

# Planning & Scheduling Fundamentals

## PARTICIPANT WORKBOOK



# OBJECTIVE

## **COURSE OBJECTIVE**

This online training course is designed to provide people with fundamental knowledge and skills for planning and scheduling large projects.

The course covers key methodologies and tools such as the Critical Path Method (CPM), Planning a schedule, an introduction to Schedule Risk Analysis, Earned Value Management (EVM), and Delay Analysis.

Participants will learn to create, analyse, and manage project schedules to assist with timely and successful project completion.

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O3 SCHEDULE REVIEWS 90

O4 DELAYS 134

O5 EARNED VALUE MANAGEMENT 160

O6 SCHEDULE RISK ANALYSIS 200

# COURSE OVERVIEW

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## 01

### **Planning a Project**

Understand the steps involved in developing a plan. Including the Team, developing the schedule, baselining, updating and communicating the schedule to the Team & Stakeholders.

## 02

### **Critical Path Explained**

Learn the fundamentals of the Critical Path method. free float, total float, Critical Path Vs Longest path, examples and an intro to CPM software.

## 03

### **Schedule Reviews**

Learn the importance of Schedule Reviews, diagnostics and Schedule Metrics.

## 04

### **Delays**

Types of delay claims, strategies for recovery and how the CPM is used for the analysis of delays.

05

## **Earned Value Management Intro**

An overview and introduction to EVM, terminology, concepts and example.

06

## **Schedule Risk Analysis Intro**

An overview and introduction to Schedule Risk Analysis

C H A P T E R

# 01

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## PLANNING A PROJECT

# STEP O - INCLUDING THE TEAM

Good planning requires input and buy-in from the project team; it is not an isolated process.

The Planner does not own the program, the program belongs to the project team and the team should be involved in updating and reporting the program's status. The Planner's role is to facilitate, coordinate, understand, interpret, and advise.

Regular reviews for changes should be carried out throughout the project's life. This will help to ensure the schedule has ongoing buy-in from the people responsible for delivering the project.

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## NOTES:

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# STEP O - INCLUDING THE TEAM

## QUIZ

**1. Involving team members in schedule planning can:**

- a/ Increase the project manager's workload.
- b/ Lead to a more realistic and achievable schedule.
- c/ Decrease the need for communication during project execution.
- d/ Solely benefit team morale.

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**2. Team members with expertise in specific activities can provide valuable insights on:**

- a/ Project budget allocation only.
- b/ Estimated durations and potential risks associated with their tasks.
- c/ The communication preferences of other team members.
- d/ The project manager's overall planning abilities..

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# STEP 0 - INCLUDING THE TEAM

## QUIZ

**3. When team members feel ownership of the project schedule, they are more likely to:**

a/ **Focus on completing tasks as quickly as possible, regardless of quality.**

b/ **Be invested in meeting deadlines and achieving project goals.**

c/ **Become resistant to any changes or adjustments to the schedule.**

d/ **Question the authority of the project manager.**

**4. Effective communication during schedule planning should include:**

a/ **A one-way presentation of the project manager's pre-determined plan.**

b/ **Technical jargon and project management acronyms.**

c/ **Open discussions about task dependencies and potential challenges.**

d/ **Focusing solely on the positive aspects of the planned schedule.**

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# STEP 0 - INCLUDING THE TEAM

## QUIZ

**5. Including team members in schedule planning can help to identify:**

**a/ Alternatives to the project manager's preferred communication style.**

**b/ Resource constraints or potential bottlenecks early on.**

**c/ The team member with the most negative attitude.**

**d/ Unrelated personal conflicts within the team.**

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**6. You are the project manager for a marketing campaign launch. Several departments (creative, social media, PR) will be involved in various stages of the campaign.**

**• How would you approach involving team members from different departments in planning the overall project schedule?**

**• What specific benefits can be gained from this approach.**

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# STEP O - INCLUDING THE TEAM

## QUIZ

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# STEP O - INCLUDING THE TEAM

## CORRECT ANSWERS

**1. Involving team members in schedule planning can:**

**b/ Lead to a more realistic and achievable schedule.**

**2. Team members with expertise in specific activities can provide valuable insights on:**

**b/ Estimated durations and potential risks associated with their tasks.**

**3. When team members feel ownership of the project schedule, they are more likely to:**

**b/ Be invested in meeting deadlines and achieving project goals.**

**4. Effective communication during schedule planning should include:**

**c/ Open discussions about task dependencies and potential challenges.**

**5. Including team members in schedule planning can help to identify:**

**b/ Resource constraints or potential bottlenecks early on.**

# STEP 1 - PLAN THE PLAN

Who is the audience?  
Level of detail required?  
Resources required?  
EVM required?  
CPM software to be used?

Output required?  
Integration with other software?  
Integration with other schedules?

Extent of documentation ?  
Resource considerations?  
Site Conditions?  
Location Impacts?  
Schedule considerations?

Methodology?  
Productivity?  
Long lead-time activities

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# STEP 1 - PLAN THE PLAN

## NOTES

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# STEP 2 - SCOPE & METHODOLOGY

**Review the documents.  
Discuss the works with the  
Project Team.**

**Determine the Phases of the  
work**

**Is there unique aspects of the  
project that could impact the  
schedule?**

**What is the form of Contract?**

**Is the project similar to other  
projects?**

**Is there benchmarking data?**

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## NOTES:

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## NOTES:

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# STEP 3 - DEFINE THE WBS

## QUIZ

**1. What is the primary purpose of a WBS?**

- a/ To define the project budget
- b/ To decompose project deliverables into manageable components
- c/ To assign activities/resources to project tasks
- d/ To identify project risks

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**2. The WBS is a:**

- a/ Linear list of tasks.
- b/ Hierarchical outline
- c/Flowchart of project activities
- d/Gantt chart depicting project schedule

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# STEP 3 - DEFINE THE WBS

## QUIZ

**3. Which of the following is NOT a characteristic of a well-defined WBS?**

a/ 100% complete - encompasses all project work

b/ Mutually exclusive - tasks don't overlap in scope

c/ Sequenced logically - reflects project workflow

d/ Highly detailed - includes individual steps (WBS should focus on deliverables, not specific actions)

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**4. The lowest level of a WBS is called a:**

a/ Phase

b/ Deliverable

c/ Work Package

d/ Activity

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# STEP 3 - DEFINE THE WBS

## QUIZ

**5. What is the relationship between the WBS and the project scope?**

a/ They are unrelated concepts in project management.

b/ The WBS defines the project scope in detail.

c/ The WBS helps ensure the project scope is fully captured.

d/ The project scope dictates the specific format of the WBS.

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**6. Explain the benefits of using a WBS in project management.**

**7. Describe the process for developing a WBS for a project.**

**8. Imagine you are the project manager for developing a new mobile app. Briefly outline the first 3 levels of your WBS.**

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# STEP 3 - DEFINE THE WBS

## QUIZ

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# STEP 3 - DEFINE THE WBS

## CORRECT ANSWERS

1. What is the primary purpose of a WBS?

**b/ To decompose project deliverables into manageable components.**

2. The WBS is a:

**b/ Hierarchical outline**

3. Which of the following is NOT a characteristic of a well-defined WBS?

**c/ Sequenced logically - reflects project workflow**

4. The lowest level of a WBS is called a:

**c/ Work Package**

5. What is the relationship between the WBS and the project scope?

**c/ The WBS helps ensure the project scope is fully captured.**

# STEP 4 - ACTIVITY LISTING

**Consider the type of schedule**

**Are there specific contract requirements relating the schedule?**

**Ensure an adequate number of activities.**

**Too many activities can become difficult to manage.**

**Activity descriptions should be clear & easily identified.**

**Consider 'intelligent' activity naming.**

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## NOTES:

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# STEP 6 - ACTIVITY LOGIC

Clearly defined logic

Realistic & credible.

No open ends (apart from first & last activity)

Most relationships to be Finish to Start

Don't use Start to Finish

Physical Logic Vs Resource logic.

Constraints - sparingly used

Constraints -

- Contract completion dates
- Important Milestones
- Establishing a start to a sequence of works
- An alternative to logic, in certain cases.

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## NOTES:

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# STEP 7 - DETERMINE THE CRITICAL PATH

Refer to Chapter 02 for detailed explanation of the Critical Path Method and calculations.

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## NOTES:

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# STEP 8 - REVIEW RESOURCES

resource unavailability times

Long lead-times for specialist resources

what client/owner resources are required? Availability?

what are the controlling resources

Is there sufficient Supervision staff?

Local conditions Vs resourcing & supervision?

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## NOTES:

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## NOTES:

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# STEP 10 - CONTINGENCY

**A schedule without contingency has a greater chance of running late.**

**Consider the inherent risks**

**Consider inclement weather**

**Consider the geographical location**

**Add activity for contingency - don't hide in the calendar!**

**Consider scope creep.**

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## NOTES:

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# STEP 11 - RE-SCHEDULE & REVIEW

Re-schedule & review with the Team

Is there a clear, continuous & realistic Critical Path?

Is the Critical Path understood?

Review near critical paths or parallel paths.

Review time saving opportunities across the whole schedule.

Is there negative Total Float?

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## NOTES:

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## NOTES:

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# STEP 13 - UPDATE THE SCHEDULE

**Updates = Forecast, not historical info**

**Schedule is dynamic and needs to reflect current info and progress.**

**Update progress against the agreed baseline.**

**Gather progress inputs by face to face meetings**

**Regular site walks/inspections to confirm progress**

**Schedule revisions - Minor Vs Major**

**Schedule revisions :**

- significant changes have occurred
- major variations
- changes to the contract
- major delays

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## NOTES:

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# STEP 14 - COMMUNICATE THE SCHEDULE STATUS

**Understand the audience & the outputs required**

**What is the message being communicated.**

**How will the message be communicated?**

**What other software can be utilised to visually communicate the message?**

**Regular face to face meetings important.**

**Review the various sources of information**

**Check the accuracy of information!**

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## NOTES:

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# STEP 14 - COMMUNICATING THE SCHEDULE

## QUIZ

**1. The primary purpose of communicating project schedule information is:**

a/ To showcase the project manager's planning abilities.

b/ To ensure all team members understand their roles and deadlines.

c/ To document every detail of the project plan.

d/ To assign blame for any potential delays.

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**2. When communicating schedule updates, it's important to:**

a/ Focus solely on negative variances (delays).

b/ Use highly technical project management jargon.

c/ Present information in a clear, concise, and visually appealing format.

d/ Avoid discussing potential risks or mitigation plans.

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# STEP 14 - COMMUNICATING THE SCHEDULE

## QUIZ

### 3. Effective communication of schedule information should consider:

- a/ Project manager's communication style only.
- b/ The specific needs and roles of different team members.
- c/ The technical complexity of the project activities.
- d/ The project budget limitations only.

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### 4. Progress updates on the project schedule should be:

- a/ Infrequent and only when there are major deviations.
- b/ Highly detailed and include every minor task update.
- c/ Regularly scheduled and focus on key milestones.
- d/ Delivered solely through email communication.

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# STEP 14 - COMMUNICATING THE SCHEDULE

## QUIZ

**5. The best approach to address potential schedule risks during communication is to:**

a/ Downplay the risks and focus on the original plan.

b/ Discuss the risks openly and outline mitigation strategies.

c/ Assign blame to specific team members for potential delays.

d/ Avoid discussing risks unless directly questioned by team members.

**6. Explain two benefits of effectively communicating project schedule information to team members.**

**7. Describe two different methods (beyond email) that can be used to communicate project schedules and progress updates.**

**8. Imagine you are the project manager for a software development project. The team has recently encountered a critical bug that is causing a delay in one of the key activities on the project schedule.**

- **How would you communicate this information to your development team?**
- **What specific details would you include in your communication?**

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# STEP 14 - COMMUNICATING THE SCHEDULE

QUIZ

A series of 18 horizontal dotted lines for writing answers.

# STEP 14 - COMMUNICATING THE SCHEDULE

CORRECT ANSWERS

1. The primary purpose of communicating project schedule information is:

**b/ To ensure all team members understand their roles and deadlines.**

2. When communicating schedule updates, it's important to:

**c/ Present information in a clear, concise, and visually appealing format.**

3. Effective communication of schedule information should consider:

**b/ The specific needs and roles of different team members.**

4. Progress updates on the project schedule should be:

**c/ Regularly scheduled and focus on key milestones.**

5. The best approach to address potential schedule risks during communication is to:

**b/ Discuss the risks openly and outline mitigation strategies.**

C H A P T E R

# 02

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CRITICAL PATH EXPLAINED

# CRITICAL PATH - TECHNICAL TERMS

## Activity

A distinct item of work completion of which is necessary to finish the project.

## Duration

A realistic, best estimate of the amount of time necessary for accomplishing the work involved in an activity. Measured in time units. eg days.

## Early Start (ES)

The earliest point in time when an activity can start, assuming all prerequisite activities take place as scheduled.

## Early Finish (EF)

The earliest date that an activity can finish, assuming that it began on its early start date.

## Late Start (LS)

The point in time by which an activity must start if there is to be no delay in subsequent activities.

## Late Finish (LF)

The date by which all work involved in an activity must be completed in order to avoid delaying subsequent activities.

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# THE CRITICAL PATH METHOD

The CPM method has Three Variables:

- 1) Time
- 2) Scope
- 3) Logic

Critical Path can be determined by

:

- manual calculation
- using a spreadsheet
- using CPM software such as Primavera P6, Microsoft Project, Asta Power Project or similar

Tasks that are not on the critical path have more leeway (float) and may be slipped (delayed) without affecting the end date of the project.

This is called float (slack).

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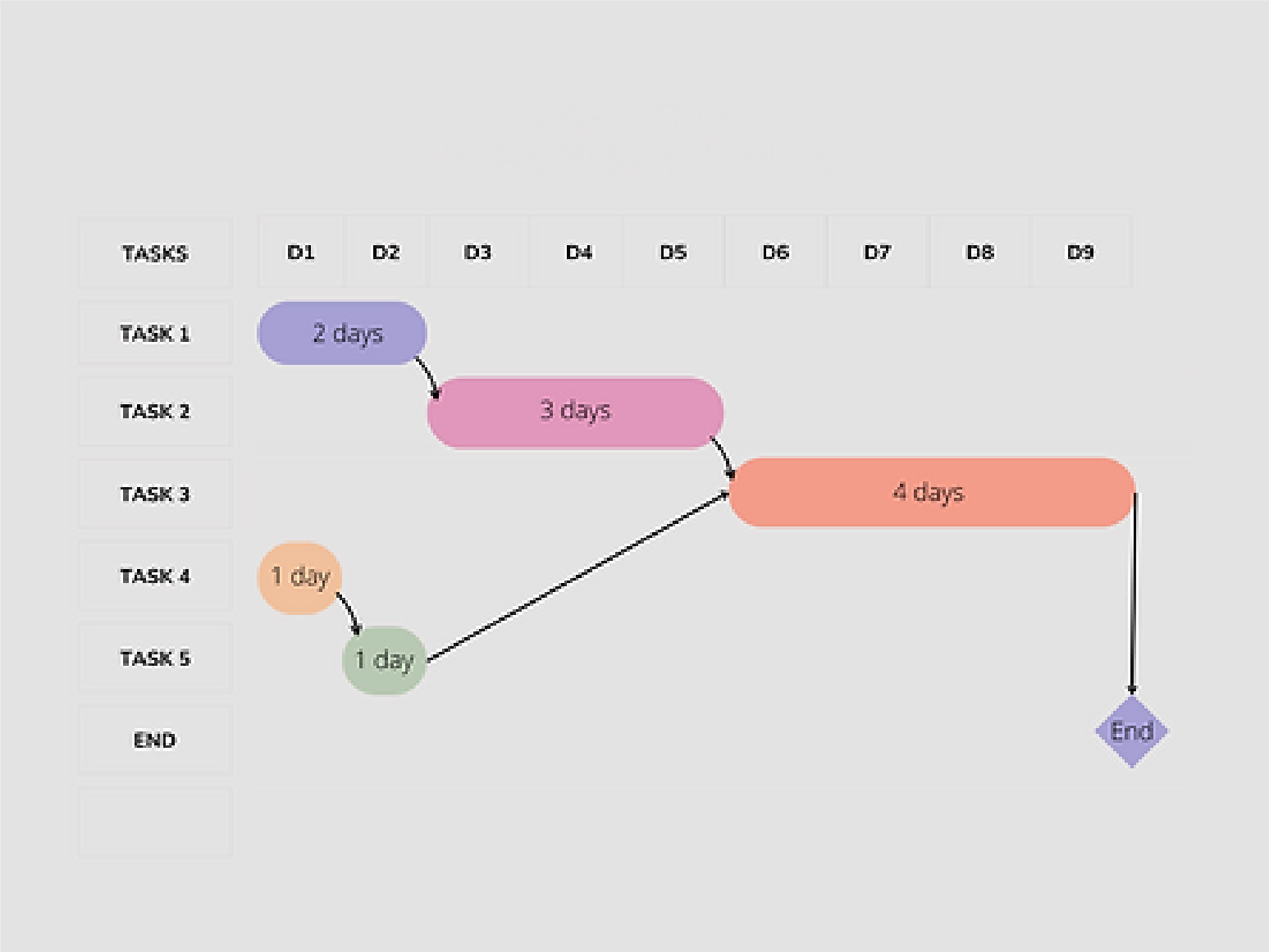
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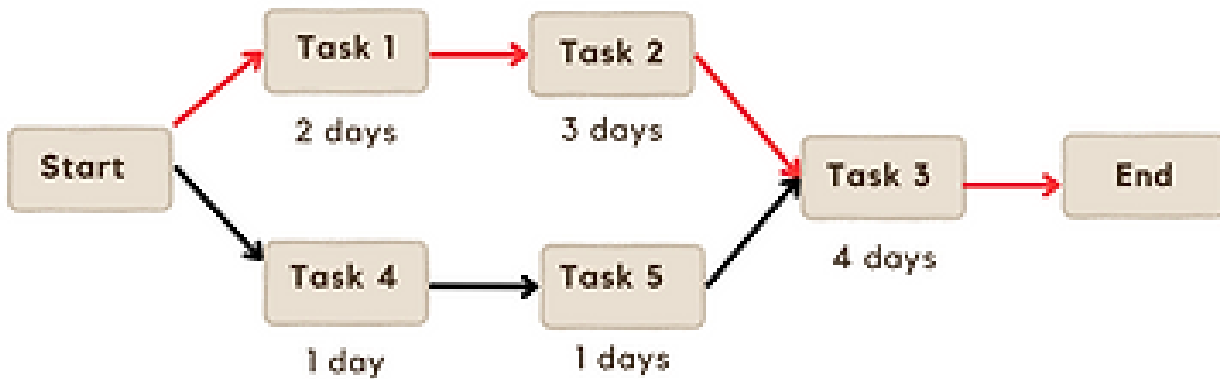
# THE CRITICAL PATH METHOD

A simple bar chart is shown here:



# THE CRITICAL PATH METHOD

Build a simple Activity Diagram, including estimating the time required (or duration) for all tasks. Based on the simple bar chart above :



# THE CRITICAL PATH METHOD

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# THE CRITICAL PATH METHOD

Next, we need to include a space on each task 'card' for early and late start and finish dates or times (times, rather than dates, are required for tasks where hours or minutes are significant).

	Start	Finish
Early	<input type="text"/>	<input type="text"/>
Late	<input type="text"/>	<input type="text"/>

Duration (days)

The early start and early finish are simply the earliest times that a task can start or finish. The late start and late finish are the latest times that a task can start or finish.

For this example, we will assume that each calendar day is available for work. Start date 13 MAR 2025 (13MAR). We also assume that the work day commences at 8am and finishes at 4pm.

Starting with the tasks at the beginning of the diagram, complete the early start and early finish for each task in turn, following the arrows to the next task, as in the figure below.

The early start of a task is the same as the early finish of the preceding task. If there is more than one predecessor task, then there are several possible early start figures. Select the latest of these.

The early finish for each task is equal to the early start plus the duration of the task. The final calculation is for the earliest completion time for the project. This is calculated in the same way as the early start date.

