University of FerhatAbbas –Setif 1
Faculty of Economics, Commerce and Management Sciences
Department of Management Sciences

Level : Third year Licence (L3)

Course:

Project Management

موجهة لطلبة السنة الثالثة إدارة أعمال

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Introduction

Project management is a fundamental discipline that plays a crucial role in the success of organizations across various sectors. It involves the planning, organizing, directing, and controlling of resources in order to achieve specific goals within a defined time frame and budget. In today's rapidly changing business environment, effective project management has become essential for ensuring efficiency, minimizing risks, and delivering high-quality results.

This course aims to provide students with a comprehensive understanding of the key concepts, tools, and techniques used in project management. It focuses on the different phases of a project life cycle, including initiation, planning, execution, monitoring, and closure. By studying this module, students will develop essential skills such as decision-making, problem-solving, teamwork, and leadership, which are necessary for managing projects successfully in both professional and academic contexts.

Topic 01 : introduction to project management

Project management is a systematic approach to planning, organizing, and controlling resources to achieve specific goals within a defined timeframe. A project is temporary, unique, and aims to deliver a product, service, or result.

The role of project management is to ensure that projects are completed on time, within budget, and meet the desired quality standards. Understanding the life cycle of a project—from initiation and planning to execution, monitoring, and closure—is essential for successful project delivery.

Effective project management improves efficiency, reduces risks, and enhances communication among team members, ultimately contributing to the success of an organization.

I. Definition of a project and project management:

1. Project: a temporary endeavor undertaken to create a unique product, service, or result.

Figure 1: definition of a project

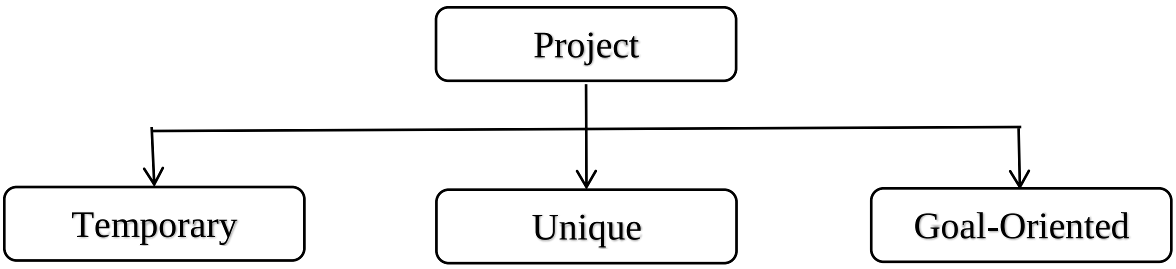


Table 1: project VS operations

Aspect	Project	Operations
Definition	Temporary, unique endeavor	Ongoing, repetitive tasks
Duration	Limited time frame	Continuous
Objective	Specific goal	Maintain business
Change	Often involves change	Stable
Resources	Allocated for project duration	Used continuously
Outcome	Unique Deliverable	Standard Output

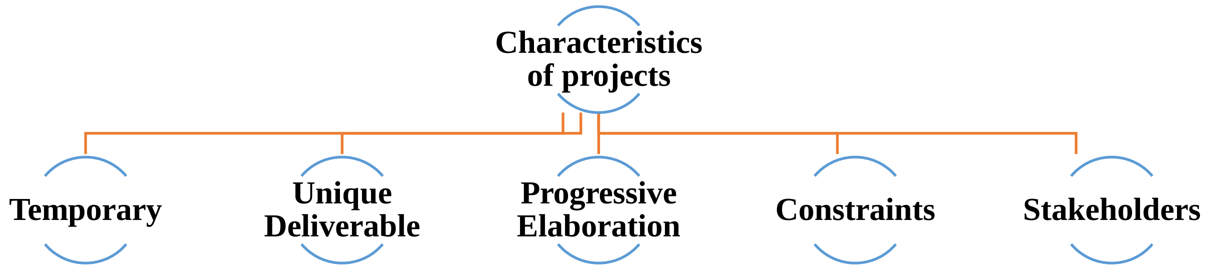
Note: a project is not a daily repetitive operation, but a specific endeavor with a defined beginning and end.

2. **Project management:** the Application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

II. Characteristics of projects :

a. **Temporary:** has a start and an end date.
b. **Unique deliverable:** produces something new or distinct.
c. **Progressive elaboration:** details are developed gradually.
d. **Constraints:** defined by scope, time, and cost (the "triple constraint").
e. **Stakeholders:** involves different parties with different interests.

Figure 2: Characteristics of projects



III. Importance and challenges of project management:

1. Importance of project management :

a. Aligns projects with organizational strategy.
b. Ensures projects are delivered on time, within budget, with expected quality.
c. Improves team coordination and communication.
d. Helps manage risks and uncertainties.
e. Increases customer satisfaction and stakeholder trust.
f. Provide templates and procedures for use by project managers.
g. Provide facilitation.
h. Stay abreast of the latest trends in project management.

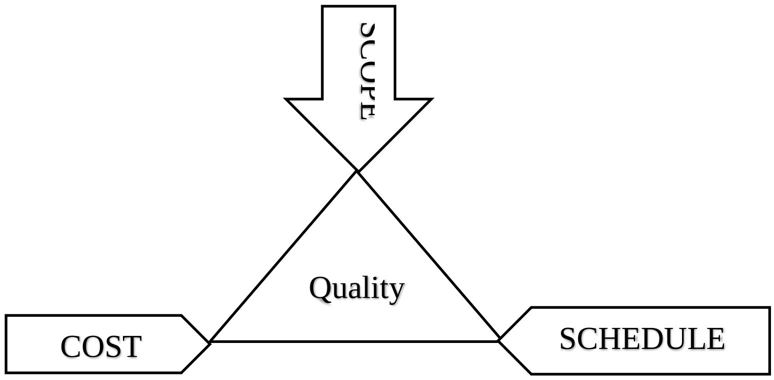
i. Serve as a repository for project reports and lessons learned.

Figure 3: **importance of project management**

2. Challenges of Project Management :

a. Scope creep – uncontrolled changes in scope.
b. Limited resources – time, budget, skilled staff.
c. Uncertainty and risks – political, economic, or technological changes.
d. Communication barriers – poor stakeholder engagement.
e. Balancing constraints – scope, time, and cost while maintaining quality.

Figure 4: constraints

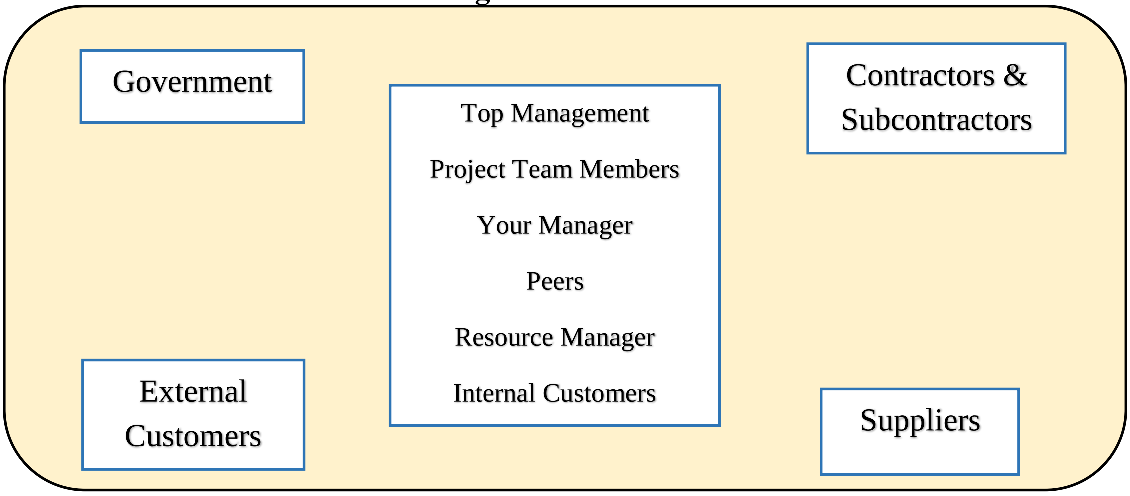


Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p16.

IV. Roles of the project manager and the project team

The success of any project depends heavily on clear roles and responsibilities, effective leadership, and collaboration. the following are the refined roles of both the Project Manager and the Project Team.

Figure 5: stakeholders



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p44.

1. Role of the project manager

The project manager is the central figure in ensuring the success of a project. He or she is responsible for defining project objectives, planning activities, allocating resources, monitoring progress, and ensuring that the deliverables meet the required quality standards. Additionally, the project manager acts as a communicator between stakeholders and the project team, ensuring alignment and resolving conflicts when they arise.

Figure 6: **role of the project manager**

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p84.

- **Key responsibilities include:**
  a. Defining scope, objectives, and deliverables.
  b. Planning and scheduling tasks.
  c. Allocating and managing resources.
  d. Monitoring progress and controlling risks.
  e. Communicating with stakeholders.
  f. Leading and motivating the project team.

2. Role of the team leader

The team leader plays a vital role in translating the project manager's vision into actionable tasks for team members. The team leader coordinates day-to-day activities, provides technical guidance, ensures team collaboration, and monitors task completion. Unlike the project manager, whose role is strategic, the team leader focuses more on operational efficiency within the team.

- **Key responsibilities include:**

a. Translating project goals into tasks.
b. Coordinating team activities.
c. Providing technical expertise and mentoring.
d. Encouraging collaboration and resolving team conflicts.
e. Reporting progress to the project manager.

3. Role of team members

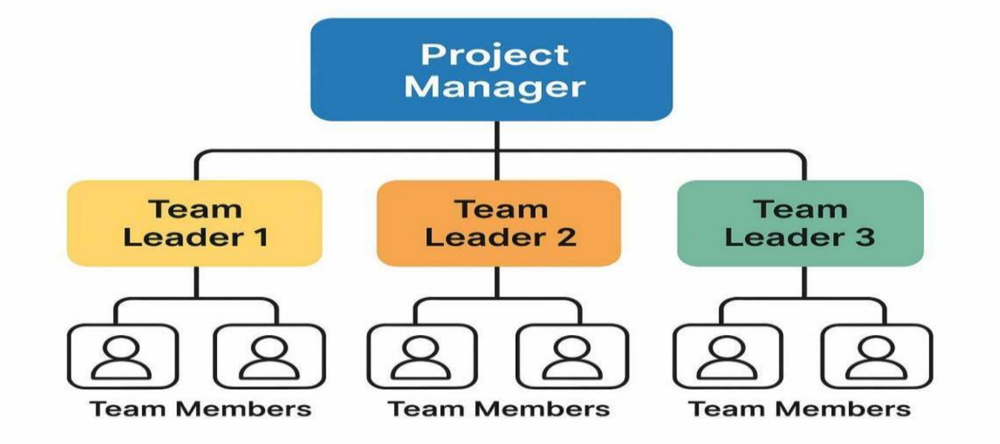
Team members are the backbone of project execution. They are responsible for carrying out specific tasks assigned by the team leader or project manager. Their effectiveness depends on technical expertise, collaboration, commitment, and communication. Successful projects require proactive team members who take responsibility and contribute ideas to improve outcomes.

- **Key responsibilities include:**

a. Executing assigned tasks effectively.
b. Collaborating and sharing knowledge with peers.
c. Communicating progress and challenges.
d. Complying with quality and safety standards.

e. Supporting innovation and problem-solving.

Figure 7: roles of the project manager and the project team



Summary :

- Projects are temporary and unique.
- Project Management ensures systematic planning, execution, and control.
- It is essential to meet strategic goals but faces challenges such as scope, resources, and risks.

Illustrative examples:

Example 01 : building a bridge

- Building a new bridge → Project (temporary, unique).
- Collecting daily tolls → Operation (repetitive, ongoing).

Discussion: Why is bridge construction a project, but toll collection is not?

Suggested answer:

Building a bridge is a project because it is temporary (has a clear start and end) and creates a unique deliverable. Collecting tolls is an operation because it is repetitive and ongoing.

Example 02 : launching a lobile app

- Temporary → Starts with planning and ends with launch.
- Unique Deliverable → A new app.
- Stakeholders → Developers, investors, users.

Discussion: what risks could threaten the success of this project?

Suggested answer: risks may include delays in development, exceeding the budget, technical failures, or low user adoption. These risks make project management essential.

Example 03: projects vs. operations

Identify each as project or operation:

1. Opening a new university campus.
2. Teaching the same class every semester.
3. Developing a COVID-19 vaccine.
4. Processing payroll for employees.

Suggested answer:

- Opening a new university campus → Project.
- Teaching the same class every semester → Operation.
- Developing a COVID-19 vaccine → Project.
- Processing payroll for employees → Operation.

Example 04 : triple Constraint

- Scope – Time – Cost
- Discussion: imagine organizing a cultural festival. If the budget is reduced,
- what happens to scope and time?

Goal: Show how constraints are interrelated.

Suggested answer: if the budget is reduced, the project team may need to reduce the scope (fewer activities or smaller scale) or extend the time (longer duration). Otherwise, quality might be compromised.

Example 05 : real-Life Discussion

Think of a recent project in Algeria (e.g., new highway, university renovation).

- What were the main challenges for this project?

Suggested answer: challenges may include lack of funding, political changes, delays in materials or resources, or poor stakeholder coordination.

Example 06 :

What is the difference between a project and daily operations?

Suggested answer: a project is temporary and unique, while operations are ongoing and repetitive.

Example 07 :

- Why is project management important in organizations?

Suggested answer: project management ensures projects are delivered on time, within budget, and meet objectives.

Example 08 :

- Identify one challenge project managers often face.

Suggested answer: one common challenge is scope creep – uncontrolled expansion of project scope.

Example 09 :

Why do you think projects are considered “temporary” while operations are ongoing?

Suggested answer: projects are temporary because they have a defined start and end, while operations are continuous and support daily business.

Example 10 :

Can you give an example from your life where you were part of a project?

Suggested answer: for example, organizing a wedding, preparing a graduation ceremony, or developing a mobile app. Each has a start, end, and unique deliverable.

Example 11 :

Why is communication so important in project management?

Suggested answer: because projects involve multiple stakeholders, good communication prevents misunderstandings, builds trust, and keeps everyone aligned.

Example 12 :

What do you think is the biggest challenge for project managers today?

Suggested answer: some challenges include managing limited resources, dealing with scope creep, and adapting to fast-changing technology.

Example 13 :

How can project management contribute to the success of an organization?

Suggested answer: by aligning projects with strategy, ensuring quality results, reducing risks, and improving customer satisfaction.

Application series 01 (introduction to project management)

Exercise 1: your personal project

Think about something in your life that could be considered a project (e.g., learning a new skill, organizing a trip, preparing for graduation). Why is it a project and not an operation?

Objective: Connect project management concepts to students' personal lives.

Model answers:

Learning a new language is a project because it has a clear start (when you begin studying), a defined goal (being able to speak fluently), and an end point (achieving the desired level). It is not an operation because it is not a repetitive daily task.

Exercise 2: project failure in real life

Search your memory (or online quickly if possible): Can you name a project (local, national, or global) that failed? Why do you think it failed? Which of the challenges (scope, cost, time, quality) were not managed well?

Objective: develop critical thinking about project success and failure.

Model answers:

The Berlin Brandenburg Airport project failed because of poor planning, budget overruns, and repeated delays. The main challenges were scope creep and lack of proper risk management.

Exercise 3: the one-minute project pitch

In pairs, imagine you are project managers. Pitch a project idea in 1 minute (e.g., starting a campus café, building a sports app, organizing a charity event). Mention: goal, timeline, and deliverable.

Objective: practice communication and concise project presentation.

Model answers:

Our project idea is to create a mobile app for university students to share study notes. The goal is to improve collaboration, the timeline is 6 months, and the deliverable is a functional app available on app stores.

Exercise 4: role-play – project stakeholders

Form small groups. Each group chooses a project (e.g., building a new student center). Assign roles: project manager, student representative, university administration, contractor. Act out a short meeting to discuss conflicting interests.

Objective: experience stakeholder interaction and negotiation.

Model answers:

The project manager explains the project plan, the student representative asks for more student-friendly spaces, the university administration worries about budget, and the contractor discusses construction challenges. The group learns how to negotiate priorities and reach compromise.

Exercise 5: project success vs. personal success

Discuss: do you think the skills needed to succeed in managing projects (planning, communication, teamwork, risk management) are the same skills needed to succeed in personal life? Give examples.

Objective: highlight the transferable value of project management skills.

Model answers :

Yes, project management skills are also life skills. For example, planning helps in managing personal finances, communication is important in family relationships, teamwork is needed in group assignments, and risk management helps in making better decisions.

Topic 02 : project life cycle and main phases

Project management is a discipline that enables organizations to transform ideas into reality through structured planning, execution, and evaluation. Every project, regardless of its size or complexity, follows a certain sequence of phases known as the project life cycle. Understanding this cycle is fundamental because it provides managers and teams with a roadmap for delivering successful outcomes.

This lecture will explore three major components: the different project life cycle models, the main phases that shape every project, and the role of stakeholders who influence and are influenced by project outcomes. By mastering these concepts, a clear view will be gained of how projects are initiated, developed, controlled, and closed, as well as the importance of engaging stakeholders throughout the process.

I. Project life cycle models

A project life cycle (PLC) is the sequence of phases that a project goes through from its initiation to its closure. It provides a structured framework for planning, executing, and evaluating projects.

Figure 8: project life cycle

Several models exist, depending on methodology, industry, and complexity:

Figure 9: **comparison of project life cycle models**

Agile: incremental delivery, frequent feedback, highly flexible
Iterative: repetitive cycles, gradual improvements, accommodates complexity
Waterfall: sequential phases, clear requirements, minimal changes

1. Traditional (waterfall) model:

a. Linear and sequential.

b. Each phase must be completed before the next begins.

c. Suitable for projects with well-defined requirements.
d. Limitation: rigid and inflexible when requirements change.

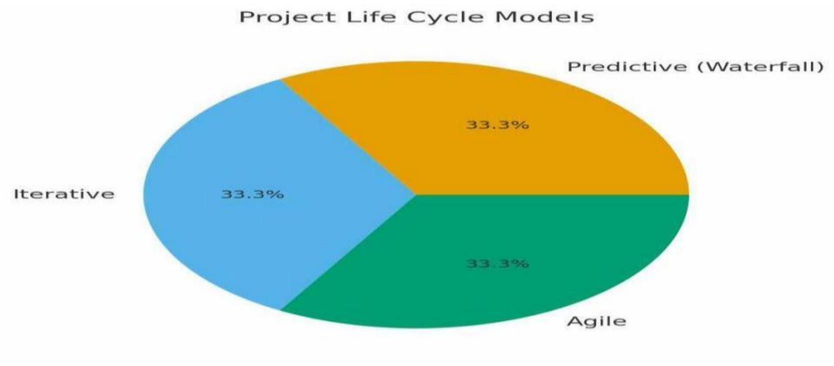
2. Spiral / iterative models

e. Project develops in repeated cycles, incorporating stakeholder feedback.
f. Includes risk analysis in each iteration.
g. Useful for large and complex projects.

3. Agile / incremental models

h. Based on flexibility, collaboration, and continuous delivery.
i. Stakeholders are highly engaged throughout the process.
j. Well-suited for IT and software development projects.

Figure 10: project life cycle models



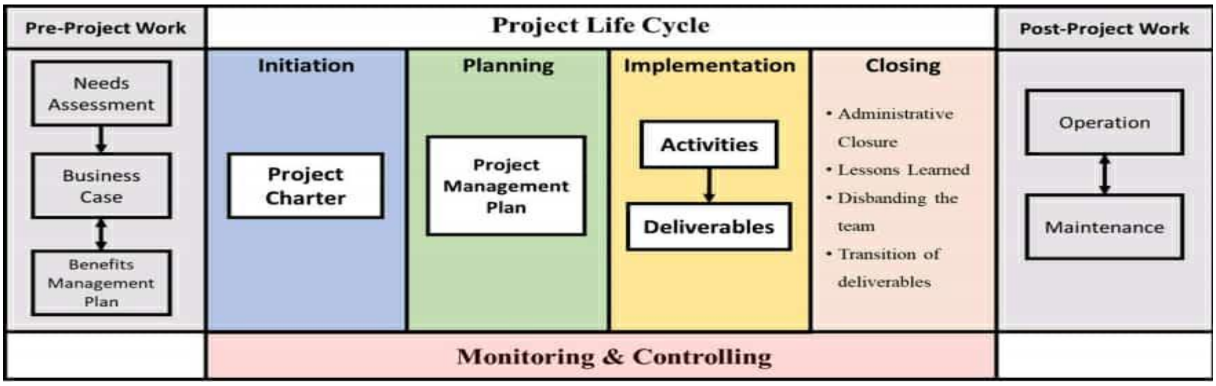
II. Main phases of the project life cycle

Most life cycle models share five core phases, even if terminology varies:

Table 2: project life cycle

project life cycle			
a. Starting b. Initiating c. Conceptualizing	a. Organizing & preparing b. Planning c. Analyzing & designing	a. Carrying out the work b. Implementing c. Executing	a. Ending the project b. Closing-out

Table 3: project life cycle



1. Initiation / concept

a. Define project objectives, scope, and feasibility.

b. Deliverable: Project Charter.

