Module No. 3

PROJECT PLANNING & SCHEDULING

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Work Breakdown Structure (WBS)

- The procedure for subdividing the overall project into smaller elements is called the work breakdown structure or WBS.
- Its purpose is to define the total project into 'pieces of work' called work packages.
- Dividing the project into work packages makes it easier to prepare project schedules & cost estimates & to assign management & task responsibilities.
- The first step in creating a WBS is to divide the total project into major categories.
- These major categories then are divided into subcategories that, in turn, are subdivided, & so on.
- This level-by-level breakdown continues so that the scope & complexity of work elements is reduced with each level of breakdown.
- Each descending level represents an increasingly detailed definition of the project work.
- The WBS is decomposed into work packages.
- The deliverable orientation of hierarchy includes both internal & external deliverables.

Work Breakdown Structure (WBS)

Outline the work breakdown structure (WBS) implemented by your project team when it is tasked to design & develop a portable music player based on following attributes as specified by the company :-

(a) High quality audio
(b) Portability
(c) Easy to use

- Portable Audio Device
  - High-Quality Audio (0.24)
    - Low Distortion (0.67)
    - Low Noise (0.33)
  - Portable (0.62)
    - Lightweight (0.33)
    - Small (0.32)
    - Ergonomic (0.16)
    - Environment (0.19)
      - Outdoor Temperatures (0.32)
      - Runner's Shock (0.10)
      - Drop Resistant (0.14)
      - Water Resistant (0.38)
  - Easy to Use (0.14)
    - Limited Controls (0.25)
    - Multiple Data Formats (0.50)
    - Long Operating Time (0.25)

WBS (contd..)

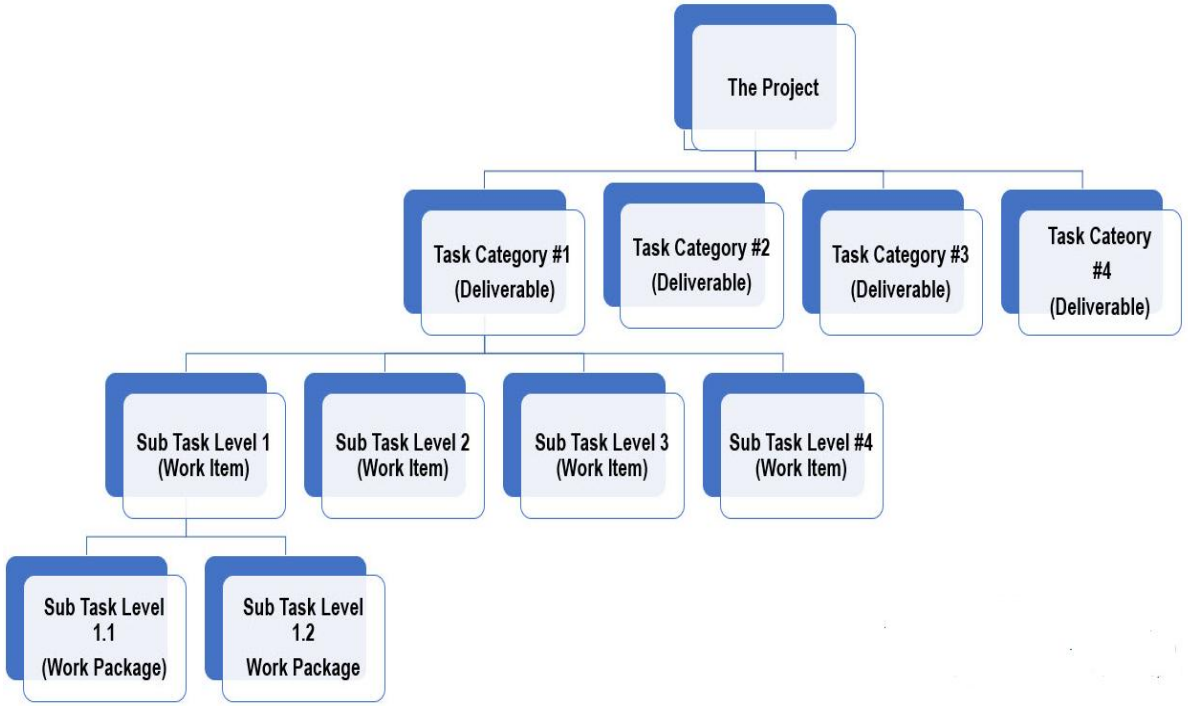
- A typical WBS might consist of the following four levels (the number of levels varies, as does the name of the element description at each level; different project methodologies use different terms):

Level	Element Description
1	Project
2	Subproject
3	Activity
4	Work Package

- There are two types of WBS:

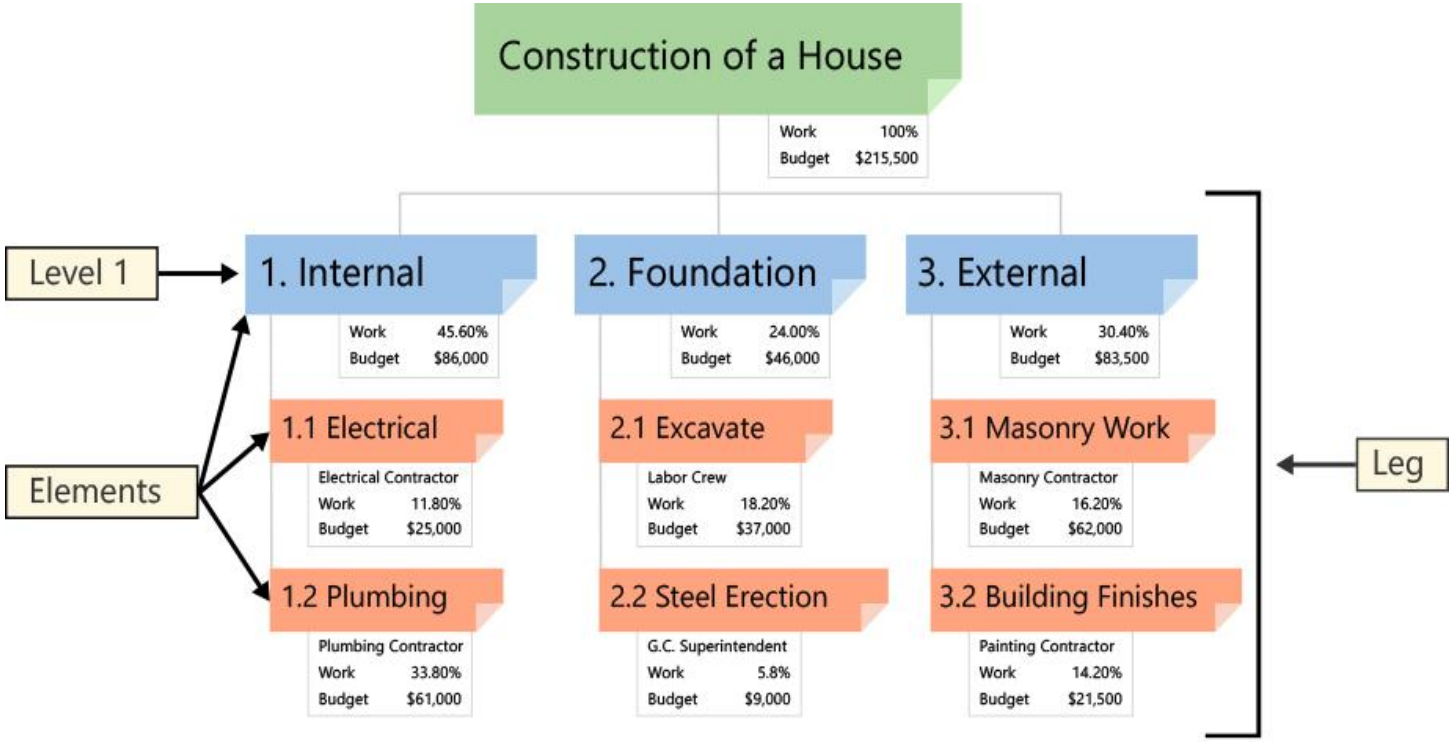
1) Deliverable-Based and

2) Phase-Based



Deliverable-Based Work Breakdown Structure

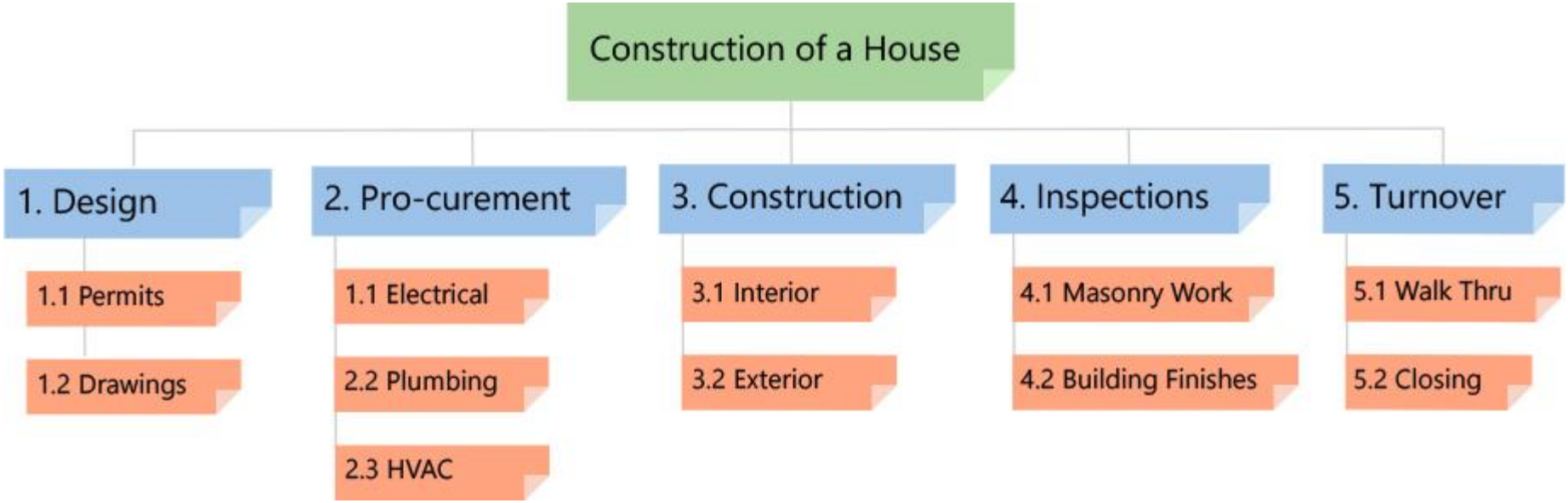
- A Deliverable-Based Work Breakdown Structure clearly demonstrates the relationship between the project deliverables (i.e., products, services or results) and the scope (i.e., work to be executed).