# THE CRITICAL PATH METHOD

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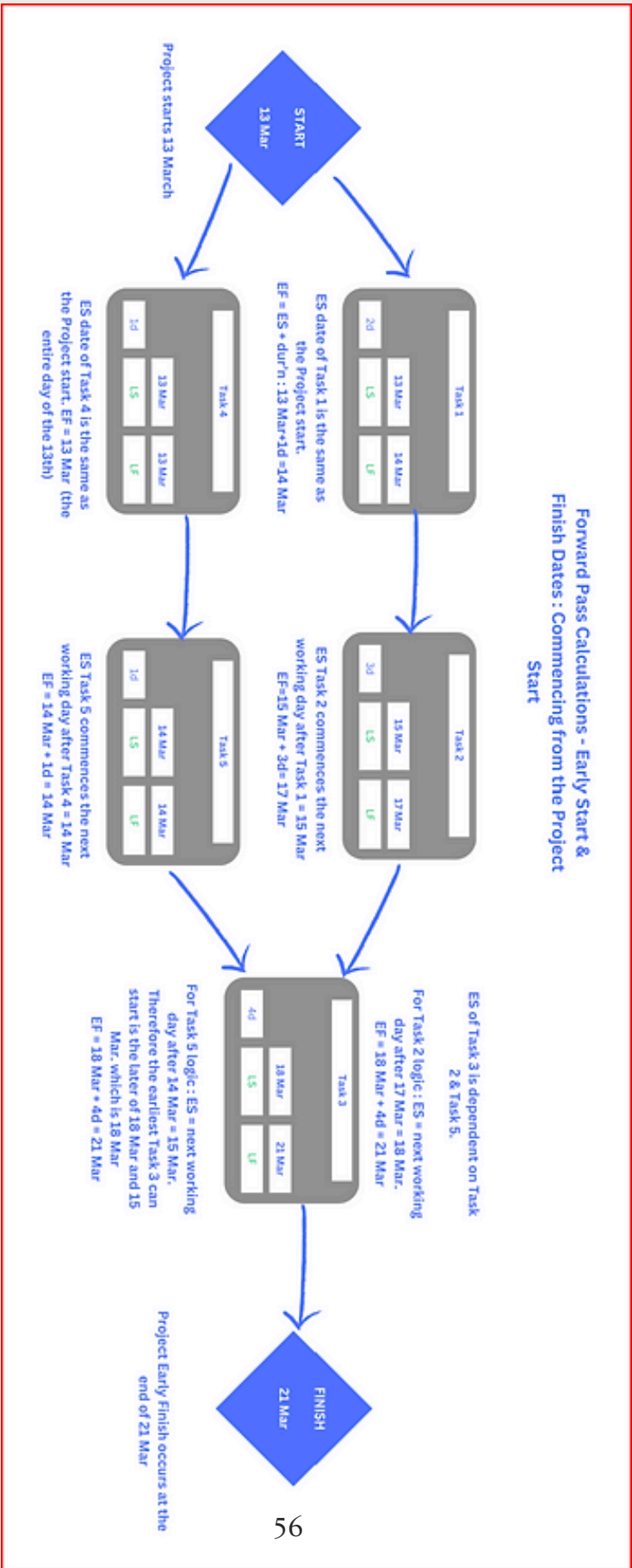
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# THE CRITICAL PATH METHOD



# THE CRITICAL PATH METHOD

Starting with the tasks at the end of the diagram, calculate the late start and late finish for each task in turn, following the arrows in the reverse direction to the previous task, as in the diagram below.

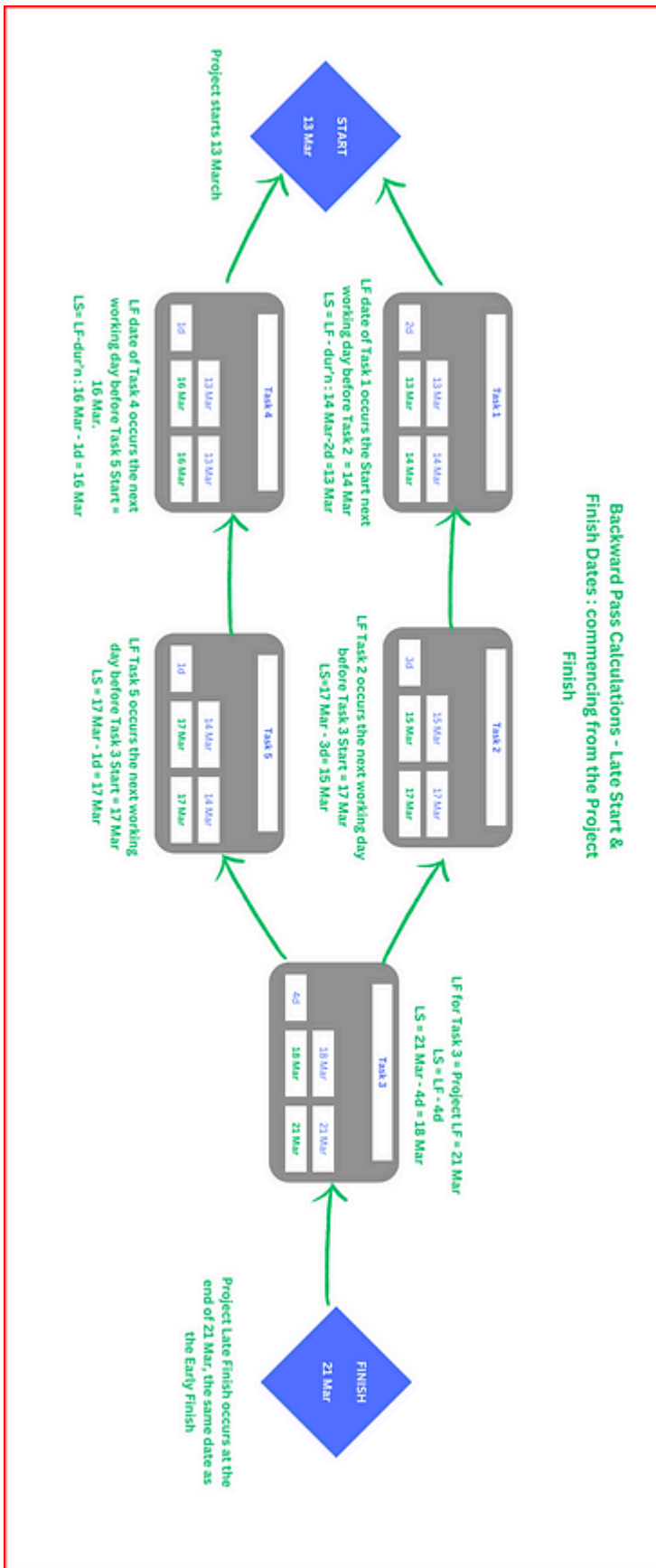
The late finish is the same as the late start of the succeeding task (for the final tasks in the project, this is equal to the earliest completion date). If there is more than one successor task, then there are several possible late figures. Select the earliest of these.

The late start for each task is the late finish minus the duration of the task.

# THE CRITICAL PATH METHOD

Blank lined area for notes or calculations.

## NOTES:





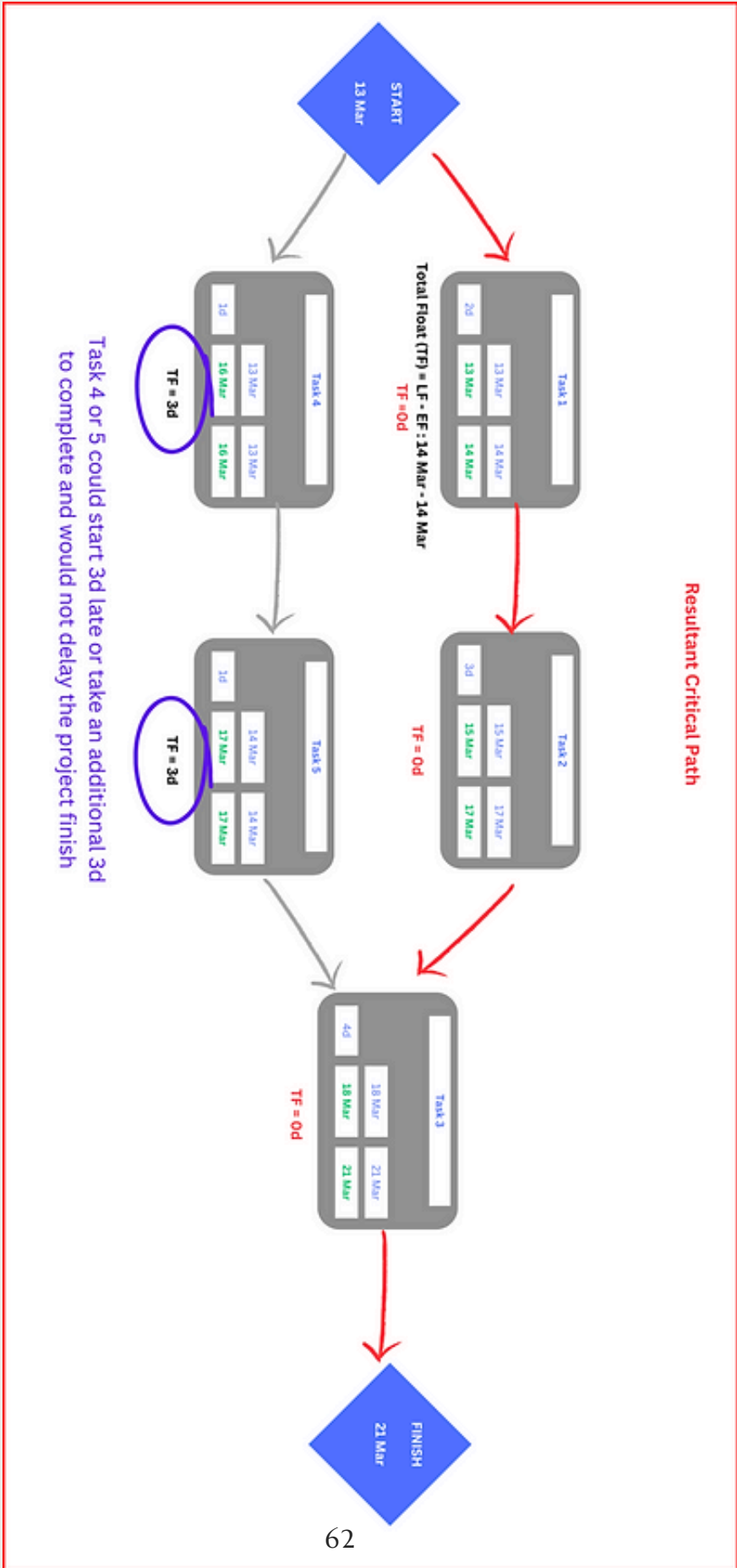
## NOTES:

You now have, for each task, the earliest and latest times that it can start and finish.

Now find the slack time (or 'float') for each task by subtracting the early start from the late start. The slack time is the amount of time the task can be slipped by without affecting the end date of the process.

The critical path can now be identified as all paths through the network where the slack time is zero.

NOTES:



# THE CRITICAL PATH METHOD

A large white rectangular area containing 20 horizontal dotted lines, spaced evenly down the page, intended for handwritten notes or calculations.

# THE CRITICAL PATH METHOD

## NOTES:

It may be possible to reduce the critical path of a project (and consequently pull in the completion date) by rearranging some tasks that have an optional sequence or by moving key people onto tasks in the critical path so you can reduce the time for these tasks.

The above 'Project' was a simple 5 Task schedule, with relatively simple logic (Finish - Start). Complex projects with numerous activities and complicated logic requires CPM software to undertake the above forward pass and backward pass calculations, quickly and accurately.

It is important, as a planner, to understand the fundamentals of CPM, before jumping into CPM software. Not all CPM software is the same.

# CONFIRMING THE CRITICAL PATH

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# CONFIRMING THE CRITICAL PATH

## NOTES:

The critical path is generally defined as the longest continuous sequence of activities in a schedule. It defines the program's earliest completion date or minimum duration.

Activities on this path are termed "critical path activities." Typically, the sequence of activities with the longest total duration is also the path through the network with the lowest total float.

Total float is the time an activity can slip before its delay affects the program end date. When the network is free of date constraints, critical activities have zero float, and therefore any delay in the critical activity causes the same day-for-day delay in the program forecast finish date.

For example, if an activity on the critical path is delayed by a week, the program finish date will be delayed by a week unless the slip is mitigated.

Therefore, the critical path is most useful as a tool to help determine which activities deserve focus and, potentially, management help.

The critical path assists program management in prioritizing resources to have the most positive effect on program performance.

Typically, total float is set to zero, and the scheduling software marks as critical all activities with zero or less-than-zero total float.

Activities with total float within a narrow range of the critical path total float are "near-critical" because they can quickly become critical if their float is used up in a delay.

# CONFIRMING THE CRITICAL PATH

## NOTES:

Near-critical paths need only a small delay of time to become critical. Management must monitor critical and near-critical activities through sound schedule management because any delay in them will delay the entire program.

Near-critical paths are monitored according to a float threshold tailored to the schedule.

For example, a brief schedule might consider a 5-day slip to be a near-critical threshold. In programs scheduled to take years, a 2- or 3-month's slip in near-critical paths might make the path critical.

Because prolonging a schedule by 5 days on a short project is as easily possible as prolonging a multiyear project several months, program managers should manage all near-critical and critical paths.

The critical path is not constant. The sequence of activities that make up the critical path changes as activities are delayed, finished early, occur out of planned sequence, and so on.

Activities that were previously critical may become noncritical, and activities that were not critical may become critical.

It is crucial that program management understand that an important activity is not necessarily "critical." At any point in time, the critical path may or may not contain activities that management believes are particularly important.

# CONFIRMING THE CRITICAL PATH

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# CONFIRMING THE CRITICAL PATH

## NOTES:

A delay in an activity may be important for any number of reasons related to scope and cost without delaying the finish milestone date. In contrast, some mundane activities—training, for example—may be on the critical path and not particularly risky but can delay the program finish date if they take longer to accomplish.

Similarly, an activity of long duration should not be referred to as a “critical path activity” simply because it will take a long time to accomplish.

“Critical activity” in scheduling parlance has a specific definition that should be adhered to when reporting and evaluating schedule data.

### **Total Float**

Once the early and late dates have been derived, the schedule can be assessed for flexibility. The difference between the time an activity may start or finish and the time it must start or finish in order for the project to be completed on time is known as total float (TF). Total float is calculated as the difference between an activity's early and late dates:

$$TF = LS - ES$$

or

$$TF = LF - EF$$

# CONFIRMING THE CRITICAL PATH

A large white rectangular area containing 20 horizontal dotted lines, intended for writing or calculation.

# TOTAL FLOAT VS FREE FLOAT

## QUIZ

**1. What does "float" represent in a project schedule?**

- a/ The estimated buffer time for completing an activity.
- b/ The number of resources assigned to an activity.
- c/ The cost associated with each activity.
- d/ The quality standard expected for each activity.

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**2. Total float refers to the amount of time an activity can be delayed:**

- a/ Without affecting the project's overall completion date.
- b/ Without impacting the start date of its successor activities.
- c/ Without exceeding its budgeted cost.
- d/ Regardless of the schedule for other activities..

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# TOTAL FLOAT VS FREE FLOAT

## QUIZ

**3. Free float is relevant for activities on the:**

- a/ Critical path only.
- b/ Non-critical path only.
- c/ Both critical and non-critical paths.
- d/ Activities with the longest durations.

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**4. An activity with zero total float has:**

- a/ The most flexibility in the schedule.
- b/ A significant buffer for delays..
- c/ No delay allowed without impacting the project timeline.
- d/ Dependencies on multiple preceding activities.

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# TOTAL FLOAT VS FREE FLOAT

## QUIZ

**5. Knowing the free float of an activity helps project managers:**

a/ Identify resource bottlenecks.

b/ Schedule resources for successor activities.

c/ Estimate the project budget more accurately.

d/ Determine the critical path of the project..

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**6. In your own words, explain the difference between total float and free float in a construction project schedule.**

**7. Describe a scenario in construction scheduling where knowing the total float of an activity would be more important than the free float**

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# TOTAL FLOAT VS FREE FLOAT

## CORRECT ANSWERS

1. What does "float" represent in a project schedule?

a/ The estimated buffer time for completing an activity.

2. Total float refers to the amount of time an activity can be delayed:

b/ Without impacting the start date of its successor activities.

3. Free float is relevant for activities on the:

c/ Both critical and non-critical paths.

4. An activity with zero total float has:

c/ No delay allowed without impacting the project timeline.

5. Knowing the free float of an activity helps project managers:

b/ Schedule resources for successor activities.

# CRITICAL PATH METHOD

## QUIZ

**1. Which of the following statements is NOT true about CPM?**

a/ CPM focuses on activities and their durations.

b/ CPM is best suited for complex projects with dependencies.

c/ CPM can be used for cost analysis of projects.

d/ CPM can predict the probability of completing a project by a specific date.

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**2. What is the term for the sequence of activities with zero slack that determines the minimum project duration?**

a/ Free Float

b/ Total Float

c/ Critical Path

d/ Network Path

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# CRITICAL PATH METHOD

## QUIZ

**3. An activity on the critical path has:**

a/ The most resources assigned to it.

b/ The longest estimated duration.

c/ Zero total float.

d/ No predecessor activities.

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**4. If a non-critical activity is delayed, the project schedule will be impacted:**

a/ Only if the delay exceeds the total float of the activity.

b/ Regardless of the amount of delay.

c/ Never, as long as it's not critical.

d/ Only if there are resource conflicts with critical activities.

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# CRITICAL PATH METHOD

## QUIZ

**5. What is the main benefit of using CPM in project management?**

a/ It guarantees a project will be completed on time.

b/ It identifies the most time-sensitive activities.

c/ It provides a detailed budget breakdown.

d/ It eliminates all risks associated with the project.

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**6. Briefly explain the difference between total float and free float in a project network diagram.**

**7. Describe two ways a project manager can use CPM to improve project efficiency.**

**8. A project consists of the following activities and their durations:**

- A: 4 days (predecessor: none)
- B: 5 days (predecessor: A)
- C: 3 days (predecessor: A)
- D: 2 days (predecessor: B)
- E: 7 days (predecessor: C)

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**Draw a network diagram for this project and identify the critical path. [Upload via online course.](#)**

# CRITICAL PATH METHOD

## CORRECT ANSWERS

1. Which of the following statements is NOT true about CPM?

d/ CPM can predict the probability of completing a project by a specific date.

2. What is the term for the sequence of activities with zero slack that determines the minimum project duration?

c/Critical Path

3. An activity on the critical path has:

c/ Zero total float.

4. If a non-critical activity is delayed, the project schedule will be impacted:

c/ Never, as long as it's not critical.

5. What is the main benefit of using CPM in project management?

b/ It identifies the most time-sensitive activities..

# YOUR DREAM HOME SCHEDULE

## ASSIGNMENT

Test your scheduling skills by planning the construction of a single-story house. Use the Critical Path Method (CPM) to identify the most critical activities and estimate the minimum project duration.

Instructions: Review the list of activities and their estimated durations (in days) below.

Identify any dependencies between activities (e.g., the foundation must be complete before framing can begin).

List your assumptions

Sketch a simple network diagram representing the project activities and their dependencies.

Based on the network diagram, calculate the Early Start (ES), Early Finish (EF), Late Start (LS), Late Finish (LF), and Total Float (TF) for each activity.

Identify the critical path and determine the minimum project duration.

Identify potential options for reducing the overall duration

*Activity List (Duration in Days):*

*A. Site Preparation (5)*

*B. Excavation & Foundation (10)*

*C. Plumbing Rough-in (3) (Depends on B)*

*D. Electrical Rough-in (4) (Depends on B)*

*E. Framing (7) (Depends on B)*

*F. Roofing (5) (Depends on E)*

*G. HVAC Installation (4) (Depends on D)*

*H. Insulation (3) (Depends on E)*

*I. Drywall Installation (5) (Depends on E & H)*

*J. Interior Painting (7) (Depends on I)*

*K. Exterior Painting (5) (Depends on F)*

*L. Flooring Installation (4) (Depends on I)*

*M. Cabinet Installation (3) (Depends on I)*

*N. Countertop Installation (2) (Depends on M)*

*O. Bathroom Fixture Installation (2) (Depends on C & I)*

*P. Final Inspection (1) (Depends on All Prior Activities)*

# YOUR DREAM HOME SCHEDULE

## ASSIGNMENT

Upload your assignment via the 'Upload files for assessment' link within the online course.

