Tentative schedule of sessions

- Oct 09: Schedule Management
- Oct 16: Schedule Management/Risk Management
- Oct 23: Risk Management
- Oct 30: Cost Management
- Nov 06: Procurement Management

Session Outline

- What will you learn in this session?
- Introduction to software projects
- The importance of Project Schedule
- …
- …
- …
- Software to assist in Project Time Management & Schedule Management

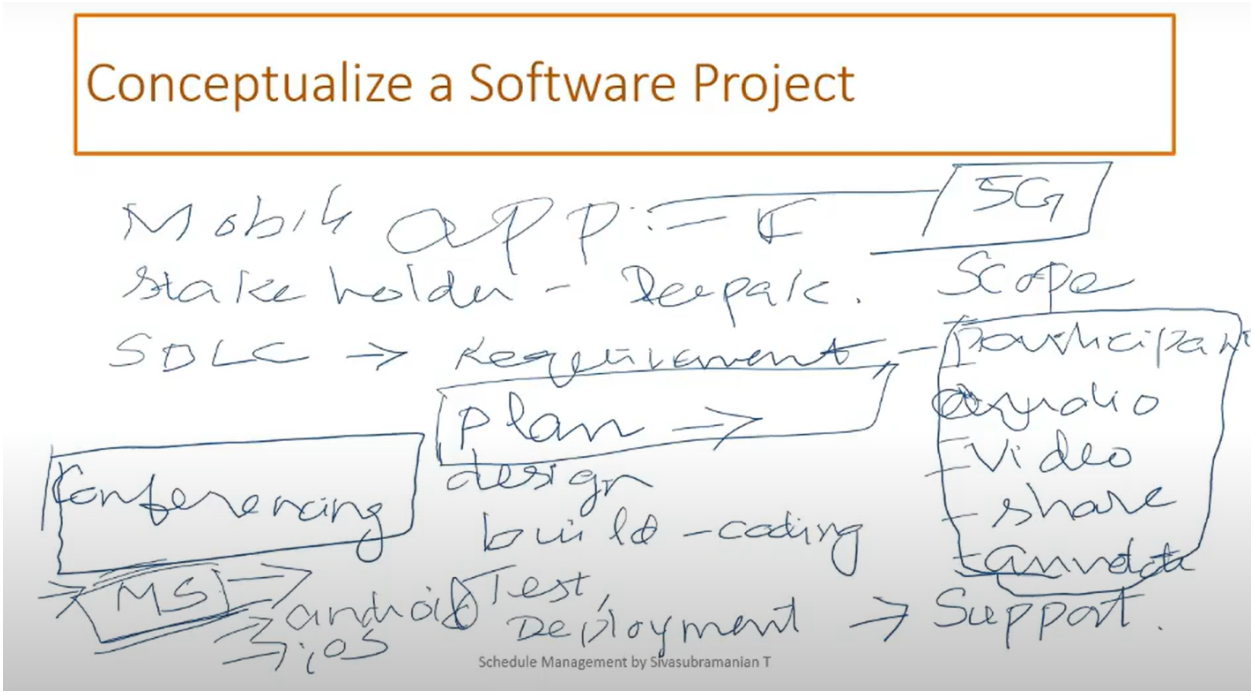
To be filled later during this session

Expected Learning Outcomes

- Understand significance of project schedules
- Tools & techniques for activity sequencing
- Understand Critical Path, Critical Tasks, Milestones, Lead and Lag times
- Dependencies on project resource availability
- Overview of CPM and PERT
- Project Scheduling Software in the market
- Scheduling best practices

Conceptualize a software project

Conceptualize a Software Project



Project time management process

Project Time Management Process

- WBS
  - Work Break-down Structure
  - Deliverable oriented hierarchical decomposition of project work
- Identifying the specific activities (aka tasks)
  - Duration, resources, cost, priority, pre-requisites / dependencies, sub-tasks
- Estimating
  - Effort, resources, duration and cost
- Developing schedule
  - Analyse dependencies, constraints, risks etc.
- Controlling schedule

Work break-down structure

Work Break-down Structures (WBS)

- To define the project's scope of work in terms of deliverables and to further decompose these deliverables into components. Depending upon the decomposition method used, the WBS can also define the project's life cycle as well as the deliverables appropriate to the project, program, or portfolio. This project scope decomposition balances management's need for control with representation of an appropriate level of detail in the WBS.
- To provide the project management team with a framework on which to base project status and progress reports.
- To facilitate communication between the project manager and stakeholders throughout the life of the project. The WBS can be used to communicate information regarding the project scope. In combination with additional data, the WBS is the framework for communicating information that includes, but is not limited to, schedule, risk, performance, dependencies, and budget.
- As a key input to other project management processes and deliverables.

WBS Dictionary

WBS Dictionary

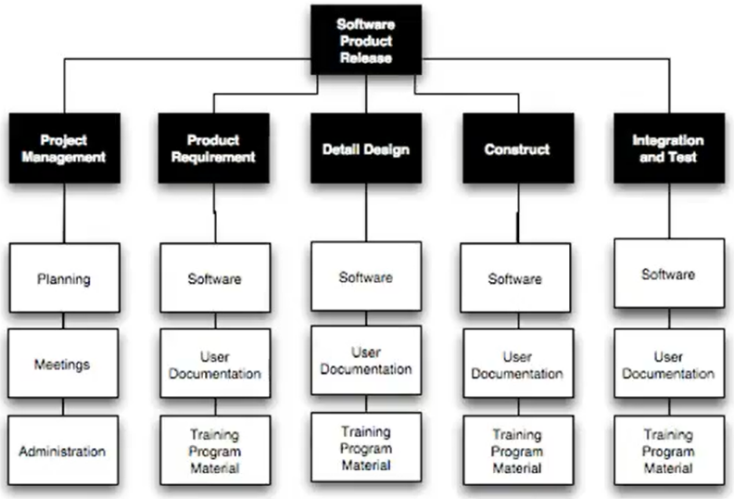
1. Identify Item
2. Describe It
3. Note Assumptions and Constraints
4. Assign Owner
5. Set Milestone
6. Make Schedule
7. List Resources
8. Calculate Cost
9. Define Quality
10. Know Acceptance Criteria
11. Collect Technical References
12. Settle Agreements

Sample WBS

Sample WBS For Software Project - 1

1 WBS for Software Implementation Project
- 1.1 Project Management
- 1.2 Product Requirements
  - 1.2.1 Software Requirements
    - 1.2.1.1 Draft Software Requirements
    - 1.2.1.2 Final Software Requirements
    - 1.2.1.3 Software Requirements Approval
  - 1.2.2 User Documentation
    - 1.2.2.1 Draft User Documentation
    - 1.2.2.2 Final User Documentation
    - 1.2.2.3 User Documentation Approval
  - 1.2.3 Training Program Materials
    - 1.2.3.1 Initial Training Requirements
    - 1.2.3.2 Initial Training Materials
    - 1.2.3.3 Trial Course Delivery
  - 1.2.4 Hardware
    - 1.2.4.1 Draft Hardware Requirements
    - 1.2.4.2 Final Hardware Requirements
    - 1.2.4.3 Hardware Requirements Approval
  - 1.2.5 Implementation & Future Support
- 1.3 Detail Software Design
  - 1.3.1 Initial Software Design
  - 1.3.2 Final Software Design
  - 1.3.3 Software Design Approval
- 1.4 System Construction
  - 1.4.1 Configured Software
  - 1.4.2 Customized User Documentation
  - 1.4.3 Customized Training Program Materials
  - 1.4.4 Installed Hardware
  - 1.4.5 Implementation & Future Support
- 1.5 Test
  - 1.5.1 System Test Plan
  - 1.5.2 System Test Cases
  - 1.5.3 System Test Results
  - 1.5.4 Acceptance Test Plan
  - 1.5.5 Acceptance Test Cases
  - 1.5.6 Acceptance Test Results
  - 1.5.7 Approved User Documentation
- 1.6 Go Live
- 1.7 Support
  - 1.7.1 Training
  - 1.7.2 End User Support
  - 1.7.3 Product Support

Sample WBS For Software Project - 2



Identifying activities

Identifying Activities

- Project schedules grow out of the basic documents that initiate a project
  - Project charter includes start and end dates and budget information
  - Scope statement and WBS help define what will be done
- Activity definition involves developing a more detailed WBS and supporting explanations to understand all the work to be done so you can develop realistic cost and duration estimates
- Inputs
  - WBS
  - Project Scope Statement
  - Enterprise environmental factors
  - Organizational process assets
  - WBS dictionary
  - Project Management Plan

Tools

Identifying Activities (...contd.)

- Tools & Techniques
  - Decomposition
  - Rolling Wave Planning
  - Expert Judgement
  - Use Cases

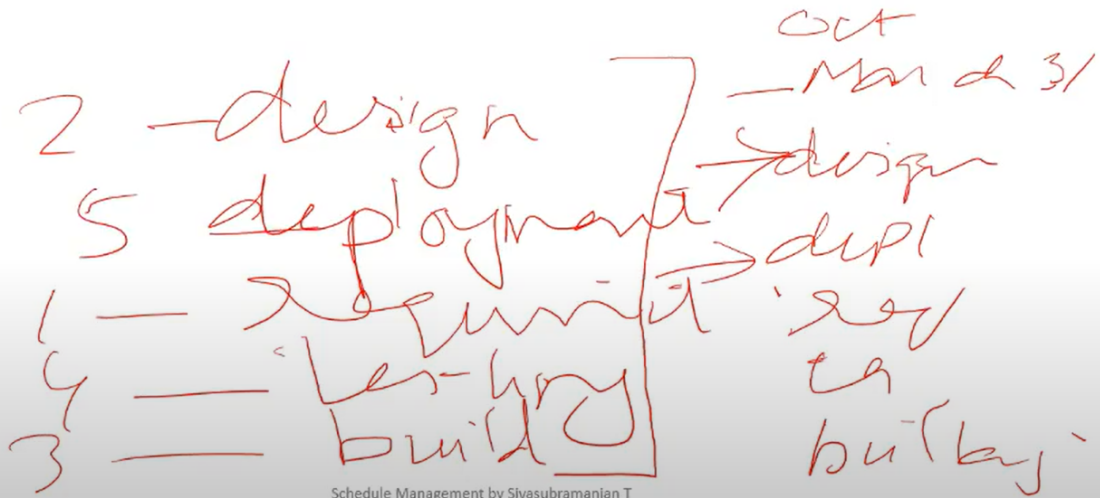
Identifying Activities (...contd.)

Outputs

- Activity List: A tabulation of activities to be included on a project schedule that includes:
  - The activity name
  - An activity identifier or number
  - A brief description of the activity
- Activity attributes provide more information such as predecessors, successors, logical relationships, leads and lags, resource requirements, constraints, imposed dates, and assumptions related to the activity
- Milestone List:
  - A **milestone** is a significant event that normally has no duration
  - It often takes several activities and a lot of work to complete a milestone
  - They're useful tools for setting schedule goals and monitoring progress
  - Examples include obtaining customer sign-off on key documents or completion of specific products

Sequencing activities

Sequencing Activities



Sequencing Activities

- Involves reviewing activities and determining dependencies
- A dependency or relationship is the sequencing of project activities or tasks
- You must determine dependencies in order to use critical path analysis
- Types of dependencies
  - Mandatory dependencies: inherent in the nature of the work being performed on a project, sometimes referred to as hard logic
  - Discretionary dependencies: defined by the project team; sometimes referred to as soft logic and should be used with care since they may limit later scheduling options
  - External dependencies: involve relationships between project and nonproject activities

Sequencing Activities (...Contd.)

- Input
  - Activity list
  - Milestones list
  - Project scope statement
  - Activity attributes
  - Approved change requests
- Tools & Techniques
  - Precedence Diagramming Method (PDM)
  - Arrow Diagramming Method (ADM)
  - Schedule Network templates
  - Dependency determination applying leads and lags

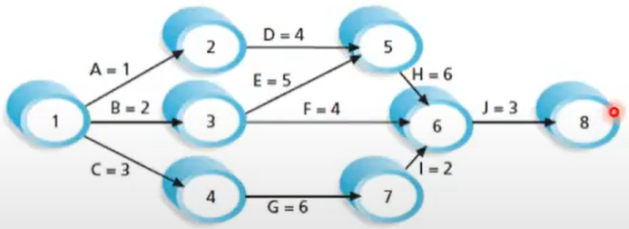
Sequencing Activities (...Contd.)

