000}{2500000} = 4\text{Years}$$

For Project B :

$$SPbP_B = \frac{10000000}{2000000} = 5\text{Years}$$

Decision: we choose the public project A.

Exercise 02

The following table shows the investment cost and net cash flows for a period of five years related to three profitable public projects

Table 08: Projects data

Statement	Project A	Project B	Project C
I_0	4000000	6000000	5000000
1	1000000	1500000	700000
2	1200000	500000	900000
3	800000	1000000	2000000
4	1000000	1500000	2000000
5	1400000	3000000	400000

Source : Prepared by the researcher.

Required: Choose the appropriate public project among the three alternatives according to the simple payback period criterion?

Solution

The appropriate public project within three alternatives:

We calculate the cumulative incremental net cash flows for each project and compare them with the initial cost for each, which are shown in the following table:

Table 09: Projects data

Statement	Project A	ΣCFN_A	Project B	ΣCFN_B	Project C	ΣCFN_C
I_0	4000000		6000000		5000000	
1	1000000	1000000	1500000	1500000	700000	700000
2	1200000	2200000	500000	2000000	900000	1600000
3	800000	3000000	1000000	3000000	2000000	3600000
4	1000000	4000000	1500000	4500000	2000000	5600000
5	1400000	5400000	3000000	7500000	400000	6000000

Source : Prepared by the researcher.

For project A:

$$SPbP = N_{(\sum CFN \leq I_0)} + \frac{I_0 - (\sum CFN)}{CFN_{T+1}} \Rightarrow SPbP_A = 4 + \frac{1000000 - 1000000}{1400000} = 4\text{years}$$

The simple payback period for the project A is 4 years.

For project B:

$$SPbP_B = 4 + \frac{6000000 - 4500000}{3000000} = 4{,}5\text{years}$$

1 year................12 months

0,5..................X

X=(12*0.5)/1=6

The simple payback period for the project B is 4 years and 6 months.

For project C:

$$SPbP_C = 3 + \frac{5000000 - 3600000}{2000000} = 3{,}7$$

1 year................12 months

0,7..................X

X=(12*0.7)/1=8,4

1 month................30 days

0,4..................X

X=(30*0,4)/1=12

The simple payback period for the project is 3 years and 8 months and 12 days.
The decision: We choose the project C because it has the shortest payback period.

Exercise 03:
An expert was asked to evaluate the following projects and select one to implement. If the data available to him is as shown in the following table:

Table 10: Projects data

Activity	cash flow ($)					
	1	2	3	4	5	6
A	50000	55000	60000	65000	70000	75000
B	50000	40000	45000	55000	65000	70000
C	50000	40000	60000	50000	70000	60000

Source : Prepared by the researcher.

If the investment value in both projects is equal to $150,000, and the discount rate is 8%,
Required: Arrange projects in terms of implementation priority?

Solution:
For Project A:

Table 11: Projects data

A = 150000					
Years	cash flow (CIF/$)	$\sum$ CIF	discount factor	present value (PV/$)	$\sum$ PV
1	50000	50000	0.926	46300	46300
2	55000	105000	0.857	47135	93435
3	60000	165000	0.794	47640	141075
4	65000	230000	0.735	47775	188850
5	70000	300000	0.681	47670	236520
6	75000	375000	0.630	47250	283770

Source : Prepared by the researcher based on previous data

For Project B:

Table 12: Projects data

B = 150000					
Years	cash flow (CIF/$)	$\sum$ CIF	discount factor	present value (PV/$)	$\sum$ PV
1	50000	50000	0.926	46300	46300
2	40000	90000	0.857	34280	80580
3	45000	135000	0.794	35730	116310
4	55000	190000	0.735	40425	156735
5	65000	255000	0.681	44265	201000
6	70000	325000	0.630	44100	245100

Source : Prepared by the researcher based on previous data

For Project C:

Table 13: Projects data

C = 150000					
Years	**cash flow (CIF/$)**	$\sum$ **CIF**	**discount factor**	**present value (PV/$)**	$\sum$ **PV**
1	50000	50000	0.926	46300	46300
2	40000	90000	0.857	34280	80580
3	60000	150000	0.794	47640	128220
4	50000	200000	0.735	36750	164970
5	70000	270000	0.681	47670	212640
6	60000	330000	0.630	37800	250440

Source : Prepared by the researcher based on previous data

1. Simple Payback Period:

For project A:

$$\text{Simple pay Back Period} = 2 + \frac{150000-105000}{60000} = 2.75 \text{ years}$$

For project B:

$$\text{Simple pay Back Period} = 3 + \frac{150000-135000}{55000} = 3.272 \text{ years}$$

For project C:

$$\text{Simple pay Back Period} = 3 + \frac{150000-150000}{50000} = 3 \text{ years}$$

We choose A then B then C.

2. Discounted Payback Period:

For project A:

$$\text{Discounted Pay Back Period} = 3 + \frac{150000-141075}{47775} = 3{,}186 \text{ years.}$$

For project B:

$$\text{Discounted Pay Back Period} = 3 + \frac{150000-116310}{40425} = 3{,}833 \text{ years.}$$

For project C:

$$\text{Discounted Pay Back Period} = 3 + \frac{150000 - 128220}{36750} = 3{,}592 \text{ years.}$$

We choose A then C then B.

3. Net Present Value (NPV)

For project A:

NPV = $\sum_{i=1}^{6}$ PV - Initial Investment = 283770 – 150000 = 133770 $ > 0

For project B:

NPV = $\sum_{i=1}^{6}$ PV - Initial Investment = 245100 – 150000 = 95100 $ > 0

For project C:

NPV = $\sum_{i=1}^{6}$ PV - Initial Investment = 250440 – 150000 = 100440 $ > 0

We choose A then C then B.

4- Profitability Index (PI)

For project A:

$$PI = \frac{\sum_{i=1}^{6} \text{PV}}{\text{Initial Investment}} = \frac{283770}{150000} = 1.891 > 1$$

For project B:

$$PI = \frac{\sum_{i=1}^{6} \text{PV}}{\text{Initial Investment}} = \frac{245100}{150000} = 1{,}634 > 1$$

For project C:

$$PI = \frac{\sum_{i=1}^{6} \text{PV}}{\text{Initial Investment}} = \frac{250440}{150000} = 1{,}669 > 1$$

We choose A then C then B.

5- Rate of return on investment (ROI)

For project A:

$$ROI = \frac{\text{Returned Amount} - \text{Invested Amount}}{\text{Invested Amount}} = \frac{375000 - 150000}{150000} = 1.5 = 150\ \%$$

For project B:

$$ROI = \frac{\text{Returned Amount} - \text{Invested Amount}}{\text{Invested Amount}} = \frac{325000 - 150000}{150000} = 1.166 = 116.6\%$$

For project C:

$$ROI = \frac{\text{Returned Amount} - \text{Invested Amount}}{\text{Invested Amount}} = \frac{330000 - 150000}{150000} = 1.2 = 120\%$$

We choose A then C then B.

Decision: Since the simple payback period and the discounted payback period are lower in Project A (compared to Projects B and C), since the NPV is positive in Project A and equals $133770, which is higher than Projects B and C, and the profitability index (PI) is greater than 1 and equals 1.891, which is higher than Projects B and C, and the return on investment (ROI) is equal to 150%, which is high, then we choose Project A and advise the company to implement it, followed by Project C and then Project B.

II. Project Action Plan[13]:

1. Definition of Project Action Plan

The Project Action Plan is a tool for planning projects. It lays out the steps for implementing a project. It usually includes the planning of:

- Objectives
- Activities
- Resources
- Responsibilities
- Time schedules
- Outcomes

Before we start to plan the project in detail, the purpose and objectives must be clear. Objectives of a project answer the question of what you are trying to achieve with the project.

- Why do I start this project?
- What do I want to achieve?

Once the objectives are clear and well defined you need to plan how to get to the set objectives. The main questions you should answer for the planning are:

- How do I reach the objectives? What are the milestones2?
- What do I need to reach these milestones and objectives?
- How do I control the quality of the outcomes?

Also it is crucial to think about the stakeholders and how to involve them, what motivations or resistance they could have towards the project and how to cope with them:

- Who are the stakeholders?
- Who should be involved?
- How to involve them?
- What are the potential risks of each stakeholder?

2. Project Planning Process[14]

The planning begins with a statement of the work to be performed and other constraints and goals that define and bound the project. The planning process includes steps to estimate the size of the work products and the resources needed, produce a schedule, identify and assess risks, and negotiate commitments. Iterating through these steps may be necessary to establish the plan for the project (i.e., the development plan).

This plan provides the basis for performing and managing the project's activities and addresses the commitments to the project's customer according to the resources, constraints, and capabilities of the project. During planning, a project is split into several activities which may be pursued in parallel or in series. The questions are

- How much effort is required to complete each activity?
- How much calendar time is needed?
- How much will the completed activity cost?

---

[13] Xia Qin. (2024). Op cit. P7.

[14] Riaz S.S. Ahamed. Project Planning: An Analysis, International Journal of Engineering Science and Technology. Vol.2(1), 2010,18-29 . p18.

The Plan define a strategic model to devise the project more effective and execute based on the strategic plan. Though there are many strategic models are recommended, each has its own Importance.

3. Types of project plan[15]

The project plan shows tasks, milestones, dependencies and schedules. It is usually implemented by way of the Gantt chart or Pert chart. The project plan should clearly show the effort requirements for each task and the team members allocated to the task. This plan is used in multi-project environments as a method of controlling and balancing resource requirements. The project plan is the starting point for the live project plan that is used in the Driving stage.

3.1.Top Down Planning[16]

The first is a forward-looking, top down approach. It starts with an understanding of the general requirements and constrains, derives a macro-level budget and schedule, then decomposes these elements into lower level budgets and intermediate milestones. From this perspective, the following planning sequence would occur:

 The project manager develops a characterization of the overall size, process, environment, people and quality required for the project.

 A macro-level estimate of the total effort and schedule is developed using a cost estimation model.

 The project manager partitions the estimate for the effort into a top-level WBS using guidelines. The project manager also partitions the schedule into major milestones dates and partitions the effort into a staffing profile, using guidelines. Now there is a project-level plan. These sorts of estimates tend to ignore many detailed project-specific parameters.

At this point subproject managers are given the responsibility for decomposing each of the WBS elements into lower levels using their top-level allocation, staffing profile, and major milestones dates as constraints.

The advantage is that the top managers, who are the most knowledgeable about the firm as a whole, drive the development of the plan.

3.2. Bottom-up-Planning

The second perspective is a backward –looking , bottom-up approach. This approach begins by analyzing the micro-level budgets and schedules, then sum all these elements into the higher level budgets and intermediate milestones. This approach tends to define and populate the WBS from the lowest level upward. The following planning sequence would occur:

 The lowest level WBS elements are elaborated into detailed tasks, for which budgets and schedules are estimated by the responsible. WBS element manager. These estimates tend to incorporate the projectspecific parameters in an exaggerated way.

[15] Riaz. S.S. Ahamed (2010). Ibid . p19.
[16] Riaz. S.S. Ahamed, (2010). Ibid. p21.

 Estimates are combined and integrated into higher level budgets and milestones. The biases of individual estimators need to be homogenized so that there is a consistent basis of negotiation.

4. The Work Breakdown Structure

4.1.Definition of the work breakdown structure[17]

The Work Breakdown Structure (WBS) is a foundational planning document that contributes to most other planning procedures the PM performs, including cost estimating, risk analysis, resource assignment, and scheduling. PMs develop a WBS to organize project requirements and define the total scope of the project. The WBS can be oriented on: (1) the actual product or system; (2) the functions provided by the product; (3) the project office functions that must be performed in the overall management of the product acquisition; or (4) combinations of product and functions.

The WBS breaks project work down into smaller pieces that can be scheduled and resourced. The WBS is a hierarchical breakdown, or decomposition, of the project work to be completed by the team. Any work that is not included in the WBS is not considered part of the project. The WBS is not a project plan or a schedule. The WBS only specifies what will be done, not how or when.

According to Riaz (2010)[18] , the most fundamental building block of a project plan is the work breakdown structure (WBS). The WBS contains a list of tasks to be accomplished, and you can implement a template WBS in a spreadsheet as a list of task names, task percentages of effort and task descriptions.

The work breakdown[19] structure according to Burke Rory (1999) is one of the main management tools used to divide the scope of work into manageable work packages that can be estimated, planned, allocated and controlled. The work breakdown structure (WBS) is often linked to what is known as the organization breakdown structure (OBS), so the OBS can be further developed to include responsibility, level of authority and lines of communication, Projects are managed by a project manager and a project team that is specifically created for the project and dissolved upon completion. The project team and company departments are integrated through a matrix structure where the project team overlays the company's hierarchical structure.

Example: Represent the following work breakdown structure:

WBS = P2-T3-WP3-WU1-A2

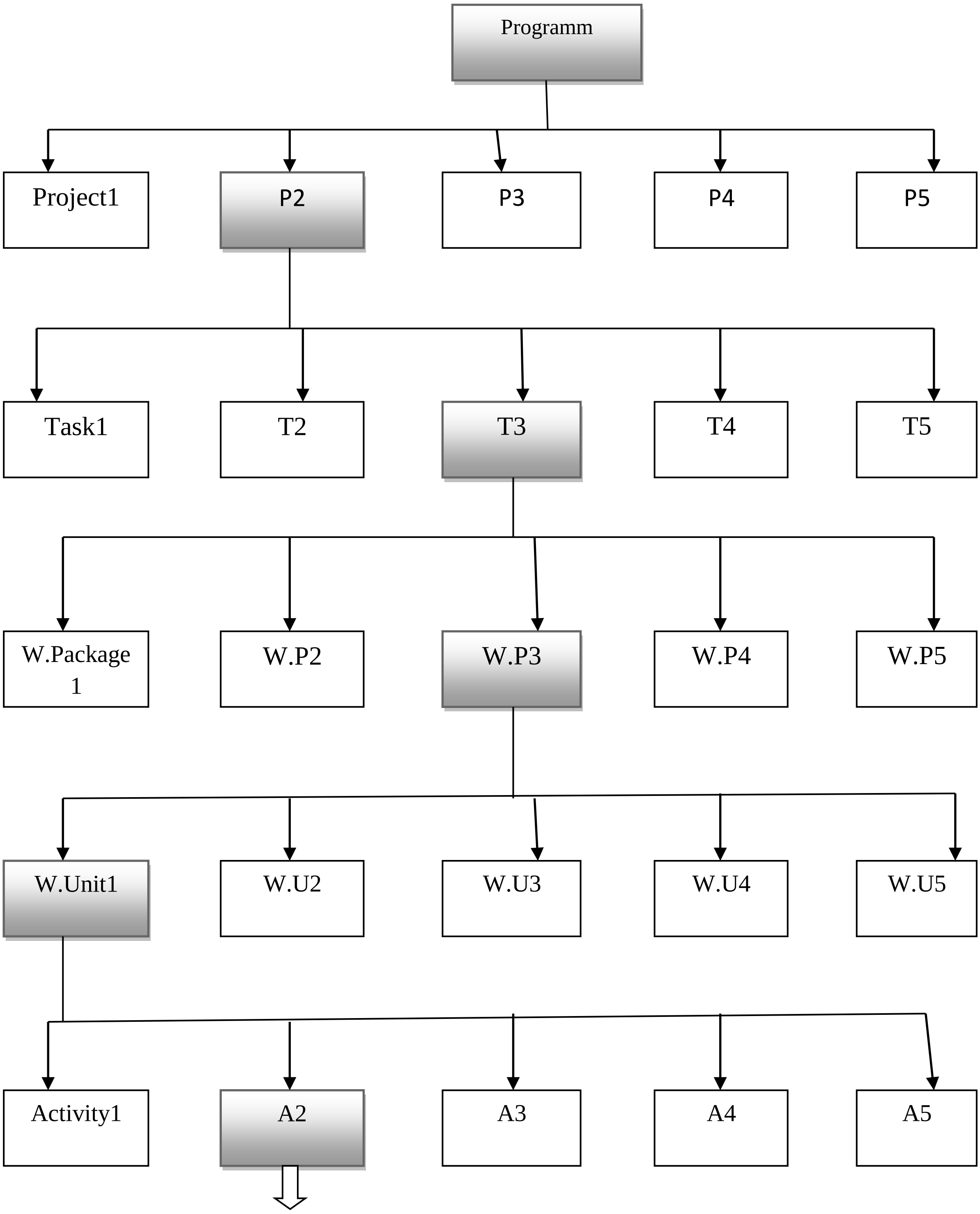
---

[17] Federal Acquisition Institute (FAI). Project Manager's Guidebook. November 24, 2015. P117

[18] Riaz. S.S. Ahamed, (201. Op cit . p23.

[19] Burke, Rory. (1999). Project Management: Planning and Control Techniques, 3rd Edition, John Wiley & Sons LTD, p88.

Figure 04: Work breakdown structure



Source :.151 موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر ، الطبعة الثانية، عمان، ص

4.2.Work Breakdown Structure Objective[20]

The object of WBS is :

- To be able to control the project by allocating resources (human, material, and financial) and giving time constraints to each task.
- To control a series of small entities that make up a whole than to control the whole enterprise as one operation.

4.3.Create Work Breakdown Structure (WBS)[21]

Create WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The key benefit of this process is that it provides a structured vision of what has to be delivered.