# CPM SOFTWARE

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# CPM SOFTWARE

## NOTES:

The three primary scheduling and control software packages used in the building, construction, and resources industries are Microsoft Project, Oracle Primavera P6, and Asta Powerproject (Elecosoft).

Each of these software packages has distinct origins, architectures, and industry applications, offering various advantages and facing certain disadvantages within their operational contexts.

## Origins

Microsoft Project was developed in the US in 1984, initially aimed at managing software development projects. Its functionality has evolved over time, with significant features like Cost Resources and Calendar Exceptions being added.

Oracle Primavera P6 originated as Eagle Ray in the 1990s, later acquired by Primavera Systems. It was designed for software and business development projects and has since become a staple in more extensive project management applications.

Asta Powerproject was developed in the early 1980s in the UK, with a strong focus on the building and construction industries. It incorporates features specifically tailored to these sectors.

# CPM SOFTWARE

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# CPM SOFTWARE

## NOTES:

### Architecture

Microsoft Project offers three versions: Standard (desktop for standalone files), Professional (desktop for server or Microsoft Project Server files), and Web App (browser-based, for Microsoft Project Server files). The Standard version is most commonly used by building and construction companies.

Oracle Primavera P6 operates projects from a database rather than single project files, supporting Oracle and Microsoft SQL databases. It comes in Professional Project Management (PPM) and Enterprise Project Portfolio Management (EPPM) database types, with Windows and Web Client applications for interfacing.

Asta Powerproject provides flexibility in operation, allowing for single or multiple project files, user concurrency, and database integration. It is favored for its concurrent licenses and free reader option, making it cost-effective.

### Industry Usage

Microsoft Project is widely used by residential builders, architects, quantity surveyors, and smaller civil construction companies. It's appreciated for its simplicity, cost-effectiveness, and familiarity among users, though it is often not updated with actual dates for revised end dates.

Oracle Primavera P6 is preferred for large commercial building projects, medium to large civil construction firms, and almost all resource companies in mining, oil, and gas industries. Its structured approach to schedule updates and extensive data handling capabilities make it suitable for large-scale projects.

Asta Powerproject has a smaller market penetration in Australia but is valued by large commercial construction companies and builder developers for its construction-specific functionality and flexible licensing.

# CPM SOFTWARE

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# CPM SOFTWARE

## NOTES:

### Advantages

Microsoft Project is known for its ease of use, widespread familiarity, cost-effectiveness, and simple deployment within IT infrastructures.

Oracle Primavera P6 excels in handling large project data, enforcing proper schedule updates, and providing robust baseline and forecasting features.

Asta Powerproject offers extensive scheduling options, construction-specific functions, and cost advantages through concurrent licensing and a free reader.

### Disadvantages

Microsoft Project can be challenging to manage in complex scenarios due to its template issues, limited relationship modelling, and difficulties in handling multiple resources and calendars.

Oracle Primavera P6 may present graphical limitations and requires careful management of planned dates and baseline data to avoid confusion.

Asta Powerproject faces challenges with market penetration and operator availability,, alongside a steep learning curve due to its advanced features. In summary, these three scheduling and control software packages offer a range of tools tailored to the diverse needs of various industries.

Microsoft Project is suited for smaller projects and users seeking simplicity and affordability. Oracle Primavera P6 caters to large-scale projects requiring detailed schedule management and data handling. Asta Powerproject is recognized for its construction-specific functionalities and flexible licensing, appealing to companies not needing to exchange schedule files frequently.

C H A P T E R

# 03

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## SCHEDULE REVIEWS

# SCHEDULE REVIEWS

## NOTES:

Schedule reviews undertaken internally for Governance/Organisation approval are an essential part of the schedule acceptance process.

A Basis of Schedule (BoS) document provides an overview of the project and the planning and schedule methodologies used.

# SCHEDULE REVIEWS

## NOTES:

### **Basis of Schedule document (BoS)**

The basis of scheduled document should include the following items:

Project description & Scope

Documents that were relied on (design documents, specifications, reports, surveys, contracts, technical requirements)

Project owners 'Schedule Management Plan'

Schedule strategy

Construction Methodology

Key Productivity information & Resources

Working Calendars

Activity duration calculations for key activities

Schedule Risk Analysis report

Explanation of Critical Path

Constraints used in the schedule

Resource Histograms

Schedule Quality Checks

Key Milestones, Completion dates, Separable Portions etc

Staging or Phase drawings

Time Chainage Diagram if relevant

Summary Schedule output

Detailed Schedule output

Critical Path

Near Critical Paths



# SCHEDULE REVIEWS

## NOTES:

### **Schedule Management Plan**

The schedule management plan is a collection of processes, approaches, templates and tools that comprise the project's execution strategy and objectives as reflected in the project's schedule.

The Schedule Management Plan should be unique to each project and defines how the schedule will be developed, updated, progressed and how it should be communicated to various levels of Management

The Schedule Management Plan can refer to Guidelines for additional information. Eg. a guideline for Time Chainage Diagram Preparation which provides details on the preparation, formatting etc of the TCD. Reference would be made to the chosen or specified CPM & TCD software.

# SCHEDULE REVIEWS

## NOTES:

### **Schedule Management Plan**

The schedule management plan is a collection of processes, approaches, templates and tools that comprise the project's execution strategy and objectives as reflected in the project's schedule.

The Schedule Management Plan should be unique to each project and defines how the schedule will be developed, updated, progressed and how it should be communicated to various levels of Management

The Schedule Management Plan can refer to Guidelines for additional information. Eg. a guideline for Time Chainage Diagram Preparation which provides details on the preparation, formatting etc of the TCD. Reference would be made to the chosen or specified CPM & TCD software.

### **Reviewing schedules by others**

Schedule reviews require detailed analysis, careful investigation, and close interaction with the project team.

The reviewer's role is not that of policing or auditing – rather it is uncovering and communicating hidden stories about the status and achievability of the project and schedule, and then working closely with the project team to help solve them.

Your organisation's teams undertake extensive reviews of schedules developed by Contractors and other stakeholders, mostly in the latter stages of the Procurement Phase (i.e. Bid schedules) and during the Delivery Phase (i.e. Contractors' Delivery schedules).

Schedule reviews help us to understand and communicate:

schedule health – is the schedule accurate and robust?

Change management – how is the schedule changing over time and how is this being managed?

Progress measurement – how is the project tracking, are its deliverables being completed as planned?

Contract compliance – is the schedule compliant with the relevant documents?

schedule achievability – is the schedule (and project) likely to be completed on time?

# SCHEDULE REVIEWS

A series of 18 horizontal dotted lines for writing.

# SCHEDULE REVIEWS

## NOTES:

Outputs of the review should strike a balance between carefully quantified data and information. Data on its own is not very useful – it needs to be organised into information to become understood and therefore useful.

Client teams should work closely with delivery Contractors, utilising the skills and experience within the client teams to add value to the Contractors' teams – it's a joint effort.

The client's role is not to simply observe but to influence and facilitate successful outcomes.

Project success is more likely when we work well together following a 'One Team Approach'.

Client planning teams should adopt the approach and behaviours below:

Establish a positive working relationship between the client and the Contractor based on genuine open communication, transparency, and a willingness to work with each other to achieve a common outcome.

Follow a 'One Team' approach by spending time at the Contractor's office and conducting joint site inspections to review progress together.



# SCHEDULE REVIEWS

## NOTES:

Show that you can add value to their team and be a second pair of eyes rather than an auditor

questions that should be asked are:

is the critical path logical and does it make sense?

- is there a parallel critical path
- assess float paths or near critical paths
- do activities have open ends ie. nil predecessors or nil successors
- Are there activities with excessive amounts of total float - a well developed network should have noncritical activities with a minimum amount of float
- can the critical path be shortened by :
  - removal of unnecessary restraints or constraints
  - overlapping or bypassing of activities
  - increase in resources ie. labour materials or equipment
  - alternative methods or methodology approach
- does the critical path pass through finishes landscaping or external works. This would be incorrect on most projects it would be unlikely that painting is a critical path activity
- does the critical path pass through the Lift motor Room or an electrical sub station on a City High rise building. For a high rise, lifts, lift motor room and permanent power are all generally critical
- have procurement, design, approval lead times being properly linked up with construction activities
- do completion activities have sufficient time allowance for local Authority inspections, and commissioning
- have constraints being applied correctly or can they be removed
- are dependencies logical or can activities be overlapped or by-passed
- is there redundant or duplicate relationships
- compare indicated total time with committed or specified time (check contractual documents, specifications, technical requirements)

# SCHEDULE REVIEWS

## NOTES:

### **Schedule Quality**

DOD Defence Contract Management Agency

In its role as the DOD executive agent for earned value management systems (EVMS), the Defence Contract Management Agency's (DCMA) mission includes conducting contractor surveillance on EVMS.<sup>46</sup> The outcome of DCMA surveillance ensures that reported contract performance data accurately reflect the status of programs.

In assessing contractor schedule reliability, DCMA ensures that the following ANSI/EIA-748 EVMS guidelines are followed:

- Schedule the authorized work to describe the sequence of work and identify significant task interdependencies required to meet the requirements of the program.
- Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.

In its assessment of the quality of a schedule, DCMA uses a 14-Point Assessment

# SCHEDULE REVIEWS

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# SCHEDULE REVIEWS

## NOTES:

(14PA), a collection of measures intended to assess the technical structure of the schedule as well as the contractor's ability to plan and execute work. The measures are:

1. Logic
2. Leads
3. Lags
4. Relationship types
5. Hard constraints
6. High float
7. Negative float
8. High duration
9. Invalid dates
10. Resources
11. Missed tasks
12. Critical path test
13. Critical path length index
14. Baseline execution index.

Several include thresholds; for example, no more than 5 percent of remaining tasks

should be missing predecessor or successor logic. However, DCMA's 14PA thresholds are not compliance triggers. Rather, they are used as a starting point toward an objective analysis of the schedule.

# SCHEDULE METRICS

## NOTES:

### **Critical Path Length Index**

The Critical Path Length Index (CPLI) measures how realistic the program completion date is, based on the remaining duration of the critical path and the amount of total float available.

CPLI is one of the standard Schedule Health Assessment Metrics and identifies programs that are having difficulty executing their critical path. The target for CPLI is 1.0 or greater. A lower value indicates an increased risk of being late at program completion.

Where Critical Path Length is the number of days from time now to the early finish date of the task or milestone representing program completion.

Total Float on the task or milestone representing program completion may be either positive or negative.

The result is an index that measures the sufficiency of the total float available relative to the remaining duration of the critical path.

For example, 20 days of float on a critical path that has 80 days remaining would result in a CPLI of 1.25 indicating a low risk of not completing on time.

However, if the critical path has 800 days remaining, a total float of 20 days would result in a CPLI of 1.03. Although this is still above the target of 1.0, it indicates there is much less room for error. To achieve a CPLI of 1.25 in this case would require 200 days of total float.



# SCHEDULE METRICS

## NOTES:

CPLI also measures the relative efficiency required to complete the program critical path on time. A CPLI of 1.00 means the program has 0 days of total float available on the critical path and therefore should accomplish one day's worth of work for every day that passes. This means the program should execute the critical path at a 100% efficiency rate to complete on time.

A CPLI less than 1.00 indicates that the program is not executing the critical path as planned and has created a negative total float condition potentially delaying program completion.

To prevent this from happening, the program should now accomplish more than one day of work for every day that passes. This means the program should now execute the critical path at an efficiency rate higher than 100%.

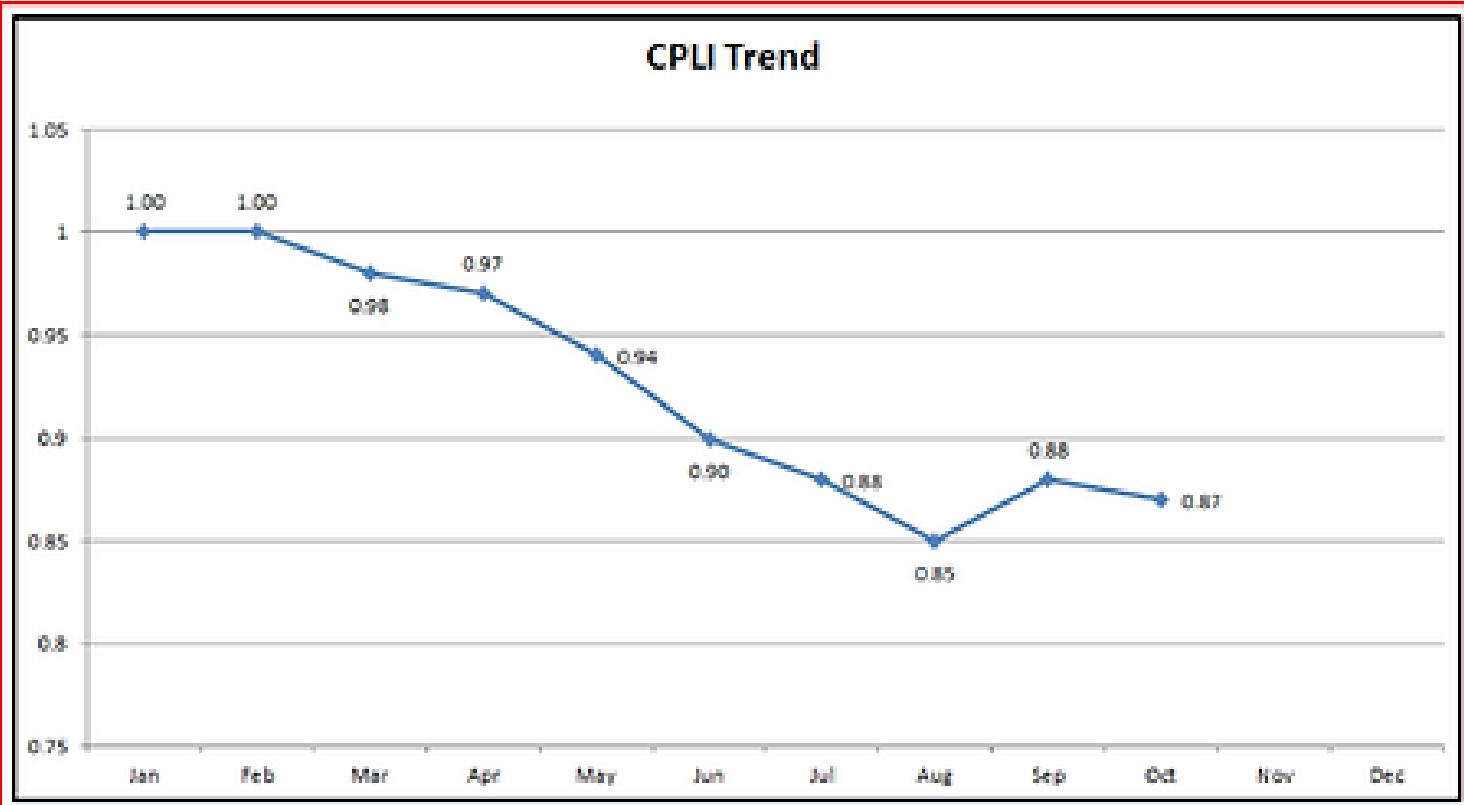
Likewise, a CPLI greater than 1.00 indicates that the program is executing the critical path ahead of plan and still has positive total float remaining. As a result, the program has a lower risk of delaying program completion since they can operate at an efficiency rate of less than 100% and still complete on time

Typically, programs calculate CPLI to program completion or an interim milestone. Any activities on or near the program critical path can directly impact this metric if not completed as planned.

Note: CPLI will not work correctly, if the network does not have a constrained finish date on the task representing program completion, because the result would be a Critical Path that has zero total float and a CPLI of 1.00 at all times.

# SCHEDULE METRICS

NOTES:



# SCHEDULE METRICS

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# SCHEDULE METRICS

## NOTES:

### **BEI baseline execution index**

BEI is a summary level snapshot measuring how well the program (or a portion of the program) has actually performed to the baseline plan.

The BEI is a simple index measure of a count of completed tasks with a count of tasks scheduled to be completed. As with most indices, 1.0 is ideal, a number greater than 1.0 indicates more task completions than planned and a number less than 1.0 indicates fewer completed tasks than planned.

Management can use this metric to evaluate schedule progress towards the baseline plan. BEI is similar in function to the Schedule Performance Index (SPI), except it is a ratio based on a simple task count.

$$BEI = \frac{\text{\# Tasks Actually Completed}}{\text{\# Tasks Planned to be Completed}}$$

# Tasks Actually Completed - Count of activities with a status updates for Actual Finish dates on or before the status date of the IMS

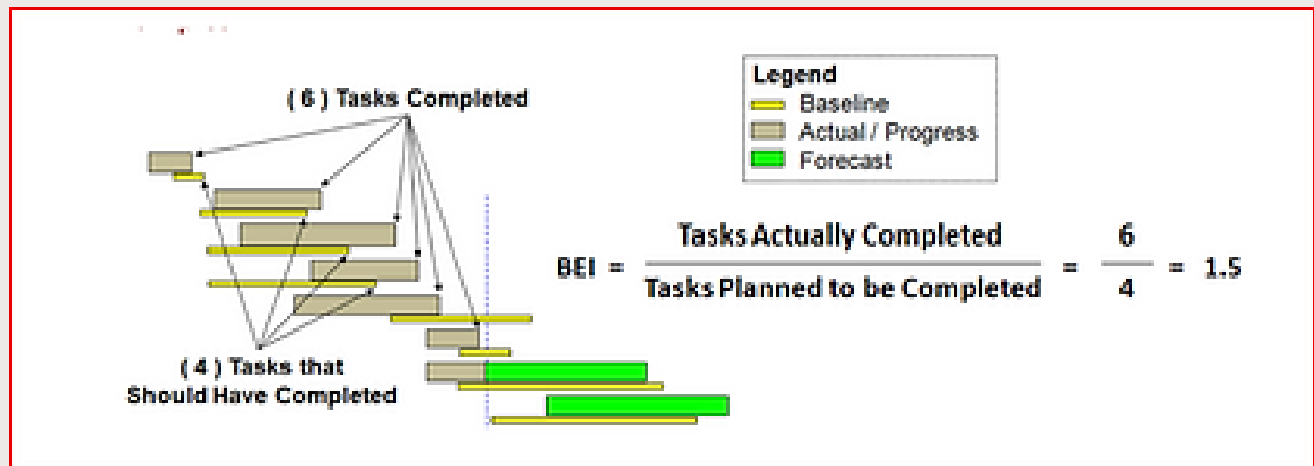
# Tasks Planned to be Completed - Count of activities with a Baseline Finish date on or before the status date of the IMS

Note: While there may be exceptions under certain circumstances, programs typically exclude the following activity categories from BEI counts and calculations: Level of Effort (LOE) and Milestones.

Programs can calculate BEI as often as the schedule has its status updated (typically weekly or monthly).

# SCHEDULE METRICS

## NOTES:





# SCHEDULE METRICS

## NOTES:

### **Current Execution Index**

The goal of this metric is to measure and indicate how well the near-term schedule represents what actually takes place through execution. This measurement provides insight into the accuracy of the forecast schedule and its abilities as a predictive model.

The index maximum is 1.00, but a sound forecast schedule will consistently trend in the greater than 80th percentile range. There is a direct correlation between the lower probability (less than 80 % probability of completion) and the program's ability to manage the projected near-term tasks. This indicates that work is slipping to the right and possibly adding to the "bow wave" of unachievable work.

Use of the CEI metric drives ownership and accountability behaviours that are necessary for program success when consistently used by program management.

You can derive CEI by comparing the number of tasks forecasted to finish within the status period to the number of those tasks that actually did finish within the status period.

# SCHEDULE METRICS

A series of 20 horizontal dotted lines for handwritten input.