- Outputs
  - Project schedule network diagrams
  - Activity list updates
  - Activity attribute updates
  - Requested changes

Sequencing technique- Network diagram

Sequencing Technique – Network Diagrams

- A project network diagram is a schematic display of the logical relationships among, or sequencing of, project activities

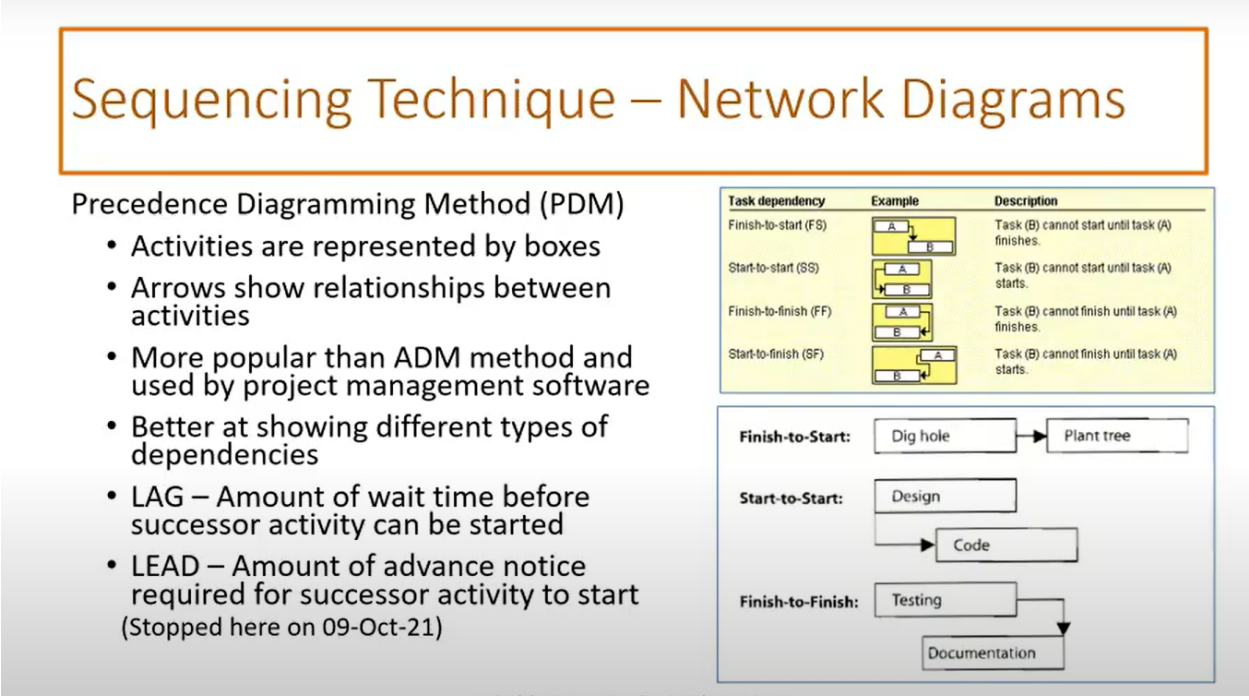


Arrow diagramming method (ADM)

Sequencing Technique – Network Diagrams

- Arrow Diagramming Method (ADM)
  - Also called activity-on-arrow (AOA) project network diagrams
  - Activities are represented by arrows
  - Nodes or circles are the starting and ending points of activities
  - Can only show finish-to-start dependencies
- Process
  - Find all of the activities that start at node 1. Draw their finish nodes and draw arrows between node 1 and those finish nodes. Put the activity letter or name and duration estimate on the associated arrow
  - Continuing drawing the network diagram, working from left to right. Look for bursts and merges.
    - Bursts occur when a single node is followed by two or more activities.
    - A merge occurs when two or more nodes precede a single node
  - Continue drawing the project network diagram until all activities are included on the diagram that have dependencies
  - As a rule of thumb, all arrowheads should face toward the right, and no arrows should cross on an AOA network diagram

Precedence diagramming method (PDM), LAG, LEAD



Video - 2 (Siva)

RSchedule management, time units

RSchedule Managment

- Schedule Management for Software Development Project
  - Develop software for a Chef to sell his food preparations
  - Web App to run in computer as well as in smart phones
  - Objective:
- Time units:
- Effort units:
  person-wee

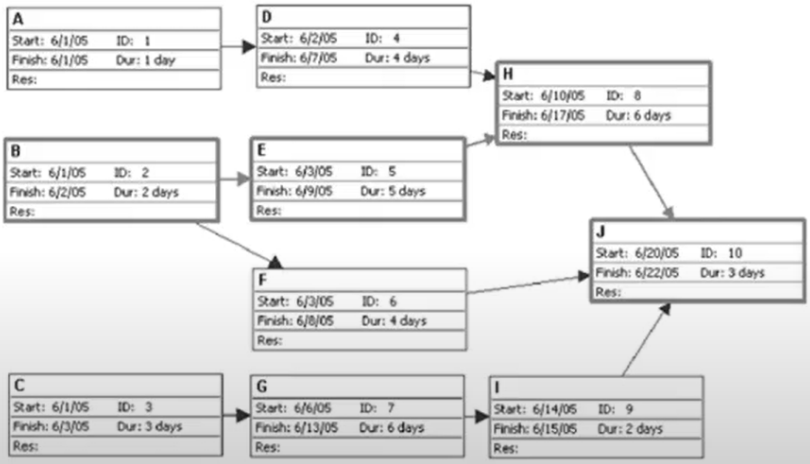
1 work day = 8 work hours (or 7 work hours)
1 work week = 5 work days (or 5.5 or 6 work days)
1 work month = 22, 21 or 20 work days
1 person-day = 1 person x 1 day
1 person-month = 1 person x 1 month
1 person-year ~ 2000 person-hours

RSchedule Managment

- Schedule Management for Software Development Project
  - Develop software for a Chef to sell his food preparations
  - Web App to run in computer as well as in smart phones
  - Objective: to sell the app
- Time units: Year, month, day, hour, minute, seconds, week
- Effort units: Person-year, person-month, person-day, person-hour, person-week
- Network diagrams

PDM Network

Sequencing Technique – PDM Network Diagrams



Effort and duration

Task Estimations – Effort, Resource & Duration

- After defining activities and determining their sequence, the next step in time management is effort, resource and duration estimation
- Effort: how much work will the activity need to be completed
- Resource includes?
  - Man-power, Equipment, Software, Network, Money, Work Space????
  - Ability to carry out projects depend on the availability of resources
  - Analyze resource implication - How requirements can be met and changes needed
  - Use resources efficiently
  - Use network to give information about time, resources and cost
- Duration includes the actual amount of time worked on an activity plus elapsed time
- Effort is the number of workdays or work hours required to complete a task. Effort does not equal duration
- People doing the work should help create estimates, and an expert should review them

Task estimation

Task Estimations – Duration

- One-Time Estimate
  - One estimate per activity, based on?
    - Expert opinon
    - Historical information
    - Guess work
- Analagous estimating
- Parametric estimating
- Three-Point Estimates

Work and duration

Work & Duration

- When working with planning tools, you change one variable at a time.
- Standard characterisation:
  - Fixed Duration. A task in which the duration is a fixed value and any changes to the work or the assigned resources, don't affect the tasks duration. (Duration is a constant).
  - Fixed Work. A task in which the amount of work is a fixed value and any changes to the tasks duration or the number of assigned resources do not affect the tasks work. (Duration $\propto$ 1/Units).
  - Fixed Unit. A task in which the assigned resources is a fixed value and any changes to the amount of work or the tasks duration do not affect the tasks units. (Work $\propto$ Duration).

Schedule development

Schedule Development

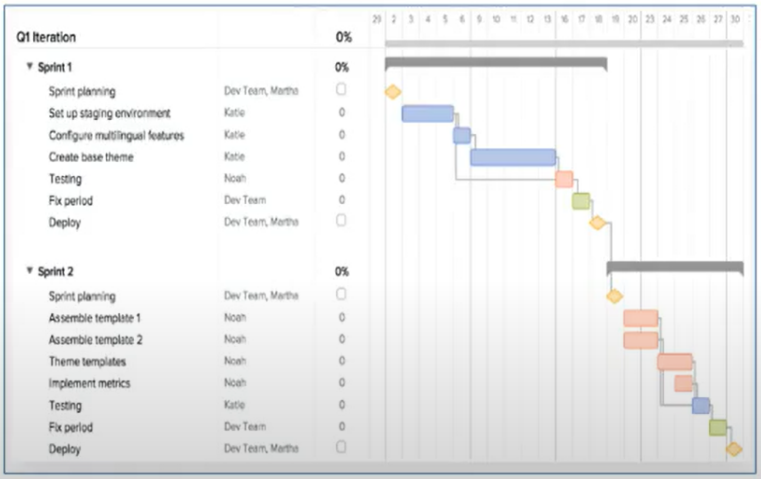
- Schedule development uses results of the other time management processes to determine the start and end date of the project and its activities
- Ultimate goal is to create a realistic project schedule that provides a basis for monitoring project progress for the time dimension of the project
- Important tools and techniques include Gantt charts, PERT analysis, critical path analysis, and critical chain scheduling

Gantt charts

Gantt Charts

- Gantt charts provide a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in a calendar format
- Symbols include:
  - A diamond: milestones or significant events on a project with zero duration
  - Thick bars: summary tasks
  - Lighter horizontal bars: tasks
  - Arrows: dependencies between tasks
- Tools: MS Project, ProjectLibre, Ganttpro, Workzone, Excel, TeamGantt, Teamwork etc.

Sample Gantt Chart



Milestones

Milestones

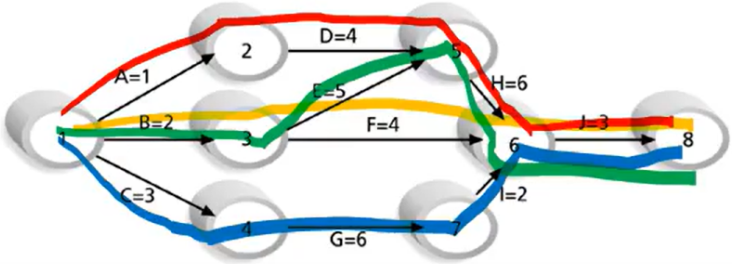
- Milestones are significant events on a project that normally have zero duration
- Many people like to focus on meeting milestones, especially for large projects
- Milestones emphasize important events or accomplishments on projects
- You can follow the SMART criteria in developing milestones that are:
  - Specific
  - Measurable
  - Assignable
  - Realistic
  - Time-framed

CPM Critical path method

Critical Path Method (CPM)

- CPM is a network diagramming technique used to predict total project duration
- A critical path for a project is the series of activities that determines the earliest time by which the project can be completed
- The critical path is the longest path through the network diagram and has the least amount of slack or float (Zero or negative)
- How to calculate the Critical Path:
  - First develop a good network diagram
  - Add the duration estimates for all activities on each path through the network diagram
  - The longest path is the critical path
  - If one or more of the activities on the critical path takes longer than planned, the whole project schedule will slip unless the project manager takes corrective action

Determining the Critical Path



Note: Assume all durations are in days.

Path 1:	A-D-H-J	Length = 1+4+6+3 = 14 days
Path 2:	**B-E-H-J**	**Length = 2+5+6+3 = 16 days**
Path 3:	B-F-J	Length = 2+4+3 = 9 days
Path 4:	C-G-I-J	Length = 3+6+2+3 = 14 days

Since the critical path is the longest path through the network diagram, Path 2, B-E-H-J, is the critical path

More on the Critical Path

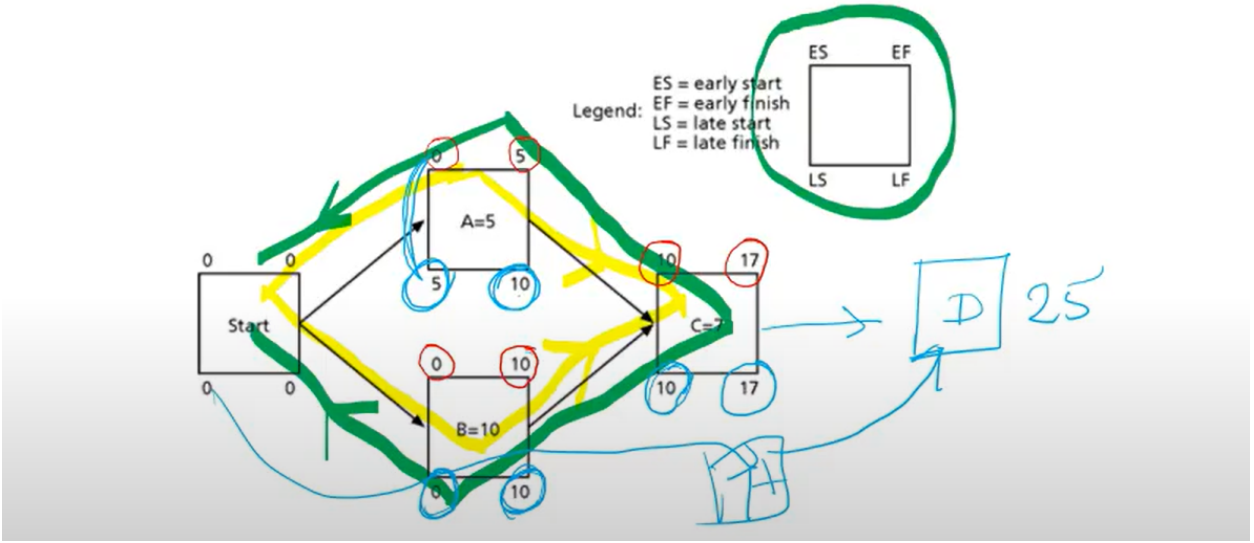
- If one or more activities on the critical path takes longer than planned, the whole project schedule will slip *unless* corrective action is taken
- Misconceptions:
  - The critical path is not the one with all the important activities; it only accounts for time.
  - There can be more than one critical path if the lengths of two or more paths are the same
- The critical path can change as the project progresses
- Near-Critical Path: Path close in duration to critical path

Free slack, float

Using Critical Path Analysis to Make Schedule Trade-offs

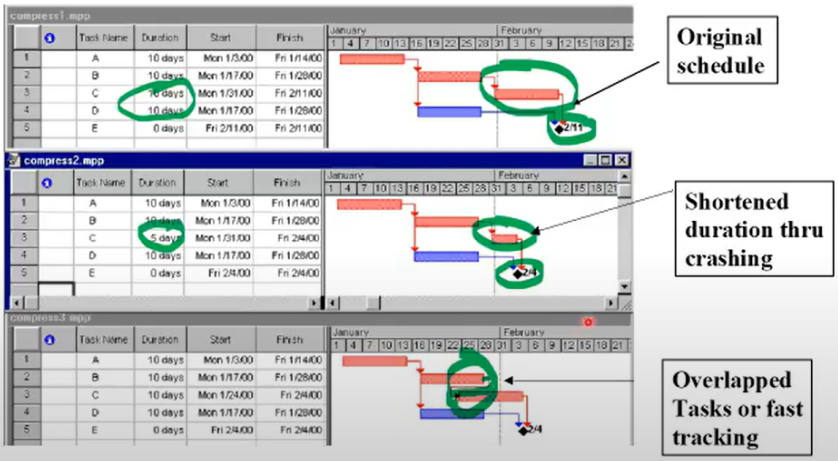
- Knowing the critical path helps you make schedule trade-offs
- *Free slack or free float* is the amount of time an activity can be delayed without delaying the early start of any immediately following activities
- *Total slack or total float* is the amount of time an activity may be delayed from its early start without delaying the planned project finish date
- A *forward pass* through the network diagram determines the early start and finish dates

Calculating Early and Late Start and Finish Dates



Crashing and fast tracking

Crashing and Fast Tracking



Techniques for Shortening a Project Schedule

- Shorten durations of critical tasks by adding more resources or changing their scope
- *Crashing* tasks by obtaining the greatest amount of schedule compression for the least incremental cost
- *Fast tracking* tasks by doing them in parallel or overlapping them

Crashing and Fast Tracking (..contd.)