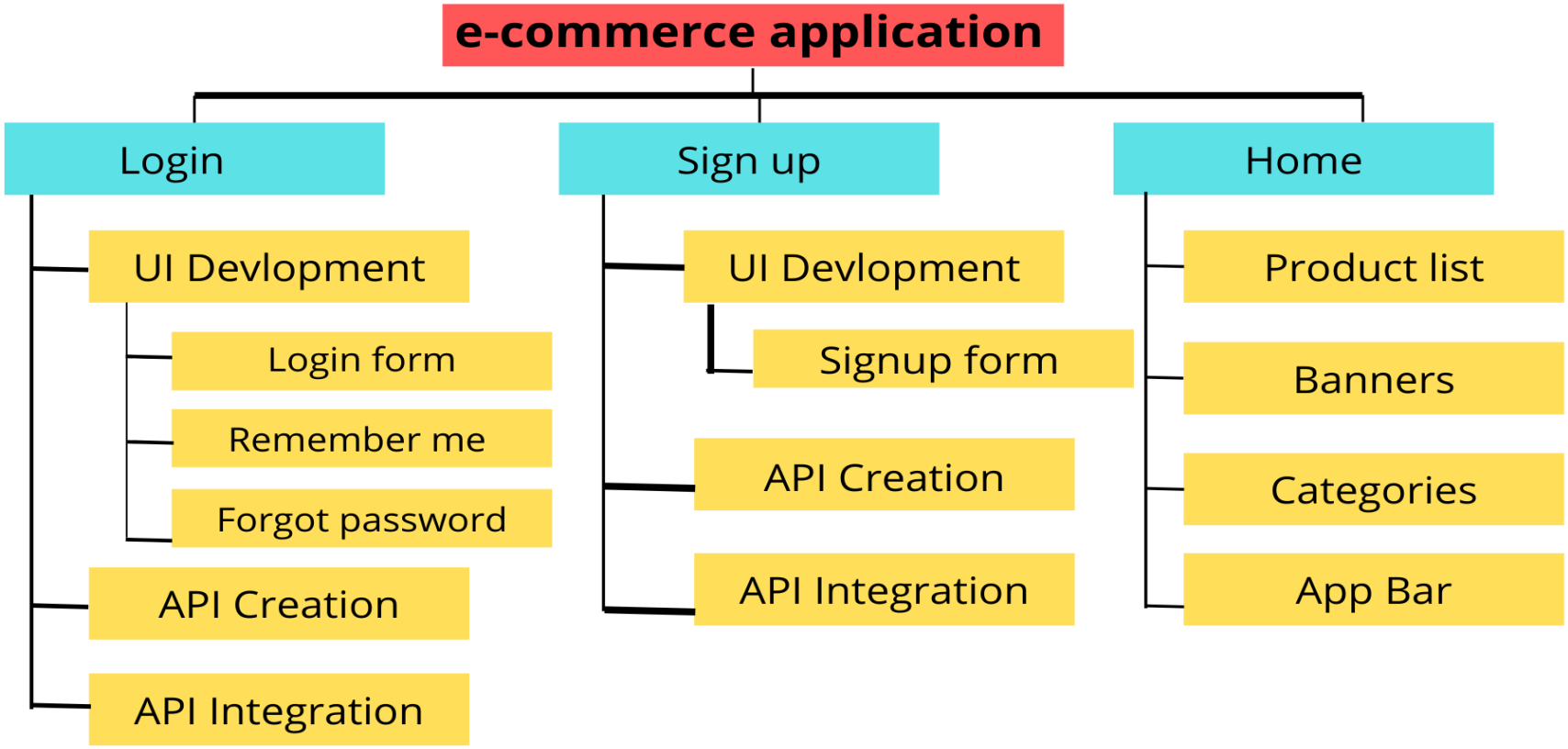
In Figure, the Level 1 Elements are summary deliverable descriptions. The Level 2 Elements in each Leg of the WBS are all the unique deliverables required to create the respective Level 1 deliverable.

Phase-Based Work Breakdown Structure

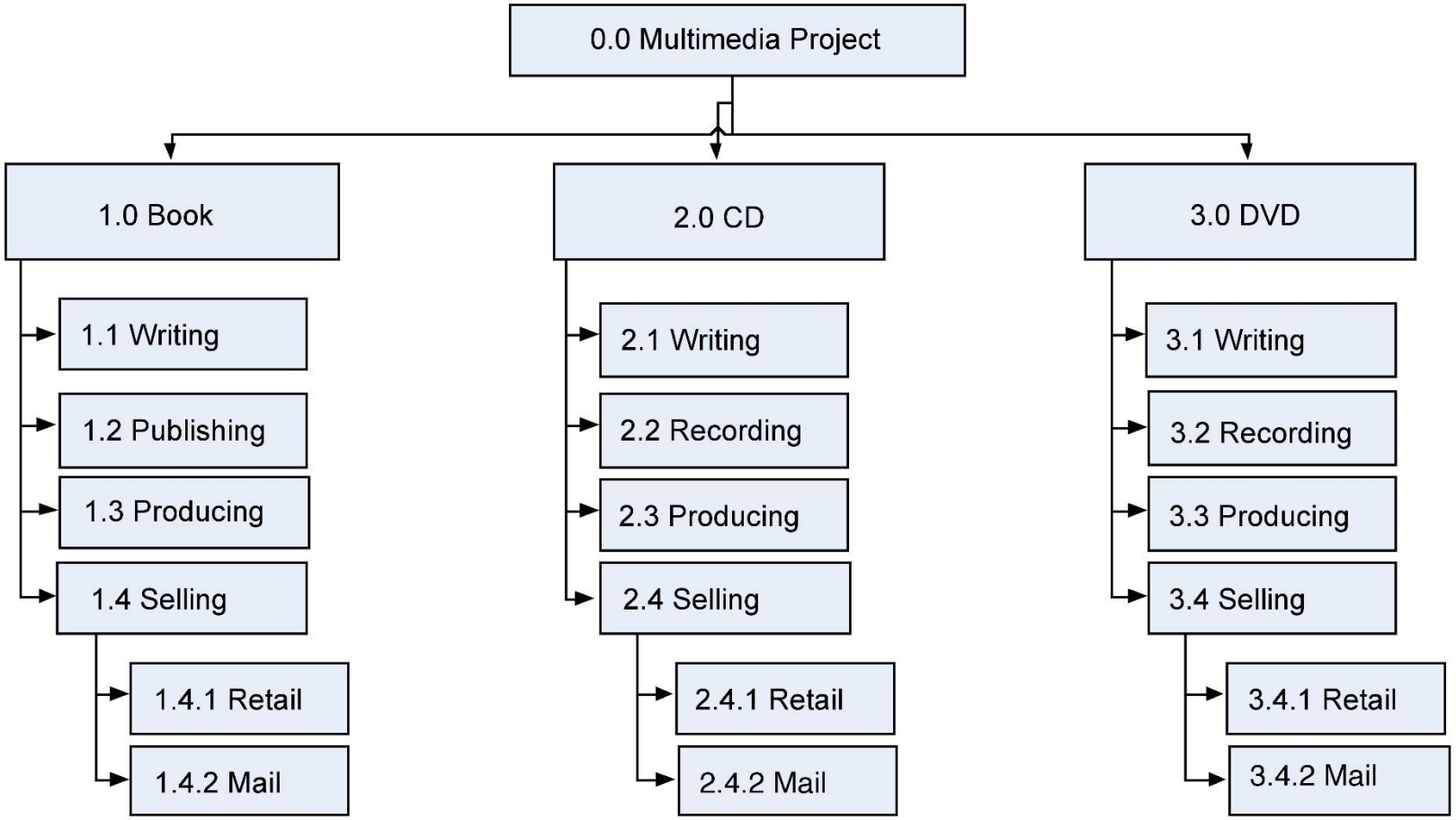
- A Phase-Based WBS requires work associated with multiple elements be divided into the work unique to each Level 1 Element.
- A WBS Dictionary is created to describe the work in each Element.



WBS Example 1



WBS Example 2



Benefits of WBS

- It helps to assign responsibilities to the project team.
- It helps the top-level management to allocate the project budget, based on which departmental budgets can be calculated.
- It helps to estimate the cost, time and risks involved in several activities of the project.
- It indicates the project milestones and control points.
- It can help identify items/ work packages that need to be outsourced to external parties.
- It helps to identify communication points and formulate a communication plan.

