Chapter 06

Project Schedule Management

erga

Project Management

Prepared by **Quality Management Dept.**

Presented by **Fouad Abou Rjeily**

Erga Academy

PM17 – PMP6 Certification

EPDM & ESM tracks

20 credits

Plan


1. Introduction
2. Environment in which projects operate
3. The role of the Project Manager
4. Project Integration Management
5. Project Scope Management
6. Project Schedule Management
7. Project Cost Management
8. Project Quality Management
9. Project Resource Management
10. Project Communications Management
11. Project Risk Management
12. Project Procurement Management
13. Project Stakeholder Management
14. Professional Responsibility

Plan

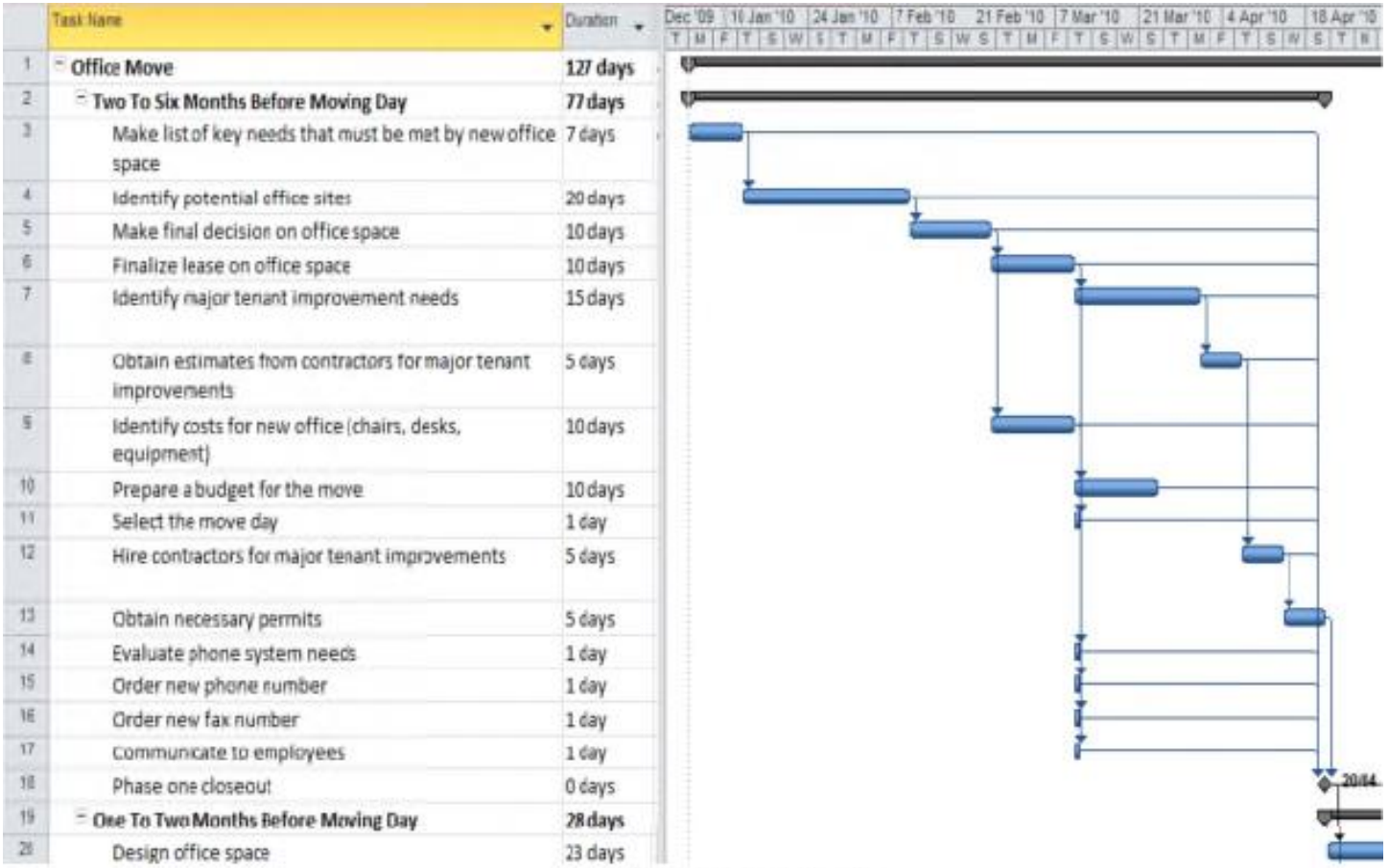
- Chapter 06- Project Schedule Management

It includes the processes required to manage the timely completion of the project successfully.

- Deliver project on time is one of the biggest challenges.
- Time has the least amount of flexibility; it passes no matter what happens on a project.
- Schedule issues are the main reason for conflicts on projects, especially during the execution stage of the project.
- For small projects, appropriate processes can be grouped in one.

Plan

- Chapter 06- Project Schedule Management



	Task Name	Duration
1	Office Move	127 days
2	Two To Six Months Before Moving Day	77 days
3	Make list of key needs that must be met by new office space	7 days
4	Identify potential office sites	20 days
5	Make final decision on office space	10 days
6	Finalize lease on office space	10 days
7	Identify major tenant improvement needs	15 days
8	Obtain estimates from contractors for major tenant improvements	5 days
9	Identify costs for new office (chairs, desks, equipment)	10 days
10	Prepare a budget for the move	10 days
11	Select the move day	1 day
12	Hire contractors for major tenant improvements	5 days
13	Obtain necessary permits	5 days
14	Evaluate phone system needs	1 day
15	Order new phone number	1 day
16	Order new fax number	1 day
17	Communicate to employees	1 day
18	Phase one closeout	0 days
19	One To Two Months Before Moving Day	28 days
20	Design office space	23 days

Bar Chart Format

Plan

- **Chapter 06- Project Schedule Management**
  - 6.1 Plan Schedule Management
  - 6.2 Define Activities
  - 6.3 Sequence Activities
  - 6.4 Estimate Activity Durations
  - 6.5 Develop Schedule
  - 6.6 Control Schedule

	Project Management Process Groups				
Knowledge Areas	Initiating	Planning	Executing	Monitoring & Controlling	Closing
6. Project Schedule Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	

Plan

Chapter 06- Project Schedule Management

- **6.1 Plan Schedule Management (***Planning***)**: The process of establishing the policies, procedures and documentation for planning, developing, executing and controlling the project schedule.
- **6.2 Define Activities (***Planning***)**: identifying the specific activities that the project team members and stakeholders must perform to produce the project deliverables.
- **6.3 Sequence Activities (***Planning***)**: identifying and documenting the relationships between project activities.
- **6.4 Estimate Activity duration (***planning***):** Estimate the number of work periods that are needed to complete individual activities with the estimated resources.
- **6.5 Develop Schedule (***planning***):** analyzing activity sequences, activity resource estimates, and activity duration estimates and schedule constraints to create the project schedule.
- **6.6 Control Schedule** (*M&C*): Monitor the status of the project to update project progress and manage changes to the schedule baseline.

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- The PMT selects a scheduling method, such as critical path or an agile approach. Then, the project-specific data, such as the activities, planned dates, durations, resources, dependencies, and constraints, are entered into a scheduling tool to create a schedule model for the project. The result is a project schedule.

- For smaller projects, defining activities, sequencing activities, estimating activity durations, and developing the schedule model are so tightly linked that they are viewed as a single process that can be performed by a person over a relatively short period of time.

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Some of the emerging practices for scheduling methods include:

- **Alterative scheduling with a backlog**. This is a form of rolling wave planning based on adaptive life cycles, such as the agile approach for product development. The requirements are documented in user stories that are then prioritized and refined just prior to construction, and the product features are developed using time-boxed periods of work. This approach is often used to deliver incremental value to the customer or when multiple teams can concurrently develop a large number of features that have few interconnected dependencies. This scheduling method is appropriate for many projects as indicated by the widespread and growing use of adaptive life cycles for product development. The benefit of this approach is that it welcomes changes throughout the development life cycle.
- …

Chapter 06- Project Schedule Management

- ...
- **On-demand scheduling**. This approach, typically used in a Kanban system, is based on the theory-of-constraints and pull-based scheduling concepts from lean manufacturing to limit a team's work in progress in order to balance demand against the team's delivery throughput.
  - On-demand scheduling does not rely on a schedule that was developed previously for the development of the product or product increments, but rather pulls work from a backlog or intermediate queue of work to be done immediately as resources become available.
  - On-demand scheduling is often used for projects that evolve the product incrementally in operational or sustainment environments, where tasks may be made relatively similar in size and scope or can be bundled by size and scope.

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Because each project is unique, the PM may need to tailor the way Project Schedule Management processes are applied.
Considerations for tailoring include:

- **Life cycle approach**. What is the most appropriate life cycle approach that allows for a more detailed schedule?
- **Resource availability**. What are the factors influencing durations?
- **Project dimensions**. How will the presence of project complexity, technological uncertainty, product novelty, pace, or progress tracking impact the desired level of control?
- **Technology support**. Is technology used to develop, record, transmit, receive, and store project schedule model information and is it readily accessible?

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Adaptive approaches use short cycles to undertake work, review the results, and adapt as necessary. These cycles provide rapid feedback on the approaches and suitability of deliverables.

- The role of the PM does not change based on managing projects using a predictive development life cycle or managing projects in adaptive environments.
- However, to be successful in using adaptive approaches, the PM will need to be familiar with the tools and techniques to understand how to apply them effectively.

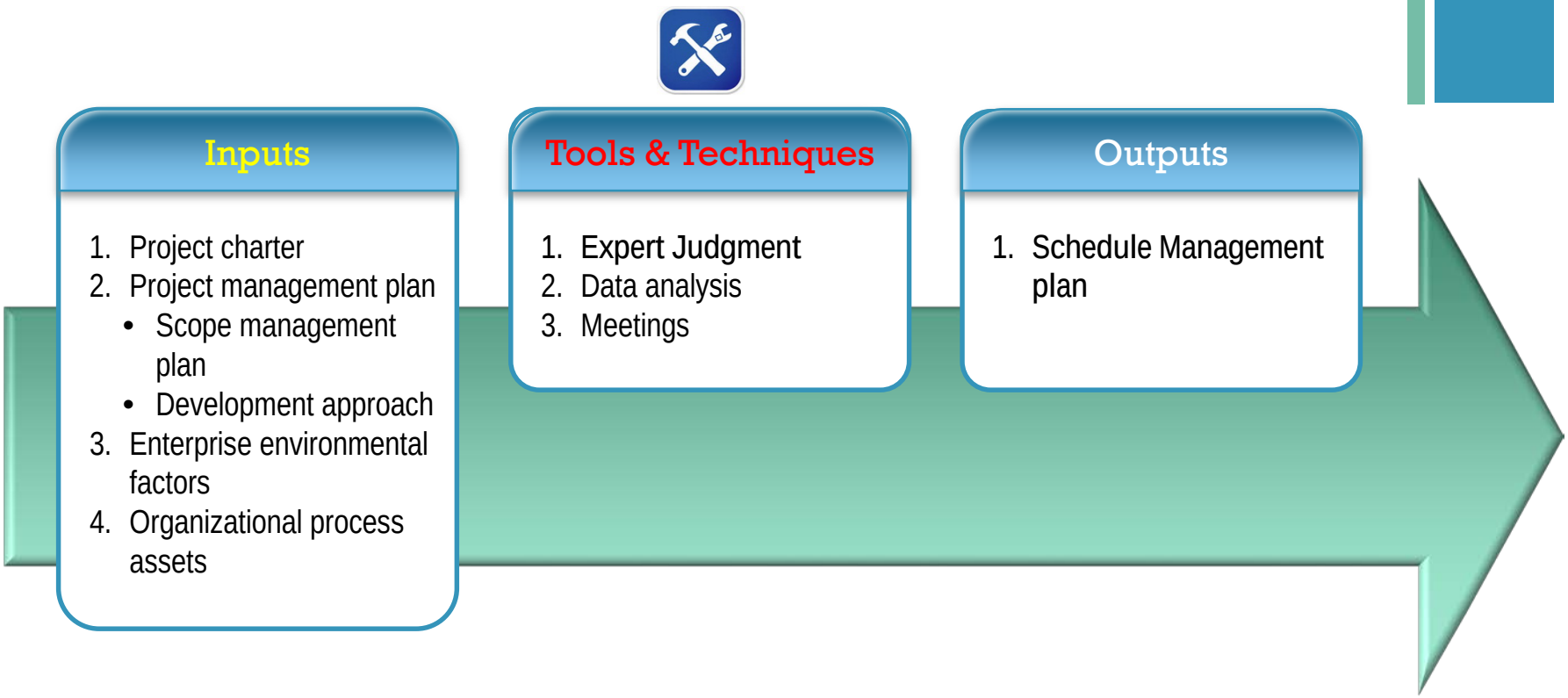
6.1 Plan Schedule Management

Establishing the policies, procedures and documentation for developing and managing, executing and controlling the project schedule.

- Who is involved in scheduling activities?
- What processes and procedures are used?
- What scheduling tool?
- How the schedule baseline will be maintained?
- How the schedule variances will be managed?

Defining a Schedule management plan ➔ Thinking and deciding in advance about how you will manage the schedule of your project.

6.1 Plan Schedule Management



6.1 Plan Schedule Management

1. Expert judgment

Expertise should be considered from individuals or groups with specialized knowledge or training in previous, similar projects:

- Schedule development, management, and control;
- Scheduling methodologies (predictive or adaptive life cycle);
- Scheduling software;
- The specific industry for which the project is developed.

The schedule management plan may also detail ways to perform fast track or crash the schedule.

6.1 Plan Schedule Management

1. Schedule Management plan

- Schedule management plan is a component of the PMP.
- You need to realize that PM should have a plan in advance on how to manage the schedule. This is a concept many PMs miss..!!!
- The schedule management plan includes:
  1. What scheduling methodology to be used on the project?
  2. What scheduling software to be used on the project?
  3. How schedule changes will be managed?
  4. How schedule variances will be managed?