Option	General Impacts to the Project
Fast track	• Adds risk • May add management time for the project manager
Crash	• Almost always adds cost • May add management time for the project manager
Reduce scope	• Could save cost and time • May negatively impact customer satisfaction
Cut quality	• Could save cost and resources • May increase risk • Requires good metrics

Critical chain

Critical Chain Scheduling

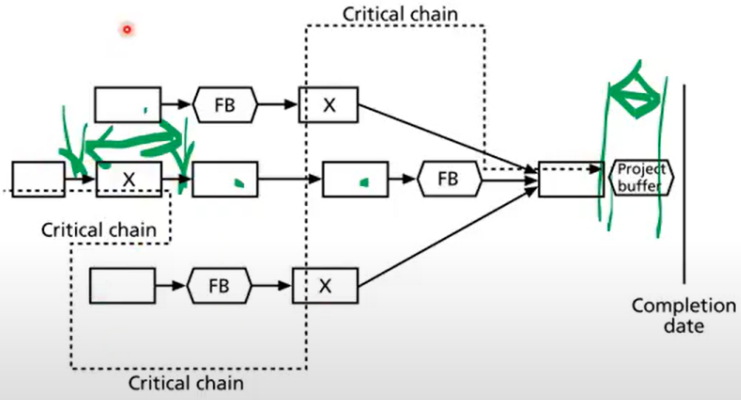
- Technique that addresses the challenge of meeting or beating project finish dates and an application of the Theory of Constraints (TOC)
- Developed by Eliyahu Goldratt in his books *The Goal* and *Critical Chain*
- Critical chain scheduling is a method of scheduling that takes limited resources into account when creating a project schedule and includes buffers to protect the project completion date
- Critical chain scheduling assumes resources do not multitask because it often delays task completions and increases total durations

Buffers and critical chain

Buffers and Critical Chain

- A buffer is additional time to complete a task
- **Murphy's Law** states that if something can go wrong, it will, and **Parkinson's Law** states that work expands to fill the time allowed. In traditional estimates, people often add a buffer and use it if it's needed or not
- Critical chain schedule removes buffers from individual tasks and instead creates
  - A project buffer, which is additional time added before the project's due date
  - Feeding buffers, which are additional time added before tasks on the critical path

Example of Critical Chain Scheduling



PERT and review technique

Program Evaluation and Review Technique (PERT)

- PERT is a network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual activity duration estimates
- PERT uses probabilistic time estimates based on using optimistic, most likely, and pessimistic estimates of activity durations

PERT Formula and Example

- PERT weighted average formula:

$$\frac{\text{optimistic time} + 4\text{X most likely time} + \text{pessimistic time}}{6}$$

- Example:

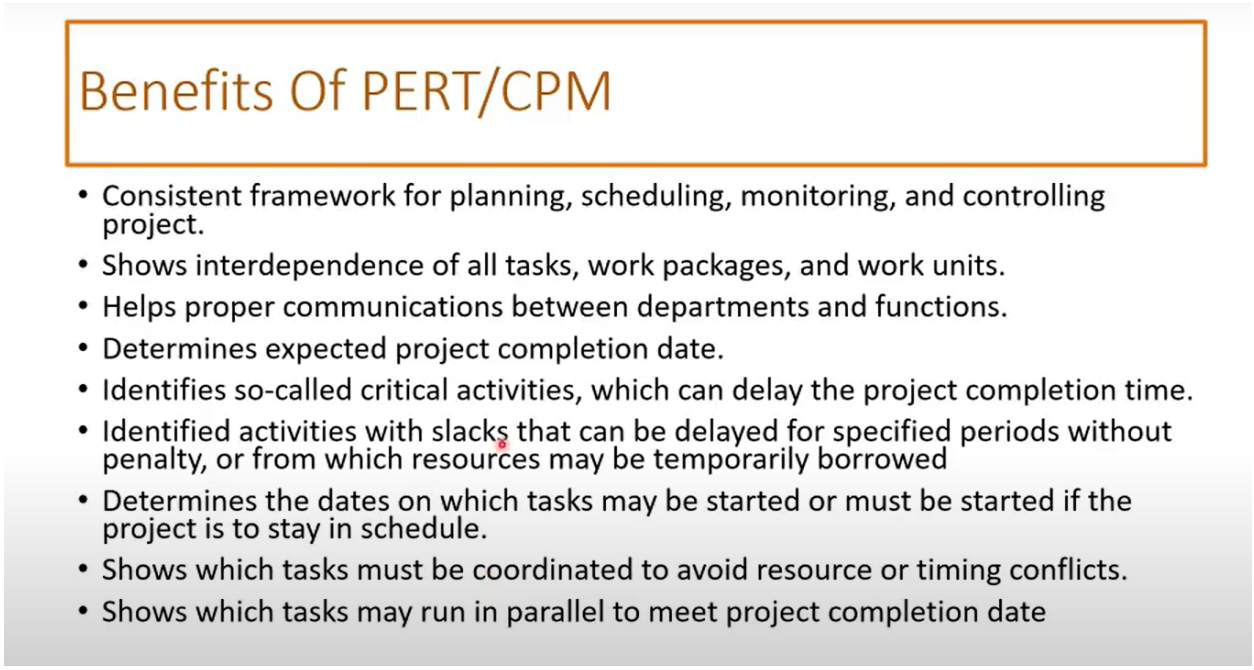
PERT weighted average = $\frac{8 \text{ workdays} + 4 \text{ X } 10 \text{ workdays} + 24 \text{ workdays}}{6}$ = 12 days

where 8 = optimistic time, 10 = most likely time, and 24 = pessimistic time

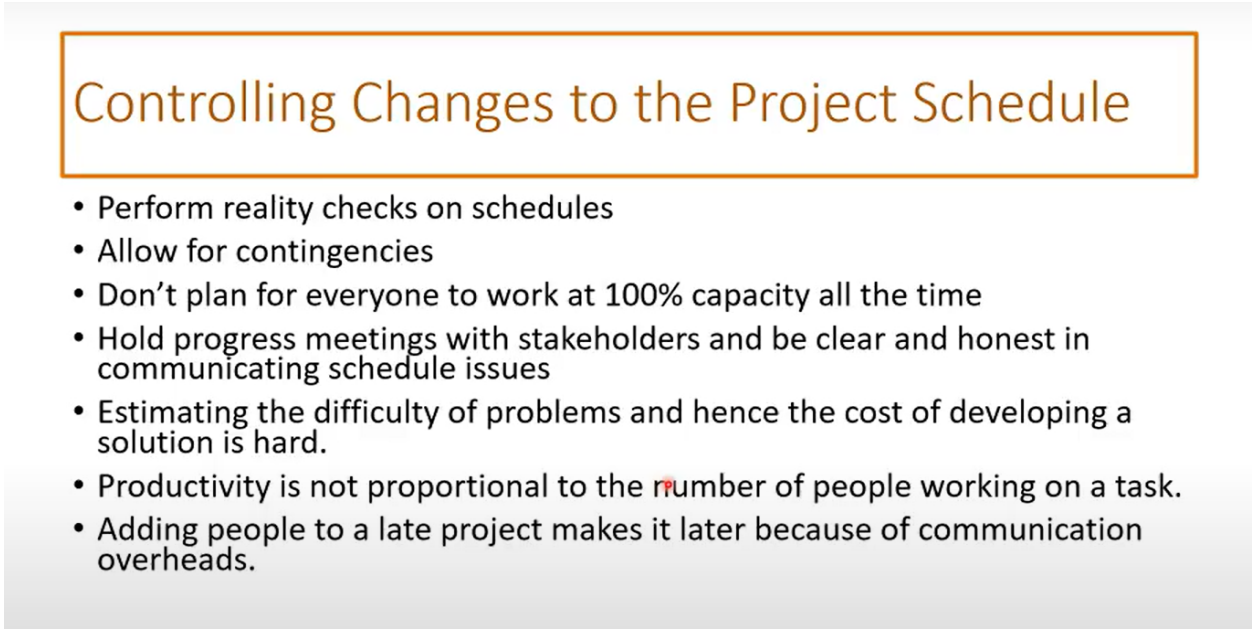
CPM vs PERT

CPM Vs PERT

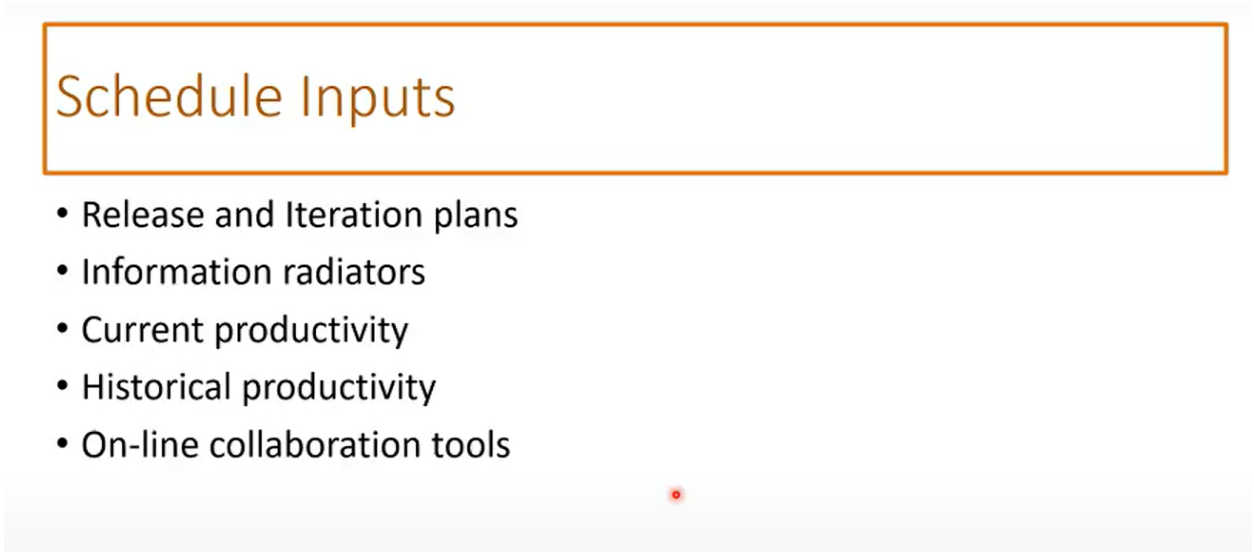
	CPM	PERT
1	Uses network, calculate float or slack, identify critical path and activities, guides to monitor and controlling project	Same as CPM
2	Uses one value of activity time	Requires 3 estimates of activity time Calculates mean and variance of time
3	Used where times can be estimated with confidence, familiar activities	Used where times cannot be estimated with confidence. Unfamiliar or new activities
4	Minimizing cost is more important	Meeting time target or estimating percent completion is more important
5	Example: construction projects, building one off machines, ships, etc	Example: Involving new activities or products, research and development etc



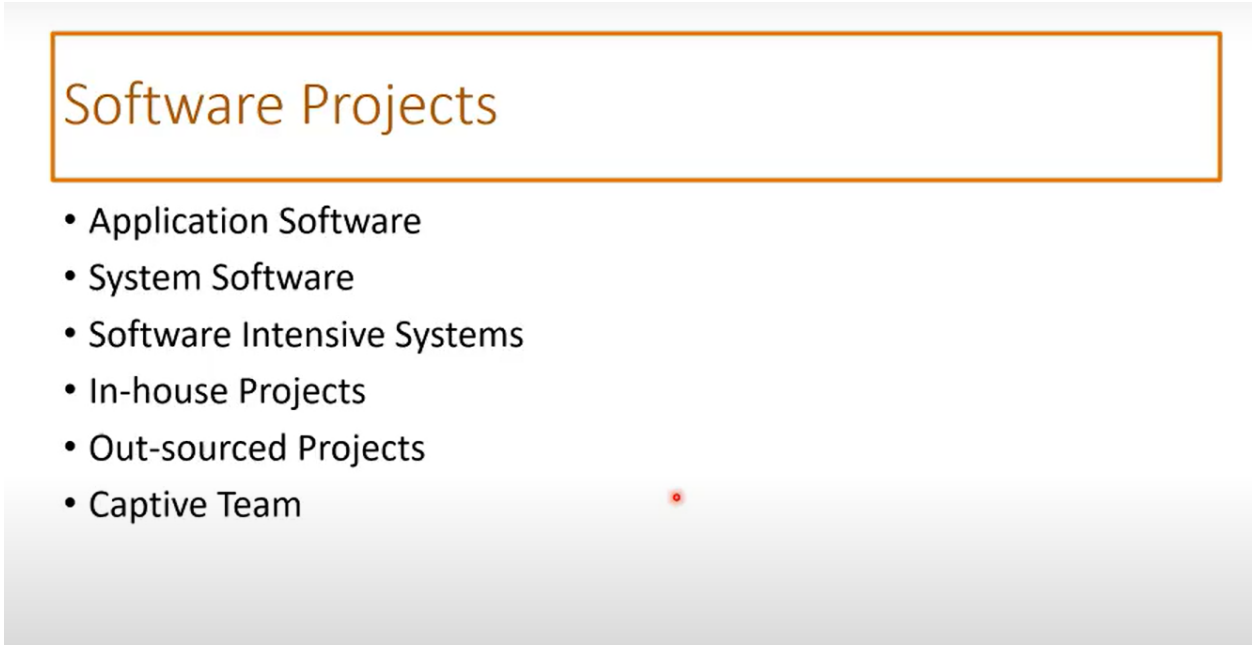
Controlling changes of project schedule



Scheduled inputs



Software projects



Software Projects

- Why is software project disaster so common?
  - Estimation techniques are poor & assume things will go well (an 'unvoiced' assumption)
  - Estimation techniques fallaciously confuse effort with progress, hiding the assumption that men and months are interchangeable
  - "… software managers often lack the courteous stubbornness of Antoine's chef."
  - Schedule progress is poorly monitored
  - When schedule slippage is recognized, the natural response is to add manpower