Linear Responsibility Chart (LRC)

- LRC is a tool used to define and depict the responsibility and authority of the project personnel.
- It is sometimes also referred to as Responsible, Accountable, Consulted, and Informed (RACI) chart or Responsibility Assignment Matrix (RAM).
- It aids effective coordination in the project.
- It basically combines the WBS against the types of resources available.
- This is extremely useful for the project manager, as it visually depicts who is responsible for each project task.

LRC (contd..)

- Authority: It refers to the person who has the right to make the required decisions, to aid in the attainment of his/her goals. It could be project sponsor, or some other stake holder, depending upon the situation.
- Responsibility: It refers to the person who has been assigned to complete a certain task or event. This is generally the person performing the activity.
- Accountability: It refers to the acceptance of achievement or failure. A person who takes the ownership of the work is considered as accountable. Generally, he/she is the manager of the person who has been assigned the responsibility.
- Consult: It refers to the person who may be consulted in case of any specific issue.
- Inform: It refers to the person who must be informed in case of any deviations.

LRC Example

Stage	Tasks	Release Manager	Project Manager	Developer	Program Manager
1	Product Planning	I	A	R	C
2	Product Development	I	I	A	R
3	Product Release	R	A	I	I

Merits and Demerits of LRC

- Merits

1. Clearly defines the roles and responsibilities of all the project participants.
2. Facilitates effective communication among the project participants.
3. Acts as a great tool for administering the responsibility and authority of people involved in the project.
4. Facilitates the delegation of authority.

- Demerits

1. Fails to describe the interactions among people working on the project.
2. The customer imposed requirements of the project limit the usefulness of LRC.

Concurrent Engineering

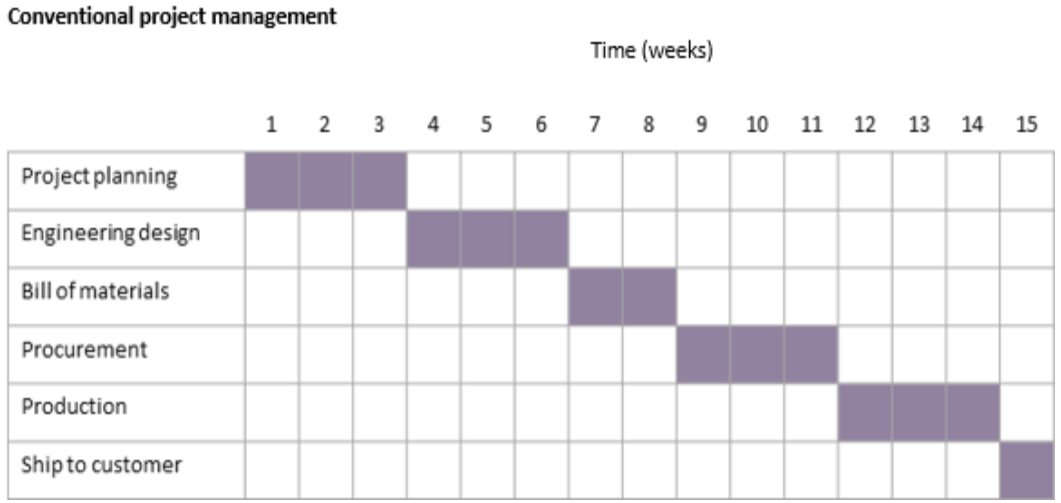
- Many individuals and groups have a stake in any product or system, and they all want different things from it.
- The designer wants it to work; the salesperson wants it to sell; the finance person wants it to be profitable; the manufacturing person wants it to be producible; and the customer wants it to meet his needs and not cost too much.
- The term concurrent engineering refers to the combined efforts of designers, developers, and producers to address all these wants to the satisfaction of everyone.

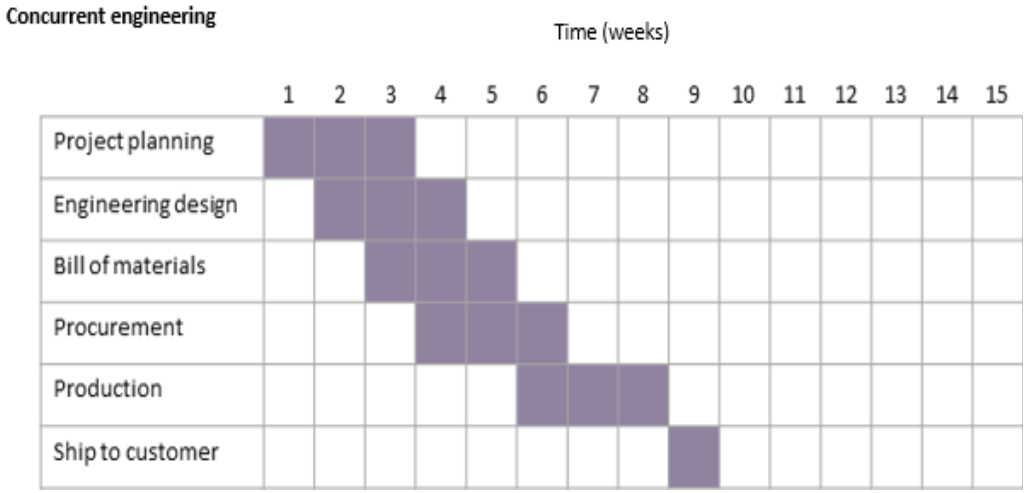
Concurrent Engineering (contd..)

- Concurrent engineering, also known as simultaneous engineering, is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively.
- It decreases product development time and also the time to market, leading to improved productivity and reduced costs.
- Introducing concurrent engineering can lead to:

1. **Competitive Advantage-** reduction in time to market means that businesses gain an edge over their competitors.
2. **Enhanced Productivity-** earlier discoveries of design problems means potential issues can be corrected soon, rather than at a later stage in the development process.
3. **Decrease Design and Development Time-** make products which match their customer's needs, in less time and at a reduced cost.

Concurrent Engineering (contd..)





This demonstrates that in Concurrent Engineering the different phases of the project life cycle overlap. It is not necessary to complete one phase before starting another.