2. Planning / definition

a. Develop detailed project management plan.

b. Includes schedule, budget, resources, risks, and communications.

c. Deliverable: comprehensive project plan.

3. Execution / implementation

a. Perform the actual work to produce deliverables.

b. Coordinate people, materials, and resources.

c. Deliverable: project deliverables.

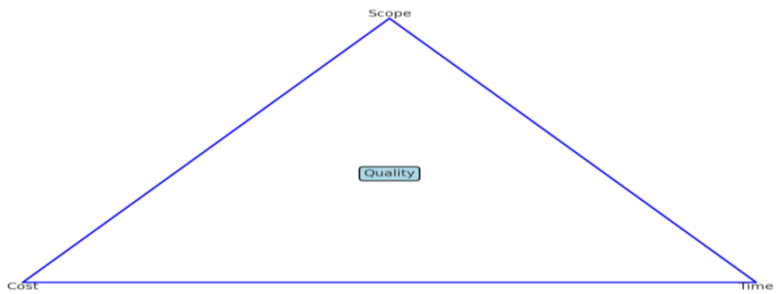
4. Monitoring and controlling

a. Track progress against baseline (cost, time, quality).

b. Manage changes and risks.

c. Deliverable: status reports, change requests.

Figure 11: track progress against baseline



5. Closure / termination

f. Formal acceptance of deliverables, release resources, document lessons learned.

g. Sometimes extended to Post-Project Evaluation (benefits realization).

Figure 12: **main phases of the project life cycle**

III. Project stakeholders

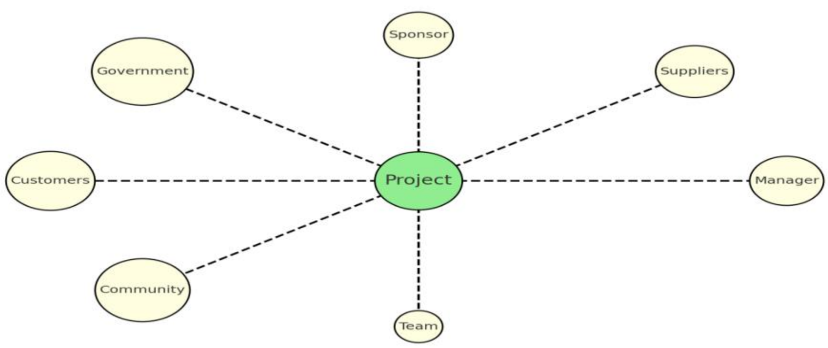
A stakeholder is any individual, group, or organization that may affect, be affected by, or perceive itself to be affected by project outcomes.

1. Types of stakeholders

a. **Internal:** project manager, project team, sponsor, senior management.

b. **External:** customers, suppliers, regulators, community.

Figure 13: **stakeholders**



2. Stakeholder roles

a. Sponsor: provides financial resources, approves major decisions.

b. Project Manager: leads the team, ensures objectives are met.

c. Team Members: execute tasks and deliver outputs.

d. Customers/Users: ultimate beneficiaries of project results.

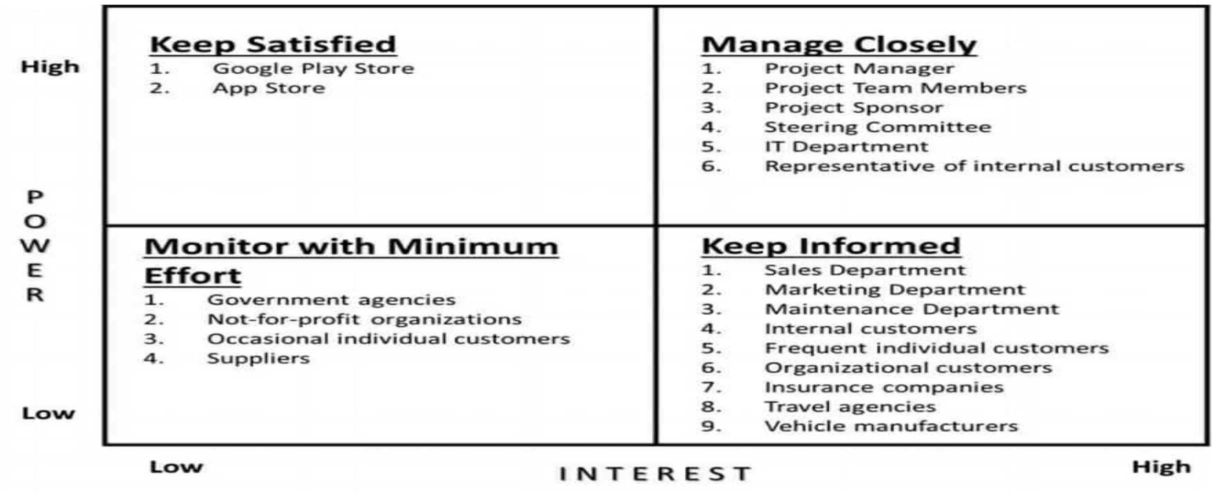
3. Stakeholder Management

a. Identify stakeholders early.

b. Analyze their interest and influence.

c. Engage them through tailored communication.

Figure 14: power and interest of project



Summary:

a) Successful projects rely on choosing the right life cycle model based on complexity and flexibility needs.

b) Clear and structured planning is critical to align objectives, resources, and schedules.

c) Active stakeholder engagement ensures support, reduces conflicts, and increases project success.

d) Continuous monitoring and adaptation allow the project to stay on track despite changes.

e) Balancing time, cost, scope, and quality is essential for achieving project goals.

f) Documenting lessons learned supports continuous improvement and knowledge transfer.

g) Strong communication and collaboration across all phases amplify efficiency and outcomes.

Illustrative examples:

Example 1: waterfall model

A construction company plans to build a new office. They complete each phase sequentially (design → foundation → structure → finishing).

Solution: by following the Waterfall model, the company ensures each step is complete before moving to the next, minimizing errors in design and construction.

Example 2: agile model

A software team develops a mobile app. They deliver small features in sprints, gather user feedback, and adjust the next sprint accordingly.

Solution: agile allows the team to adapt quickly to changes, improving customer satisfaction and reducing development risks.

Example 03: identifying phases

A software company wants to develop a new mobile app. Match the following activities with the correct project phase:

Table 4: identifying phases

Phase Options	Activity
1. Initiation	a) Define project goals and scope
2. Execution	b) Develop the app features in sprints
3. Monitoring & Controlling	c) Monitor progress and adjust schedules
4. Closing	d) Deliver the app to the client
5. Planning	e) Create a detailed project plan

Solution – answer key:

a) Initiation

b) Execution

c) Monitoring & Controlling

d) Closing

e) Planning

Example 04: life cycle models

For each project scenario, identify the most suitable life cycle model (Waterfall, Iterative, Agile):

1. Building a hospital where design must be strictly followed.
2. Developing a complex enterprise software with frequent client feedback.
3. Creating a new mobile game where features can be released incrementally.

Solution – answer key:

1. Waterfall → sequential, minimal changes.
2. Iterative → allows cycles and improvements.
3. Agile → incremental delivery with feedback.

Example 05: stakeholders identification

Consider a project to organize a university conference. Identify possible internal and external stakeholders.

Solution – answer key:

a. **Internal stakeholders:** project manager, organizing team, faculty members.

b. **External stakeholders:** sponsors, guest speakers, students, vendors, local authorities.

Example 06: triple constraint

A project manager has to reduce costs in a project. Explain how this might affect time, scope, and quality.

Solution – answer key:

a. Reducing costs may:

- Increase project time (less resources available).
- Limit scope (fewer features can be implemented).
- Affect quality (lower budget for materials or testing).

b. The project manager must balance the triple constraint to minimize negative impact.

Example 07: inputs – process – outputs

For a project of developing a website, identify:

c. Inputs → e.g., client requirements, team skills, software tools
d. Process → e.g., coding, designing, testing
e. Outputs → e.g., a fully functional website

Solution – Answer Key:

a. Inputs: client requirements, team skills, software tools
b. Process: coding, designing, testing
c. Outputs: fully functional website ready for deployment

Example 08: project phase identification – advanced scenario

Scenario:

A multinational company plans to launch a new e-commerce platform. Activities include:

1. Conducting market research and feasibility study.
2. Designing system architecture and database.
3. Developing the website in incremental modules.
4. Continuous testing and client feedback incorporation.
5. Launching the platform and providing training to employees.

Task: match each activity to the correct project phase.

Solution – answer key:

1. **Initiation:** conducting market research and feasibility study.
2. **Planning:** designing system architecture and database.
3. **Execution:** developing the website in incremental modules.
4. **Monitoring & Controlling:** continuous testing and client feedback incorporation.
5. **Closing:** launching the platform and providing training to employees.

Example 09: choosing life cycle model

Scenario 1: developing an autonomous drone system for industrial inspection where safety and specifications must be strictly followed.

Scenario 2: creating a marketing campaign website that will be updated based on weekly analytics and client feedback.

Task: identify the most suitable life cycle model for each scenario.

Solution – answer key:

a. Scenario 1 → waterfall: strict sequential process ensures safety and compliance.
b. Scenario 2 → agile: iterative and flexible approach allows updates based on feedback.

Example 10: stakeholder analysis

Scenario: a city is implementing a smart traffic management system. Identify at least three internal and three external stakeholders.

Solution – answer key:

a. **Internal stakeholders:** project manager, IT team, Operations team.
b. **External stakeholders:** city authorities, citizens (users), technology vendors, traffic police.

Example 11: triple constraint challenge

Scenario: the project manager must **accelerate the timeline** for launching a mobile banking app without increasing the budget.

Task: explain the impact on **scope and quality**, and propose a solution.

Solution – answer key:

a. Accelerating timeline without extra budget may:
   - Reduce scope (some features may be postponed).
   - Potentially affect quality (less time for testing).
b. **Solution:** Prioritize essential features for the first release, plan a phased rollout for additional features, and maintain quality standards.

Example 12: inputs–process–outputs – realistic scenario

Scenario: Developing an AI-based chatbot for customer service.

Task: Identify inputs, processes, and outputs.

Solution – answer key:

a. **Inputs:** customer queries dataset, AI algorithms, development team skills, software tools.
b. **Process:** data preprocessing, algorithm training, testing chatbot responses.

c. **Outputs:** functional AI chatbot integrated with customer service platform.

Application series 02 (project life cycle and main phases)

Exercise 1:

Identify the most suitable life cycle model for each scenario:

1. A construction company plans to build a new office. They complete each phase sequentially (design → foundation → structure → finishing).

2. A software team develops a mobile app. They deliver small features in sprints, gather user feedback, and adjust the next sprint accordingly.

3. Developing an autonomous drone system for industrial inspection where safety and specifications must be strictly followed.

4. Creating a marketing campaign website that will be updated based on weekly analytics and client feedback.

Exercise 2:

Identify possible internal and external stakeholders for each scenario:

1. Consider a project to organize a university conference.

2. A city is implementing a smart traffic management system.

Exercise 3:

Identify inputs, processes, and outputs for each scenario:

1. project of developing a website.

2. Developing an AI-based chatbot for customer service.

Exercise 4:

A multinational company plans to launch a new e-commerce platform. Activities include:

1. Continuous testing and client feedback incorporation.

2. Designing system architecture and database.

3. Conducting market research and feasibility study.

4. Launching the platform and providing training to employees.

5. Developing the website in incremental modules.

Task: Match each activity to the correct project phase.

Topic 03 : project environement

Every project exists within a specific environment that influences its planning, execution, and success. Understanding this environment is essential because it allows project managers and teams to identify factors that can affect the project positively or negatively.

I. Importance of analyzing project environment

Analyzing the project environment helps in:

1. Recognizing internal and external factors that impact project outcomes.
2. Anticipating challenges and potential risks.
3. Identifying opportunities for improvement and growth.
4. Making informed decisions and strategic plans.

By systematically examining the environment, using tools such as PESTEL for external analysis and SWOT for internal factors, projects can achieve better alignment with their goals and increase their chances of success.

II. Definition of project environment :

The project environment refers to all internal and external factors that influence a project's success.

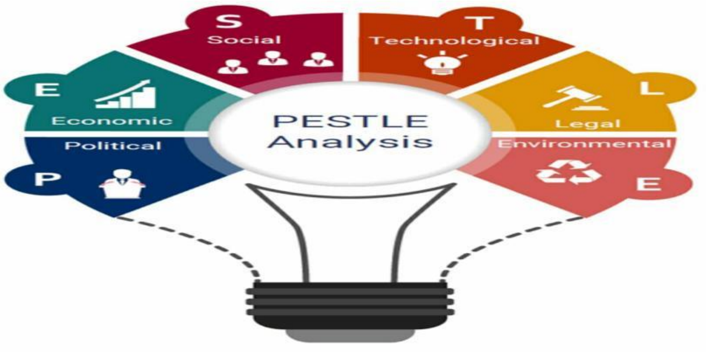
III. Internal and external environment:

The internal environment includes factors within the organization Includes culture, structure, policies, resources, and internal stakeholders. the external environment involves factors outside the organization that affect project performance, like economy, technology, and Legal regulations, market, laws, and society, politics, competition.

IV. PESTEL model:

The PESTEL model is a tool used to analyze the external environment of a project or organization. It helps identify factors that can affect performance, opportunities, and risks.

Figure 15: the PESTEL model



PESTEL stands for:

P – Political: government policies, regulations, stability, and legal issues that affect the project.

E – Economic: economic conditions like inflation, interest rates, exchange rates, and market trends.

S – Social: social and cultural factors such as demographics, lifestyle changes, and customer behavior.

T – Technological: technological advancements, innovation, and availability of new tools or software.

E – Environmental: environmental laws, sustainability, climate, and ecological impacts.

L – Legal: legal requirements, labor laws, and industry regulations affecting the project.

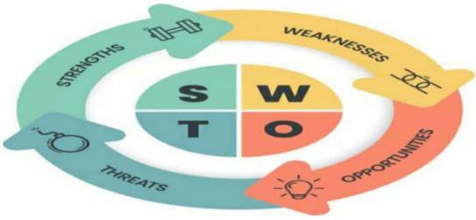
Why it is useful:

1. Helps managers understand the external environment.
2. Supports strategic planning and risk management.
3. Identifies opportunities and threats outside the organization.

V. SWOT analysis: internal and external factors

SWOT analysis is a strategic planning tool used to identify and evaluate the Strengths, Weaknesses, Opportunities, and Threats of a project, organization, or business.

Figure 16: SWOT analysis



A. **Strengths (S):** internal advantages or positive attributes that help achieve objectives.

1. Strong brand reputation.
2. Skilled and experienced team.
3. Advanced technology or equipment.
4. Strong financial position.

B. **Weaknesses (W):** internal limitations or areas that need improvement.

1. Limited marketing budget.
2. Dependence on a single supplier.
3. Outdated software or systems.
4. Lack of specialized skills in some areas.

C. **Opportunities (O):** external factors or situations that could be beneficial.

1. Growing market demand.
2. Technological advancements.
3. Expansion into new markets.
4. Strategic partnerships.

D. **Threats (T):** external challenges or risks that could hinder success.

1. Strong competition.
2. Changes in government regulations.
3. Economic downturn.
4. Rapid changes in customer preferences.

SWOT helps decision-makers understand their current position and plan strategies to maximize strengths and opportunities while minimizing weaknesses and threats.

VI. Challenges in managing environment :

Rapid change, uncertainty, and conflicting interests are key challenges.

Illustrative Examples:

Here are the five following projects:

- **a.** Construction of a new university building.
- **b.** Launch of a mobile banking app.
- **c.** Development of a renewable energy plant.
- **d.** Organization of an international conference.
- **e.** Introduction of an e-learning platform.

identify key internal and external factors and present how these influence project performance.

Summary :

1. Projects exist within internal and external environments.
2. Internal factors include team skills, resources, and organizational processes.
3. External factors include regulations, market conditions, and stakeholder expectations.
4. PESTEL analysis helps identify external factors affecting projects.
5. SWOT analysis helps identify internal strengths and weaknesses, and external opportunities and threats.
6. stakeholders have significant influence on project success.
7. Project performance depends on managing both internal and external factors effectively.
8. understanding the environment of a project is essential for planning and risk management.

Topic 04 : RACI matrix for project management

After understanding what a project is, how it is managed, and the different stages of its life cycle, as well as the influence of the project environment, it is important to identify the roles and responsibilities of everyone involved in the project.

One of the most effective tools used in project management to clarify these roles is the RACI matrix.

The RACI matrix helps ensure that all project tasks are clearly assigned, responsibilities are well defined, and communication between team members is efficient. By using this matrix, project managers can prevent confusion, overlapping duties, or accountability gaps, which ultimately improves coordination and overall project performance.

learning how to apply the RACI matrix is essential. It allows students and practitioners to better understand teamwork dynamics, decision-making processes, and accountability in real project scenarios. Therefore, mastering this tool not only supports effective project execution but also builds strong managerial and leadership competencies for future careers.

I. What is the RACI Matrix?

The RACI matrix is a responsibility assignment chart that maps out every task, milestone, or key decision involved in completing a project and assigns individuals to their respective duties, whereby the acronym RACI stands for the four roles that stakeholders might play in any project. The RACI matrix brings structure to describing the roles that stakeholders play within a project, and it clarifies responsibilities and ensures that everything the project needs done is assigned an individual to do it.

II. The four roles:

1. **Responsible:** the people who do the work.

These are the individuals who must complete the task or objective or make the decision. Ensure that there is neither too much work assigned to one individual nor too many individuals responsible for one task.

2. **Accountable:** the person who is the point of contact for the work completed.

This individual must sign off or approve when the task, objective, or decision is complete. This individual also must make sure that responsibilities are assigned in the matrix for all related activities. This is not to say that the individual responsible is not also accountable for their work, but simply indicates that someone other than the responsible party is signing off or recognizing the task has been completed. There should only be one person accountable for each task or decision delineated, but it is possible to have the same individual listed as both responsible and accountable.

3. **Consulted:** the people who be communicated with regarding decisions and tasks.

These individuals are active participants and are kept in the loop of all tasks and decisions.

4. **Informed:** the people who will be updated on progress and decisions.

These individuals need updates on progress or decisions, but do not need to be formally consulted, nor do they contribute directly to the task or decision.

III. Creating a RACI matrix

The first steps for developing this matrix for communication and project management is to list both the stakeholders involved in the project and the major tasks, milestones, or decisions that will be made throughout the course of the project.

To ensure that the RACI matrix is effective and contributes to the success of the project, confirm with each stakeholder their role in the project, including resolving any disagreements or ambiguities, and save the matrix with other important project documents.

IV. Practical rule:

1) Every task must have clearly defined Responsible and Accountable individuals.
2) Any stakeholder related to the deliverables who is not mentioned in other roles is automatically assumed to be Informed.
3) If the stakeholder needs to participate in decision-making or provide input, they must be explicitly designated as Consulted.

V. Importance of the RACI matrix:

1. The RACI Matrix clarifies roles and responsibilities, reducing confusion within the project team.
2. It helps ensure that every task is properly assigned and that no responsibility is overlooked.
3. It enhances communication and coordination among project stakeholders.
4. It allows the project manager to identify workload imbalances and reassign tasks when needed.
5. It supports accountability and transparency by showing who is responsible, accountable, consulted, and informed.
6. It helps in decision-making by defining clearly who has the authority to approve actions or deliverables.
7. It improves project efficiency and contributes to meeting deadlines and project objectives.
8. It serves as a reference tool throughout the project to track progress and team engagement.

VI. RACI matrix example:

You are part of a Quality Improvement (QI) project at NCHC. The project involves several tasks that must be coordinated among different stakeholders, including the **principal investigator, research coordinator, research committee, department director, and data collectors**.

Read the following scenarios describing project responsibilities, then complete the RACI matrix by assigning the correct role (Responsible, Accountable, Consulted, or Informed) for each stakeholder in every task.

Project Activities:

1. **Submission of Project Application:** The **Research Coordinator** prepares and submits the project application. The **Principal Investigator** is accountable for its accuracy and

approval. The **Research Committee** and the **Department Director** are consulted, while the **Data Collectors** are only informed.

2. **Review and approval of application:** the **research committee** is responsible for reviewing and approving the application. The **principal investigator** remains accountable. The **research coordinator** provides the necessary documents and support (consulted). The **department director** is also consulted, while the **data collectors** are informed.

3. **Development of protocol:** the **research coordinator** is responsible for drafting the protocol. The **research committee** is accountable for validating its compliance. The **principal investigator** is consulted for scientific input, while both the **department director** and **data collectors** are informed.

4. **Distribution of materials and measures:** the **department director** ensures distribution and is responsible for this task. The **research coordinator** is accountable. The **principal investigator** is consulted, the **research committee** is informed, and the **data collectors** are consulted to confirm receipt.

5. **Data collection:** the **data collectors:** are responsible for carrying out the task. The **principal investigator** is accountable for data integrity. The **research coordinator** and **department director** are consulted for coordination, while the **research committee** is informed.

6. **Data analysis:** the **principal investigator** is responsible for analyzing the data. The **research coordinator** is accountable for ensuring timely and correct analysis. The **department director** is consulted, while the **research committee** and **data collectors** are informed.

7. **Evaluation of revised workflow:** the **research committee** is accountable for making the final decision on workflow revisions. The **principal investigator** is responsible for presenting the results. The **research coordinator** is consulted, the **department director** is consulted as well, and the **data collectors** are informed.