Software Projects

- **Optimism**
  - "All programmers are optimists"
  - 1st false assumption: "all will go well" or "each task takes only as long as it 'ought' to take"
  - The Fix: Consider the larger probabilities
- Cost (overhead) of communication (and training)
  - Typical formula: n(n-1)/2
  - How long does a 12 month project take?
    - 1 person: 12 month
    - 2 persons = 7 months (1 man-months extra)
    - 3 persons = 5 months (1 man-months extra)
  - Fix: don't assume adding people will solve the problem

Software Projects

- Sequential nature of the process
  - "The bearing of a child takes nine months, no matter how many women are assigned"
- What is the most mis-scheduled part of process?
  - Testing (the most linear process)
- Why is this particularly bad?
  - Occurs late in process and w/o warning
  - Higher costs: primary and secondary
- Fix: Allocate more test time
  - Understand task dependencies

Software Projects

- Q: "How does a project get to be a year late"?
  - A: "One day at a time"
- Studies
  - Each task: twice as long as estimated
  - Only 50% of work week was programming
- Fixes
  - No "fuzzy" milestones (get the "true" status)
  - Reduce the role of conflict
  - Identify the "true status"

Software Projects

- The seeds of major software disasters are usually sown in the first three months of commencing the software project. Hasty scheduling,irrational commitments, unprofessional estimating techniques,and carelessness of the project management function are the factors that tend to introduce terminal problems. Once a project blindly lurches forward toward an impossible delivery date, the rest of the disaster will occur almost inevitably.

T. Capers Jones

Software Projects

- Half finish late and over budget
- Nearly a third are abandoned before completion
  - The Standish Group, in Infoworld
- Get & keep users involved & informed
- Watch for scope creep / feature creep

Video-3:

Session Outline

- What will you learn in this session?
- The importance of Project Risk Management
- …
- …
- …
- Software to assist in Project Risk Management

Expected Learning Outcomes

- Understand Project Risk Management (based on PMI and/or PRINCE2 standards and definitions)
- Describe the process for identification, analysis and prioritization of project risks
- Apply risk identification tools and techniques
- Apply qualitative risk analysis tools and techniques
- Describe quantitative risk analysis tools and techniques
- Apply risk response planning
- Plan to monitor and control project risks

RISK

What is a Risk?

A dictionary definition of risk is
'adverse consequences of future events'
Or
"a future trouble"

PRINCE2 standard defines risk as
'an uncertain event or set of events that, should it occur, will have an effect on the achievement of objectives'

PMI standard defines risk as
'an uncertain event or condition that, if it occurs, has a positive or a negative effect on a project's objectives'

Software Risk Samples

Risk Description	Probability of Occurrence	Loss Size (Days)	Risk Exposure (Days)
Insufficient QA time to validate on all browsers and OS types.	45%	6	2.7
Lack of verifiable sample data to validate end product.	35%	18	6.3
Inadequate staff available until very late in cycle.	25%	7	1.8
More effort on the user guide may be necessary.	25%	18	4.5
Backup and restore requires 3rd-party solutions (not evaluated yet).	20%	12	2.4
Insufficient time for external stakeholders to provide feedback	10%	5	0.5
		Total Risk Exposure	**18.2**

What is Risk Management?

- The process involved with identifying, analyzing, and responding to risk. It includes maximizing the results of positive risks and minimizing the consequences of negative events
- Why do we need to manage risks?
  - Project problems can be reduced as much as 90% by using risk analysis
  - Positives:
    - More info available during planning
    - Improved probability of success/optimum project
  - Negatives:
    - Belief that all risks are accounted for
    - Project cut due to risk level

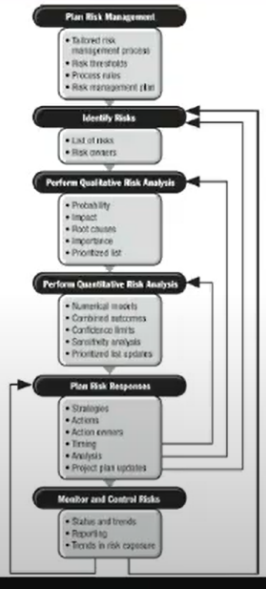
Risk Management (contd.)

- Project risk management is the art and science of identifying, analyzing, and responding to risk *throughout the life of a project*
- Risk can *help improve project success* by helping select good projects, determining project scope, and developing realistic estimates
- *Negative risk* involves understanding potential problems that might occur in the project and how they might impede project success, also *called threats*
- *Positive risks are* risks that result in good things happening; also called *opportunities*
- The goal of project risk management is to *minimize* potential *negative risks* while *maximizing* potential *positive risks*
- Risks are present in the projects primarily due to *uncertainty* in the project
- *Known Risks* are those that are identified and analyzed and can be planned for those
- *Unknown risks* are those risk which cannot be managed proactively. Project team allocate contingency to tackle these kind of risks

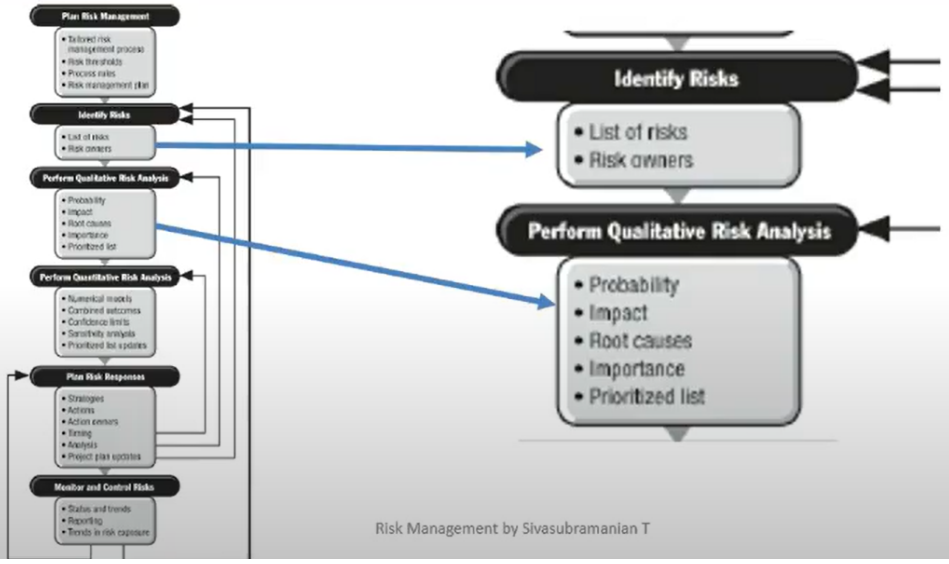
Terms and definitions - a recap

- Environmental factors
  - Environment in which the project is being executed and it includes organizational environment, technological environment, political environment etc.
- Organizational assets
  - People, processes and tools, knowledge base, software, partnerships, etc.
- Project Management Plan
  - Plan detailing the execution plan in terms of project organization, stakeholders, methodology etc.
- Project scope document
  - Requirement specification including functional and non-functional requirements and boundaries of the project scope

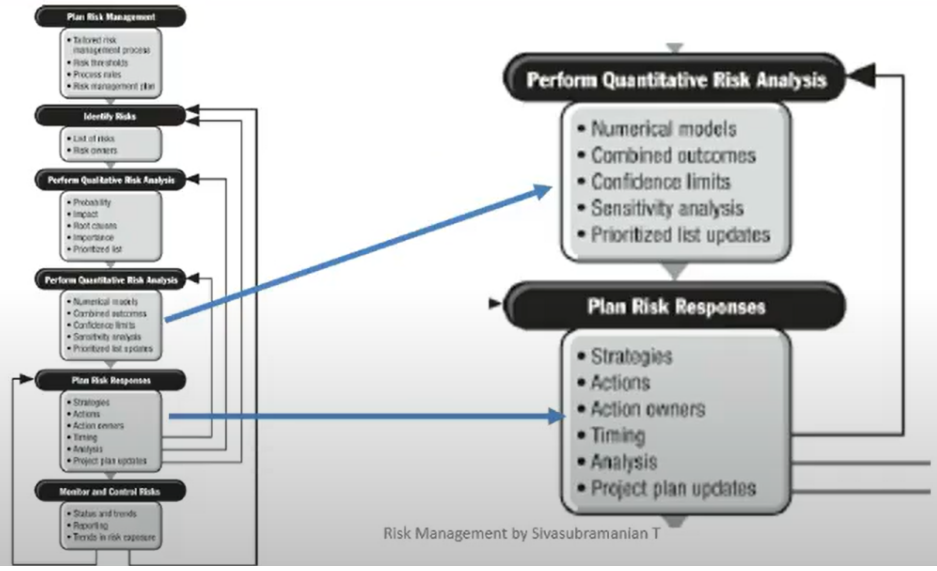
PMI's Risk Management Process

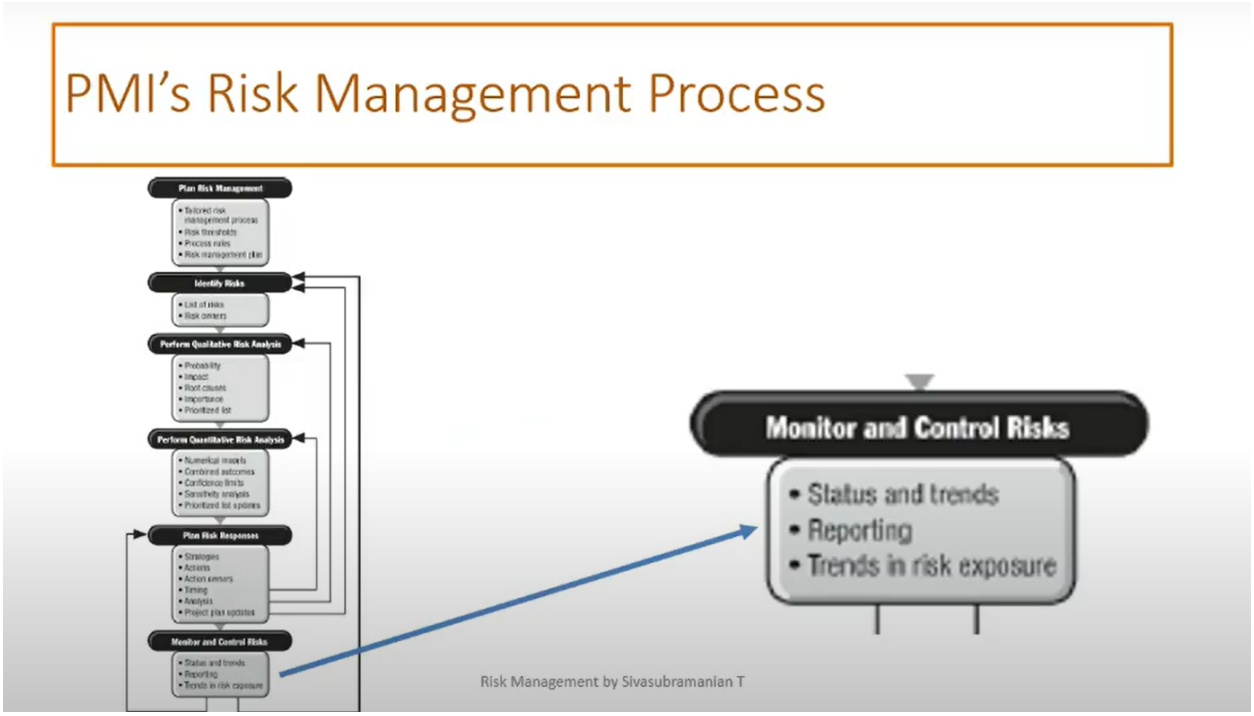


PMI's Risk Management Process



PMI's Risk Management Process





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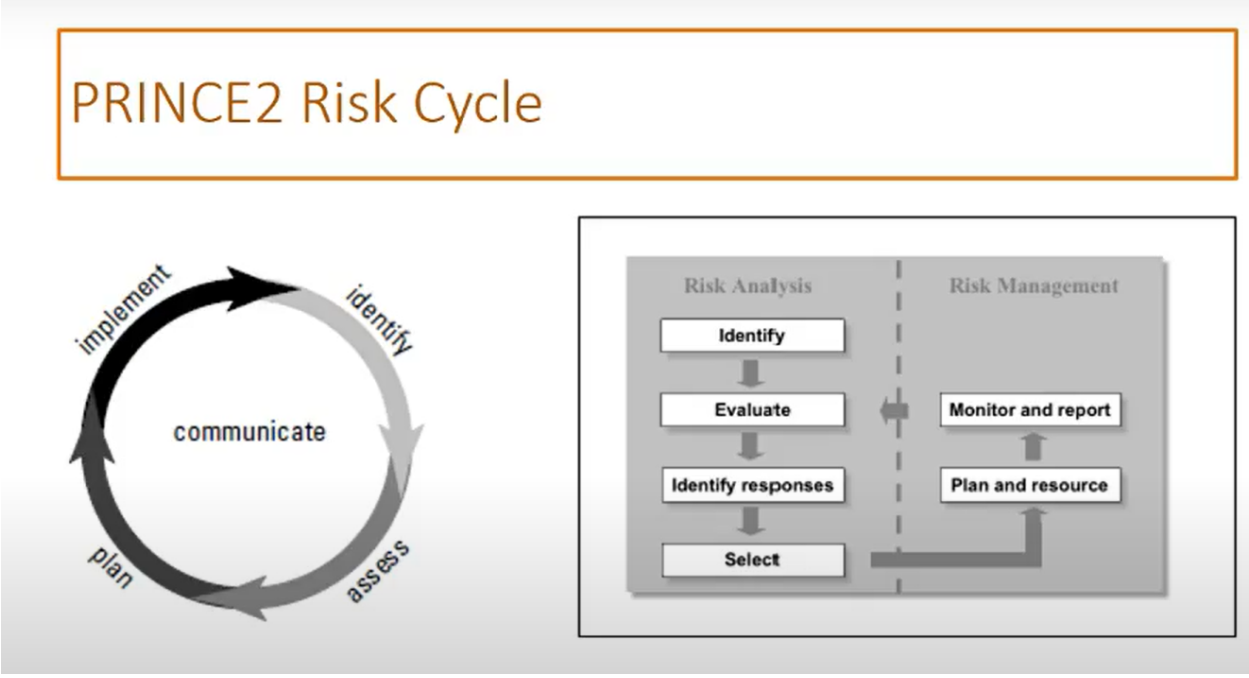