6.1 Plan Schedule Management

1. Schedule Management plan

The schedule management plan can establish the following:

- **Project schedule model development**. The scheduling methodology and the scheduling tool to be used in the development of the project schedule model are specified.
- **Release and iteration length**. When using an adaptive life cycle, the time-boxed periods for releases, waves, and iterations are specified. Time-boxed periods are durations during which the team works steadily toward completion of a goal. Time-boxing helps to minimize scope creep as it forces the teams to process essential features first, then other features when time permits.
- **Level of accuracy**. The level of accuracy specifies the acceptable range used in determining realistic activity duration estimates and may include an amount for contingencies.
- …

6.1 Plan Schedule Management

1. Schedule Management plan (cont'd)

- **Units of measure.** Each unit of measurement (such as staff hours, staff days, or weeks for time measures, or meters, liters, tons, kilometers, or cubic yards for quantity measures) is defined for each of the resources.
- **Organizational procedures links**. The work breakdown structure (WBS) provides the framework for the schedule management plan, allowing for consistency with the estimates and resulting schedules.
- **Control thresholds**. Variance thresholds for monitoring schedule performance may be specified to indicate an agreed-upon amount of variation to be allowed before some action needs to be taken. Thresholds are typically expressed as percentage deviations from the parameters established in the baseline plan.
- …

6.1 Plan Schedule Management

1. Schedule Management plan (cont'd)

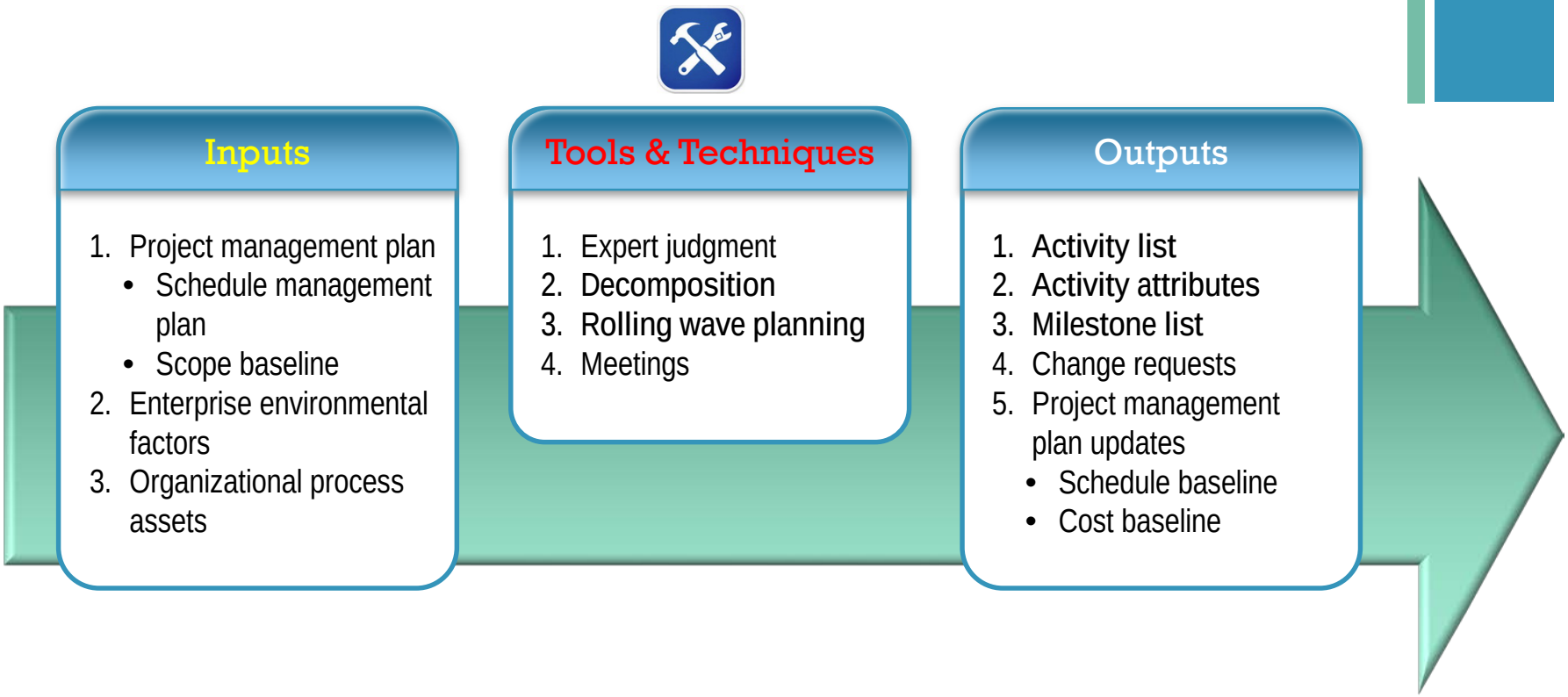
- **Project schedule model maintenance**. The process used to update the status and record progress of the project in the schedule model during the execution of the project is defined.
- **Rules of performance measurement**. Earned value management (EVM) rules or other physical measurement rules of performance measurement are set. It may specify:
  - Rules for establishing percent complete,
  - EVM techniques (baselines, fixed-formula, % complete, etc.) to be employed,
  - Schedule performance measurements such as schedule variance (SV) and schedule performance index (SPI) used to assess the magnitude of variation to the original schedule baseline.
- **Reporting formats**. The formats and frequency for the various schedule reports are defined.

6.2 Define Activities

Identifying and documenting the specific actions to be performed to produce the project deliverables.

- Work packages are decomposed into activities.
- Activity level is small enough to estimate, schedule, monitor and manage.
- Activities are the basis for providing estimates for budgets, scheduling, executing and monitoring and controlling of project work.
- These activities are then sequenced in the next process: activity sequencing.

6.2 Define Activities



6.2 Define Activities

2. Decomposition

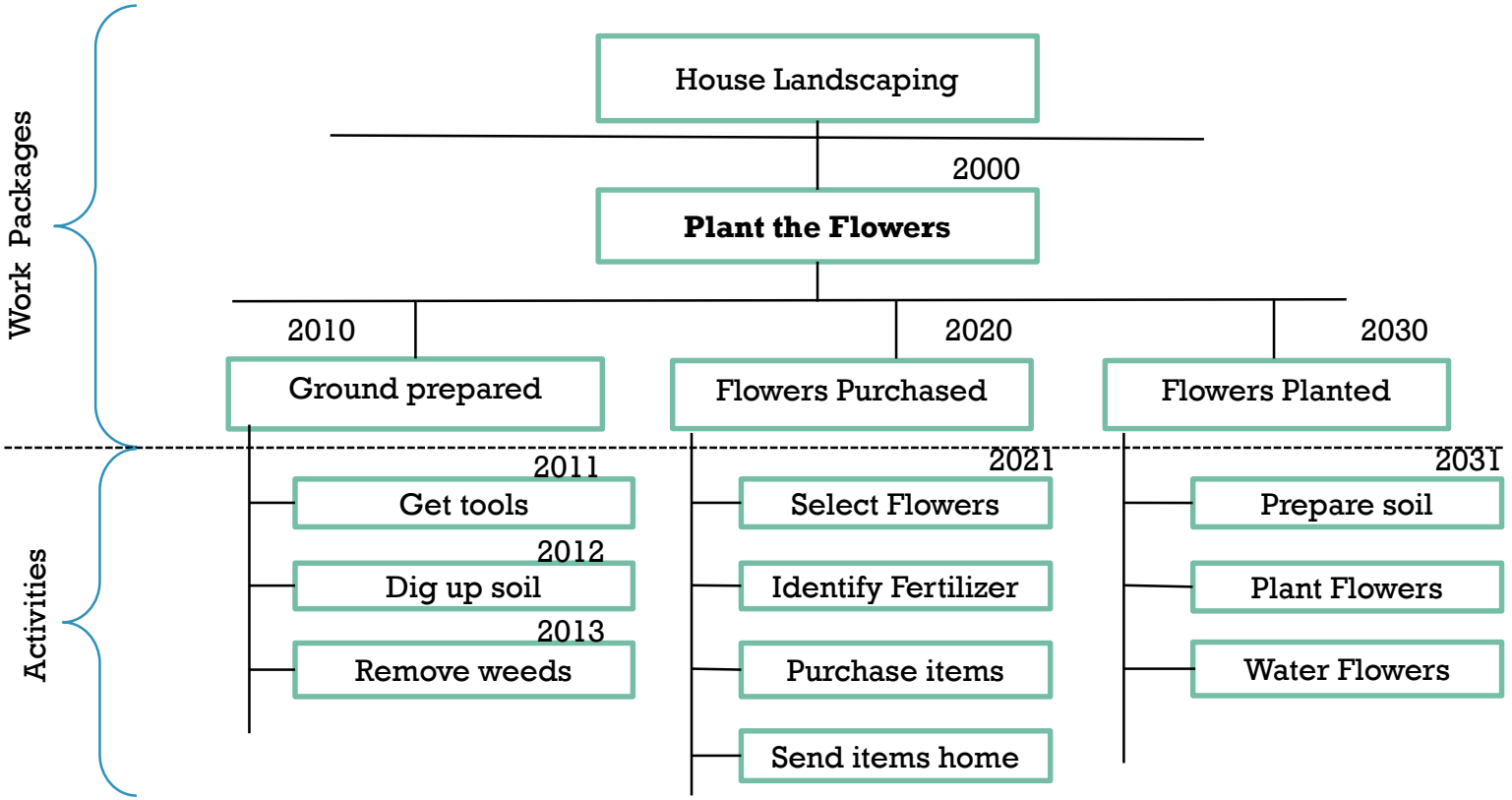
Subdividing the project **work packages** WBS into smaller, more manageable components, called **activities**.

- The WBS is the basis for this decomposition.
- Activities are all efforts needed to complete the related work package.
- It should involve the PT members for more accurate results.

6.2 Define Activities

Input → **Tools & Techniques** → Output

2. Decomposition - Example



6.2 Define Activities

3. Rolling Wave Planning

- Work that is imminent is planned in detail while work that is way off in the future is planned at a high level.
- As the work in the future approaches, more detail is allotted to planning this work.
- This is an iterative approach to planning, commonly found in methods such as SCRUM or other Agile Project Management methodologies:
  - Encourages adaptability (Changing requirements).
  - Encourages planning.
  - Is great for Research & Development, High-Tech, Invention projects.
  - Is good for projects with changing scope.

6.2 Define Activities

1. **Activity List:** A tabulation of activities that includes:
   - The activity name.
   - An activity identifier or number.
   - A brief description of the activity.

2. Activity attributes: Activity attributes describe the characteristics of the activities and are an extension of the activity list:
   - WBS ID,
   - description,
   - predecessors,
   - successors,
   - logical relationships,
   - leads and lags,
   - resource requirements,
   - constraints,
   - imposed dates,
   - assumptions related to the activity.

6.2 Define Activities

3. Milestone List

Milestones are typically major accomplishments or a significant event of the project and mark the completion of major deliverables or some other key events in the project.

- The milestone list records these accomplishments and documents whether the milestone is mandatory or optional.
- They're useful tools for setting schedule goals and monitoring progress.
- Milestones have zero duration because they represent a significant point or event.
- Examples include obtaining customer sign-off on key documents or completion of specific products.

6.3 Sequence Activities

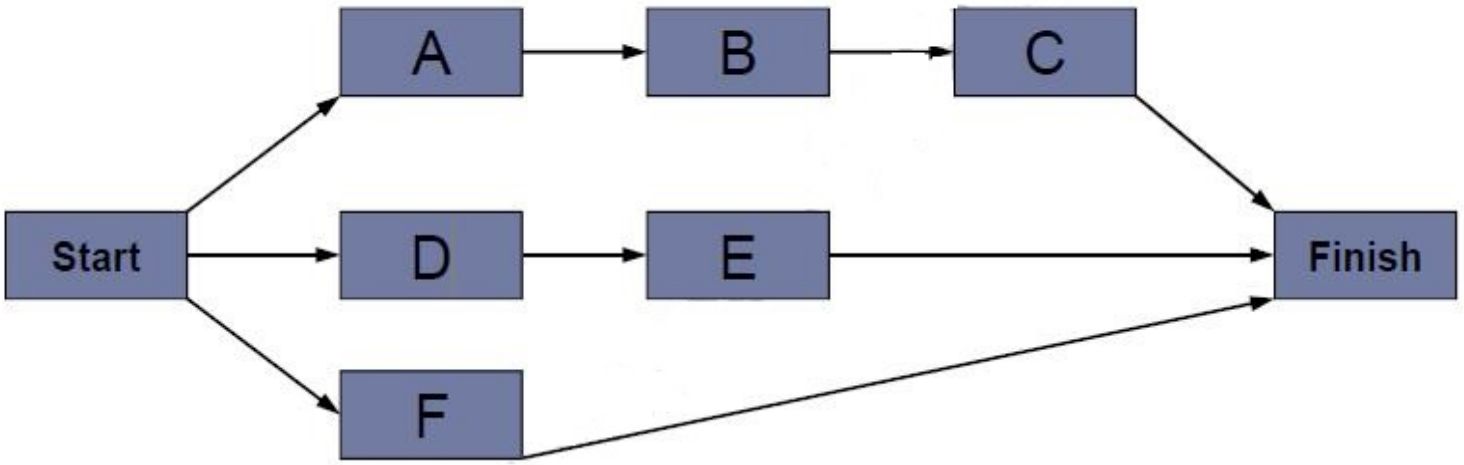
Identifying and documenting relationships among the activities.

- Logical relationships exist between activities.
- Activities are characterized as 'Predecessor' and 'Successor'.
- Every activity & milestone has at least one PREDECESSOR (except the first one).
- Every activity & milestone has at least one SUCCESSOR (except the last one).
- In this process, activities are sequenced based on how the work will be performed. The result is a network diagram (or project schedule network diagram) and it involves reviewing activities and determining dependencies
- A **dependency** or **relationship** is the sequencing of project activities or tasks.