Project Budgeting

- One of the major limitation of any project is the capital.
- Almost every aspect of the project, such as the technology to be used in the execution, the workforce required, and the quality of materials needed, gets affected by its budget.
- During the budgeting process, costs are estimated at the work package level in detail. These costs are then added to come up with the budget for the project.
- Steps in project budgeting:

1. Estimating the costs
2. Determining the budget
3. Monitoring and controlling the budget
4. Updating the budget

Estimating the costs

- In this process, one can estimate the cost of various aspects of the project.
- Project cost estimation involves estimation of labour cost, material cost, equipment cost, cost of quality, services cost, facilities cost and other costs such as allowance for inflation and contingency reserves.
- Project cost estimation must consider the “Full Life Cycle Cost”.
- To calculate resource/project costs, you can use four tools:

1. Analogous Estimating
2. Parametric Estimating
3. Three Points Estimating
4. Bottom-up Estimating

Analogous Estimating

- You use this technique when limited project information is available.
- This technique does not provide a reliable estimation.
- The benefits of this technique are a quick result with less effort.
- Here, you estimate the cost of the project by comparing it with any similar project in the past.
- You will look into the organization's historical records. Then you will use your expert judgment to find your project's cost estimate.
- If your organization has completed many similar projects, you will select the one that most closely resembles yours.
- The estimate can be accurate if the similarity is high and the estimators are subject experts.
- Analogous estimating is also known as top-down estimating.

Parametric Estimating

- Like analogous estimating, parametric estimation uses historical data to calculate cost; however, it uses statistical data.
- It takes variables from similar projects and applies them to the current one.
- If, for instance, the cost of implementing a new data field in an IT system were $20,000 according to historical data, and a project required 15 new data fields, the total cost of this part of the project would be 15 x $20,000 = $300,000.
- Similarly, you can calculate the cost of other parameters: human resources, materials, equipment, etc.
- Parametric estimation is more accurate than analogous estimation.

Three-Points Estimating

- This technique helps reduce biases and uncertainties while estimating assumptions.
- Here, you determine three estimates, instead of one, and you take their average to reduce the uncertainties, risks, and biases.
- Two commonly use three points estimates are beta and triangular.
- PERT (Program Evaluation and Review Technique) is based on the beta distribution.
- The PERT estimate formula is:
- Ce = (Co + 4Cm + Cp) / 6
- Where Ce = Expected Cost.
- Cm is the Most Likely Cost. It considers a typical case where everything goes as usual. Cp is the Pessimistic Cost, where almost everything goes wrong. Co is the Optimistic Cost, where everything goes better than presumed.
- The triangular estimate formula is:
- Ce = (Co + Cm + Cp) / 3
- This technique minimizes the biased views of the data.

Bottom-up Estimating

- This is the most accurate technique and provides reliable results.
- You can use this technique when you have all the project details.
- This technique is costly and time-consuming.

Budgeting: From the top-down or bottom up?

There are as many ways to budget as there are organizations in the world, however the two main approaches involve setting the budget from a specified upper limit (top-down) or building budgets from the ground up based on need (bottom-up). This infographic explains the difference between the two major approaches. Budgets can built using either approach or a combination of the two.

TOP-DOWN BUDGETING

Definition

Top-down budgeting starts at the highest level of the organization and works downwards. The top of the organization determines appropriate financial allowance for departments and imposes budget on lower layers of the organization.

Advantages

Can save time for lower management, as they respond to a budget given to them rather than creating one on their own.

One budget is created at one time rather than having to combine budgets from several departments.

Disadvantages

Those who are not directly involved with the day-to-day operations of a department may not be aware of the particular expenses related to the department

Decreased motivation due to lack of ownership of the budget

BOTTOM-UP BUDGETING

Definition

Starts at the lowest level of the organization and works upwards. A budget is decided by lower-level management and then presented to top management for approval.

Advantages

Lower management creates the budget based on the needs of their department

Budget made by those closest to the department

Increased motivation due to ownership of the budget

Upper management can concentrate more on strategy

Budget holders have the opportunity to participate in setting their own budgets (also called participative budgeting)

Disadvantages

Budgets may not be in line with corporate objectives

Budgetary slack: managers set targets that are too easy to achieve

AssetWORKS

Determining the Budget

- Determining the project budget is the process of sanctioning the costs approved in the estimation process.
- This step involves the creation of a time-phased aggregation of costs over the period of the project.
- Budget defines the amount of money required at different timelines in the project.
- This budget is used to allocate funds, as well as monitor the performance of the project during the execution in terms of costs.

Monitoring and Controlling the Budget

- When the project is under implementation, it is important that the expenses are monitored closely.
- Periodic reports of the expenses are compared with the baseline regularly, and any deviations are studied and analysed carefully.
- Controlling the budget ensures that the unnecessary changes that may affect the project budget are not allowed.
- It may sometimes happen that the money which was allocated has not been used; while at some other instances, the expenditure of the project may be more than what had been allocated.
- This is called variance, and the project manager must always try to avoid it, as it may lead to a strain on budget of the project.

Reasons for cost overrun

- Improperly defined Scope
- Improperly created WBS
- Improper technique used for estimation
- Project delays leading to schedule crashing
- Quality failures
- Change in the project environment, market conditions, prices, etc.
- Ineffective scope control leading to scope creep
- Unforeseen and uncontrollable risks

Updating the Budget

- The budget needs to be updated to reflect the authorised changes.
- The authorisation in the budget must come from the sponsor of the project.
- If due to some reasons, the budget has to be changed without the authorisation from the sponsor, then the organisation executing the project has to bear the loss.
- After the budget has been updated, it is important that the same is communicated to all the stakeholders of the project on time.

Network and Scheduling Techniques

- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
- Gantt Chart

Critical Path Method

- Critical path method (CPM) is a resource-utilization algorithm for scheduling a set of project activities.
- The essential technique for using CPM is to construct a model of the project that includes the following:

1. A list of all tasks required to complete the project
2. The dependencies between the tasks
3. The estimate of time (duration) that each activity will take to complete

- **In project management, the critical path is the longest sequence of tasks that must be completed to successfully conclude a project, from start to finish.**
- The tasks on the critical path are known as critical activities because if they're delayed, the whole project will be delayed.
- By identifying the critical path, you can determine the total duration of a project.