# SCHEDULE METRICS

## NOTES:

1. At the beginning of the status period, create a "snapshot" of the status period (capturing

Forecast Finishes).

2. Execute through the status period.

3. Retrieve initial "snapshot".

4. Compare actual finish dates to the initial "snapshot".

Program teams that can effectively manage the road ahead have a higher percentage of success. The intent of CEI is to focus the program team on ensuring the forecast schedule is accurate and then executing to it as effectively as possible.

Note: Tasks in this formula should exclude LOE and Summary lines (but should include all other tasks/milestones). Be careful when establishing the parameters of this metric, unlike BEI, the numerator should contain only tasks that were previously forecasted to finish and did finish in the defined window.

$$CEI = \frac{\text{\# of tasks that finished in the window (of the tasks forecasted to finish)}}{\text{\# of tasks forecasted to finish in the defined window}}$$

Example

37 = # of tasks forecasted to finish in the window

29 = # of tasks that finished in the window (out of the 37 forecasted to finish in

the window)

CEI = 29/37 = .78

# SCHEDULE METRICS

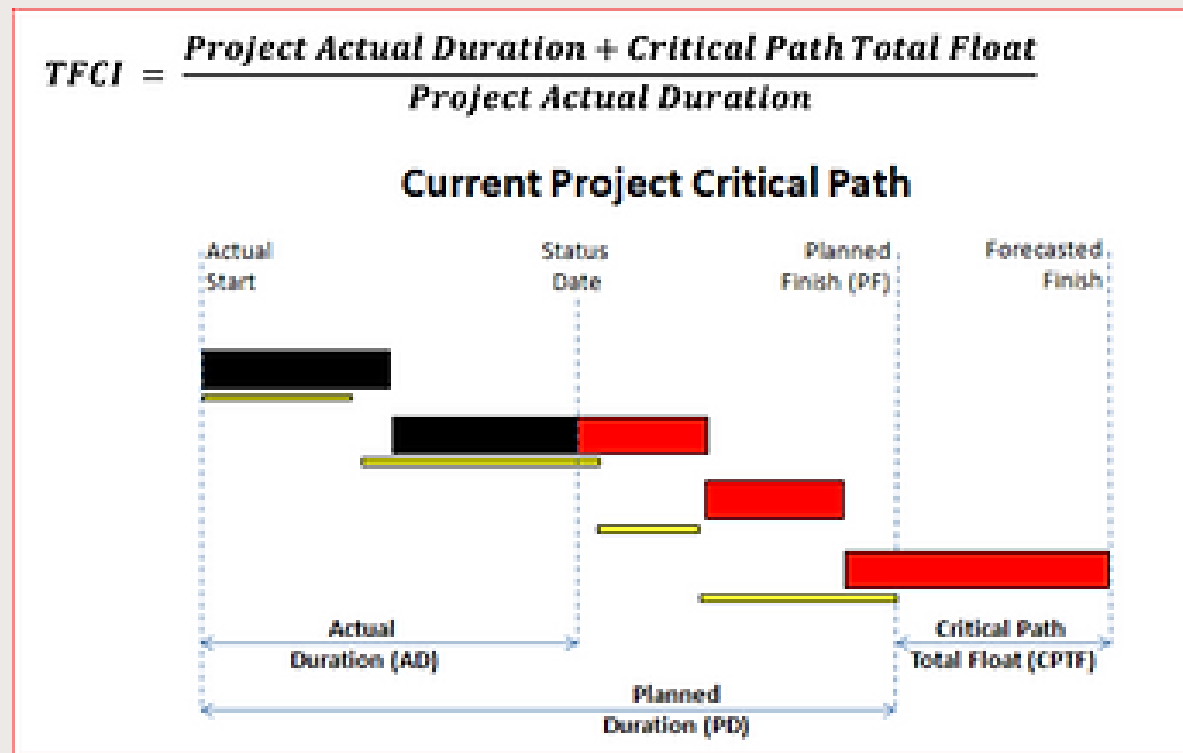

# SCHEDULE METRICS

## NOTES:

### Total Float Consumption Index

The focus of the TFCI is to provide a duration-based performance index calculating total float consumption as an efficiency factor.

The TFCI can be used to assess the achievability of the project completion date in any network schedule rather than just using the total float as a static indicator of projected completion. Program personnel use TFCI to estimate a projected forecast finish date.





# SCHEDULE METRICS

## NOTES:

Note: If the Critical Path Total Float is not being calculated to the baseline finish of the project, Baseline Finish Variance should be used in place of CPTF.

For any schedule using the critical path method, such as an IMS, total float is created or consumed based on network logic, completion of activities, and constraints within.

This is commonly referred to as total float management. Managing a schedule by total float allows Applied Project Status to be quantified, Predicted Critical Path Total Float to be calculated, and a forecast finish date to be pinpointed.

A TFCI of less than 1.00 indicates that a project may not complete on-time and applying that indicator to the total program duration (as depicted in steps #1 through #4 below) predicts where a project would complete if trends persist or corrective action is not taken.



# SCHEDULE METRICS

## NOTES:

### Example

#### Step 1: Find the TFCI

How is the program doing so far? If the TFCI is below 1.0, then the program may not complete on-time without mitigation.

Project Actual Duration = span of actual working time accrued (in days or like unit of measure), from the beginning of the program through the status date.

$$TFCI = \frac{\text{Actual Duration} + \text{Critical Path Total Float}}{\text{Actual Duration}} = \frac{763 + (-23)}{763} = 0.97$$

#### Step 2: Find Predicted Critical Path Total Float

This provides a quantitative assessment of future total float management using the total float consumed to date as an efficiency factor. How much total float will the project have by the baseline program finish date?

$$CCCC = DD (TT - 11) = 22 \cdot 22 (.97 - 11) = -77$$

If the TFCI trend of 0.97 persists, then the project will be -71 days behind schedule at project completion instead of -23 days at the baseline program finish date.

#### Step 3: Find the Predicted Forecast Finish Date

Using the project calendar (which includes non-working days) add 71 working days to the baseline finish date to calculate a Predicted Forecast Finish date

# SCHEDULE METRICS

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# SCHEDULE METRICS

## NOTES:

*Predicted Finish = BL Finish – PCPTF = Feb 16 – (-71 days) = May 26*

Avoid exaggerating the predicted impact. TFCI functions on the premise that downstream forecasts are not adjusted based on past performance.

If proper attention is given to accurate forecasting, TFCI can “double dip” the projected impact and predict a slip larger than past performance would suggest.

Depending on how the IMS is modelled, the CPTF may not ever be greater than zero, even if the project is forecasted to complete earlier than planned. Because of this, TFCI is intended to be used to analyse delinquent projects only.

An inherent property of the TFCI formula is early project instability. When a project is newly underway, its Actual Duration (AD) will be small.

Since AD is the denominator of the TFCI equation, any change in CPTF in the numerator will have a magnified effect on the outcome of the metric. Because of this, less emphasis should be placed on TFCI during the first few months of a project.

# SCHEDULE METRICS

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# SCHEDULE METRICS

## NOTES:

### **Schedule Rate Chart**

#### Actual Finish v. Baseline Finish

Compare the number of cumulative tasks with Actual Finish dates in each past period to the number of cumulative baselined tasks planned to finish in the period.

This indicates the difference between the planned and actual task completion rate. Programs conduct further analysis to understand the reasoning behind the variance, which could include the type of tasks, complexity of tasks, or resource availability.

#### Forecast Finish v. Baseline Finish

Compare the number of cumulative tasks with Forecasted Finish dates in each future period to the number of cumulative baselined tasks planned to finish in the period.

This indicates the difference between the planned and forecasted task completion rate. Programs conduct further analysis to understand the reasoning behind the variance, which could include the type of tasks, complexity of tasks, or resource availability.

#### Bow Wave Analysis

A schedule bow wave occurs when tasks continually slip into the future. If this continues to happen as the program progresses, it could result in an insurmountable number of tasks forecasted for completion in one or more status periods.

Programs should identify potential bow waves by comparing historical monthly completion rates to forecasted monthly completion rates.

# SCHEDULE METRICS

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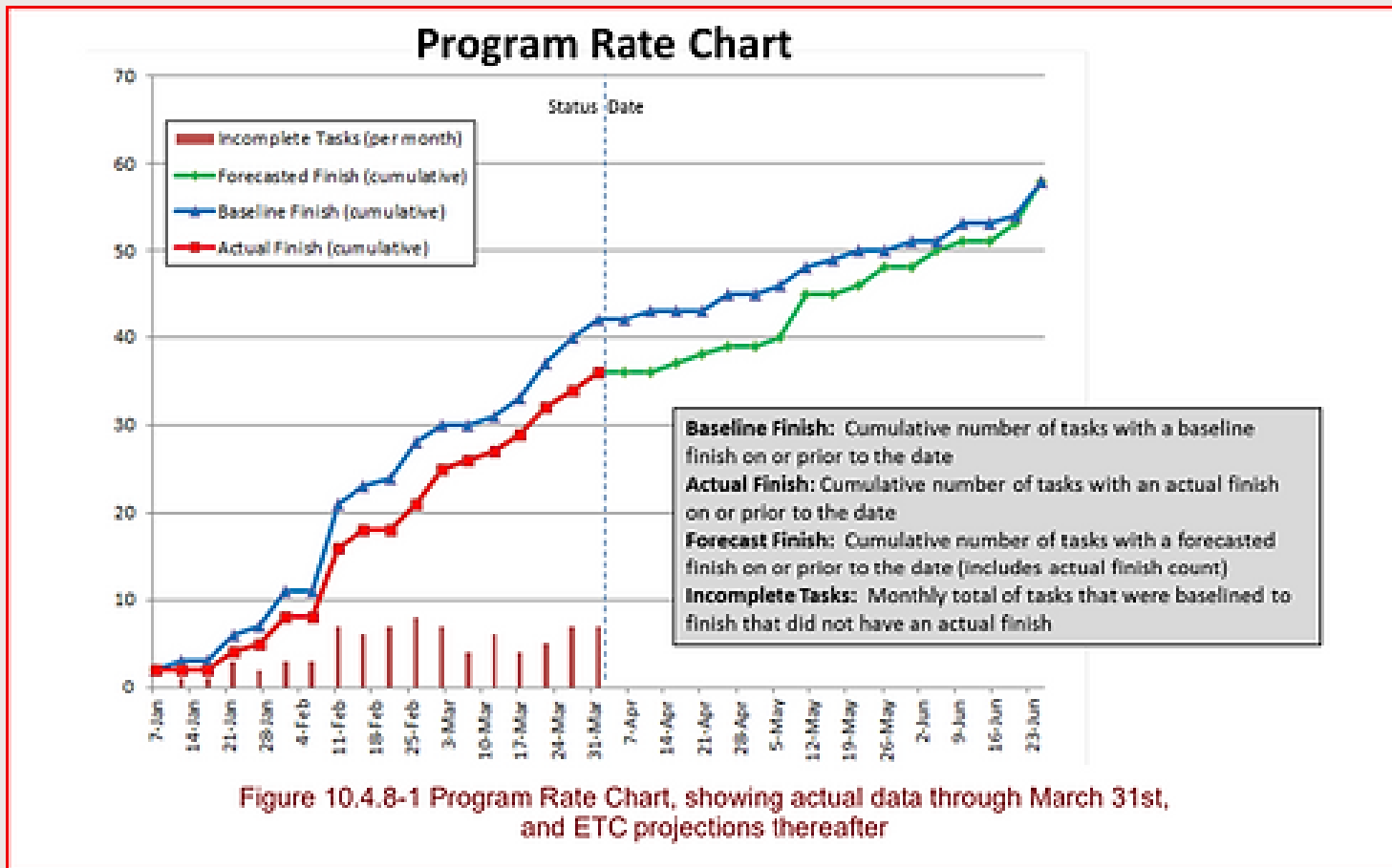
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# SCHEDULE METRICS

## NOTES:



## Calculations

**Actual Finish (Cumulative)** – Total number of tasks with an Actual Finish prior to the end of the status period.

**Forecast Finish (Cumulative)** – Total number of tasks with Forecast Finish prior to the end of the status period.

**Baseline Finish (Cumulative)** – Total number of tasks with Baseline Finish prior to the end of the status period.

**Incomplete Tasks (Status Period)** – Number of tasks in the status period with an Actual Start date prior to the end of the status period and no Actual Finish date.

# SCHEDULE METRICS

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# SCHEDULE METRICS

## NOTES:

### Things to Promote

Every task in the schedule has to be baselined for the chart to be useful Rate Chart should be created based on a statused and validated IMS Data in this chart should be analysed and compared to the data in the SPI, CPLI, and BEI to make informed choices and drive action Investigate and understand any unusual changes in the slope of the lines at or near "Time Now".

Sharp inclines may be an indication of an unachievable "bow wave" of effort that has been allowed to accumulate.

Avoid using LoE tasks

# SCHEDULE METRICS

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# SCHEDULE METRICS

## NOTES:

### **Schedule Diagnostics**

There are numerous schedule indices, as indicated above, however these checks lack information about the "quality" of a schedule, as they do not assess the scope of work that the schedule represents, logic, methodology or resources.

The following 'diagnostics' can assist the discussion on 'schedule quality' :

Activity count - Count of Activities in progress over time periods, the number of critical activities in each time period and the cumulative number of activities starting and finishing in each time period.

Duration Analysis - Duration of activities occurring over time periods by category and the number of critical activities in progress in each time period

Duration Vs Float - Duration and Float for all activities in schedule, Depends on the 'Set thresholds' for acceptable duration and float values and the number of activities that meet those thresholds

Constraint Analysis - Indicates constraints in schedule including, current schedule date vs constraint date, indicates type of constraints applied and balance line indicating whether activity date is on constraint date or earlier/later.

Logic Type - Type of logic used in schedule, distribution of logic time over time periods, and total count of logical relationships over time period.

Logic Analysis - Indicates the number of relationships occurring over time periods, indicates activities with no predecessors or no successors and when these occur, and a measure of Logic density.

Lag Analysis - Indicates relationships with lag values, Indicates use of lags over time periods, and Indicates the value of the lag for each relationship.

Logic Density - Activities with a high number of relationships , when these high relationship activities occur in time and an indication of how many of the relationships are driving relationships.

# SCHEDULE REVIEWS & METRICS

## QUIZ

**1. The DCMA 14-point assessment is primarily used for:**

a/ Cost estimation in construction projects.

b/ Evaluating the quality and logic of project schedules.

c/ Identifying resource allocation inefficiencies.

d/ Developing communication plans for stakeholders.

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**2. A project schedule that adheres to the DCMA 14-point assessment is more likely to:**

a/ Be completed under budget.

b/ Be realistic and achievable

c/ Minimize the need for progress monitoring.

d/ Eliminate all potential risks associated with the project.

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# SCHEDULE REVIEWS & METRICS

## QUIZ

**3. Which DCMA point focuses on the overall logic and network connectivity within the schedule?**

a/ Calendar Days versus Working Days Consistency

b/ Activity Durations are Realistic and Achievable

c/ Logic Network is Intellectually Consistent

d/ Holidays are Accounted for Properly

**4. A high percentage of unfinished tasks with total float exceeding a specific threshold would be a concern according to which DCMA point?**

a/ Weekend Days are Accounted for Properly

b/ Activity Interdependencies are Defined Correctly

c/ Schedule Network Contains Excessive Hammocks (Hammock refers to tasks with high total float)

d/ Early Start/Late Start Dates are Sequenced Logically.

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# SCHEDULE REVIEWS & METRICS

## QUIZ

**5. The DCMA 14-point assessment emphasizes the importance of:**

a/ Including extensive narrative descriptions for each activity.

b/ Using a consistent calendar system throughout the schedule

c/ Focusing solely on the critical path activities.

d/ Minimizing the level of detail included in the schedule.

**6. Briefly explain the concept of "critical path" and its relationship to the DCMA 14-point assessment.**

**7. Describe two benefits of using the DCMA 14-point assessment for project schedules.**

**8. A project manager is reviewing a schedule for a new product launch. The schedule uses a mix of working days and calendar days, and some weekend days are included for critical path activities. There are also a few activities with total float exceeding 20 days.**

**• Identify two DCMA 14-point concerns based on the information provided.**

**• Explain how**

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# SCHEDULE REVIEWS & METRICS

## CORRECT ANSWERS

1. The DCMA 14-point assessment is primarily used for:

**b/ Evaluating the quality and logic of project schedules.**

2. A project schedule that adheres to the DCMA 14-point assessment is more likely to:

**b/ Be realistic and achievable**

3. Which DCMA point focuses on the overall logic and network connectivity within the schedule?

**c/ Logic Network is Intellectually Consistent**

4. A high percentage of unfinished tasks with total float exceeding a specific threshold would be a concern according to which DCMA point?

**c/ Schedule Network Contains Excessive Hammocks  
(Hammock refers to tasks with high total float)**

5. The DCMA 14-point assessment emphasizes the importance of:

**b/ Using a consistent calendar system throughout the schedule**

C H A P T E R

# 04



## EARNED VALUE MANAGEMENT INTRO

# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

For Earned Value Methods to be successful :

- progress % needs to be accurate
- 
- for accurate % complete the schedule needs to be understood
- 
- for the schedule to be understood requires the whole project team to be on-board and own the schedule
- 

### **Intro to Earned Value Management**

Earned Value Management (EVM) is a project management technique used for measuring project performance and progress in an objective manner. It integrates project scope, cost, and schedule measures to help project managers assess the project's performance and progress. By using EVM, managers can identify and quantify project performance issues in a timely manner, allowing for corrective actions to be taken before these issues become more significant problems.

### **Key Concepts of EVM**

EVM is based on three key metrics:

**Planned Value (PV):** Also known as Budgeted Cost of Work Scheduled (BCWS), it represents the total cost of work planned to be completed by a certain date. It's the approved budget assigned to scheduled work.

**Actual Cost (AC):** Also known as Actual Cost of Work Performed (ACWP), it represents the actual cost incurred for the work performed on an activity up to a particular point in time.

**Earned Value (EV):** Also known as Budgeted Cost of Work Performed (BCWP), it represents the value of work actually completed to date compared to the planned value or budget. It's the approved budget for the work actually completed by the specified time.