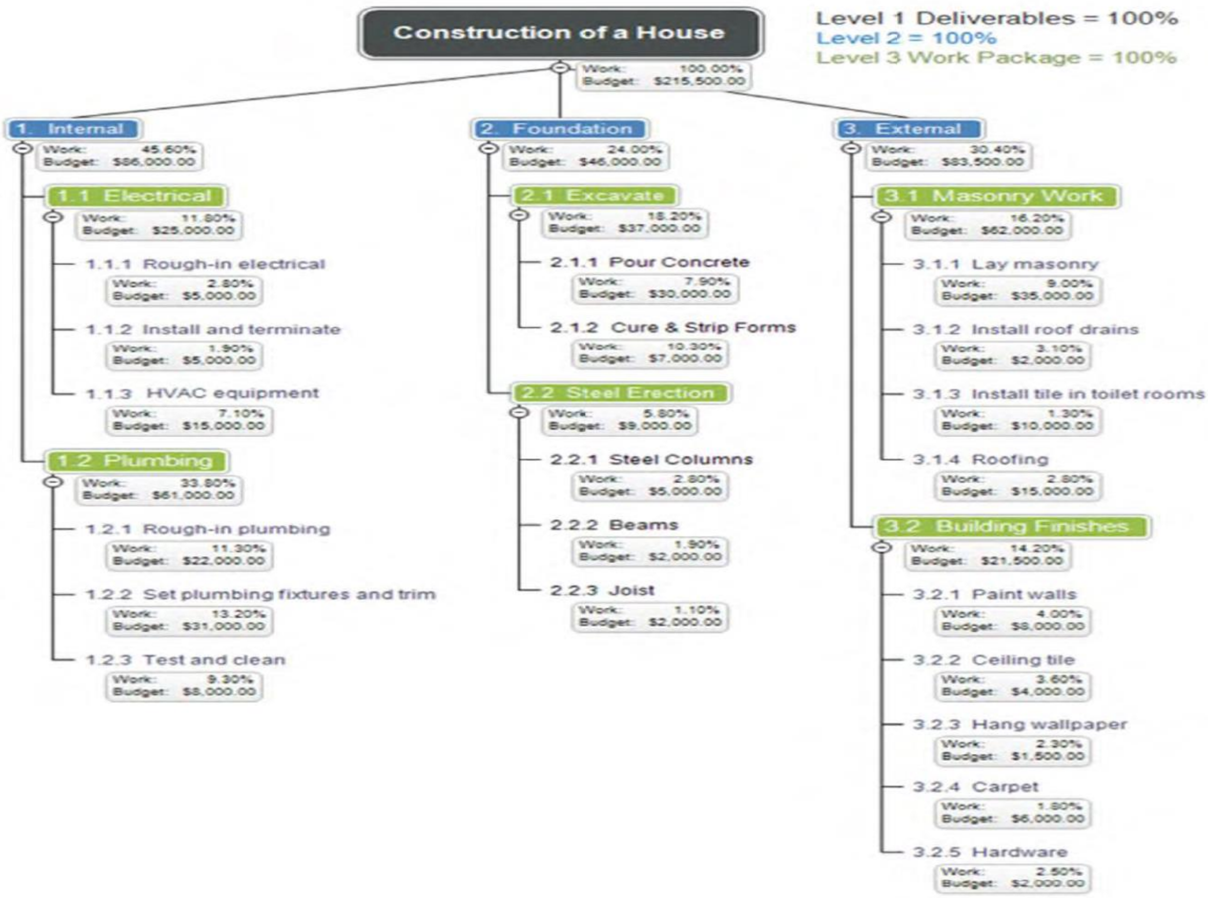
The WBS is a hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables. The WBS organizes and defines the total scope of the project, and represents the work specified in the current approved project scope statement.

The planned work is contained within the lowest level of WBS components, which are called work packages. A work package can be used to group the activities where work is scheduled and estimated, monitored, and controlled. In the context of the WBS, work refers to work products or deliverables that are the result of activity and not to the activity itself. The following Figure 05 is a practical example of a work breakdown structure.

[20] Albert Lester. *(*2014). Op cit. P51.

[21] Project Management Institute. (2013). Op cit. P125.

Figure 05: Example Work Breakdown Structure (WBS)



Source: Federal Acquisition Institute (FAI). Project Manager's Guidebook. November 24, 2015. P118.

The process of developing a WBS[22] is straightforward, but the result can become rather large and complex depending on the project. The PM is responsible for developing the WBS; however, it is a best practice to include the project team in developing the WBS to ensure it covers all possible project requirements and needs. The WBS is created through four steps:

1. List all of the project's requirements.
2. Identify the deliverables that are needed for each requirement.
3. Divide the work for each deliverable into small, manageable pieces, called work packages.
4. Review the WBS to ensure it includes all activities needed to complete the project.

The preponderance of time developing the WBS will be spent in Step 3: developing work packages. Work packages are the lowest level on the WBS. An individual work package

[22] Federal Acquisition Institute (FAI). (2015). Op cit. P119.

comprises all activities needed to complete it. A work package: 1) can be scheduled, 2) its costs can be estimated, 3) the work can be monitored, and 4) the work can be controlled. If those areas cannot define a single work package, then the activity must be further decomposed until all work in that package can be defined and broken down no further. Additionally, the work products coming from each work package should be mutually exclusive and not overlapping. If work products are overlapping, it may result in duplication of efforts.

5. Cost Breakdown Structure and Risk Breakdown Structure

5.1. Cost Breakdown Structure[23]

The degree to which the WBS needs to be broken down before a planning network can be drawn will have to be decided by the project manager, but there is no reason why a whole family of networks cannot be produced to reflect each level of the WBS.

Once the WBS (or PBS) has been drawn, a bottom-up cost estimate can be produced starting at the lowest branch of the family tree. In this method, each work package is costed and arranged in such a way that the total cost of the packages on any branch must add up to the cost of the package of the parent package on the branch above. If the parent package has a cost value of its own, this must clearly be added before the next stage of the process.

It can be seen that a WBS is a powerful tool that can show clearly and graphically who is responsible for a task, how much it should cost, and how it relates to the other tasks in the project. It was stated earlier that the WBS is not a programme, but once it has been accepted as a correct representation of the project tasks, it will become a good base for drawing up the network diagram. The interrelationships of the tasks will have to be shown more accurately, and the only additional items of information to be added are the durations. An alternative to the bottom-up cost allocation is the top down cost allocation. In this method, the cost of the total project (or subproject) has been determined and is allocated to the top package of the WBS (or PBS) diagram. The work packages below are then forced to accept the appropriate costs so that the total cost of each branch cannot exceed the total cost of the package above.

5.2. Risk Breakdown Structure[24]

Although the WBS may have been built up by the project team, based on their collective experience or by brainstorming, there is always the risk that a stage or task has been forgotten. An early review then opens up an excellent opportunity to refine the WBS and carry out a risk identification for each task, which can be the beginning of a risk register. At a later date a more rigorous risk analysis can then be carried out. The WBS does in effect give everyone a better understanding of the risk assessment procedure.

Indeed, this is another type of breakdown structure is the risk breakdown structure. Here the main risks are allocated to the WBS or PBS in either financial or risk rating terms, giving a good overview of the project risks. In another type of risk breakdown structure the main areas of risk are shown in the first level of the risk breakdown structure, and the possible risk headings are listed below.

[23] Albert Lester. (2014). Op cit. P53.
[24] Albert Lester. (2014). Op cit. P55-56.

Chapter 03

I. Project Scheduling

Introduction

Project scheduling is the process of organizing and planning tasks and activities within a specific timeframe to efficiently achieve project objectives. This process includes determining the sequence of tasks, allocating resources, and setting deadlines, ensuring project completion on time and within budget.

Project scheduling is an essential part of project management, as it:

- Project scheduling is a coordinated framework for planning, directing, and controlling a project.
- Project scheduling demonstrates the dependencies and overlaps of all activities and tasks within a project.
- Scheduling indicates when a project requires allocating resources.

1. Project Scheduling Definition[1]

A schedule is a planning document, but it can be used effectively only if it is rich enough in useful and accurate information. A schedule lacking sufficient information is no more than an obnoxious administrative hurdle that does not contribute to the successful completion of the project. The process of creating a schedule begins with the identification of tasks that must be completed in order to finish the project. This step is primarily the responsibility of the Director since it is intimately related to the architecture of the system as conceived by the Director.

2. Project Scheduling Stages[2]

The primary source for scheduling all the activities and tasks in a project is the project WBS. The WBS is constructed from the project's requirements, and it organizes and defines the total scope of the project. The WBS breaks project work up into smaller pieces, which will enable you to schedule and cost-out the work. The WBS may be deliverable-based and focus on when actual products, or "deliverables" in the scope, are developed and arrive at their point of use; or it may be phase-based focusing on the activities occurring in the life-cycle phases and milestones of the project. Once your WBS is created, there are six steps to scheduling project work logically and effectively:

2.1. Defining the Activities and Tasks. A task is an actual component of work to be performed that cannot be practically subdivided and can be assigned to a single entity, such as an individual person or small group of persons of similar skills. Tasks are created by breaking down the work package deliverables of the WBS.

2.2. Sequence. After identifying the tasks, put them in the order they will be performed. While doing this, determine which tasks depend upon other tasks so you can schedule them appropriately.

[1] Riaz S.S. Ahamed. (2010). Op cit . p25.
[2] Federal Acquisition Institute (FAI). (2015). Op cit. Pp121-122.

2.3. Resource. Once the tasks are organized in a logical order, assign people and resources to the tasks.

2.4. Duration. Next, estimate how long you think each task will take, or its duration.

2.5. Display. Display it in the format of your choice (Gantt, Milestone, Network).

2.6. Analyze. This analysis includes validating the schedule to ensure all tasks were included, identifying the end date of your project, and making changes to adjust the end date if needed. As with most planning processes, you will progressively elaborate the schedule, adding more and more details with each step of the scheduling process.

3. Basic Network Principles[3]

3.1.The Network

The network is a flow diagram showing the sequence of operations of a process. Each individual operation is known as an activity and each meeting point or transfer stage between one activity and another is an event or node. If the activities are represented by straight lines and the events by circles, it is very simple to draw their relationships graphically, and the resulting diagram is known as the network. In order to show whether an activity has to be performed before or after its neighbour, arrowheads are placed on the straight lines, but it must be explained that the length or orientation of these lines is quite arbitrary. This format of network is called activity on arrow (AoA), as the activity description is written over the arrow. Some planners also prefer to show the interrelationship of activities by using the node as the activity box and interlinking them by lines. The durations are written in the activity box or node and are therefore called activity on node (AoN) diagrams.

3.2.Network Analysis

Network analysis, consists of two basic operations:

1. Drawing the network and estimating the individual activity times
2. Analysing these times in order to find the critical activities and the amount of float in the non-critical ones

3.3.Advantages of network scheduling techniques[4]

Advantages of network scheduling techniques include:

• They form the basis for all planning and predicting and help management decide how to use its resources to achieve time and cost goals.

• They provide visibility and enable management to control “one-of-a kind” programs.

• They help management evaluate alternatives by answering such questions as how time delays will influence project completion, where slack exists between elements, and what elements are crucial to meet the completion date.

[3] Albert Lester. (2014). Op cit. P106.

[4] Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P494.

• They provide a basis for obtaining facts for decision-making.
• They utilize a so-called time network analysis as the basic method to determine manpower, material, and capital requirements, as well as to provide a means for checking progress.
• They provide the basic structure for reporting information.
• They reveal interdependencies of activities.
• They facilitate "what if " exercises.
• They identify the longest path or critical paths.
• They aid in scheduling risk analysis.

3.4. Network analysis objectives[5]

Interdependencies are shown through the construction of networks. Network analysis can provide valuable information for planning, integration of plans, time studies, scheduling, and resource management. The primary purpose of network planning is to eliminate the need for crisis management by providing a pictorial representation of the total program. The following management information can be obtained from such a representation:
• Interdependencies of activities
• Project completion time
• Impact of late starts
• Impact of early starts
• Trade-offs between resources and time
• "What if" exercises
• Cost of a crash program
• Slippages in planning/performance
• Evaluation of performance

3.5.Network components

Networks are composed of events and activities. The following terms are helpful in understanding networks:
• **Event[6]:** Equivalent to a milestone indicating when an activity starts or finishes.
• **Activity:** The element of work that must be accomplished.
• **Duration:** The total time required to complete the activity.[7]Having drawn the network, the next step is to ascertain the duration or time of each activity. These may be estimated in the light of experience, where, the shorter the durations, the more accurate they are. and these are times written under the activity.
• **Effort[8]:** The amount of work that is actually performed within the duration. For example, the duration of an activity could be one month but the effort could be just a two-week period within the duration.
• **Critical Path:** This is the longest path through the network and determines the duration of the project. It is also the shortest amount of time necessary to accomplish the project.

---

[5] Harold Kerzner. (2009). Op cit. P496.
[6] Harold Kerzner. (2009). Ibid. P 496.
[7] Albert Lester. (2014). Op cit. P110.
[8] Harold Kerzner. (2009). Op cit. P 496.

3.6.Activity drawing methods

3.6.1. Activity on arrow (AoA)[9]

In AOA networks, the activities are represented by arcs and events by nodes. Each activity should be represented by one and only one arc. The start node (the tail) indicates the start of an activity and the finish node (the head) its completion. These nodes correspond to the events of the activity starting and ending, respectively.

3.6.2. Precedence or Activity on Node (AoN) Diagrams[10]

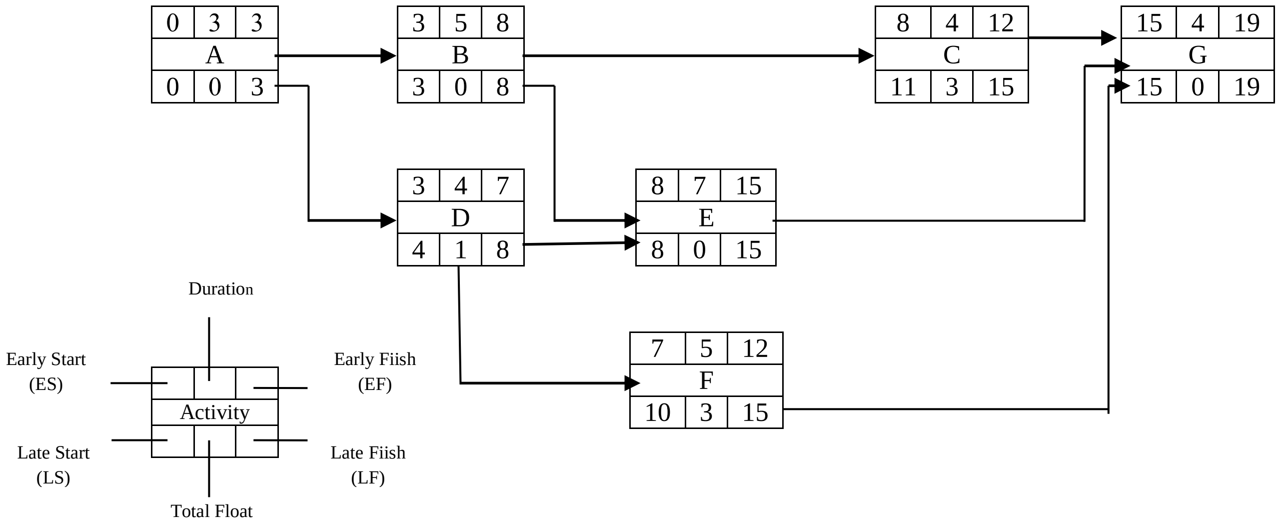
Some planners prefer to show the interrelationship of activities by using the node as the activity box and interlinking them by lines. The durations are written in the activity box or node and are therefore called activity on node (AoN) diagrams. This has the advantage that separate dummy activities are eliminated. In a sense, each connecting line is, of course, a dummy because it is timeless. The network produced in this manner is also called variously a precedence diagram or a circle and link diagram. Precedence diagrams have a number of advantages over arrow (AoA) diagrams in that:

1. No dummies are necessary;
2. They may be easier to understand by people familiar with flowsheets;
3. Activities are identified by one number instead of two so that a new activity can be inserted between two existing activities without changing the identifying node numbers of the existing activities; and
4. Overlapping activities can be shown very easily without the need for the extra dummies

[9] Ulusoy. G, Hazır. Ö. (2021). Planning and Network Modeling of Projects. Springer Nature Switzerland AG, Springer Texts in Business and Economics. P64.

[10] Albert Lester. Project Management, Planning, and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards. Sixth Edition. 2014. Elsevier Publisher, Oxford, UK. P117.

Figure 06: AoN diagram



Source : Albert Lester. Project Management, Planning, and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards. Sixth Edition. 2014. Elsevier Publisher, Oxford, UK. P118.

4. Most Common Scheduling Techniques

4.1. Gantt or Bar Charts[11]

The Gantt chart is a type of bar chart that displays tasks along a timeline. The current date is shown with a dashed vertical line running from the top to the bottom. There are no standard symbols for a Gantt chart. Some versions simply show the planned beginnings and ends of tasks with the vertical lines on the task bar. Others add a symbol, usually a triangle, to denote the beginning or end.

You can visually track the progress of an activity easily using a Gantt chart. As the work progresses, the bar for the task fills to show the work being done.

There are a few reasons the Gantt chart is widely used. First, it is easy to track the progress of tasks visually with the progress bars. It is a concise format that is relatively simple to read once you are familiar with it. It is also a great format to use for reporting progress to management because it allows for progress to be visualized. The drawback with using a Gantt chart is that it does not show relationships and dependencies between tasks.

[11] Federal Acquisition Institute (FAI). (2015). Op cit. P125.

4.1.1. Gantt Chart Components[12]

 Consists of two axes (horizontal and vertical).

 The horizontal axis shows the time required to complete an activity, indicating the start and end points.

 The vertical axis shows the types or names of activities.

 It is drawn as a rectangle, with the beginning indicating the start of work on the activity and the end indicating the end of work on the activity.

 The length of the rectangle indicates the time required to complete the activity.

Example:

Implementing a project requires the four activities shown in the table, which shows the time required to complete each activity per week.

Table14: Project Activities

Activity	Activity time (week)
A	10
B	8
C	6
D	4

Source: موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص 163

With noting that:

 Activities A and B can start simultaneously and in parallel.