The critical path method (CPM) is used in project management to create project schedules and helps project managers create a timeline for the project. The critical path method includes:

- Identifying every task necessary to complete the project and the dependencies between them
- Estimating the duration of the project tasks
- Calculating the critical path based on the tasks' duration and dependencies to identify the critical activities
- Focusing on planning, scheduling and controlling critical activities
- Setting project milestones and deliverables
- Setting stakeholder expectations related to deadlines

Critical Path – Definition of Terms

- ***Earliest start time (ES):*** This is simply the earliest time that a task can be started in your project. You cannot determine this without first knowing if there are any preceding tasks, or figuring out other constraints that might impact the start of this task.
- ***Latest start time (LS):*** This is the very last minute in which you can start a task before it threatens to upset your project schedule. And you need to calculate what the latest finish time is for the same reason. By having a clear picture of this timeframe, you can better schedule the project to meet its deadline.
- ***Earliest finish time (EF):*** The earliest an activity can be completed, based on its duration and its earliest start time.
- ***Latest finish time (LF):*** The latest an activity can be completed, based on its duration and its latest start time.
- ***Float.*** Also known as slack, float is a term that describes how long you can delay a task before it impacts the planned schedule and threatens the project's deadline. The tasks on the critical path have zero float. You can either calculate the float using the steps above, or by using project management software. If an activity has a float greater than zero, it means it can be delayed without affecting the project completion time.
- ***Crash duration.*** This describes the shortest amount of time that a task can be scheduled. You can get there by moving around resources, adding more towards the end of the task, to decrease the time needed to complete the task. This often means a reduction in quality, but is based on a relationship between cost and time.
- ***Critical path drag.*** If time is added to the project because of a constraint, that is called a critical path drag, which is how much longer a project will take because of constraints on tasks in the critical path.

How to Calculate the Critical Path

- **Collect Activities:** Use a work breakdown structure to collect all the project activities that lead to the final deliverable.
- **Identify Dependencies:** Figure out which tasks are dependent on other tasks before they can begin.
- **Create a Network Diagram:** A critical path analysis chart, or network diagram, depicts the order of activities.
- **Estimate Timeline:** Determine the duration of each activity.
- **Use the Critical Path Algorithm:** The algorithm has two parts; a forward pass and a backwards pass.
- **Forward Pass:** Use the network diagram and the duration of each activity to determine their earliest start (ES) and earliest finish (EF). The ES of an activity is equal to the EF of its predecessor, and its EF is determined by the formula EF = ES + t (t is the activity duration). The EF of the last activity identifies the expected time required to complete the entire project.
- **Backward Pass:** Begins by assigning the last activity's earliest finish as its latest finish. Then the formula to find the LS is LS = LF – t (t is the activity duration). For the previous activities, the LF is the smallest of the start times for the activity that immediately follows.
- **Identify the Float of Each Activity:** The float is the length of time an activity can be delayed without increasing the total project completion time. Since the critical path has no float, the float formula reveals the critical path: Float = LS – ES
- **Identify the Critical Path:** The activities with 0 float make up the critical path.
- **Revise During Execution:** Continue to update the critical path network diagram as you go through the execution phase.

CPM Example

Activity	Predecessor	Duration (in Months)
A	--	3
B	--	4
C	B	3
D	A	1
E	A	3
F	D	3

Activity	Predecessor	Duration	ES	EF	LS	LF	Total Slack	Free Slack
A	--	3	0	3	0	3	0	0
B	--	4	0	4	0	4	0	0
C	B	3	4	7	4	7	0	0
D	A	1	3	4	3	4	0	0
E	A	3	3	6	4	7	1	1
F	D	3	4	7	4	7	0	0

Critical Path = A-D-F and B-C Duration = 7 months

PERT

- PERT stands for Program Evaluation Review Technique.
- PERT is a project management planning tool used to calculate the amount of time it will take to realistically finish a project.
- It is a system that helps in proper scheduling and coordination of all tasks throughout a project.
- It also helps in keeping track of the progress, or lack thereof, of the overall project.
- PERT charts were created in the 1950s to help manage the creation of weapons and defense projects for the US Navy.

Creating a PERT Chart

- A flowchart is used to depict the Project Evaluation Review Technique.
- Nodes represent the events, indicating the start or end of activities or tasks.
- The directorial lines indicate the tasks that need to be completed, and the arrows show the sequence of the activities.
- There are four definitions of time used to estimate project time requirements:

1. Optimistic time – The least amount of time it can take to complete a task
2. Pessimistic time – The maximum amount of time it should take to complete a task
3. Most likely time – Assuming there are no problems, the best, or most reasonable, estimate of how long it should take to complete a task.
4. Expected time – Assuming there are problems, the best estimate of how much time will be required to complete a task.

- To implement a PERT chart:

1. Identify the different tasks needed to complete a project. Make sure to add these in the right order and indicate the duration of each task.
2. Create a network diagram. Use arrows to represent the activities and use nodes as milestones.
3. Determine the critical path and possible slack.