You *must* determine dependencies in order to use **critical path** analysis

6.3 Sequence Activities

Network Diagram Sample



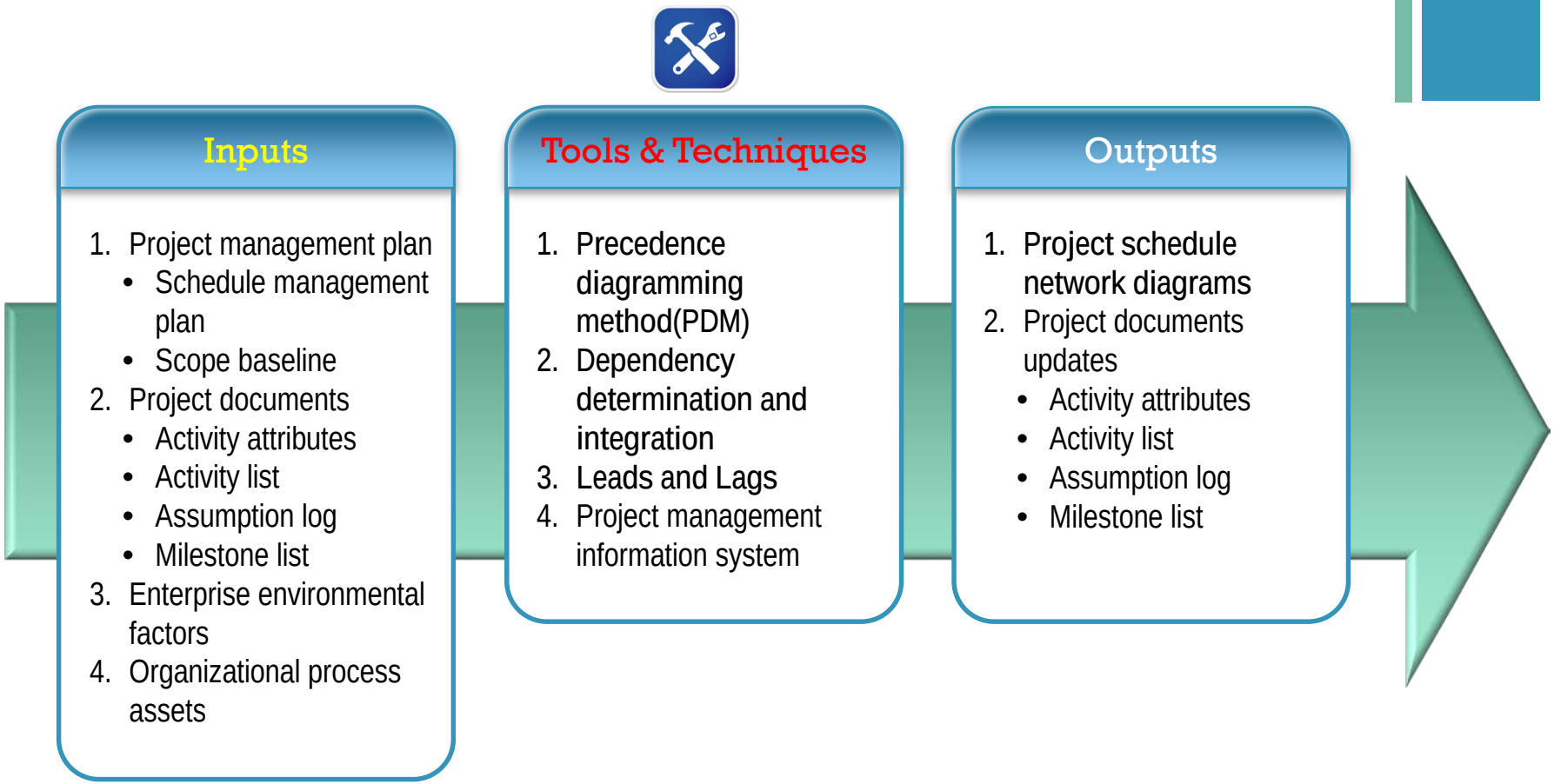
6.3 Sequence Activities

How do Network Diagrams help you?

- Help to justify your time estimate for the project.
- Aid in effective planning, organizing and controlling the project.
- Show interdependencies of all activities.
- Show workflow so the team will know what activities need to happen in which sequence.
- Identify opportunities to compress the schedule in planning and throughout the life of the project.
- Show project progress when used for controlling the schedule and reporting.
- Sequencing and building up network diagram will reveal in identifying new risks and will result in updating the risk register.
- They are the preferred technique for showing activity sequencing.
- Two main formats are the Arrow and Precedence diagramming methods; a secondary format is GERT.

For the exam, know that, in its pure form, the network diagram shows just dependencies. If activity duration estimates are added, the network diagram could also show the critical path.

6.3 Sequence Activities



6.3 Sequence Activities

Input → **Tools & Techniques** → Output

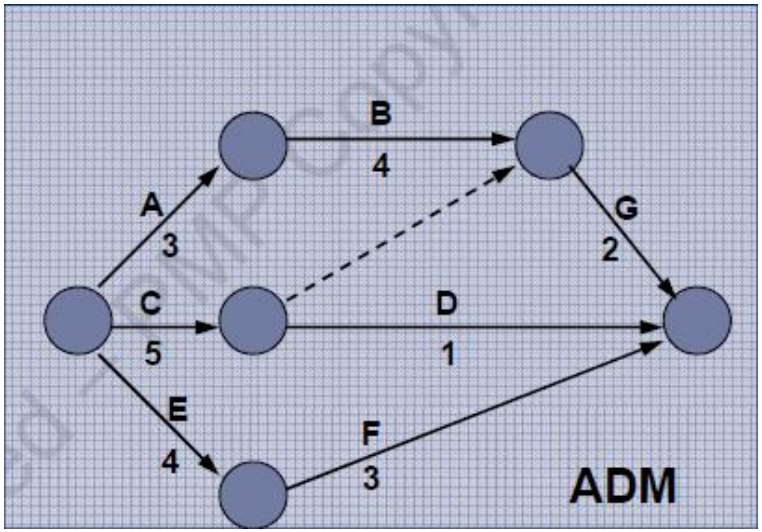
1. Precedence Diagramming Method (PDM)

Arrow Diagramming Method (ADM) or (AOA)

ADM is a method of constructing a project schedule network diagram that uses arrows to represent activities and connects them at nodes to show their dependencies.

- This technique is also called activity-on-arrow (AOA).
- ADM uses only finish-to-start FS relationship.

Rule: Only one connecting arrow between nodes.



6.3 Sequence Activities

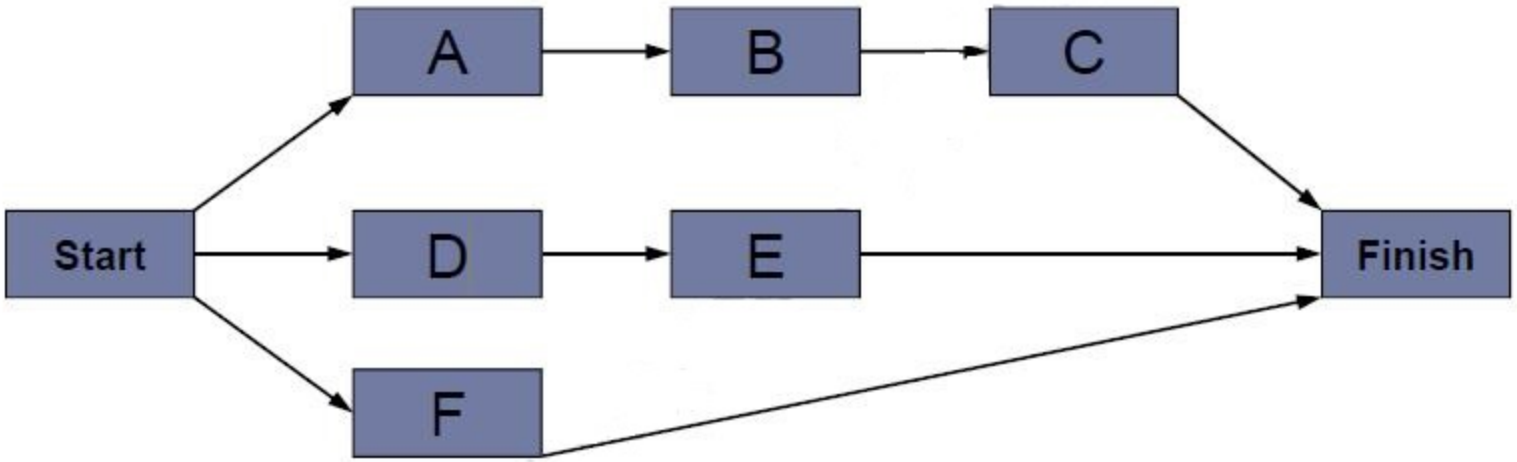
Input → **Tools & Techniques** → Output

1. Precedence Diagramming Method (PDM) (cont'd)

Activity on Node (AON)

It is the method used by most project management software packages.

- This is a method of constructing a project network diagram.
- This technique is also called activity-on-node (AON).



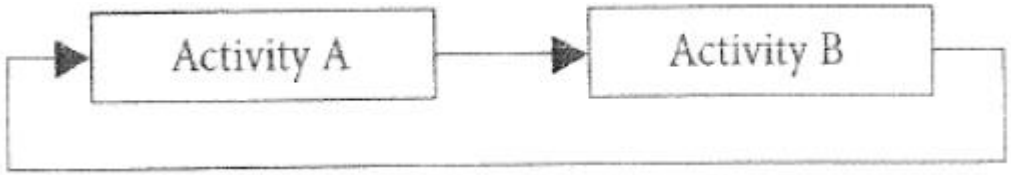
6.3 Sequence Activities

1. Precedence Diagramming Method (PDM) (cont'd)

GERT (Graphical Evaluation & Review Technique)

The GERT approach addresses the majority of the limitations associated with PERT/CPM technique. GERT allows loops between tasks. The fundamental drawback associated with the GERT technique is the complex program (Monte Carlo simulation) required to model the GERT system.

- It allows loops between activities.
- *Very rarely used on the exam*.



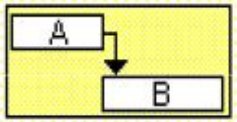
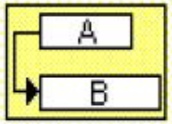
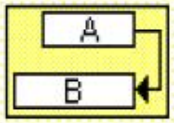
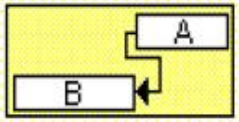
6.3 Sequence Activities

Input → **Tools & Techniques** → Output

2. Dependency determination and integration

Task dependencies

The nature of the dependencies between linked tasks. You link tasks by defining a dependency between their finish and start dates. For example, the "Contact caterers" task must finish before the start of the "Determine menus" task. There are four kinds of task dependencies in Microsoft Project:

Task dependency	Example	Description
Finish-to-start (FS)		Task (B) cannot start until task (A) finishes.
Start-to-start (SS)		Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)		Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)		Task (B) cannot finish until task (A) starts. (Rarely Used)

FS Most commonly used

SF very rarely used

6.3 Sequence Activities

2. Dependency determination and integration (cont'd)

Dependencies are relationships between the activities in which one activity is dependent on another to complete an action or perhaps an activity is dependent on another to start an action before it can proceed.

Four types of dependencies:

a. **Mandatory dependencies**
b. **Discretionary dependencies**
c. **External dependencies**
d. **Internal dependencies**

6.3 Sequence Activities

2. Dependency determination and integration (cont'd)

a. Mandatory Dependencies:

These dependencies are the natural order of activity.

- For example, you can't begin building your house until your foundation is in place. These relationships are also called hard logic.

b. Discretionary dependencies:

These dependencies are the preferred order of activities. It is defined by the project management team.

- This dependency can be changed easily if needed, while the other type of dependencies cannot.
- These relationship are also known as soft logic, preferred logic, or preferential logic.

6.3 Sequence Activities

2. Dependency determination and integration (cont'd)

c. External dependencies:
As its name implies, these are dependencies outside of the project team's control. Examples include the delivery of equipment from a vendor, the deliverable of another project, or the decision of a committee, lawsuit, or expected new law.

d. Internal dependencies:
Internal dependencies between project activities and are generally within the PT's control.

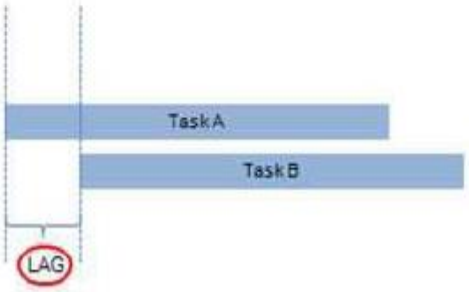
6.3 Sequence Activities

Input → **Tools & Techniques** → Output

3. Lead and Lags

A **lead** may be added to start an activity before the predecessor activity is completed. For example, coding might be able to start five days before the design is finished.

A **lag** is inserted as waiting time between activities, such as needing to wait three days after pouring concrete before constructing the frame for the house



Example:

"Lag" can also be represented in the project network diagram as

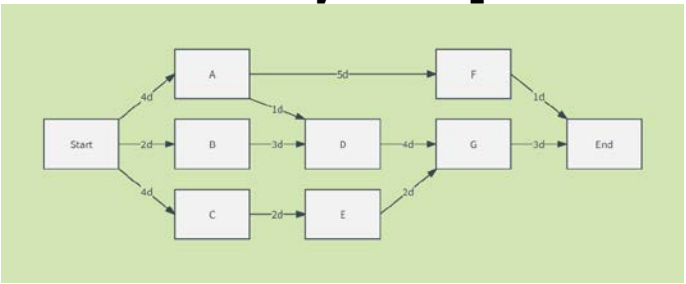
(SS + 10) (*start to start + 10 days lag*)

6.3 Sequence Activities

1. Project Schedule Network Diagrams

A project schedule network diagram is a graphical representation of the logical relationships, also referred to as dependencies, among the project schedule activities.

- It can be produced manually or by using a project management software.
- Activities that have multiple predecessor activities indicate a path convergence. Activities that have multiple successor activities indicate a path divergence. Activities with divergence and convergence are at greater risk as they are affected by multiple activities or can affect multiple activities.



6.4 Estimate Activity Durations

Estimating the number or work periods needed to complete individual activities with the estimated resources.

Rely on the Availability and quality of the INPUTS

Can be progressively elaborated

Activity Duration: Approximate number of work periods

6.4 Estimate Activity Durations

- The tasks are first identified, the sequencing of the activities takes place, resources are defined and then durations are estimated.
- The Activity Duration Estimating process attempts to estimate the work effort, and number of work periods needed to complete each schedule activity.
- The primary output of this process is the activity duration estimates.
- It uses information from the scope of work, required resource types or skill levels, estimated resource quantities, and resource calendars

6.4 Estimate Activity Durations

Other factors for consideration when estimating duration include:

- **Law of diminishing returns**. When one factor (resource) used to determine the effort required to produce a unit of work is increased while all other factors remain fixed, a point will eventually be reached at which additions of that one factor start to yield progressively smaller or diminishing increases in output.
- **Number of resources**. Increasing the number of resources to twice the original number of the resources does not always reduce the time by half, as it may increase extra duration due to risk, and at some point adding too many resources to the activity may increase duration due to knowledge transfer, learning curve and additional coordination.
- **Advances in technology**. For example, an increase in the output of a manufacturing plant may be achieved by procuring the latest advances in technology, which may impact duration and resource needs.
- **Motivation of staff**. The PM also needs to be aware of Student Syndrome or procrastination—when people start to apply themselves only at the last possible moment before the deadline, and Parkinson's Law where work expands to fill the time available for its completion.