Barry boehm

Barry Boehm's Risk Management Process

Risk Management Approach / Strategy

- Strategy is going to vary from project to project
  - Size: Small Vs Big
  - Business criticality: Low Vs High
  - Low risk Vs High-risk
- Approach
  - Risk Management Planning
  - Risk Identification
  - Qualitative Risk Analysis
  - Quantitative Risk Analysis

  } Risk Assessment

  - Risk Response Planning
  - Risk Monitoring
  - Risk Control

  } Risk Control

Planning

Risk Management Planning

- This process will enhance the possibility of success of the other risk management processes
- Deciding how to approach, plan, and execute the risk management activities in the project
- The project team should review project documents and understand the organization's and the sponsor's approaches to risk
- The level of detail will vary with the needs of the project
- Ensures to provide sufficient resources and time for risk management activities
- The main output of risk management planning is a risk management plan—a plan that documents the approach/strategy/procedures for managing risk throughout a project

Risk Management Planning - Inputs, Tools & Output

- Inputs:
  - Enterprise Environment Factors
  - Organizational Process Assets
  - Project Scope Statement
  - Project Management Plan
- Tools & Techniques:
  - Planning meetings and analysis

Output: Risk Management Plan

Risk Management Plan - Typical Contents

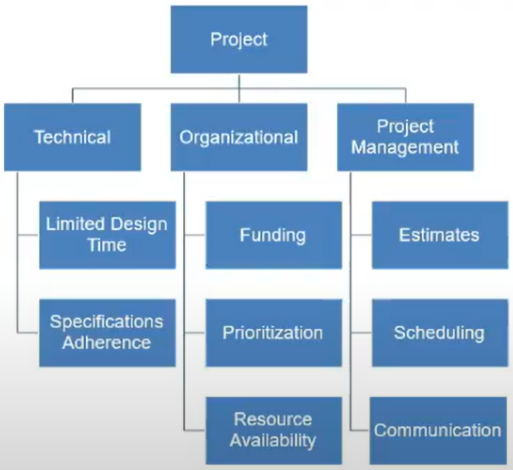
- Risk Management Plan describes how risk management will be structured and performed on the project. It is a subset of the project management plan. It includes :
  - Methodology
  - Roles and responsibilities
  - Tools & Techniques
  - Scale, budget and schedule
  - Timing
  - Risk categories (RBS - Risk Breakdown Structures)
  - Risk probability and impact
  - Risk tolerance & response
  - Risk documentation – recording and reporting (Risk Register)

Broad Risk Categories

- External Vs Internal
- Project Vs Product Vs Business
- Categories
  - Strategic
  - Market risk
  - Financial risk
  - Technology risk
  - People risk
  - Structure/process risk
  - Cultural
  - Sponsor-Caused risk
  - Customer or Customer's customer
  - Project Management
  - Economic
  - Legal and Regulatory
  - Organizational
  - Political
  - Environmental

RBS

Risk Breakdown Structure (RBS)



Sources

Sources of Risks in Software Projects

- Project size and complexity
  - Effort hours
  - Calendar time
  - Estimated budget
  - Team size (number of resources)
  - Number of sites
- Requirements
  - Ambiguous requirements
  - No clear vision and objectives
  - Volatile requirements
  - Unrealistic or aggressive performance standards
  - Complex requirements
  - No Scope control
- Stakeholder involvement
  - All key stakeholders not identified
  - Missing —buy-in from a key stakeholder
  - Stakeholder not completely identified
  - Key stakeholders not fully engaged
  - Users resistance to change
  - Conflicts between users
- Funding
  - Reduction in available capital
  - Cash flow issues
  - Inflation or exchange rate factors
- Change Impact
  - Replacement or new system
  - Impact on business policies
  - Impact on business processes
- Organization
  - Changes to project objectives
  - Lack of priorities, processes
  - Lack of project management —buy-in and support
- Sponsorship
  - Lack of strong executive commitment
  - Lack of clear ownership
  - Loss of political support

Risk Management by Sivasubramanian T

Sources of Risks in Software Projects (contd.)

- Schedule
  - Improper planning
  - Estimate assumptions are not holding true
  - Schedule contingency is not adequate
  - In-sufficient milestone check-points
- Technology
  - Missing technical data
  - Use of unproven technology
  - Use of non-standard technology
  - High level of technical complexity
  - External interfaces
- Vendors and Suppliers
  - Contract types
  - Risk-reward elements
  - Procurement process
- External factors
  - Changes in legal and regulatory environment
  - Approvals from governmental agencies, Political changes
  - COTS
- Facilities
  - Adequate for team productivity requirements
  - Adequate for project security requirements
- Team
  - Attrition
  - Competence levels of staff
  - Full-time or part-time roles
  - Virtual team
  - Staff commitments
  - Team members lack of specialized skill required by the project
- Project Management
  - Lack of experience
  - Poor leadership
  - Poor communications
  - Tracking but no control

Risk Management by Sivasubramanian T

Typical Risk Factors & Mitigation Options

- Unrealistic schedule and budget
  - Business-case analysis
  - Incremental development
  - Reuse of software
  - Modification of schedule and budget
- Requirements and developed functions do not match
  - Business-case analysis
  - Prototyping
  - Application description in early phases
- Standard software, external components
  - Benchmarking
  - Prototyping
  - Review of reference installations
  - Compatibility analysis
  - Review of suppliers
- Inadequate architecture, performance, quality
  - Simulation
  - Benchmarking
  - Modeling
  - Prototyping
- Human error on part of staff
  - Employ the best people
  - Rewards
  - Training
  - Peer reviews
- Constant alteration of requirements
  - Increased threshold for changes
  - Incremental development
  - Change management process
  - Change control board

Identification

Risk Identification

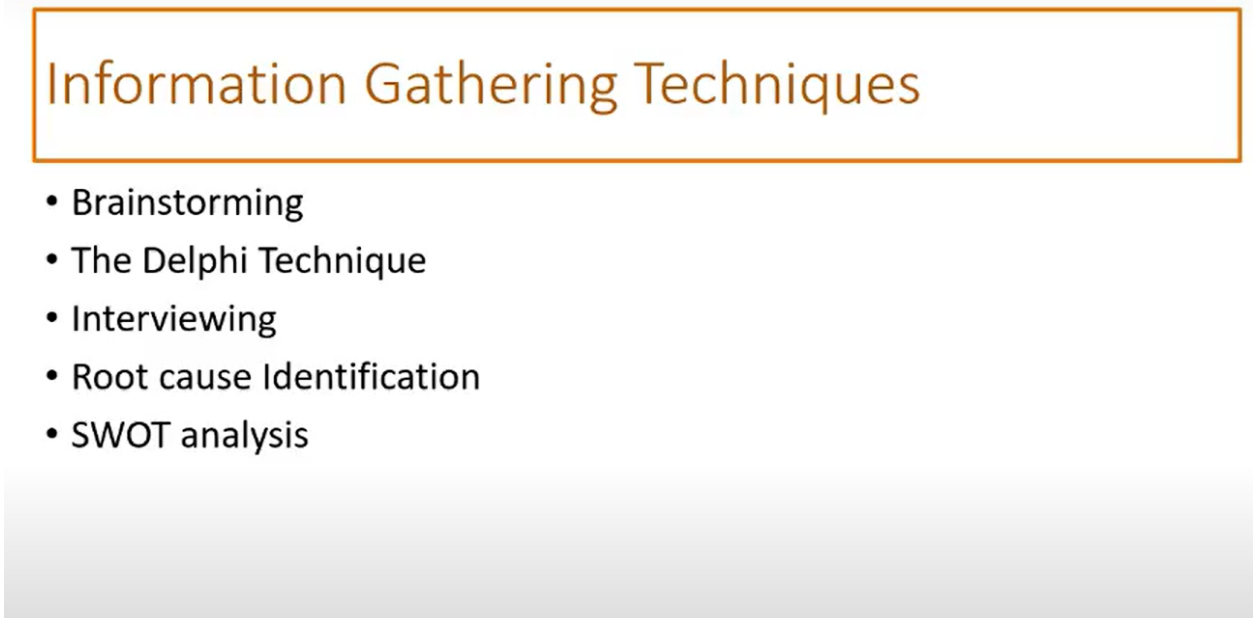
- Risk identification is the process of determining which risks might affect the project and documenting their characteristics
- An iterative process because new risk may become known as project progresses though its life cycle.
- This process usually leads to the Qualitative Risk Analysis, alternatively it can lead directly to the Quantitative Risk Analysis process.

Risk Identification - Inputs, Tools & Output

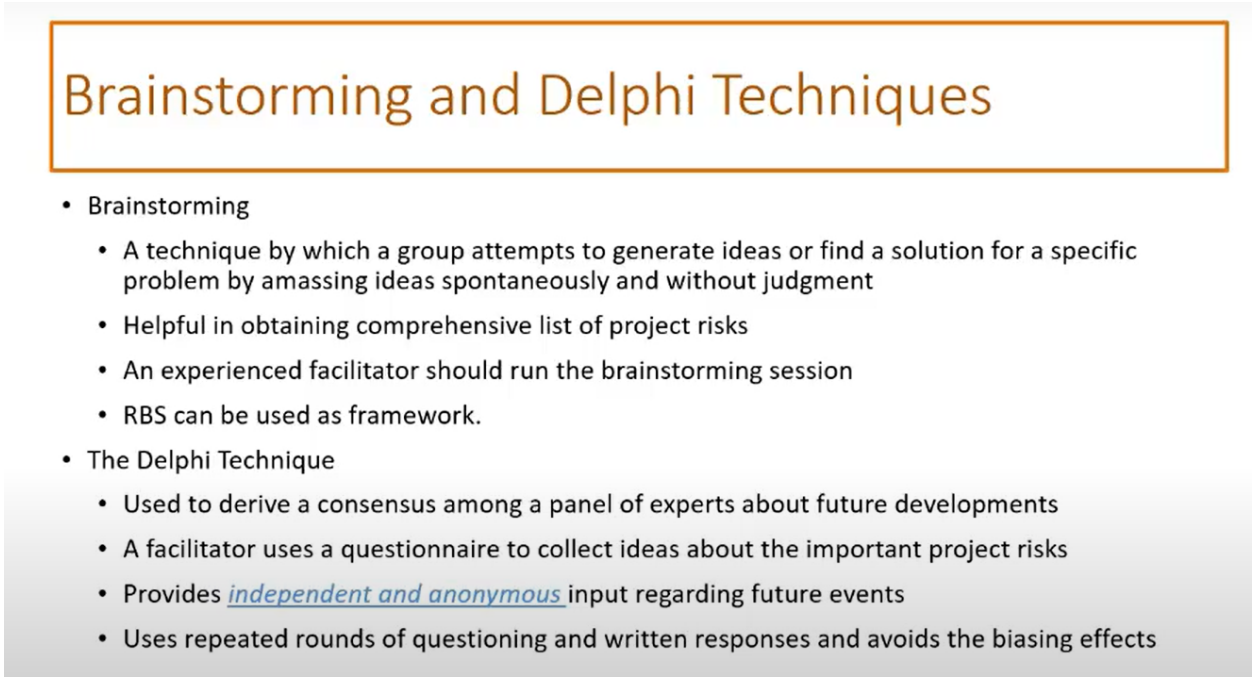
- Inputs:
  - Enterprise Environment Factors
  - Organizational Process Assets
  - Project Scope Statement
  - Project Management Plan
  - Risk Management Plan
- Tools & Techniques:
  - Documentation Reviews
  - Information gathering techniques
  - Checklist analysis
  - Assumption analysis
  - Diagramming techniques

Output: Risk Register

Information gathering



Brainstorming and delphi techniques



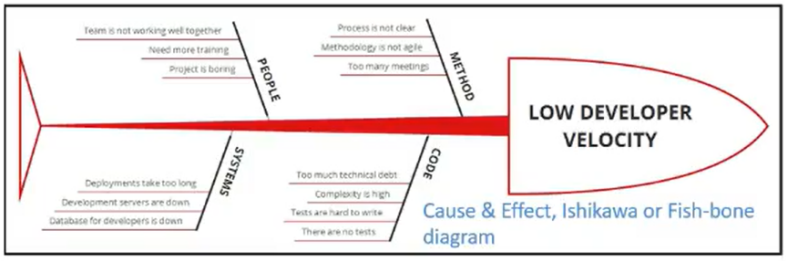
Interviewing

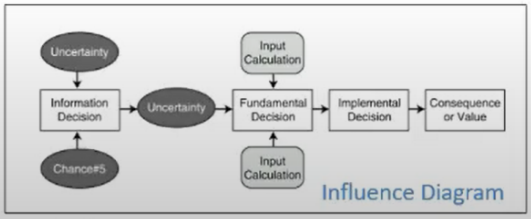
Interviewing, RCA and SWOT Analysis

- Interviewing
  - It is a fact-finding technique for collecting information in face-to-face, phone, e-mail, or instant-messaging discussions
  - Interviewing people with similar project experience such as SME, project team , stakeholders, is an important tool for identifying potential risks
- Root Cause Analysis helps in identifying the root cause of the risks so that effective risk responses can be developed
- SWOT analysis (strengths, weaknesses, opportunities, and threats) can also be used during risk identification