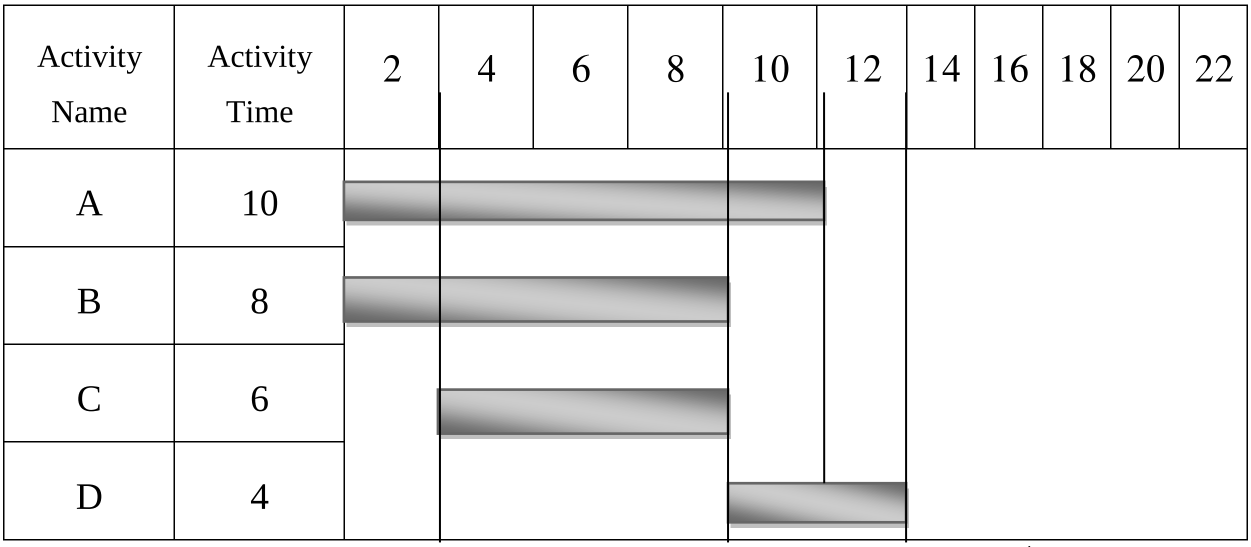
 Activity C starts two weeks after the start of Activities A and B.

 Activity D cannot start until after Activity C has finished.

[12] موسى أحمد خير الدين، 2014، مرجع سابق، ص 163.

Solution:

Figure 07: Gantt Chart



Source: موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص 164

• From the figure 07 we can see that the time required to complete the project is 12 weeks.

4.2. Arrow Diagram Method (ADM) [Sometimes called the Critical Path Method (CPM)]

Identification the earliest and latest times for each event[13].

The earliest and latest times were identified as the time when an event can be expected to take place. To make full use of the capabilities of PERT/CPM, four values were defined:

• **The earliest time when an activity can start (ES)**

- It means the earliest time that each activity can start,
- The early start of the first activity in the project is equal to zero.
- The early start of any activity is equal to the early finish of the previous activity (EF)
- In case there is more than one early finish before any activity, we take the earliest finish with the longest time, because no activity can start before the completion of all previous activities associated with it.

• **The earliest time when an activity can finish (EF), EF = ES + D**

- It means the earliest possible time for that activity to end.
- The early end of any activity is equal to the early start of that activity plus the time required to complete that activity.

• **The latest time when an activity can start (LS), LS = LF – D**

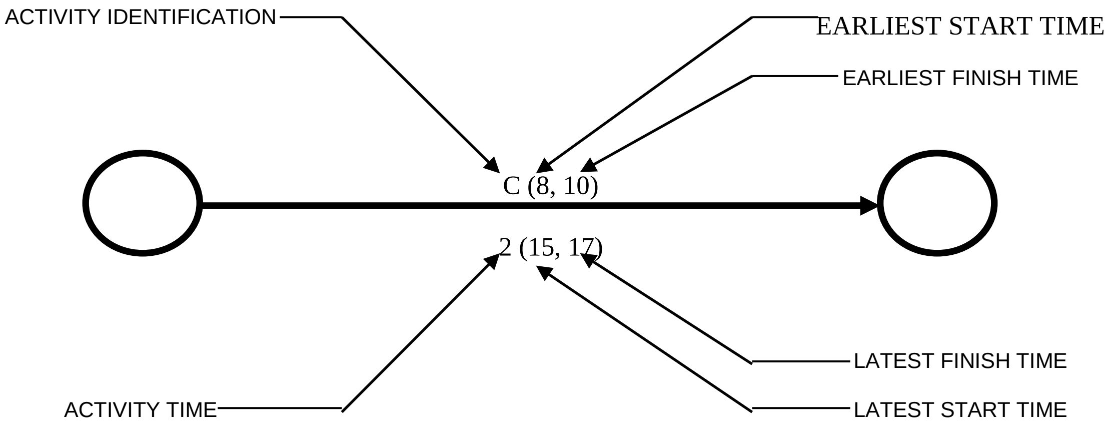
- It represents the maximum delay in the start time of an activity without delaying the project as a whole.
- The late start (LS) of any activity is equal to the late finish of the activity minus the completion time of the activity.

[13] Harold Kerzner. (2009). Op cit. P503.

• **The latest time when an activity can finish (LF)**

 It is the maximum delay in the end time of an activity without delaying the execution time of the project as a whole.
 The late finish of an activity is the same as the late start of the successor activity.
 In case there is more than one successor activity (more than one late start), we choose the activity with the shortest time (the least late start) to calculate the late finish of the current activity.
 The late finish (LF) of the last activity in the project is the same as its early finish (EF).
Figure 08 shows the earliest and latest times identified on the activity.

Figure 08: The Earliest and Latest Times Identified on the Activity

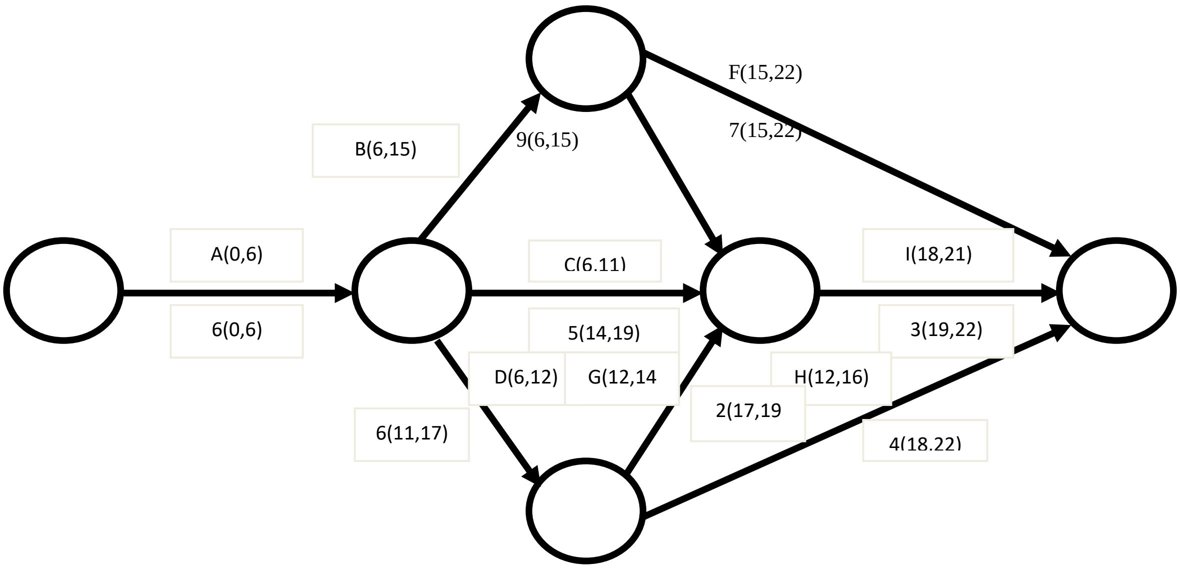


Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P506

To calculate[14] the earliest starting times, we must make a forward pass through the network (i.e., left to right). The earliest starting time of a successor activity is the latest of the earliest finish dates of the predecessors. The earliest finishing time is the total of the earliest starting time and the activity duration.
To calculate the latest times, we must make a backward pass through the network by calculating the latest finish time. Since the activity time is known, the latest starting time can be calculated by subtracting the activity time from the latest finishing time. The latest finishing time for an activity entering a node is the earliest starting time of the activities exiting the node.
Figure 09 shows the earliest and latest starting and finishing times for a typical network.

[14] Harold Kerzner.. (2009). Op cit. P506.

Figure 09: A typical PERT chart with slack times



Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P506

Example:

To illustrate the development of the project network using the Critical Path Method (CPM), the activity times are defined as in the following table:

Table 15 : Project activities times

Activity	Activity Description	Activity Time	Previous Activity
A	Building the interior parts	2	-
B	Determine the ceiling and floor	3	-
C	building a chimney	2	A
D	Concrete pouring and frame construction	4	A , B
E	Building an incinerator	4	C
F	Installation of a pollution monitoring device	3	C
G	Air purifier installation	5	D , E
H	Examination and Testing	2	F , G

Source: موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص 174

Required:

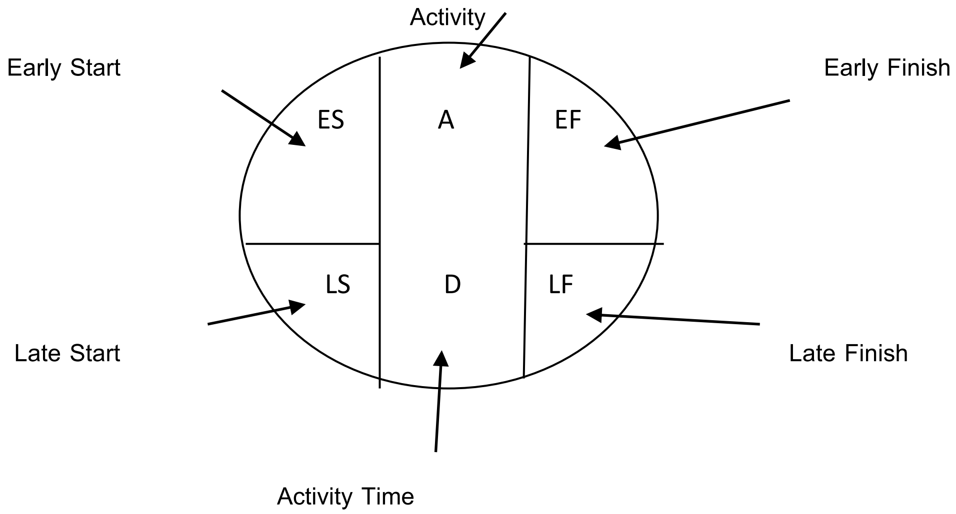
1. Draw the project network using the activity-on-Node (AON) method.
2. Determine the early start (ES) and early finish (EF) times for project activities.
3. Determine the late start (LS) and late finish (LF) times for project activities.

4. Determine the project's critical path (CP).

5. Determine the project's slack times (ST).

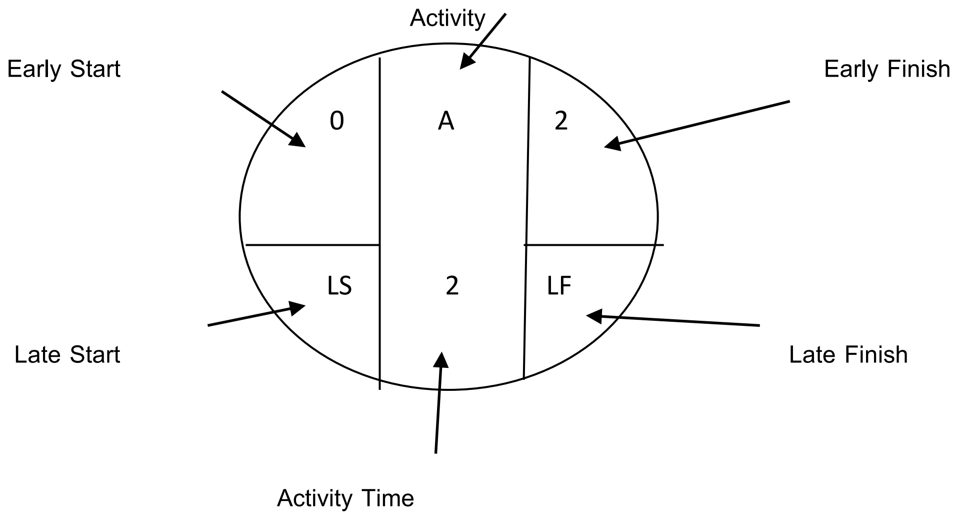
Solution:

2. Determine the: Early Start (ES), Early Finish (EF), Late Start (LS), Late Finish (LF) Explaining the details of the activity on node (AON) diagram



Early finish = Early start + Activity completion time	EF = ES + D
Late start = Late finish – Activity completion time	LS = LF – D
Slack time = Late start - Early start OR Slack time = Late finish - Early finish	ST = LS – ES OR ST = LF – EF

We illustrate this by drawing Activity A.



Early Start and Early Finish Times for Activity A:

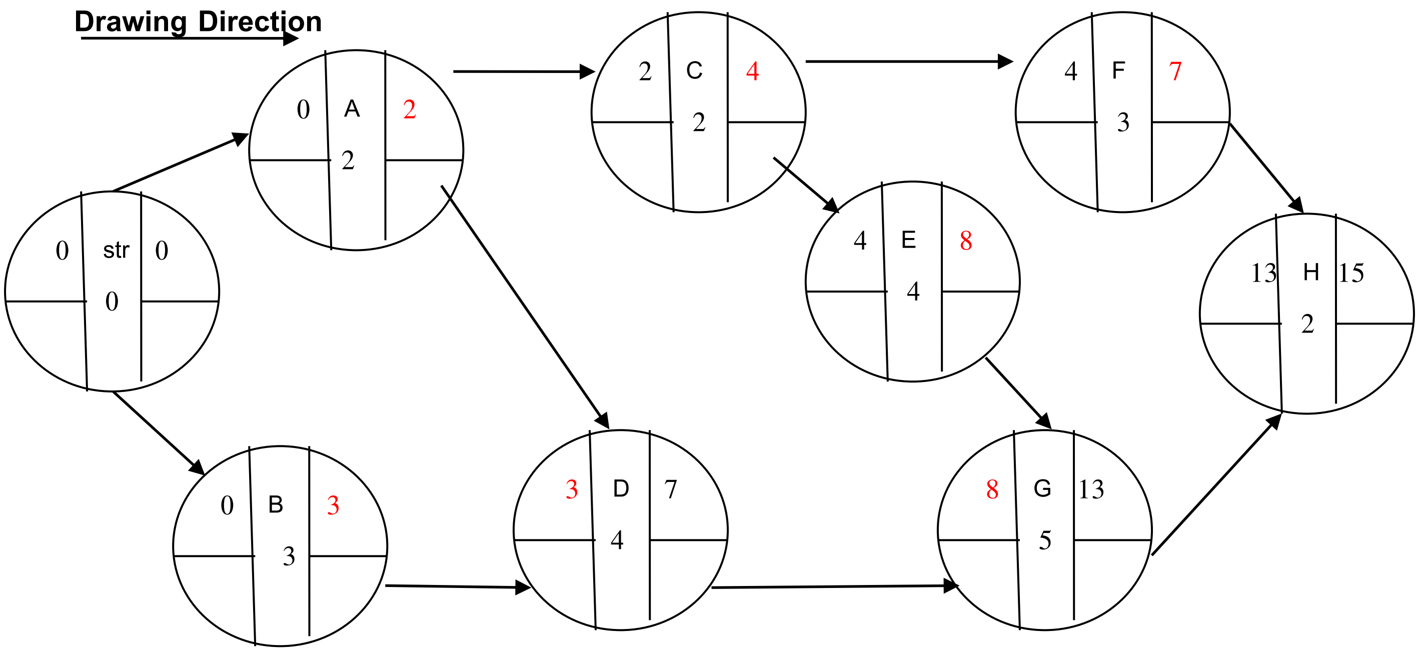
•The early start (ES) of activity A is the same as the early finish of the preceding activity (Start activity) and equals zero.

•The early finish (EF) of activity A is EF = ES + 2 = 0 + 2 = 2 weeks.

•Thus, determining the early starts (ES) and early finishes (EF) of project activities is illustrated as follows:

Draw a project network to illustrate the early starts (ES) and early finishes (EF) of project activities using the AON method.

Figure 10: Early Start (ES) and Early Finish (EF) Times Identified on the Activity

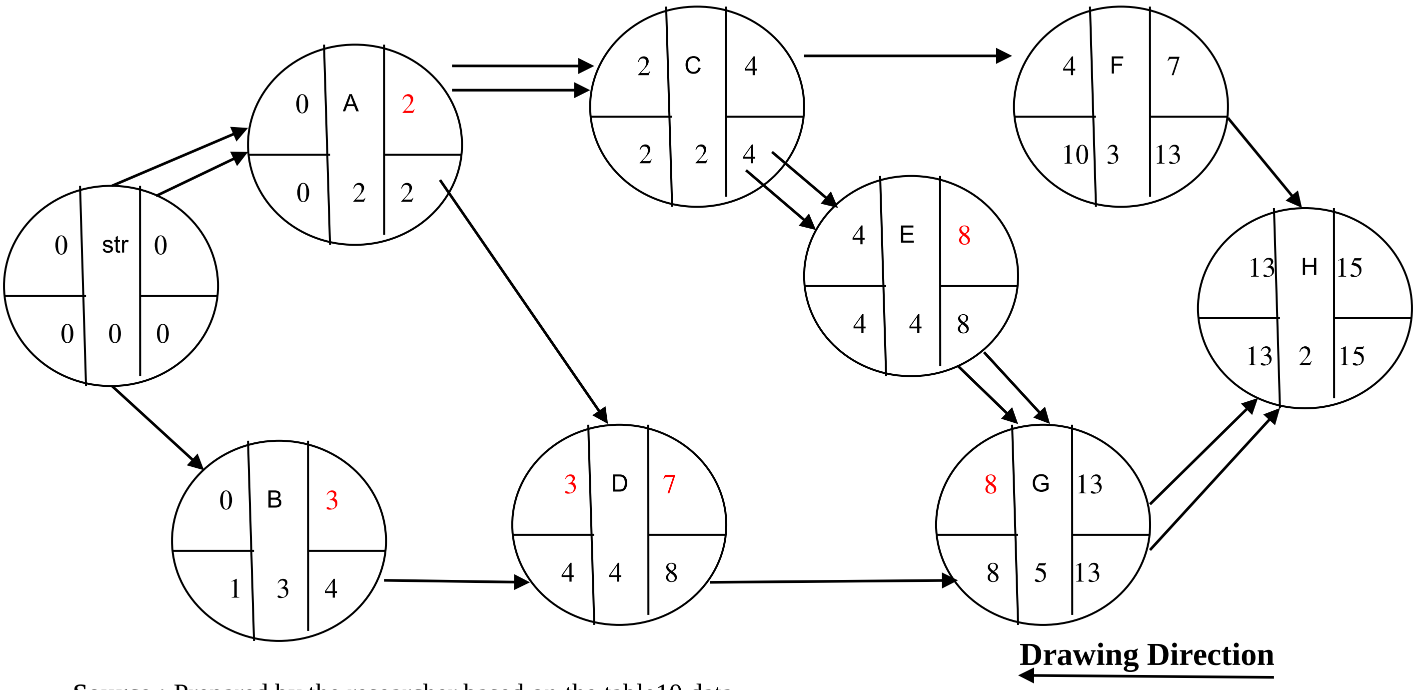


Source : Prepared by the researcher based on table10 data

3. Determine the late start (LS) and late finish (LF) times for project activities. Referring to the previous figure and the equations, we can plot the aforementioned times for project activities as shown in the following figure:

- Draw the project network by adding the early finish (EF) and late finish (LF) times for project activities using the AON method.