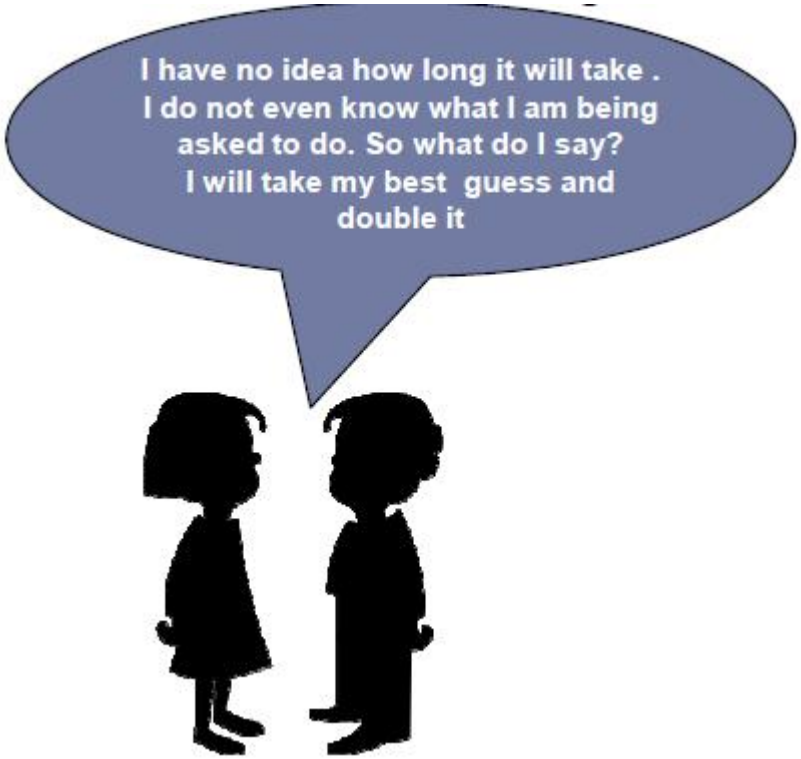
6.4 Estimate Activity Durations

Padding

- Just think about estimating in real word
- Are your hearing from the team member the following?

  This is an example of padding.

- Padding is a unprofessional Project management
- Realize this concept which will be useful for exam.
- A pad is extra time or cost added to an estimate because the estimator does not have enough information

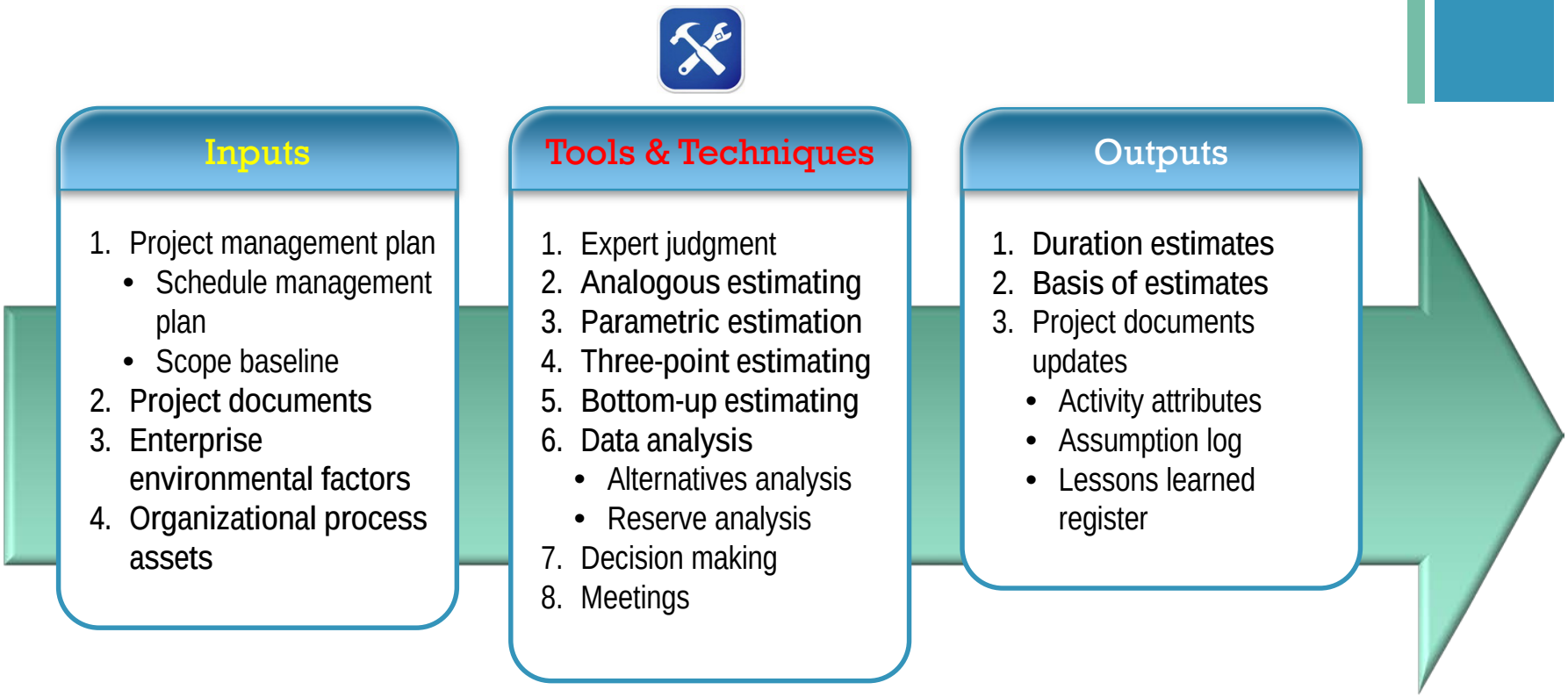


6.4 Estimate Activity Durations

If the person doing the work is estimating the duration, then what is the PMs role in estimating?

1. Provide the team with enough information to properly estimate each activity.
2. Let those doing the estimation know how refined their estimates must be.
3. Do a complete sanity check on estimate.
4. Prevent padding.
5. Formulate a reserve (you can learn more in Risk management area).
6. Make sure assumptions made during estimation are recorded for later review.

6.4 Estimate Activity Durations



6.4 Estimate Activity Durations

2. Project documents

Project documents that can be considered as inputs include:

- Activity attributes.
- Activity list.
- Assumption log.
- Lessons learned register..
- Milestone list.
- Project team assignments.
- Resource breakdown structure.
- Resource calendars.
- Resource requirements.
- Risk register.

6.4 Estimate Activity Durations

3. Enterprise Environmental Factors

Include but are not limited to:

- Duration estimation databases,
- Productivity metrics,
- Published commercial information,
- Location of team members.

4. Organizational Process Assets

Include but are not limited to:

- Historical duration information,
- Project calendars,
- Estimating policies,
- Scheduling methodology,
- Lessons learned repository.

6.4 Estimate Activity Durations

2. Analogous Estimating

Analogous estimating uses historical information of similar activity in past project & uses expert judgment.

- Analogous estimating is frequently used to estimate project duration when there are limited amount of information available in the project.
- It is generally less costly & less time consuming compared to other estimation techniques, but it is also less accurate.
- Analogous duration estimating is most reliable when the previous activities are similar in fact and not just appearance, and the project team members preparing the estimates have the needed expertise.

6.4 Estimate Activity Durations

3. Parametric Estimating

Estimation based on a set "Parameter"

- Estimation is done based on historical records from previous projects & other available information.
- Durations can be quantitatively determined by multiplying the quantity of work to be performed by the number of labor hours per unit of work.
- Example: Time per installation, cost per sq. feet

6.4 Estimate Activity Durations

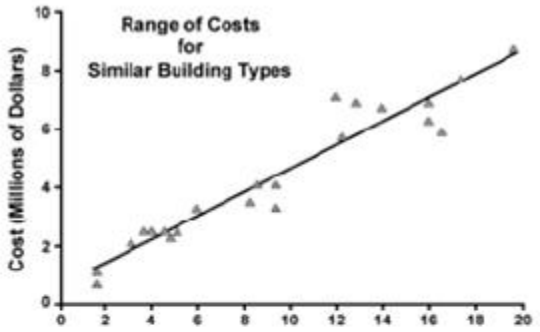
Input → **Tools & Techniques** → Output

3. Parametric Estimating (cont'd)

There are two ways an estimator can create parametric Estimates:

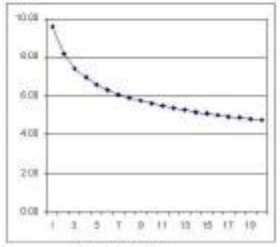
a. **Regression Analysis** (Scatter diagram): This diagram tracks two variables to see if they are related and creates a mathematical formula to use in the future parametric estimating.

b. **Learning curve**: Example: The 100th room painted will take less than the first room because of improved efficiency.

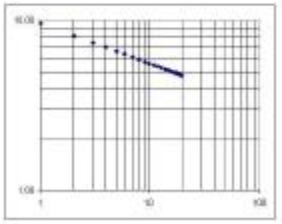


Learning Curve Example

$$Y_n = Y_1 \cdot n^{-b} = (9.6) \cdot n^{-0.2345}$$



Normal Scale



Log-Log Scale

6.4 Estimate Activity Durations

4. Three-Point Estimating

(PERT Analysis: Program Evaluation & Review Technique)

Three-point estimates are based on determining three types of estimates:

- **Most likely.** The duration of the schedule activity, given the resources likely to be assigned, their productivity, realistic expectations of availability for the schedule activity, dependencies on other participants.
- **Optimistic.** The activity duration is based on a best case scenario of what is described in the most likely estimate.
- **Pessimistic.** The activity duration is based on a worst-case scenario of what is described in the most likely estimate.

An activity duration estimate can be constructed by using an average of the three estimated durations. That average will often provide a more accurate activity duration estimate than the single point estimate.

6.4 Estimate Activity Durations

4. Three-Point Estimating (cont'd)

PERT Calculations

- The Optimistic Time (a): Is the minimum time an activity could take (the situation, where every thing goes well).
- The Mostly Likely Time (m): Is the normal time to complete the Job. It is the time would occur most frequently if activity could be repeated.
- The Pessimistic Time (b): Is the maximum time an activity could take (the situation, where bad luck is encountered at every step).

1. Triangular distribution (simple or straight)= (a + m + b) / 3

2. Beta distribution or PERT = (a + 4*m + b) / 6

Standard Deviation = (b-a) / 6

Activity Variance = $[(b-a) / 6]^2$ (Variance = standard deviation squared)

The standard deviation of the total path is determined as the square root of the sum of the squares of standard deviation.

6.4 Estimate Activity Durations

Input → **Tools & Techniques** → Output

4. Three-Point Estimating (cont'd)

One point estimate

This type of estimation has the following negative effect on the project:

1. It may force the people into padding their estimates.
2. It hides important information about risks and uncertainties from the PM, which is needed to better planning and controlling the project.
3. It creates a schedule that no one believes in, thus losing buy-in in to the project management process.
4. When a person estimates that activity will take 50 days but it is completed in 15 days, it can make the person who provided the estimate look untruthful and untrustworthy.
5. It has the estimators working against the PM to protect themselves rather than with the PM to help all involved in the project.

6.4 Estimate Activity Durations

5. Bottom-Up Estimating

Bottom-up estimating is a method of estimating project duration or cost by aggregating the estimates of the lower-level components of the WBS.

- When an activity's duration cannot be estimated with a reasonable degree of confidence, the work within the activity is decomposed into more detail.
- The detail durations are estimated.
- These estimates are then aggregated into a total quantity for each of the activity's durations.
- Activities may or may not have dependencies between them that can affect the application and use of resources.
- If there are dependencies, this pattern of resource usage is reflected and documented in the estimated requirements of the activity.

6.4 Estimate Activity Durations

6. Data analysis

Data analysis techniques that can be used for this process include but are not limited to:

- **Alternatives analysis.** It is used to compare various levels of resource capability or skills; scheduling compression techniques; different tools (manual versus automated); and make, rent, or buy decisions regarding the resources. This allows the team to weigh resource, cost, and duration variables to determine an optimal approach for accomplishing project work.

- **Reserve analysis.** It is used to determine the amount of contingency and management reserve needed for the project. Duration estimates may include contingency reserves, sometimes referred to as schedule reserves, to account for schedule uncertainty. Contingency reserves are the estimated duration within the schedule baseline, which is allocated for identified risks that are accepted.

6.4 Estimate Activity Durations

General Concepts

❖ Heuristics

- A heuristic means a rule of thumb. Example of heuristic is the 80/20 rule: This rule, applied to quality, suggests that 80 percent of quality problems are caused by 20 percent of potential sources of problems.
- A schedule heuristic might be "*Design work is always 15 percent of the total project length*".
- The results of parametric estimates can become heuristic.

❖ Parkinson Theory

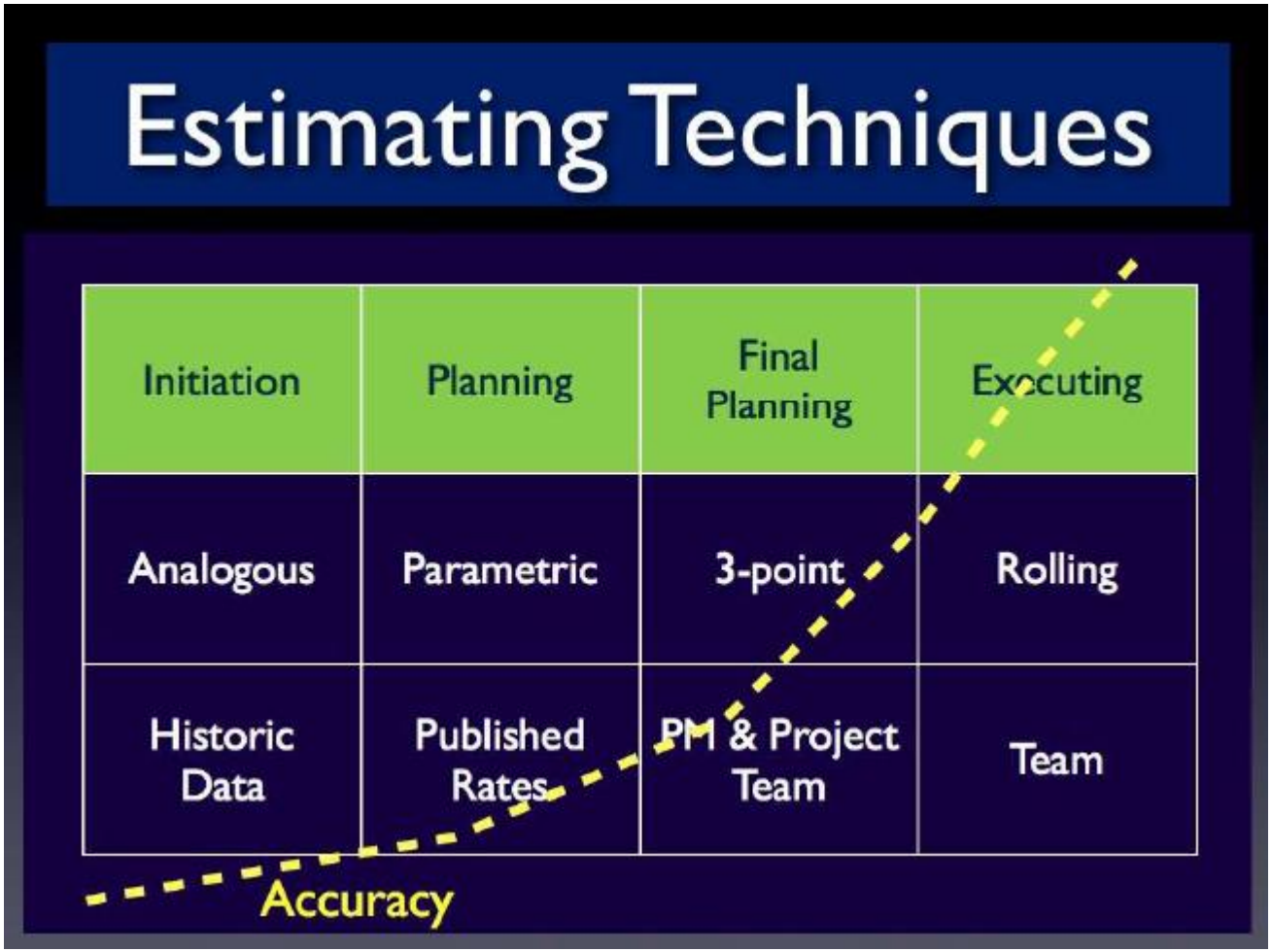
states that "work" expands so as to fill the time available for its completion

❖ Student syndrome or Procrastination

People start to apply themselves only at the last possible moment before the deadline.