Diagramming

Diagramming Techniques



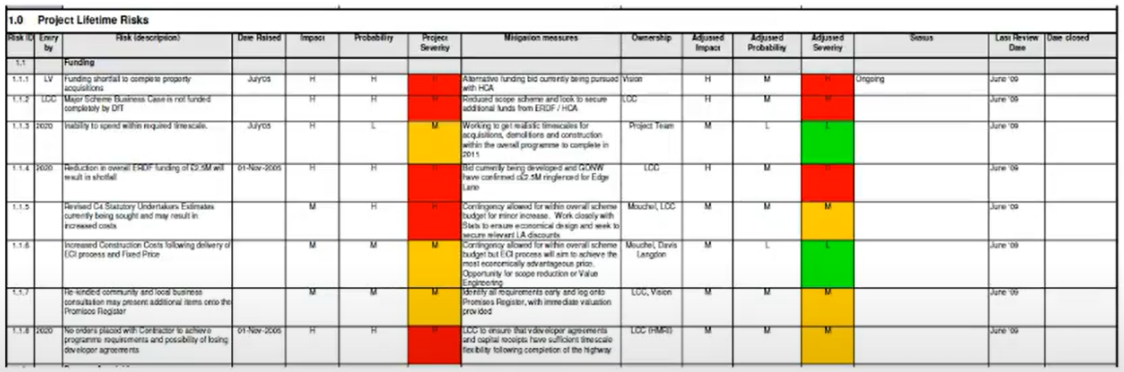


Register

Risk Register

- A risk register is:
  - A document that contains the results of various risk management processes and that is often displayed in a table or spreadsheet format
  - A tool for documenting potential risk events and related information
- Risk events refer to specific, uncertain events that may occur to the detriment or enhancement of the project

Risk Register - Sample



1.0 Project Lifetime Risks

Risk ID	Entry by	Risk (description)	Date Raised	Impact	Probability	Project Severity	Mitigation measures	Ownership	Adjusted Impact	Adjusted Probability	Adjusted Severity	Status	Last Review Date	Date closed
1.1		Funding												
1.1.1	LV	Funding shortfall to complete property acquisitions	July'05	H	H	H	Alternative funding bid currently being pursued with HCA	Vision	H	M	H	Ongoing	June '09	
1.1.2	LDC	Major Scheme Business Case is not funded completely by DfT		H	H	H	Reduced scope scheme and look to secure additional funds from ERDF / HCA	LDC	H	M	H		June '09	
1.1.3	2020	Inability to spend within required timescale.	July'05	H	L	M	Working to get realistic timescales for acquisitions, demolitions and construction within the overall programme to complete in 2011	Project Team	M	L	L		June '09	
1.1.4	2020	Reduction in overall ERDF funding of £2.5M will result in shortfall	01-Nov-2005	H	H	H	Bid currently being developed and GONW have confirmed c£2.5M ringfenced for Edge Lane	LDC	H	M	H		June '09	
1.1.5		Revised C4 Statutory Undertakers Estimates currently being sought and may result in increased costs		M	H	H	Contingency allowed for within overall scheme budget for minor increase. Work closely with Statutory Undertakers to ensure economical design and seek to secure relevant I.A discounts	Mouchel, LDC	M	M	M		June '09	
1.1.6		Increased Construction Costs following delivery of ECI process and Fixed Price		M	M	M	Contingency allowed for within overall scheme budget but ECI process will aim to achieve the most economically advantageous price. Opportunity for scope reduction or Value Engineering	Mouchel, Davis Langdon	M	L	L		June '09	
1.1.7		Re-kindled community and local business consultation may present additional items onto the Promises Register		M	M	M	Identify all requirements early and log onto Promises Register, with immediate valuation provided	LDC, Vision	M	M	M		June '09	
1.1.8	2020	No orders placed with Contractor to achieve programme requirements and possibility of losing developer agreements	01-Nov-2005	H	H	H	LDC to ensure that developer agreements and capital receipts have sufficient timescale flexibility following completion of the highway	LDC (HMR)	M	M	M		June '09	

Sample

Software Project Risk Register - Sample

Event	Type of Risk	Probability	Actions	Possible Impact
Payroll system power user is approaching retirement and could leave during the project	People	Medium	■ Document "as-is" and "to-be" processes ■ Create desk guides ■ Do job shadowing	■ Retirement will result in lack of technical expertise in the payroll system ■ Could cause future payroll run issues
Budget cuts could threaten project funding	Planning	High	■ Provide monthly progress updates for council	■ End of project ■ Cut corners in implementation ■ Lack of maintenance and support
New interface might be needed for homegrown automated time entry system	Technology	High	■ Engage vendor early ■ Identify necessary interfaces in project statement of work	■ Interface troubles will affect launch ■ User data entry requirements might change as result of changing interfaces

Qualitative risk analysis

Qualitative Risk Analysis

- Assess the likelihood and impact of identified risks to determine their magnitude and priority
- Qualitative analysis can also identify risks that should be evaluated on a quantitative basis
- It includes methods for prioritizing the identified risks for further action
- A watch list (non-critical or non-top risks) is a list of risks that are low priority, but are still identified as potential risks. They should be regularly monitored to check if probability and impact rating have changed

Qualitative Risk Analysis - Inputs, Tools & Output

- Inputs
  - Organizational Process Assets
  - Project Scope Statement
  - Risk management plan
  - Risk Register
- Tools & Techniques
  - Risk probability and impact assessment
  - Probability and impact matrix
  - Risk data quality assessment
  - Risk categorization
  - Risk urgency assessment

Output: Risk Register (Updates)

Impact matrix

Probability - Impact Matrix

- A probability/impact matrix or chart lists the relative probability of a risk occurring on one side of a matrix or axis on a chart and the relative impact of the risk occurring on the other
- List the risks and then label each one as high, medium, or low in terms of its probability of occurrence and its impact if it did occur
- Can also calculate risk factors
- Numbers that represent the overall risk of specific events based on their probability of occurring and the consequences to the project if they do occur

Probability - Impact : Definitions Sample

Probability Scale

Likelihood Class	Likelihood of Occurrence (events/year)
Very Low (VLOW)	<0.01% chance of occurrence
Low (LOW)	0.01 - 0.1% chance of occurrence
Moderate (MOD)	0.1 - 1% chance of occurrence
High (HI)	1 - 10% chance of occurrence
Very High (VHI)	>10% chance of occurrence

Impact Scale

Consequence	Quality
Very High (VHI)	Fatal error / System crash
High (HI)	Not all critical features are functional
Moderate (MOD)	All features are working but performance is slow
Low (LOW)	Some of the non-critical features are not working
Very Low (VLOW)	Usability errors such as tabs not in order, field layout not proper etc.

Probability - Impact Matrix: Sample

Probability and Impact Risk Ranking

Probability	Threats					Opportunities					Probability
VHI	L	M	M	H	H	H	H	M	M	L	VHI
HI	L	L	M	H	H	H	H	M	L	L	HI
MOD	L	L	M	H	H	H	H	M	L	L	MOD
LOW	L	L	L	M	H	H	M	L	L	L	LOW
VLOW	L	L	L	L	M	M	L	L	L	L	VLOW
	VLOW	LOW	MOD	HI	VHI	VHI	HI	MOD	LOW	VLOW	
	Impact (Threats)					Impact (Opportunities)					

Risk Register Update

- Add
  - Probability and Impact Matrix results
  - Perform quality check on results
  - Categorize the risks to make them easier to handle
  - Perform urgency assessment to determine which risk need immediate attention

Quantitative

Quantitative Risk Analysis

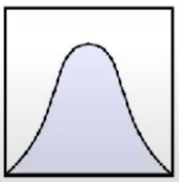
- Quantitative Risk Analysis is performed on risk that have been prioritized by the Qualitative Risk Analysis process as potentially and substantially impacting the project's competing demands.
- Numerical Analysis of the probability and impact of high risk identified in Qualitative Risk Analysis
- Often follows qualitative risk analysis, but both can be done together or sometimes can be performed directly after risk identification
- Large, complex projects involving leading edge technologies often require extensive quantitative risk analysis
- Should be repeated after Risk Response Planning as well as part of risk Monitoring and control

Quantitative Risk Analysis -Inputs, Tools & Output

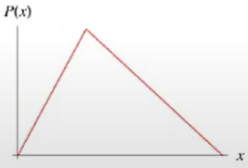
- Inputs
  - Organizational process assets
  - Project Scope Statement
  - Risk Management Plan
  - Risk Register
  - Project management plan
    - Project Schedule Management Plan
    - Project Cost Management Plan
- Tools
  - Data gathering and representation techniques
  - Quantitative risk analysis and modeling techniques

Quantitative Risk Analysis - Tools

- Data Gathering and Representation Techniques
  - Interviewing – to quantify the probability and impact of risks on project objectives
  - Probability Distribution - Continuous probability distribution such as Beta and Triangular distribution represent the uncertainty in values. For example : schedule or cost. These charts represent possible value of time or cost against relative likelihood.



Beta Distribution

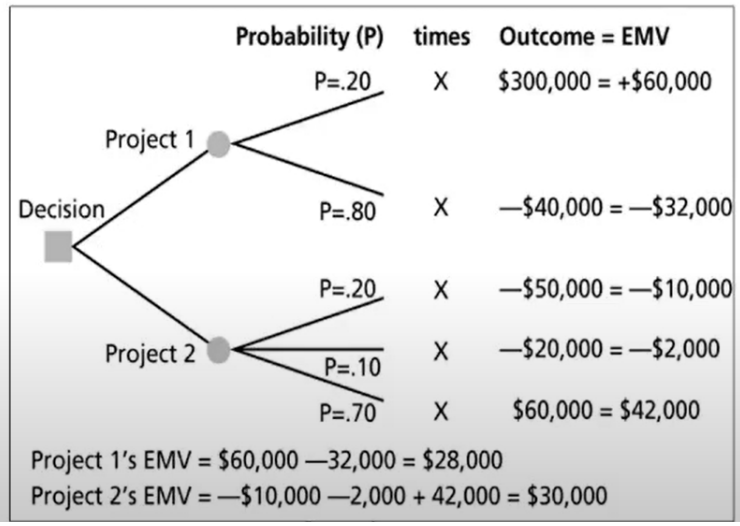


Triangular Distribution

Quantitative Analysis and Modeling Techniques

- Sensitivity Analysis
  - Sensitivity analysis is a technique used to show the effects of changing one or more variables on an outcome
  - Spreadsheet software, such as Excel, is a common tool for performing sensitivity analysis
  - Helps to determine which risks have the most potential impact on the project
  - Similar to DOE (Design of experiments)
- Estimated or Expected Monetary Value (EMV)
  - Estimated monetary value (EMV) is the product of a risk event probability and the risk event's monetary value
  - EMV of opportunities is expressed as positive values, and those of risks will be negative.
- Decision Tree Analysis
  - A decision tree is a diagramming analysis technique used to help select the best course of action in situations in which future outcomes are uncertain

Expected Monetary Value (EMV) - Example



Modeling and simulation

Modeling & Simulation

- Simulation uses a representation or model of a system to analyze the expected behavior or performance of the system.
- It translates the uncertainties into potential impact on project objectives.
- Simulations are typically performed using Monte Carlo technique.
- Monte Carlo analysis is a technique that converts uncertainties in input variables of a model into probability distributions. By combining the distributions and randomly selecting values from them, it recalculates the simulated model many times and brings out the probability of the output.
- It helps to understand the impact of uncertainty and develop plans to mitigate that risk.
- Provides the probability of completing project on a specific day or for any specific cost
- Results in probability distribution

Risk response planning

Risk Response Planning

- After identifying and quantifying risks, you must decide how to respond to them
- Process of developing options and actions to enhance opportunities and reduce threats of the project objectives
- Inputs
  - Risk Management Plan
  - Risk Register
- Tools & Techniques
  - Strategy for negative risk or threats
  - Strategy for positive risk or opportunities
  - Strategy for both threats and opportunities
  - Contingent response strategy

Output:
Risk register (updates)
Project management plan (updates)
Risk-related contractual agreements

Risk response strategy

Risk Response Strategy

- Response techniques or strategies for negative risks:
  - Avoid (Relaxing the objective that is in jeopardy, reducing scope, extending schedule)
  - Transfer (Buying insurance, performance bonds, warranties, guarantees, contracts)
  - Mitigate (conducting more tests, choosing more stable supplier, prototype)
- Response techniques or strategies for positive risks:
  - Exploit (Add work or change the project to make sure the opportunity occurs, assigning more talented resources to reduce the time to completion)
  - Share (Allocate ownership of the opportunity to a third party, joint venture, partnerships)
  - Enhance (Increase the likelihood, probability and positive impacts of the risk event)
- Strategy for both threats and opportunities
  - Accept (If it happens, it happens)

Risk monitoring and control

Risk Monitoring and Control

- Involves executing the risk management process to respond to risk events
- Process of identifying, analyzing, and planning for newly arising risks, keeping track of the identified risks and risks on watchlist, monitoring trigger conditions for contingency plans, monitoring residual risks, evaluating the effectiveness of risk responses
- Workarounds are unplanned responses to risk events that must be done when there are no contingency plans

Risk Monitoring and Control - Inputs, Tools & Output

- Inputs
  - Risk management plan
  - Risk Register
  - Approved change requests
  - Work Performance information
  - Performance Reports
- Tools & Techniques
  - Risk reassessment
  - Risk audits
  - Variance and trend analysis
  - Technical performance measurement
  - Reserve analysis
  - Status meetings

Output:
Risk register (updates)
Requested Changes
Recommended corrective actions
Recommended preventive action
Organizational Process assets (updates)
Project management plan (updates)

Reality Check!