# EARNED VALUE MANAGEMENT INTRO

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# EARNED VALUE MANAGEMENT INTRO

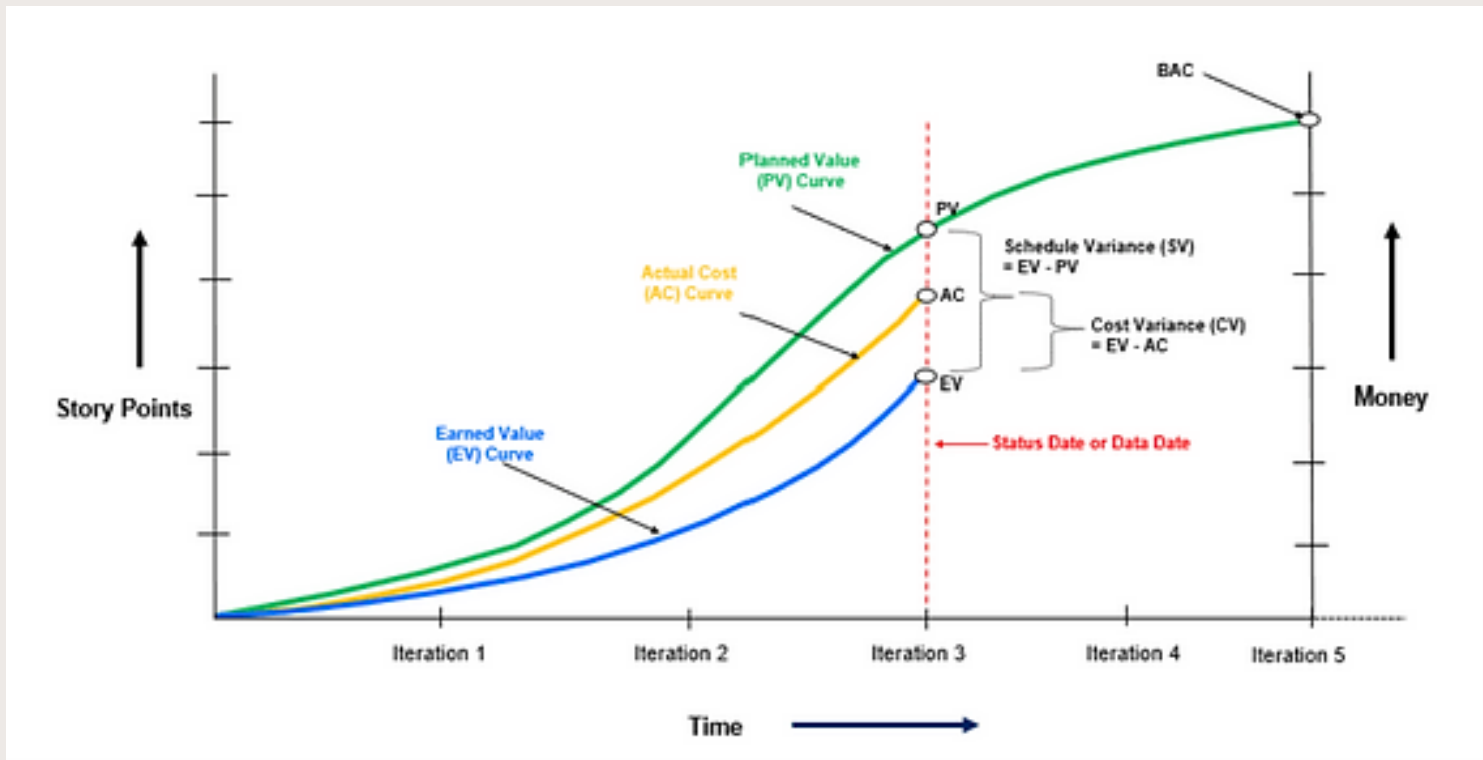
## NOTES:

NAME	DESCRIPTION	SIMPLIFIED DESCRIPTION
<b>Budget at Completion (BAC)</b>	The sum of all budgets established for the work to be performed.	Total Planned Work
<b>Planned Value (PV)</b>	The approved budget assigned to the scheduled work.	Work planned as of the data date.
<b>Earned Value (EV)</b> also known as BCWP (Budgeted Cost of Work Performed)	The measure of work performed, expressed in terms of the budget approved for that work.	Work done as of the data date.
<b>Actual Cost (AC)</b>	The realised cost incurred for the work performed during a specific time period.	Money spent as on the data date.
<b>Schedule Variance (SV)</b>	$SV = EV - PV$ . The amount by which the project is ahead or behind the planned delivery date as on the data date.	+ve = ahead of schedule. -ve = behind schedule. Zero = on schedule.
<b>Cost Variance (CV)</b>	$CV = EV - AC$ The amount of budget deficit or surplus as on the data date.	+ve = Under Budget. -ve = Over Budget. Zero = On budget.
<b>Schedule Performance Index (SPI)</b>	$SPI = EV / PV$ . A measure of schedule efficiency.	>1 = Ahead of Schedule. <1 = Behind Schedule. Zero = On schedule.
<b>Cost Performance Index (CPI)</b>	$CPI = EV / AC$ . A measure of the Cost Efficiency	>1 = Under Budget. <1 = Over Budget. Zero = On Budget



# EARNED VALUE MANAGEMENT INTRO

## NOTES:



## EVM Formulas

EVM employs several formulas to assess project performance, including:

Cost Variance (CV) =  $EV - AC$ : Indicates whether the project is under or over budget. A positive CV means the project is under budget, while a negative CV indicates it's over budget.

Schedule Variance (SV) =  $EV - PV$ : Indicates whether the project is ahead or behind schedule. A positive SV means the project is ahead of schedule, while a negative SV indicates it's behind schedule.

Cost Performance Index (CPI) =  $EV / AC$ : Measures the cost efficiency of the project's work performed. A CPI greater than 1 indicates the project is under budget, while a CPI less than 1 indicates it's over budget.

Schedule Performance Index (SPI) =  $EV / PV$ : Measures the efficiency of the project's work progress. An SPI greater than 1 indicates the project is ahead of schedule, while an SPI less than 1 indicates it's behind schedule.

# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### **Implementation of EVM**

To implement EVM, a project must have:

**A Baseline Plan:** This includes a detailed project scope, schedule, and budget. The baseline plan is essential for comparing actual performance against planned performance.

**Regular Progress Updates:** Updating the actual costs and the work completed at regular intervals is necessary to measure the project's performance accurately.

**EVM Software or Tools:** While not strictly necessary, EVM software can simplify the calculation and visualization of EVM metrics.

#### **Benefits of EVM**

**Objective Performance Measurement:** EVM provides quantitative data on project performance, reducing the subjectivity in assessing project health.

**Early Warning of Performance Issues:** By continuously monitoring CV, SV, CPI, and SPI, project managers can identify issues early and take corrective actions.

**Improved Decision-Making:** EVM data supports more informed decision-making regarding project scope, schedule, and cost adjustments.

**Enhanced Stakeholder Confidence:** Demonstrating control over the project's scope, schedule, and budget can improve stakeholders' confidence in project management.

# EARNED VALUE MANAGEMENT

## INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### **Challenges in Implementing EVM**

**Complexity:** Understanding and correctly applying EVM principles can be challenging, especially for those new to the technique.

**Resource-Intensive:** Setting up and maintaining EVM systems can require significant effort and resources, particularly for large and complex projects.

**Cultural Acceptance:** Integrating EVM into an organization's project management practices may face resistance from those accustomed to traditional methods.

Schedule WBS Vs CBS (Cost Breakdown Structure)

Schedule software & Cost software integration issues

Accurate end of period status for costs and schedule

In summary, Earned Value Management is a powerful and effective technique for monitoring and controlling project performance. By providing a comprehensive view of project health through objective metrics, EVM enables project managers to deliver projects on time, within budget, and to scope, thereby increasing the likelihood of project success.

Utilising Earned Value Management is a well-established method for assessing project performance. It is a reliable, data-driven, and well-respected method for figuring out how the task is progressing. Before you begin using it, there are a few things you should know, though, as with any strategy.

Every system has its limits, and EVM is not an exception. When a team is new to earned value, they face three primary challenges:

It doesn't gauge how satisfied customers are.

The numbers could not tell the complete story or have enough context.

You require trustworthy data.

# EARNED VALUE MANAGEMENT INTRO

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# EARNED VALUE MANAGEMENT INTRO

## NOTES:

### **NOT THE WHOLE STORY IS TOLD BY THE NUMBERS**

EVM is highly favoured by many due to its data-driven approach to project progress display, which completely eliminates the subjective and arbitrary nature of status reporting. An effective earned value management system depends on the underlying facts to offer an unbiased image, so there is no need to worry about the project team "massaging" the report and exaggerating progress measures.

When someone reports a task as 80% accomplished for the third week in a row, there are no questions asked because the data supports the report.

That being said, the data does not tell the entire tale. If the folks in your audience are unfamiliar with earned value or have not previously seen the report, you will need to provide some background information and story to help them understand what the EVM report implies.

EVM is not a judge; although your data may indicate that you are ahead or behind schedule, being behind doesn't always imply "bad." The data may be reported for a variety of reasons, so you'll need to apply your professional judgment to provide context for those who require it.

# EARNED VALUE MANAGEMENT INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### **YOU REQUIRE ACCURATE DATA.**

Since earned value computations depend on data, your EVM metrics will also be inaccurate if your numbers are off. Unfortunately, even if the measures were derived using shaky data, some people will still regard them as gospel.

When an organisation begins to use earned value seriously, this is frequently the largest obstacle. For the underlying data to yield meaningful EV computations, its quality must be reliable and fast enough.

The project team may need to make significant behavioural and mental adjustments as a result. In order to establish reliable baselines, they will need to start providing updates on their progress in real time and work harder at planning ahead.

Furthermore, projects that move quickly may cause the EVM numbers to become outdated very soon. Even with correct data, it can be difficult to enter it into the system and make use of it if the numbers lose their meaning quickly.

Working with out-of-date data is a major challenge because the primary goal of EVM reporting is to identify patterns and take action before they become problems. That means that instead of being a helpful management tool, your EVM data becomes a historical record of project performance.

Strong reporting tools ensure that you have the procedures in place to provide you with reliable data in a timely manner, which will help you establish the conditions for success.

# EARNED VALUE MANAGEMENT

## INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### MAKING EVM WORK

There are limitations to any strategy and business instrument, including EVM. They don't stop you from using it, and we contend that by being aware of the system's limitations, you may make greater use of it. You can utilise EVM to help project delivery in a suitable and efficient manner if you understand what it can achieve for you.

#### Example

Creating Earned Value Management (EVM) curves involves plotting the key metrics of EVM (Planned Value, Actual Cost, and Earned Value) over time to visually represent the project's performance. These curves provide a quick and intuitive way to assess whether the project is on track, ahead of schedule, or behind schedule, and whether it is under budget or over budget.

To illustrate, let's create a hypothetical example of a project with a duration of 12 months and a total budget (BAC - Budget at Completion) of \$120,000. The project is planned to progress linearly, meaning an equal amount of work (and thus cost) is expected to be completed each month. However, the actual progress and costs will vary. We'll plot the Planned Value (PV), Actual Cost (AC), and Earned Value (EV) over time.

For simplicity, let's assume:

The project spends \$10,000 per month as per the plan (PV).

Actual Costs (AC) and Earned Value (EV) will be varied to show typical project scenarios.

Let's plot an example with the following specifics:

Months 1-4: The project progresses as planned, spending exactly \$10,000 each month, and completing the planned work.

Months 5-8: The project encounters issues, leading to higher costs (\$12,000 per month) and slower progress (only \$8,000 worth of work completed per month).

Months 9-12: The project implements corrective actions, reducing costs (\$9,000 per month) and catching up on progress (\$11,000 worth of work completed per month).

We'll generate EVM curves based on these assumptions.

# EARNED VALUE MANAGEMENT

## INTRO

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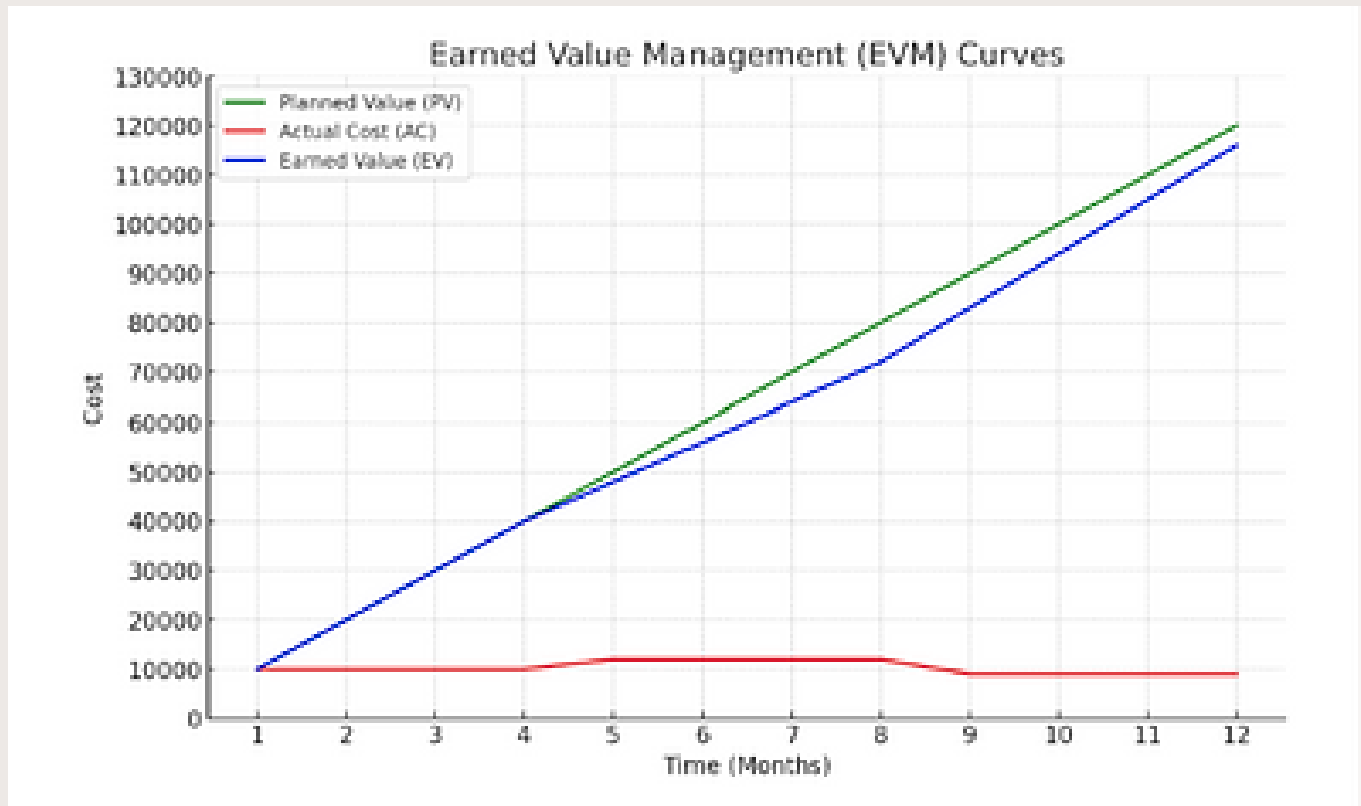
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# EARNED VALUE MANAGEMENT INTRO

## NOTES:



The EVM curves plotted above represent the hypothetical project's performance over 12 months, based on the provided assumptions:

**Planned Value (PV) Curve (Green):** Shows a linear progression, indicating that the project was planned to spend \$10,000 per month, reflecting a steady planned progress toward project completion.

**Actual Cost (AC) Curve (Red):** Initially matches the PV curve, indicating that actual spending was as planned. However, between months 5 and 8, the curve rises above the PV, showing that the project experienced higher actual costs due to encountered issues. In the last four months, the curve's slope decreased, reflecting the implementation of corrective actions to reduce costs.

**Earned Value (EV) Curve (Blue):** Starts off matching the PV curve, indicating that the project was progressing as planned. However, during months 5-8, the EV curve falls below the PV curve, demonstrating that less work was completed than planned, despite the higher costs. In the final months, the EV curve's steeper slope indicates that the project began to catch up on progress, though it did not fully meet the planned value by the project's end.

This visualization allows project managers and stakeholders to quickly assess the project's health. The period where AC exceeds PV and EV indicates cost overruns and schedule delays. The latter improvement in EV relative to AC and PV suggests effective corrective actions, though challenges in fully catching up are evident. This graphical representation is invaluable for communicating project status and supporting decision-making in project management.

# EARNED VALUE MANAGEMENT

## INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### **Challenges of using EVM**

Even though Earned Value Management is a valuable tool, mega construction projects can present some specific challenges:

#### **Data Quality and Availability:**

Mega projects often involve complex structures and numerous stakeholders. Gathering accurate and timely data from all parties can be difficult.

Delays in cost reporting or inconsistent data entry can lead to misleading EVM calculations.

The sheer size of the project can make data management cumbersome.

the maturity of the project schedule and the project costs maybe mis-aligned. Eg. the schedule level of detail may show a slab construction details as survey > site preparation > formwork > Rebar > Concrete. Whereas the cost (budget) may show 'Level X structure'. The costs may need be split into sub elements until a particular work scope is awarded to different 'structure' sub-contractors

#### **Scope Creep and Baseline Changes:**

The scope of a mega project may shift mid-construction due to unforeseen circumstances or design changes. Frequent revisions to the baseline can make it difficult to accurately track progress and cost performance using EVM.

#### **Lack of Expertise:**

EVM requires a good understanding of the methodology and interpretation of the metrics. Large teams with varying levels of experience may not all be well-versed in using EVM effectively.

Pressure to meet performance targets can sometimes lead to manipulation of data to present a rosier picture. This can mask underlying problems and hinder corrective actions.

# EARNED VALUE MANAGEMENT INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

### QUIZ

Your answer here

**1. What metric in EVM compares the value of work completed to the budgeted cost for that work?:**

a/ Schedule Performance Index (SPI)

b/ Cost Performance Index (CPI)

c/ Estimate at Completion (EAC)

d/ Schedule Variance (SV).

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**2. A project with a CPI of 1.1 indicates:**

a/ The project is behind schedule.

b/ The project is under budget.

c/ The project is spending less than planned per unit of work completed.

d/ There is no information about the project schedule..

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# EARNED VALUE MANAGEMENT

## INTRO

### NOTES:

#### Integration with Complex Scheduling:

Mega projects often have intricate scheduling with interdependencies between tasks. Accurately reflecting this complexity in the EVM model can be challenging.

Here are some ways to address these challenges:

- Understand the schedule!
- Accurate and timely status updates (schedule)
- Accurate and timely cost updates
- Invest in robust data collection and management systems - automation of processes to allow for quality time spent with the project team to review:
  - progress/status update
  - understand the impact of the progress update on the schedule
  - understand and agree the mitigations that are required
- Establish clear communication protocols for project changes and baseline updates.
- Provide training for project personnel on EVM principles and best practices.
- Foster a culture of transparency and accountability in project reporting.
- Utilise specialised EVM software to streamline calculations and integrate with scheduling tools.
- 'Plan the Plan' - remember to think ahead when planning the original schedule:
  - What reports are required?
  - Who is the audience?
  - Does the Schedule software adopted for the project produce sufficient EVM reports?
  - Does the data need to be exported to another software system to undertake the EVM?
  - Does the Schedule WBS align with the Cost Breakdown Structure (CBS)?
  - Do activities with the schedule software require particular coding to 'communicate' with other software packages?
  - CPM software is great for processing copious amounts of activities and complex relationships. However, the output generated for review/reporting is dismal. Exporting data to external packages is now the norm to produce highly visual :
    - trackers
    - charts
    - heat maps,
    - trend charts

# EARNED VALUE MANAGEMENT INTRO

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# EARNED VALUE MANAGEMENT

## INTRO

QUIZ

### 3. What is the main purpose of Earned Value Management?

a/ To track project resources effectively.

b/ To assess project performance in terms of cost and schedule.

c/ To identify and manage project risks.

d/ To develop a detailed project communication plan.

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### 4. Earned Value (EV) is calculated by:

a/ Actual Cost (AC) + Schedule Variance (SV)

b/ Planned Value (PV) - Cost Variance (CV)

c/ The value of work performed according to the project schedule.

d/ The total budget allocated to the project.

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# EARNED VALUE MANAGEMENT

## INTRO

### QUIZ

**5. A positive Schedule Variance (SV) signifies:**

a/ The project is exceeding its budget.

b/ The project is ahead of schedule.

c/ There is a cost overrun on the project

d/ The project is experiencing resource shortages.

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**6. Briefly explain the difference between Cost Performance Index (CPI) and Schedule Performance Index (SPI).**

**7. Describe two benefits of using Earned Value Management in project management.**

**8. A project is at week 10. The Planned Value (PV) for this point is \$50,000, and the Actual Cost (AC) is \$55,000. Calculate the Cost Variance (CV) and Cost Performance Index (CPI) for the project.**

**9. Explain how a project manager can use Earned Value Management to identify potential project problems and take corrective actions.**

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# EARNED VALUE MANAGEMENT

## INTRO

CORRECT ANSWERS

1. What metric in EVM compares the value of work completed to the budgeted cost for that work?:

**b/ Cost Performance Index (CPI)**

2. A project with a CPI of 1.1 indicates:

**c/ The project is spending less than planned per unit of work completed.**

3. What is the main purpose of Earned Value Management?

**b/ To assess project performance in terms of cost and schedule.**

4. Earned Value (EV) is calculated by:

**c/ The value of work performed according to the project schedule.**

5. A positive Schedule Variance (SV) signifies:

**b/ The project is ahead of schedule.**

C H A P T E R

# 05



DELAYS

# DELAYS

## NOTES:

### Timing of Analysis

**Prospective analyses** are performed in real-time, prior to the delay event, or where the analysis takes place, in real-time, with the delay event. In all cases prospective analysis consists of the analyst's best estimate of future events.

Prospective analysis occurs while the project is still underway and may not evolve into a forensic context.