Table 5: solution

task/decision	principal investigator	research coordinator	research committee	department director	data collectors
Submission of project application	A	R	C	C	I
Review and approval of application	A	C	R	C	I
Development of protocol	C	R	A	I	I
Distribution of materials and measures	C	A	I	R	C
Data collection	A	C	I	C	R
Data analysis	R	A	I	C	I
Evaluation of revised workflow	R	C	A	C	I

*Color coating the cells by role will help easily identify who needs to do what and when.

Source: North Country. (2020). RACI matrix for project management description and example.

Application series (topic 04: RACI matrix for project management)

Exercise 1:

Setif university has launched a campus sustainability project to make the campus more eco-friendly by reducing waste, saving energy, and encouraging sustainable habits among students and staff.

The project team includes:

a. Sustainability Coordinator (SC)
b. Facilities Manager (FM)
c. Student Union Representative (SU)
d. Procurement Officer (PO)
e. University Administration (UA)
f. Communications Team (CT)

1. Energy audit: the facilities manager leads the inspection of all university buildings and ensures that energy consumption data is accurately collected. The sustainability coordinator compiles the results and prepares an energy-saving proposal to be presented to the university administration. The Administration reviews the report and provides formal approval before implementation. Meanwhile, the communications team is kept updated on the progress to start preparing awareness materials, and the student union representative is asked to share feedback from students.

2. Waste reduction program: a new waste sorting and recycling system is developed under the guidance of the sustainability coordinator. The procurement officer arranges for the purchase of recycling bins and other necessary materials, while the facilities manager oversees their installation in key areas of the campus. The student union representative takes part in promoting the initiative among students, and the university administration is periodically updated on its progress.

3. Awareness campaign: the communications team takes charge of creating posters, videos, and digital content to raise environmental awareness on campus. The sustainability coordinator provides the environmental information and messages used in the materials. The student union representative encourages students to participate actively in the campaign. The university administration reviews the campaign plan before launch, and the procurement officer is informed in case external sponsors are involved.

4. Green procurement policy: the procurement officer prepares a new purchasing policy focused on selecting environmentally friendly suppliers. The sustainability coordinator ensures that the proposed policy supports the university's sustainability goals. The university administration reviews and validates the policy before official adoption. Both the facilities manager and the student union representative are invited to share their opinions on the practicality of applying the policy, while the communications Team is notified once the policy is finalized.

5. Evaluation and reporting: at the end of the project, the sustainability coordinator compiles a detailed sustainability performance report. The university administration examines the document and approves the final version. The facilities manager and procurement officer provide the required operational and purchasing data. The student union representative receives a summary of the results, and the communications team prepares to share the final outcomes through campus channels.

Task: based on the information above, create a complete RACI Matrix identifying who is: Responsible (R); Accountable (A); Consulted (C); Informed (I) for each activity. Explain briefly why you assigned each role based on textual clues.

Exercise 2:

A team at Setif university is launching a new E-learning platform for students and professors.

The team includes:

a. Project Manager (PM)

b. System Developer (SD)

c. Training Coordinator (TC)

d. Quality Supervisor (QS)

e. Faculty Representative (FR)

f. University Administration (UA)

Read the following project phases carefully and deduce the R, A, C, and I roles for each.

1. Project planning: the university administration requested the project, but the project manager organizes the first planning meeting and ensures the timeline is realistic. The faculty representative provides input on user expectations, while the quality supervisor only observes for compliance. The system developer is not yet involved.

2. System Design: The System Developer begins drafting the system architecture. The Project Manager validates all milestones. The Quality Supervisor gives technical feedback when necessary. The Faculty Representative is kept updated about progress, and the University Administration is informed of major decisions.

3. Training sessions: the training coordinator organizes workshops for professors and students. The project manager monitors the training progress and ensures it aligns with the overall schedule. The faculty representative collaborates to gather feedback from participants. The system developer offers technical help during sessions. The university administration receives training reports.

4. Quality evaluation: the quality supervisor leads the review of system performance after testing. The system developer provides data and explanations about any issues. The project manager ensures recommendations are implemented. The university administration and faculty representative are notified of evaluation results.

5. Launch and feedback: the university administration approves the launch. The project manager ensures all elements are ready. The system developer assists in final adjustments. The training coordinator collects user feedback post-launch. The quality supervisor monitors the first month's performance.

Task: based on the information above, create a complete RACI matrix identifying who is: Responsible (R); Accountable (A); Consulted (C); Informed (I) for each activity. Explain briefly why you assigned each role based on textual clues.

Exercise 3:

Setif university has decided to create a smart library system that will automate borrowing, cataloging, and access to digital resources. The project team includes:

a. Project Manager (PM)
b. IT Engineer (ITE)
c. Procurement Officer (PO)
d. Library Director (LD)
e. Academic Committee (AC)
f. University Administration (UA)

Read the following phases carefully and deduce the R, A, C, and I for each activity:

1. Needs assessment: the library director gathers information about current library problems and desired improvements. The academic committee shares suggestions about resources needed for teaching. The project manager prepares a summary report for decision-making. The university Administration receives the report to make a go/no-go decision. The IT engineer is only informed about the outcomes.

2. Technical design: the IT engineer begins to design the digital infrastructure. The project manager follows up closely to ensure deadlines are met. The library director and academic committee review draft designs and suggest adjustments. The university administration is informed about progress. The procurement officer is consulted regarding required hardware.

3. Purchasing and installation: the procurement officer initiates the purchasing process for necessary equipment. The project manager validates the supplier's compliance with university standards. The IT engineer installs and configures the system. The library director checks that the installation meets library needs. The university administration is kept informed.

4. Training and pilot testing: the library director leads staff training and supervises pilot testing. The IT engineer provides technical support. The project manager monitors schedule and budget compliance. The academic committee gives feedback on user experience. The university administration is informed of test outcomes.

5. Official launch: The University Administration gives final approval to launch. The Project Manager oversees all preparations for opening day. The Library Director manages communication with staff and students. The IT Engineer stands by for troubleshooting. The Procurement Officer ensures remaining invoices are closed.

Task: Using the clues provided in the scenario, complete a RACI Matrix identifying who is Responsible (R), Accountable (A), Consulted (C), and Informed (I) for each project activity. Justify your assignments briefly using the text clues.

Exercise 4:

Setif University is organizing a Blood Donation Week in collaboration with the local hospital.

The project aims to raise awareness about the importance of blood donation and to encourage students and staff to take part in this humanitarian activity.

A dedicated project team is formed to plan, organize, and supervise the event to ensure its success and safety.

Project team members:

a. Project Manager (PM)

b. Health Department Representative (HDR)

c. Facilities Manager (FM)

d. Student Association Leader (SL)

e. Communications Officer (CO)

f. Hospital Liaison Officer (HLO)

Main activities description:

1. **Selecting the date and venue:** the facilities manager checks the availability of suitable spaces and confirms logistics. The project manager approves the final location and date. The health department representative and hospital liaison officer are consulted to ensure that the venue meets safety and medical standards. The student leader and communications officer are informed once the decision is made.

2. **Preparing the halls and reception areas:** the facilities manager is responsible for setting up the donation halls and ensuring cleanliness and accessibility. The project manager supervises the preparation process and is accountable for approving the setup before launch. The health department representative and hospital liaison officer are consulted to verify that the arrangements comply with hygiene and equipment requirements. The Student Leader helps by coordinating volunteers, while the communications officer is informed to plan photo and media coverage.

3. **Awareness campaign:** the communications officer leads the creation of posters, flyers, and social media posts to promote blood donation. The student leader is responsible for distributing materials and encouraging student participation. The health department representative provides medical information and ensures message accuracy. The project manager and hospital liaison officer are informed of progress.

4. **Scheduling with the Hospital:** the hospital liaison officer coordinates with hospital staff to define the donation schedule, medical staff availability, and safety procedures. The

project manager validates the schedule before implementation. The health department representative, facilities manager, and student leader are informed of the final plan.

5. **Event supervision and reporting:** the project manager oversees all activities throughout the week and ensures smooth coordination between all parties. The health department representative and hospital liaison officer provide daily updates on safety and logistics. The student leader supports volunteer management, while the communications officer covers media updates. The facilities manager ensures continuous readiness of the premises.

Task: Using the clues provided in the scenario, complete a RACI Matrix identifying who is Responsible (R), Accountable (A), Consulted (C), and Informed (I) for each project activity. Justify your assignments briefly using the text clues.

Topic 05 : project planning and scheduling

I. Work Breakdown Structure (WBS):

work of the project via a work breakdown structure **(WBS)** begins. The WBS defines the scope of the project and breaks the work down into components that can be scheduled, estimated, and easily monitored and controlled. The idea behind the WBS is simple: you subdivide a complicated task into smaller tasks, until you reach a level that cannot be further subdivided. Anyone familiar with the arrangements of folders and files in a computer memory or who has researched their ancestral family tree should be familiar with this idea. You stop breaking down the work when you reach a low enough level to perform an estimate of the desired accuracy. At that point, it is usually easier to estimate how long the small task will take and how much it will cost to perform than it would have been to estimate these factors at the higher levels. Each descending level of the WBS represents an increased level of detailed definition of the project work.

WBS describes the products or services to be delivered by the project and how they are decomposed and related. It is a deliverable-oriented decomposition of a project into smaller components. It defines and groups a project's discrete work elements in a way that helps organize and define the total work scope of the project.

A WBS also provides the necessary framework for detailed cost estimating and control, along with providing guidance for schedule development and control.

Overview

WBS is a hierarchical decomposition of the project into phases, deliverables, and work packages. It is a tree structure, which shows a subdivision of effort required to achieve an objective (e.g., a program, project, and contract). In a project or contract, the WBS is developed by starting with the end objective and successively subdividing it into manageable components in terms of size, duration, and responsibility (e.g., systems, subsystems, components, tasks, subtasks, and work packages), which include all steps necessary to achieve the objective.

The purpose of developing a WBS is to:

a. Allow easier management of each component.
b. Allow accurate estimation of time, cost, and resource requirements.
c. Allow easier assignment of human resources.
d. Allow easier assignment of responsibility for activities.

1. Definition & concept:

According to the Project Management Institute (PMI), a WBS is defined as:

"a deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables".

It is further described as:

"a product-oriented 'family tree' of project components that organizes and defines the total scope of the project. Each descending level represents an increasingly detailed definition of a project component".

In simpler terms: it breaks the "what" of the project into manageable chunks, not the "how" or "when."

✧ Why this is important:

a. It gives clarity on what needs to be done to create the deliverables.

b. It provides a common framework for planning, cost estimation, scheduling, and control.

c. It emphasizes deliverables (nouns) rather than activities (verbs) at the top levels.

d. It improves communication within the project team and with stakeholders by making scope transparent.

e. It provides a baseline for tracking progress, monitoring control, and identifying changes or scope creep.

2. Types / structure of WBS:

a. **Deliverable-oriented WBS:** Focuses on the major deliverables or products of the project (e.g., a building, a software module, a service).

b. **Phase-based WBS:** Organizes the work by project phases (Initiation, Planning, Execution, Monitoring/Control, Closure).

c. Other variations may include **risk-based, responsibility-based** structures depending on project type.

Structure aspects:

a) **<u>Hierarchical:</u>** top level is the overall project, next levels are major deliverables/sub-components, descending until work packages.

Level 3 (and beyond) further decomposes these into smaller, more manageable parts, until reaching the level where work can be assigned and controlled.

The number of levels is determined by the project's complexity, size and control needs:

b) **<u>Code numbering:</u>** often each element is given a code (e.g., 1.0, 1.1, 1.1.1) to reflect hierarchy.

Effective coding ensures that each element's location and level in the structure is unambiguous.

<u>Work packages:</u>

At the lowest meaningful level of the WBS are the work packages. A work package is the smallest unit of work for which cost, duration and resources can be estimated and managed. A work package should be sized so that it is manageable (for example, some guidelines refer to durations such as 8-80 hours) and its output measurable.

Because of these features, work packages are a fundamental control point in project scope, schedule and cost monitoring.

Why this matters:

a) The **levels** provide logical structure and traceability from the highest scope element down to work that can be assigned and monitored.

b) The **codes** enable consistent identification, integration with systems and reporting across the project lifecycle.

c) The **work packages** provide the practical unit of work for estimation, assignment, monitoring and control.

d) By clearly structuring a WBS with appropriate levels, codes and work packages, project managers create a robust foundation for planning, execution and control.

3. Key principles & rules:

a. **100% rule:** The WBS must include 100% of the work defined by the project scope and must capture all deliverables — internal, external, interim. The sum of the child elements must equal 100% of the parent level.

b. **Mutually exclusive elements:** Work packages should not overlap; each piece of work appears only once to avoid duplication and ambiguity.

c. **Proper level of detail:** The lowest level should be manageable (work package) and defined enough to estimate cost, schedule, and assign responsibility. Too much decomposition is as problematic as too little.

4. Common mistakes / challenges:

a. Confusing WBS with an activity list (verbs) rather than deliverables (nouns). The WBS should describe **what** will be delivered, not necessarily **how**.

b. Decomposing too far (too many levels) or not far enough (something too large to manage).

c. Failing to apply the 100% rule (missing work or overlapping work).

d. Not linking WBS to other project planning elements (schedule, cost, resources).

5. Practical steps to create a WBS:

1) Define the project scope and major deliverables (from project charter or scope statement).

2) Determine the major deliverables/components (level 2).

3) Decompose each major deliverable into smaller sub-deliverables until you reach work packages that can be estimated, assigned, and controlled.

4) Apply the 100% rule to ensure completeness; check for overlaps or gaps.

5) Assign identifiers/codes to each WBS element.

6) Create a WBS dictionary (optional but useful) to describe for each element: description, responsible person, cost estimate, resources, milestones.

7) Validate the WBS with stakeholders/project team and update as project evolves (progressive elaboration).

6. Relationship with other project management processes:

a. The WBS feeds into many planning processes: schedule development (what needs to be done then when), cost estimating (how much each work package will cost), resource planning.

b. In the PMBOK context, the WBS is created during the **Define Scope** process and serves as input to many downstream processes.

c. The WBS is not a schedule, nor does it show dependencies or resource assignments (those come later).

6.1. Relation of the WBS to the project plan:

A well-constructed Work Breakdown Structure (WBS) forms the foundation of the project plan.

In other words: the WBS answers what needs to be done; the project plan determines when, how much, with whom. Once work packages in the WBS are defined, each work package becomes the basis for estimating cost, duration, required resources, and risk.

Therefore, you should transition from WBS → work package list → project activities → project schedule → cost and resource plan.

6.2. Relation of the WBS to the Gantt chart:

While the WBS lays out the structured hierarchy of deliverables and work packages, the Gantt Chart visually shows when these pieces of work will be performed and how they relate in time. A WBS is not a schedule, but it is the input into creating one.

In practical terms: each lowest-level work package in the WBS becomes one or more tasks on the Gantt chart, with dependencies, start dates, end dates, and durations. The Gantt chart thus translates the hierarchical WBS structure into a time-based view. The WBS defines the scope structure; the Gantt chart schedules that structure. Without a good WBS, the Gantt chart may omit important deliverables or include duplicate/ unnecessary work.

“WBS → project plan → Gantt Chart”

a. The WBS defines what must be done (scope).

b. The project plan defines how, when, who, and how much (schedule, cost, resources).

c. The Gantt chart provides a visual timeline of the project plan based on the WBS's work packages.

Illustrative example:

Example of a WBS:

If I want to clean a room, I might begin by picking up clothes, toys, and other things that have been dropped on the floor. I could use a vacuum cleaner to get dirt out of the carpet. I might take down the curtains and take them to the cleaners, and then dust the furniture. All of these tasks are subtasks performed to clean the room. As for vacuuming the room, I might have to get the vacuum cleaner out of the closet, connect the hose, empty the bag, and put the machine back in the closet. These are smaller tasks to be performed in accomplishing the subtask called vacuuming. Figure shows how this might be portrayed in WBS format.

0.0 Clean Room

1. 1.0 Mop floor.
   - A. 1.1 Get mop and bucket out.
   - B. 1.2 Mix cleaner with water in bucket.
   - C. 1.3 Rinse out bucket and mop.
2. 2.0 Dust
   - A. 2.1 Coffee table
   - B. 2.2 Blinds
3. 3.0 Vacuum
   - A. 3.1 Get vacuum out of closet
   - B. 3.2 Vacuum carpet
   - C. 3.3 Empty bag
   - D. 3.4 Connect hose and plug
4. 4.0 Pick up floor
   - A. 4.1 Toys

a) 4.1.1 Put toys in box

B. 4.2 Clothes

b) 4.2.1 Hang up in closet

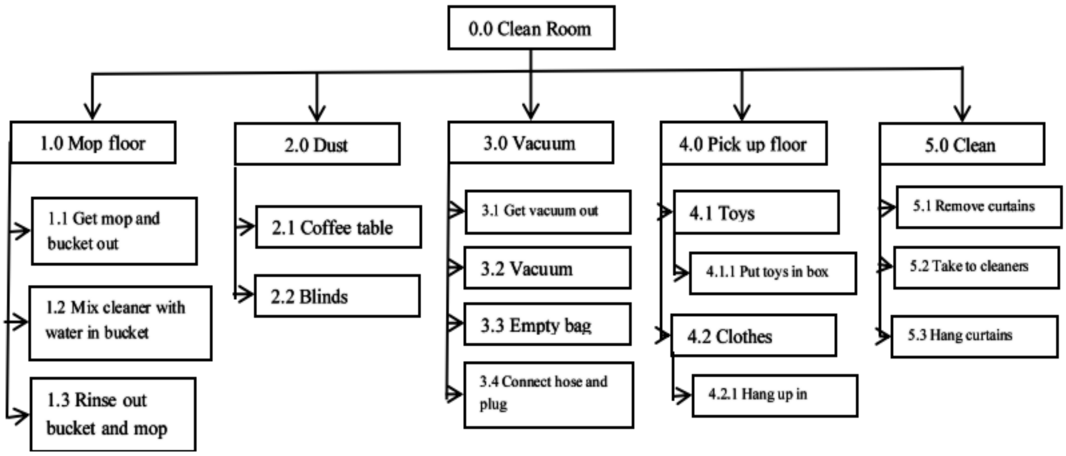
5. 5.0 Clean curtains

C. 5.1 Remove curtains

D. 5.2 Take to cleaners

E. 5.3 Hang curtains

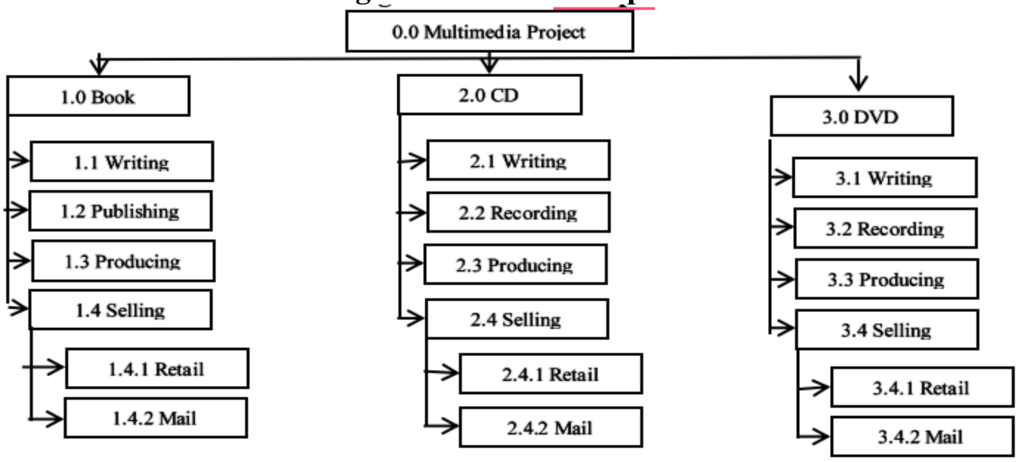
Figure 17: **WBS example**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p87.

For example, if you are doing a multimedia project the deliverables might include producing a book, CD, and a DVD.

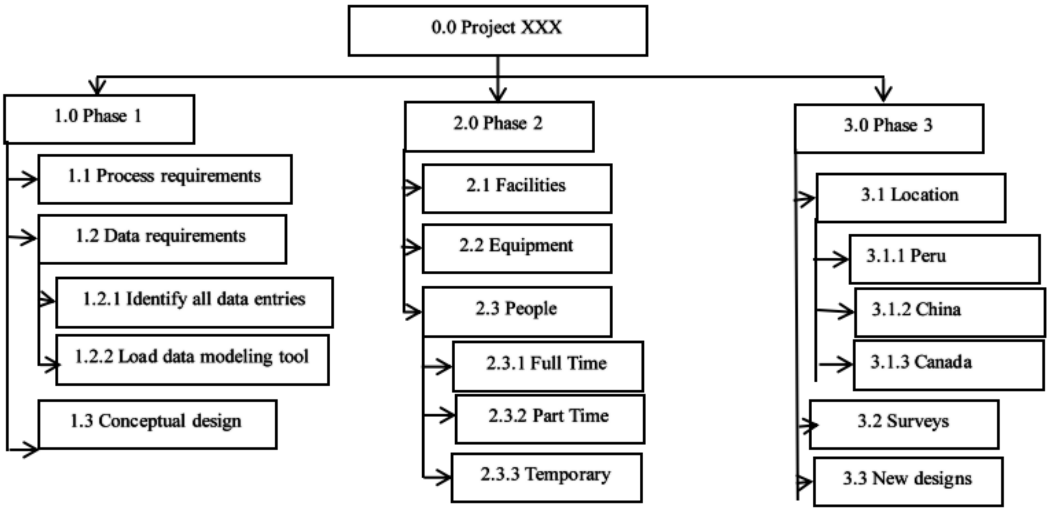
Figure 18: WBS example



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p89.