- 96 percent of global executives believe their risk management could be improved, according to an Ernst and Young survey
- 39 percent of executives admit they were caught off-guard by risk events that impacted project success "extensively" or "a great deal."
- Although only 15.5 percent have formal guidelines on how to assess the probability or potential impact of a risk event, 60.5 percent believe risks are being effectively reviewed and monitored
- What's happening on Project A may have implications on Project B, but you can't make judgments unless you have accurate project data
- Low-likelihood, high-impact risks that can have a huge effect on the company warrant more time and thought on how to mitigate and control them
- You have to consider worst-case scenarios and the impact of interrelated risks if they happen concurrently
- Always be prepared for the unexpected
- Whether it's COVID lock down, Dengue fever, torrential rain or a food-borne illness outbreak, the plan has to be in place to deal with the event before the event happens

Results of Effective Risk Management

- Unlike crisis management, good project risk management often goes unnoticed
- Well-run projects appear to be almost effortless, but a lot of work goes into running a project well
- Project managers should strive to make their jobs appear simple to reflect the results of well-run projects

Critical Success Factors

- Clear project / business objectives
- Unambiguous scope definition with boundaries, including functional and non-functional requirements
- Plan any COTS use carefully
- Active involvement of business stakeholders throughout the project
- Integrated project team representing all functions
- Effective project management
- Strong project controls
- Robust systems and processes
- Acknowledge all project risks
- Communicate frequently and honestly

Software Projects Risk Ranking Survey Results

1. Project size (# stakeholders)
2. Application complexity (# Interfaces / integrations with other systems)
3. Technology acquisition
4. Insufficient resources
5. Lack of team expertise
6. Lack of user support
7. Lack of user experience
8. Lack of clear role definition
9. Intensity of conflicts

Source: Jiang, J. J. & Klein, G. (2001). Software project risks and development focus. *Project Management Journal, 32*(1), 4–9.

Top Risks In Indian Software Industry

1. Requirement specification changes or variability
2. Team composition
3. Control processes
4. Third-party dependencies

Video - 4
COST MANAGEMENT

What is Project Cost Management?

- Cost is a resource sacrificed or foregone to achieve a specific objective or something given up in exchange
- Costs are usually measured in monetary units like rupees or dollars or any currency
- Project Cost Management includes the processes involved in planning, estimating, budgeting, and controlling costs so that the project can be completed within the approved budget

Cost Management Processes

- **Cost estimating**: developing an approximation or estimate of the costs of the resources needed to complete a project. This is the process where estimates for each activity are made. What do we estimate?
- **Cost budgeting**: allocating the overall cost estimate to individual work items to establish a baseline for measuring performance. This is the process of combining all estimates into one budget.
- **Cost control**: influencing the factors that create cost variances and controlling changes to the project budget

Financial Terms

- Most members of an executive board better understand and are more interested in financial terms than IT terms, so IT project managers must speak their language
  - **Profits** are revenues minus expenditures
  - **Profit margin** is the ratio of profits to revenues
  - **Cash flow** analysis determines the estimated annual costs and benefits for a project and the resulting annual cash flow
  - **Life cycle costing** considers the total cost of ownership, or development plus support costs, for a project.
  - **Value Engineering** or **Value analysis** is finding a less costly way to do the same work. Decreasing cost but maintaining the same scope.
- **Tangible costs** or **benefits** are those costs or benefits that an organization can easily measure in rupees, dollars etc.
- **Intangible costs** or **benefits** are costs or benefits that are difficult to measure in monetary terms

Financial Terms (contd.)

- **Fixed Cost** are cost that do not change as production changes. Such as set up cost, rental etc.
- **Variable Cost** are cost that change with the amount of production or the amount of work. Such as cost of material, supplies, wages
- **Direct costs** are costs that can be directly related to producing the products and services of the project
- **Indirect costs** are costs that are not directly related to the products or services of the project, but are indirectly related to performing the project
- **Sunk cost** is money that has been spent in the past; when deciding what projects to invest in or continue, you should *not* include sunk costs
- **Opportunity Cost** is the cost of choosing one alternative and therefore giving up the potential benefits of another alternative

Financial Terms (contd.)

- **Reserves** are money included in a cost estimate to mitigate cost risk by allowing for future situations that are difficult to predict
- **Contingency reserves** are estimated costs to be used at the discretion of the project manager to deal with anticipated, but not certain events. These events are also called **"known unknowns**" and are part of the project scope and cost baselines
- **Management reserves** are budgets reserved for unplanned, but potentially required changes to project scope and cost. They are called "**unknown unknowns**" and Project manager must obtain approval before spending this reserve. They are not distributed as budget, therefore are not a part of earned value calculations

Financial Terms (contd.)

- **Fiscal year** (or financial year, or sometimes budget year) is used by government accounting and budget purposes, which varies between countries. It is also used for financial reporting by businesses and other organizations. In India, fiscal year is between April 01 to March 31. (US: Jan-Dec, Australia: Jul-Jun, Thailand: Oct-Sep)
- **Capex** (capital expenditure or capital expense) is the money an organization or corporate entity spends to buy, maintain, or improve its fixed assets, such as buildings, vehicles, equipment, or land. The expense is considered capex if the financial benefit of the expenditure extends beyond the current fiscal year
- **Opex** (operating expenditure or operating expense) is an ongoing cost for running a product, business, or system

Cost Management Plan

- A Cost Management plan
  - Is a document that describes how the organization will manage cost baseline and cost variance on the project
  - Can be formal or informal, but part of Project Management Plan (part of Develop Project Management Plan Process)
  - States how estimates will be stated, at what level of WBS
  - Helps to determine if the variance is within the allowable limits and any action to be taken

Cost Estimation

Cost Estimation

- Estimate should be based on a WBS to improve accuracy.
- Estimation should be done by the person doing the work whenever possible.
- A cost baseline should be kept and not changed except for approved changes.
- Changes are approved in integrated change control.
- Corrective and preventive actions should be recommended when cost problems occur.
- A project manager should never just accept requirements from management, but rather analyze the needs of the project, come up with own estimates and reconcile any differences to produce a realistic objectives.
- A project manager should always ensure that adequate funds are available for the project.
- Plans should be revised whenever necessary.
- Padding is not an acceptable project management practice

Types of cost estimates

Types of Cost Estimates

Type of estimate	When done	Why done	How accurate
Rough Order of Magnitude (ROM)	Very early in the project lifecycle	Provides estimate of costs for selection decisions	-50% to +100%
Budgetary	Early	Puts rupees in the budget plans	-10% to +25%
Definitive	Later in the project	Provides details for purchase; Estimates actual costs	-5% to +10%

Cost Estimating – Inputs, Tools and Techniques and Outputs

Inputs	Tools & Techniques	Outputs
•Enterprise Environmental factors •Organizational Process Assets •Project Scope Statement •WBS •WBS Dictionary •Project Management Plan -Schedule mgmt. plan -Staffing mgmt. plan -Risk register	•Analogous estimating •Determine Resource Costs rates •Bottom-up estimating •Parametric Estimating •Project Management Software •Vendor bid analysis •Reserve analysis •Cost of Quality	•Activity Cost Estimate •Activity Cost Estimate Supporting Detail •Requested Changes •Cost Mgmt. Plan (Updates)

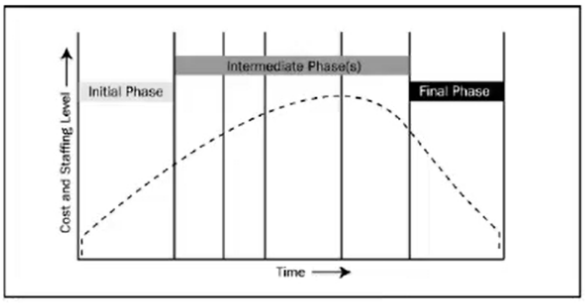
Cost Estimation Tools and Techniques

- **Analogous** or **top-down** estimates: use the actual cost of a previous, similar project as the basis for estimating the cost of the current project
  - Quick but less accurate
  - Less costly but needs considerable experience to do well
- **Bottom-up** estimates: involve estimating individual work items or activities and summing them to get a project total
  - Takes time but more accurate
  - Based on the detailed analysis, requires time to break down the project in smaller pieces
- **Parametric modeling**: uses a statistical relationship between historical data and other variables to calculate a cost estimate (lines of code, square foot in construction)
  - Uses project characteristics (parameters) in a mathematical model to estimate project costs
  - Can produce high level of accuracy depending upon the sophistication, as well as underlying resource quantity and cost data built into the model

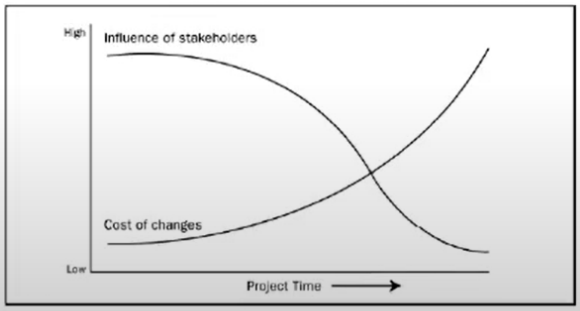
Sample Project Cost Estimate

WBS Items	Units / Hrs	Cost/ Unit/ Hours	Sub-total	WBS Level 1 totals	% of Total
1. Project Management				**$306,300**	20%
Project Manager	960	$100	$96,000		
Project Team Members	1920	$75	$144,000		
Contractors (10% of Software Development and Testing)			$66,300		
2. Hardware				**$76,000**	5%
Hardware devices	100	$600	$60,000		
Servers	4	$4000	$16,000		
3. Software				**$614,000**	40%
Licensed Software	100	$200	$20000		
Software development			$594,000		
4. Testing (10% of total Hardware and Software cost)			$69,000	**$69,000**	5%
5. Training and Support				**$202,400**	13%
Trainee Cost	100	$500	$50,000		
Travel Cost	12	$700	$8,400		
Project Team Members	1920	$75	$144,000		
6. Reserves (20% of total estimate)			$253,540	**$253,540**	17%
Total project estimate				**$1,521240**	

Cost of changes



Tip : The ability to influence cost is greatest at the early stages of the project, and this is why early scope definition is critical.



Source: PMI PMBOK (Third Edition)

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Cost budgeting

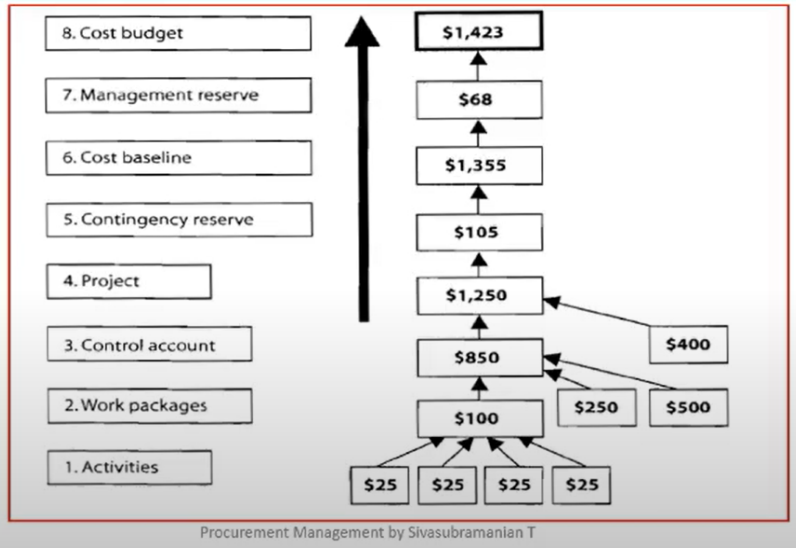
Cost Budgeting

- Cost budgeting involves allocating the project cost estimate to individual work items over time
- The WBS is a required input to the cost budgeting process since it defines the work items
- An important goal is to produce a **cost baseline**
  - A time-phased budget that project managers use to measure and monitor and control overall cost performance on the project
  - It is developed by summing estimated costs by period and is usually displayed in the form of S-curve
  - Cost baseline is a component of Project Management Plan
  - Cost baseline includes Contingency reserve and cost budget includes Management Reserves.