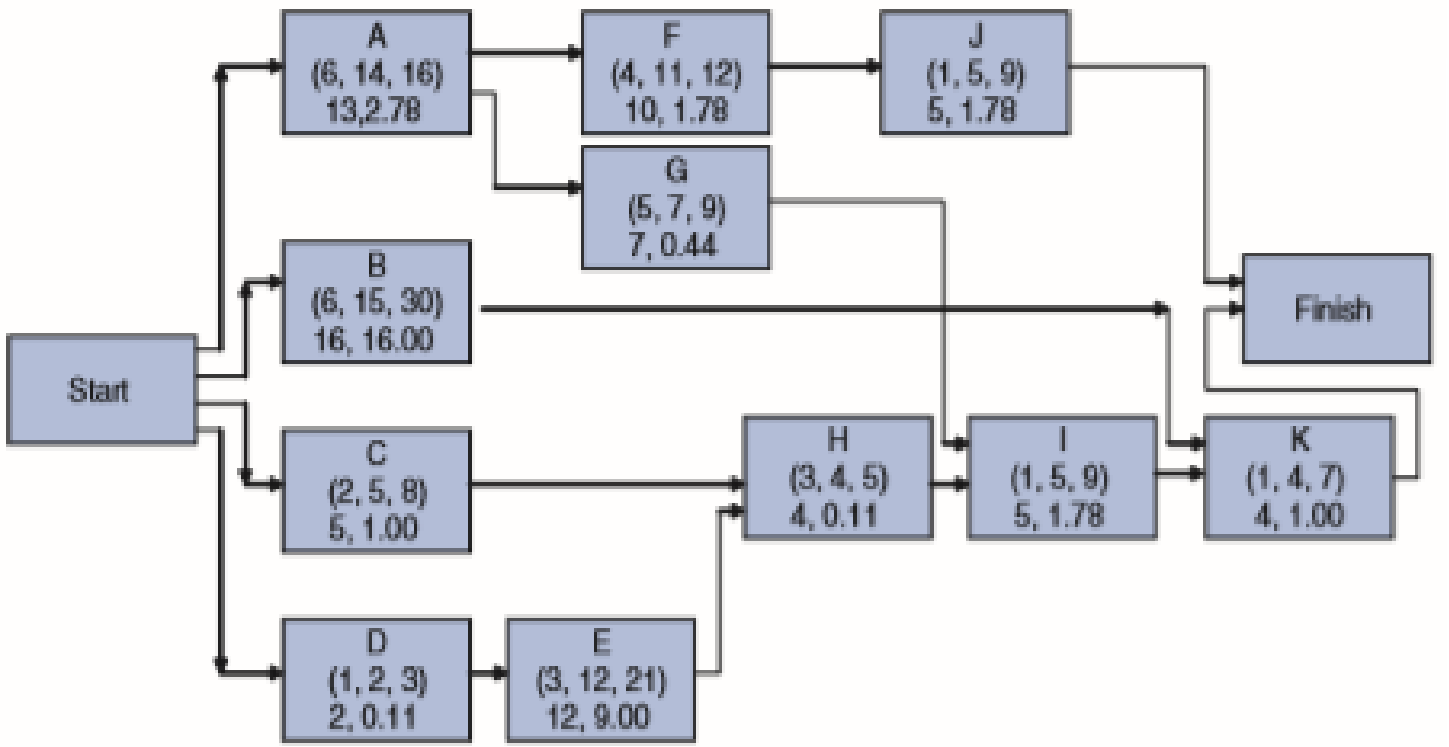
- **Advantages of PERT**

1. It helps maximize the use of resources.
2. It makes project planning more manageable.
3. It’s useful even if there is little or no previous schedule data.
4. It enables project managers to better estimate or determine a more definite completion date.

- **Disadvantages of PERT**

1. In complex projects, many find PERT hard to interpret, so they may also use a Gantt Chart, another popular method for project management.
2. It can be tedious to update, modify, and maintain the PERT diagram.
3. It entails a subjective time analysis of activities and, for those who are less experienced or are biased, this may affect the project’s schedule.

PERT Example



Key

Activity
(a, m, b)
t_e, V

The mean expected time of each activity is $t_e = \frac{a + 4m + b}{6}$

The variance of each activity $= V = \left(\frac{b - a}{6}\right)^2$

An R & D project has a list of tasks to be performed whose time estimates are given in the Table , as follows.

Time Estimates for R & D Project

Activity i j	Activity Name	T_0	t_m (in days)	t_p
1-2	A	4	6	8
1-3	B	2	3	10
1-4	C	6	8	16
2-4	D	1	2	3
3-4	E	6	7	8
3-5	F	6	7	14
4-6	G	3	5	7
4-7	H	4	11	12
5-7	I	2	4	6
6-7	J	2	9	10

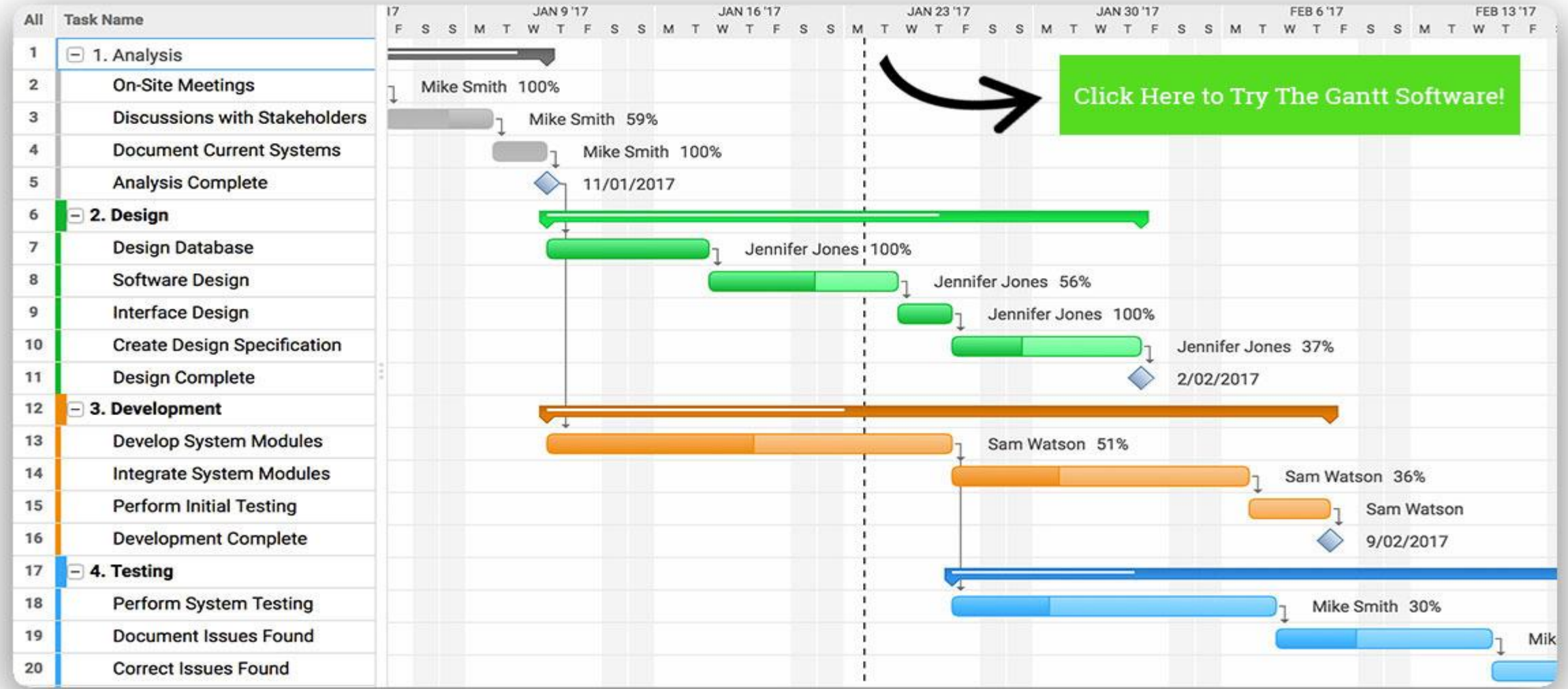
a. Draw the project network.
b. Find the critical path.
c. Find the probability that the project is completed in 19 days. If the probability is less than 20%, find the probability of completing it in 24 days.