Many projects are structured or organized by project phases. Each phase would represent the first level of the WBS and their deliverables would be the next level and so on.

Figure 19: WBS example



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p 89.

WBS exercise:

Much work has to be done before June. First, Sally figures out what work needs to be done. She starts to put together a to-do list:

a. Invitations
b. Flowers
c. Wedding cake
d. Dinner menu
e. Band

Since many different people are involved in the making of the wedding, it takes much planning to coordinate all the work in the right order by the right people at the right time.

Initially, Sally was worried that she didn't have enough time to make sure that everything would be done properly. However, she knew that she had some powerful time management tools on her side when she took the job, and these tools would help her to synchronize all the required tasks.

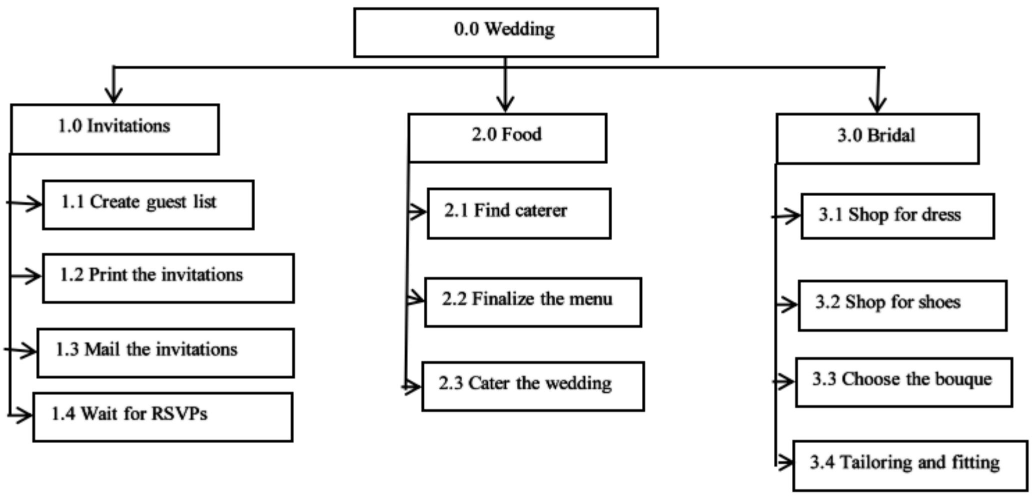
To get started, Sally arranged all the activities in a work breakdown structure. The next exercise presents part of the WBS Sally made for the wedding.

Arrange the following activities into the WBS to show how the work items decompose into activities.

a. Shop for shoes
b. Create guest list
c. Have the tailoring and fitting done
d. Shop for dress
e. Find caterer
f. Cater the wedding
g. Wait for RSVPs
h. Mail the invitations
i. Finalize the menu
j. Print the invitations
k. Choose the bouque

Solution to exercise:

Figure 20: WBS example



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p96.

II. EstImating activity time :

Determining the elapsed time between events requires that responsible functional managers evaluate the situation and submit their best estimates. The calculations for critical paths and slack times in the previous sections were based on these best estimates.

In this ideal situation, the functional manager would have at his disposal a large volume of historical data from which to make his estimates. Obviously, the more historical data available, the more reliable the estimate. Many programs, however, include events and activities that are nonrepetitive. In this case, the functional managers must submit their estimates using three possible completion assumptions:

- **a.** Optimistic completion time. This time assumes that everything will go according to plan and with minimal difficulties. This should occur approximately 1 percent of the time.
- **b.** Pessimistic completion time. This time assumes that everything will not go according to plan and maximum difficulties will develop. This should also occur approximately 1 percent of the time.
- **c.** 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.

Before these three times can be combined into a single expression for expected time, two assumptions must be made. The first assumption is that the standard deviation, δ, is one-sixth of the time requirement range. This assumption stems from probability theory, where the end points of a curve are three standard deviations from the mean. The second assumption requires that the probability distribution of time required for an activity be expressible as a beta distribution.

The expected time between events can be found from the expression (**three-point estimating (PERT method)**):

$$\boldsymbol{te} = \frac{\boldsymbol{a + 4m + b}}{\boldsymbol{6}}$$

where $\mathbf{t_e}$ = 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, $\mathbf{t_e}$, would be 5 weeks. This value for $\mathbf{t_e}$ 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 $\mathbf{t_e}$ 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.

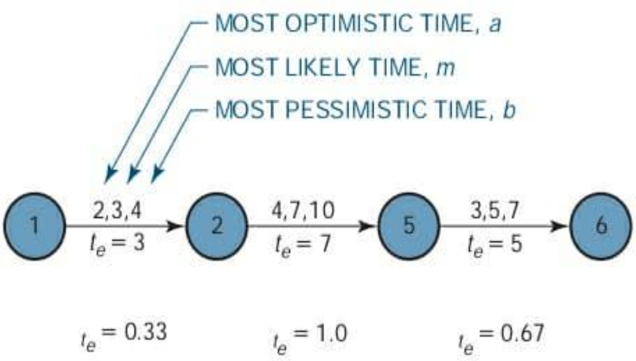
Estimating total project time

In order to calculate the probability of completing the project on time, the standard deviations of each activity must be known. This can be found from the expression:

$$\delta_{te} = \frac{b - a}{6}$$

where $\boldsymbol{\delta_{te}}$ is the standard deviation of the expected time, $\mathbf{t_e}$. Another useful expression is the variance, $\boldsymbol{\upsilon}$, which is the square of the standard deviation. The variance is primarily useful for comparison to the expected values. However, the standard deviation can be used just as easily, except that we must identify whether it is a one, two, or three sigma limit deviation.

Figure 21: **expected time analysis**



Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p513.

deviations. The total path standard deviation is calculated by the square root of the sum of the squares of the activity standard deviations using the following expression:

$$\sigma_{total} = \sqrt{\sigma_{1-2}^{2} + \sigma_{2-5}^{2} + \sigma_{5-6}^{2}}$$
$$= \sqrt{(0.33)^2 + (1.0)^2 + (0.67)^2}$$
$$= 1.25$$

The purpose of calculating δ is that it allows us to establish a confidence interval for each activity and the critical path. From statistics, using a normal distribution, we know that there is a 68 percent chance of completing the project within one standard deviation, a 95 percent chance within two standard deviations, and a 99.73 percent chance within three standard deviations.

This type of analysis can be used to measure the risks in the estimates, the risks in completing each activity, and the risks in completing the entire project. In other words, the standard deviation, δ, serves as a measurement of the risk. This analysis, however, assumes that normal distribution applies, which is not always the case.

1. Statistical indicators in PERT analysis

The **Program Evaluation and Review Technique (PERT)** not only estimates expected durations but also allows for probabilistic scheduling.

Two key indicators are:

A. **Standard deviation (σ):** (P-O)\6

Measures the uncertainty of an activity's duration.

C. **Variance (σ²):** ((P-O)\6)^2

Used to calculate overall project duration risk.

D. **Probability of completion:**

The likelihood that the project will finish before a certain time is estimated using the normal distribution:

$$Z = (T - TE)\backslash\sigma_{project}$$

Example:

If TE = 80 days, σ_project = 4 days, and desired completion time = 85 days → Z = (85-80) \4 = 1,25 ---probability ≈ 89%.

As an example of measuring risk, consider a network that has only three activities on the critical path as shown below (all times in weeks):

Table 6: measuring risk

Activity	Optimistic Time	Most Likely Time	Pessimistic Time	T_{ex}	σ	σ^2
A	3	4	5	4	2/6	4/36
B	4	4,5	8	5	4/6	16/36
C	4	6	8	6	2/6	16/36
				15		01

Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p515.

From the above table, the length of the critical path is 15 weeks. Since the variance (i.e., δ^2) is 1.0, then $\boldsymbol{\delta_{path}}$, which is the square root of the variance, must be 1 week.

We can now calculate the probability of completing the project within certain time limits:

a. The probability of getting the job done within 16 weeks is
b. 50% (1 ⁄2)(68%), or 84%.
c. Within 17 weeks, we have 50% (1 ⁄2)(95%), or 97.5%.
d. Within 14 weeks, we have 50% (1 ⁄2)(68%), or 16%.
e. Within 13 weeks, we have 50% (1 ⁄2)(95%), or 2.5%.

Estimating activity durations is a critical step in the project time management process. Once activities are identified through the Work Breakdown Structure (WBS), the next logical step is to determine how long each activity will take to complete.

According to the PMBOK® Guide (Project Management Institute, 2021), estimating activity durations involves assessing the amount of work required and the resources available to determine the number of periods needed to complete each activity.

2. Inputs to duration estimation

Duration estimation depends on various inputs, including:

a. **Activity list:** all activities defined in the WBS.

b. **Activity attributes:** details such as required resources and constraints.

c. **Resource requirements:** type and quantity of labor, materials, and equipment.

d. **Resource calendars:** availability of resources.

e. **Project scope statement:** clarifies what is included/excluded.

f. **Organizational process assets:** historical data, estimation templates, expert databases.

Example: If a similar past activity took 10 days with 3 workers, the new estimate can be adjusted based on team experience or resource changes.

3. Other key estimation techniques: There are several recognized methods for estimating activity durations:

3.1 Expert judgment

a. Based on the experience of professionals or subject matter experts.

b. Fast but subjective.

c. Often used in early project phases.

Example: Experienced engineers estimate the installation of new equipment will take 7–10 days.

3.2 Analogous estimating (top-down)

a. Uses data from previous similar projects.

b. Less accurate, but quick and cost-effective.

c. Useful when detailed data are unavailable.

Formula: Estimated Duration = Actual Duration of Similar Project × Adjustment Factor

3.3 Parametric estimating

a. Based on statistical relationships between variables.

b. Highly quantitative and repeatable.

Example: If it takes 5 hours to inspect 100 units, then inspecting 1,000 units ≈ 50 hours.

3.4 Bottom-up estimating

a. Each work package is broken into smaller tasks.

b. Durations are estimated individually and summed.

c. Most accurate but time-consuming.

Used when WBS is well defined.

3.5 Simulation and monte carlo analysis

a. Uses probability distributions to simulate thousands of scenarios.

b. Provides a range of possible durations and probabilities.

Example: There is a 70% chance that the project will be completed within 85 days.

4. Factors affecting duration estimates

a. Resource productivity and skill levels

b. Project complexity and scope clarity

c. Weather or environmental conditions

d. Technology and tools availability

e. Learning curve and repetition effect

f. Risks and uncertainty

5. Estimation biases and risks

a. **Optimism bias:** underestimating time.

b. **Anchoring bias:** relying on initial data.

c. **Strategic misrepresentation:** intentional underestimation for approval.

Mitigation: use historical data, peer review, and sensitivity analysis.

6. Practical example

Table 7: expected duration and standard deviation

activity	Optimistic (O)	Most Likely (M)	Pessimistic (P)	expected duration (E)	standard deviation (σ)
design	4 days	6 days	8 days	(4+4×6+8)/6 = 6 days	(8–4)/6 = 0.67
testing	2 days	3 days	5 days	(2+4×3+5)/6 = 3.17 days	(5–2)/6 = 0.5

7. Difference between duration and effort

Although often used interchangeably, duration and effort represent two distinct concepts in project scheduling.

Duration refers to the total elapsed time between the start and finish of an activity, including non-working periods (e.g., weekends or breaks).

Effort refers to the total amount of labor time required to complete the work, usually measured in person-hours or person-days.

Example: If an activity requires 40 labor hours and one person works 8 hours per day, the duration will be 5 days. If two people work simultaneously, the duration becomes 2.5 days while effort remains 40 hours. Understanding this distinction is crucial for resource allocation and realistic scheduling.

8. Estimating durations in agile project environments

A. In traditional (predictive) projects, duration estimation relies on time-based units such as days or weeks.

B. However, Agile methodologies (e.g., Scrum, Kanban) use relative estimation techniques that rely on experience rather than fixed time measures.

Common Agile estimation practices include:

a. **Story points:** represent the relative complexity, risk, and effort of user stories.

b. **Velocity:** measures how many story points a team completes in one iteration (sprint).

c. **Planning poker:** a consensus-based technique where team members discuss and agree on estimates.

Example: If a team's velocity is 40 story points per sprint and the backlog totals 200 story points, the estimated duration is around 5 sprints.

9. Duration estimation under time constraints (crashing and fast tracking)

When a project has a fixed deadline, managers may need to compress the schedule without changing the project scope. Two primary methods are used:

A. Crashing:

a. Involves adding extra resources (labor, equipment, cost) to shorten activity durations.

b. Usually increases project cost.

c. Used only on activities along the critical path.

B. Fast Tracking:

a. Involves performing activities in parallel that were originally scheduled in sequence.

b. Reduces schedule time but increases risk and coordination complexity.

Example:

A construction project may start interior design (non-structural work) before the full completion of structural activities to save time.

10. Common pitfalls in duration estimation

Project managers should be aware of frequent mistakes that undermine schedule accuracy:

Table 8: common pitfalls in duration estimation

pitfall	description	mitigation
Ignoring setup or transition times	Overlooking preparation or switching tasks	Include buffer time for setup/cleanup
Overreliance on optimistic estimates	Assuming best-case scenario	Use three-point estimation
Neglecting non-productive time	Breaks, approvals, travel time	Account for realistic working calendars
Failing to update estimates	Not revising after scope/resource changes	Implement rolling wave planning
Lack of team involvement	Estimates made by managers only	Involve task performers in estimation

11. Summary

a. Duration estimation bridges WBS and project scheduling.

b. Choosing the right estimation technique depends on project data availability, complexity, and required accuracy.

c. Combining expert judgment with quantitative methods improves reliability.

Application Series (Topic 05-02: ESTIMATING ACTIVITY TIME)

Exercise:

consider a network that contains Six activities on the critical path as shown below (all times in weeks)

Activity identifier	Activity title	Optimistic	Most Likely	Pessimistic	T_{EX}	δ	δ^2
01	Develop high-level scope	**3**	**4**	**6**			
02	Identify overall project risks	**3**	**5**	**9**			
03	Develop high-level schedule	**4**	**6**	**10**			
04	Identify main resources and develop a high-level budget	**1**	**2**	**5**			
05	Identify key stakeholders and project team member roles	**5**	**7**	**12**			
06	Develop project approval requirements and project exit criteria	**3**	**5**	**9**			
Total					**...**		**...**

1. Completing the table above.

2. Calculate the risks in completing the entire project (δ_{path}).

3. calculate the probability of completing the project within certain time limits.

4. And explain aboute for each indicatores.

III. Gantt Charts

Instructor Prompt:

Have you ever faced delays in completing a group project because of poor coordination or unclear deadlines? How could such delays have been avoided? Such challenges often occur when project tasks are not properly scheduled. A Gantt Chart helps visualize the sequence and duration of activities, making project planning more transparent and efficient.

Example:

Consider organizing a university seminar. The main tasks may include planning the agenda, inviting speakers, booking the venue, preparing materials, and conducting the event. By arranging these tasks on a Gantt Chart, you can clearly see which activities can run simultaneously and which depend on others.

Connection:

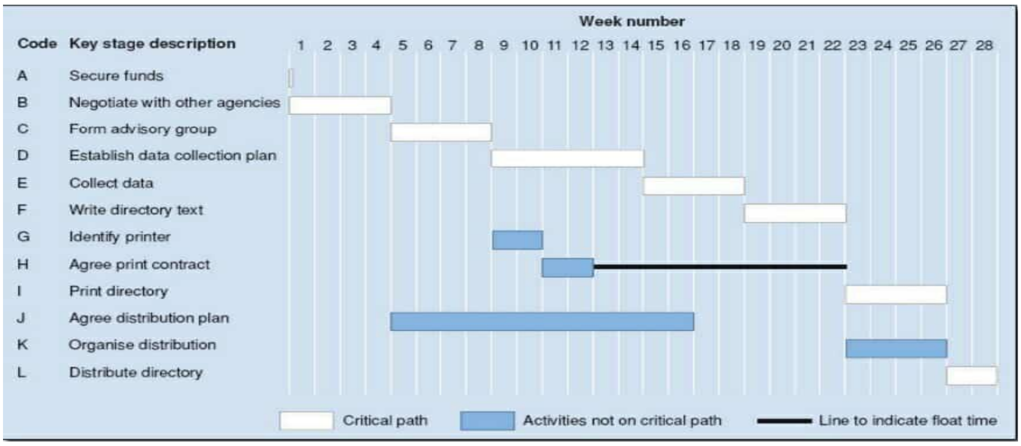
This situation can be effectively managed using a Gantt Chart, a project management tool that organizes activities, defines their durations, and shows their interdependencies — helping teams plan, monitor, and control time efficiently.

Creating the Gantt Chart

A Gantt chart is a type of bar chart, developed by Henry Gantt, that illustrates a project schedule. Gantt charts are easy to read and are commonly used to display schedule activities. These charts display the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts also show the dependency relationships (i.e., precedence network) between activities.

Gantt charts show all the key stages of a project and their duration as a bar chart, with the time scale across the top. The key stages are placed on the bar chart in sequence, starting in the top left corner and ending in the bottom right corner. A Gantt chart can be drawn quickly and easily and is often the first tool a project manager uses to provide a rough estimate of the time that it will take to complete the key tasks. Sometimes it is useful to start with the target deadline for completion of the whole project, because it is soon apparent if the time scale is too short or unnecessarily long. The detailed Gantt chart is usually constructed after the main objectives have been determined.

Figure 22: **Gantt chart**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p101.

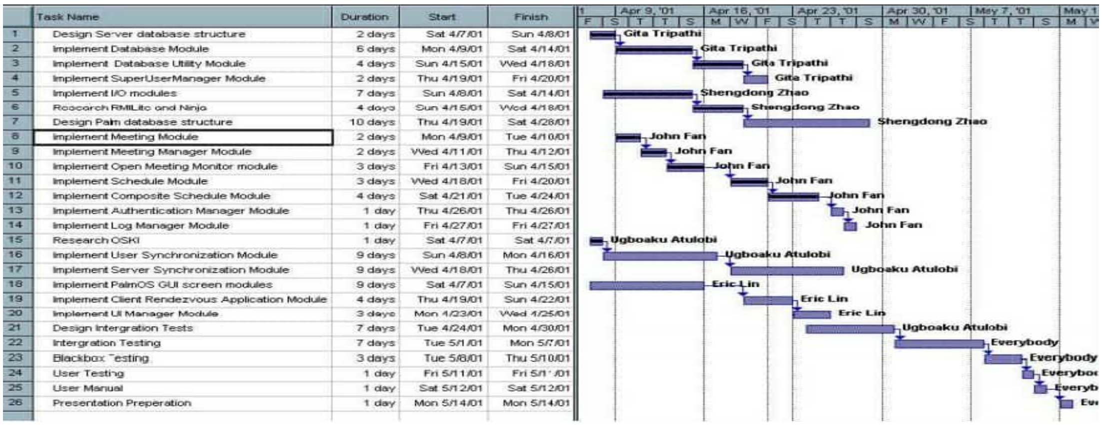
In this example in Figure, **key stage K (Organize distribution)** starts at week 23 so that its end point coincides with **key stage L (Distribute directory)**. However, K could begin as early as week 17, as soon as key stage J is completed. Key stage K is therefore said to have **"slack".**

Key stage H (Agree print contract) has been placed to end at week 12. However, it could end as late as week 22, because key stage I (Print directory) does not begin until week 23. Key stage H is therefore said to have **"float".** Float time can be indicated on the chart by adding a line ahead of the bar to the latest possible end point. **Slack and float** show you where there is flexibility in the schedule, and this can be useful when you need to gain time once the project is up and running.

For a complex project, you may decide to produce a separate Gantt chart for each of the key stages. If you do this shortly before each key stage begins, you will be able to take any last-minute eventualities into account. These charts **provide a useful tool for monitoring and control as the project progresses**.

Gantt charts are relatively easy to draw by hand, but this doesn't offer the same level of **flexibility during monitoring** that you would get from a software package. Various programs are available to assist project managers in scheduling and control. Once the data have been entered, a program helps you to work on "what if" scenarios, showing what might happen if a key stage is delayed or speeded up. This is more difficult if you are working manually.

Figure 23: **an example of a Gantt chart**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p113.

Illustrative example:

The following exercise presents a list of project activities with their durations and immediate predecessors. Use this information to construct a Gantt chart and analyze the project schedule.

Table 9: sequence of events

activity	immediate predecessors	time (Weeks)
A	-	1
B	A	5
C	A	2
D	B	2
E	B	2
F	C	2
G	C	3
H	DF	2
I	H	3
J	EI	3
K	GJ	2

Questions:

1. Based on the Gantt chart, calculate the total duration required to complete the project.
2. Identify the critical path and the critical activities on it.
3. Identify, if present, the non-critical activities and categorize them based on whether they have slack time or float time.
4. What is the amount of slack for the activities that have slack?
5. What is the amount of float for the activities that have float?

