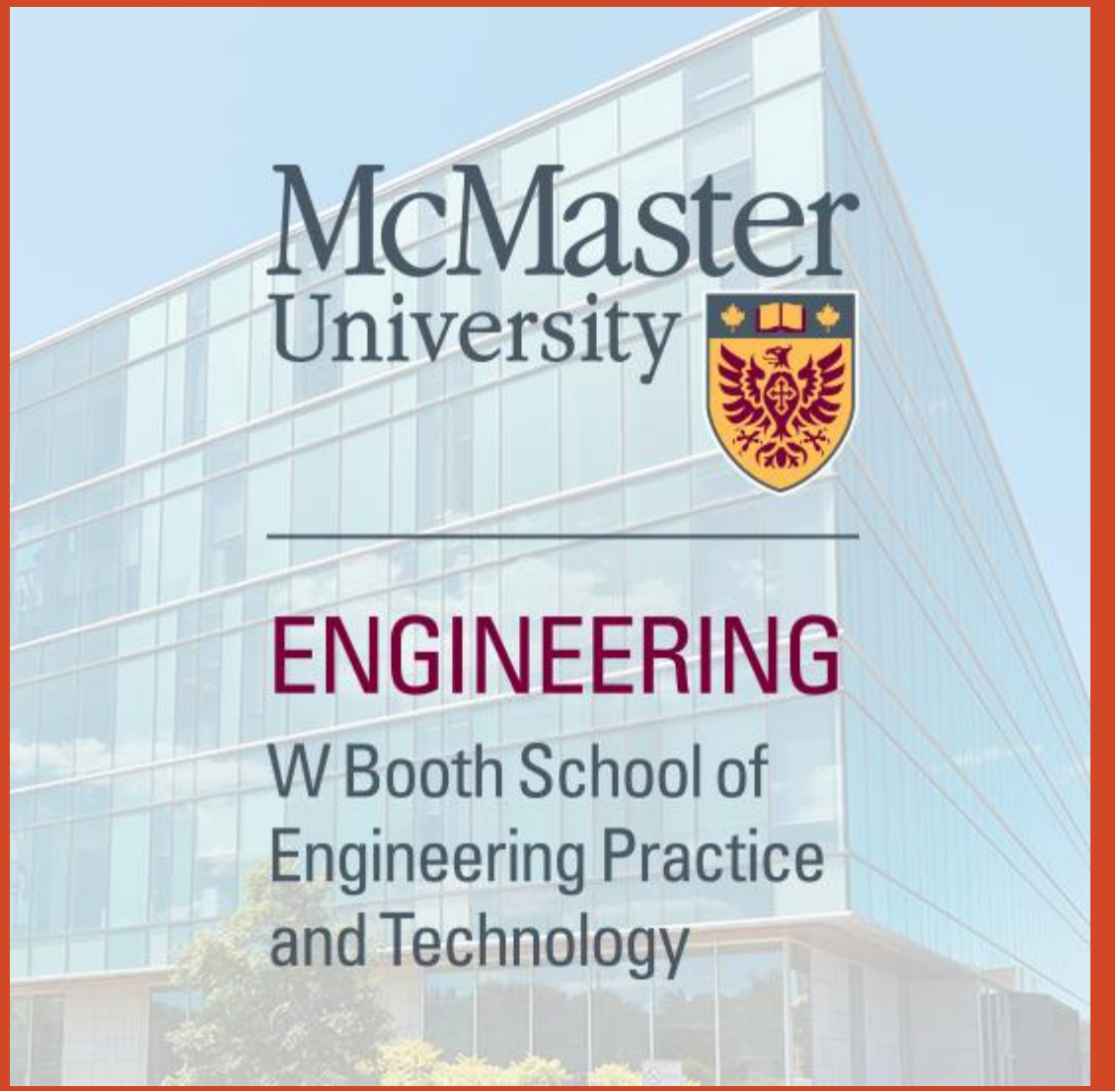
Practical Project Management for Today's Business Environment

Fall 2024

Week 5: Time, Cost and Quality



Dr. Mikhail Hanna, PhD, PMP, PMI-RMP

Learning Objectives

- Key points:
  - Learn how time, cost, and quality interact in project management.
  - Explore real-world tools to manage these constraints effectively.
  - Apply these concepts using case studies from various industries.

Agenda

- Introduction to the Triple Constraints
- Time Management Techniques
- Cost Management Techniques
- Quality Management Tools
- Case Studies and Real-Life Examples
- Group Exercise: Risk Register with Triple Constraints
- Q&A and Homework Assignment

Triple Constraints: Time, Cost and Quality Overview

- **Time**: The project schedule and the time allocated to complete each task.
- **Cost**: The financial resources required to complete the project.
- **Quality**: The degree to which the project meets its specifications and delivers value.
- **Interrelationship**: When you change one, you impact the others (e.g., reducing time may increase costs due to overtime labor).
- **Real-Life Example**: Heathrow Terminal 5: Tight schedules meant construction and testing phases overlapped, leading to delayed openings and increased costs to meet quality standards.

Time Management

Time Management: Importance in Project Success

- Time management is critical for staying on track with project deadlines.
- Tools like Critical Path Method (CPM) and Gantt Charts help keep tasks on schedule.
- Managing resources efficiently ensures that the project doesn't go beyond deadlines, which could lead to penalties or client dissatisfaction.
- Real-Life Example: Burj Khalifa Construction: Managed with a highly detailed time schedule using CPM and Gantt charts. Delays in certain supply chain elements extended the project's completion time but were carefully controlled to avoid escalating costs.

1.Design and Planning: Architecture, structural design, MEP (Mechanical, Electrical, Plumbing) design, etc.
2.Foundation Works: Excavation, piling, and other substructure activities.
3.Superstructure: Erecting the reinforced concrete and steel framework.
4.Facade Installation: Installing the iconic glass and aluminum curtain wall.
5.Interior Fit-out: Work on floors, walls, ceilings, HVAC systems, etc.
6.MEP Installation: Electrical systems, plumbing, and HVAC.
7.Testing and Commissioning: Verifying building systems.
8.Finishing and Landscaping: Final architectural detailing and external areas.

The Burj Khalifa project schedule would likely have been broken down into manageable work packages using a tool like a Gantt chart, with potentially 30,000+ detailed activities. These would have been tracked using project management tools to maintain the overall timeline.