Gantt Chart

- A Gantt chart is a project management tool assisting in the planning and scheduling of projects of all sizes.
- A Gantt chart is a bar chart that provides a visual view of tasks scheduled over time.
- It is a useful way of showing what work is scheduled to be done on a specific day.
- It can also help you view the start and end dates of a project in one simple chart.
- The vertical axis of a Gantt chart shows the tasks that need to be completed, while the horizontal axis represents time.
- On a Gantt chart you can easily see:

1. The start date of the project
2. What the project tasks are
3. Who is working on each task
4. When tasks start and finish
5. How long each task will take
6. How tasks group together, overlap and link with each other
7. The finish date of the project

Gantt Chart Example



Why use a Gantt chart?

A Gantt chart is used for the following activities:

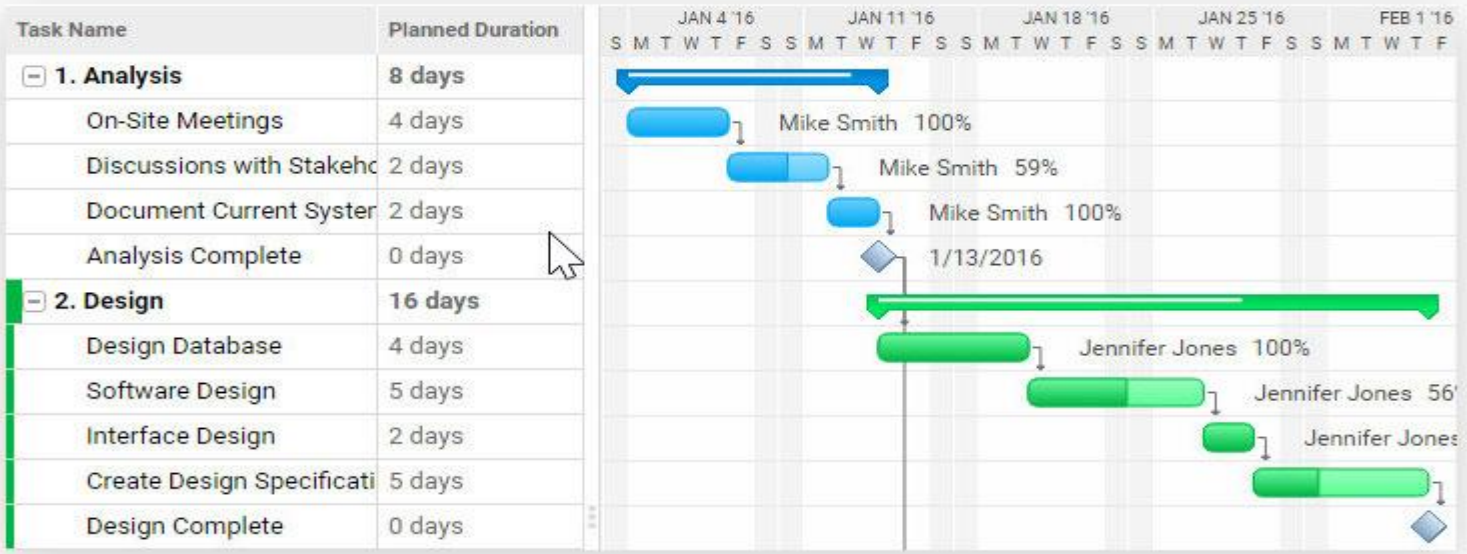
- Establish the initial project schedule - who is going to do what, when and how long will it take.
- Allocate resources - ensure everyone knows who is responsible for what.
- Make project adjustments - the initial plan will need many adjustments.
- Monitor and report progress - helps you stay on schedule.
- Control and communicate the schedule - clear visuals for stakeholders and participants.
- Display milestones - shows key events.
- Identify and report problems - As everything is depicted visually you can immediately see what should have been achieved by a certain date and, if the project is behind schedule, you can take action to bring it back on course.

Possible downfalls of Gantt Chart

- Gantt charts are not perfect and can become overly complex with too many dependencies and activities.
- Gantt charts are also not good at showing the relative priorities of individual tasks and the resources expended on a task. They can clearly show the elapsed time of a task but don't easily communicate how many people may be needed to complete it.

Milestones

- Milestones are represented by a diamond symbol on the Gantt and have no duration.
- A milestone marks the end of a piece of work or phase of the project.
- They are often fixed dates or important dates that you need to be aware of.



Project Management Information System (PMIS)

- A PMIS is typically a computer-driven system to aid a project manager in the development of the project.
- A PMIS can calculate schedules, costs, expectations, and likely results.
- The goal of a PMIS is to automate, organize, and provide control of the project management processes.
- The Project Management Book of Knowledge (PMBOK) states that a PMIS is “an information system consisting of the tools and techniques used to gather, integrate, and disseminate the outputs of project management processes. It is used to support all aspects of the project from initiating through closing and can include both manual and automated systems.”

PMIS (contd..)

- PMIS are system tools and techniques used in project management to deliver information.
- Project managers use the techniques and tools to collect, combine and distribute information through electronic and manual means.
- PMIS is used by upper and lower management to communicate with each other.
- A typical PMIS software system has:

➢WBS creation tools

➢Calendaring features

➢Scheduling abilities

➢PERT Charts, Gantt Charts

➢Calculating critical path, project schedule

➢Resource tracking and levelling

PMIS (contd..)

- It is an automated system to quickly create, manage, and streamline the project management processes.
- PMIS also includes a configuration management system.
- Configuration management is an approach for tracking all approved changes, versions of project plans, blueprints, software numbering, and sequencing.

Essential Features of a PMIS

- **Schedule and Planning:** Computes early and late schedule, slack times and the critical path
- **Resource Management:** Including resource loading, leveling, allocation, etc.
- **Budget:** Associate cost with individual tasks for more accurate budget estimation and generation.
- **Control and Performance:** Analyze and control cost and performance, updating existing plans as actual against planned data changes, provide what-if scenarios for the project manager.
- **Reporting and Communication:** Creation of graphs and charts of collected and analyzed data that can be shared with stakeholders and team members.
- **Integration and Ease of Use:** Some PMIS will access data from different projects for multi-project analysis, integrating with other systems, such as payroll, inventory, etc. The easier a PMIS is to use, the less time and money required to train.

Examples of PMIS

- Microsoft Project (MS Project)
- Project Scheduler
- Welcom
- Trakker
- Primavera