Real-Life Example – Preparing a Graduation Project:

Example Title: “Developing a Graduation Project – Gantt Chart Illustration”

Suppose a team of students is preparing their graduation project. The main activities are listed below with estimated durations (in weeks).

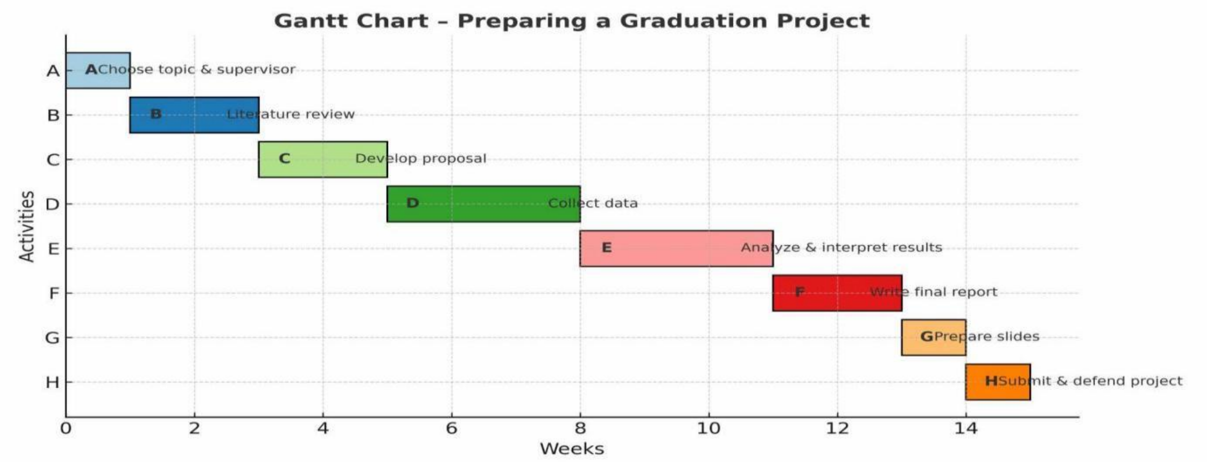
This example illustrates how to use a Gantt Chart to plan and visualize the schedule of a graduation project.

Table 10: immediate predecessor

Activity	Description	Duration (Weeks)	Immediate Predecessor
A	Choose project topic and supervisor	1	-
B	Conduct preliminary literature review	2	A
C	Develop project proposal	2	B
D	Collect data	3	C
E	Analyze data and interpret results	3	D
F	Write the final report	2	E
G	Prepare presentation slides	1	F
H	Submit and defend the project	1	G

Solution:

Figure 24: GANTT Chart



Explanation:

1. A Gantt Chart can be drawn with each activity represented by a horizontal bar.
2. The bars show when each task starts and ends, and whether some tasks can overlap (e.g., data collection might start before the literature review is fully completed, depending on the project).
3. This helps visualize the project schedule, estimate total duration, and identify possible bottlenecks.

Key Digital Tool:

a. MS project (for advanced planning)

b. TeamGantt (**www.teamgantt.com**)

c. Tom's planner (**www.tomsplanner.com**)

the basic steps is include:

1. Enter each activity name and its duration.
2. Define dependencies (which task must finish before another can start).
3. View the generated Gantt Chart — the software automatically creates bars and timelines.

Common Mistakes When Creating a Gantt Chart

1. Defining vague or overlapping tasks.
2. Ignoring task dependencies.
3. Overestimating or underestimating activity durations.
4. Not updating the chart when project changes occur.
5. Treating the Gantt Chart as static rather than a living planning tool.

Conclusion:

A Gantt Chart is more than a scheduling tool—it is a communication and coordination instrument that helps teams see progress, anticipate delays, and stay aligned toward shared goals.

Application Series (Topic 05-03: Gantt Charts)

Exercise 1:

Directorate of Culture of Sétif Province wishes to restore a historical site located in the city of Jamila. For this purpose, it contacted two companies specialized in restoration and requested them to submit their proposals regarding the completion time. The first company submitted the following offer:

Activity	Immediate Predecessor	Duration (Months)
A	**-**	**1**
B	**A**	**3**
C	**B**	**2**
D	**B**	**2**
E	**C**	**4**
F	**D**	**2**
G	**D**	**2**
H	**CD**	**2**
I	**EFGH**	**2**
J	**GI**	**1**

Questions:

1. Based on the Gantt chart, calculate the total duration required to complete the project.

2. Identify the critical path and the critical activities on it.

3. Identify, if present, the non-critical activities and categorize them based on whether they have slack time or float time.

4. What is the amount of slack for the activities that have slack?

5. What is the amount of float for the activities that have float?

Exercise 2:

The company produces and markets equipment used in the industrial sector. In order to fulfill a customer's order, the planning and scheduling department has prepared a chart showing the sequence of operations to be carried out for completing the order:

/	Activity	Duration (Days)	Immediate Predecessor
A	Determining material and supply requirements	**1**	**-**
B	Purchasing raw materials and supplies	**2**	**A**
C	Scheduling production	**5**	**A**
D	Production	**4**	**CB**
E	Packaging	**1**	**DC**
F	Order delivery	**4**	**E**

Questions:

1. Based on the Gantt chart, calculate the total duration required to complete the project.
2. Identify the critical path and the critical activities on it.
3. Identify, if present, the non-critical activities and categorize them based on whether they have slack time or float time.
4. What is the amount of slack for the activities that have slack?
5. What is the amount of float for the activities that have float?

Exercise 3:

You are provided with the data of a specific project:

Activity	Duration (Days)	Immediate Predecessor
A	2	-
B	2	A
C	1	A
D	2	A
E	1	BD
F	1	C
G	2	E
H	3	EFG

Questions:

1. Based on the Gantt chart, calculate the total duration required to complete the project.
2. Identify the critical path and the critical activities on it.
3. Identify, if present, the non-critical activities and categorize them based on whether they have slack time or float time.
4. What is the amount of slack for the activities that have slack?
5. What is the amount of float for the activities that have float?

IV. Critical Path Method (CPM) & PERT:

The critical path describes the sequence of tasks that would enable the project to be completed in the shortest possible time. It is based on the idea that some tasks must be completed before others can begin. A critical path diagram is a useful tool for scheduling dependencies and controlling a project. In order to identify the critical path, the length of time that each task will take must be calculated.

Networks are composed of events and activities. The following terms are helpful in understanding networks:

a. **Event:** Equivalent to a milestone indicating when an activity starts or finishes.
b. **Activity:** The element of work that must be accomplished.
c. **Duration:** The total time required to complete the activity.
d. **Effort:** 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.
e. **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.

Figure (25) shows the standard nomenclature for PERT networks.

The circles represent **events**, and arrows represent **activities**. The numbers in the circles signify the specific events or accomplishments. The number over the arrow specifies the time needed (hours, days, months), to go from event 6 to event 3.

The events need not be numbered in any specific order. However, event 6 must take place before event 3 can be completed (or begin).

In figure (A), event 26 must take place prior to events 7, 18, and 31.

In figure (B), the opposite holds true, and events 7, 18, and 31 must take place prior to event 26.

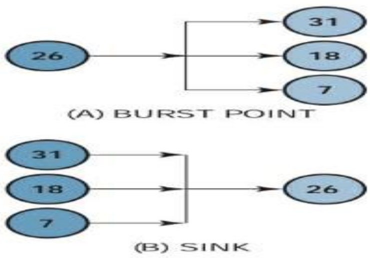
figure (B) is similar to **“and gates”** used in logic diagrams.

Figure 25: **standard PERT nomenclature**

Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p497.

PERT is basically 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).

Figure 26: **PERT sources (burst points) and sinks**



Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p497.

One of the purposes of constructing the **PERT** chart is to determine how much time is needed to complete the project. **PERT**, therefore, uses time as a common denominator to analyze those elements that directly influence the success of the project, namely, **time, cost, and performance**.

The construction of the network requires two inputs.

1. First, do events represent the start or the completion of an activity?
   - Event completions are generally preferred.
2. The next step is to define the sequence of events, as shown in Table:

Table 11: sequence of events

activity	immediate predecessors	time (Weeks)
A	-	1
B	A	5
C	A	2
D	B	2
E	B	2
F	C	2
G	C	3
H	DF	2
I	H	3
J	EI	3
K	GJ	2

Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p499.

Figure shows a typical PERT network. The bold line in Figure represents the critical path, which is established by the longest time span through the total system of events. The critical path is composed of events 1–2–3–5–6–7–8–9. The critical path is vital for successful control of the project because it tells management two things:

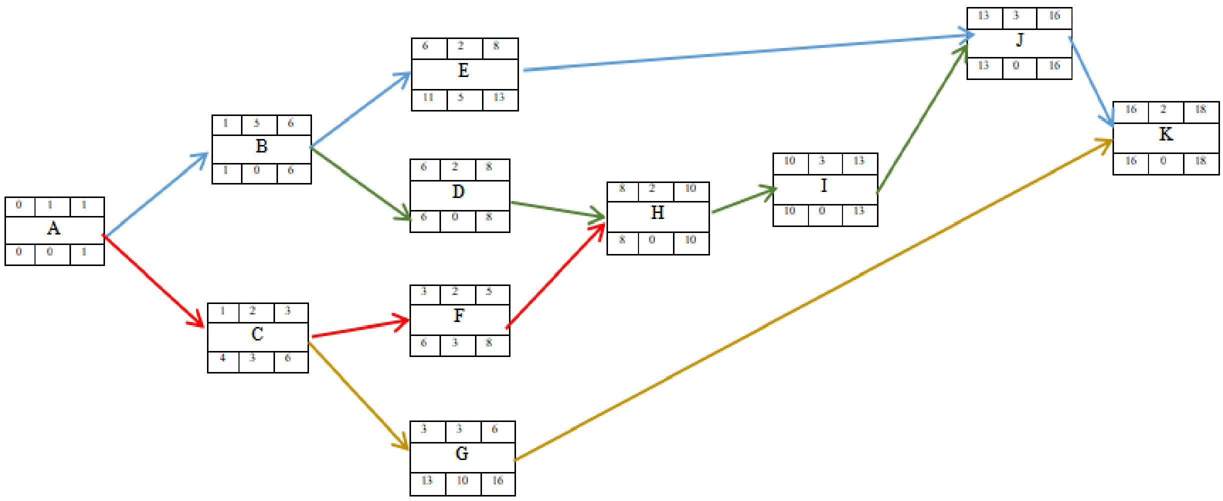
a. Because there is no slack time in any of the events on this path, any slippage will cause a corresponding slippage in the end date of the program unless this slippage can be recovered during any of the downstream events (on the critical path).
b. Because the events on this path are the most critical for the success of the project, management must take a hard look at these events in order to improve the total program.

Using PERT we can now identify the earliest possible dates on which we can expect an event to occur, or an activity to start or end. There is nothing overly mysterious about this type of calculation, but without a network analysis the information might be hard to obtain.

The nomenclature for 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 PERT and CPM 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).

Figure 27: **simplified PERT network**



Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p500.

Paths:

ABEJK = 13 Weeks

ABDHIJK = 18 Weeks

ACFHIJK = 15 Weeks

ACGK =8 Weeks

The critical path is **ABDHIJK = 18 Weeks.**

The duration of this project is **18 Weeks.**

a. **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.

b. **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.

Since there exists only one path through the network that is the longest, the other paths must be either equal in length to or shorter than that path. Therefore, there must exist events and activities that can be completed before the time when they are actually needed. The time differential between the scheduled completion date and the required date to meet critical path is referred to as the slack time.

The critical path is vital for resource scheduling and allocation because the project manager, with coordination from the functional manager, can reschedule those events not on the critical path for accomplishment during other time periods when maximum utilization of resources can be achieved, provided that the critical path time is not extended. This type of rescheduling through the use of slack times provides for a better balance of resources throughout the company, and may possibly reduce project costs by eliminating idle or waiting time.

Slack can be defined as the difference between the latest allowable date and the earliest expected date based on the nomenclature below:

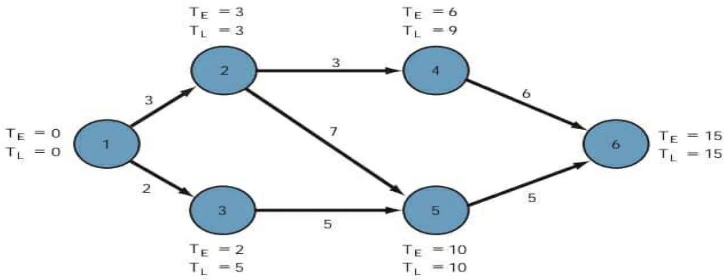
TE = the earliest time (date) on which an event can be expected to take place

TL = the latest date on which an event can take place without extending the completion date of the project

Slack time = TL - TE

The calculation for slack time is performed for each event in the network, by identifying the earliest expected date and the latest starting date. For event 1, TL - TE = 0. Event 1 serves as the reference point for the network and could just as easily have been defined as a calendar date. As before, the critical path is represented as a bold line. The events on the critical path have no slack (i.e., TL = TE) and provide the boundaries for the noncritical path events.

Figure 28: **network with slack time**



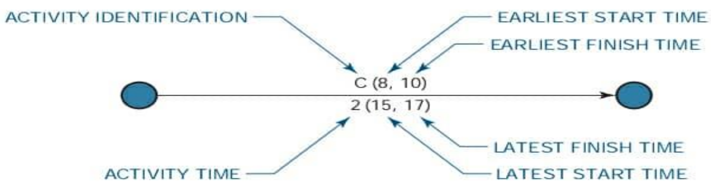
Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p503.

To make full use of the capabilities of PERT/CPM, we could identify four values:

a) The earliest time when an activity can start (ES)
b) The earliest time when an activity can finish (EF)
c) The latest time when an activity can start (LS)
d) The latest time when an activity can finish (LF)

To calculate 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.

Figure 29: **slack identification**



Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, p506.

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.

The identification of slack time can function as an early warning system for the project manager. As an example, if the total slack time available begins to decrease from one reporting period to the next, that could indicate that work is taking longer than anticipated or that more highly skilled labor is needed. A new critical path could be forming.

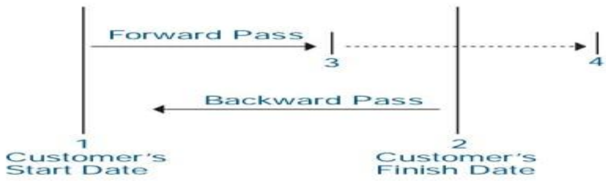
When performing a forward pass through a network, we work from left to right beginning at the customer's starting milestone (position 1). The backward pass, however, begins at the customer's end date milestone (position 2). If the forward pass ends at position 3, which is before the customer's end date, it is possible to have slack on the critical path. This slack is often called reserve time and may be added to other activities or filled with activities such as report writing so that the forward pass will extend to the customer's completion date.

At this point, it is important to understand the physical meaning of slack. Slack measures how early or how late an event can start or finish. When slack is calculated on the activity, it is usually referred to as float rather than slack, but most project managers use the terms interchangeably. For activity C in Figure, the float is eight units. If the float in an activity is zero, then it is a critical path activity.

Another term is maximum float. The equation for maximum float is:

Maximum float = latest finish - earliest start - duration

Figure 30: **slack time**



Source: Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling. 13th ed., Wiley, 507.

Transferring resources from slack paths to more critical paths is only one method for reducing expected project time. Several other methods are available:

a. Elimination of some parts of the project
b. Addition of more resources (i.e., crashing)
c. Substitution of less time-consuming components or activities
d. Parallelization of activities
e. Shortening critical path activities
f. Shortening early activities
g. Shortening longest activities
h. Shortening easiest activities
i. Shortening activities that are least costly to speed up
j. Shortening activities for which you have more resources
k. Increasing the number of work hours per day

Let's take a look at an example. The length of time in weeks for each key stage is estimated:

Table 12: stages of the critical path

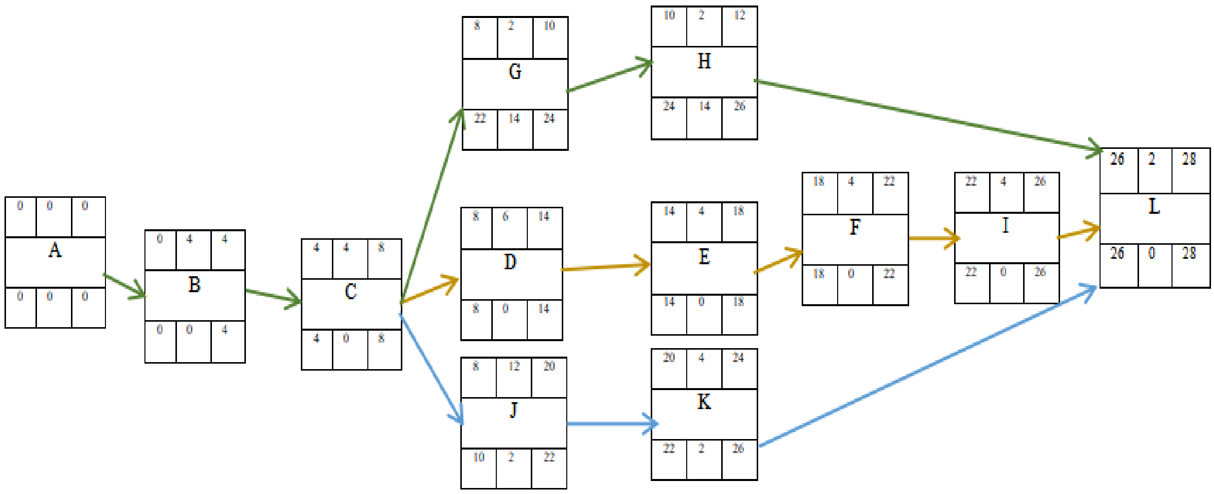
Key stage	**estimated time in weeks**	**immediate predecessors**
A. Secure funds	**0**	**-**
B. Negotiate with other agencies	**4**	**A**
C. Form advisory group	**4**	**B**
D. Establish data collection plan	**6**	**C**
E. Collect data	**4**	**D**
F. Write directory text	**4**	**E**
G. Identify printer	**2**	**C**
H. Agree print contract	**2**	**G**
I. Print directory	**4**	**F**

J. Agree distribution plan	**12**	**C**
K. Organize distribution	**4**	**J**
L. Distribute directory	**2**	**KIH**

We have given the key stage “Secure funds” an estimated time of zero weeks because the project cannot start without the availability of some funding, although estimates would provide detail at a later stage. The stages can now be lined up to produce **a network diagram** that shows that there are three paths from start to finish and that the lines making up each path have a minimum duration.

If we now trace each of the possible paths to **“Distribute directory”** (the finishing point), taking dependencies into account, the route that has the longest duration is known as the critical path. This is the minimum time in which it will be possible to complete the project.

Figure 31: **critical path diagram**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p105.

Paths:

ABCGHL = 14 Weeks

ABCDEFIL = 28 Weeks

ABCJKL = 26 Weeks

The critical path: ABCDEFIL

The duration required to complete the project is **28 Weeks**.

In this example, **the critical path** is A–B–C–D–E–F–I–L, and the earliest completion date for the project is the sum of the estimated times for all the stages on the critical path – **28**

weeks – from the point of securing the funding. All the key stages on the critical path must be completed on time if the project is to be finished on schedule.

Mapping the critical path helps to identify the activities that need to be monitored most closely.

Project schedule and critical path:

The critical path method is an important tool for keeping your projects on track. Every network diagram has something that is called **the critical path**. **It's the string of activities that, if you add up all of the durations, is longer than any other path through the network. It usually starts with the first activity in the network and usually ends with the last one.**

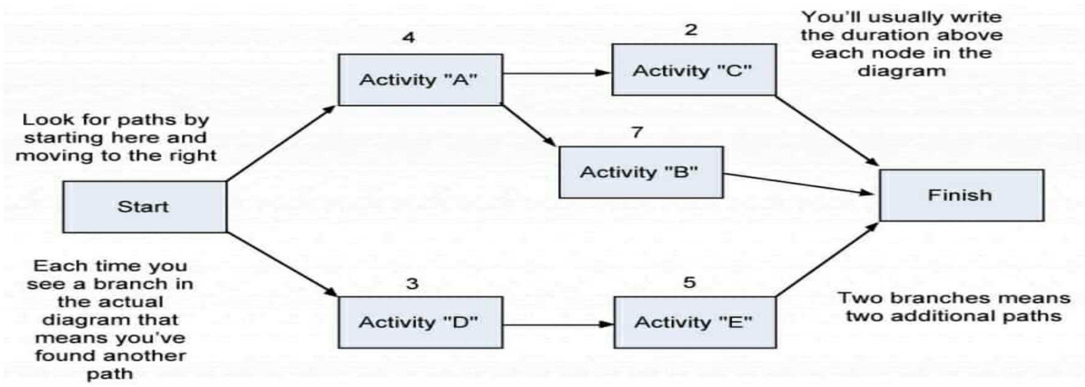
The reason that the critical path is **critical is that every single activity on the path must finish on time in order for the project to come in on time. A delay in any one of the critical path activities will cause the entire project to be delayed.**

Knowing where your critical path is can give you a lot of freedom. If you know an activity is not on the critical path, then you know a delay in that activity may not necessarily delay the project. This can really help you handle emergency situations. Even better, it means that if you need to bring your project in earlier than was originally planned, you know that adding resources to the critical path will be much more effective than adding them elsewhere.