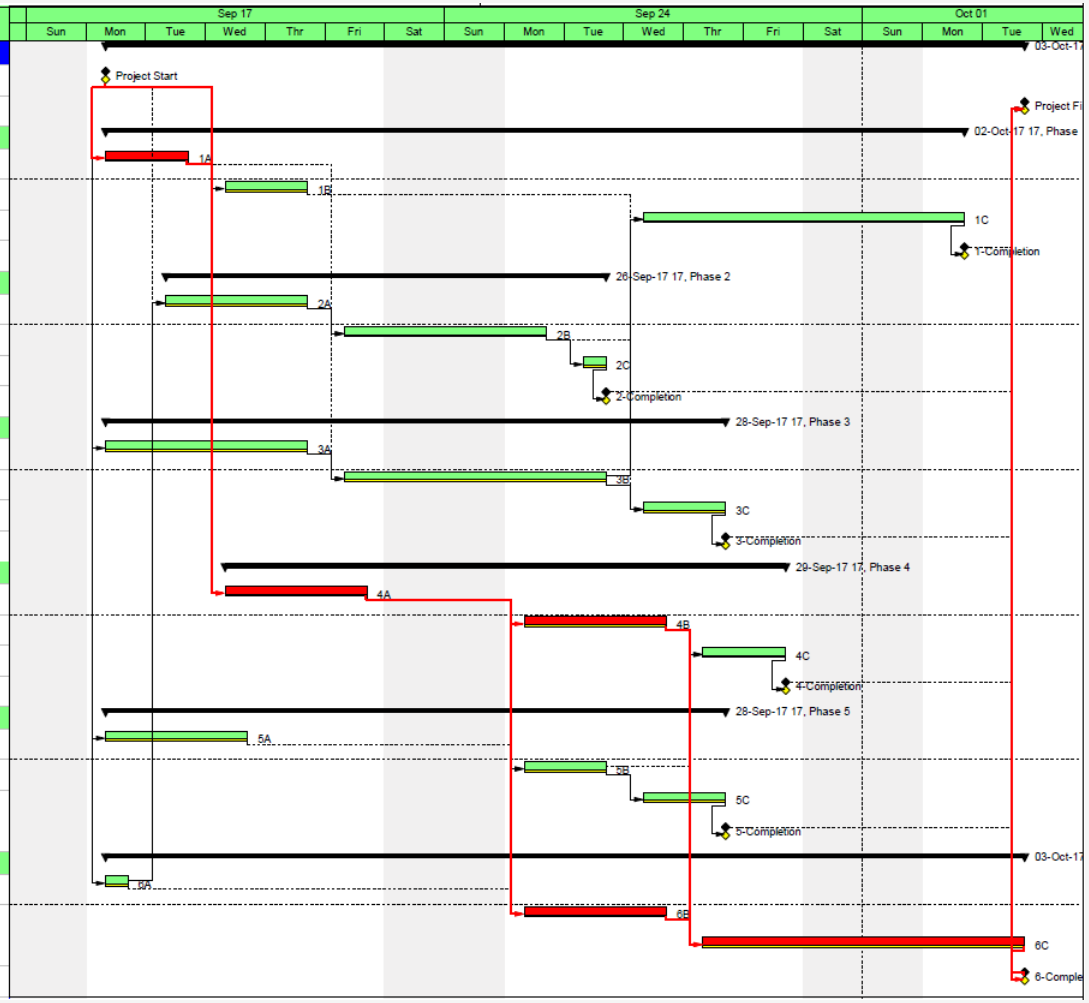
Time Management Tools: Gantt Charts

- **Gantt Charts**: A visual scheduling tool that breaks down a project into tasks, showing their start and end dates along a timeline.
- **Benefits**: Provides a clear picture of project timelines and potential bottlenecks.
- **How to create:** Break down each project phase into tasks, identify dependencies, and plot them on the chart.
- **Graphic**: A detailed Gantt chart showing tasks for an event planning project.
- **Real-Life Example:** London Crossrail Project: Used detailed Gantt charts to manage complex timelines across numerous contractors and project phases. Delays were visually captured and accounted for, showing direct impact on cost.

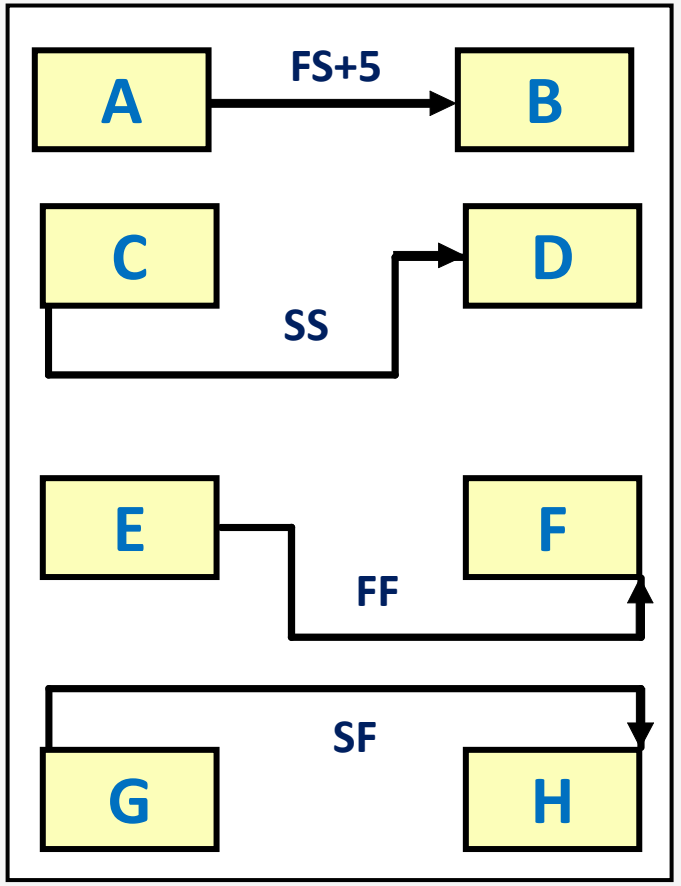
Time Management Tools: Critical Path Method

- **CPM**: A technique to identify the longest path of dependent tasks, which determines the project's duration.
- Tasks not on the critical path can have some flexibility (float) without delaying the project.
- Identifying the critical path helps prioritize resources and attention on the most time-sensitive tasks.

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float	Primary Constraint	Primary Constraint Date
MultiplePhaseExample.xml		12.00	18-Sep-17 08	03-Oct-17 17	0.00		
A1000	Project Start	0.00	18-Sep-17 08		0.00		
A1250	Project Finish	0.00		03-Oct-17 17	0.00		
Phase 1		11.00	18-Sep-17 0	02-Oct-17 17	1.00		
A1010	1A	2.00	18-Sep-17 08	19-Sep-17	0.00		
A1020	1B	2.00	20-Sep-17 08	21-Sep-17	4.00		
A1030	1C	4.00	27-Sep-17 08	02-Oct-17 17	1.00		
A1040	1-Completion	0.00		02-Oct-17 17	1.00		
Phase 2		6.00	19-Sep-17 0	26-Sep-17 1	5.00		
A1050	2A	3.00	19-Sep-17 08	21-Sep-17	4.00		
A1060	2B	2.00	22-Sep-17 08	25-Sep-17	4.00		
A1070	2C	1.00	26-Sep-17 08	26-Sep-17	5.00		
A1080	2-Completion	0.00		26-Sep-17	5.00		
Phase 3		9.00	18-Sep-17 0	28-Sep-17 1	3.00		
A1090	3A	4.00	18-Sep-17 08	21-Sep-17	1.00		
A1100	3B	3.00	22-Sep-17 08	26-Sep-17	1.00		
A1110	3C	2.00	27-Sep-17 08	28-Sep-17	3.00		
A1120	3-Completion	0.00		28-Sep-17	3.00		
Phase 4		8.00	20-Sep-17 0	29-Sep-17 1	2.00		
A1130	4A	3.00	20-Sep-17 08	22-Sep-17	0.00		
A1140	4B	3.00	25-Sep-17 08	27-Sep-17	0.00		
A1150	4C	2.00	28-Sep-17 08	29-Sep-17	2.00		
A1160	4-Completion	0.00		29-Sep-17	2.00		
Phase 5		9.00	18-Sep-17 0	28-Sep-17 1	3.00		
A1170	5A	3.00	18-Sep-17 08	20-Sep-17	5.00		
A1180	5B	2.00	25-Sep-17 08	26-Sep-17	3.00		
A1190	5C	2.00	27-Sep-17 08	28-Sep-17	3.00		
A1200	5-Completion	0.00		28-Sep-17	3.00		
Phase 6		12.00	18-Sep-17 0	03-Oct-17 17	0.00		
A1210	6A	1.00	18-Sep-17 08	18-Sep-17	4.00		
A1220	6B	3.00	25-Sep-17 08	27-Sep-17	0.00		
A1230	6C	4.00	28-Sep-17 08	03-Oct-17 17	0.00		
A1240	6-Completion	0.00		03-Oct-17 17	0.00		