**Retrospective analyses** are performed after the delay event has occurred and the impacts are known.

The timing may be soon after the delay event but prior to the completion of the overall known project, or after the completion of the entire project.

Under many contracts the term 'delay' is not defined and is used with a variety of different meanings.

The lack of a clear definition of the word 'delay' in many contracts often leads to confusion when discussing the effects of delays, particularly when addressing concurrency. Confusion typical leads to the involvement of Third parties ie. delay specialists (schedule analysis and legal teams) on the owners side and contractors side .

A clearer definition in contract documents of how delays will be recorded and assessed would seem a logical and cost efficient way to resolve delay claims with minimal Third party involvement.

To simplify the discussion of delay in general we adopt the following terminology:

- An 'Event' is any issue under consideration.
- A 'Delaying Event' is an Event that did (or may have) delayed one or more activities on the Project.
- A 'Critical Delay' is a Delaying Event that has been found, by analysis, to have caused a delay to the completion of the Project or the Works.

The 'Cause' of an Event, be it delaying or not may be in a different time period to the Event the subject of analysis.

For example, in the case of a variation involving additional work the Cause would be the direction to vary the works and the Event would be the actual additional work itself.

### Other terminology

- Total Float is the amount of time an activity may be delayed without delaying the project end date.
- Free Float is the amount of time an activity may be delayed without delaying the start date of another successor activity
- Contingency – is an amount of time allocated to an activity to allow for risk factors such as inclement weather or Industrial disputes. (represented as a separate bar).
- Concurrency – is where two or more events are thought to be incurred at the same time and either overlap or partly overlap.

# DELAYS & CLAIMS

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# DELAYS - TYPES OF CLAIMS

## NOTES:

Delay, productivity losses and disruption are three intrinsically related concepts that may significantly affect the outcome of a construction project.

Disruption may result from acceleration or from site or other conditions which were unforeseen by the contractor.

Productivity losses may result from acceleration, disruption or from mitigated delay. It has generally been accepted that claims involving these concepts are more difficult to prepare and quantify than those based on "pure delay". When the theoretical and practical aspects of preparing claims that feature analyses of productivity and disruption are considered, the following becomes apparent:

- If a contractor's work has been adversely and compensably affected, the practicalities of construction programming and the ambiguities that exist in the critical path method mean that it may not be obvious whether a delay claim or disruption claim should be prepared.
- Labour productivity, as recorded by a construction contractor, is an appropriate approximation of total or "true" productivity for the purposes of claim preparation.
- Productivity losses may be attributable to any combination of several causes; furthermore, studies have been conducted that provide rough quantifications of the severity of these causes.



# DELAYS - TYPES OF CLAIMS

## NOTES:

Construction contractors tend to have insufficient comprehension of the information systems that are required for effective claim preparation; this includes site diaries and other site documentation, as well as programming and progress reporting systems.

As with other impacts, it is preferable if productivity analyses are conducted with reference to actual field data, as opposed to relying on initial estimates.

Learning curve effects can be analysed by referring to a project's productivity records, and are most significant on repetitive projects where the repetitive elements are substantially similar.

The party preparing a construction claim should not lose sight of the basic elements required to prove damages in common law.



# DELAYS - TYPES OF CLAIMS

## NOTES:

### **Retrospective longest path analysis**

In the retrospective longest path analysis approach, the focus lies on determining the critical path as it actually unfolded during the project, distinct from the contemporaneous or actual critical path identified through other methods.

This methodology involves several steps to unveil insights into project performance. Initially, the delay analyst establishes or verifies a detailed as-built schedule, capturing the project's actual timeline accurately.

Subsequently, tracing back from the project's completion date, the delay analyst identifies the longest continuous path - the retrospective as-built critical path. This path showcases the sequence of activities that significantly influenced the project's overall duration & completion.

Further investigation into project records ( site diaries, correspondence, meeting minutes, interviews etc.) follows to understand the causes behind identified critical delays. By scrutinising events and circumstances throughout the project's lifecycle, the analyst gains insights into factors contributing to deviations from the planned timeline.

However, it's essential to acknowledge a limitation of this method: its relatively constrained ability to accommodate shifts in the critical path during project execution.

While effective in pinpointing key delays and their causes, this approach may not fully capture instances where the critical path underwent changes during the project's progression.

A loss of productivity, or disruption claim is in relation to labour and the costs thereof, bringing in to question the assumptions made by the Contractor when tendering. However, Owners must be aware that if they have provided information which the Contractor has relied upon in assessing the productivity that they believe they will achieve, and that information proves to be incorrect, then the Contractor may have valid claims, even if the Contract seeks to preclude such claims.

It is essential therefore for a Contractor to implement adequate site controls to enable presentation of delay and disruption claims in a timely manner to accurately assess the impact and to document claims adequately.



# DELAYS - TYPES OF CLAIMS

## NOTES:

Definition of a Delay Claim for – Disruption, Acceleration or Loss of Productivity

In construction claims, a delay can be two things. It can be the time during which some part of the construction project has been extended beyond what was originally planned due to an unanticipated circumstance.

A delay can also be the incident that affects the performance of a particular activity, without affecting project completion.

An incident of delay can originate from within the contractors organization or from any of the other factors interacting upon the construction project.

Incidences of delay from within the contractor's organization are essentially those occurrences that the contractor itself has caused. Incidences outside of the contractors organization may be caused by the owner, the designer, other prime contractors, subcontractors, suppliers, labour unions, nature, or any number of other organizations and entities that participate in the construction process.



# DELAYS - TYPES OF CLAIMS

## NOTES:

### **Project Impacts**

In order to understand and assess productivity and disruption, it is important to

understand some of the basic terms and logic that the industry uses when describing

such events.

Foreseen events - those within the Contractor's control, such as their resource levels or material procurement program, or may not be within their control but imposed upon them by the Contract conditions such as inclement weather.

Unforeseen events - Owner changes, ground conditions, industrial action, changes to legislation, safety issues, acts of god and the such like.

Impact claim - is defined as any claim relating to lost productivity, disruption, acceleration or delay.

Acceleration - is a means of mitigating a delay in a construction program by allocating more resources to a project so that critical activities are performed in less time. Acceleration may also be as a result of a Contractor planning to complete a project earlier than the allotted time. As a consequence, acceleration should be viewed as the alternative to delay, giving both the Owner and the Contractor the option to accept delay, possibly with costs, or acceleration, most likely with costs.

Float - Contingency in programmed duration, which is either built in to the programmed duration, or identified within the programme of works.



# DELAYS - TYPES OF CLAIMS

## NOTES:

Disruption - material alteration, unanticipated by the Contractor, of the performance conditions expected of the Contractor at the time of bidding.' However, a prudent Contractor, bidding in a commercially realistic environment, would allow for some disruption to the progress of his/her works.

When disruption occurs, the Contractor is unable to proceed with work at the rate that he/she had planned and thus incurs inefficiencies and therefore costs.

This definition of disruption encompasses interference, where the Contractor is prevented from proceeding as planned due to the actions of other project parties (e.g. variations ordered by the Principal) and interruption, where the Contractor is forced to temporarily stop working (e.g. industrial action).

Loss of Productivity - may occur as a result of acceleration or disruption of a Contractor's workforce, thus resulting in extra costs. Productivity losses occur due to the "Principle of Reduced Productivity", described below.

Activity dependent delay - If a delay occurs on the critical path of a project, then by definition, it will extend the date of completion unless mitigated. This would be termed an activity dependent delay.

However, the progress will also be resource dependent, and hence a delay may not appear to delay the end date as there could be float, however, if the resources are critical in say a particular trade, that may delay the end date.

# DELAYS & CLAIMS

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# DELAYS - TYPES OF CLAIMS

## NOTES:

### **Reduced Productivity**

A Contractor plans to allocate resources and time activities in the most efficient and cost-effective manner possible, so therefore, any deviation from his/her planned program may incur lost productivity and therefore additional costs.

### **The Extension of Time or "Pure Delay" Claim**

If a Contractor has experienced a delay on the critical path of the works, that is not of his or her doing he/she would normally be entitled to a corresponding extension of time to fulfil his/her contractual requirements (an "excusable delay"). Dependent upon the conditions of the contract that the Contractor may have entered into, this delay may not need to be on the critical path of the works.

The Contractor will however have to address issues of concurrency of delay when making the claim.

### **The Delay Cost Claim**

If a Contractor is entitled to an extension of time to completion of their works, then in certain circumstances it follows that the Contractor will also be entitled to the costs incurred as a direct result of that delay.

### **The Direct Acceleration Cost Claim**

If a Contractor accelerates his/her work and the acceleration is compensable, there are direct costs associated with the acceleration that it may be able to claim.

# DELAYS & CLAIMS

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# DELAYS - TYPES OF CLAIMS

## NOTES:

### **The Loss of Productivity Claim**

The costs of loss of productivity may arise from acceleration or disruption. In the case of acceleration, this claim may be regarded as an indirect acceleration cost claim. Whether the costs are compensable will depend on the contract or the common law entitlement.

### Presentation of Project Programme or Schedule

The standard tool used for the planning and control of progress is the Critical Path Method (CPM) of scheduling activities.

In order to assess the impact of delaying and/or disrupting events on the progress of a project it has become accepted practice that CPM scheduling forms the basis of such assessment.

Any schedule errors, scope omission or missing logic needs to be corrected before proper assessment of delays can commence.

It is now the general view in America in that the Project owns the float.

In my view, this will only encourage Contractors to produce programs of many critical or near critical paths to remove float entirely.

The difficulties in determining criticality will almost certainly be exacerbated if the Contractor's construction program is unsatisfactory. For example, on one large project with several possible critical paths, the Contractor's program may contain the following problems:

- un-resourced schedule
- inconsistent updating
- dubious constrained Milestones
- Critical Path that doesn't seem logical or make sense
- programmes of works that have been updated retrospectively rather than proactively, thus the programme of works becomes a tracking documents of how the works were built, rather than demonstrating how the remainder of the works are to be undertaken, and to where the critical path of the project is affected.

# DELAYS & CLAIMS

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# DELAYS - TYPES OF CLAIMS

## NOTES:

### **Concurrency of Delay**

"Concurrent delays" is the term given to the situation where a Contractor is delayed by a delay of the Owner or his agents "an excusable delay" which may entitle the Contract to an extension of time and is also delayed by an event which is within his control and would not on its own be grounds for an extension of time (a "non-excusable delay").

The question in this situation is whether the Contractor is entitled to an extension of time and costs of that delay or simply an extension of time.

# DELAYS STRATEGIES FOR RECOVERY

## NOTES:

### **Strategies for recovery/acceleration**

Common techniques that schedulers and management teams use to recover schedule variances and, in general, accelerate a schedule. Schedule recovery is a managerial effort to recover from the interruption of events on the planned schedule.

Acceleration refers to a reduction in the duration of the overall schedule. The focus for schedule recovery or acceleration should be on critical activities and, in particular, on long-duration critical activities.

Because critical activities drive key milestone dates, the overall schedule duration will be reduced only by reducing the critical paths. Some of the strategies described below may have contractual implications.

# DELAYS & CLAIMS

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# DELAYS STRATEGIES FOR RECOVERY

## NOTES:

Technique	Description	Impact
<b>Fast-tracking</b>	Reduce the sequential dependencies between activities to partial dependencies. For example, F-S logic is changed to S-S logic to force parallel work.	Resources may become overallocated; quality may also be reduced and risk introduced if activities ideally executed in sequence are now executed in parallel.
<b>Crashing</b>	Add resources to time-dependent activities to complete work faster.	Requires additional resources and thus increases costs; may also reduce quality if activities are executed faster and with less-experienced labour & sufficient supervision.
<b>Split long activities</b>	Split long activities into shorter activities that can be worked in parallel	Resources may become overallocated, or unavailable.
<b>Review constraint and lag assumptions</b>	Reassess assumptions related to forcing activities to begin on certain dates.	If the original date constraint or lag is justified, removing the constraint or lag may not be realistic.
<b>Review duration estimates</b>	Revisit duration estimates using progress records as actual effort is recorded.	
<b>Add overtime and reduce vacations</b>	Review non-working periods and assign overtime work. Add additional work shifts.	Costs will increase over standard labor rates; as overtime increases, morale decreases eventually affecting the quality of the product/project negatively.
<b>Reduce scope</b>	Decrease scope to reduce both duration and costs.	Scope is the primary reason for performing the work, and it may not be possible to delete some requirements.
<b>Schedule contingencies</b>	Allocate contingency to absorb delay in accordance with identified risk mitigation plans.	Using contingency too early in a project reduces the likelihood of the schedule's completing on time, particularly if the reason for a delay was a risk that was not previously identified and quantified. Contingency can be split an appropriately allocated to diffeent phases of the project/product ie Design/Procurement/Production.

*F-S: Finish to Start logic.*

*S-S: Start to Start logic*

# DELAYS & CLAIMS

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# DELAYS - CPM ANALYSIS

## NOTES:

### **CPM Based Analysis**

A number of methods of analysing the effect of delay on completion of the works have been developed utilising the CPM schedules that were prepared at the commencement of a project and during the project.

The most commonly used names for these methods are:

- As planned impacted (APIP)
- As built but for (ABBF)
- Windows analysis
- Snapshot analysis

# DELAYS & CLAIMS

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# DELAYS - CPM ANALYSIS

## NOTES:

### **As Planned Impacted Program (ASIP)**

The impacted as-planned analysis involves the insertion of delay events into a baseline or as-planned schedule to determine the hypothetical impact of such delay events.

This method involves modifying the baseline or as-planned schedule to include new activities and logic to represent delay events. The difference between the project completion date in the impacted as-planned schedule and the original as-planned schedule quantifies the delay.

This methodology is simple and does not require an as-built schedule. However, it is considered a hypothetical model as it does not rely on as-built data.



# DELAYS - CPM ANALYSIS

## NOTES:

The As-Built But For (ABBF)

The ABBF analysis is more difficult to perform than the APIP (above) due to difficulties CPM software have in respect of as-built dates as historical events fixed in time, and the need for being able to obtain accurate records of events.

It is therefore necessary to create a logic network that in fact calculates start and finish dates which are identical to historical start and finish dates.

The analytical steps that are necessary for this technique are as follows:

- Prepare a comprehensive list of all changes or unanticipated events that occurred during the programme and relate those changes and events to specific points in time.
- Prepare an accurate written description of each major change or event.
- Establish whether the change or unanticipated event is compensable and/or excusable.
- Document the contractual bases.
- Obtain hard copies and computerised disks if possible of the baseline programme and any subsequent revisions.
- Establish or confirm as-built dates for critical and near critical activities over the life of the works.
- Using the as-built dates up-date the last recorded "as planned" project to reflect the complete history through to completion.
- Identify differences between planned and actual critical path performance.
- Prepare a table which compares "as planned" and "as-built" start and finish dates as well as "as planned" and "as-built" lag durations for the activities.
- Determine the extent of the variations in calendar days for various options where an activity either takes longer to complete, is completed earlier, starts later or starts earlier than planned.
- Establish the cause or causes for each variance.
- Determine the responsibility for change or unanticipated events.
- Incorporate that information in the table noted at (IX) above.
- Create a discreet activity for each delay and incorporate it into the network logic.
- Adjust the duration of the delayed activity so that the combined duration of the imposed delay and the delayed activity equal the as-built duration of the delayed activity.



# DELAYS - CPM ANALYSIS

## NOTES:

Simulations can then be performed by setting to zero the duration of the events but for which the project would have been completed earlier in the case of:

Owner caused delays

Contractor caused delays

All delaying events, and Neutral delays.

The principal benefit of this method is that it produces a method by which an as-built programme can be compared against one which would have transpired had none of the events occurred for which time or money is claimed.

The drawbacks to this method are:

- The extraction of somewhat arbitrarily established delays from the as-built programme and the manipulation of that process can conceal the effects of a Contractor's delays however this can be discovered by running several "what if" scenarios;
- The critical path which contains delaying activities will be the primary critical path at completion of the works and this may not represent the critical path during the construction of the works

# DELAYS & CLAIMS

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# DELAYS - CPM ANALYSIS

## NOTES:

### Windows Analysis

The windows analysis is based not on the whole Contract period but particular windows in time and therefore looks at events which have affected progress within each window of a Contract sequentially.

In terms of the analysis within the window it can be carried out by any method that appears suitable such as the ABBF discussed above.

Within each window the programme update takes into account any delay inefficiencies which are at the Contractor's risk and any changes to logic or durations since the last update.

It is therefore appropriate to consider that the programme which closes each window represents the as-built programme at that time and also the as-planned programme for the next window.

There are ten basic steps of the Window Analysis method, they being:

- Locate the original baseline programme and all as-planned programmes and updates identifying the original Contract completion date and actual completion date.
- Determine the window time periods to be analysed.
- List the activities on the first as-planned programme which were programmed to start within the first window period.
- Using contemporaneous records identify the actual start and finish dates for the activities listed in step 3.
- Analyse the dates and determine the delay or advancement of each activity.
- Establish the cause or causes for each delay and determine from the project documentation the responsibility for each variance.
- Verify that the status of the programme at the end of the first window is the same as the opening status in the next window.
- Repeat stages 3 - 7 until all windows have been analysed.
- Calculate the delay to the entire project by adding the net delays and advancement for each window.
- Summarise the results of calculation and apportion responsibility.

The principal advantage of the window analysis is that because the window represents a limited period in time it will affect a few activities which renders the interpretation of the results of the analysis more convincing than they turn out to be when the analysis is based on hundreds of activities over the whole Contract period.

# DELAYS & CLAIMS

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# DELAYS - CPM ANALYSIS

## NOTES:

### Snapshot Analysis

This method is a programme analysis technique which is designed to identify and quantify impacts on the schedule through an analysis of the status of the project at the time critical events occurred.

The as-built history of the project including Contract changes and time impacts is established up to the event and the programme is recalculated. The as-planned or uncompleted portion of the programme is then used to forecast the outstanding work.

The impact of any delay causing event can then be assessed by comparing the newly established completion date to the previous as planned completion date.

The method of analysis is as follows:

- At the start of the analysis identify the as-planned network and gather relevant records and documents.
- Identify the first event that is -
  - excusable and compensable
  - excusable but non compensable.
  - neither compensable nor excusable.
- Identify the dates on which the events in (2) above occurred.
- Using progress data update and re-analyse the network and recalculate the critical path.
- Using the update network simulate the relevant event by adding in the particular delay activity and the difference between the forecast end-date and the finish date now calculated is the potential delay.

Once all activity delays have been quantified the origin and causes can then be researched and responsibility for each delay apportioned.

Sixteen categories of productivity loss, which essentially cover the same ground as the aforementioned eleven, were also identified and defined by the Mechanical Contractor's Association of America (MCAA), as follows:

- - Stacking of trades ie. Concurrency of workforce labour.
- - Poor Morale and attitude
- - Reassignment of manpower
- - Crew size inefficiency
- - Concurrent operations
- - Dilution of supervision
- - Learning curve
- - Errors and omissions
- - Beneficial occupancy
- - Joint occupancy
- - Site access
- - Logistics
- - Fatigue
- - Ripple
- - Overtime
- - Season and weather change



# DELAYS & CLAIMS

## QUIZ

**1. The primary purpose of delay analysis in construction projects is to:**

a/ Assign blame for project delays to specific parties.

b/ Identify the root causes and extent of schedule delays.

c/ Justify cost overruns associated with the project.

d/ Reduce communication between project stakeholders.

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**2. Common methods used in delay analysis include:**

a/ Expert opinion only.

b/ Time Impact Analysis (TIA) and Schedule Window Analysis.

c/ Solely relying on the contractor's daily logs/diaries/correspondence etc

d/ Focusing on the critical path activities only.

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# DELAYS

## QUIZ

### 3. A well-documented contemporaneous notice:

a/ Should be sent after a significant delay has already occurred.

b/ Is not required for submitting a delay claim.

c/ Provides a stronger foundation for a potential claim.

d/ Focuses solely on the financial impact of the delay.

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### 4. Excusable delays might include:

a/ Poor planning by the contractor.

b/ Unforeseeable weather conditions.

c/ Delays caused by subcontractors not under the contractor's control (with proper notice).

d/ Material delivery delays due to supplier issues the contractor could have anticipated.