It's easy to find the critical path in any project. Of course, on a large project with dozens or hundreds of tasks, you'll probably use software like **Microsoft Project** to find the critical path for you. But when it does, it's following the same exact steps that are followed here.

A. Step 1. start with a network diagram.

Figure 32: **create a network diagram**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p112.

B. **Step 2.** Find all the paths in the diagram. A path is any string of activities that goes from the start of the project to the end.

   a. Start > Activity “A” > Activity “B” > Finish
   b. Start > Activity “A” > Activity “C” > Finish
   c. Start > Activity “D” > Activity “E” > Finish

C. **Step 3.** Find the duration of each path by adding up the durations of each of the activities on the path.

   a. Start > Activity “A” > Activity “B” > Finish = 4 + 7 = 11
   b. Start > Activity “A” > Activity “C” > Finish = 4 + 2 = 6
   c. Start > Activity “D” > Activity “E” > Finish = 3 + 5 = 8

D. **Step 4.** The first path has a duration of 11, which is longer than the other paths, so it’s the critical path. The schedule can also be displayed using a Gantt chart.

Illustrative example:

Exercise: project schedule planning

Your team has been asked to test and document enhancements to a web application that allows buyers to purchase custom-printed canvas shoes. The tasks and dependencies are as follows:

a. Create a testing plan

Once the testing plan is ready, your team can:

b. Test the user interfaces
c. Test the database

d. Test the network

e. Write the documentation first draft

When the user interface tests are complete, you can:

A. Perform user testing—enlist some users to test the user interface

When the database and network testing are complete, you can:

B. Perform integration testing—network with the database

When all integration testing and user testing are complete, you can:

C. Perform system testing

Then you can:

D. Review and revise documentation

After all other tasks are complete, you can:

E. Obtain management approval

Table 13: duration estimates for the tasks:

activity	duration (Day)
A	3
B	10
C	6
D	7
E	20
F	5
G	3
H	8
I	4
J	5

Create a network diagram and a Gantt chart for the project tasks.

1. What is the planned duration for the testing project?

2. What is the critical path for the testing project?

3. For each task NOT on the critical path, calculate the amount of slack available.

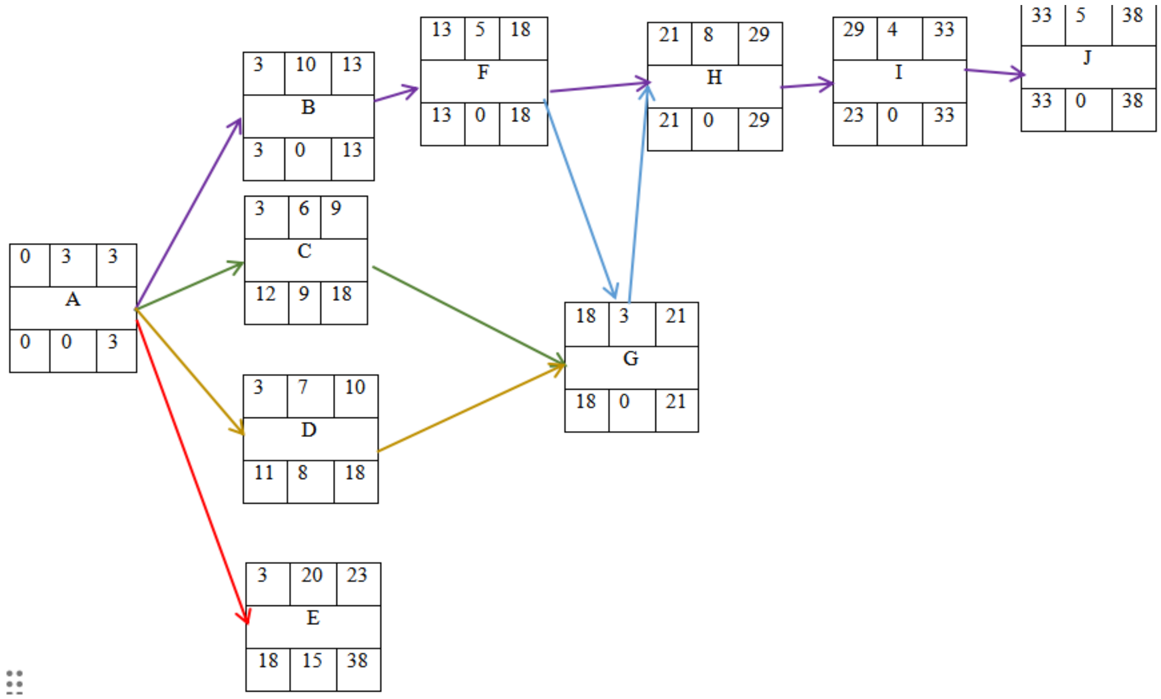
4. If the user testing of the user interface takes 15 days, what will the impact be on the project duration?

The solution:

Table 14: immediat predecessorse

activity	duration (Day)	immediat predecessorse
A	3	-
B	10	A
C	6	A
D	7	A
E	20	A
F	5	B
G	3	DCF
H	8	FG
I	4	H
J	5	I

Figure 33: **PERT network**



Paths:

ABFHIJ = 35 days

ABFGHIJ = 38 days

ACGHIJ = 29 days

ADGHIJ = 30 days

AE = 23 days

The critical path = 38 days is **ABFGHIJ,** and the path **ABFHIJ** is also critical path because the Slack time in activity within this path is equal Zero (0).

Application Series (Topic 05-04: Critical Path Method (CPM) & PERT)

Exercise 1:

Directorate of Culture of Sétif Province wishes to restore a historical site located in the city of Jamila. For this purpose, it contacted two companies specialized in restoration and requested them to submit their proposals regarding the completion time. The first company submitted the following offer:

Activity	Immediate Predecessor	Duration (Months)
A	**-**	**1**
B	**A**	**3**

C	**B**	**2**
D	**B**	**2**
E	**C**	**4**
F	**D**	**2**
G	**D**	**2**
H	**CD**	**2**
I	**EFGH**	**2**
J	**GI**	**1**

✧ **Questions:**

1. Draw a **PERT/CPM network**, showing for each activity (ES, EF, LS, LF, and slack time).
2. Extract from the network the project paths and the duration of each path, identify the critical paths, and determine the shortest time required to complete the project.
3. Compare the results you obtained in the **Gantt chart** with those obtained in the **PERT/CPM** analysis.

Exercise 2:

The company produces and markets equipment used in the industrial sector. In order to fulfill a customer's order, the planning and scheduling department has prepared a chart showing the sequence of operations to be carried out for completing the order:

/	Activity	Duration (Days)	Immediate Predecessor
A	Determining material and supply requirements	**1**	**-**
B	Purchasing raw materials and supplies	**2**	**A**
C	Scheduling production	**5**	**A**
D	Production	**4**	**CB**
E	Packaging	**1**	**DC**
F	Order delivery	**4**	**E**

* **Questions:**

1. Draw a **PERT/CPM network**, showing for each activity (ES, EF, LS, LF, and slack time).
2. Extract from the network the project paths and the duration of each path, identify the critical paths, and determine the shortest time required to complete the project.
3. Compare the results you obtained in the **Gantt chart** with those obtained in the **PERT/CPM** analysis.

Exercise 3:

You are provided with the data of a specific project:

Activity	Duration (Days)	Immediate Predecessor
A	2	-
B	2	A
C	1	A
D	2	A
E	1	BD
F	1	C
G	2	E
H	3	EFG

Questions:

1. Draw a **PERT/CPM network**, showing for each activity (ES, EF, LS, LF, and slack time).
2. Extract from the network the project paths and the duration of each path, identify the critical paths, and determine the shortest time required to complete the project.
3. Compare the results you obtained in the **Gantt chart** with those obtained in the **PERT/CPM** analysis.

Topic 06: project resources and cost management

I. Estimating costs and budgets:

Every project boils down to money. If you had a bigger budget, you could probably get more people to do your project more quickly and deliver more. That's why no project plan is complete until you come up with a budget. But no matter whether your project is big or small, and no matter how many resources and activities are in it, the process for figuring out the bottom line is always the same.

It is important to come up with detailed estimates for all the project costs. Once this is compiled, you add up the cost estimates into a budget plan. It is now possible to track the project according to that budget while the work is ongoing.

Often, when you come into a project, there is already an expectation of how much it will cost or how much time it will take. When you make an estimate early in the project without knowing much about it, that estimate is called a rough order-of-magnitude estimate (or a ballpark estimate). This estimate will become more refined as time goes on and you learn more about the project. Here are some tools and techniques for estimating cost:

Determination of resource cost rates: People who will be working on the project all work at a specific rate. Any materials you use to build the project (e.g., wood or wiring) will be charged at a rate too. Determining resource costs means figuring out what the rate for labour and materials will be.

Example (01):

A company is working on an air conditioning installation project in a building. It requires:

a. 5 workers, cost per worker = 2,000 DZD/day

b. 2 installation machines, cost per machine = 5,000 DZD/day

c. 50 kg of installation materials, cost per kg = 500 DZD

d. Activity duration = 3 days

Cost calculation for each resource:

a. **Workers =** 5 × 2,000 × 3 = 30,000 DZD

b. **Machines =** 2 × 5,000 × 3 = 30,000 DZD

c. **Materials =** 50 × 500 = 25,000 DZD

Total activity cost = 30,000 + 30,000 + 25,000 = 85,000 DZD

Here, the **resource cost rate** for each type of resource was used as a tool to accurately estimate the activity cost.

Vendor bid analysis: Sometimes you will need to work with an external contractor to get your project done. You might even have more than one contractor bid on the job. This tool is about evaluating those bids and choosing the one you will accept.

Example (02):

You need 10 machines to carry out a specific activity. You request price quotations from 3 vendors:

a. **Vendor A** → $1200 per machine

b. **Vendor B** → $1100 per machine

c. **Vendor C** → $1500 per machine

Analyzing the quotations leads you to select **Vendor B**.

The estimated cost of the activity = 1100 × 10 = $11,000.

Reserve analysis: You need to set aside some money for cost overruns. If you know that your project has a risk of something expensive happening, it is better to have some cash available to deal with it. Reserve analysis means putting some cash away in case of overruns.

Example (03):

The project team estimates that installing the information system will cost **200,000 DZD**, but there are potential risks related to delays in server delivery.

After performing reserve analysis, the team decides to add **10%** as a contingency reserve to address this risk.

Total estimated cost = 200,000 DZD + (10% × 200,000) = 220,000 DZD

Cost of quality: You will need to figure the cost of all your quality-related activities into the overall budget. Since it's cheaper to find bugs earlier in the project than later, there are always quality costs associated with everything your project produces. Cost of quality is just a way of tracking the cost of those activities. It is the amount of money it takes to do the project right.

Example (04):

To reduce errors during the construction project, the project team plans to **conduct quality training costing 50,000 DZD** and **perform inspection tests costing 30,000 DZD**. The team also expects that, if errors occur, around **20,000 DZD will be spent on rework**.

Total cost of quality = 50,000 DZD (prevention) + 30,000 DZD (appraisal) + 20,000 DZD (failure) = 100,000 DZD

a. **Base project cost =** 200,000 DZD

b. **Contingency reserve (10%) =** 20,000 DZD

c. **Cost of quality (COQ) =** 100,000 DZD

Total estimated project cost = base cost + contingency reserve + COQ = 320,000 DZD

Once you apply all the tools in this process, you will arrive at an estimate for how much your project will cost. Now you are ready to build your budget plan.

Estimating costs:

the amount of time and resources used to make the estimates should be appropriate to the size and complexity of the project. The methods used to estimate the cost of the project during the selection phase are generally faster and consume fewer resources than those used to create detailed estimates in later phases. They rely more on the expert judgment of experienced managers who can make accurate estimates with less detailed information. Estimates in the earliest stages of project selection are usually based on information from previous projects that can be adjusted—**scaled**—to match the size and complexity of the current project or developed using standardized formulas.

analogous estimate:

An estimate that is based on other project estimates is an **analogous estimate**. If a similar project cost a certain amount, then it is reasonable to assume that the current project will cost about the same. Few projects are exactly the same size and complexity, so the estimate must be adjusted upward or downward to account for the differences.

Example (05): analogous estimate for John's Move

John sold his apartment and purchased another one. It is now time to plan for the move. John asked a friend for advice about the cost of his move. His friend replied, "I moved from an apartment a little smaller than yours last year and the distance was about the same. I did it with a 14-foot truck. It cost about $575 for the truck rental, pads, hand truck, rope, boxes, and gas." Because of the similarity of the projects, John's initial estimate of the cost of the move was less than $700 so he decided that the cost would be affordable and the project could go forward.

Parametric estimate:

If the project consists of activities that are common to many other projects, average costs are available per unit. For example, if you ask a construction company how much it would cost to build a standard office building, the estimator will ask for the size of the building in square feet and the city in which the building will be built. From these two factors—size and location—the company's estimator can predict the cost of the building. Factors like size and location are **parameters**—measurable factors that can be used in an equation to calculate a result. The estimator knows the average cost per square foot of a typical office building and adjustments for local labour costs. Estimates that are calculated by multiplying measured parameters by cost-per-unit values are **parametric estimates**.

Example (06): parametric estimate for John's Move

To estimate the size of the truck needed for John's move, the parameter used by a truck rental company is the number of bedrooms. The company assumes that the number of bedrooms is the important parameter in determining how big a truck is needed for a move. John has a one-bedroom apartment, so he chooses the 14-foot truck. Once the size is determined, other parameters, such as distance and days, are used to estimate the cost of the truck rental.

Figure 34: **parametric cost estimate**

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p138.

Bottom-Up Estimating:

The most accurate and time-consuming estimating method is to identify the cost of each item in each activity of the schedule, including labour and materials. If you view the project schedule as a hierarchy where the general descriptions of tasks are at the top and the lower levels become more detailed, finding the price of each item at the lowest level and then summing them to determine the cost of higher levels is called **bottom-up estimating.**

Example (07): bottom-up estimate for John's Move

Table 15: detailed cost estimate

Category	Description	Activity	Quantity	Unit Price	Cost
Packing Materials	Small Boxes	2.1	10	1,70$	17,00$
Packing Materials	Medium Boxes	2.1	15	2,35$	35,25$
Packing Materials	Large Boxes	2.1	7	3,00$	21,00$
Packing Materials	Extra-Large Boxes	2.1	7	3,75$	26,25$
Packing Materials	Short-Hanger Boxes	2.1	3	7,95$	23,85$
Packing Materials	Box Tape	2.1	2	3,85$	7,70$
Packing Materials	Markers	2.1	2	1,50$	3,00$
Packing Materials	Mattress/Spring Bags	2.1	2	2,95$	5,90$
Packing Materials	Life Straps per Pair	2.1	1	24,95$	24,95$
Packing Materials	Bubble Wrap	2.1	1	19,95$	19,95$
Packing Materials	Furniture Pads	2.1	4	7,95$	31,80$
Truck	Rental	2.2	-	-	400,00$
Truck	Gas at 10mpg	2.2	200	2,25$	45,00$

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p139.

After evaluating the bids by the moving companies, John decides the savings are worth his time if he can get the packing done with the help of his friends. He decides to prepare a detailed estimate of costs Table (01) for packing materials and use of a rental truck. He looks up the prices for packing materials and truck rental costs on company websites and prepares a detailed list of items, quantities, and costs.

This type of estimate is typically more accurate than an analogous or parametric estimate. In this example, the sum of packing materials and truck expenses is estimated to be $661.25.

The estimate can be rolled up—subtotaled—to display less detail. This process is made easier using computer software. On projects with low complexity, the cost estimates can be done on spreadsheet software. On larger projects, software that manages schedules can also manage costs and display them by activity and category. For example, the subtotal feature could be used in Excel and collapsed to show the subtotals for the two categories of costs (Figure 01).

Table 16: sum of detailed costs by type

Type	Description	Quantity	Unit Price	Cost
A	**Packing Materials Total**			**216,65 $**
B	**Truck Total**			**445,00 $**
C	**Grand Total**			**661,65 $**

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p140.

Activity-Based Estimates:

An activity can have costs from multiple vendors in addition to internal costs for labour and materials. Detailed estimates from all sources can be reorganized so those costs associated with a particular activity can be grouped by adding the activity code to the detailed estimate (Table 02).

Table 17: costs associated with activities

Category	Activity	Cost
Packing Materials	2.1	$216.65
Truck	2.2	$445.00

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p140.

The detailed cost estimates can be sorted and then subtotaled by activity to determine the cost for each activity.

Illustrative example:

Example (08): You are provided with the data of a specific project:

Table 18: direct and indirect cost

Activity	Immediate Predecessor	Duration (Months)	Direct cost per month (1000 DZ)	Indirect cost
A	-	1	84	35% from the activity`s direct costs
B	A	5	123	61% from the activity`s direct costs
C	A	2	92	40% from the activity`s direct costs
D	B	2	112	22% from the activity`s direct costs
E	B	2	273	56% from the activity`s direct costs
F	C	2	164	11% from the activity`s direct costs
G	C	3	178	78% from the activity`s direct costs
H	DF	2	212	63% from the activity`s direct costs
I	H	3	166	40% from the activity`s direct costs
J	EI	3	123	55% from the activity`s direct costs
K	GJ	2	100	8% from the activity`s direct costs

Questions:

1. Calculate the Estimated Project Cost.

2. Prepare the Cumulative Estimated Budget for the Project.

Solution:

Table 19: estimated project cost

Activity	IP	Duration (Months)	Direct cost (1000 DZD)	Total Indirect cost (1000 DZD)	Total cost (1000 DZD)	Average Cost per month
A	-	1	84	29,4	113,4	**113,4**
B	A	5	123 × 5 = 615	375,15	990,15	**198,03**
C	A	2	92 × 2 = 184	73,6	257,6	**128,8**
D	B	2	112 × 2 = 224	49,28	273,28	**136,64**
E	B	2	273 × 2 = 546	305,76	851,76	**425,88**
F	C	2	164 × 2 = 328	36,08	364,08	**182,04**
G	C	3	178 × 3 = 534	416,52	950,52	**316,84**
H	DF	2	212 × 2 = 424	267,12	691,12	**345,56**
I	H	3	166 × 3 = 498	199,2	697,2	**232,4**
J	EI	3	123 × 3 = 369	202,95	571,95	**190,65**
K	GJ	2	100 × 2 = 200	16	216	**108**
Estimated project Cost			**4006**	**1.971,06**	**5.977,06**	/

Table 20: cumulative estimated budget for the project

Activity	IP	D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
A	-	1	113,4																		113,4
B	A	5		198,03	198,03	198,03	198,03	198,03													990,15
C	A	2		128,8	128,8																257,6
D	B	2							136,64	136,64											273,28
E	B	2							425,88	425,88											851,76
F	C	2				182,04	182,04														364,08
G	C	3				316,84	316,84	316,84													950,52
H	DF	2									345,56	345,56									691,12
I	H	3											232,4	232,4	232,4						697,2
J	EI	3														190,65	190,65	190,65			571,95
K	GJ	2																	108	108	216
Monthly Totals			113,4	326,83	326,83	696,91	696,91	514,87	562,52	562,52	345,56	345,56	232,4	232,4	232,4	190,65	190,65	190,65	108	108	5.977,06
Moving totals			113,4	440,23	767,06	1.463,97	2.160,88	2.675,75	3.238,27	3.800,79	4.146,35	4.491,91	4.724,31	4.956,71	5.189,11	5.379,76	5.570,41	5.761,06	5.869,06	5.977,06	

Evaluating the Budget During the Project:

A project manager must regularly compare the amount of money spent with the budgeted amount and report this information to managers and stakeholders. It is necessary to establish an understanding of how this progress will be measured and reported.

a budget report must compare the amount spent with the amount that is expected to be spent by that point in the project. Basic measures such as percentage of activities completed, percentage of measurement units completed, and percentage of budget spent are adequate for less complex projects, but more sophisticated techniques are used for projects with higher complexity.

Application Series (Topic 06-01 : Project Resources and Cost Management)

Exercise 1:

Directorate of Culture of Sétif Province wishes to restore a historical site located in the city of Jamila. For this purpose, it contacted two companies specialized in restoration and requested them to submit their proposals regarding the completion time. The first company submitted the following offer:

Activity	Immediate Predecessor	Duration (Months)	Direct cost per month (1000 DZ)	Indirect cost (1000 DZ)
A	-	1	84	?
B	A	3	123	?
C	B	2	92	?
D	B	2	112	?
E	C	4	273	?
F	D	2	164	?
G	D	2	178	?
H	CD	2	212	?
I	EFGH	2	166	?
J	GI	1	123	?

Questions:

1. Preparing the project's estimated budget, given that:

a. For activities whose total direct costs are less than or equal to 250,000 DZD, their indirect costs are 50% of these direct costs.

b. For activities whose total direct costs range between 250,001 DZD and 400,000 DZD, their indirect costs are 30% of the direct costs.

c. For activities whose total direct costs exceed 400,000 DZD, their indirect costs are 20% of the direct costs.