Time Management Tools: Activity Relationships



A MUST FINISH BEFORE B STARTS
Place Embeds > Pour Concrete

C MUST START BEFORE D CAN START
Formwork and Rebar

E MUST FINISH BEFORE F CAN FINISH
Wiring and HVAC

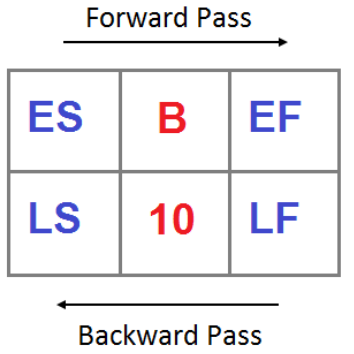
G MUST START BEFORE H CAN FINISH
e.g., keep legacy system online while new system is trialed

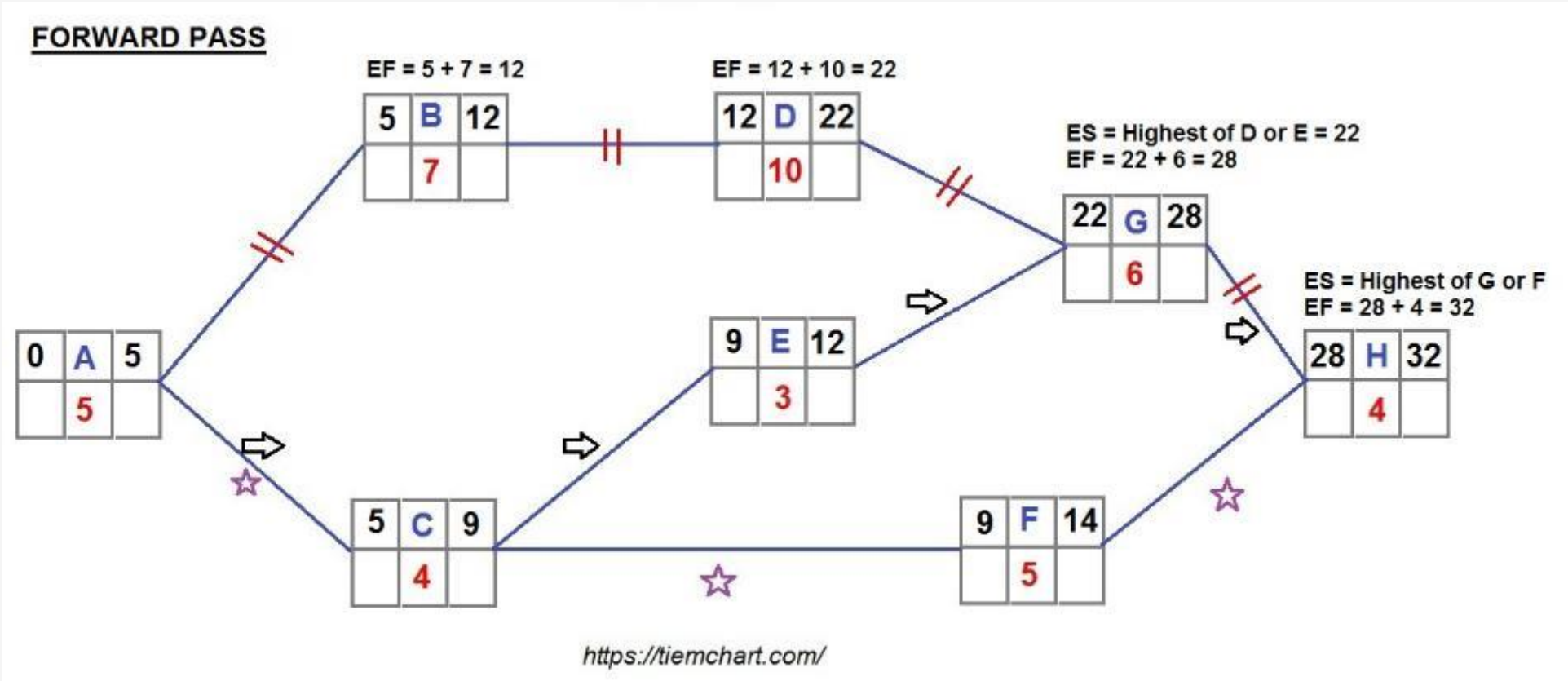
CPM Algorithm

- **Forward pass:**
  - Determines Early Start and Finish of activities.
  - All preceding activities must finish before a successor, early start of a given node is the maximum of early finishes of preceding nodes.
  - As a practical example, the forward pass determines the shortest time to complete a sequence of tasks.
  - Start from the first activity: $ES_1 = 0$ and $EF_1 = ES_1 + D_1$.
  - Work from left to right
  - For succeeding activities:
    - $ES_j = \max_i EF_i$
    - $EF_j = ES_j + D_j$
- The total project duration is the EF of the last activity.

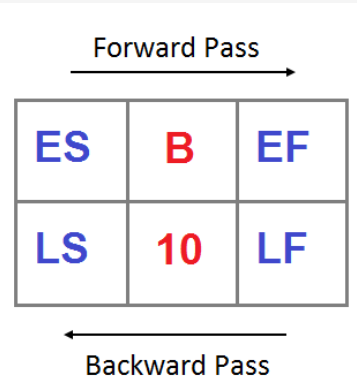
- **Backward pass:**
  - Determines Late Start and Finish dates.
  - Preceding activity must finish before any following activity, late finish of a given activity is minimum of late starts of successors.
  - In practice, given the final completion time of a sequence of tasks, the backward pass allows calculating the latest point in time the sequence has to be initiated.
  - Start from the last activity $LF_n = EF_n$ and $LS_n = LF_n - D_n$.
  - For preceding activities:
    - $LFi = \min_j LSj$
    - $LSi = LF_i - D_i$
- The total project duration is the EF of the last activity.