Figure 11: Late Start (LS) and Late Finish (LF) Times Identified on the Activity



Source : Prepared by the researcher based on the table10 data

Early finish for the first activity A and B = 0

If there is more than one early finish (previous), we take the earliest finish with the longest time.

Early finish = Early start + completion time.

Late finish = Late start for the subsequent activity.

If there is more than one late start (successor), we choose the later start with the shortest time.

Late start = Late finish – completion time.

4. Determine the Critical Path: To determine the critical path, you must first identify all possible paths in the project, as follows:

Path 1: Start + A + C + F + H = 0 + 2 + 2 + 3 + 2 = 9 weeks.

Path 2: Start + A + C + E + G + H = 0 + 2 + 2 + 4 + 5 + 2 = 15 weeks.

Path 3: Start + A + D + G + H = 0 + 2 + 4 + 5 + 2 = 13 weeks.

Path 4: Start + B + D + G + H = 0 + 3 + 4 + 5 + 2 = 14 weeks.

Then we choose the longest path, which is the second path: Start + A + C + E + G + H, which equals 15 weeks. To ensure that the critical path is correct, all activities on it must be critical and not stagnant (i.e., they do not have any excess time), as shown by the critical path line shown by the double arrows in the figure.

5. Determining Slack Time (ST): To determine slack time, you must first identify the stagnant activities, which are those activities that, if delayed, will not delay the project as a whole. These activities are shown in the table, and it is clear that the slack time equals 8 weeks.

The following table summarizes the results.

Table16: Project activities times

Activity	Time	Previous Activity	ES	EF	LS	LF	Nature of activity	ST
A	2	-	0	2	0	2	Critical.A	-
B	3	-	0	3	1	4	slack	1
C	2	A	2	4	2	4	Critical.A	-
D	4	A , B	3	7	4	8	slack	1
E	4	C	4	8	4	8	Critical.A	-
F	3	C	4	7	10	13	slack	6
G	5	D , E	8	13	8	13	Critical.A	-
H	2	F , G	13	15	13	15	Critical.A	-
						Total slack = 8 weeks		

Source: Prepared by the researcher based on the table10 data.

Exercise: The following table includes a set of sequential activities required to program a project.

Table17: Project activities times and costs

Activity	Previous activity	Activity time (week)	Crashing cost($)
A	-	6	60
B	-	4	60
C	A	5	50
D	B,C	3	85
E	B	6	90
F	D,E	8	80
G	F	4	40
H	G,E	3	55

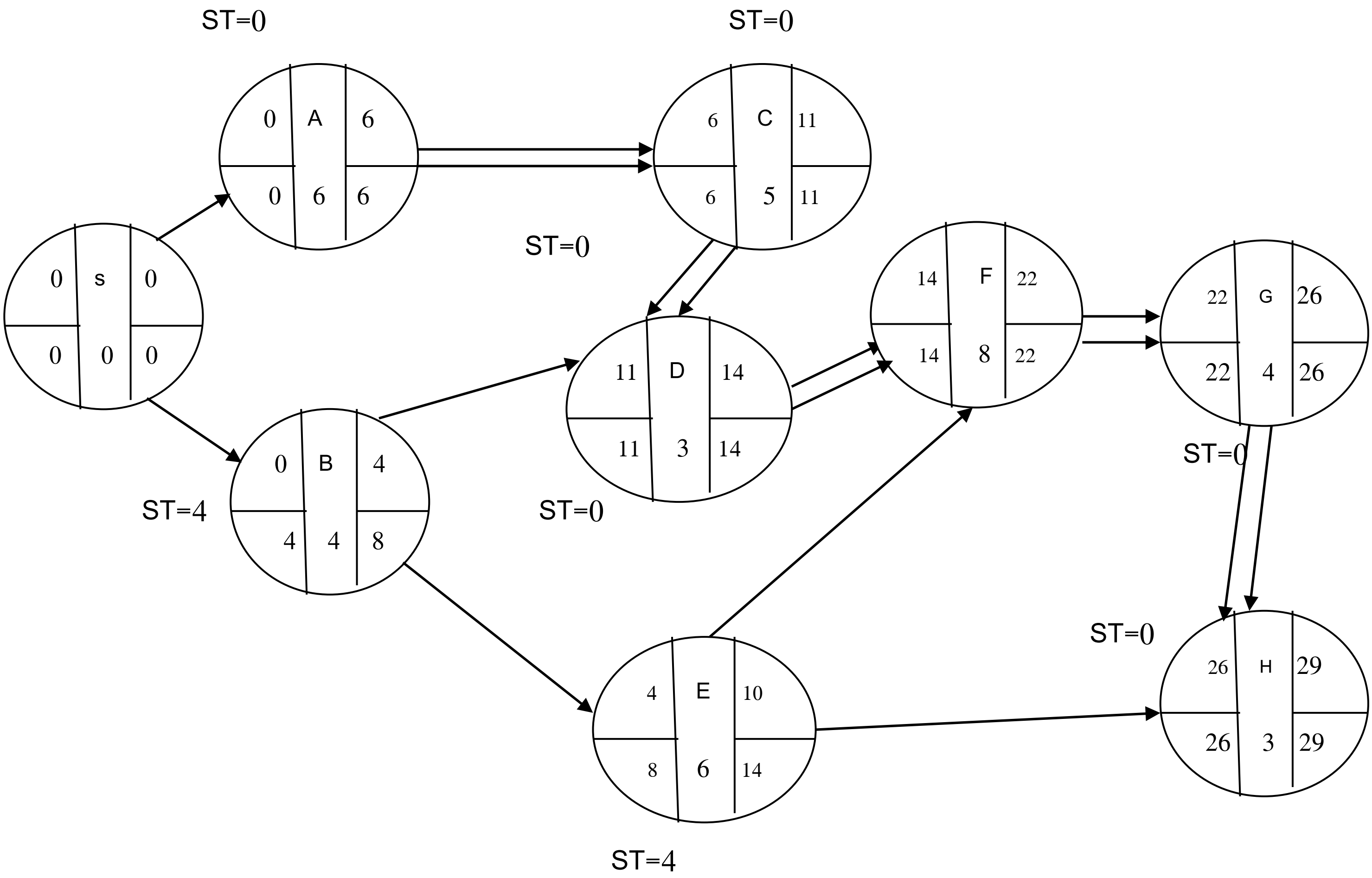
Source: Prepared by the researcher

Required: Draw the project network? Calculate the project's critical path? If you know that the cost of compressing the project activities is one week for each activity, - calculate the cost of crashing the project so that the new path becomes equal to 22 weeks, provided that the crashing of each activity does not exceed two weeks only?

Solution:

• **Network drawing:**

Figure 12: Network drawing



Source : Prepared by the researcher based on the table17 data

• **Path and Critical Path Calculation:**

Path1:S + A + C + D + F + G + H = 0 + 6 + 5 + 3 + 8 + 4 + 3 = 29 CP

Path2: S +B + D +F + G + H = 0 + 4 + 3 + 8 + 4 +3 = 22

Path3: S + B + E + F + G + H = 0 + 4 + 6 + 8 + 4 + 3 = 25

Path4: S + B + E + H = 0 + 4 + 6 + 3 = 13

• **Crashing cost calculation:**

$$\left.\begin{array}{l} 29 - 22 = 7 \\ 25 - 22 = 3 \\ 22 - 22 = 0 \end{array}\right\} = 10/2 = 5 \text{ (There are 5 crashing activities).}$$

Only five activities from the critical path (path 1) are crashed (considering it contains six activities).
The following table summarizes the results.

Table 18: Summary of results

Activity	Time/Week	Crashing Cost/$/Week	Crashed cost/$	Crashed Time/week
A	**6**	**60**	**120**	**4**
B	4	60	60	4
C	**5**	**50**	**100**	**3**
D	**3**	**85**	**85**	**3**
E	6	90	90	6
F	**8**	**80**	**160**	**6**
G	**4**	**40**	**80**	**2**
H	**3**	**55**	**110**	**1**
Total	**39**	**520**	**805**	**29**

Source : Prepared by the researcher based on previous data

4.3. Program Evaluation and Review Technique (PERT)[15]

PERT is a management planning and control tool. It can be considered as a road map for a particular program or project in which all of the major elements (events) have been completely identified, together with their corresponding interrelations. PERT charts are often constructed from back to front because, for many projects, the end date is fixed and the contractor has front-end flexibility. One of the purposes of constructing the PERT chart is to determine how much time is needed to complete the project.

4.3.1. Estimate Activity Time[16]

Determining the time elapsed between events requires the responsible functional managers to assess the situation and provide their best estimates. This depends on the amount of historical data available to them, and the more historical data available, the more reliable the estimate. In this case, functional managers should provide their estimates using three possible assumptions for completion:

• **Optimistic completion time.** This time assumes that everything will go according to plan and with minimal difficulties.

• **Pessimistic completion time.** This time assumes that everything will not go according to plan and maximum difficulties will develop.

• **Most likely completion time.** This is the time that, in the mind of the functional manager, would most often occur should this effort be reported over and over again.

The expected time between events can be found from the expression:

$$\text{ET} = \frac{a + 4\,m + b}{6}$$

Where:
ET = expected time,
a = most optimistic time,
b = most pessimistic time, and
m = most likely time.

As an example, if a = 3, b = 7, and m = 5 weeks, then the expected time, ET, would be 5 weeks. This value for ET would then be used as the activity time between two events in the construction of a PERT chart. This method for obtaining best estimates contains a large degree of uncertainty. If we change the variable times to a = 2, b = 12, and m = 4 weeks, then ET will still be 5 weeks. The latter case, however, has a much higher degree of uncertainty because of the wider spread between the optimistic and pessimistic times. Care must be taken in the evaluation of risks in the expected times.

[15] Harold Kerzner. (2009). Op cit. P498.
[16] Harold Kerzner. (2009). Ibid. Pp512-513.

4.3.2. Estimating Total Project Time[17]

In order to calculate the probability of completing the project on time, the variance (δ^2) and standard deviations (σ) of each activity must be known. This can be found from the expression:

- **Calculating the variance for the overall project time (δ^2)**

 By calculating the variance for each project activity.
 Adding the variances for only the critical activities (those on the critical path.(
 The sum of the variances on the critical path is the variance for the overall project.
 The variance is calculated according to the following equation **:**

$$\delta^2 = (\frac{b-a}{6})^2$$

- **Calculate the project standard deviation (σ):** using the following equation:

$$\sigma = \sqrt{\delta^2}$$

- **Calculate the standard value (Z) for the project:** according to the following equation:

$$Z = \frac{(X-\mu)}{\sigma} = \frac{(X-CP)}{\sigma}$$

Where:
μ or CP: is the project completion time on the critical path.
X: is the time we seek to complete the project.
σ: is the project's standard deviation.

- **We return to the probability table for the standard value:**

 In statistics, this is called the (Z) table.
 We extract the probability corresponding to the standard value that resulted in previous point. This is the percentage, i.e., the probability that we will complete the project at the time we seek (desired).

[17] Harold Kerzner. (2009). Ibid. P513.

Example: Here is the following data about a project's activities

Table 19 : Project Activities Data

Activity	Previous Activity	Optimistic time a (week)	Preferred time m (week)	Pessimistic time b (week)
A	-	1	2	3
B	-	2	4	6
C	A,B	1	4	7
D	C	1	2	9
E	B	1	2	3
F	D,E	3	4	11

Source: Prepared by the researcher

Required:
1. Draw the project network.
2. Calculate the critical path.
3. Calculate the project's standard deviation.
4. What is the probability that the project will finish one week late from the expected date?

Solution:
1. Expected time for each activity (for example, activity A):

$$ET_A = \frac{1+4*2+3}{6}=2$$

2. Draw the project network using the activity-on-node method, then calculate all paths and determine the critical path for the expected times (ET).
3. Calculate the variance for each activity (e.g., Activity A)

$$\delta^2 = (\frac{3-1}{6})^2=0{,}111$$

4. Calculate the variance for the project as a whole by collecting the variances for the activities on the critical path and the results are recorded in the table (20).
5. Calculate the standard deviation of the project using the following equation:

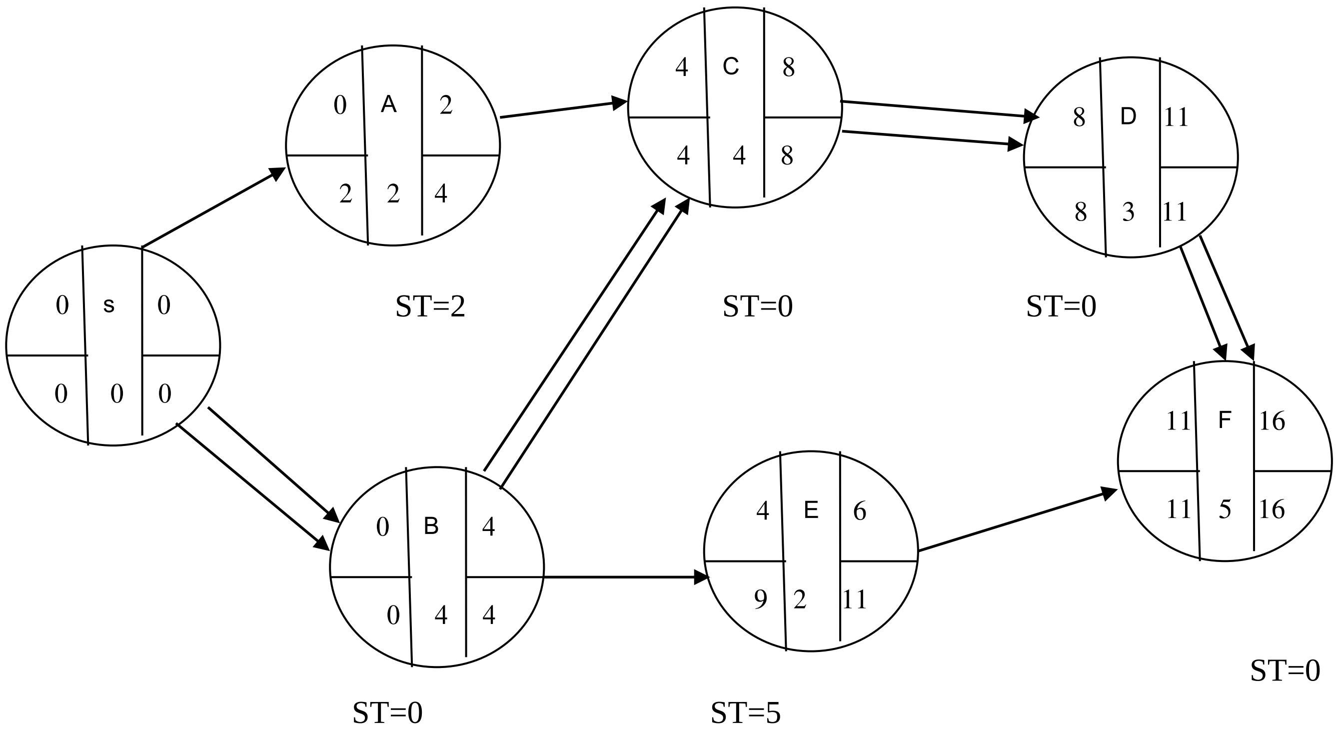
$$\sigma = \sqrt{4{,}998}=2{,}235$$

5. Calculate the Z-score for the project using the following equation:

$$Z = \frac{(17-16)}{2,235} = 0,447$$

Note: The value of CP is 16, resulting from the question. Because the requirement is the possibility of completing the project one week late from the expected date, then X = 17.
7. Back to the probability table for the standard value Z and the value Z = 0.447, we find that the probability of completing the project one week after its expected date is equal to 67%.
Network drawing:

Figure 13: Network drawing



Source : Prepared by the researcher based on the data of example.