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# DELAYS

## QUIZ

**5. The purpose of a delay claim is to:**

a/ Penalize other parties involved in the project.

b/ Recover costs incurred due to a compensable delay.

c/ Extend the project completion date automatically.

d/ Demonstrate the contractor's inefficiency in project execution

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**6. Explain the difference between a excusable delay and a non-excusable delay in a construction project.**

**7. Describe two key elements a contractor should include in a well-documented delay claim.**

**8. A construction project experiences a delay due to a labor strike impacting several key subcontractors. The strike was unforeseen and lasted for two weeks. The contractor believes this is an excusable delay and intends to submit a claim for additional costs incurred.**

**• What steps should the contractor take to strengthen their delay claim position**

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# DELAYS

## CORRECT ANSWERS

**1. The primary purpose of delay analysis in construction projects is to:**

**b/ Identify the root causes and extent of schedule delays.**

**2. Common methods used in delay analysis include:**

**b/ Time Impact Analysis (TIA) and Schedule Window Analysis.**

**3. A well-documented contemporaneous notice:**

**c/ Provides a stronger foundation for a potential claim.**

**4. Excusable delays might include:**

**b/ Unforeseeable weather conditions.**

**5. The purpose of a delay claim is to:**

**b/ Recover costs incurred due to a compensable delay.**

C H A P T E R

# 06

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## SCHEDULE RISK ANALYSIS INTRO

# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Intro to Schedule Risk Analysis**

Quantitative Schedule Risk Analysis (QSRA) is a sophisticated technique used in project management to understand and quantify the uncertainty associated with the schedule of a project.

SQRA is a highly specialised field that is far more than just learning how to 'drive' Risk software. Interpreting the outputs from the 'software' is where knowledge and understanding is essential and typically based on many years of experience.

Opportunity (positive aspect of uncertainty) or Risk (negative aspect of uncertainty) should be considered and evaluated.

During the Planning phase of the Project, it should be clearly established what the Projects schedule strategy is. I.e. what is the base case for the schedule:

is the base case reflecting aggressive but reasonably achievable performance?

Does the base case reflect historical data?

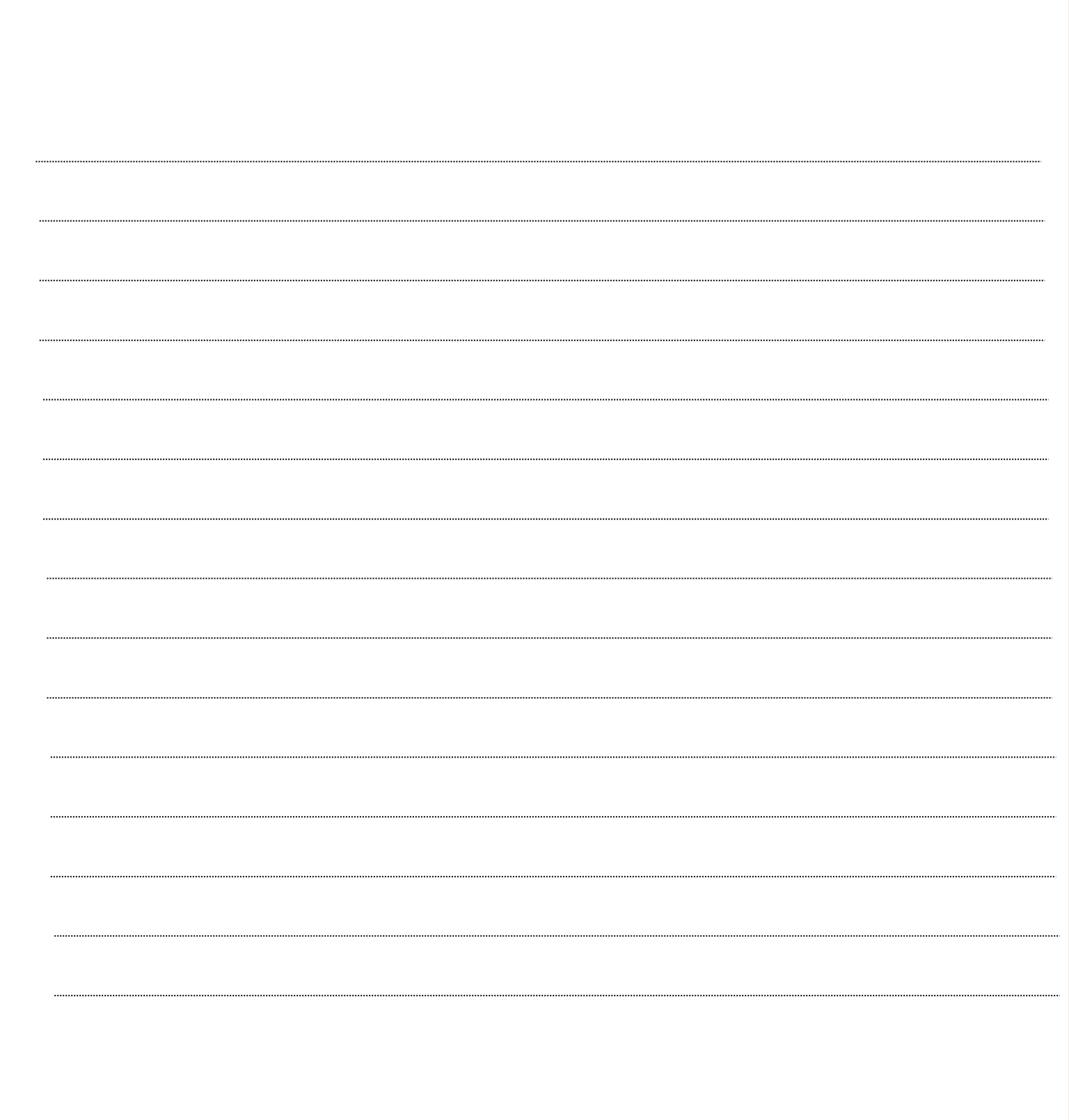
Explicit objectives are needed as the schedule contingency is assessed relative to the base case. If the base case is not known or understood, then it is challenging to effectively determine the contingency.

A historic norms strategy assumes average historical performance and is a strategy for mediocre performance at best.

SQRA goes beyond identifying potential risks by evaluating the probability and impact of these risks on the project's completion date.

QSRA helps project managers make informed decisions by providing a statistical probability of project completion dates and identifying the key risk factors that might affect the schedule. This analysis is crucial for complex projects where timing is critical, and delays could have significant financial or operational impacts.

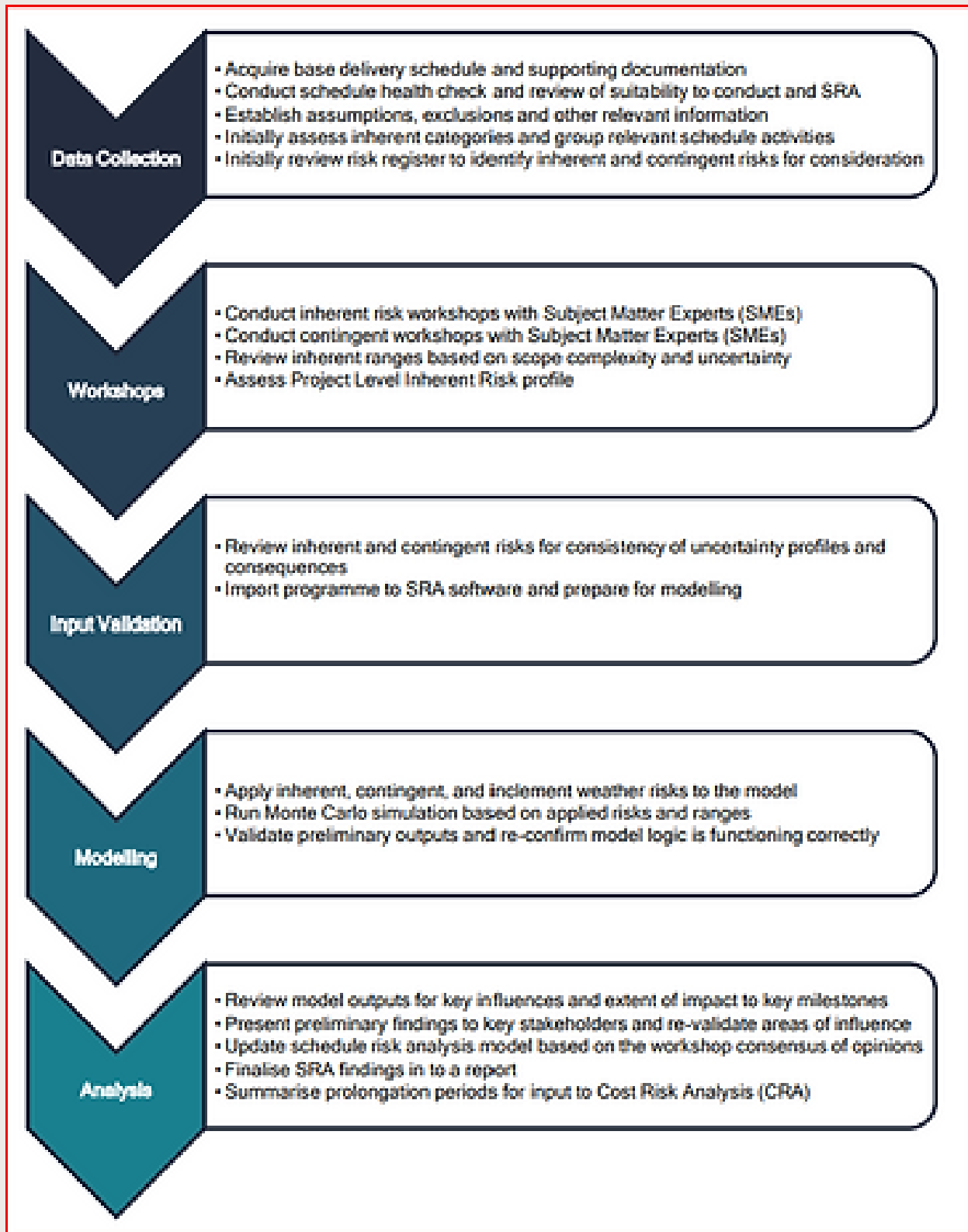
# SCHEDULE RISK ANALYSIS INTRO



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# SCHEDULE RISK ANALYSIS INTRO

## NOTES:





# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Process of QSRA**

The QSRA process typically involves the following steps:

**Risk Identification:** Identifying the risks that could potentially impact the project schedule. This step involves brainstorming sessions, expert interviews, historical data analysis, and review of project documents.

**Data Collection and Modelling:** Gathering data on the identified risks, including their probability of occurrence and potential impact on the project schedule. This data is then used to model the risks, often using a three-point estimate (optimistic, most likely, pessimistic) for task durations to account for uncertainty.

**Schedule Model Creation:** Developing a detailed project schedule model that incorporates all tasks, dependencies, and constraints. This model is usually created using project management software that supports schedule risk analysis, such as Primavera P6 or Microsoft Project.

**Integration of Risks into Schedule Model:** Integrating the risk data into the schedule model. This integration allows the simulation of how identified risks might affect the project timeline.

**Monte Carlo Simulation:** Performing a Monte Carlo simulation on the integrated schedule model. Monte Carlo simulation is a computational technique that uses repeated random sampling to obtain a statistical distribution of possible project completion dates. This simulation provides a range of possible outcomes based on the identified risks and their impacts, rather than a single deterministic completion date.

**Analysis of Results:** Analysing the results of the Monte Carlo simulation to understand the probability of meeting project milestones and the overall completion date. This analysis often includes identifying the "critical risks" or the risks that have the most significant impact on the project schedule.

**Risk Mitigation Planning:** Based on the analysis, developing risk mitigation strategies for the most critical risks. This step involves planning actions to either reduce the probability of these risks occurring or minimize their impact on the project schedule if they do occur.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Benefits of QSRA**

**Informed Decision Making:** Provides project managers with a statistical basis for making informed decisions regarding schedule contingencies and risk responses.

**Identification of Critical Risks:** Helps in pinpointing which risks have the most significant potential to impact the project schedule, allowing for targeted risk management efforts.

**Improved Stakeholder Confidence:** By quantifying schedule risks, QSRA can improve confidence among stakeholders in the project's timelines and risk management practices.

**Resource Optimization:** Identifies potential schedule delays, allowing project managers to optimize resource allocation and potentially reduce costs by focusing on mitigating critical risks.

### **Challenges**

**Complexity:** QSRA can be complex and requires a good understanding of statistical methods and risk modelling.

**Data Quality:** The accuracy of QSRA heavily depends on the quality and reliability of the risk data collected.

**Software Requirements:** Requires access to specialized project management software that can perform Monte Carlo simulations and handle complex project schedules.

In conclusion, Quantitative Schedule Risk Analysis is a powerful tool for managing and mitigating schedule risks in project management. It provides a more nuanced understanding of potential delays, enabling project managers to plan more effectively and increase the likelihood of project success.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **SRA Curve & Tornado Chart**

The SRA curve shows the probability of project completion over time. In this simplified example, the curve indicates that there's a 60% chance the project will be completed by the end of Month 6 (on time).

However, the probability of completion increases to 80% by the end of Month 7, 95% by the end of Month 8, and reaches 100% by the end of Month 9, illustrating a clear risk of delay.

This visualization helps stakeholders understand the likelihood of meeting the project's scheduled completion date and supports decision-making regarding risk mitigation and contingency planning.

### **Tornado Chart - Schedule Risk Impact**

The Tornado Chart visually represents the impact of various risks on the project's schedule, ranked from highest to lowest. In this scenario,

This chart is instrumental in prioritizing risk management efforts, focusing on mitigating the risks with the greatest potential impact on the project schedule.

Together, these visualizations provide a comprehensive view of the potential schedule risks a project faces, enabling more informed decision-making and effective risk management strategies.

# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### Definition of Schedule Risk Analysis

A schedule risk analysis uses statistical techniques to predict a level of confidence in meeting a program's completion date. This analysis focuses on uncertainty and key risks and how they affect the schedule's activity durations. Because each activity has an uncertain duration that depends in part on uncertainties about effort and resources, the entire duration of the overall program schedule is also uncertain. Therefore, unless a statistical simulation is run, calculating the completion date from schedule logic and duration estimates in the schedule tends to underestimate the overall program critical path duration.

Estimates of activity durations should be viewed as forecasts based on the best information available at the time. Assumptions regarding resource availability and productivity, required effort, and availability of materials, among other things, allow for the determination of the most likely activity durations.

However, there is inherent uncertainty about the most likely duration estimate that can cause activities to shorten or lengthen.

Activity duration estimates include inherent uncertainty, estimating error, and, perhaps, estimating bias. For instance, if a conservative assumption about labour productivity was used in calculating the duration of an activity and during the simulation, a better labour productivity is possible, then the activity will shorten, at least for that iteration.

However, schedule underestimation is more pronounced when the schedule durations or schedule logic include optimistic bias. Activity durations and logic in a CPM schedule may be overly optimistic if there is pressure from the customer or instruction from management to finish earlier than the unbiased duration estimates imply.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Schedule Uncertainty and Risk**

The terms risk and uncertainty are often used interchangeably, but they have distinct definitions in program risk analysis.

Uncertainty refers to a situation in which little to no information is known about the outcome. A risk is an uncertain event that could affect the program positively or negatively.

Stated another way, risk and its outcomes can be quantified in some definite way, while uncertainty cannot be defined because of ambiguity.

In a situation that includes unfavourable and favourable events, the probability is that an unfavourable event will occur (a threat or harm) or that a favourable event will occur (an opportunity or improvement).

Uncertainty and risk events may contain elements of both opportunity and threat. Schedule activity durations should account for both risk and uncertainty.

Risk and uncertainty in scheduling refer to the fact that because activity durations are forecasts, there is always a chance that actual activity durations—and therefore scheduled start dates and finish dates—will differ from the plan. There will always be some aspect of the unknowable, and there will never be enough data available in most situations to develop a known frequency distribution of possible durations.

Risk events that can be listed and defined should be included in a program's risk register in the form of threats and opportunities. Uncertainty arises because of the inherent variability in the actions of individuals and organizations working toward a plan. Uncertainty may also include estimating error and even systematic bias, such as when estimates are consistently optimistic. These events are often called "unknown unknowns." As the program progresses, some uncertainties may be revealed or elaborated on and defined in the risk register as a threat or an opportunity. Prudent organizations recognize that uncertainties and risks can become better defined as the program advances and conduct periodic re-evaluations of the risk register.

As we describe in the following sections, threats and opportunities, as well as general uncertainty, can be incorporated and quantified to some degree using schedule risk analysis.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Merge Bias and Schedule Underestimation**

One of the most important reasons for performing a schedule risk analysis is that the overall program schedule duration may well be greater than the sum of the path durations for lower-level activities.

This is so partly because of schedule uncertainty and schedule structure. A schedule's structure has many points where parallel paths merge that can cause the schedule to lengthen.

Merge points may include key program events such as preliminary design review, the beginning or ending of project phases, or product deliveries. The timing of these merge points is determined by the latest merging path.

Thus, if a required element is delayed, the merge event will also be delayed. Because any merging path can be risky, any merging path can determine the timing of the merge event.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Conducting a Schedule Risk Analysis**

Schedule risk analysis relies on statistical simulation to randomly vary the following:

- activity durations according to their probability distribution;
- threats and opportunities according to their probability and the distribution of

their effect on affected activities if they were to occur; and • the existence of a risk or probabilistic branch.

The objective of the simulation is to develop a probability distribution of possible completion dates that reflect the program plan (represented by the schedule) and its quantified uncertainties and risks.

From the cumulative probability distribution, the organization can match a date to its degree of risk tolerance. For instance, an organization might want to adopt a program completion date that provides a 70 percent probability that it will finish on or before that date, leaving a 30 percent probability that it will overrun, given the schedule and the risks as they are known and calibrated.

The organization can thus adopt a plan and promise completion on dates that are consistent with its preferred level of confidence in the overall integrated schedule. A schedule risk analysis can provide valuable information to senior decision makers.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Risk analysis should not be focused solely on the deterministic critical path—that is, the critical path as defined by the initial or current set of inputs in the schedule model.

Because the durations of activities are uncertain, with risk considered, any activity may potentially affect the program's completion date. Hence, the path that is most likely to determine the finish date is uncertain.

If the analysis is to be valid, the program must have a good schedule network that clearly identifies the work that is to be done and the relationships between detailed activities.

The schedule should be based on a minimum number of justified date constraints. It is important to represent all work in the schedule, because any activity can become critical under some circumstances.

Complete and correct schedule logic that addresses the logical relationships between predecessor and successor activities is also important. The analyst needs to be confident that the schedule will automatically calculate the correct dates and critical paths when the activity durations change, as they do thousands of times during a simulation.

If time or resources are insufficient to simulate the full program, or if detail in the future is unclear, perhaps because of rolling wave planning, the simulation can be performed with a summary version of the schedule. The summary schedule is a condensed form of the schedule that rolls detail activities into long-duration activities. By reducing the number of activities in the schedule, analysts reduce the time spent collecting data about and assigning risks and probability distributions to detail activities.

However, if a summary schedule is used for a schedule risk analysis, it is important that the schedule show enough detail to yield practical results. A summary schedule that is condensed too much will not convey the effort in very long activities, the activities that should have assigned risks, or how total float is distributed among key activities and milestones.

For example, activities in the summary version of the schedule should show critical hand-offs. If an activity is 4 months long but a critical hand-off is expected halfway through, the activity should be broken down into separate 2-month activities that logically link the hand-off between activities.

# SCHEDULE RISK ANALYSIS INTRO

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# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Finally, condensing the schedule may hide merging paths. As discussed in the previous section, merging paths are the source of much risk.

After the risk information is developed, the statistical simulation is run and the resulting cumulative distribution curve, the S curve, displays the probability associated with the range of program completion dates.

The results of risk analysis are best viewed as inputs to program management rather than as forecasts of how the program will be completed. The results indicate when the program is likely to finish without the program team's taking additional risk mitigation steps. The high-priority risks can be identified and used to guide further risk mitigation action.

A schedule risk analysis may show that a given schedule has more risk than is acceptable.