6.4 Estimate Activity Durations

Input → **Tools & Techniques** → Output



6.4 Estimate Activity Durations

1. Duration Estimates

Activity duration estimates reflect how long each activity will take to complete.

Example: 2 weeks +/- 2 days, which indicates that the activity will take at least eight days and not more than twelve days (assuming a five day workweek)

2. Basis of estimates

Supporting detail for duration estimates may include:

- Documentation of the basis of the estimate (how it was developed),
- Documentation of all assumptions made,
- Documentation of any known constraints,
- Indication of the range of possible estimates (e.g., ±10%) to indicate that the duration is estimated between a range of values),
- Indication of the confidence level of the final estimate,
- Documentation of individual project risks influencing this estimate.

6.5 Develop Schedule

Analyzing activity sequences, durations, resource requirements and schedule constraints to create a schedule model for project execution and monitoring and controlling.

Objective: create **Project Schedule**

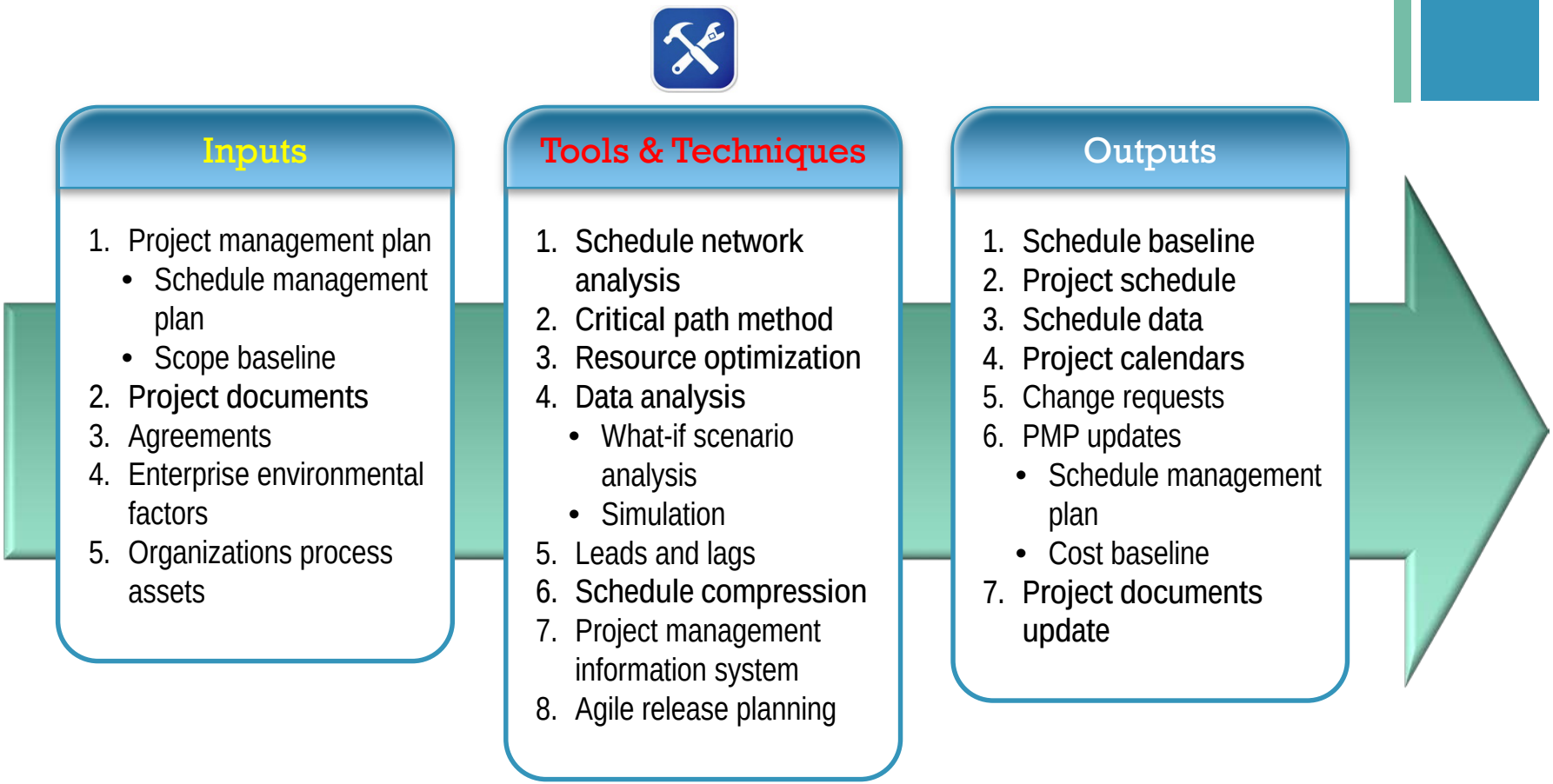
It is an ITERATIVE process

Determine the planned Start/End dates of all activities & milestones

6.5 Develop Schedule

- The Schedule Development process is the heart of the Planning process group.
- The Schedule Development process means everything you need to do to develop a finalized schedule that is bought-in, approved, realistic and formal.
- PM has to do the following:
  1. Work with stakeholder's priorities.
  2. Look for alternatives to complete the works.
  3. Meet with managers to negotiate for resources' availability.

6.5 Develop Schedule



6.5 Develop Schedule

2. Project documents

Project documents that can be considered as inputs include:

- Activity attributes.
- Activity list.
- Assumption log.
- Basis of estimates.
- Duration estimates.
- Lessons learned.
- Milestone list.
- Project schedule network diagrams.
- Project team assignments.
- Resource calendars.
- Resource requirements.
- Risk register.

6.5 Develop Schedule

1. Schedule Network Analysis

This technique uses various **analytical techniques** to produce the project schedule, such as:

- Critical Path method (CPM).
- Critical Chain method (CCM).
- Resources optimization techniques.
- Modeling techniques.

6.5 Develop Schedule

2. Critical Path method

The critical path method includes determining the longest path in the network diagram (the critical path), the earliest and latest an activity can start and the earliest and latest it can be completed for all scheduled activities.

Critical Path is the path with the longest duration in the network diagram

FORWARD & BACKWARD PASS:

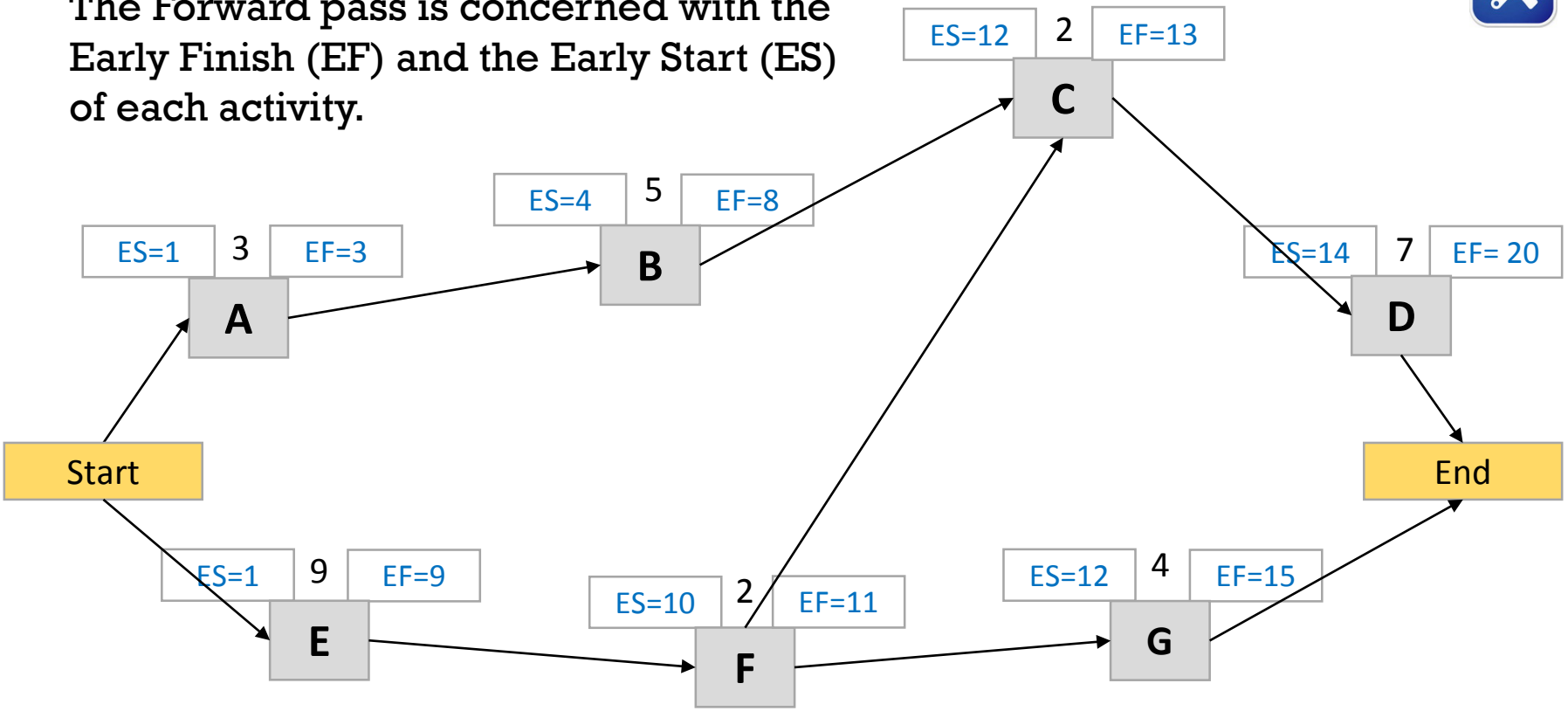
- Early Start (ES)
- Early Finish (EF)
- Late Start (LS)
- Late Finish (LF)

6.5 Develop Schedule

Input → **Tools & Techniques** → Output

2. Critical Path method (cont'd)

The Forward pass is concerned with the Early Finish (EF) and the Early Start (ES) of each activity.



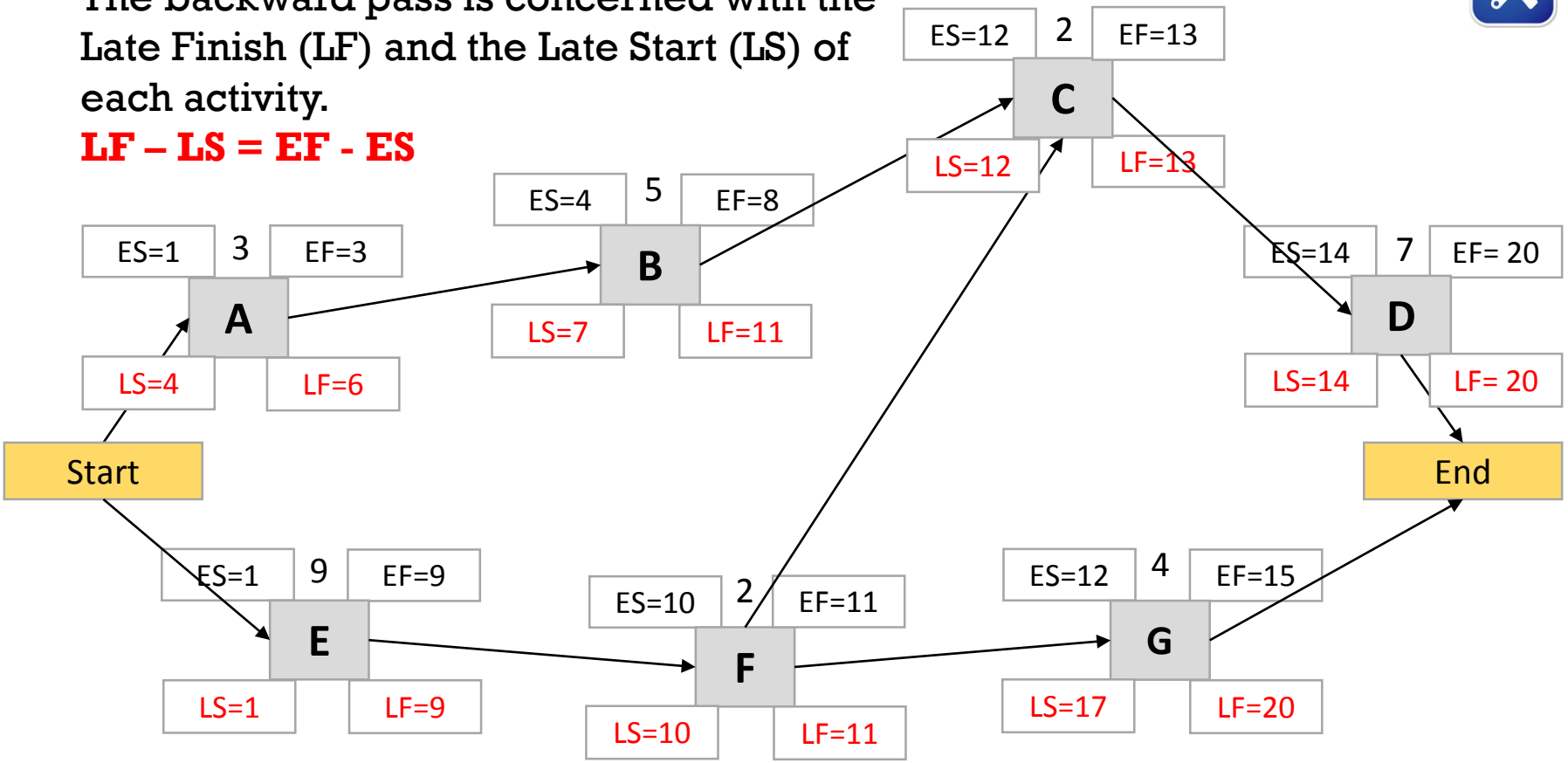
6.5 Develop Schedule

Input → **Tools & Techniques** → Output

2. Critical Path method (cont'd)

The backward pass is concerned with the Late Finish (LF) and the Late Start (LS) of each activity.