Calculating all paths and the critical path:
Path 1: S + A + C + D + F = 0 + 2 + 4 + 3 + 5 = 14
Path 2: S + B + C + D + F = 0 + 4 + 4 + 3 + 5 = 16 CP (critical path)
Path 3: S + B + E + F = 0 + 4 + 2 + 5 = 11

Table 20: Summary of results

Activity	Previous Activity	Optimistic time a (week)	Preferred time m (week)	Pessimistic time b (week)	Expected Time ET (Week)	Variance δ^2	Project Variance as a whole **δ^2** (cp)
A	-	1	2	3	2	0.111	
B	-	2	4	6	4	0.444	0.444
C	A,B	1	4	7	4	1.00	1.000
D	C	1	2	9	3	1.777	1.777
E	B	1	2	3	2	0.111	
F	D,E	3	4	11	5	1.777	1.777
					المجموع		=4.998
					$\sigma = \sqrt{4,998}$=2,235		

Source: Prepared by the researcher

6. The Difference Between PERT and CPM[18]

The nomenclature between PERT and CPM is the same and both techniques are often referred to as arrow diagramming methods, or activity-on-arrow networks. The differences between them are:

• PERT uses three time estimates (optimistic, most likely, and pessimistic) to derive an expected time. CPM uses one time estimate that represents the normal time (i.e., better estimate accuracy with CPM).

• PERT is probabilistic in nature, based on a beta distribution for each activity time and a normal distribution for expected time duration. This allows us to calculate the “risk” in completing a project. CPM is based on a single time estimate and is deterministic in nature.

• Both PERT and CPM permit the use of dummy activities in order to develop the logic.

• PERT is used for R&D projects where the risks in calculating time durations have a high variability. CPM is used for construction projects that are resource dependent and based on accurate time estimates.

• PERT is used on those projects, such as R&D, where percent complete is almost impossible to determine except at completed milestones. CPM is used for those projects, such as construction, where percent complete can be determined with reasonable accuracy and customer billing can be accomplished based on percent complete.

[18] Harold Kerzner. (2009). Op cit. Pp499-500.

II. Schedule Analysis[19]

Introduction

There are three basic steps to analyzing the project schedule: review for validity, determine the project's end date using the critical path method, and adjust the schedule, if necessary. When reviewing the schedule for validity, ensure that all project tasks are included in the schedule. For each task, check that its duration estimate and dependencies are correct. For any tasks happening in the near future, confirm that resources are assigned and that those resources are available to do the work.

The next step in schedule analysis is to determine the project's end dates using the critical path method, which is the longest path through the network of the project's tasks. The critical path method calculates the earliest possible end date for all project tasks. Since the project can't be completed until all these tasks are done, the critical path is the shortest possible, or minimal, duration of the entire project. If the project's duration is too long for any reason, such as a client-dictated end date, look for ways to shorten the schedule. This is called schedule compression.

1. Schedule Compression[20]

If the project's end date is later than desired, you may need to compress the schedule. This is best done either as soon as the schedule is created or as the project progresses and dates adjust. The two most commonly used schedule compression techniques are crashing and fast tracking.

1.1.Crashing the Schedule

Crashing the schedule is only possible where additional resources will shorten the length of a task. Crashing involves making schedule and cost trade-offs, such as adding overtime hours for some or all of your employees to allow the work to be finished by the requested deadline or adding employees to the project that would help finish the work in a shorter amount of time. If either of these are possible solutions, then determine if the associated cost trade-off is acceptable.

1.2.Fast Track the Schedule

To fast track the schedule, make changes to when the work is performed. Look for tasks that are scheduled to start when other tasks finish. Is it possible to have the dependent task begin before its predecessor is finished? Are there any tasks occurring later in the project that could be moved sooner and performed in parallel with others? In other words, can you gain some schedule concurrency?

---

[19] Federal Acquisition Institute (FAI). (2015). Op cit P127.
[20] Federal Acquisition Institute (FAI). (2015). Ibid. P129.

2. Advices to Use Schedule Compression Techniques

Both crashing and fast tracking can increase the project's risk and should be planned and managed carefully. If neither of these techniques can shorten the duration of your project, you may want to examine the project's scope. Look for any potential work included in the project that is not required to meet the project goals.

Finally, investigate if there are resources with higher skill levels to do the work. This is only helpful if the increased skill translates to an ability to do the work faster due to increased costs of higher-skilled labor. If the work cannot be completed in a faster time that justifies the increased cost, then this is not a cost-effective alternative unless the due date is more critical than budget.

3. Project Crashing[21]

Is the process of shorting a project's duration while being prepared to bear the additional costs associated with this shorten. When implementing the Shorten process, the following points must be taken into account:

1. The project crashing process is evaluated and decided upon after subjecting it to the cost and benefit principle.

2. The decision to adopt the project crashing process is made in the presence of a set of compelling reasons, including:

 Project scheduling error: Project activities may have been set with overly optimistic execution times. When implementation begins, it becomes apparent that these activities are difficult to complete within the scheduled times, requiring additional costs to complete the project within the stated timeframe.

 The emergence of internal environmental conditions: leading to a delay in the implementation of some critical activities, the delay in which leads to a delay in the implementation of the project as a whole.

For example: employee absences, delayed arrival of critical resources, technical difficulties, lack of liquidity needed to implement some activities.

 External environmental conditions: may lead to delays in the implementation of some critical activities. For example, suppliers may delay the delivery of essential resources; climate conditions that disrupt project work, such as floods, snow, and hurricanes; or the occurrence of wars and social unrest, which may make the continuation of the project highly risky.

 Acceleration based on customer request: The customer is willing to offer a financial reward (bonus) for completing the project before its scheduled time, and this reward is compared with the additional cost resulting from the crashing process (cost and benefit).

---

[21] موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص 188.

 A change in government laws and regulations: This results in a change in the method of implementing the project, such that the project completion time is accelerated, while incurring additional costs resulting from that.

3. The crashing process begins primarily on the critical path, because it is the longest path, and any crashed of the project implementation time means shortening the critical path time, by crashing critical activities. We then look at the other paths and decide if they need to be crashed or the crashing process has no effect on those paths and they remain as they are.

Example: Assuming there are four paths for programming a project:
Path1 = 60 weeks (Critical Path)
Path2 = 50 weeks
Path3 = 45 weeks
Path4 = 40 weeks

 If we want to crash the project to be completed in 52 weeks, the crashing process takes place only on the critical path and not the other paths, because the critical path remains the longest path even after crashing.
 However, if we wanted to crash the project to 48 weeks, we would need to crash the critical path by 12 weeks, making the critical path 2 weeks shorter than the second path. Therefore, we would also need to crash the second path to 48 weeks, and the crashing cost would be the cost of crashing the critical path and the second path.
4. The crashed cost is calculated as follows: Calculate the crashing cost per unit of time according to the following equation:

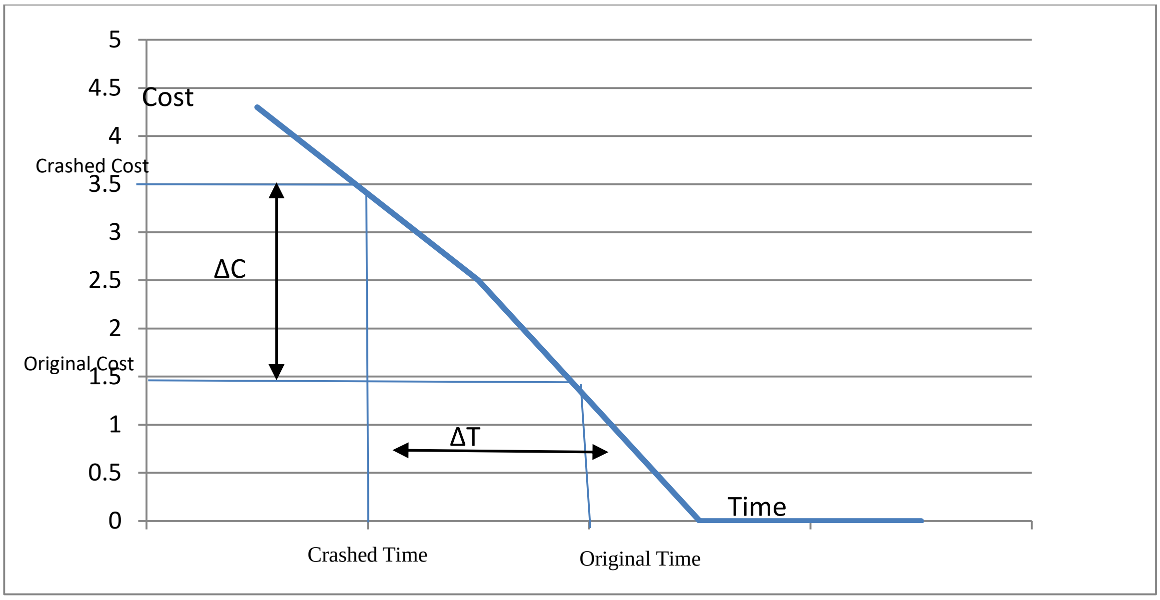
$$\text{Crashing Cost of one time unit } = \frac{\Delta C}{\Delta T}$$

Where:

ΔC = Crashed Cost – Original Cost.
ΔT = Original Time – Crashed Time.

This can be expressed graphically as follows:
The crashed cost per unit of time is multiplied by the number of time units (crashing time).

Figure 14: Project Crashing



Source :191 موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص

Example:
The data in the following table shows the times required to complete the eight project activities, with a compression (acceleration) cost of one week for each activity. The project has the following paths:
Path 1: = A + C + E + G + H = 34 weeks. (Critical Path (CP))
Path 2: = A + C + F + H = 20 weeks.
Path 3: = A + D + G + H = 24 weeks.
Path 4: = B + D + G + H = 21 weeks.

Table 21: Project activities data

Activity	Time/ Week	Crashing Cost/$/Week
A	6	1000
B	3	500
C	5	1500
D	4	1250
E	8	500
F	3	1000
G	8	1500
H	6	750

Source.192 موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص

Required: Calculate the cost of crashing the project, where the new path becomes 28 weeks, provided that the crashing time of any activity shall not exceed a period of two weeks only.

The solution:

 Since the new critical path time will be 28 weeks, this means that the original critical path time of 34 weeks will still be the critical path even after being crashed by six weeks, and therefore the crashing process will be done on the original critical path only.
 The time required for crashed is 6 weeks, with the crashing time for any activity not exceeding two weeks. Therefore, we move to the critical activity (which is on the critical path) with the lowest acceleration cost, which is activity (E), and crash it by two weeks at a cost of $1000 (500 x 2 (two weeks)), then we move to the next activity in terms of crashing cost, which is activity (H), and crash it by two weeks at a cost of $1500 (750 x 2 (two weeks)) for the two weeks. So far, we have crashed 4 weeks, with two weeks remaining. We move to activity (A), because it is the activity with the lowest crashing cost after activity H, and we accelerate it by two weeks as well at a cost of $2000 (1,000 x 2) for the two weeks. We have crashed the project by 6 weeks, with a total crashing cost equal to:
1000 + 1500 + 2000 = $4500.
Note: In the crashing process, the cost increases by the crashing value, but the time also decreases by the crashing value.

Table 22 : Summary of results

Activity	Time/Week	Crashing Cost/$/Week	Critical Path	Crashed cost/$	Crashed Time/week
A	**6**	**1000**	Yes	**2000**	**4**
B	3	500	No	500	3
C	5	1500	Yes	1500	5
D	4	1250	No	1250	4
E	**8**	**500**	Yes	**1000**	**6**
F	3	1000	No	1000	3
G	8	1500	Yes	1500	8
H	**6**	**750**	Yes	**1500**	**4**
Total	43	8000			
Total Crashing Cost				**4500$**	**14**
Total	43	8000		10250	37

Source: Prepared by the researcher

Chapter 04

Introduction

We noted in the previous chapter that project scheduling is the process of converting the project plan into a schedule for implementing all project activities from the start date to the completion date. Therefore, project budgeting is the process of estimating project costs by identifying the resources needed to implement all project activities, while estimating the expected cost of these resources at the time of their use. To develop a project budget, there are steps that must be followed to arrive at a more accurate budget:

• Predicting the resources needed to implement the project.
• Predicting when these resources will be needed.
• Predicting the cost of these resources at the time of their use.
• Predicting the potential risks that the project will face when acquiring these resources.

1. Definition of Project Budget[1]

Project budgeting is the process of estimating the cost of a project by identifying the resources needed to implement all project activities and estimating the expected cost of these resources at the time of their use, resulting in the estimated cost of the project, including all its activities and events from the moment of initiation to the moment of completion. (Project budgeting is the process of pricing the project plan).

2. Steps to develop a project budget to achieve accuracy

- Predicting the resources needed to implement the project.
- Predicting when we will need these resources.
- Predicting the cost of these resources at the time of their use.
- Predicting the impact of price inflation on these resources.
- Predicting the potential risks that the project will face while seeking to obtain these resources.

3. Budget Planning and Implementation[2]

As requirements are developed, the project manager must consider the budget life cycle and project funding priorities. Project costs are also estimated and become inputs for budget planning and programming. The project manager must continually monitor the budget, ensure that the project is within the approved budget, and forecast future budgets. It goes through the following stages:

[1] موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان، ص ص201.
[2] Federal Acquisition Institute (FAI). (2015). Op cit P47.

3.1. Resource Allocation Process

Planning, programming, budgeting, and implementation is a cyclical process consisting of four distinct but interrelated phases.

• Planning. Identifying strategic priorities and the capabilities required to achieve the strategy.

• Programming. Applying resources to programs and projects that provide the capabilities required to achieve the strategic priorities.

• Budgeting. Properly pricing programs, developing justifications, and an implementation plan.

• Implementation. Implementing and monitoring the spending of approved plans.

3.2. Feasibility Study[3]

The feasibility study is the intersection of requirements development and budgeting. The approval of the feasibility study is the formal start of the project and its financing. Initial funding for the project will likely be the minimum required to keep the project solvent until substantive funding amounts come in from future budget requests. In this case, a second (or revised) feasibility study may be needed to justify substantive funding amounts.

3.3. Budget and Timeline Planning

It is important to provide budget information in a timely manner to secure funding for programmes and projects and to be vigilant in communications regarding budget requests.

3.4. Budget Implementation[4]

• Budget authority. It is the funding of all requirements, or it is the authorization to allocate funds for approved tasks such as payroll, supplies, and other operating expenses for a specified period of time, a specified purpose, and a specified amount.

• Commitments. They are budgetary and accounting actions taken to authorize funds and reserves for future obligations in the current fiscal year. Essentially, a commitment is an appropriation of funds that will be used in the future to purchase goods or services. As pre-existing obligations, they are not legally binding and do not burden the Fund.

• Expenditure. Expenditure is the actual disbursement of funds in exchange for goods or services. It is often used interchangeably with the term “expenditure.” When obligations become payable based on a certified invoice, bond, or note, expenditures result in the actual disbursement of cash from treasury accounts. The administrative lag that occurs between the receipt of a legal billing action and the disbursement of cash must be managed and accounted for in financial transactions and timelines.

---

[3] Federal Acquisition Institute (FAI). (2015). Op cit. P49.

[4] Federal Acquisition Institute (FAI). (2015). Ibid. P51.

3.5. Project Budget Implementation[5]

The project manager and project team are responsible for ensuring the proper implementation of the project budget. Allocations are structured for a specific purpose, amount, and year. Some types of allocations are intended for use only in the year in which they are allocated. Other allocations are multi-year so that they can be obligated in the fiscal year in which they are first allocated and in additional years thereafter. At any given time, the project team can provide information for future budget requirements, implement and account for current budget authority to operate the project, and track multi-year funds over several years to ensure that they are being used appropriately and within the timeframe of use.

3.6. Cost Estimating[6]

As part of the budgeting process, the project manager is responsible for creating cost estimates which can be a challenging task for him. The project manager is encouraged to use all the resources available at his disposal to create accurate cost estimates.

Creating cost estimates is an iterative process, beginning with the highest levels of project information until it becomes more and more granular. Estimates may not be exact and are usually given in ranges showing the lowest and highest predictions. Ranges represent the PM's level of confidence in the cost estimating process and product. The smaller the range, the more confident the PM is with the estimate.

Estimates set the baseline expectations for the project. Estimates are used to determine how long the project is likely to take, how much it should cost, and the amount of resources needed.

3.6.1. Preliminary Estimate. The preliminary estimate is made during AoA of the concept and subsequent selection period, so little cost detail exists. The preliminary estimate is used to set the initial funding level of the project. Accuracy of the preliminary estimate can be as much as plus or minus fifty percent. A preliminary estimate may also be called a feasibility estimate or a rough order of magnitude (ROM).

3.6.2. Budget Estimate. The budget estimate is developed in the Concept Planning phase and may also be called a design, control, or appropriation estimate. More information is available about the concept, allowing for a basic budget. Accuracy of the budget estimate is roughly minus twenty to plus twenty-five percent.

3.6.3. Definitive Estimate. The definitive estimate is developed near the end of the Concept Planning phase. At this point, well-defined requirements and product specifications exist and are detailed in the work breakdown structure (WBS). Accuracy of the definitive estimate is plus or minus ten percent. The definitive estimate is used to create the project's cost baseline.

[5] Federal Acquisition Institute (FAI). (2015). Ibid. P53.
[6] Federal Acquisition Institute (FAI). (2015). Op cit. Pp57-58.

Potential costs included in estimates to consider are:
• Labor
• Equipment
• Materials
• Services
• Overhead
• Inflation
• Contingencies
• Risk

4. Methods of preparing the estimated budget[7]

Multiple techniques exist for estimating costs. Some of the most frequently used are**:**

4.1. Top-Down Estimates.

Estimates derived from looking at the entire project and basing the estimate on previous costs. Top-down estimates are less accurate than other forms of estimating. Top-down estimating is often used early in the project life-cycle when little information exists.

4.2. Bottom-Up Estimates. Estimates derived from examining costs for each item in the WBS. This approach is very detailed—it requires a detailed WBS and additional time to examine each WBS element.

4.3. Analogy. Comparison to one similar existing system; based on judgments. Little or no data exists, and the estimate is relatively quick, easy, and flexible. Analogy is frequently used in early project life-cycle phases. When generating an analogous cost estimate, examine a similar project and use actual information, not estimated or predicted information, from that project to predict the cost of like elements in another project. Another way of generating an analogous cost estimate is by using a large quantity of historical data and then basing the upcoming project's costs on those averages.