In this case, a review of the activities, dependencies, and network might help derive a shorter schedule. In some cases, the scope may need to be reduced. However, the initial estimates of effort and duration should not be changed without sufficient justification.

Changing durations simply because an earlier finish date is preferred is likely to increase the risk of delaying a project.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Collecting Anonymous and Unbiased Risk Data**

A schedule risk analysis requires the collection of program risk data. Risk data should be derived from a quantitative risk assessment and should not be based on arbitrary percentages or factors.

A risk assessment is a part of the program's overall risk management process in which risks are identified and analysed and the program's risk exposure is determined. As risks are identified, risk-handling plans are developed and incorporated into the program's cost estimate and schedule, as necessary.

Risk data can be collected in the form of three-point durations or by using the risk driver approach, to be described in the next section. The three-point estimates represent inherent uncertainty, estimating error, and perhaps estimating bias, while risk drivers represent identified risk events with probabilities as well as the likely effect if they occur.

Regardless of which type of risk analysis is performed, it is essential that subject matter experts (SME) be interviewed who are directly responsible for or involved in the workflow activities

Estimates derived from interviews should be formulated in a consensus of knowledgeable technical experts and should be coordinated with the same people who manage the program and its risk mitigation watch list.

Employees involved in the program from across the entire organization should be considered for interviewing. Lower-level employees have valuable information on day-to-day tasks in specific areas of the program, including their insight into how individual risks might affect their workflow responsibilities.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Managers and senior decision makers have insight into all or many areas of the program and can provide a sense of how risks might affect the program as a whole.

The starting point for the risk interviews is the program's existing risk register. Interviewees are asked to provide their opinion on threats and opportunities and should be encouraged to introduce additional risk events that are not on the risk register.

If unbiased data are to be collected, interviewees must be assured that their opinions on threats and opportunities will remain anonymous. They should also be guaranteed non attribution and should be provided with an environment in which they are free to brainstorm on worst and best case scenarios.

It is particularly important to interview SMEs without an authoritative figure in the room to avoid motivational bias.

Motivational bias is a source of bias that arises when interviewees feel threatened (whether justifiably or non-justifiably) if they give their true thoughts about a program.

This threat is typically from fear of being punished by someone in authority. Most commonly, interviewees are labelled trouble makers or are ostracized from the team if their worst case scenario is worse than management's opinion.

Risk workshops may exhibit social and institutional pressures to conform, perhaps to get consensus or to shorten the interview session. The organization may greatly discourage introducing a risk that has not been previously considered, particularly if the risk is sensitive or may negatively affect the program.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

If an interviewee is accompanied by someone, risk analysts cannot guarantee that the interviewee's responses are unbiased.

Once the distributions have been established, a statistical simulation (typically a Monte Carlo simulation) uses random numbers to select specific durations from each activity probability distribution, and a new critical path and dates are calculated, including major milestone and program completion dates.

The Monte Carlo simulation continues this random selection thousands of times, creating a new program duration estimate and critical path each time. The resulting frequency distribution displays the range of program completion dates along with the probabilities that activities will occur on these dates.

Three-point duration risk analyses, an acceptable method of conducting SRAs, are widely used. However, a disadvantage of using three-point duration ranges to represent all the risk in an analysis is that probability distributions for durations derived from risk interviews cannot be attributed to individual risk events.

Interviewees may be combining any number of threats and opportunities in their single best case and worst case estimates.

For example, a construction manager may suggest a worst-case scenario of 6 days to install drywall. However, the delay may be caused by lack of materials, poor labour productivity, poor weather, last-minute design changes, or some serial combination of all four risks. It is also possible that the SME has increased the pessimistic duration estimate to account for general uncertainty, in effect accounting for "unknown unknowns."

The result of the three-point duration SRA is a recommended amount of schedule contingency that covers both quantified risks and some level of uncertainty but gives no indication of which risks are most likely to affect the schedule.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Schedule Risk Analysis with Risk Drivers**

A second way to determine schedule activity duration uncertainty is to analyse the probability that risks from the risk register may occur and what their effect on schedule activities will be if they do occur.

With this approach, a probability distribution of the risk impact—expressed as a multiplicative factor—on the duration of activities in the schedule is estimated and the risks are assigned to specific activities in the schedule. If a risk does not occur in an iteration, then the scheduled duration does not change for that activity. In this way, activity duration risk is estimated indirectly by the root cause risks and their assignments to activities.

A risk can be assigned to multiple activities and the durations of some activities can be influenced by multiple risks. This risk driver approach focuses on risks and their contribution to time contingency as well as on risk mitigation. The risk driver method can be used to examine how various risks may affect the house construction schedule.

We can suspect that the biggest risk in the construction schedule involves design and that the plan may be too aggressive in assuming that the design will be completed early. Moreover, late or defective materials and changes by the owner are also likely to affect the schedule.

In addition to including discrete threats and opportunities, we can include risks that represent ambiguity about the future. The existence of these ambiguities is known (their likelihood is 100 percent) but their effects are unknown.

For example, we know that the productivity of labour will affect the duration of many activities, but whether the overall effect is positive (an opportunity) or negative (a threat) is unknown.

We can also include some element of general uncertainty. For example, we know that natural variability surrounds each of our duration estimates, so we include an uncertainty to represent a global estimating error.

By combining the two methods, three-point estimates may be used to represent bias and uncertainty, while risk drivers are used to represent identifiable risk events that may be mitigated.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Prioritising Risks**

No program can mitigate all risk and uncertainty. Some risks may be highly probable yet cause a relatively small delay to the finish date. Conversely, a risk may potentially delay the program a long time but be highly unlikely to ever occur. In addition, it is impossible to fully mitigate uncertainty because of its inherent ambiguity.

Therefore, regardless of the method used to examine schedule activity duration uncertainty, it is important to identify the risks that contribute most to the program schedule risk. These risks can then be targeted for mitigation strategies.

Sensitivity measures reflecting the correlation of the activities or the risks with the final schedule duration can be produced by most schedule risk software.

The duration sensitivity chart identifies activities and paths that tend to be associated with project risk.

Risk analysis should also identify the activities that most often ended up on the critical path during the simulation, so that near risk-critical path activities can be identified and closely monitored. Risk criticality represents the percentage of simulation iterations that an activity or milestone is on the critical path.

The activities most likely to be on the critical path may not be the most risky themselves. The activities may be critical because they are appearing on a path

whose criticality is driven by some risk affecting other activities.

Sensitivity indexes and correlation measures are useful starting points for assessing the possible magnitude of realized risks, but they have limited use in prioritizing risks.

Thus, while the chart is useful for indicating where risk is the greatest, it cannot be used to identify specific

risks for mitigation.

If the risk drivers method is used, the risks can be prioritized by their effect on the risk of finishing on time and their share of required contingency. If one risk at a time is removed and the Monte Carlo simulation is rerun, the contribution of each risk to the required contingency can be calculated at any percentile.

# SCHEDULE RISK ANALYSIS INTRO

A large white rectangular area containing 20 horizontal dotted lines, serving as a template for notes or a schedule risk analysis.

# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

The general process is to:

- Run the SRA using all risks and uncertainties. Record the finish date at the desired percentile—for example, 80 percent.
- Remove a risk and run the SRA again. Compare the 80th percentile date with the date of the full model. The difference in the two dates is the expected contribution (or days saved) of the removed risk.
- Replace the risk, remove the next risk, rerun to the SRA, and again compare the

80th percentile date to the date from the full SRA simulation and calculate the

difference in days.

Continue removing risks and uncertainties one by one; the risk with the highest contribution in days is the most important risk.

To identify the next most important risk, the most important risk identified above is removed from the model and the process is repeated

As the risks are removed and the next most important risks are identified, a prioritized list of risks and uncertainty can be created.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Correlation**

Other capabilities are possible once the schedule is viewed as a probabilistic statement of how the program might unfold. One that is notable is the correlation between activity durations.

Positive correlation is when two activity durations are both influenced by the same external force and can be expected to vary in the same direction within their own probability distributions in any consistent scenario.

Correlation might be positive and fairly strong if, for instance, the same assumption about the maturity of a technology is made to estimate the duration of design, fabrication, and testing activities or the contractor's productivity affecting multiple activities that have been bid.

If the technology maturity is not known with certainty, it would be consistent to assume that design, fabrication, and testing activities would all be longer or shorter together.

Likewise, if a particular trade is relatively unproductive in the house construction

example, we may expect all activities associated with that trade to be delayed to some degree.

Without specifying correlation between these activity durations in simulation, some iterations or scenarios would have some activities that are thought to be correlated go long and others short in their respective ranges during an iteration.

This would be inconsistent with the idea that they all react to the same assumptions about technology maturity or trade productivity.

Specifying correlations between related activities ensures that each iteration represents a scenario in which their durations are consistently long or short in their ranges together.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Because schedules tend to add durations (given their logical structure), if the durations are long together or short together, there is a chance that projects will be very long or very short.

Correlation affects the low and high values in the simulation results. This means that the high values are even higher with correlation and the low values are even lower, because correlated durations tend to reinforce one another down the schedule paths.

In practice, if the organization wants to focus on the 80th percentile, correlation matters; correlation does not matter as much around the mean duration from the simulation.

Figure 2 shows the effect of adding correlation between activity durations in the three point risk simulation for the house construction schedule. In this example, 90 percent correlation was added between activities that are related trades. While the 90 percent correlation is high (correlation is measured between  $-1.0$  and  $1.0$ ), there is often no actual data on correlation, so expert judgment is often used to set the correlation coefficients.

Assuming this degree of correlation, we get the result shown in figure 7. Notice that the correlation has widened the overall distribution. The 50th percentile is nearly the same in both cases, February 25 without correlation and February 24 with correlation. However, the 80th percentile increases by one workweek, from March 4 to March 9, when correlation is added.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

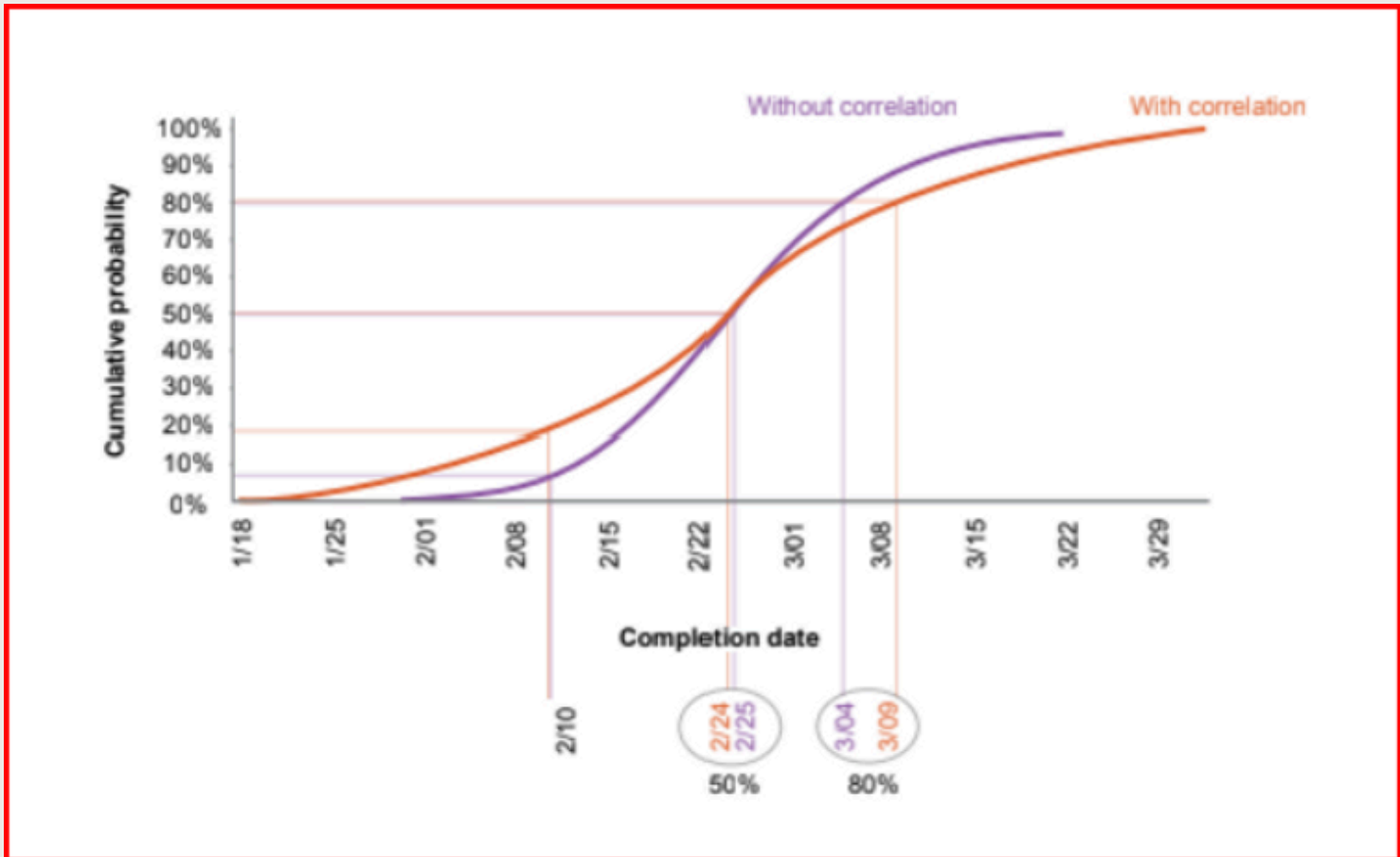


Figure 2

Using three-point estimates for activity durations requires estimating correlation coefficients, often in the absence of historical data. Inconsistent correlation matrices often result in this pairwise setting of correlation coefficients.

In the risk driver method, assigning a risk to multiple activities causes them to be correlated, because if the risk occurs on one assigned activity during the simulation, it occurs on all the assigned activities. If there are also some risks on one activity but not another, correlation will be less than 100 percent.

Modelling correlation with risk drivers avoids the difficult task of estimating a number of pairwise correlations.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

### **Schedule Contingency**

A baseline schedule includes margin or a reserve of extra time, referred to as schedule contingency, to account for known and quantified risks and uncertainty.

The contingency represents a gap in time between the finish date of the last activity (the planned date) and the finish milestone (the committed date).

When schedule contingency is depicted this way, a delay in the finish date of the predecessor activity results in a reduction of the contingency activity's duration. This reduction translates into the consumption of schedule contingency.

Schedule contingency should be calculated by performing a schedule risk analysis and comparing the schedule date with that of the simulation result at a desired level of certainty.

For example, an organization may want to adopt an 80 percent chance that its program will finish on time or earlier. The amount of contingency necessary would be the difference in time between the 80th percentile date from the cumulative distribution and the date of the deterministic finish date in the schedule.

For some programs, the 80th percentile is considered a conservative promise date. Other organizations may focus on another probability, such as the 65th or 55th percentile.

However, because schedule distributions tend to be right skewed (that is, the program has a greater tendency to finish late than early), the mean of the distribution tends to be larger than the 50 percent confidence level.

The 55th or 65th percentiles are not as certain as the 80th percentile and may expose the program to overruns if they are adopted. Factors such as project type, contract type, and technological maturity affect each organization's determination of its tolerance for schedule risk.

# SCHEDULE RISK ANALYSIS INTRO

## QUIZ

**1. What is the primary objective of Schedule Risk Analysis?**

a/ To minimize project costs.

b/ To identify and quantify potential delays in project activities.

c/ To develop a detailed communication plan for stakeholders.

d/ To assign resources efficiently for project tasks.

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**2. Monte Carlo Simulation is a popular tool used in SRA for:**

a/ Identifying critical path activities.

b/ Estimating project completion probability with different scenarios.

c/ Calculating project budget variance.

d/ Developing a risk mitigation plan.

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# SCHEDULE RISK ANALYSIS INTRO

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# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Schedule contingency or reserve is held by the program manager but can be allocated to contractors, subcontractors, partners, and others as necessary for their scope of work.

When contingency needs to be allocated, a formal change process should be followed.

Subjecting schedule contingency to the program's change control process ensures that variances can be tracked and monitored and that the use of contingency is transparent and traceable.

Schedule contingency may appear as a single activity just before the finish milestone or it may be dispersed throughout the schedule as multiple activities before key milestones or allocated to different phases of the project (Design, Procurement, Installation/Construction, Commissioning).

For example, it might be appropriate to plan a contingency activity before the start of a key integration activity that depends on several external inputs to ensure readiness to start. It is preferable that contingency be held as one activity just before the finish milestone for several reasons.

In general, apportioning contingency in advance to specific activities is not recommended because risks that will actually occur and the magnitude of their effects are not known in advance. In addition, dispersing contingency to specific key milestones may cause its consumption prematurely or superfluously.



# SCHEDULE RISK ANALYSIS INTRO

## NOTES:

Contingency that is dispersed throughout the schedule is less visible and may be harder to track and monitor. Dispersion may also encourage team members to work toward late dates rather than the expected early dates.

By aggregating contingency, everyone on the project will be working to protect the schedule contingency as a whole, not simply their own portions. Finally, if contingency activities are dispersed within the schedule network, care must be taken that the contingency activities do not affect total float and, therefore, critical path calculations.

Contingency activities should not become critical because no resources or scope are associated with them and they cannot practically delay a successor activity.

Regardless of whether contingency is captured at the end of the schedule or just before key milestones, representing it as activities will help ensure that the schedule is not hiding potential problems.

Contingency can also be quickly identified and zeroed out before schedule health measures are calculated or an SRA is conducted if it is represented as activities.

Finally, schedule contingency should not be represented as a lag between two activities. Lags have no descriptive name in schedules and the associated contingency may become lost within the network logic.

Notice that contingency is not the same as total float. Total float is the amount of time by which an activity can be delayed before it affects the finish milestone.

Total float is directly related to network logic and is calculated from early and late activity dates. Schedule contingency, in contrast, is determined by a schedule risk analysis.

A schedule risk analysis compares the schedule date with that of the simulation result at a desired level of certainty and is calculated by quantifying uncertainties and risks that may affect the finish date.



# SCHEDULE RISK ANALYSIS INTRO

## QUIZ

**3. Which of the following is NOT a common technique used in Schedule Risk Analysis?**

a/ Program Evaluation and Review Technique (PERT)

b/ Critical Path Method (CPM) - Used for deterministic scheduling, not risk analysis

c/ Sensitivity Analysis

d/ Expert Judgment

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**4. What is the difference between Schedule Risk Identification and Schedule Risk Assessment?**

a/ Identification focuses on potential delays, while assessment analyzes their likelihood and impact.

b/ Both terms are interchangeable.

c/ Identification prioritizes risks, while assessment focuses on causes.

d/ Identification uses qualitative methods, while assessment uses quantitative methods.

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# SCHEDULE RISK ANALYSIS INTRO

## QUIZ

**5. A project with a large buffer (float) in its critical path is generally considered:**

a/ More likely to experience cost overruns.

b/ Less susceptible to schedule delays.

c/ Requiring a more detailed risk management plan.

d/ Benefiting less from Schedule Risk Analysis.

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**6. A construction project has identified a potential risk of material delivery delays. This risk could potentially delay several critical path activities.**

• How would you approach this risk using Schedule Risk Analysis techniques?

• Briefly explain the steps involved in analyzing the impact of this risk on the project schedule.

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**7. Discuss the advantages and limitations of using Monte Carlo Simulation for Schedule Risk Analysis.**

# SCHEDULE RISK ANALYSIS INTRO

## CORRECT ANSWERS

1. What is the primary objective of Schedule Risk Analysis?

**b/ To identify and quantify potential delays in project activities.**

2. Monte Carlo Simulation is a popular tool used in SRA for:

**b/ Estimating project completion probability with different scenarios.**

3. Which of the following is NOT a common technique used in Schedule Risk Analysis?

**b/ Critical Path Method (CPM) - Used for deterministic scheduling, not risk analysis.**

4. What is the difference between Schedule Risk Identification and Schedule Risk Assessment?

**b/Both terms are interchangeable.**

5. A project with a large buffer (float) in its critical path is generally considered:

**b/ Less susceptible to schedule delays.**

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