LF – LS = EF - ES

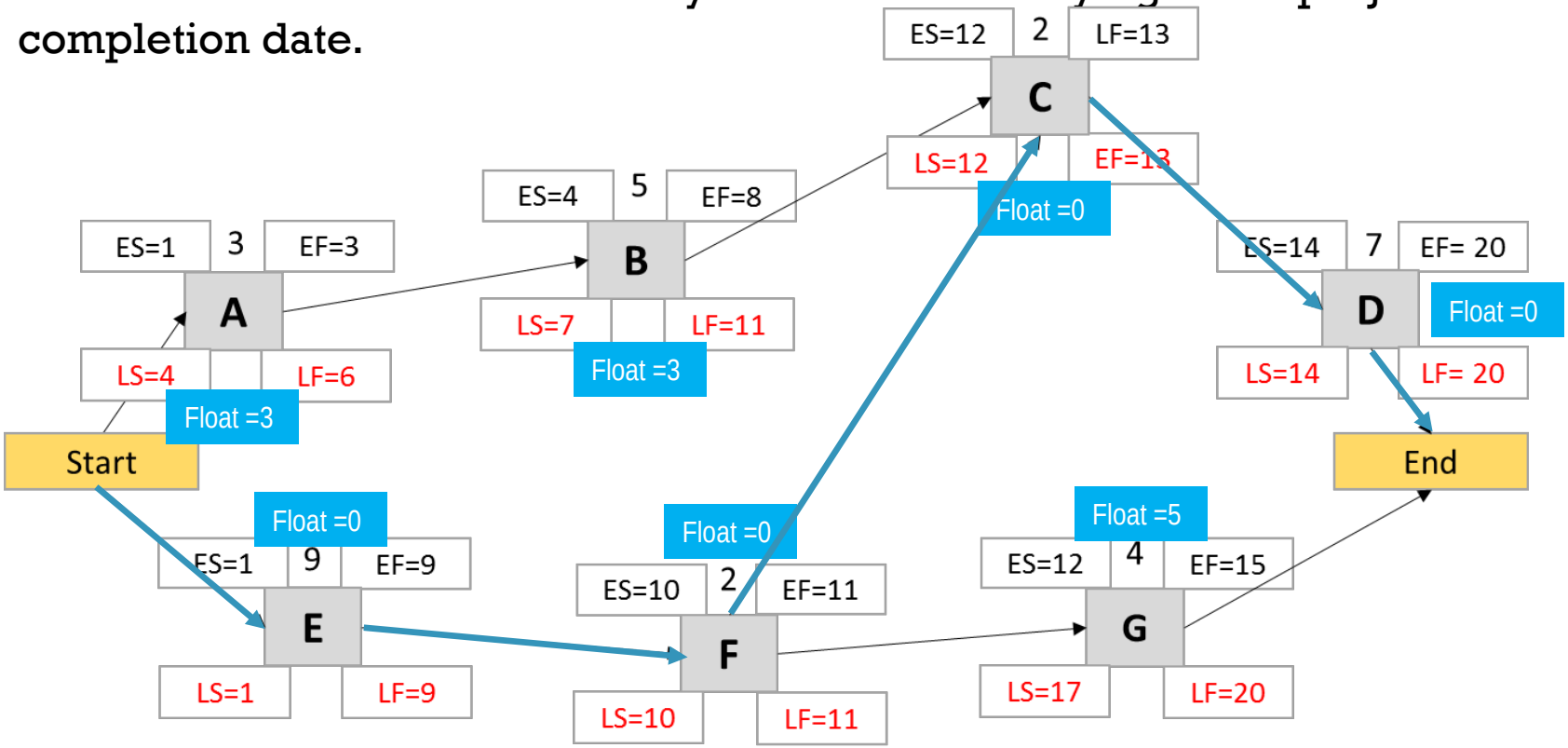


6.5 Develop Schedule

Input → **Tools & Techniques** → Output

2. Critical Path method (cont'd)

To calculate float, (LS – ES) or (LF – EF). The **total float** is the amount of time a task can be delayed without delaying the project completion date.



6.5 Develop Schedule

2. Critical Path method (cont'd)

How the Critical Path helps the PM?

1. *Helps prove how long the project will take.*
2. *Helps the PM determine where to focus his/her project management efforts.*
3. *Helps determine if an issue needs immediate attention.*
4. *Provides vehicle to compress the schedule during the project planning and whenever there are changes.*
5. *Provides vehicle to determine which activities have float and can therefore be delayed without delaying the project.*

TRICK: The easiest way to find the critical path is to identify all paths through the network diagram and add the activity durations along each path. The path with the longest duration is the critical path.

6.5 Develop Schedule

2. Critical Path method (cont'd)

❖ ***Near Critical path***

PMs should be familiar with the concept of a near critical path.

The path is close in duration to the critical path. Some thing can happen in the project that shortens the critical path or lengthens the near critical path to the point, where the near critical path becomes critical.

- *The closer in length the near critical and critical paths, then the project has more risk.*
- *The PM should spend both time and effort monitoring and controlling critical and near critical path activities so the critical path activities do not delay the project completion*

6.5 Develop Schedule

2. Critical Path method (cont'd)

❖ ***Float (slack)***

PMs should be familiar with the concept of float.

Total float (slack) **>>** *Total float is the amount of time an activity can be delayed without delaying the project end date or an externally imposed milestone. This is the key type of float.*

Free float (slack)**>>** *This is the amount of time an activity can be delayed without delaying the early start of its successor(s).*

Project float (slack)**>>** *Project float is the amount of time a project can be delayed without delaying the externally imposed project completion date required by the customer or management or previously committed to by the PM .*

6.5 Develop Schedule

2. Critical Path method (cont'd)

- ***Float (slack)***
- ***Activities on the critical path almost always have zero float.***
- ***Delayed activities within Critical path may result in negative float.***
- ***Floats is an asset and extremely useful for a PM and most PMs know where they have float and use it to help manage a project.***
- ***Float can be calculated as follows***

Float = Late start – Early start or Late finish- Early finish

(Example: You have a late start of 30, early start of 18 and late finish of 34, what is the float? 30-18=12)

Less experienced resource can be assigned to an activity with the most float, this gives PM some level of security and even if this activity take little longer, the project will not be delayed.

6.5 Develop Schedule

2. Critical Path method (cont'd)

Test your knowledge!

- ***Can there be more than one critical path?***
  Yes, you can have two, three or many critical paths
- ***Do you want to be there?***
  No, it increases risk.
- ***How much float does the critical path have?***
  Generally the critical path should have zero float
- ***Can there be negative float?***
  Yes, it shows the project is behind schedule
- ***Would you leave the project with a negative float?***
  No, you compress/fast track, it generally increase in cost/ risk.
- ***In case any activity is delayed then will the project end date changes ?***
  No, not automatically, but the PM should investigate the options such as fast tracking and crashing the schedule to meet the new date. Then with the approved changes, the PM should change the network diagram accordingly.

6.5 Develop Schedule

2. Critical Path method (cont'd)

Exam focus

You'll encounter float, scheduling, and critical path activities on the PMP exam. Please remember a few important rules:

- Always draw out the network diagram presented on your scratch paper. It may be used in several questions.
- Know how to calculate float.
- You may encounter questions that ask on what day of the week a project will end if no weekends or holidays are worked. No problem. Add up the critical path, divide by 5 (Monday through Friday), and then figure out which day of the week the activity will end on.

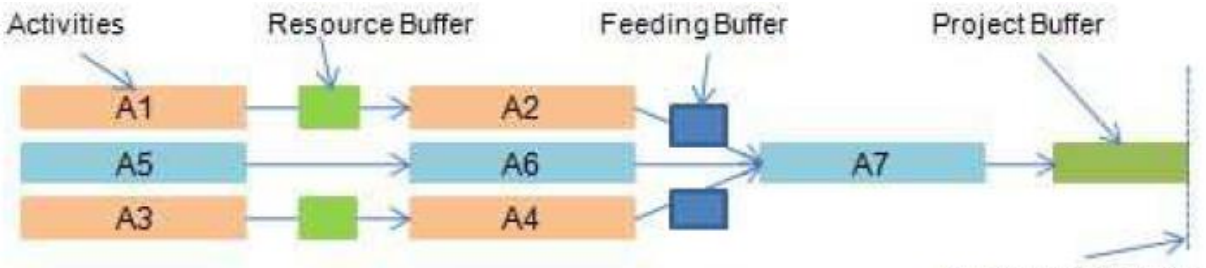
6.5 Develop Schedule

Input → **Tools & Techniques** → Output

Critical Chain Method (CCM)

In Critical chain method, it allows the project team to place buffers on any project schedule path to account for limited resources and project uncertainties.

- CCM introduces the concept of buffers and "buffer management"
- The **resource constrained** critical path is known as "Critical Chain".
- The focus is on completing each activity in order to complete the entire project by the promised end date.

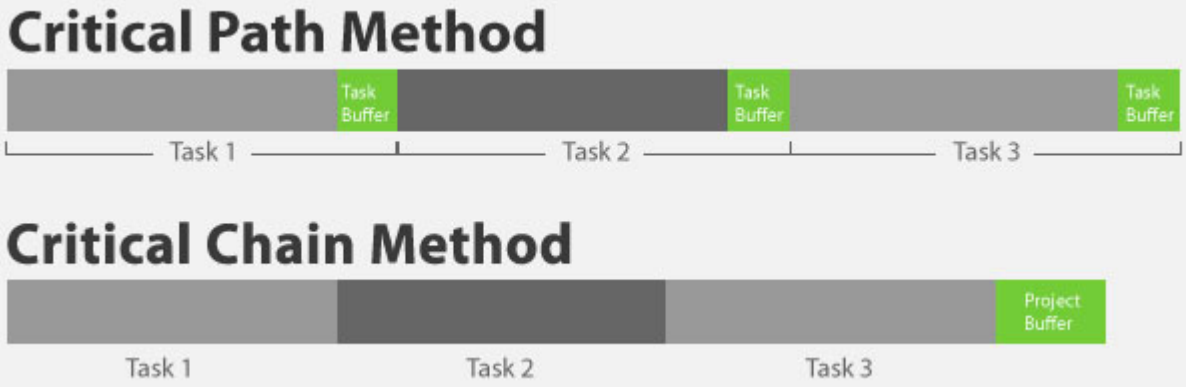


Critical Chain Scheduling and Buffers

6.5 Develop Schedule

Input → **Tools & Techniques** → Output

Critical Chain Method (CCM) (cont'd)



6.5 Develop Schedule

Critical Path Method versus Critical Chain Method

The **Critical Path Method** allows the PMT to easily visualize the sequence of tasks and the estimated duration of individual tasks in a straight-forward manner, something most people are familiar with. However, since there are no overall buffers to be added to the critical path, PMT members may, while estimating for the duration of individual tasks, try to add "implicit buffers" conservatively to each task with a view to protect the overall schedule. This may result in "too much" buffers added to the critical path and make the estimation not efficient. The PM needs to monitor closely the progress of individual tasks as one task progresses at a slower than expected pace will adversely affect the whole project schedule.

The **Critical Chain Method,** on the other hand, just put the tasks together in a chain by considering the minimal time needed for individual tasks. An overall "project buffer" is added to the end of the chain which provides some protection against the project schedule. This may result in higher efficiency of the buffer estimation by combining the individual implicit buffer for an explicit buffer. PMT members would be able to provide a more aggressive schedule for each tasks as there is an overall buffer to protect the project schedule. The PM will focus on managing the overall buffer during the executing and monitoring processes.

6.5 Develop Schedule

3. Resource Optimization Techniques

Resource optimization techniques can be used to adjust the schedule model due to demand and supply of resources; they include but are not limited to:

- **Resource leveling**
- **Resource smoothing**

6.5 Develop Schedule

3. Resource Optimization Techniques (cont'd)

❖ **Resource leveling**

A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing demand for resources with the available supply.

- Resource leveling can be used when shared or critically required resources are only available at certain times or in limited quantities, or over-allocated, such as when a resource has been assigned to two or more activities during the same period.
- Resource leveling can often cause the original critical path to change, usually to increase.
- Another method for resource leveling is to take resources off of non critical path activities and apply them to critical-path activities to ensure the project end date is met.

6.5 Develop Schedule

3. Resource Optimization Techniques (cont'd)

❖ **Resource Smoothing**

Resource smoothing means the uniform distribution of resource allocation over the project.

- A technique that adjusts the activities of a schedule model such that the requirements for resources on the project do not exceed certain predefined resource limits.
- In resource smoothing, as opposed to resource leveling, the project's critical path is not changed and the completion date may not be delayed.