2. What is the total cost of the project?

3. Prepare the project's cumulative budget.

Exercise 2:

The company produces and markets equipment used in the industrial sector. In order to fulfill a customer's order, the planning and scheduling department has prepared a chart showing the sequence of operations to be carried out for completing the order:

Activity	Duration (Days)	Immediate Predecessor	Costs			
			Indirect Costs	Direct Costs		
				Labor (Number of Workers)	Raw Materials (Number of Units per day)	Depreciation of Production Equipment (Number of Units)
A	**1**	**-**	20% of the Activity's Direct Costs	**1**	**2**	**10**
B	**2**	**A**	20% of the Activity's Direct Costs	**3**	**7**	**20**
C	**5**	**A**	20% of the Activity's Direct Costs	**1**	**4**	**5**
D	**4**	**CB**	20% of the Activity's Direct Costs	**4**	**12**	**40**
E	**1**	**DC**	20% of the Activity's Direct Costs	**1**	**5**	**10**
F	**4**	**E**	20% of the Activity's Direct Costs	**1**	**1**	**4**

Questions:

Preparing the project's estimated budget, knowing that for the completion of the project, each activity requires a certain number of workers per day, consumes a specific quantity of raw materials, and incurs a share of the depreciation cost of production equipment, as shown in the table above.

It is also known that the daily wage of one worker is 15,000 DZD, the cost of one unit of raw materials is 35,000 DZD, and the share of depreciation of production equipment is 600 DZD per unit for each working day.

Exercise 3: You are provided with the data of a specific project:

Activity	Duration (Days)	Immediate Predecessor	Direct Costs			Indirect Costs
			Labor Workforce	Consumable materials	Equipment rental	
			Number of Workers per day	Daily (per kg)	Daily number of equipment units	
A	2	-	1	10	1	10% from the activity`s direct labor
B	2	A	2	20	1	40% from the activity`s consumed materials
C	1	A	3	30	1	20% from the activity`s total equipment rental
D	2	A	1	10	1	20% from the activity`s direct labor
E	1	BD	2	20	1	15% from the activity`s consumed materials
F	1	C	3	30	1	20% from the activity`s total equipment rental
G	2	E	1	10	1	8% from the activity`s total direct costs
H	3	EFG	2	20	1	Nothing

Questions:

1. Preparing the project's estimated budget and determining the project's estimated total cost, knowing that the project requires daily use of labor, materials, and rented equipment:

a. The daily wage of one worker is 3,000 DZD.

b. The cost of one kilogram of consumed materials is 400 DZD.

c. The rental cost of one machine is 18,000 DZD per day.

2. Prepare the project's cumulative budget.

II. Earned Value Management (EVM) :

Earned value analysis

A method that is widely used for medium- and high-complexity projects is the **earned value management (EVM)** method. EVM is a method of periodically comparing the budgeted costs with the actual costs during the project. It combines the scheduled activities with detailed cost estimates of each activity.

The **budgeted cost of work scheduled (BCWS)** comprises the detailed cost estimates for each activity in the project. The amount of work that should have been done by a particular date is the **planned value (PV)**.

The **budgeted cost of work performed (BCWP)** is the budgeted cost of work scheduled that has been done. If you sum the BCWP values up to that point in the project schedule, you have the **earned value (EV).** The amount spent on an item is often more or less than the estimated amount that was budgeted for that item. The **actual cost (AC)** is the sum of the amounts actually spent on the items.

Schedule Variance (SV)

The project manager must know if the project is on schedule and within the budget. The difference between planned and actual progress is the **variance**. The **schedule variance (SV)** is the difference between the earned value (EV) and the planned value (PV). Expressed as a formula, $SV = EV - PV$. If less value has been earned than was planned, the schedule variance is negative, which means the project is behind schedule.

Cost Variance (CV)

The difference between the earned value (EV) and the actual cost (AC) is the cost variance (CV). Expressed as a formula, $CV = EV - AC$. A positive CV indicates the project is under budget.

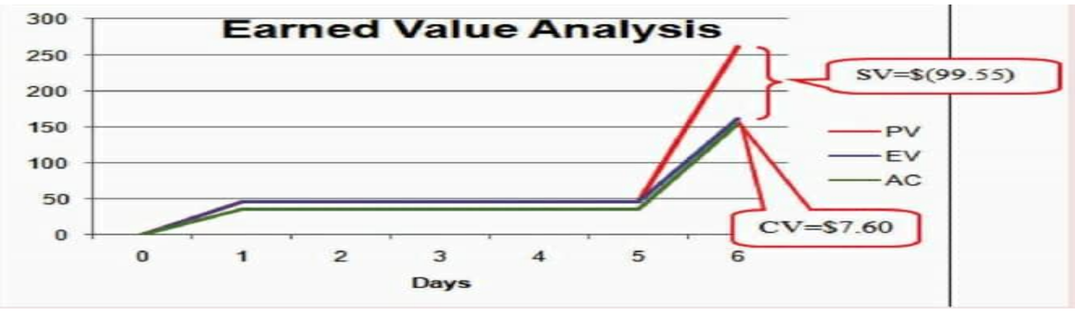
Variance Indexes for Schedule and Cost

The schedule variance and the cost variance provide the amount by which the spending is behind (or ahead of) schedule and the amount by which a project is exceeding (or not fully using) its budget. They do not give an idea of how these amounts compare with the total budget.

The ratio of earned value to planned value gives an indication of how much of the project is completed. This ratio is **the schedule performance index (SPI)**. The formula is SPI = EV ÷ PV.

The ratio of the earned value to the actual cost is the cost performance index (CPI). The formula is CPI = EV ÷ AC.

Figure 35: **example for schedule variance and cost varianc**



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p146.

During the project, the manager can evaluate the schedule using the schedule variance (SV) and the schedule performance index (SPI), and the budget using the cost variance (CV) and the cost performance index (CPI).

Estimated Cost to Complete the Project:

Part way through the project, the manager evaluates the accuracy of the cost estimates for the activities that have taken place and uses that experience to predict how much money it will take to complete the unfinished ativities—**the estimate to complete (ETC)**.

To calculate the ETC, the manager must decide if the cost variance observed in the estimates to that point are representative of the future. For example, if unusually bad weather causes increased cost during the first part of the project, it is not likely to have the same effect on the rest of the project. If the manager decides that the cost variance up to this point in the project is atypical—not typical—then the estimate to complete is the difference between the original budget for the entire project—the **budget at completion (BAC)**—and the earned value (EV) up to that point. Expressed as a formula, ETC = BAC − EV.

If the manager decides that the cost variance is caused by factors that will affect the remaining activities, such as higher labour and material costs, then the estimate to complete (ETC) needs to be adjusted by dividing it by the cost performance index (CPI).

Estimate Final Project Cost

If the costs of the activities up to the present vary from the original estimates, this will affect the total estimate of the project cost. The new estimate of the project cost is the estimate at completion (EAC). To calculate the EAC, the **estimate to complete (ETC)** is added to the actual cost (AC) of the activities already performed. Expressed as a formula, EAC = AC + ETC.

Table 21: summary of terms and formulas for earned value analysis

Term	Acronym	Description	Formula
Actual Cost	**AC**	The mony actually spent on projects up to the present	-
Budget at Completion	**BAC**	Original budget for the project (same as BCWS)	-
Cost Performance Index	**CPI**	Ratio of Earned Value to Actual Cost	**CPI = EV ÷ AC**
Cost Variance	**CV**	Difference Between Earned Value and Actual Cost	**CV = EV - AC**
Earned Value	**EV**	Sum of the estimates for work actually done up to the present	-
Estimate at Completion	**EAC**	Revised Estimate of total project cost	**EAC = AC + ETC**
Estimate to Complete	**ETC**	Money to Complete the project if early cost variance is typical	**ETC = (BAC - EV) ÷ CPI**

Planned Value	**PV**	Sum of the estimates for work done up to the present	-
Schedule Performance Index	**SPI**	Ratio of Earned Value to Planned Value	**SPI = EV ÷ PV**
Schedule Variance	**SV**	Difference Between Earned Value and Planned Value	**SV = EV - PV**
Overall Project Performance Index	**OPPI**	Schedule Performance Index Multiplied by Cost Performance Index	**OPPI = SPI x CPI**
Additional Amount Required to Complete the Project	**AARCP**	defference Between Estimate At Completion (EAC) and Budget At Completion (BAC)	**AARCP = EAC - BAC**

Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p148.

To summarize:

A. Extra money is allocated in a contingency fund to deal with activities where costs exceed estimates. Funds are allocated in a management reserve in case a significant opportunity or challenge occurs that requires change of scope but funds are needed immediately before a scope change can typically be negotiated.

B. Schedule variance is the difference between the part of the budget that has been spent so far (EV) versus the part that was planned to be spent by now (PV). Similarly, the cost variance is the difference between the EV and the actual cost (AC).

C. The schedule performance index (SPI) is the ratio of the earned value and the planned value. The cost performance index (CPI) is the ratio of the earned value (EV) to the actual cost (AC).

D. The formula used to calculate the amount of money needed to complete the project (ETC) depends on whether or not the cost variance to this point is expected to continue (typical) or not (atypical). If the cost variance is atypical, the ETC is simply the original total budget (BAC) minus the earned value (EV). If they are typical of future cost variances, the ETC is adjusted by dividing the difference between BAC and EV by the CPI.

E. The final budget is the actual cost (AC) to this point plus the estimate to complete (ETC).

Establishing a Budget:

Once you have broken your project down into activities, you will be able to calculate your overall project costs by estimating and totaling the individual activity costs.

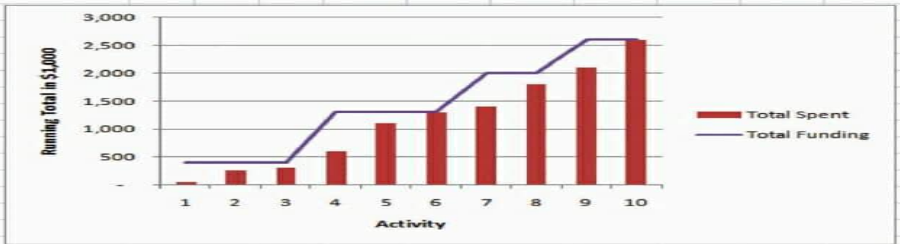
This process of subtotaling costs by category or activity is called **cost aggregation**.

Budget Timeline:

Costs are associated with activities, and since each activity has a start date and a duration period, it is possible to calculate how much money will be spent by any particular date during the project. The money needed to pay for a project is usually transferred to the project account shortly before it is needed. These transfers must be timed so that the money is there to pay for each activity without causing a delay in the start of the activity. If the money is transferred too far in advance, the organization will lose the opportunity to use the money somewhere else, or they will have to pay unnecessary interest charges if the money is borrowed. A schedule of money transfers is created that should match the need to pay for the activities. The process of matching the schedule of transfers with the schedule of activity payments is called **reconciliation**. Refer to Figure, which shows the costs of 10 major activities in a project. Funds are transferred into the project account four times. Notice that during most of the project, there were more funds available than were spent except at activity 6 when all the available funds were spent.

Figure 36: **Fund transfers and expenditures**

Activity	1	2	3	4	5	6	7	8	9	10
Cost	50	200	50	300	500	200	100	400	300	500
Total Spent	50	250	300	600	1,100	1,300	1,400	1,800	2,100	2,600
Transfers	400			900			700		600	
Total Funding	400	400	400	1,300	1,300	1,300	2,000	2,000	2,600	2,600
Cash in Account	350	150	100	700	200	-	600	200	500	-



Source: Adrienne Watt (2014) – **Project Management**, 2nd Edition BCcampus Open Textbook Project, p150.

In the project budget profile shown in Figure, there is no margin for error if the total of the first six activities exceeds the amount of funding at that point in the project.

Illustrative Example:

Example: You are provided with the data of a specific project:

Activity	Immediate Predecessor	Duration (Months)	Direct cost per month (1000 DZ)	Indirect cost
A	-	1	84	35% from the activity`s direct costs
B	A	5	123	61% from the activity`s direct costs
C	A	2	92	40% from the activity`s direct costs
D	B	2	112	22% from the activity`s direct costs
E	B	2	273	56% from the activity`s direct costs
F	C	2	164	11% from the activity`s direct costs
G	C	3	178	78% from the activity`s direct costs
H	DF	2	212	63% from the activity`s direct costs
I	H	3	166	40% from the activity`s direct costs
J	EI	3	123	55% from the activity`s direct costs
K	GJ	2	100	8% from the activity`s direct costs

After Calculate the Estimated Project Cost and Prepare the Cumulative Estimated Budget for the Project (Budget at Completion **(BAC/BCWS)**), we have the following information regarding what the company accomplished After **four (04) months**, **ten (10) months**, and **sixteen (16) months**:

Activity	The Fourth Month		The Tenth Month		The Sixteenth Month	
	Actual Costs (1000 DZD)	Actual Completion Rate (%)	Actual Costs (1000 DZD)	Actual Completion Rate (%)	Actual Costs (1000 DZD)	Actual Completion Rate (%)
A	200	100%	200	100%	200	100%
B	995	80%	1005	100%	1005	100%
C	250	100%	250	100%	250	100%
D			260	100%	260	100%
E			850	100%	850	100%
F			370	100%	370	100%
G			900	100%	900	100%
H			655	90%	706	100%
I					632	100%
J					500	95%
K						
CV						
SV						
SPI						
CPI						
PPI						
ETC						
EAC						
AARCP						

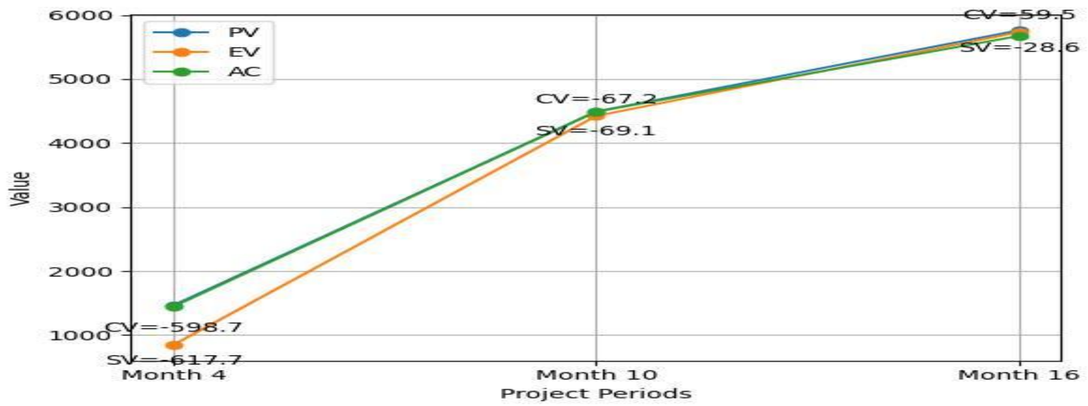
Questions: After Calculating the following elements for each period: **PV; EV; AC,** represent them graphically in an **S-curve**, and also Complete the table above**.**

Solution:

The cumulative Estimated Budget for this project is fully complited in the less part, Now we contenue calculated Index For Earned Value:

Activity	The Fourth Month			The Tenth Month			The Sixteenth Month		
	PV	**EV**	**AC**	**PV**	**EV**	**AC**	**PV**	**EV**	**AC**
A	113,4	113,4	200	113,4	113,4	200	113,4	113,4	200
B	594,09	475,272	995	990,15	990,15	1005	990,15	990,15	1005
C	257,6	257,6	250	257,6	257,6	250	257,6	257,6	250
D				273,28	273,28	260	273,28	273,28	260
E				851,76	851,76	850	851,76	851,76	850
F	182,04			364,08	364,08	370	364,08	364,08	370
G	316,84			950,52	950,52	900	950,52	950,52	900
H				691,12	622,008	655	691,12	691,12	706
I							697,2	697,2	632
J							571,95	543,3525	500
K									
Total	**1.463,97**	**846,272**	**1.445**	**4.491,91**	**4.422,798**	**4.490**	**5.761,06**	**5.732,4625**	**5673**
CV	**(-598,728)**			**(-67,202)**			**59,4625**		
SV	**(-617,698)**			**(-69,112)**			**(-28,5975)**		
CPI	**0,585**			**0,985**			**1,01048**		
SPI	**0,578**			**0,9846**			**0,995**		
PPI	**0,338**			**0,9698**			**1,0054**		
ETC	**8.770,577**			**1.577,93**			**242,06**		
EAC	**10.215,577**			**6.067,93**			**5.915,06**		
AARCP	**4.238,517**			**90,87**			**(-62)**		
							We don`t need any additional amount		
							If we continue at the same pace, we will save 62000$ by the time the project is completed.		

Figure 37: **S-curve**



Application Series (Topic 06-02 : Earned Value Management (EVM))

Exercise 1:

After Calculate the Estimated Project Cost and Prepare the Cumulative Estimated Budget for the Project (Budget at Completion **(BAC/BCWS)**), we have the following information regarding what the company accomplished After **six (06) months**, **nine (09) months**, and **twelve (12) months:**

Activity	The sixth month		The ninth month		The twelfth month	
	Actual Costs (DZD)	**Actual Completion Rate (%)**	**Actual Costs (DZD)**	**Actual Completion Rate (%)**	**Actual Costs (DZD)**	**Actual Completion Rate (%)**
A	450.000	100%	450.000	100%	450.000	100%
B	560.000	100%	560.000	100%	560.000	100%
C	270.000	90%	300.000	100%	300.000	100%
D			290.000	85%	310.000	100%
E					341.000	100%
F					440.000	100%
G					630.000	100%
H					400.000	100%
I					760.000	95%
CV						
SV						
SPI						
CPI						
PPI						
ETC						
EAC						
AARCP						

Questions: After Calculating the following elements for each period: **PV; EV; AC,** represent them graphically in an **S-curve**, and also Complete the table above**.**

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Exercise 2:

After Calculate the Estimated Project Cost and Prepare the Cumulative Estimated Budget for the Project, we have th following information regarding what the company accomplished After **six (06) days**, **ten (10) days**, and **thirteen (13) days:**

Activity	The sixth day		The tenth day		The thirteen day	
	Actual Costs (DZD)	Actual Completion Rate (%)	Actual Costs (DZD)	Actual Completion Rate (%)	Actual Costs (DZD)	Actual Completion Rate (%)
A	339.000	100%	339.000	100%	339.000	100%
B	467.000	100%	467.000	100%	467.000	100%
C	266.000	80%	390.000	100%	390.000	100%
D			190.000	100%	190.000	100%
E					338.000	100%
F					234.000	50%
CV						
SV						
SPI						
CPI						
PPI						
ETC						
EAC						
AARCP						

Questions: After Calculating the following elements for each period: **PV; EV; AC,** represent them graphically in an **S-curve**, and also Complete the table above**.**

Exercise 3:

After Calculate the Estimated Project Cost and Prepare the Cumulative Estimated Budget for the Project, we have th following information regarding what the company accomplished After **three (03) days**, and **eight (08) days:**

Activity	**The third day**			**The eighth day**		
	Actual Costs (DZD)	**Actual Completion Rate (%)**	**Planned Completion rate (%)**	**Actual Costs (DZD)**	**Actual Completion Rate (%)**	**Planned Completion rate (%)**
A	550.000	100%	100%	550.000	100%	100%
B	430.000	80%	50%	520.000	100%	100%
C	772.000	60%	100%	850.000	100%	100%
D	650.000	100%	50%	650.000	100%	100%
E				430.000	100%	100%
F				322.000	100%	100%
G				270.000	80%	100%
H						30%
CV						
SV						
SPI						
CPI						
PPI						
ETC						
EAC						
AARCP						

Questions: After Calculating the following elements for each period: **PV; EV; AC,** represent them graphically in an **S-curve**, and also Complete the table above**.**

Test the application 01

A company is planning a project consisting of nine activities, identified as: A – B – C – D – E – F – G – H – I. The total duration of path: A → C → J = 5 days; and the path: A → C → E → G → H → I = 18 days.

On day 8, of the project, the finance department reported a cumulative cost of: 950,000 DZD, The project manager commented: "This rapid increase in cost suggests that we must be on the critical path".

Activity	Immediate Predecessor	Duration (day)
A	**-**	½ of B
B	**A**	?
C	**A**	½ of B
D	**B**	A + ½ of C
E	**BC**	(B + C) ÷ 3
F	**D**	2 × E
G	**E**	F – (½ × D)
H	**FG**	the greater of (F or G) + ½ of A
I	**H**	½ of the total duration of path (A → B → D)
J	**C**	??

Questions:

1. Calculate the duration of each activity (A through J).

2. Complete the following Table:

Activity	Total Cost (DZD)	Average Daily Cost (DZD/Day)
A	120.000	?

3. Draw a PERT/CPM network, showing for each activity (ES, EF, LS, LF, and slack time). Extract from the network the project paths and the duration of each path, identify the critical paths, and the near-critical activities in the project, and determine the shortest time required to complete the project.

4. Based on the Gantt chart, calculate the total duration required to complete the project. Identify the critical path and the critical activities on it. Identify, if present, the non-critical activities and the amount of float for the activities that have float.