4.4. Parametric. Comparison to many similar existing systems, and based on statistical analysis. The PM determines primary cost drivers and establishes Cost Estimating Relationships (CERs). Parametric is used in early to mid-project life-cycle phases. When generating a parametric cost estimate, the estimator uses some of the parameters identified for an upcoming project as well as findings from market research to define known data points for the project. Relationships exist between these known data points. Costs are estimated by applying a mathematical equation to these relationships to scale them larger or smaller until they match the project's parameters. The exact equation varies depending on the relationship scaled to fit the project.

[7] Federal Acquisition Institute (FAI). (2015). Ibid. P58.

Chapter 05

Introduction

The major reason why many companies avoid changeover to a project management organizational structure is either fear or an inability to handle the resulting conflicts. Conflicts are a specific way in a project structure and can generally occur at any level in the organization, usually as a result of conflicting objectives.

1. Definition of Conflict[1]

Conflict is defined as an antagonistic state of opposition, disagreement or incompatibility between two or more parties. The conflicts happen as a result of interactions among interdependent people who perceive that their interests are incompatible, inconsistent or in tension; Lewis Coser, (1956), an American sociologist, defined conflict as the clash of values and interests, the tension between that is and what some groups feel ought to be.

2. Causes of Conflict[2]

Conflicts can be caused by differences in opinions, cultural background or customs, project objectives, political aspirations, or personal attitudes. Other factors that tend to cause conflicts are poor communications, weak management, competition for available resources, unclear objectives, and arguments over methods and procedures.

Conflict between organizations can often be traced back to loose contractual arrangements, sloppy or ambiguous documentation, and non-confirmation in writing of statements or instructions.

3. Ways to Deal with Conflict[3]

In many organizations the project manager continually seeks to solve crises evolving from conflicts, and delegates the day-to-day responsibility of running the project to the project team members.

The ability to handle conflicts requires an understanding of why they occur. Asking and answering these four questions may help handle and prevent conflicts.

- What are the project objectives and are they in conflict with other projects?
- Why do conflicts occur?
- How do we resolve conflicts?
- Is there any type of analysis that could identify possible conflicts before they occur?

3.1. Objectives[4]

Each project must have at least one objective. The objectives of the project must be made known to all project personnel and all managers, at every level of the organization. If this information is not communicated accurately, then it is entirely possible that upper-level managers, project managers, and functional managers may all have a different interpretation of the ultimate objective, a situation that invites conflicts.

---

[1] Abdul Fattah Farea Hussein, Yaser Hasan Salem Al-Mamary. (2019). Conflicts: Their Types , Their Negative And Positive Effects On Organizations. International Journal of Scientific & Technology Research. Volume 8, Issue 08, August 10-13. P10

[2] Albert Lester. (2014). Op cit. P393.

[3] Harold Kerzner. (2009). Op cit. P296.

[4] Harold Kerzner. (2009). Ibid. Pp296-298.

Project objectives must be:
• Specific, not general
• Not overly complex
• Measurable, tangible, and verifiable
• Realistic and attainable
• Consistent with resources available or anticipated
• Consistent with organizational plans, policies, and procedures

Some practitioners use the more simplistic approach of defining an objective by saying that the project's objective must follow the SMART rule, whereby:
• S specific
• M measurable
• A attainable
• R realistic or relevant
• T tangible or time bound

There always exists the question of whether the objective is attainable within time, cost, and performance constraints. It might be possible to achieve the initial objective, but at an incredibly high production cost, and in some cases many projects are directed and controlled using a management-by-objective (MBO) approach. The philosophy of management by objectives:
• Is proactive rather than reactive management
• Is results oriented, emphasizing accomplishment
• Focuses on change to improve individual and organizational effectiveness

3.2. The Conflict Environment

In the project environment, conflicts are inevitable, but conflicts and their resolution can be planned for. For example, conflicts can easily develop out of a situation where members of a group have a misunderstanding of each other's roles and responsibilities, and the resolution here is embedded in collaboration in which people must rely on one another. Without this, mistrust will prevail.

The most common types of conflicts involve:
• Manpower resources
• Equipment and facilities
• Capital expenditures
• Costs
• Technical opinions and trade-offs
• Priorities
• Administrative procedures
• Scheduling
• Responsibilities
• Personality clashes

Each of these conflicts can vary in relative intensity over the life cycle of a project. However, project managers believe that the most frequently occurring conflicts are over schedules but the potentially damaging conflicts can occur over personality clashes.

3.3. Dispute Resolution[5]

Although each project within the company may be inherently different, the company may wish to have the resulting conflicts resolved in the same manner. The four most common methods are:

1. The development of company-wide conflict resolution policies and procedures
2. The establishment of project conflict resolution procedures during the early planning activities
3. The use of hierarchical referral
4. The requirement of direct contact

• Many companies have attempted to develop company-wide policies and procedures for conflict resolution, but this method is often doomed to failure because each project and conflict is different. Furthermore, project managers, by virtue of their individuality, and sometimes differing of their authority and responsibility, prefer to resolve conflicts in their own fashion.

• Hierarchial referral for conflict resolution is the best method because neither the project manager nor the functional manager will dominate. Under this arrangement, the project and functional managers agree that for a proper balance to exist their common superior must resolve the conflict to protect the company's best interest. Unfortunately, this is not realistic because the common superior cannot be expected to continually resolve lower-level conflicts and it gives the impression that the functional and project managers cannot resolve their own problems.

• The last method is direct contact in which conflicting parties meet face-to-face and resolve their disagreement. Unfortunately, this method does not always work and, if continually stressed, can result in conditions where individuals will either suppress the identification of problems or develop new ones during confrontation.

Many conflicts can be either reduced or eliminated by constant communication of the project objectives to the team members.

4. Conflict Management and Dispute Resolution[6]

Conflict management covers a wide range of areas of disagreement from smoothing out a simple difference of opinion to settling a major industrial dispute.

Projects, as life in general, tend to have conflicts. Wherever there are a wide variety of individuals with different aspirations, attitudes, views, and opinions there is a possibility that what may start out as a misunderstanding escalates into a conflict. It is one of the functions of a project manager to sense where such a conflict may occur and, once it has developed, to resolve it as early as possible to prevent a full-blown confrontation that may end in a strike, mass resignations, or a complete stoppage of operations.

---

[5] Harold Kerzner. (2009). Op cit. P300.

[6] Albert Lester. (2014). Op cit. P393.

4.1. Conflict Resolution Procedures [7]

Good project managers realize that conflicts are inevitable, but that good procedures or techniques can help resolve them. Once a conflict occurs, the project manager must:

• Study the problem and collect all available information
• Develop a situational approach or methodology
• Set the appropriate atmosphere or climate If a confrontation meeting is necessary between conflicting parties.

The project manager should be aware of the logical steps and sequence of events that should be taken. These include:

• Setting the climate: establishing a willingness to participate
• Analyzing the images: how do you see yourself and others, and how do they see you?
• Collecting the information: getting feelings out in the open
• Defining the problem: defining and clarifying all positions
• Sharing the information: making the information available to all
• Setting the appropriate priorities: developing working sessions for setting priorities and timetables
• Organizing the group: forming cross-functional problem-solving groups
• Problem-solving: obtaining cross-functional involvement, securing commitments, and setting the priorities and timetable
• Developing the action plan: getting commitment
• Implementing the work: taking action on the plan
• Following up: obtaining feedback on the implementation for the action plan

4.2. Conflict Mitigation Measures [8]

The project manager or team leader should also understand conflict minimization procedures. These include:

• Pausing and thinking before reacting
• Building trust
• Trying to understand the conflict motives
• Keeping the meeting under control
• Listening to all involved parties
• Maintaining a give-and-take attitude
• Educating others tactfully on your views
• Being willing to say when you were wrong
• Not acting as a superman and leveling the discussion only once in a while

[7] Harold Kerzner. (2009). Op cit. P303.
[8] Harold Kerzner. (2009). Op cit. P304.

4.3. Characteristics of a Conflict Resolution Manager [9]

Whatever techniques are adopted in resolving disputes, the personality of the project manager or facilitator plays a major role. Patience, tact, politeness, and cool-headedness are essential irrespective of the strength or weakness of the technical case. Any agreement or decision made by a human being is to a large extent subjective, and human attributes (or even failings) such as honour, pride, status must be taken into account. It is good politics to allow the losing party to keep their self-respect and self-esteem. Team members may or may not like each other, but any such feelings must not be allowed to detract from the professionalism required to do their job.

In general, confrontation is preferable to withdrawal, but to follow such a course, project managers should practise the following:

• Be a role model and set an example to the team members in showing empathy with the conflicting parties.

• Keep an open door policy and encourage early discussion before it festers into a more serious issue.

• Hear people out and allow them to open up before making comments.

• Look for a hidden agenda and try to find out what is really going on as the conflict may have different (very often personal) roots.

4.4. Understanding Superior, Subordinate, and Functional Conflicts[10]

In order for the project manager to be effective, he must understand how to work with the various employees who interface with the project. These employees include upper-level management, subordinate project team members, and functional personnel. Quite often, the project manager must demonstrate an ability for continuous adaptability by creating a different working environment with each group of employees.

The type and intensity of conflicts can also vary with the type of employee, both conflict causes and sources are rated according to relative conflict intensity.

The specific mode that a project manager will use might easily depend on whom the conflict is with, this modes also will increase or decrease the potential conflict intensity. For example, although project managers consider, in general, that withdrawal is their least favorite mode, it can be used quite effectively with functional managers. In dealing with superiors, project managers would rather be ready for an immediate compromise than for face-to-face confrontation that could favor upper-level management.

[9] Albert Lester. (2014). Op cit. P395.
[10] Harold Kerzner. (2009). Op cit. P302.

5. Conflict Resolution Modes[11]

The management of conflicts places the project manager in the precarious situation of having to select a conflict resolution mode. Based upon the situation, the type of conflict, and whom the conflict is with, the most important modes:

5.1. Confronting (or Collaborating)

With this approach, the conflicting parties meet face-to-face and try to work through their disagreements. This approach should focus more on solving the problem. This approach is collaboration and integration where both parties need to win. This method should be used:
• When you and the conflicting party can both get at least what you wanted and maybe more
• To reduce cost
• To create a common power base
• To attack a common foe
• When skills are complementary
• When there is enough time
• When there is trust
• When you have confidence in the other person's ability
• When the ultimate objective is to learn

5.2. Compromising

To compromise is to bargain or to search for solutions until satisfaction prevails between the two parties. Compromising is often the result of confrontation. Some people argue that compromise is a "give and take" approach, which leads to a "win-win" position. Others argue that compromise is a "lose-lose" position, since neither party gets everything he/she wants or needs. Compromise should be used:
• When both parties need to be winners
• When you can't win
• When others are as strong as you are
• When you haven't time to win
• To maintain your relationship with your opponent
• When you are not sure you are right
• When stakes are moderate
• To avoid giving the impression of "fighting"

5.3. Smoothing (or Accommodating)

This approach is an attempt to reduce the emotions that exist in a conflict. This is accomplished by emphasizing areas of agreement and de-emphasizing areas of disagreement. Smoothing does not necessarily resolve a conflict, but tries to convince both parties to remain at the bargaining table because a solution is possible. In smoothing, one may sacrifice one's own goals in order to satisfy the needs of the other party. Smoothing should be used:
• To reach an overarching goal
• To create obligation for a trade-off at a later date

[11] Harold Kerzner. (2009). Ibid. Pp304-306.

• When the stakes are low
• When liability is limited
• To maintain harmony
• When any solution will be adequate
• To create goodwill (be magnanimous)
• When you'll lose anyway
• To gain time

5.4. Forcing (or Competing, Being Uncooperative, Being Assertive)

This is what happens when one party tries to impose the solution on the other party. Conflict resolution works best when resolution is achieved at the lowest possible levels. The higher up the conflict goes, the greater the tendency for the conflict to be forced, with the result being a "win-lose" situation in which one party wins at the expense of the other. Forcing should be used:

• When you are right
• When stakes are high
• When important principles are at stake
• When you are stronger (never start a battle you can't win)
• To gain status or to gain power
• When the relationship is unimportant
• When it's understood that a game is being played
• When a quick decision must be made

5.5. Avoiding (or Withdrawing)

Avoidance is often regarded as a temporary solution to a problem. The problem and the resulting conflict can come up again and again. Some people view avoiding as cowardice and an unwillingness to be responsive to a situation. Avoiding should be used:

• When you can't win
• When the stakes are low
• When the stakes are high, but you are not ready yet
• To gain time
• To unnerve your opponent
• To preserve neutrality or reputation
• When you think the problem will go away
• When you win by delay

6. Methods of Resolving Conflict Between Organizations [12]

Where the conflict is between two organizations and no agreement can be reached by either discussions or negotiations between the parties, it may be necessary to resort to one of the following five established methods of dispute resolution available to all parties to a contract. These, roughly in order of cost and speed, are:

- Conciliation
- Mediation
- Adjudication
- Arbitration
- Litigation

6.1. Conciliation

The main purpose of conciliation, which is not used very often in commercial disputes, is to establish communications between the parties so that negotiations can be resumed. Conciliators should not try to apportion blame, but to focus on the common interests of the parties and the systemic reasons for the breakdown of relationships.

6.2. Mediation

In mediation, the parties in dispute contact and engage a third party either directly or via the mediation service of one of the established professional institutions. Although the parties retain control over the final outcome, which is not enforceable, the mediator, who is impartial and often experienced in such disputes, has control over the proceedings and pace of the mediation process. The mediator must on no account show him/herself to be judgemental or give advice or opinions, even if requested to do so. His or her main function is to clarify and explore all the common interests and issues as well as possible options, which may lead to a mutually beneficial and acceptable settlement. Once an agreement has been reached, it must be recorded in writing.

6.3. Adjudication

Although adjudication has always been an option in resolving disputes, before 1996 it required the agreement of both parties. This also meant that both parties had to agree about who would be the adjudicator. As this in itself was often a source of disagreement, it was not a common method of dispute resolution until the 1996 Construction Act, more accurately called Housing Grants, Construction and Regeneration Act 1996, was passed. This Act allowed one party to apply to one of a number of registered institutions called the Adjudicator Nominating Body (ANB) to appoint an independent adjudicator. The other party is then obliged by law to accept both the adjudication process and the nominated adjudicator.

[12] Albert Lester. (2014). Op cit. Pp395-396.

6.4. Arbitration

Many contracts contain an arbitration clause, which, in the case of a dispute, requires the parties to either agree to the appointment of an arbitrator, or ask one of the recognized chartered institutions to appoint an independent arbitrator. The arbitrator asks for submissions from both parties (preferably in writing), and has the power to open up all the books and documents relating to the dispute, call witnesses, and seek expert opinions. In most cases both sides will be assisted by legal and technical advisers, which could generate considerable costs. Unlike an adjudicator, the arbitrator has the right to award all or part of the costs of the case against one or both of the parties as he sees fit. Generally there is a three-month time limit, but this can be extended by the arbitrator if necessary.

Chapter 06

I. Project Risks

Introduction

Project plans are "living documents" and are therefore subject to change. Changes are needed in order to prevent or rectify unfortunate situations.
These unfortunate situations can be called project risks.
Risk refers to those dangerous activities or factors that, if they occur, will increase the probability that the project's goals of time, cost, and performance will not be met. Many risks can be anticipated and controlled. Furthermore, risk management must be an integral part of project management throughout the entire life cycle of the project. Some common risks include:

- Poorly defined requirements
- Lack of qualified resources
- Lack of management support
- Poor estimating
- Inexperienced project manager

1. Definition of Risk[1]

Risk is a measure of the probability and consequence of not achieving a defined project goal. Most people agree that risk involves the notion of uncertainty. Can the product be produced within budgeted cost? Can the new product launch date be met? Aprobability measure can be used for such questions; for example, the probability of not meeting the new product introduction date is 0.15. However, when risk is considered, the consequences or damage associated with the event occurring must also be considered.
Goal A, with a probability of occurrence of only 0.05, may present a much more serious (risky) situation than goal B, with a probability of occurrence of 0.20, if the consequences of not meeting goal A are, in this case, more than four times more severe than the inability to meet goal B. Risk is not always easy to evaluate since the probability of occurrence and the consequence of occurrence are usually not directly measurable parameters and must be estimated by judgment, statistical, or other procedures.
Risk has two primary components for a given event:

- A probability of occurrence of that event
- Impact (or consequence) of the event occurring (amount at stake)

Figure 17–1 shows the components of risk.
Conceptually, the risk for each event can be defined as a function of probability and consequence (impact); that is, Risk f (probability, consequence)
In general, as either the probability or consequence increases, so does the risk. Both the probability and consequence must be considered in risk management.
A project risk[2] can also be defined as any event that prevents or limits the achievement of your objectives as defined at the outset of the project, and these objectives may be revised and changed as the project progresses through the project life-cycle.

[1] Harold Kerzner. (2009). Op cit. P742.
[2] Rory Burke. (2000) Project Management : planning and Control Techniques. Third Edition. John Wiley and Sons LTD. P230.

2. Risk identification tools[3]

Risk identification is an art. It requires the project manager to probe, penetrate, and analyze all data. Tools that can be used by the project manager include:
- Decision support systems
- Expected value measures
- Trend analysis/projections
- Independent reviews and audits

3. Risk Management Process Steps

Managing project risks is not as difficult as it may seem. There are six steps in the risk management process:
- Identification of the risk
- Quantifying the risk
- Prioritizing the risk
- Developing a strategy for managing the risk
- Project sponsor/executive review
- Taking action

4. Risk Analysis[4]

Suppose you have a choice between two projects, both of which require the same initial investment, have identical net present values, and require the same yearly cash inflows to break even. If the cash inflow of the first investment has a probability of occurrence of 95% and that of the second investment is 70%, then risk analysis would indicate that the first investment is better.

Risk analysis refers to the chance that the selection of this project will prove to be unacceptable. In capital budgeting, risk analysis is almost entirely based upon how well we can predict cash inflows since the initial investment is usually known with some degree of certainty. The inflows, of course, are based upon sales projections, taxes, cost of raw materials, labor rates, and general economic conditions.