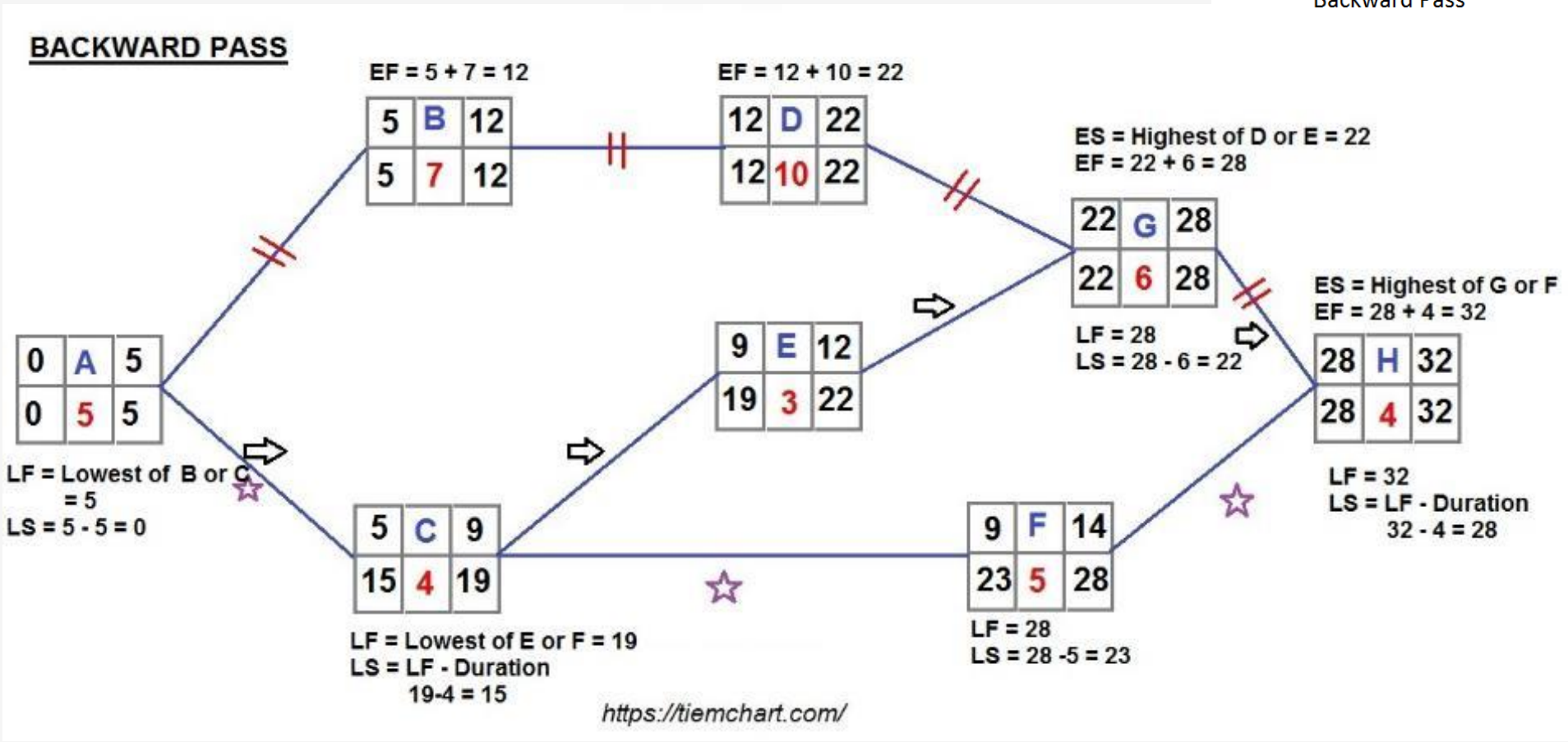
CPM Scheduling - Example





CPM Scheduling - Example





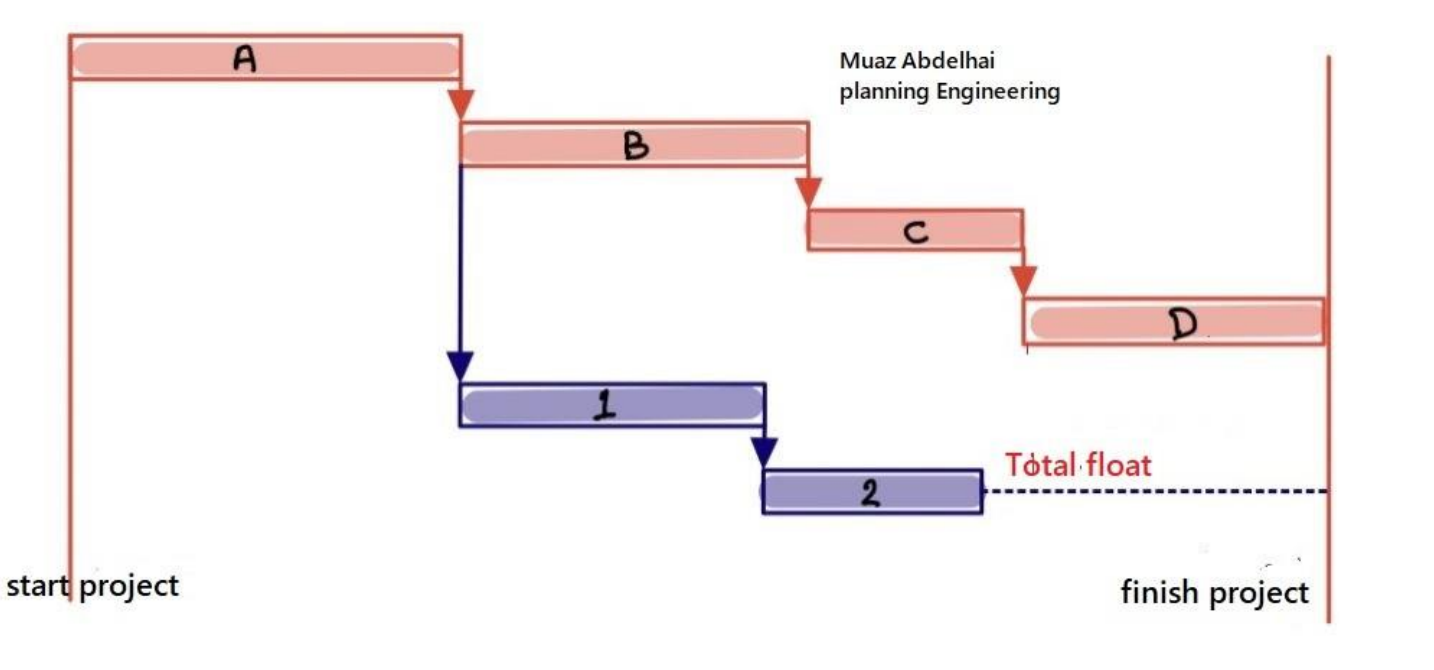
CPM Algorithm

- **Forward pass:**
  - Determines Early Start and Finish of activities.
  - All preceding activities must finish before a successor, early start of a given node is the maximum of early finishes of preceding nodes.
  - As a practical example, the forward pass determines the shortest time to complete a sequence of tasks.
  - Start from the first activity: $ES1 = 0$ and $EF1 = ES1 + D1$.
  - Work from left to right
  - For succeeding activities:
    - $ESj = \max_{\top i} EFi$
    - $EFj = ES\_j + D\_j$
  - The total project duration is the EF of the last activity.

- **Backward pass:**
  - Determines Late Start and Finish dates.
  - Preceding activity must finish before any following activity, late finish of a given activity is minimum of late starts of successors.
  - In practice, given the final completion time of a sequence of tasks, the backward pass allows calculating the latest point in time the sequence has to be initiated.
  - Start from the last activity: $LF\_n = EF\_n$ and $LS\_n = LF\_n - D\_n$.
  - For preceding activities:
    - $LFi = \min_{\top j} LSj$
    - $LSi = LF\_i - D\_i$
  - The total project duration is the EF of the last activity.