5. Compare the results you obtained in the Gantt chart with those obtained in the PERT/CPM analysis.

Solution:

Duration (A) + Duration (C) +Duration (E) + Duration (G) + Duration (H) + Duration (I) = 18 days

So:

$$18=\frac{1}{2}X+\frac{1}{2}X+\frac{X+\frac{1}{2}X}{3}+2\times\frac{X+\frac{1}{2}X}{3}-\frac{1}{2}\left(\frac{1}{2}X+\frac{1}{4}X\right)+2\times\frac{X+\frac{1}{2}X}{3}+\frac{1}{2}\left(\frac{1}{2}X\right)+\frac{1}{2}\left[\!\left[\frac{1}{2}X+X+\left(\frac{1}{2}X+\frac{1}{4}X\right)\right]\!\right]$$

F = $2\times\frac{X+\frac{1}{2}X}{3}\longrightarrow$ **Max or Greater**

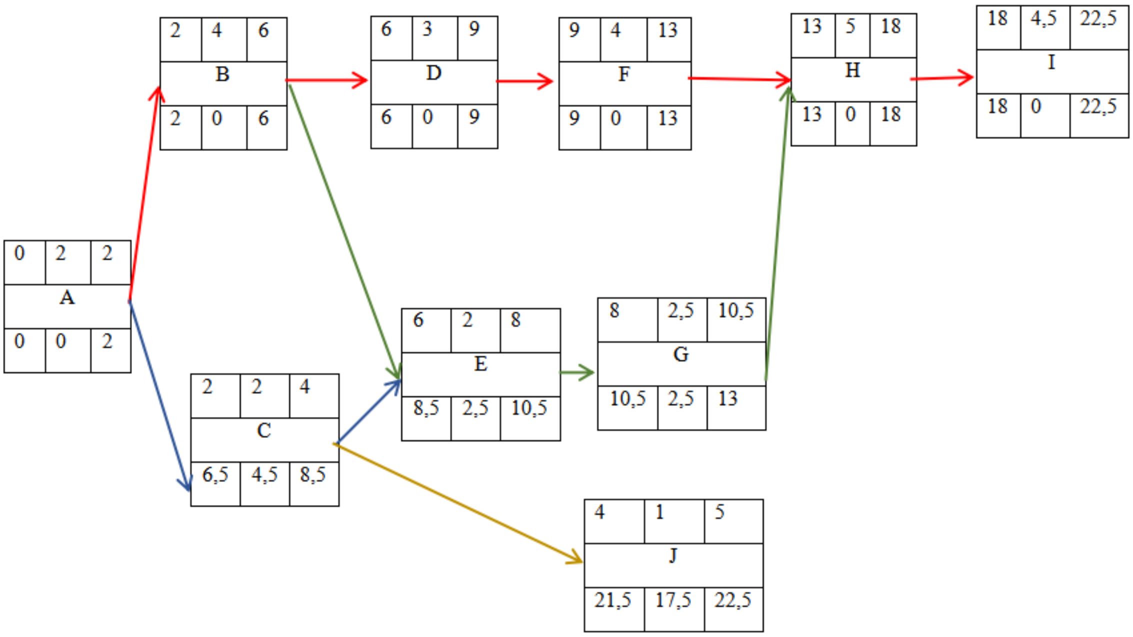
G = $2\times\frac{X+\frac{1}{2}X}{3}-\frac{1}{2}\left(\frac{1}{2}X+\frac{1}{4}X\right)$

So: X = 4

Activity	Immediate Predecessor	Duration (day)
A	**-**	**2**
B	**A**	**4**
C	**A**	**2**
D	**B**	**3**
E	**BC**	**2**
F	**D**	**4**
G	**E**	**2,5**
H	**FG**	**5**
I	**H**	**4,5**
J	**C**	**1**

Activity	Total Cost (DZD)	Duration	Average Daily Cost (DZD/Day)
A	120.000	2	60.000

Figure 38: **PERT network**



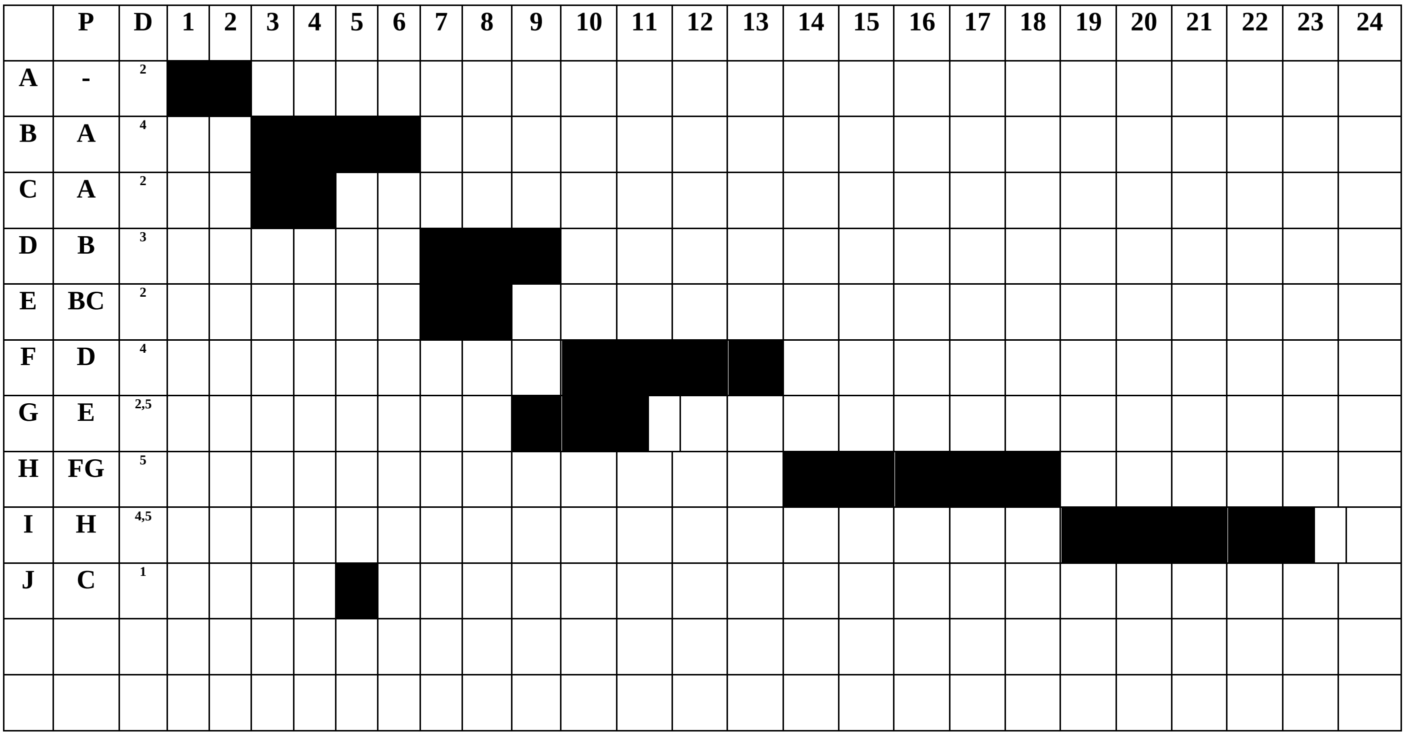
Paths:

1. ABDFHI = 22,5 days
2. ABEGHI = 20 days
3. ACEGHI = 18 days
4. ACJ = 5 days

The Critical Path is : ABDFHI = 22,5 days

Activity near Critical Path is **E** and **G**, because the Slack is just equal 2,5 days.

Figure 39: GANTT Chart



The non critical path:

J: the amount of float time is 17,5 days.

G: the amount of float time is 2,5 days.

E: the amount of float time is 2,5 days.

C: the amount of float time is 4,5 days.

the comparison between the results we obtained in the Gantt chart with we obtained in the PERT/CPM analysis:

The GANTT chart provides a visual timeline but does not show the critical path, while the PERT/CPM analysis identifies the critical path and the scheduling flexibility. It also shows that the project duration is consistent in both methods, although PERT offers deeper analytical insights.

Test the application 02

The company TechBuild plans to carry out a small project consisting of eight activities. It has a capital of 350 million Algerian dinars, distributed among three shareholders. The company also relies on a bank loan covering 18% of the annual investment program. The project data are given as follows:

Activity	Duration (days)	Number of Workers	Daily wage per woker (DA)	Total material & financial resources (DA)	Immediate Predecessor
A	4	3	9.000	15.000	-
B	3	2	8.500	0	A
C	5	4	8.000	12.000	A
D	2	3	9.000	0	B
E	6	5	7.000	20.000	CD
F	3	2	7.500	0	EC
G	4	6	6.500	18.000	C
H	2	4	9.000	0	FG

I. Indirect Costs (IC):

A. If the activity duration is greater than 4 days, indirect costs equal 12% of the total direct costs of that activity.

B. Otherwise, IC is at least 25% of the total direct costs of that activity.

II. Quality Costs (QC):

A. Activity A (High accuracy): Quality cost equals 10% of the labor cost of the activity.

B. Activity C (Prone to repetitive errors): Quality cost equals the cost of one additional working day for this activity.

C. Activities E and H (Sensitive equipment / final testing): Quality cost equals 8% of the total direct costs for each of these two activities.

III. Risk Costs (RC):

A. If the number of workers ≤ 5, then: RC = 5% of the total direct cost of the activity.

B. If the activity duration > 4 days and the number of workers ≥ 4, then: RC = cost of half a working day for that activity.

C. If the duration ≥ 3 days (fast-track activity), then: RC exceeds 3% of the daily wage per worker for that activity.

Required: Prepare both: the estimated budget, and the cumulative estimated budget for this project.

Solution:

Table 22: Average Daily Cost

Activity	IP	Duration	Direct Cost		Total DC (1)	Total Indirect Cost (2)	QC (3)	RC (4)	Total Cost (1+2+3+4)	Average Daily Cost (DZD/Day)
			Workers							
A	**-**	**4**	108.000	15.000	123.000	**(75%)** 92.250	10.800	-	226.050	56.512,5
B	**A**	**3**	51.000	0	51.000	**(75%)** 38.250	-	17.510	106.760	35.586,66
C	**A**	**5**	160.000	12.000	172.000	**(12%)** 20.640	32.000	16.000	240.640	48.128
D	**B**	**2**	54.000	0	54.000	**(75%)** 40.500	-	27.810	122.310	61.155
E	**CD**	**6**	210.000	20.000	230.000	**(12%)** 27.600	18.400	132.500	408.500	68.083,33
F	**EC**	**3**	45.000	0	45.000	**(75%)** 33.750	-	15.450	94.200	31.400
G	**C**	**4**	156.000	18.000	174.000	**(75%)** 130.500	-	8.700	313.200	78.300
H	**FG**	**2**	72.000	0	72.000	**(75%)** 54.000	5.760	37.080	168.840	84.420
Estimated project cost			**856.000**	**65.000**	**921.000**	**437.490**	**66.960**	**255.050**	**1.680.500**	/

Table 23: Cumulative Estimated Budget for the project:

Acti	IP	Dur	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
A	-	4	56.512,5	56.512,5	56.512,5	56.512,5																		226.050
B	A	3					35.586,66	35.586,66	35.586,66															106.760
C	A	5					48.128	48.128	48.128	48.128	48.128													240.640
D	B	2								61.155	61.155													122.310
E	CD	6										68.083,33	68.083,33	68.083,33	68.083,33	68.083,33	68.083,33							408.500
F	EC	3																31.400	31.400	31.400				94.200
G	C	4										78.300	78.300	78.300	78.300									313.200
H	FG	2																			84.420	84.420		168.840
Total per Day			56.512,5	56.512,5	56.512,5	56.512,5	83.714,66	83.714,66	83.714,66	109.283	109.283	146.383,33	146.383,33	146.383,33	146.383,33	68.083,33	68.083,33	31.400	31.400	31.400	84.420	84.420		1.680.500
Moving Totals			56.512,5	113.025	169.537,5	226.050	309.764,66	393.479,32	477.193,98	586.476,98	695.758,98	842.143,31	988.526,64	1.134.909,97	1.281.293,3	1.349.376,63	1.417.459,96	1.448.859,96	1.480.259,96	1.511.659,96	1.596.079,96	1.680.499,96		

1. Workers:

A = 9.000 × 4 × 3 = **108.000**

B = 8.500 × 3 × 2

C = 8.000 × 5 × 4

D = 9.000 × 2 × 3

E = 7.000 × 6 × 5

F = 7.500 × 3 × 2

G = 6.500 × 4 × 6

H= 9.000 × 2 × 4

2. Indirect Cost:

a. **E,C** > **4 days / So: DC × 12%**

b. **Others: DC × 75%**

3. QC:

A = 108.000 × 10 %

C = 160.000 ÷ 5 = 8.000 × 4 = 32.000

E = 230.000 × 8%

H = 72.000 × 8%

4. RC:

a. **Nember of workers ≥ 5,** We have **E** and **G,** So: Total of Direct Cost for each activity × 5%

b. C,E / C ≥ 4, and E = 5 ≥ 4, RC = $\frac{Total\ Cost\ of\ workers}{Duration} \times \frac{1}{2}$

c. B,D,F,H = $\frac{Total\ Cost\ of\ workers}{Duration} \times 1{,}03$

d. E = Total of Direct Cost for each activity × 5% + $\frac{Total\ Cost\ of\ workers}{Duration} \times \frac{1}{2}$ = 230.000 × 5% + $\frac{210.000}{6} \times \frac{1}{2}$ =

115.000 + 17.500 = **132.500**

First Term Exam

Question: Give me the comparison of Project Life Cycle Models. And what is the importance of work packages.

Exercise: You are provided with the data of a specific project (Working days are all days of the week except Friday):

Activity	Immediate Predecessor	Duration (per Weeks)	Direct cost per Day (1000 DZ)
A	-	1	84
B	A	2	123
C	A	2	92
D	B	1	112
E	BC	1	273
F	D	3	164
G	E	1	178

Questions:

1. Preparing the project's estimated budget, given that:

d. For activities whose average direct costs are less than or equal to 850,000 DZD, their indirect costs are 36% of direct cost for each activity.

e. For activities whose average direct costs exceed 850,000 DZD, their indirect costs are 20% of the direct costs for each activity.

2. Prepare the project's cumulative budget.

we have the following information regarding what the company accomplished After **Three and Six Weeks:**

Activity	Three Weeks		Six Weeks	
	Actual Costs (1000 DZD)	Actual Completion Rate (%)	Actual Costs (1000 DZD)	Actual Completion Rate (%)
A	800	100%	800	100%
B	1.800	100%	1.800	100%
C	1.430	80%	1.500	100%
D	655	73%	780	100%
E			1.287	100%
F			1.900	99%
G				79%

Questions:

After Calculating the following elements for each period: **PV; EV; AC,** represent them graphically in an **S-curve**, and also Calculate: **CV/SV/CPI/SPI/PPI/ETC/EAC/AARCP**, and explain the result for each indecat**.**

Solution:

A. the comparison of Project Life Cycle Models:

1. **Agile:** Incremental delivery, frequent feedback, highly flexible.
2. **Iterative:** Repetitive cycles, gradual improvements, accommodates complexity.
3. **Waterfall:** Sequential phases, clear requirements, minimal changes.

B. the importance of work packages: 1

The **work packages** provide the practical unit of work for estimation, assignment, monitoring and control.

Table 24: the project's estimated budget: 5

Activity	IP	D	Direct Cost (1000)	Indirect Cost (1000)	Total Cost (1000)	Average Cost per Week (1000)
A	-	1	84 × 6 = 504	504 × 0,36 = 181,44	685,44	**685,44**
B	A	2	123 × 6 × 2 = 1.476	1.476 × 0,36 = 531,36	2.007,36	**1.003,68**
C	A	2	92 × 6 × 2 = 1.104	1.104 × 0,36 = 397,44	1.501,44	**750,72**
D	B	1	112 × 6 = 672	672 × 0,36 = 241,92	913,92	**913,92**
E	BC	1	273 × 6 = 1.638	1.638 × 0,2 = 327,6	1.965,6	**1.965,6**
F	D	3	164 × 6 × 3 = 2.952	2.952 × 0,2 = 590,4	3.542,4	**1.180,8**
G	E	1	178 × 6 = 1.068	1.068 × 0,2 = 213,6	1.281,6	**1.281,6**
Estimated Budget Cost			**9.414**	**2.483,76**	**11.897,76**	/

Average Direct Cost for each activity:

A = 504 ÷ 1 = 504 ≤ 850; So: Indirect Cost = 36% for Direct Cost of activity A.

B = 1.476 ÷ 2 = 738 ≤ 850; So: Indirect Cost = 36% for Direct Cost of activity B.

C = 1.104 ÷ 2 = 552 ≤ 850; So: Indirect Cost = 36% for Direct Cost of activity C.

D = 672 ÷ 1 = 672 ≤ 850; So: Indirect Cost = 36% for Direct Cost of activity D.

E = 1.638 ÷ 1 = 1.638 > 850; So: Indirect Cost = 20% for Direct Cost of activity E.

F = 2.952 ÷ 3 = 984 > 850; So: Indirect Cost = 20% for Direct Cost of activity F.

G = 1.068 ÷ 1 = 1.068 > 850; So: Indirect Cost = 20% for Direct Cost of activity G.

Table 25: the project's cumulative budget:

Activity	IP	D	1	2	3	4	5	6	7	Total
A	-	1	**685,44**							685,44
B	A	2		**1.003,68**	**1.003,68**					2.007,36
C	A	2		**750,72**	**750,72**					1.501,44
D	B	1				**913,92**				913,92
E	BC	1				**1.965,6**				1.965,6
F	D	3					**1.180,8**	**1.180,8**	**1.180,8**	3.542,4
G	E	1					**1.281,6**			1.281,6
Total per Week			**685,44**	**1.754,4**	**1.754,4**	**2.879,52**	**2.462,4**	**1.180,8**	**1.180,8**	**11.897,76**
Moving Totals			**685,44**	**2.439,84**	**4.194,24**	**7.073,76**	**9.536,16**	**10.716,96**	**11.897,76**	

3,5

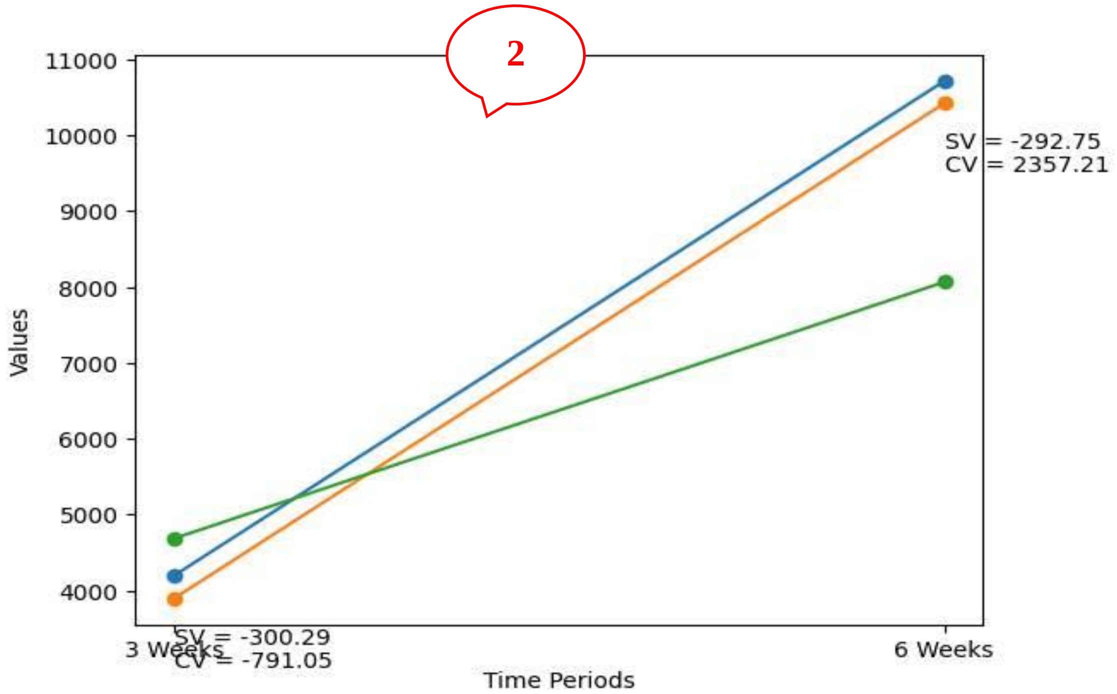
Table 26: PV; EV; AC, CV/SV/CPI/SPI/PPI/ETC/EAC/AARCP:

Activity	Three Weeks			Six Weeks		
	PV	EV	AC	PV	EV	AC
A	685,44	685,44	800	685,44	685,44	800
B	2.007,36	2.007,36	1.800	2.007,36	2.007,36	1.800
C	1.501,44	1.201,152	1.430	1.501,44	1.501,44	1.500
D			655	913,92	913,92	780
E				1.965,6	1.965,6	1.287
F				2.361,6	2.337,984	1.900
G				1.281,6	1.012,464	
Total	**4.194,24**	**3.893,952**	**4.685**	**10.716,96**	**10.424,208**	**8.067**
CV	**(-791,048) the project is exceeding its budget**			**2.357,208 the progect not fully using its budget**		
SV	**(-300,288) the project is behind schedule**			**(-292,752) the project is behind schedule**		
CPI	**0,831**			**1,292**		
SPI	**0,928**			**0,972**		
PPI	**0,771**			**1,255**		
ETC	**9.631,537**			**1.140,52**		
EAC	**14.316,537**			**9.207,52**		
AARCP	**2.418,777**			**(-2.690,24)**		
				We don`t need any additional amount.		
				If we continue at the same pase, we will save (2.690,24 × 1.000 DZD) by the time the project is completed.		

3,5

3,5

Figure 40: **S-curve**



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