Sensitivity analysis is a simple way of assessing risk. A common approach is to estimate NPV based upon an optimistic (best case) approach, most likely (expected) approach, and pessimistic (worst case) approach. Both Projects A and B require the same initial investment of $10,000, with a cost of capital of 10%, and with expected five-year annual cash inflows of $5,000/year. The range for Project A's NPV is substantially less than that of Project B, thus implying that Project A is less risky. Arisk lover might select Project B because of the potential reward of $27,908, whereas a risk avoider would select Project A, which offers perhaps no chance for loss.

[3] Harold Kerzner. (2009). Op cit. Pp603-604.
[4] Harold Kerzner. (2009). Ibid. P618.

5. Tailoring Considerations[5]

Because each project is unique, it is necessary to tailor the way Project Risk Management processes are applied. Considerations for tailoring include but are not limited to:

Project size. Does the project's size in terms of budget, duration, scope, or team size require a more detailed approach to risk management? Or is it small enough to justify a simplified risk process?

Project complexity. Is a robust risk approach demanded by high levels of innovation, new technology, commercial arrangements, interfaces, or external dependencies that increase project complexity? Or is the project simple enough that a reduced risk process will suffice?

Project importance. How strategically important is the project? Is the level of risk increased for this project because it aims to produce breakthrough opportunities, addresses significant blocks to organizational performance, or involves major product innovation?

Development approach. Is this a waterfall project, where risk processes can be followed sequentially and iteratively, or does the project follow an agile approach where risk is addressed at the start of each iteration as well as during its execution?

Tailoring of the Project Risk Management processes to meet these considerations is part of the Plan Risk Management process, and the outcomes of tailoring decisions are recorded in the risk management plan.

[5] Project Management Institute. A Guide To The Project Management Body Of Knowledge (PMBOK guide). Sixth Edition. Project Management Institute. 2017. P393.

II. Project Risks Management

Introduction

In the past, most project decisions took into account cost and schedule as information was available about them, in addition to technical risks. Technology forecasting was rarely done other than extrapolating past technical knowledge to the present. For projects with a duration of less than one year, it was usually assumed that the environment, especially the technological environment, is known and stable. For projects with a duration of more than one year, technology forecasting must be taken into account, due to continuous improvements in technology and the possibility of changing and uncertain environments. What are the risks?

The risk management process [6]should be designed to do more than just identify potential risks. The process must also include a formal planning activity, analysis to estimate the probability and predict the impact on the project of identified risks, a risk response strategy for selected risks, and the ability to monitor and control the progress in reducing these selected risks to the desired level.

If risk management is set up as a continuous, disciplined process of planning, identifying, analyzing, developing risk responses, and monitoring and controlling, then the system will easily supplement other processes such as planning, budgeting, cost control, quality, and scheduling. Surprises that become problems will be diminished because the emphasis will now be on proactive rather than reactive management. Risk management can be justified on almost all projects. The level of implementation can vary from project to project, depending on such factors as size, type of project, who the customer is, contractual requirements, relationship to the corporate strategic plan, and corporate culture.

Risk management is particularly important when the overall stakes are high and/or a great deal of uncertainty exists.

1. Definition of Risk Management

Risk management[7] is the act or practice of dealing with risk. It includes planning for risk, identifying risks, analyzing risks, developing risk response strategies, and monitoring and controlling risks to determine how they have changed.

Project Risk Management[8] is defined by the project management body of knowledge (PMBOK) as: "the processes concerned with identzfying, analysing and responding to uncertainty [throughout the project life-cycle]. It includes maximising the results of positive events and minimising the consequences of adverse events".

Risk management[9] is not a separate project office activity assigned to a risk management department but rather is one aspect of sound project management. Risk management should be closely coupled with key project processes, including: overall project management, systems engineering, configuration management, cost, design/engineering, earned value, manufacturing, quality, schedule, scope, and test. (Project management and systems

---

[6] Harold Kerzner. (2009). Op cit. P742.
[7] Harold Kerzner. (2009). Op cit. P742.
[8] Rory Burke. Project Management : planning and Control Techniques. Third Edition. John Wiley and Sons LTD. 2000. P230.
[9] Harold Kerzner. (2009). Op cit. p743.

engineering are typically the two top-level project processes. While risk management can be linked to either of these processes, it is typically associated with project management.)
Proper risk management is proactive rather than reactive, positive rather than negative, and seeks to increase the probability of project success.

2. Types of Decision Making: Certainty, Risk, and Uncertainty[10]

Decision-making falls into three categories: certainty, risk, and uncertainty. Decision-making under certainty is the easiest case to work with. With certainty, we assume that all of the necessary information is available to assist us in making the right decision, and we can predict the outcome with a high level of confidence.

2.1.Decision-Making under Certainty[11]

Decision-making under certainty implies that we know with 100 percent accuracy what the states of nature will be and what the expected payoffs will be for each state of nature. Mathematically, this can be shown with payoff matrices.
To construct a payoff matrix, we must identify (or select) the states of nature over which we have no control. We then select our own action to be taken for each of the states of nature. Our actions are called strategies. The elements in the payoff table are the outcomes for each strategy.
A payoff matrix based on decision-making under certainty has two controlling features.
● Regardless of which state of nature exists, there will be one strategy that will produce larger gains or smaller losses than any other strategy for all the states of nature.
● There are no probabilities assigned to each state of nature. (This could also be stated that each state of nature has an equal likelihood of occurring.)

Example: Consider a company wishing to invest $50 million to develop a new product. The company decides that the states of nature will be either a strong market demand, an even market demand, or a low market demand. The states of nature will be represented as N1 a strong (up) market, N2 an even market, and N3 a low market demand. The company also has narrowed their choices to one of three ways to develop the product: either A, B, or C. There also exists a strategy S4, not to develop the product at all, in which case there would be neither profit nor loss. We shall assume that the decision is made to develop the product. The payoff matrix for this example is shown in Table 23.

Table 23: Payoff Matrix (Profit in Millions)

Strategy	States of Nature		
	N1 = Up	N2 = Even	N3 = Low
S1 = A	50$	40$	-50$
S2 = B	50$	50$	60
S3 = C	100$	80$	90

Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P748.

[10] Harold Kerzner. (2009).ibid. P747.
[11] Harold Kerzner. (2009). Ibid. P747.

Looking for the controlling features in Table 23, we see that regardless of how the market reacts, strategy S3 will always yield larger profits than the other two strategies. The project manager will therefore always select strategy S3 in developing the new product. Strategy S3 is the best option to take.

Table 17–2 can also be represented in subscript notation. Let $P_{i,j}$ be the elements of the matrix, where P represents profit. The subscript i is the row (strategy), and j is the column (state of nature). For example, P2,3 the profit from choosing strategy 2 with N3 state of nature occurring. It should be noted that there is no restriction that the matrix be square, but at a minimum it will be a rectangle (i.e., the number of states of nature need not equal the number of possible strategies).

2.2.Decision-Making under Risk[12]

In most cases, there usually does not exist one strategy that dominates for all states of nature. In a realistic situation, higher profits are usually accompanied by higher risks and therefore higher probable losses. When there does not exist a dominant strategy, a probability must be assigned to the occurrence of each state of nature.

Risk can be viewed as outcomes (i.e., states of nature) that can be described within established confidence limits (i.e., probability distributions). These probability distributions should ideally be either estimated or defined from experimental data.

Consider Table 24 in which the payoffs for strategies 1 and 3 of Table 23 are interchanged for the state of nature N3.

From Table 24, it is obvious that there does not exist one dominant strategy. When this occurs, probabilities must be assigned to the possibility of each state of nature occurring. The best choice of strategy is, therefore, the strategy with the largest expected value, where the expected value is the summation of the payoff times and the probability of occurrence of the payoff for each state of nature. In mathematical formulation,

$$E_i = \sum_{j=1}^{N} P_{i,j} p_j$$

where Ei is the expected payoff for strategy i, Pi,j is the payoff element, and pj is the probability of each state of nature occurring. The expected value for strategy S1 is therefore

$$E_1 = (50)(0.25) + (40)(0.25) + (90)(0.50) = 67.50$$

Table 24: Payoff Table (Profit in Millions)

Strategy	States of Nature		
	N1	N2	N3
	0.25	0.25	0.50
S1	50	40	90
S2	50	50	60
S3	100	80	-50

Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P748.

[12] Harold Kerzner. (2009). Op cit. P748-749.

Repeating the procedure for strategies 2 and 3, we find that E_2 =55, and E_3 = 20. Therefore, based on the expected value, the project manager should always select strategy S_1. If two strategies of equal value occur, the decision should include other potential considerations (e.g., frequency of occurrence, resource availability, time to impact). (Note: Expected value calculations require that a risk neutral utility relationship exists. If the decision- maker is not risk neutral, such calculations may or may not be useful, and the results should be evaluated to see how they are affected by differences in risk tolerance.)

To quantify potential payoffs, we must identify the strategy we are willing to take, the expected outcome (element of the payoff table), and the probability that the outcome will occur. In the previous example, we should accept the risk associated with strategy S_1 since it gives us the greatest expected value (all else held constant). If the expected value is positive, then this strategy should be considered. If the expected value is negative, then this strategy should be proactively managed.

An important factor in decision-making under risk is the assigning of the probabilities for each of the states of nature. If the probabilities are erroneously assigned, different expected values will result, thus giving us a different perception of the best strategy to take. Suppose in Table 24 that the assigned probabilities of the three states of nature are 0.6, 0.2, and 0.2. The respective expected values are:

$$E_1 = 56$$
$$E_2 = 52$$
$$E_3 = 66$$

In this case, the project manager would always choose strategy S3 (all else held constant).

2.3.Decision-Making under Uncertainty[13]

The difference between risk and uncertainty is that under risk there are assigned specific probabilities, and under uncertainty meaningful assignments of specific probabilities are not possible. As with decisionmaking under risk, uncertainty also implies that there may exist no single dominant strategy. The decision-maker, however, does have at his disposal four basic criteria from which to make a management decision. The use of each criteria will depend on the type of project as well as the project manager’s tolerance to risk. **The first criterion is the Hurwicz criterion**, often referred to as **the maximax criterion**. (This criteria was developed by Nobel Economics Laureate Leonid Hurwicz.) Under the Hurwicz criterion, the decision-maker is always optimistic and attempts to maximize profits by a go-for-broke strategy. This result can be seen from the example in Table 24. The maximax criterion says that the decision-maker will always choose strategy S_3 because the maximum profit is 100. However, if the state of nature were N_3, then strategy S_3 would result in a maximum loss instead of a maximum gain. The use of the maximax, or Hurwicz criterion, must then be based on how big a risk can be undertaken and how much one can afford to lose. A large corporation with strong assets may use the Hurwicz criterion, whereas the small private company might be more interested in minimizing the possible losses.

[13] Harold Kerzner. (2009). Op cit. Pp749-751.

A small company may be more apt to use **the Wald, or maximin criterion**, where the decision-maker is concerned with how much he can afford to lose. In this criteria, a pessimistic rather than optimistic position is taken with the viewpoint of minimizing the maximum loss.

In determining the Hurwicz criterion, we looked at only the maximum payoffs for each strategy in Table 24. For the Wald criterion, we consider only the minimum payoffs. The minimum payoffs are 40, 50, and 50 for strategies S_1, S_2, and S_3, respectively. Because the project manager wishes to minimize his maximum loss, he will always select strategy S_2 in this case. If all three minimum payoffs were negative, the project manager would select the smallest loss if these were the only options available. Depending on a company's financial position, there are situations where the project would not be undertaken if all three minimum payoffs were negative.

The third criterion is the Savage, or **minimax criterion**. Under this criterion, we assume that the project manager is a sore loser. To minimize the regrets of the sore loser, the project manager attempts to minimize the maximum regret; that is, the minimax criterion.

Table 25: Regret Table

Strategy	States of Nature			Maximum Regrets
	N1 = Up	N2 = Even	N3 = Low	
S1	50	40	0	50
S2	50	30	30	50
S3	0	0	140	140

Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P750.

The first step in the Savage criterion is to set up a regret table by subtracting all elements in each column from the largest element. Applying this approach to Table 24, we obtain Table 25.

The regrets are obtained for each column by subtracting each element in a given column from the largest column element. The maximum regret is the largest regret for each strategy, that is, in each row. In other words, if the project manager selects strategy S_1 or S_2, he will only be sorry for a loss of 50. However, depending on the state of nature, a selection of strategy S_3 may result in a regret of 140. The Savage criterion would select either strategy S_1 or S_2 in this example.

The fourth criterion is the Laplace criterion. The Laplace criterion is an attempt to transform decision-making under uncertainty to decision-making under risk. Recall that the difference between risk and uncertainty is a knowledge of the probability of occurrence of each state of nature. The Laplace criterion makes an a priori assumption based on Bayesian statistics: If the probabilities of each state of nature are not known, then we can assume that each state of nature has an equal likelihood of occurrence. The procedure then follows decision-making under risk, where the strategy with the maximum expected value is selected. Using the Laplace criterion applied to Table 24, and thus assuming that $P_1 = P_2 = P_3 = 1/3$, we obtain Table 26. The Laplace criterion would select strategy S_1 in this example.

Table 26: Laplace Criterion

Strategy	Expected Value
S1	60
S2	53.3
S3	43.3

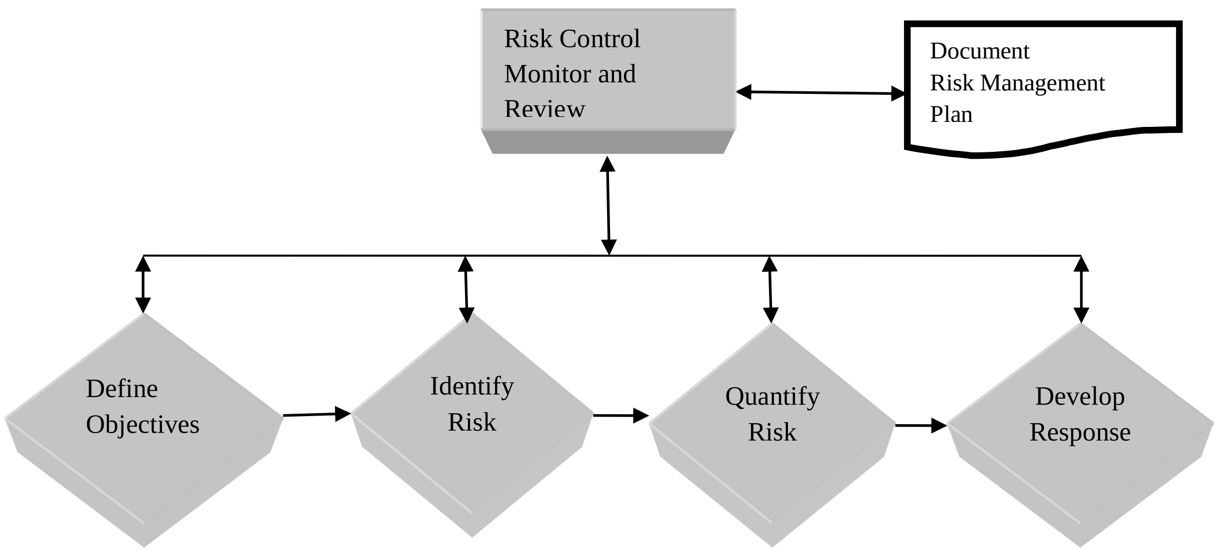
Source: Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York. P751.

The important conclusion to be drawn from decision-making under uncertainty is the risk that the project manager wishes to incur. For the four criteria previously mentioned, any strategy can be chosen depending on how much money we can afford to lose and what risks we are willing to take.

3. Risk Management Process[14]

It is important that a risk management strategy be established early in a project and that risk be continually addressed throughout the project life cycle. Risk management includes several related actions, including risk: planning, identification, analysis, response (handling), and monitoring and control. The generally accepted risk management model sub-divides the risk management process into the following elements (see figure 15):

Figure 15: Risk Management Model



Source: Rory Burke. Project Management : planning and Control Techniques. Third Edition. John Wiley and Sons LTD. P230.

[14] Harold Kerzner. (2009). Op cit. P753.

3.1. Plan Risk Management: The process of developing and documenting an organized, comprehensive, and interactive strategy and methods for identifying and analyzing risks, developing risk response plans, and monitoring and controlling how risks have changed.

- **Define Objectives[15]:** define the context of your work and your plan for success. This defines what you have to achieve to be successful and establishes a basis for dealing with risk and future decisions.

- **Identify Risks[16]:** Identify Risks is the process of identifying individual project risks as well as sources of overall project risk, and documenting their characteristics. The key benefit of this process is the documentation of existing individual project risks and the sources of overall project risk. It also brings together information so the project team can respond appropriately to identified risks. This process is performed throughout the project.