Time Management: Total Float

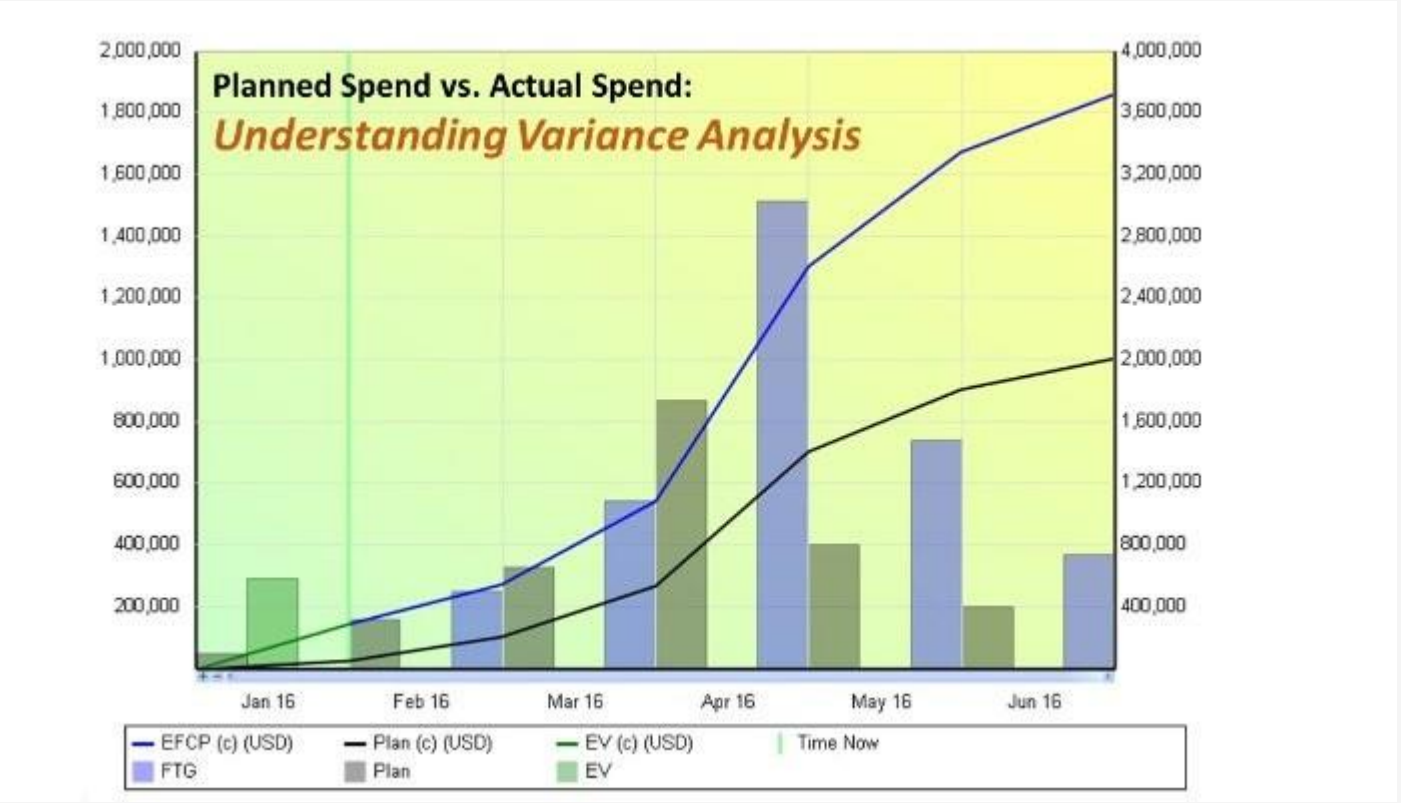
- Total float is what we are aware of and is commonly referred to as a float.
- TF defines the amount of time that an activity can be delayed without delaying the project completion date. On a critical path, the total float is zero.
- Total float is often known as the slack.
- You can calculate the total float by:
  - $ES_{ij} - LS_{ij}$
  - $EF_{ij} - LF_{ij}$



Cost Management

Cost Management: Keeping Projects on Budget

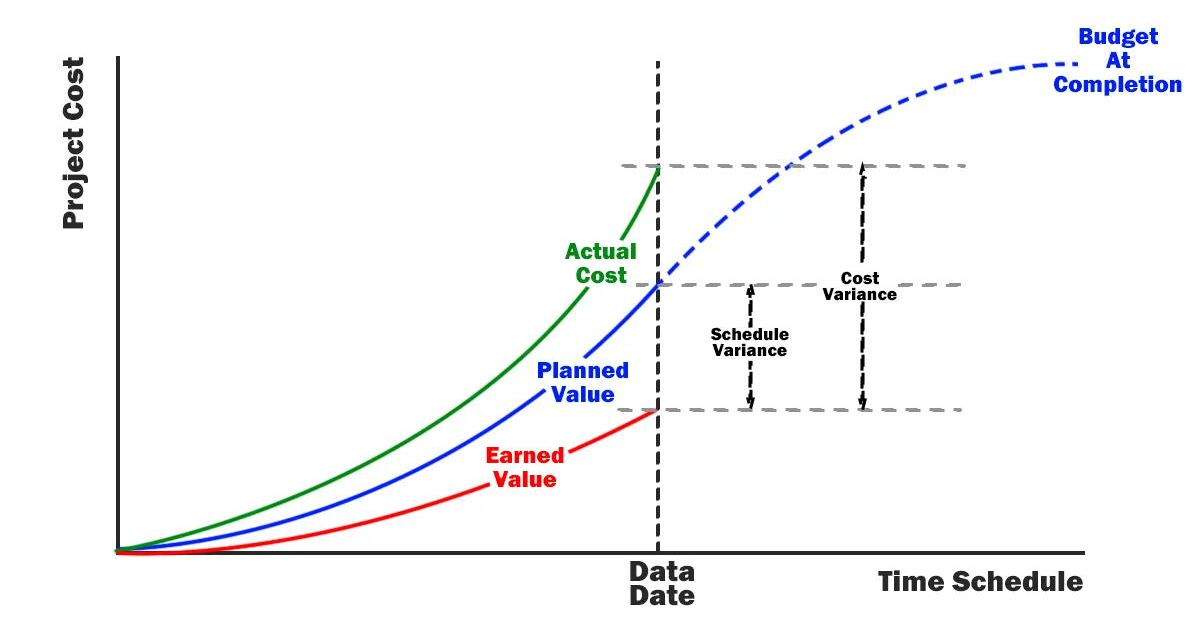
- Effective cost management is crucial for ensuring that projects remain financially viable.
- **Cost Estimation**: Techniques include Bottom-Up (starting with detailed estimates for individual tasks) and Top-Down (high-level estimation based on previous projects).Budgeting: Once estimates are approved, they form the project's budget.
- **Cost Control**: Monitoring expenditures and implementing corrective measures when costs exceed forecasts.
- **Real-Life Example**: Sydney Opera House: Originally budgeted at AUD 7 million, the final cost exceeded AUD 100 million due to a lack of detailed cost estimation and poor cost control throughout the project.



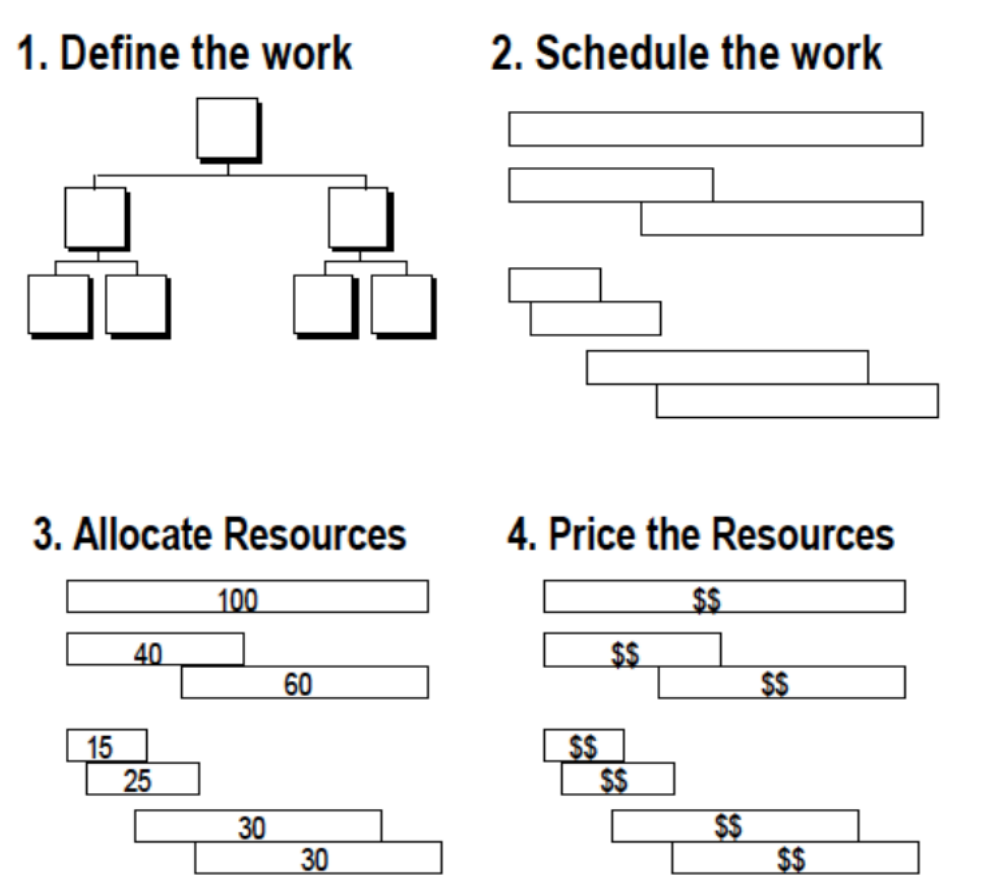
Cost Management Tools: Earned Value Management (EVM)