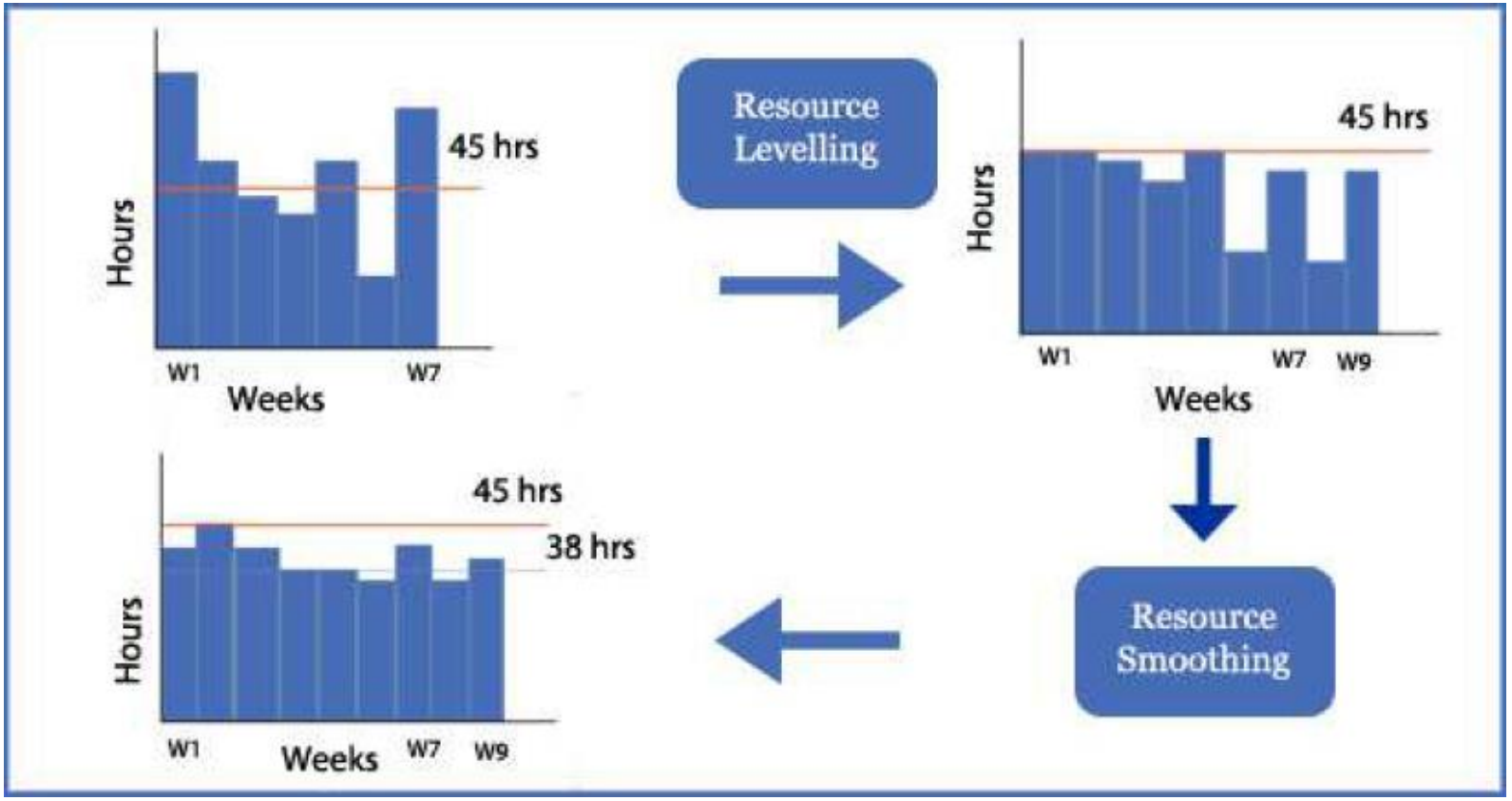
Example:

A resource working 30 hours this week, 10 hours next week, and 20 hours the week after next week. When you apply resource smoothing, the resource will work 20 hours this week, 20 hours next week, and 20 hours the week after. You see, the total amount of hours remains 60 hours, but is more uniformly distributed over the weeks.

6.5 Develop Schedule

Input → **Tools & Techniques** → Output

3. Resource Optimization Techniques (cont'd)
Resource Leveling/Smoothing Example



6.5 Develop Schedule

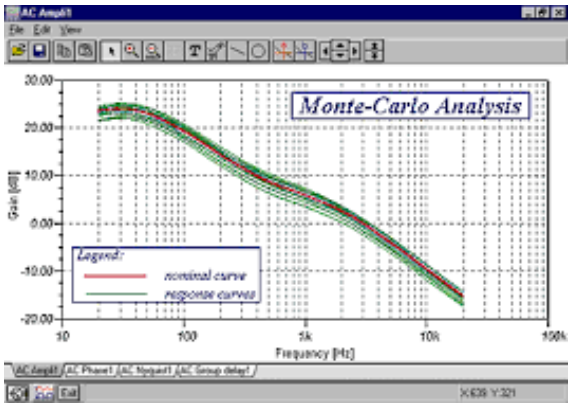
Input → **Tools & Techniques** → Output

4. Data analysis

❖ "What-if" scenario analysis

"What-if" scenario analysis uses different sets of activity assumptions while developing schedule.

- For example, what would happen if a major deliverable was delayed or the weather prevents you from completing a deliverable on time?
- What-if analysis weighs these questions and their assumptions and determines the feasibility of the project schedule under these conditions.
- Monte Carlo Analysis is the most famous "What-If" Scenario techniques



6.5 Develop Schedule

4. Data analysis (cont'd)

❖ **Simulation**

Simulation models the combined effects of individual project risks and other sources of uncertainty to evaluate their potential impact on achieving project objectives. The most common simulation technique is Monte Carlo

"**Monte Carlo analysis**" uses a computer software to simulate the outcome of the project, making of three point estimates (optimistic, pessimistic and most likely) for each activity in the network diagram.

Monte Carlo simulation can tell you the following:

- The probability of completing the project on any specific day
- The probability of completing the project for any specific amount of cost.
- The probability of any activity actually being on the critical path.
- The overall project risk.

6.5 Develop Schedule

6. Schedule Compression

Schedule compression techniques are used to shorten or accelerate the schedule duration without reducing the project scope in order to meet schedule constraints, imposed dates, or other schedule objectives. Schedule compression techniques include:

❖ **Crashing**

This involves making cost and schedule trade offs to determine how to compress the schedule the most for the least incremental cost, while maintaining project scope.

- This approach *adds more resources to activities* on the critical path to complete the project earlier. Crashing by definition always results in increased cost.
- When crashing a project, costs are added as the labor expenses increase.
- The PM must also consider the expenses in relation to the gains of completing on time.

6.5 Develop Schedule

6. Schedule Compression (cont'd)

❖ **Fast Tracking**

This method changes the relationship of activities. With fast tracking, activities that would normally be done in sequence are allowed to be done in parallel.

Exam focus

In crashing or fast tracking, it is best to see all potential choices and then select the choice or choices that have least negative impact on the project.

Question: *If you have negative project float, would you first choose to tell the customer the date could not be met and ask for more time?*

***Answer**: No, the first choice would be to analyze what could be done about the negative float by doing schedule compression.*

6.5 Develop Schedule

6. Schedule Compression (cont'd)

Crashing versus Fast tracking

Crashing	Fast tracking
Increase the project cost	Increase the project risk
Can change the critical path	Can change the critical path
Can be done by increasing resources on critical activities	Can be done by changing the relationship between activities
Obtain the greatest amount of compression for the incremental cost	Changing the relation from FS to SS
	Can result in rework

6.5 Develop Schedule

8. Agile release planning

Agile release planning provides a high-level summary timeline of the release schedule (typically 3 to 6 months) based on the product roadmap and the product vision for the product's evolution.

Agile release planning also determines the **number of iterations** or **sprints** in the release, and allows the product owner and team to decide how much needs to be developed and how long it will take to have a releasable product based on business goals, dependencies, and impediments.

6.5 Develop Schedule

Input → **Tools & Techniques** → Output

8. Agile release planning (cont'd)

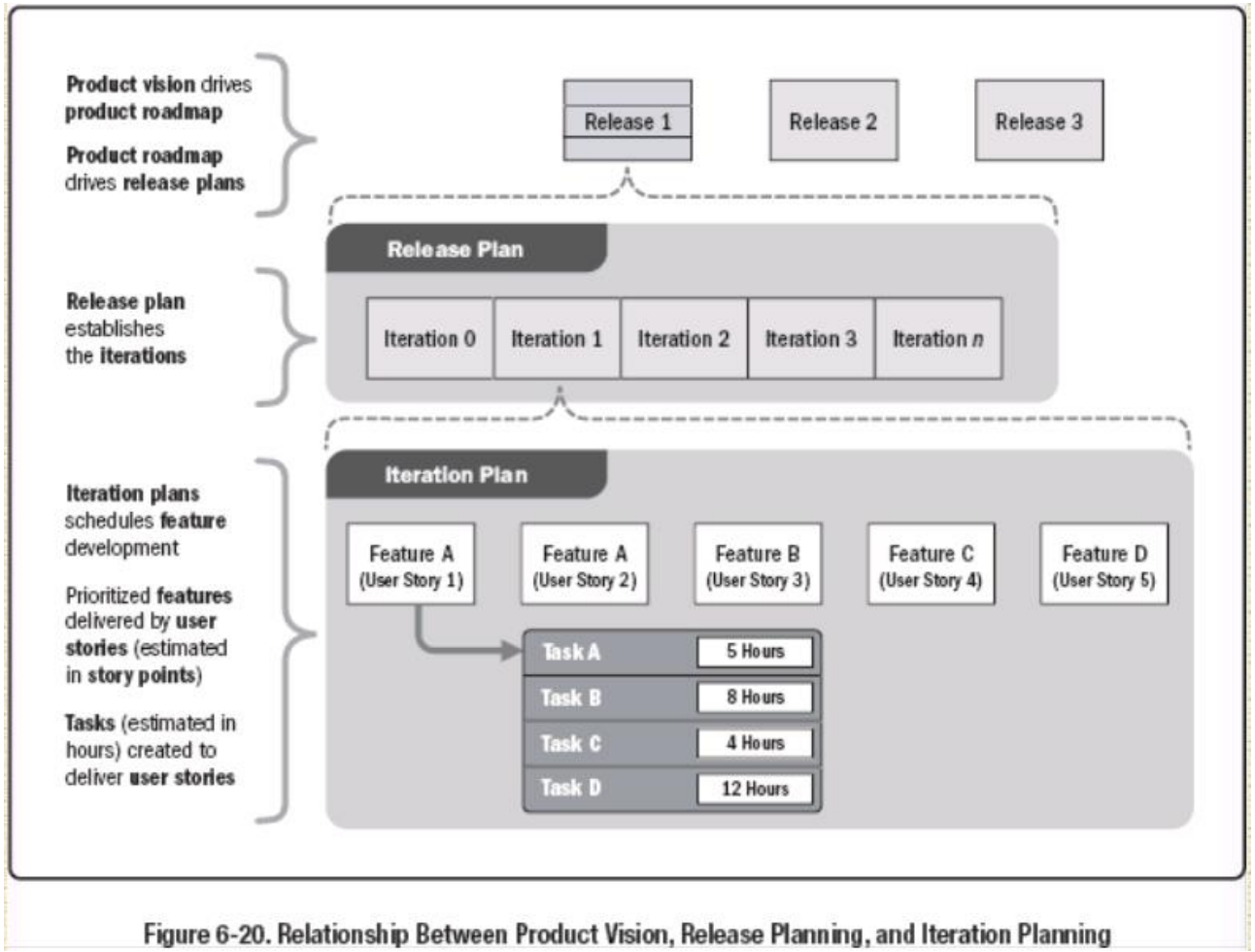


Figure 6-20. Relationship Between Product Vision, Release Planning, and Iteration Planning

6.5 Develop Schedule

1. Schedule Baseline

A schedule baseline is a specific version of the *project schedule* developed from the schedule network analysis.

- It is accepted and approved by all stakeholders which contains baseline start dates and baseline finish dates.
- The schedule baseline is a component of the project management plan.
- Schedule baseline can only be changed by formally approved changes.
- Meeting the schedule baseline is one of the measures of project success.

6.5 Develop Schedule

Input → Tools & Techniques → Output

1. Schedule Baseline - Example

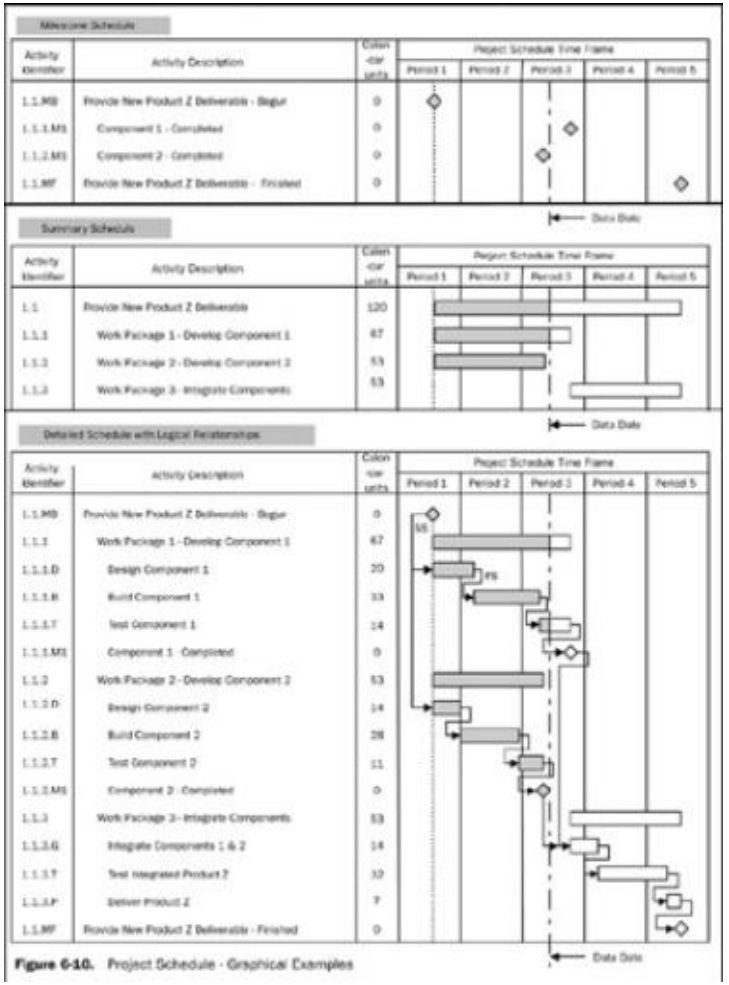


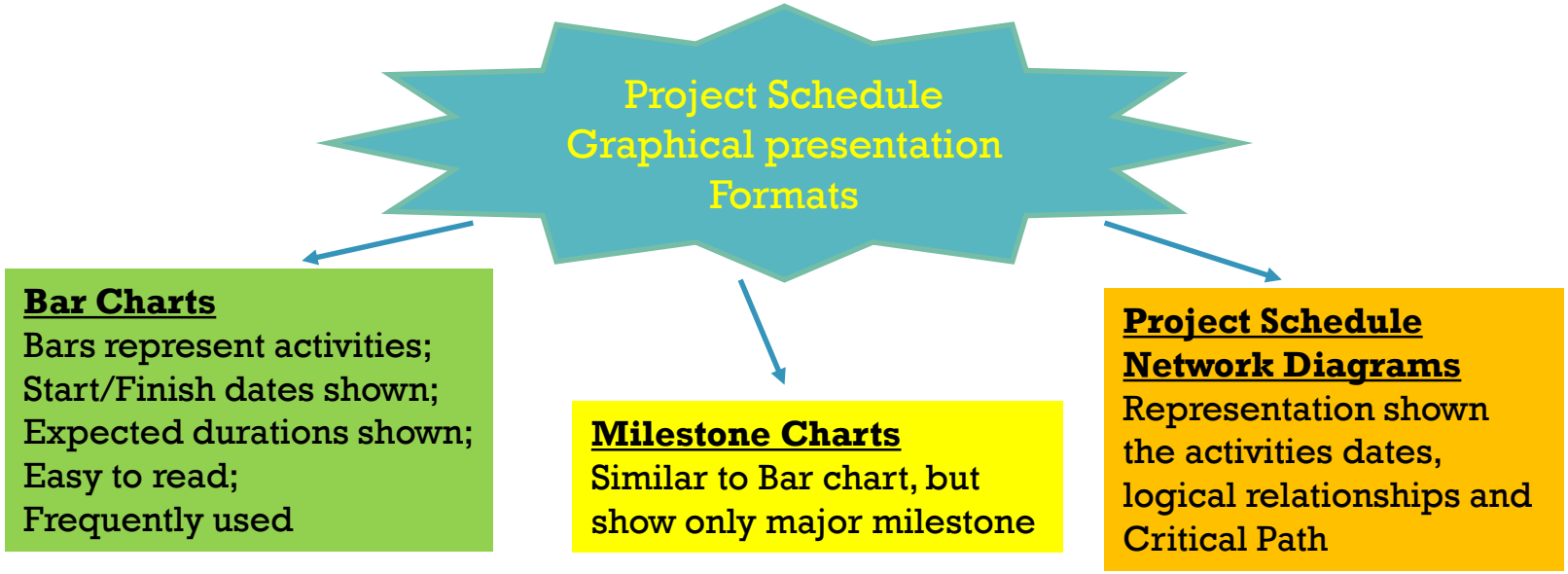
Figure 6-10. Project Schedule - Graphical Examples

6.5 Develop Schedule

2. Project Schedule

A project Schedule should contain at least the activities with their start and finish planned dates.