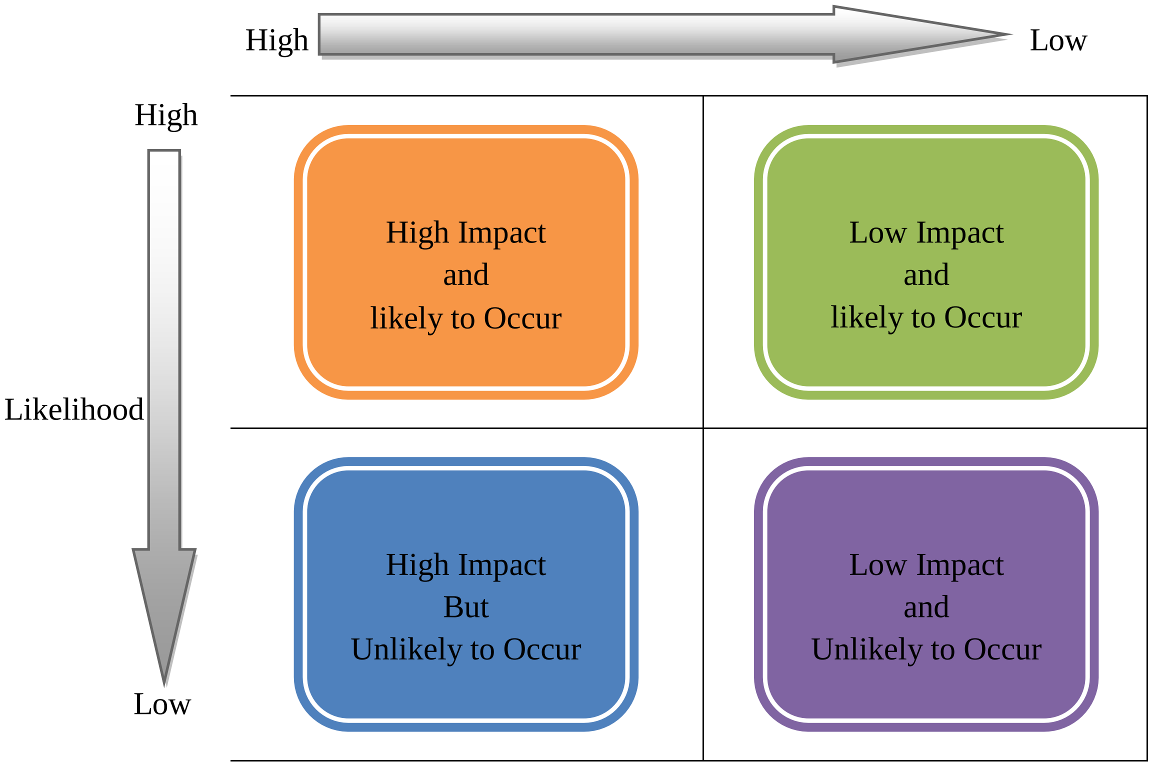
- **Quantify Risk[17]:** evaluate and prioritize the level of risk and uncertainty and quantify frequency of occurrence and impact.

3.2.Risk Evaluation[18]

After the potential risks have been identified, the project team then evaluates each risk based on the probability that a risk event will occur and the potential loss associated with it. Not all risks are equal. Some risk events are more likely to happen than others, and the cost of a risk can vary greatly. Having criteria to determine high-impact risks can help narrow the focus on a few critical risks that require mitigation. For example, suppose high-impact risks are those that could increase the project costs by 5% of the conceptual budget or 2% of the detailed budget. Only a few potential risk events meet these criteria. These are the critical few potential risk events that the project management team should focus on when developing a project risk mitigation or management plan. Risk evaluation is about developing an understanding of which potential risks have the greatest pos-sibility of occurring and can have the greatest negative impact on the project (Figure 16: Risk and Impact).

[15] Rory Burke.(2000). op cit P230.
[16] Project Management Institute. (2017). Op cit P400.
[17] Rory Burke. (2000). Op cit P231.
[18] Adrienne Watt. Project Management. The Open University Of Hong Kong. 2016. P221.

Figure 16: Risk and Impact



Source: Adrienne Watt. Project Management. The Open University Of Hong Kong. 2016. P222.

There is a positive correlation—both increase or decrease together—between project risk and project complexity. A project with new and emerging technology will have a high-complexity rating and a correspondingly high risk. The project management team will assign the appropriate resources to the technology managers to ensure the accomplishment of project goals. The more complex the technology, the more resources the technology manager typically needs to meet project goals, and each of those resources could face unexpected problems.

Risk evaluation often occurs in a workshop setting. Building on the identification of the risks, each risk event is analyzed to determine the likelihood of occurrence and the potential cost if it did occur. The likelihood and impact are both rated as high, medium, or low. A risk mitigation plan addresses the items that have high ratings on both factors—likelihood and impact.

• **Perform Risk Analysis**[19]**:** The process of examining each identified risk to estimate the probability and predict the impact on the project. It includes both qualitative risk analysis and quantitative risk analysis.

[19] Harold Kerzner. (2009). Op cit. P753.

 Perform Qualitative Risk Analysis[20]
Perform Qualitative Risk Analysis is the process of prioritizing individual project risks for further analysis or action by assessing their probability of occurrence and impact as well as other characteristics. The key benefit of this process is that it focuses efforts on highpriority risks. This process is performed throughout the project.
 Perform Quantitative Risk Analysis[21]
Perform Quantitative Risk Analysis is the process of numerically analyzing the combined effect of identified individual project risks and other sources of uncertainty on overall project objectives. The key benefit of this process is that it quantifies overall project risk exposure, and it can also provide additional quantitative risk information to support risk response planning.

• **Plan Risk Response[22]:** The process that identifies, evaluates, selects, and implements one or more strategies in order to set risk at acceptable levels given program constraints and objectives. This includes the specifics on what should be done, when it should be accomplished, who is responsible, and associated cost and schedule. A risk or opportunity response strategy is composed of an option and implementation approach. Response options for risks include acceptance, avoidance, mitigation (also known as control), and transfer. Response options for opportunities include acceptance, enhance, exploit, and share. The most desirable response option is selected, and a specific implementation approach is then developed for this option.

• **Document[23]:** the risk management plan documents how you propose to tackle risk on your project.

• **Monitor and Control Risks[24]:** The process that systematically tracks and evaluates the performance of risk response actions against established metrics throughout the acquisition process and provides inputs to updating risk response strategies, as appropriate.

4. Ways To Deal With Risks[25]

- **Avoid:** The best thing you can do with a risk is avoid it. If you can prevent it from happening, it definitely won't hurt your project. The easiest way to avoid this risk is to walk away from the cliff, but that may not be an option on this project.

- **Mitigate:** If you can't avoid the risk, you can mitigate it. This means taking some sort of action that will cause it to do as little damage to your project as possible.

[20] Project Management Institute. (2017). Op cit P410.
[21] Project Management Institute. (2017). Op cit P417.
[22] Harold Kerzner. (2009). Op cit. P753.
[23] Rory Burke. (2000). Op cit Pp230-231.
[24] Harold Kerzner. (2009). Op cit. P753.
[25] Adrienne Watt. (2016). Op cit. P219.

- **Transfer:** One effective way to deal with a risk is to pay someone else to accept it for you. The most common way to do this is to buy insurance.
- **Accept:** When you can't avoid, mitigate, or transfer a risk, then you have to accept it. But even when you accept a risk, at least you've looked at the alternatives and you know what will happen if it occurs. If you can't avoid the risk, and there's nothing you can do to reduce its impact, then accepting it is your only choice.

By the time a risk actually occurs on your project, it's too late to do anything about it. That's why you need to plan for risks from the beginning and keep coming back to do more planning throughout the project.

The risk management plan tells you how you're going to handle risk in your project. It documents how you'll assess risk, who is responsible for doing it, and how often you'll do risk planning (since you'll have to meet about risk planning with your team throughout the project).

Some risks are technical, like a component that might turn out to be difficult to use. Others are external, like changes in the market or even problems with the weather. It's important to come up with guidelines to help you figure out how big a risk's potential impact could be. The impact tells you how much damage the risk would cause to your project. Many projects classify impact on a scale from minimal to severe, or from very low to very high. Your risk management plan should give you a scale to help figure out the probability of the risk. Some risks are very likely; others aren't.

5. Project Risks During Its Life Cycle[26]

Project risk is dealt with in different ways depending on the phase of the project.

- **Initiation**

Risk is associated with things that are unknown. More things are unknown at the beginning of a project, but risk must be considered in the initiation phase and weighed against the potential benefit of the project's success in order to decide if the project should be chosen.

- **Planning Phase**

Once the project is approved and it moves into the planning stage, risks are identified with each major group of activities. A risk breakdown structure (RBS) can be used to identify increasing levels of detailed risk analysis.

- **Implementation Phase**

As the project progresses and more information becomes available to the project team, the total risk on the project typically reduces, as activities are performed without loss. The risk plan needs to be updated with new information and risks checked off that are related to activities that have been performed.

Understanding where the risks occur on the project is important information for managing the contingency budget and managing cash reserves. Most organizations develop a plan for

[26] Adrienne Watt. (2016). Op cit Pp226-229.

financing the project from existing organizational resources, including financing the project through a variety of financial instruments. In most cases, there is a cost to the organization to keep these funds available to the project, including the contingency budget. As the risks decrease over the length of the project, if the contingency is not used, then the funds set aside by the organization can be used for other purposes.

To determine the amount of contingency that can be released, the project team will conduct another risk evaluation and determine the amount of risk remaining on the project. If the risk profile is lower, the project team may release contingency funds back to the parent organization. If additional risks are uncovered, a new mitigation plan is developed including the possible addition of contingency funds.

- **Closeout Phase**

During the closeout phase, agreements for risk sharing and risk transfer need to be concluded and the risk breakdown structure examined to be sure all the risk events have been avoided or mitigated. The final estimate of loss due to risk can be made and recorded as part of the project documentation. If a Monte Carlo simulation was done, the result can be compared to the predicted result.

References

References

1. Abdul Fattah Farea Hussein, Yaser Hasan Salem Al-Mamary. (2019). Conflicts: Their Types , Their Negative And Positive Effects On Organizations. International Journal of Scientific & Technology Research. Volume 8, Issue 08, August 10-13.

2. Adrienne Watt. Project Management. The Open University Of Hong Kong. 2016.

3. Albert Lester. Project Management, Planning, and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards. Sixth Edition. 2014. Elsevier Publisher, Oxford, UK.

4. Crispin George. (2020). An Understanding of the Different Selection Models used to Select Projects in an Organization. International Journal of Innovative Science and Research Technology. Volume 5, Issue 3, March – 2020.

5. Department for Business Innovation & Skills (BIS). (2010). Guidelines for Managing Projects :How to organize, plan, and control projects, November.

6. Harold Kerzner. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Tenth Edition. John Wiley & Sons, Inc. (2009). New York.

7. Megh Bahadur KC . (2020). Project definition, Lifecycle and role of Project Managers. Research Gate.

8. Project Management Institute. A Guide to the Project Management Body of Knowledge (PMBOK III ® Guide). Fifth Edition. 2013.

9. Project Management Institute. A Guide To The Project Management Body Of Knowledge (PMBOK guide). Sixth Edition. Project Management Institute. 2017.

10. Riaz S.S. Ahamed. Project Planning: An Analysis, International Journal of Engineering Science and Technology. Vol.2(1), 2010,18-29 .

11. Rory Burke. (2000) Project Management : planning and Control Techniques. Third Edition. John Wiley and Sons LTD.

13. Ulusoy. G, Hazır. Ö. (2021). Planning and Network Modeling of Projects. Springer Nature Switzerland AG, Springer Texts in Business and Economics.

14. Xia Qin, Project Management and Project Action Plan, Dialogue on innovative Higher Education Strategies, https://www.lpmu.upj.ac.id › userfiles › files ›.12/08/2024. 19 :18.

15. عبد الستار محمد العلي، إدارة المشروعات العامة، دار المسيرة، عمان، الأردن.

16. موسى أحمد خير الدين، 2014، إدارة المشاريع المعاصرة، دار وائل للنشر، الطبعة الثانية، عمان.

Appendices

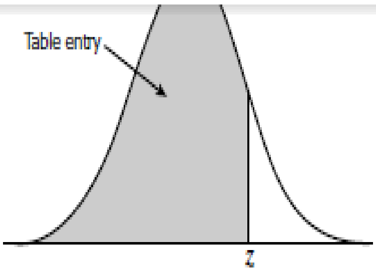


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995

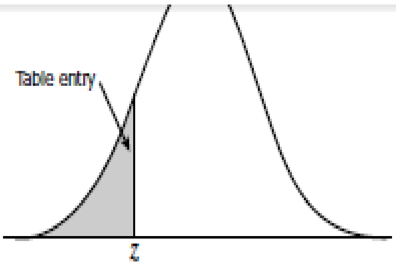


Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

$PVIF_{r,n}$

%11	%10	%9	%8	%7	%6	%5	%4	%3	%2	%1	r ← / n ↓
0.901	0.909	0.917	0.926	0.935	0.943	0.952	0.962	0.971	0.980	0.990	1
0.812	0.826	0.842	0.857	0.873	0.890	0.907	0.925	0.943	0.961	0.980	2
0.731	0.751	0.772	0.794	0.816	0.840	0.864	0.889	0.915	0.942	0.971	3
0.659	0.683	0.708	0.735	0.763	0.792	0.823	0.855	0.888	0.924	0.961	4
0.593	0.621	0.650	0.681	0.713	0.747	0.784	0.822	0.863	0.906	0.951	5
0.535	0.564	0.596	0.630	0.666	0.705	0.746	0.790	0.837	0.888	0.942	6
0.482	0.513	0.547	0.583	0.623	0.665	0.711	0.760	0.813	0.871	0.933	7
0.434	0.467	0.502	0.540	0.582	0.627	0.677	0.731	0.789	0.853	0.923	8
0.391	0.424	0.460	0.500	0.544	0.592	0.645	0.703	0.766	0.837	0.914	9
0.352	0.386	0.422	0.463	0.508	0.558	0.614	0.676	0.744	0.820	0.905	10
0.317	0.350	0.388	0.429	0.475	0.527	0.585	0.650	0.722	0.804	0.896	11
0.286	0.319	0.356	0.397	0.444	0.497	0.557	0.625	0.701	0.789	0.887	12
0.258	0.290	0.326	0.368	0.415	0.469	0.530	0.601	0.681	0.773	0.879	13
0.232	0.263	0.299	0.340	0.388	0.442	0.505	0.577	0.661	0.758	0.870	14
0.209	0.239	0.275	0.315	0.362	0.417	0.481	0.555	0.642	0.743	0.861	15
0.188	0.218	0.252	0.292	0.339	0.394	0.458	0.534	0.623	0.728	0.853	16
0.170	0.198	0.231	0.270	0.317	0.371	0.436	0.513	0.605	0.714	0.844	17
0.153	0.180	0.212	0.250	0.296	0.350	0.416	0.494	0.587	0.700	0.836	18
0.138	0.164	0.194	0.232	0.277	0.331	0.396	0.475	0.570	0.686	0.828	19
0.124	0.149	0.178	0.215	0.258	0.312	0.377	0.456	0.554	0.673	0.820	20
0.112	0.135	0.164	0.199	0.242	0.294	0.359	0.439	0.538	0.660	0.811	21
0.101	0.123	0.150	0.184	0.226	0.278	0.342	0.422	0.522	0.647	0.803	22
0.091	0.112	0.138	0.170	0.211	0.262	0.326	0.406	0.507	0.634	0.795	23
0.082	0.102	0.126	0.158	0.197	0.247	0.310	0.390	0.492	0.622	0.788	24
0.074	0.092	0.116	0.146	0.184	0.233	0.295	0.375	0.478	0.610	0.780	25
0.044	0.057	0.075	0.099	0.131	0.174	0.231	0.308	0.412	0.552	0.742	30
0.026	0.036	0.049	0.068	0.094	0.130	0.181	0.253	0.355	0.500	0.706	35
0.009	0.014	0.021	0.031	0.048	0.073	0.111	0.171	0.264	0.410	0.639	45
0.005	0.009	0.013	0.021	0.034	0.054	0.087	0.141	0.228	0.372	0.608	50

$PVIF_{r,n}$

%50	%45	%35	%30	%25	%20	%18	%16	%14	%12	r ← / n ↓
0.667	0.690	0.741	0.769	0.800	0.833	0.847	0.862	0.877	0.893	1
0.444	0.476	0.549	0.592	0.640	0.694	0.718	0.743	0.769	0.797	2
0.296	0.328	0.406	0.455	0.512	0.579	0.609	0.641	0.675	0.712	3
0.198	0.226	0.301	0.350	0.410	0.482	0.516	0.552	0.592	0.636	4
0.132	0.156	0.223	0.269	0.328	0.492	0.437	0.476	0.519	0.567	5
0.088	0.108	0.165	0.207	0.262	0.335	0.370	0.410	0.456	0.507	6
0.059	0.074	0.122	0.159	0.210	0.279	0.314	0.354	0.400	0.452	7
0.039	0.051	0.091	0.123	0.168	0.233	0.266	0.305	0.351	0.404	8
0.026	0.035	0.067	0.094	0.134	0.194	0.225	0.263	0.308	0.361	9
0.017	0.024	0.050	0.073	0.107	0.162	0.191	0.227	0.270	0.322	10
0.012	0.017	0.037	0.056	0.086	0.135	0.162	0.195	0.237	0.287	11
0.008	0.012	0.027	0.043	0.069	0.112	0.137	0.168	0.208	0.257	12
0.005	0.008	0.020	0.033	0.055	0.093	0.116	0.145	0.182	0.229	13
0.003	0.006	0.015	0.025	0.044	0.078	0.099	0.125	0.160	0.205	14
0.002	0.004	0.011	0.020	0.035	0.065	0.084	0.108	0.140	0.183	15
0.002	0.003	0.008	0.015	0.028	0.054	0.071	0.093	0.123	0.163	16
0.001	0.002	0.006	0.012	0.023	0.045	0.060	0.080	0.108	0.146	17
0.001	0.001	0.005	0.009	0.018	0.038	0.051	0.069	0.095	0.130	18
*	0.001	0.003	0.007	0.014	0.031	0.043	0.060	0.083	0.116	19
*	0.001	0.002	0.005	0.012	0.026	0.037	0.051	0.073	0.104	20
*	*	0.002	0.004	0.009	0.022	0.031	0.044	0.064	0.093	21
*	*	0.001	0.003	0.007	0.018	0.026	0.038	0.056	0.083	22
*	*	0.001	0.002	0.006	0.015	0.022	0.033	0.049	0.074	23
*	*	0.001	0.002	0.005	0.013	0.019	0.028	0.043	0.066	24
*	*	0.001	0.001	0.004	0.010	0.016	0.024	0.038	0.059	25
*	*	*	*	0.001	0.004	0.007	0.012	0.020	0.033	30
*	*	*	*	*	0.002	0.003	0.006	0.010	0.019	35
*	*	*	*	*	*	0.001	0.001	0.003	0.006	45
*	*	*	*	*	*	*	0.001	0.001	0.003	50

المصدر: تيم فائز، 2011، مبادئ الإدارة المالية، الطبعة الثانية، إثراء للنشر والتوزيع، عمان، الأردن.