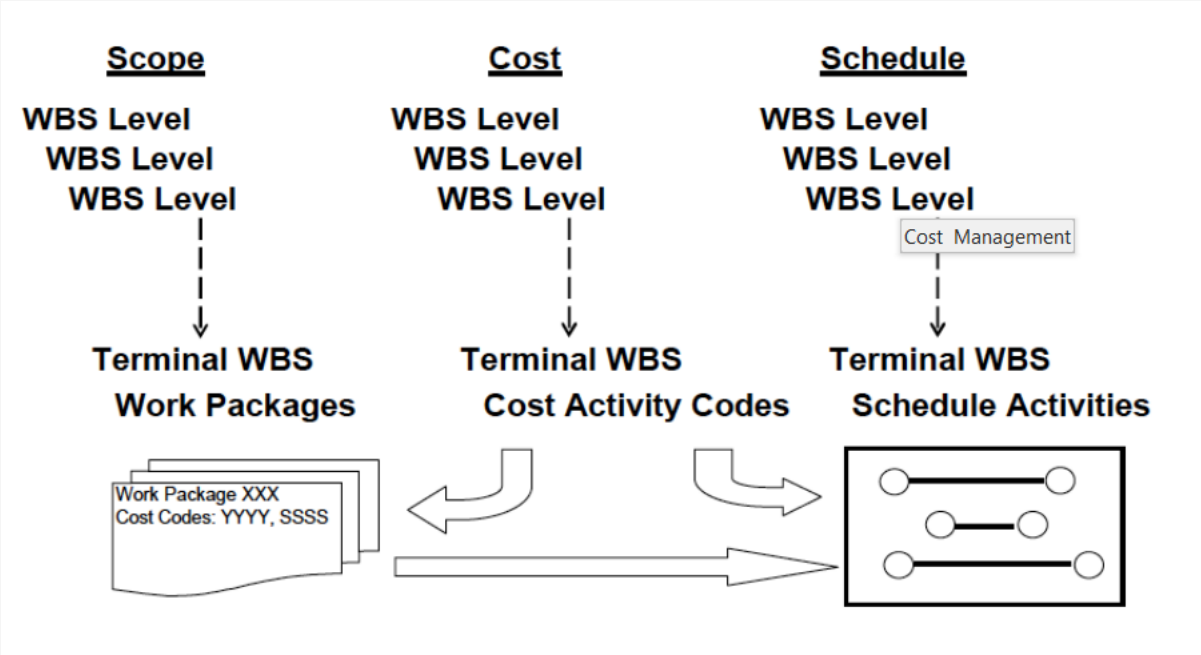
- EVM is a technique that integrates scope, schedule, and cost to provide a more accurate picture of project performance.
- Key Metrics:
  - **Planned Value (PV):** Budgeted cost for the work scheduled.
  - **Actual Cost (AC):** Actual expenditure incurred.
  - **Earned Value (EV):** Value of the work actually completed.
  - **Cost Performance Index (CPI)** and **Schedule Performance Index (SPI)** are used to forecast the project's cost and schedule efficiency.

Real-Life Example: Big Dig (Boston): EVM was used to monitor performance, but even with monitoring, the project faced immense cost overruns due to unforeseen geological challenges



Cost Management Tools: Pre-Planning for EVM





Method of Capturing Performance

Discrete Effort (4 Possible Techniques)

- Measured based on defined tasks or activities identified as work and planning packages resulting in a particular product or service.

Apportioned Effort

- A task interdependent to an appropriate Discrete Effort work or a planned package and is measured as part of that task that supports the results in a product or service.

Level of Effort

- [work] of a general or supportive nature which does not produce definite end products and cannot be practically measured by discrete earned value techniques.

Earned Value Measurement Method		Characteristic
Discrete Effort or Measurable Effort	**Fixed Formula** Percent Start/Percent Finish	50/50, 25/75, etc. Part of work is credited for EV as soon as it starts, the rest, when the work is completed.
		0/100 Method credits EV only for completed work.
	Percent-Complete	Work progress is (subjective) estimated as a percent complete of the BAC at each measurement point.
	Weighted Milestones	Work package has one or more milestone with an objective, verifiable accomplishment with it.
	Weighted Milestones with Percent-Complete	(see above) The accomplishment between the milestones is estimated
	Units Completed Physical Measurement	PV and EV are directly related to measurable or quantifiable production results.
Apportioned Effort		Work progress has a direct intrinsic performance relationship to another discrete Work Package (the measurement base).
Level of Effort		The EV is always equal the PV at the end of each reporting period. There is never a schedule variance.

Metrics and Performance Measurement

CV	Cost Variance How far over or under budget am I?	CV = EV – AC (-) = over (+) = under
CV%	Cost Variance % How far over or under budget expressed as a %	CV% = (CV) / (EV) (-%) = over (+%) = under
SV	Schedule Variance How far ahead or behind schedule am I?	SV = EV – PV (-) = behind (+) = ahead
SV%	Schedule Variance % How far ahead or behind schedule expressed as a %	SV% = (SV) / (PV) (-%) = behind (+%) = ahead
VAC	Variance At Completion Variance of total actual cost and expected cost	VAC = BAC – EAC

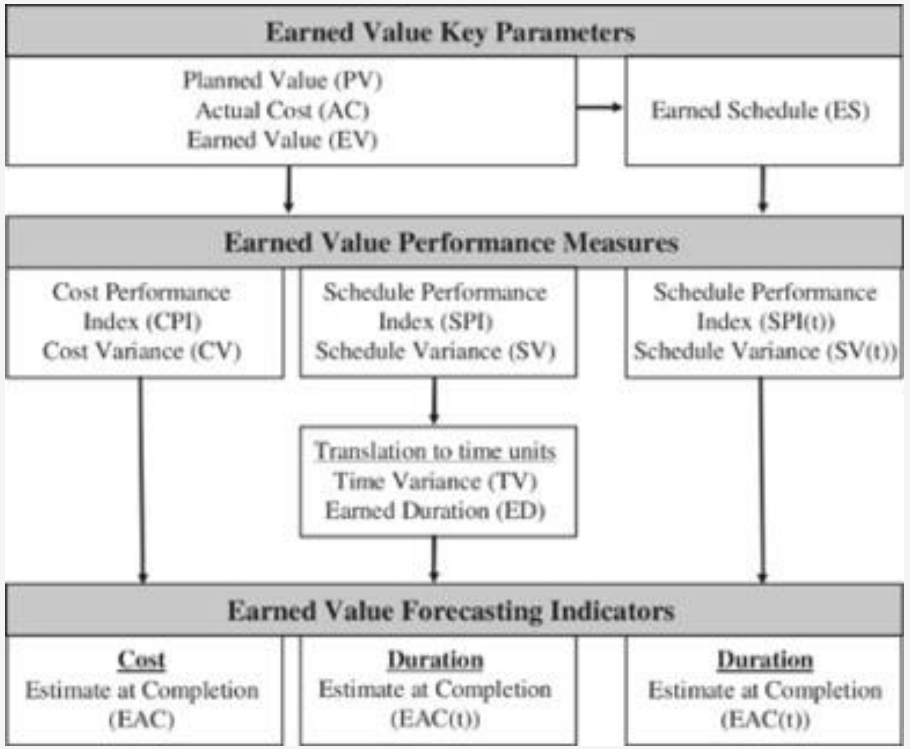
Earned Value (EV):

This figure tells you how much your project earned. Every hour that each team member works adds value to the project.