- A project Schedule is considered PRELIMINARY schedule until the resources availability is confirmed (before the PMP is completed)



6.5 Develop Schedule

2. Project Schedule (cont'd)

The purpose of the Schedule Development process is to determine the start and finish date for each activity.

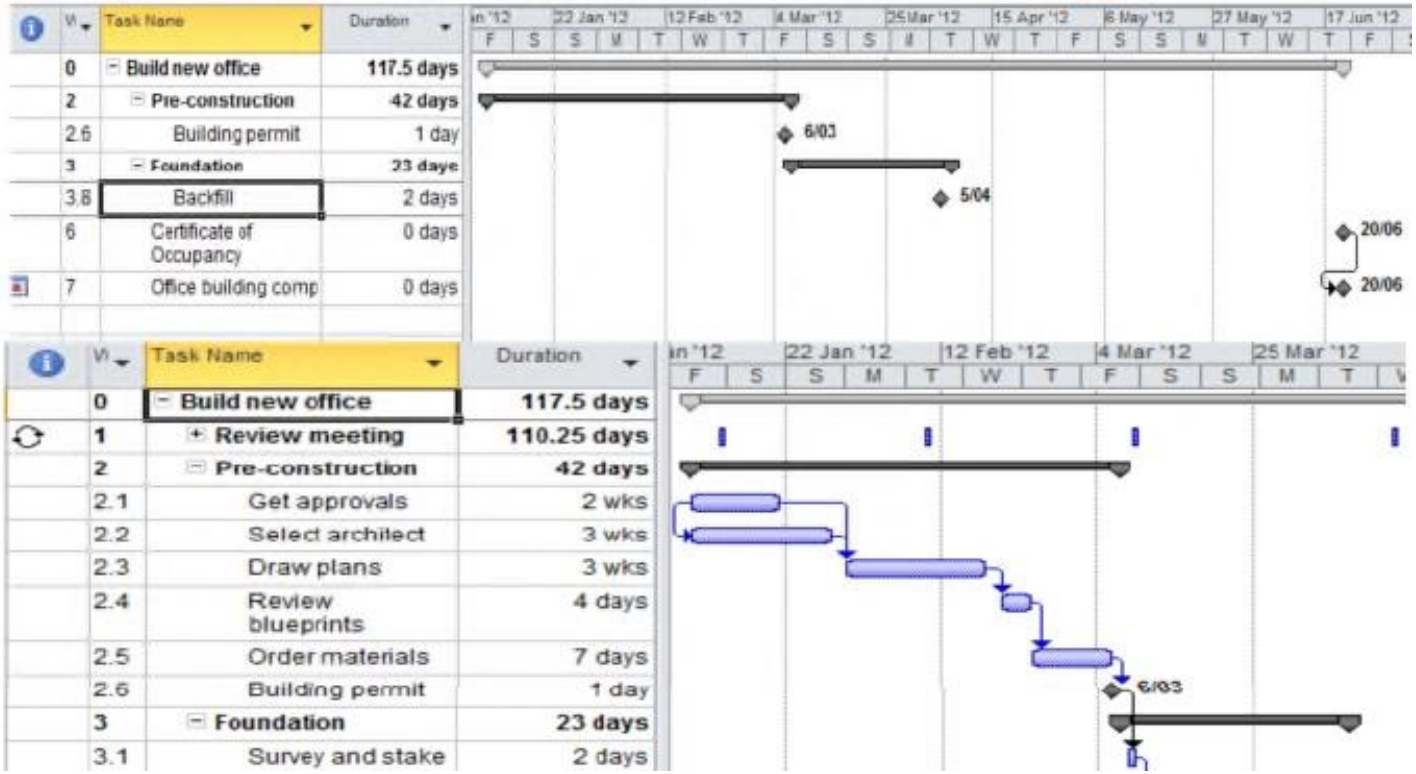
- The project schedule will detail this information as well as the resource assignments.
- The project schedule should be approved and signed-off by stakeholders and functional managers.
  - This assures that stakeholders have read the schedule and understood the dates and resource commitments.

6.5 Develop Schedule

Input → Tools & Techniques → Output

2. Project Schedule (cont'd)

Examples... Bar Charts & Milestone Charts



	Task Name	Duration
0	Build new office	117.5 days
2	Pre-construction	42 days
2.6	Building permit	1 day
3	Foundation	23 days
3.8	Backfill	2 days
6	Certificate of Occupancy	0 days
7	Office building comp	0 days

	Task Name	Duration
0	Build new office	117.5 days
1	Review meeting	110.25 days
2	Pre-construction	42 days
2.1	Get approvals	2 wks
2.2	Select architect	3 wks
2.3	Draw plans	3 wks
2.4	Review blueprints	4 days
2.5	Order materials	7 days
2.6	Building permit	1 day
3	Foundation	23 days
3.1	Survey and stake	2 days

6.5 Develop Schedule

3. Schedule Data

The schedule data for the project schedule is the collection of information for describing and controlling the schedule.

Information frequently supplied as supporting detail includes:

- ❖ Resource requirements by time period, often in the form of a resource histogram;
- ❖ Alternative schedules, such as best-case or worst-case, not resource-leveled or resource-leveled, or with or without imposed dates;
- ❖ Applied schedule reserves.

Schedule data could also include such items as:

- resource histograms,
- cash-flow projections,
- order and delivery schedules,
- or other relevant information.

6.5 Develop Schedule

4. Project Calendars

A project calendar identifies working days and shifts that are available for scheduled activities.

7. Project documents updates

Project documents that may be updated as a result of carrying out this process include but are not limited to:

- Activity attributes.
- Assumption log.
- Duration estimates.
- Lessons learned register.
- Resource requirements
- Risk register

6.6 Control Schedule

Monitoring the status of the project to update the project schedule and managing changes to the schedule baseline.

6.6 Control Schedule

- Updating the schedule model requires knowing the actual performance to date. Any change to the schedule baseline can only be approved through the *Perform Integrated Change Control* process.

- Control Schedule, as a component of the *Perform Integrated Change Control* process, is concerned with:
  - Determining the current status of the project schedule,
  - Influencing the factors that create schedule changes,
  - Reconsidering necessary schedule reserves,
  - Determining if the project schedule has changed,
  - Managing the actual changes as they occur.

6.6 Control Schedule

- When an agile approach is used, Control Schedule is concerned with:
  - Determining the current status of the project schedule by comparing the total amount of work delivered and accepted against the estimates of work completed for the elapsed time cycle;
  - Conducting retrospectives (scheduled reviews to record lessons learned) for correcting processes and improving, if required;
  - Reprioritizing the remaining work plan (backlog);
  - Determining the rate at which the deliverables are produced, validated, and accepted **velocity** in the given time per iteration (agreed-upon work cycle duration, typically 2 weeks or 1 month);
  - Determining that the project schedule has changed;
  - Managing the actual changes as they occur.

6.6 Control Schedule

Inputs

1. Project management plan
   - Schedule management plan
   - Schedule baseline
   - Scope baseline
   - Performance measurement baseline
2. Project documents
   - Lessons learned register
   - Project calendars
   - Resource calendars
   - Schedule data
3. Work performance data
4. Organizational process assets

Tools & Techniques

1. Data analysis
   - Earned value analysis
   - Iteration burndown chart
   - Performance reviews
   - Trend analysis
   - Variance analysis
   - What-if scenario analysis
2. Critical path method
3. Project management information system
4. Resource optimization
5. Leads and lags
6. Schedule compression

Outputs

1. Work performance information
2. Schedule forecasts
3. Change requests
4. PMP updates
5. Project documents updates
   - Assumption log
   - Basis of estimates
   - Lessons learned register
   - Project schedule
   - Resource calendars
   - Risk register
   - Schedule data

6.6 Control Schedule

1. Data analysis

Data analysis techniques that can be used for this process include:

- **Earned value analysis**. Schedule performance measurements such as schedule variance (SV) and schedule performance index (SPI) are used to assess the magnitude of variation to the original schedule baseline.
- **Iteration burndown chart**. This chart tracks the work that remains to be completed in the iteration backlog. It is used to analyze the variance with respect to an ideal burndown based on the work committed from iteration planning. A forecast trend line can be used to predict the likely variance at iteration completion and take appropriate actions during the course of the iteration. A diagonal line representing the ideal burndown and daily actual remaining work is then plotted. A trend line is then calculated to forecast completion based on remaining work.

6.6 Control Schedule

Input → **Tools & Techniques** → Output

1. Data analysis (cont'd)

Iteration burndown chart (cont'd)

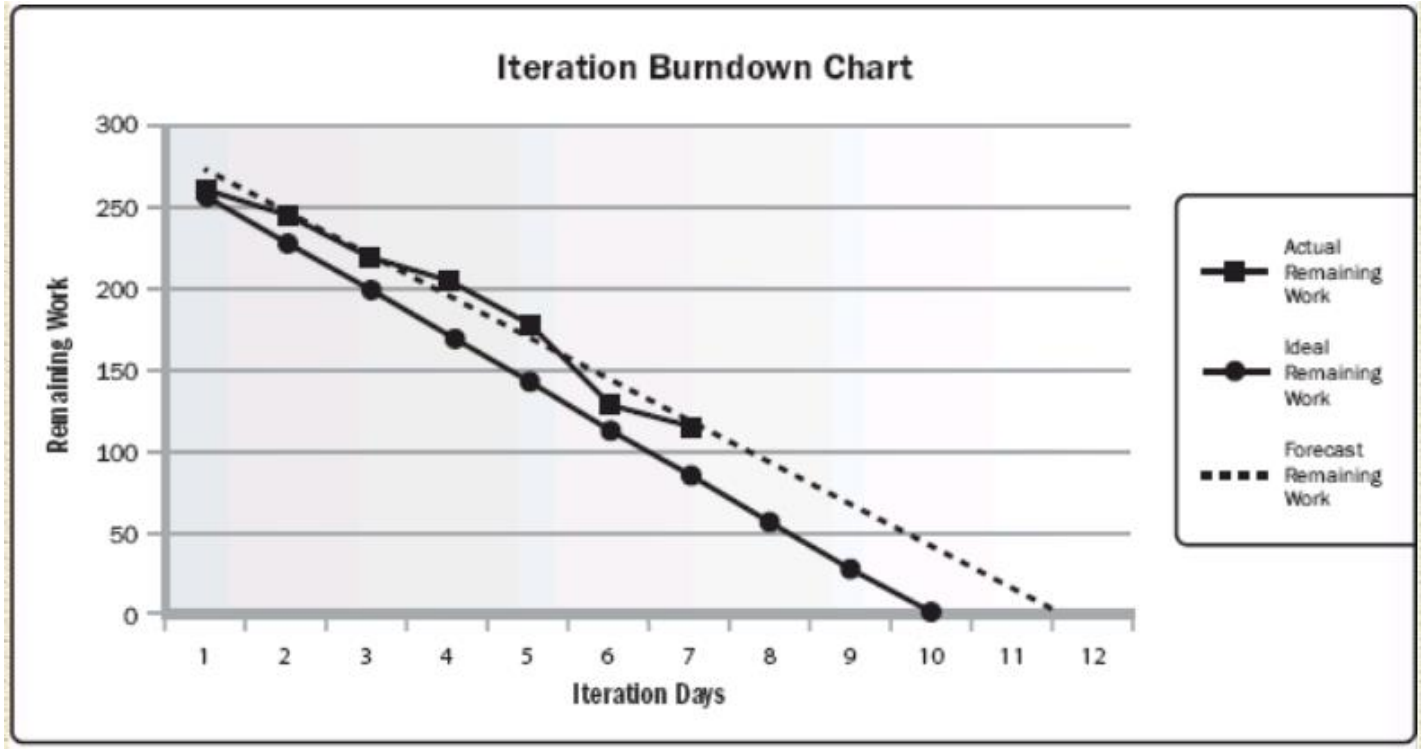


Figure 6-24. Iteration Burndown Chart

6.6 Control Schedule

1. Data analysis (cont'd)

- …
- **Performance reviews**. Performance reviews measure, compare, and analyze schedule performance against the schedule baseline such as actual start and finish dates, percent complete, and remaining duration for work in progress.
- **Trend analysis**. Trend analysis examines project performance over time to determine whether performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparing to future performance goals in the form of completion dates.
- **What-if scenario analysis**. What-if scenario analysis is used to assess the various scenarios guided by the output from the Project Risk Management processes to bring the schedule model into alignment with the PMP and approved baseline.
- …

6.6 Control Schedule

1. Data analysis (cont'd)

- …
- **Variance analysis.** Variance analysis looks at variances in planned versus actual start and finish dates, planned versus actual durations, and variances in float. Part of variance analysis is determining the cause and degree of variance relative to the schedule baseline, estimating the implications of those variances for future work to completion, and deciding whether corrective or preventive action is required. *For example, a major delay on any activity not on the critical path may have little effect on the overall project schedule, while a much shorter delay on a critical or near-critical activity may require immediate action.*

6.6 Control Schedule

1. Work performance information

WPI includes info on how the project work is performing compared to the schedule baseline. Variances in the start and finish dates and the durations can be calculated at the work package level and control account level. For projects using earned value analysis, the (SV) and (SPI) are documented for inclusion in WPRs.

2. Schedule forecasts

Schedule updates are forecasts of estimates or predictions of conditions and events in the project's future based on info and knowledge available at the time of the forecast. Forecasts are updated and reissued based on WPI provided as the project is executed. The info is based on the project's past performance and expected future performance based on corrective or preventive actions. This can include earned value performance indicators, as well as schedule reserve info that could impact the project in the future.

Thank you

Knowledge area

- You can find the whole Project Management Professional course on Z:\eLibraries\eBooks\Management\PMP 6 Course
- You can also visit www.pmi.org for more information

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