You can figure it out by taking the percentage of the hours that the team has worked and multiplying it by the BAC.

If the total cost of the project is $200,000, then the Earned Value is $200,000 × 35% = $70,000.

Metrics and Performance Measurement

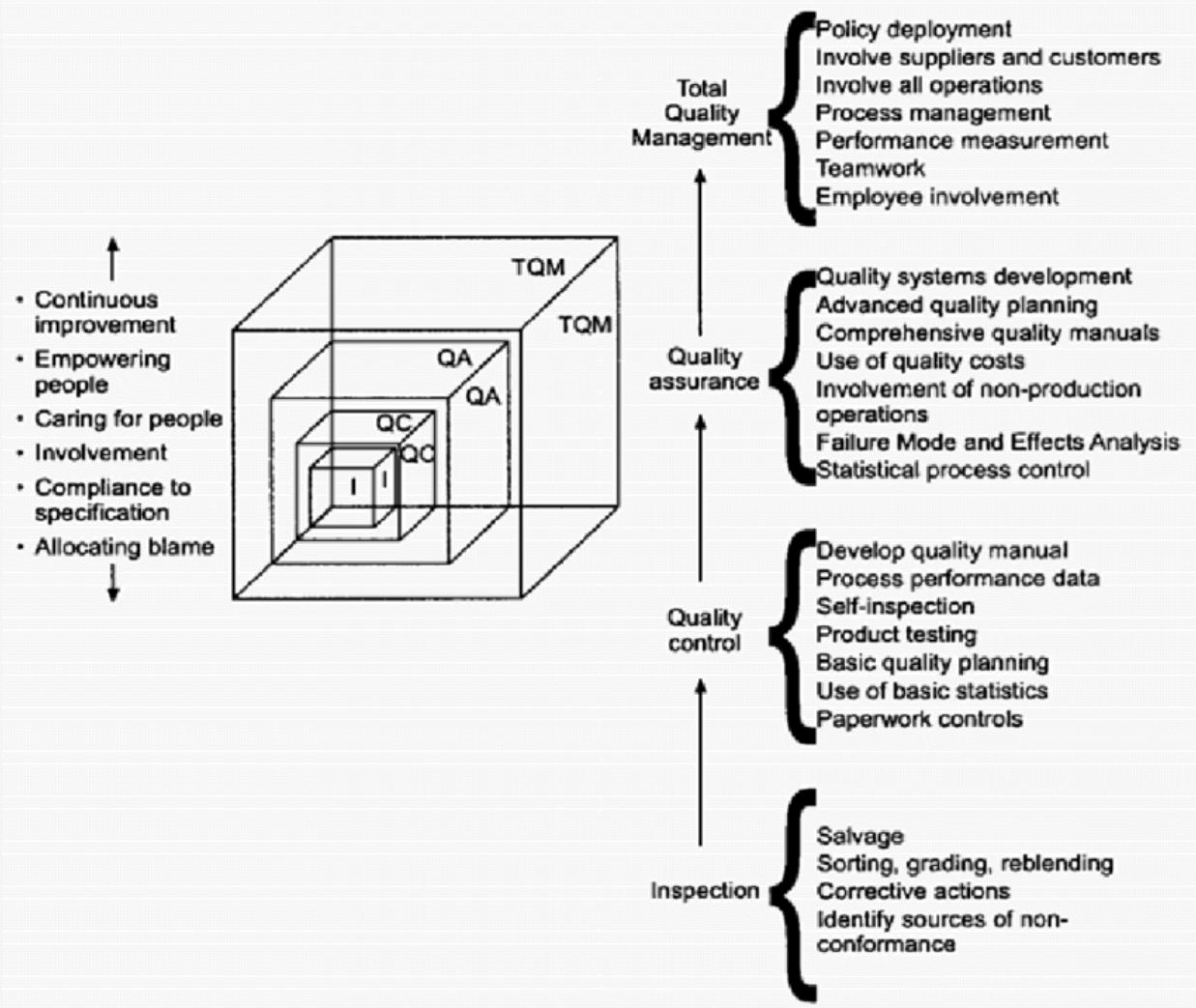


Name	Formula	What it says	Why you use it
BAC—Budget at Completion	No formula – it's the project budget	How much money you'll spend on the project	To tell the sponsor the total amount of value that he's getting for the project
PV—Planned Value	$PV = BAC \times$ Planned % Complete	What your schedule says you should have spent	To figure out what value your plan says you should have delivered so far
EV—Earned Value	$EV = BAC \times$ Actual % Complete	How much of the project's value you've really earned	EV lets you translate how much work the team's finished into a dollar value
AC—Actual Cost	What you've actually spent on the project	How much you've actually spent so far	The amount of money you spend doesn't always match the value you get!
SPI—Schedule Performance Index	$SPI = \frac{EV}{PV}$	Whether you're behind or ahead of schedule	To figure out whether you've delivered the value your schedule said you would
SV—Schedule Variance	$SV = EV - PV$	How much ahead or behind schedule you are	This puts a dollar value on exactly how far ahead or behind schedule you are
CPI—Cost Performance Index	$CPI = \frac{EV}{AC}$	Whether you're within your budget or not	Your sponsor is always most interested in the bottom line!
TCPI—To-Complete Performance Index	$TCPI = \frac{BAC-EV}{BAC-AC}$	How well your project must perform to stay on budget.	This will let you forecast whether or not you can stick to your budget.
CV—Cost Variance	$CV = EV - AC$	How much above or below your budget you are	Your sponsor needs to know how much it costs to get him the value you deliver

Quality Management

Quality Management: Meeting Project Standards

- Project Quality Management works to **ensure** that the **project requirements**, including **product requirements**, are **met** and **validated**
- Project Quality Management includes the processes and activities of the performing organization that:
  - determine **quality policies**, **objectives**, and **responsibilities**
  - so that the project will **satisfy the needs** for which it was undertaken.
- **Quality Assurance (QA):** Proactive processes aimed at ensuring quality (e.g., inspections, testing).
- **Quality Control (QC)**: Monitoring outcomes to ensure deliverables meet quality criteria.



Quality Management Approach

- **Customer Satisfaction**: understanding, evaluating, defining, and managing combination of:
  - conformance to requirements (the project must produce what it said it would produce), and
  - fitness for use (the product or service must satisfy real needs)
- **Prevention Over Inspection**: The cost of preventing mistakes is generally much less than the cost of correcting them, as revealed by inspection
- **Management Responsibility**: Management must provide resources needed to meet quality levels and thus succeed
- **Continuous Improvement**: The plan-do-check-act cycle is the basis for quality improvement (as defined by Shewhart and modified by Deming)

Quality: the degree to which a set of inherent characteristics fulfill requirements

- Quality level that fails to meet quality requirements is always a PROBLEM

Grade: a category assigned to product or service having the same functional use but different technical characteristics

- Low grade may not be a problem

Quality Costing

QUALITY COSTING

QUALITY COSTING refers to the costs that a company incurs to come up with a quality product. It is the cost to prevent, detect, and address quality issues in a product. Objective is to ensure that the product meets the expectations of the buyer.

HOW IT ARISES ?

Issues can also arise because of -

- error at the time of production
- Supplier sending wrong or inferior material
- Incorrect entry of customer order

eFinanceManagement.com

FORMULA TO CALCULATE

Cost of Quality (COQ) = Cost of Control Plus Cost of Failure of Control

Cost of Control includes Prevention Cost and Appraisal Cost

Cost of Failure of Control includes Internal Failure Cost Plus External Failure Cost.

TYPES OF QUALITY COSTS

PREVENTION COSTS
These are the costs that help company to prevent or minimize quality issues from occurring.

APPRAISAL COSTS
These are also known as Inspection Costs which help to prevent quality issues from occurring.

INTERNAL FAILURE COSTS
These include tangible costs after a company produces a defective or inferior product before shipment

EXTERNAL QUALITY COSTS
It includes both tangible and intangible costs on a product dispatched to a customer.

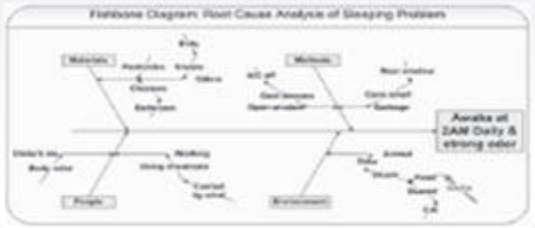
Prevention Costs	Appraisal (Detection) Costs
Quality engineering	Inspection of materials
Quality training	Packaging inspection
Recruiting	Product acceptance
Quality audits	Process acceptance
Design reviews	Field testing
Quality circles	Continuing supplier verification
Marketing research	
Prototype inspection	
Vendor certification	

Internal Failure Costs	External Failure Costs
Scrap	Lost sales (performance-related)
Rework	Returns/allowances
Downtime (defect-related)	Warranties
Reinspection	Discounts due to defects
Retesting	Product liability
Design changes	Complaint adjustment
Repairs	Recalls
	Ill will

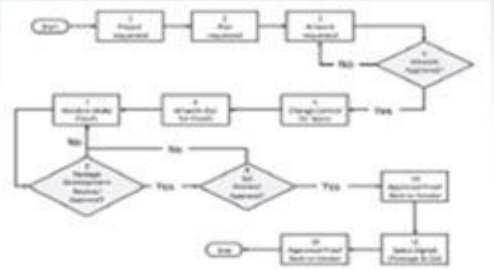
Quality Costing

Quality Control Tools

Cause & Effect Diagram



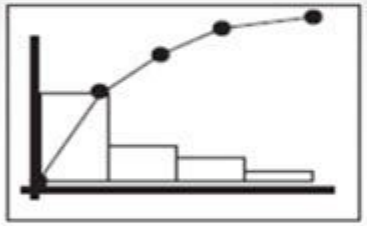
Flowcharts



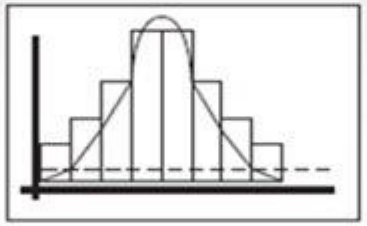
Checksheets

Category	Strokes	Frequency
Attribute 1		
Attribute 2		
Attribute ...		
Attribute n		

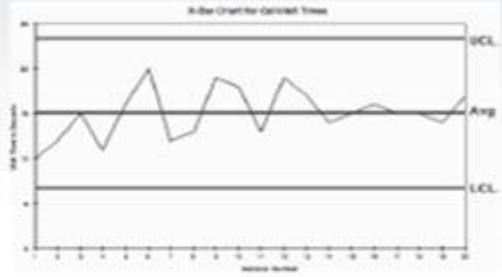
Pareto Diagrams



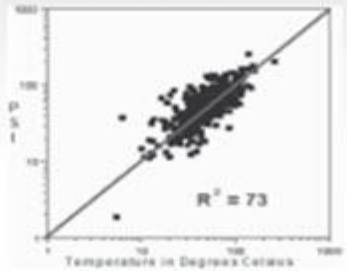
Histograms



Control Charts



Scatter Diagrams



Quality Assurance Vs Control

	Quality Assurance	Quality Control
Definition	A set of activities for ensuring quality in the processes by which products are developed.	A set of activities for ensuring quality in products. The activities focus on identifying defects in the actual products produced.
Focus	**Proactive:** Aims to prevent defects with a focus on the process used to make the product. Determines compliance to project policies/procedures.	**Reactive:** Aims to identify (and correct) defects in the finished product. Measures specific project results against standards.
Goal	The goal is to improve development and test processes so that defects do not arise when the product is being developed.	The goal is to identify defects after a product is developed and before it's released.
How	Establish a good QM system and the assessment of its adequacy. Periodic conformance audits of the operations of the system.	Finding and eliminating sources of quality problems through tools and processes so that customer's requirements are continually met.
What	Prevention of quality problems through planned and systematic activities including documentation. Corrective or preventive action as a result of the audit.	The activities or techniques used to achieve and maintain the product quality, process and service. Defect repair and measurement of quality indicators.
Tools	• Standards and Metric Development • Checklists • Peer Reviews • Product Reviews	• Assessment of Metrics • Checklists • Process Audit • Stage Gate Audits • Testing Inspections

Group Exercise

Schedule

What is the overall project duration?

What is the critical path?

ID	Activity	Predecessor	Duration (Weeks)
A	Set conference date	-	2
B	Establish theme	-	5
C	Select Conference site	A	5
D	Obtain Speakers	B	6
E	Develop Brochure	C, D	9
F	Obtain Mailing Labels	C, D	5
G	Mail Brochure	E, F	2
H	Obtain Speaker Materials	D	4
I	Receive Registration	G	6
J	Confirm all Arrangement	H, I	1
K	Prepare Conference Kits	J	2

EVM

Find the following:

- Schedule Variance (SV)
- Cost Variance (CV)
- Schedule Performance Index (SPI)
- Cost Performance Index (CPI)
- Estimate to Completion (ETC)
- Estimate at Completion (EAC)
- To-complete Performance Indec (TCPI)

Earned Value Management (EVM) Assignment Problems

1. Using the information below, calculated the figures in the table and describe what the results of each calculation mean to you as a project manager. What do you propose to do?

PV= $25,000
EV= $30,000
AC= $29,000
BAC = $100,000

Quality

Which quality control technique or tool should be used when trying to determine the cause of a major defect?

A. Pareto Chart

B. Control Chart

C. Histogram

D. Fishbone diagram

The term _____ indicates the degree to which a particular product or service meets requirements, while _____ indicates a category or rank used to distinguish that item from other similar items.

A. Quality, grade

B. Grade, standard

C. Grade, quality

D. Quality, standard

Key Takeaway

- Time Management: Critical Path Method (CPM) and Gantt Charts are essential tools for ensuring project timelines stay on track.
- Cost Management: Use Earned Value Management (EVM) and cost control techniques to stay within budget and manage financial resources effectively.
- Quality Management: Ensuring consistent quality through Quality Assurance (QA) and Quality Control (QC) processes is crucial for delivering successful projects.
- Interconnection of Constraints: Always consider how changes in time, cost, or quality impact the other two constraints. Finding a balance is key.

Reference

- Kerzner, H. (2017). Project Management: A Systems Approach to Planning, Scheduling, and Controlling (12th Edition). Wiley.
  - Available at: Wiley Online Library
- PMBOK Guide (6th Edition) by the Project Management Institute (PMI).
  - Available at: PMI Website
- Gantt Chart Tool: Project scheduling software like Microsoft Project or online Gantt chart tools.
  - MS Project Overview
- Critical Path Method (CPM): A comprehensive guide to CPM scheduling for complex projects.
  - Available at: CPM Scheduling Overview
- Earned Value Management (EVM): Understanding cost control and forecasting with EVM.
  - Available at: EVM Overview
- Six Sigma for Quality Control: Learn more about Six Sigma and DMAIC processes.
  - Available at: Six Sigma Methodology

Homework

Research the topic of **PROJECT TIME-COST TRADE-OFF**

https://hvacsimplified.in/wp-content/uploads/2022/03/CH-5-PROJECT-TIME-COST-TRADE-OFF.pdf