Cost Budgeting – Inputs, Tools and Techniques and Outputs

Inputs	Tools & Techniques	Outputs
•Project Scope Statement •WBS •WBS Dictionary •Activity Cost Estimates •Activity Cost Estimates Supporting Detail •Project schedule •Resource Calendar •Contract •Cost Mgmt. Plan	•Cost Aggregation •Reserve analysis •Parametric Estimating •Funding limit reconciliation	•Cost Baseline •Project Funding Requirements •Cost Mgmt. Plan (Updates) •Requested Changes

Cost Budgeting



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Control

Cost Control

- Cost Control includes
  - Influencing the factors that create changes to the cost baseline
  - Managing the actual changes when they occur
  - Assuring the potential cost overruns do not exceed the authorized funding
  - Monitoring cost performance to detect variances from cost baseline
  - Preventing incorrect or unapproved changes from being included
  - Informing appropriate stakeholders for approved changes
  - Taking corrective actions to bring the cost overruns within acceptable limits

Cost Control – Inputs, Tools and Techniques and Outputs

Inputs	Tools & Techniques	Outputs
•Cost Baseline •Project Funding Requirements •Performance Reports •Work Performance information •Approved change requests •Project Management Plan	•Cost Change Control system •Performance Measurement Analysis •Forecasting •Project Performance Reviews •Project Management Software •Variance Management	•Cost Estimates (updates) •Cost Baseline (updates) •Performance Measurements •Forecasted Completion •Requested Changes •Recommended Corrective Actions •Organizational process Assets (updates) •Project Management Plan (updates)

Cost Control – Tools and Techniques

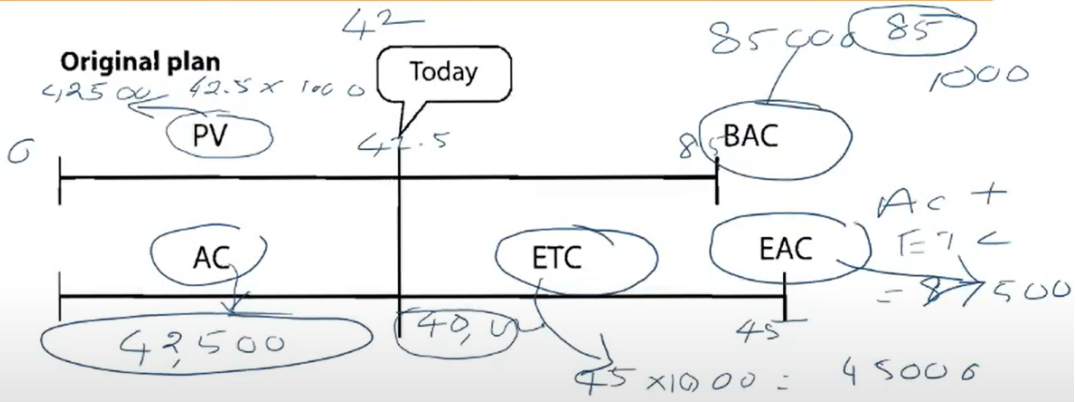
- Performance Measurement Analysis
  - This helps to assess the magnitude of any variances that will invariably occur
  - Earned Value Technique (EVT) compares the cumulative value of budgeted cost of work performed (earned) at the original allocated budget amount to both the budgeted cost of work scheduled(planned) and to the actual cost of work performed (actual)
  - This technique is especially useful for cost control, resource management and production

EVM

Earned Value Management (EVM) Technique

- EVM is a project performance measurement technique that integrates scope, time, and cost data
- A method to measure project performance against the project baseline
- Results from Earned Value Analysis, indicate potential deviation of the project from cost and schedule baselines
- Can be used to forecast future performance and project completion dates and costs

Estimate At Complete (EAC) Vs Estimate To Complete (ETC)



Some more Financial & Accounting terms

- Present Value
  - Present value means the value today of future cash flows
- Net Present Value
  - Present value of total benefits (income or revenues) less the costs over many time periods
- Internal Rate of Return
  - The rate at which the project inflows (revenues) and project outflows (costs) are equal
- Payback Period
  - The number of time periods it takes to recover the investment before you start accumulating profits
- Benefit Cost Ratio
  - Benefit to cost ratio. > 1 means benefits are greater than the costs

Depreciation

Depreciation

- Loosing value of an asset over time
- Two types of depreciation
  - Straight Line Depreciation
    - The same amount of depreciation is taken every year
  - Accelerated Depreciation : Depreciates faster than straight line
    - Double Declining Balance
    - Sum of the years digits

Exercise Test yourself! For each row on the following chart, enter the letter of the project you would select if the following information was provided.

	Project A	Project B	Which Project Would You Pick?
Net present value	$95,000	$75,000	
IRR	13 percent	17 percent	
Payback period	16 months	21 months	
Benefit cost ratio	2.79	1.3	

You have two projects to choose from. Project A will take three years to complete and has an NPV of $45,000. Project B will take six years to complete and has an NPV of $85,000. Which one would you prefer?

Answer *Project B.*

What is the opportunity cost of selecting project B?

Answer *$45,000.*

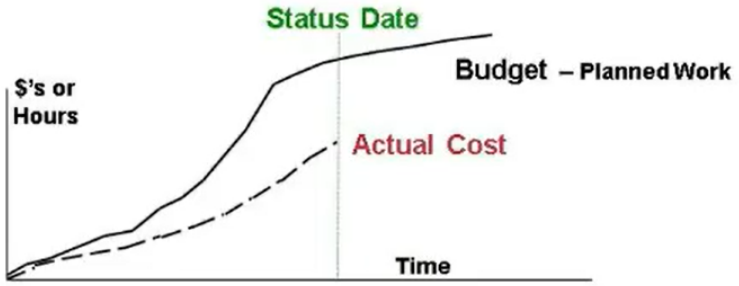
You have two projects to choose from; Project A with an IRR of 21 percent or Project B with an IRR of 15 percent. Which one would you prefer?

Answer *Project A.*

Earned value management

Traditional Project Cost Curve

What can you tell about project performance from this cost curve?



- ❑ 1. Completing work for less than the budgeted amount
- ❑ 2. Behind the project schedule
- ❑ 3. Spending less than planned
- ❑ 4. Behind schedule & completing work for less than the budget amount

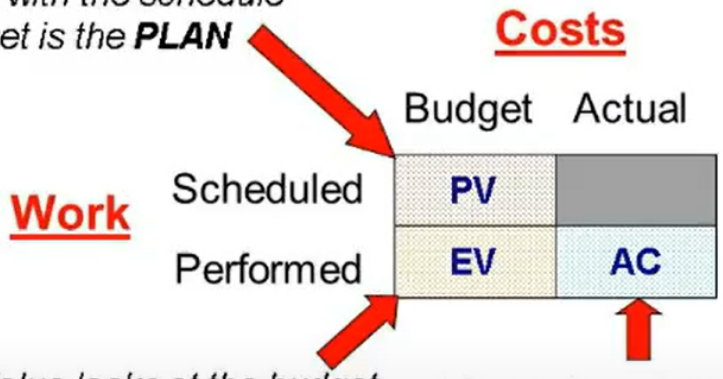
Earned Value Terms

- **Planned Value (PV):** -This is the budget cost of *what was scheduled to be done*
- **Actual Cost (AC):** This is *what the work actually cost*
- **Earned Value (EV):** This is *what was actually done (earned)*

EV = % Complete x budget $ for that activity

Earned Value Relationships

*The work with the schedule and budget is the **PLAN***



Earned Value looks at the budget amount for the work performed

*The work performed (done) and the costs for that work are **ACTUAL** results*

Units Completed - Examples

- Example: installation of 1000 feet of 8" water main. If 400 feet are installed:

  % Complete = (400/1000)x100 = 40%

- Pipe fabrication drawings – 100 required and 45 are done. Progress?
- New computers for office – total of 500 to install, 350 done. Progress?

Qualitative Progressing

- **Level of Effort** - assumes the progress of the activity is equal to the amount spent

- **Individual Judgment** - Important to get multiple opinions of progress, this provides a 'checks and balance' on the progress accuracy

Incremental Milestone Example

Engineering Drawing

Task	Incremental Progress	Cumulative Progress
Drawing started	10%	10%
Prepare first draft	35%	45%
Conduct first review	10%	55%
Prepare updates	10%	65%
Conduct final reviews	10%	75%
Prepare final revisions	15%	90%
Obtain approvals	10%	100%

Schedule & Cost: Variance & Index

- **Schedule Variance**
  measures schedule performance at a point in time:

$$SV = EV - PV$$

- **Schedule Performance Index**
  ratio of work performed to work scheduled (earned / plan):

$$SPI = EV \setminus PV$$

- **Cost Variance**
  measures cost performance at a point in time:

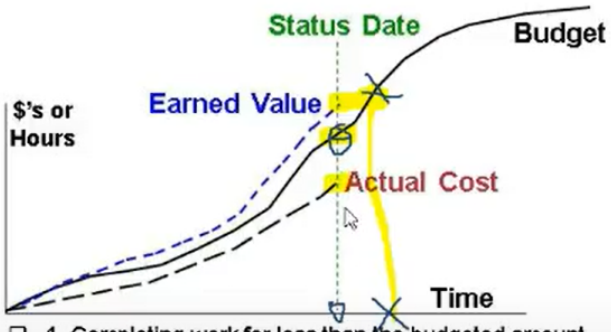
$$CV = EV - AC$$

- **Cost performance index**
  ratio of budget costs for work performed to actual costs:

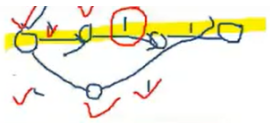
$$CPI = EV \setminus AC$$

Earned Value Analysis Curve

What can you tell about project performance from this cost curve?



- ☐ 1. Completing work for less than the budgeted amount
- ☐ 2. Ahead of the project schedule
- ☐ 3. Ahead of the project schedule & spending less than planned
- ☐ 4. Ahead of schedule & completing work for less than the budget amount



SPI Warning!!!

- **Caution!** The Schedule Performance Index may or may not accurately reflect the true schedule condition of the project!
  - Total Float must also be considered!
  - SPI > 1.0 may occur by "earning" progress on non-critical activities

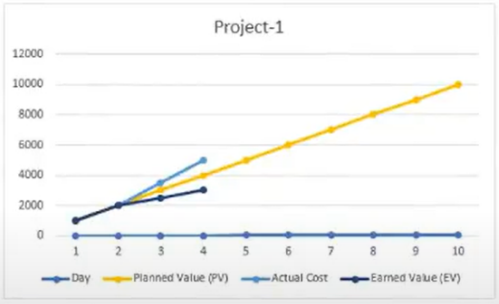
Key Cost Forecasting Terms

- **Budget at Completion (BAC)** - sum of all authorized budgets allocated to a project - the "Performance Measurement Baseline"
- **Estimate to Complete (ETC)** - the expected *additional* cost to complete the project
- **Estimate at Completion (EAC)** - the expected *total* cost of the project when the defined scope of work is completed

EVM Example-1

- Cost per day = 1000 Rs.; Value per program = 1000 Rs.

Day	Cumulative cost (Rs.)	# Cumulative Programs to complete	Planned Value (PV)	Actual Cost	Actual pgms. completed	Earned Value (EV)
1	1000	1	1000	1000	1	1000
2	2000	2	2000	2000	2	2000
3	3000	3	3000	3500	2.5	2500
4	4000	4	4000	5000	3	3000
5	5000	5	5000			
6	6000	6	6000			
7	7000	7	7000			
8	8000	8	8000			
9	9000	9	9000			
10	10000	10	10000			



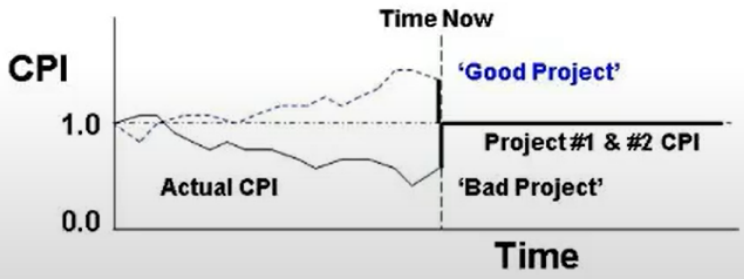
EVM Example-2

- Cost per day = 1000 Rs.; Value per program = 1000 Rs.

Day	Cumulative cost (Rs.)	# Cumulative Programs to complete	Planned Value (PV)	Actual Cost	Actual pgms. completed	Earned Value (EV)
1	1000	1	1000	1000	1	1000
2	2000	2	2000	2000	2	2000
3	3000	3	3000	3000	3.2	3200
4	4000	4	4000	4000	4.5	4500
5	5000	5	5000	5000	6	6000
6	6000	6	6000			
7	7000	7	7000			
8	8000	8	8000			
9	9000	9	9000			
10	10000	10	10000			

EAC Formulas: CPI = 1

- 'Mathematical' ***or*** 'Overrun-to-Date' EAC
- **EAC = AC + (BAC - EV)** - assumes the plan will be met for the remaining work (CPI = 1.0)
- Yields the most **optimistic** EAC when CPI < 1.0



Comments on Cumulative CPI

- Cumulative CPI has been shown to stabilize as early as the 20% completion point of the project
- "…researchers found the cumulative **CPI does not change by more than 10% once a contract is 20% complete**; in most cases, the cumulative CPI one worsens as a contract proceeds to completion"[1]

[1] Dr. David S. Christensen, "Using Performance Indices to Evaluate the Estimate at Completion," *The Journal of Cost Analysis of the Society of Cost Estimating and Analysis*, Spring 1994, page 19.

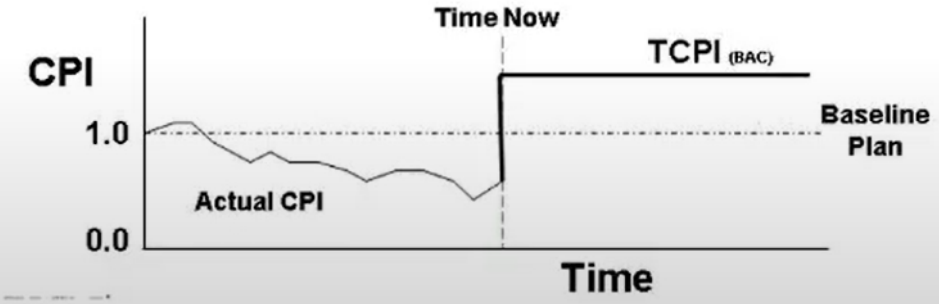
To-Complete Performance Index

- **TCPI** – provides a forecast of the required performance level, expressed as a CPI, which must be achieved on the remaining work in order to meet the project financial goal, which can be:
  - Current authorized budget
  - Project Manager's current EAC
- **TCPI** – provides a sanity check for the Project Manager on whether the required CPI for the rest of the project is obtainable
- Remember: "…cumulative CPI does not change by more than 10% once a contract is 20% complete…"

TCPI Formulas

$$TCPI_{(BAC)} = \frac{\text{Work Remaining}}{\text{Funds Remaining}} = \frac{(BAC - EV)}{(\mathbf{BAC} - AC)}$$

$$TCPI_{(EAC)} = \frac{\text{Work Remaining}}{\text{Funds Remaining}} = \frac{(BAC - EV)}{(\mathbf{EAC} - AC)}$$



How to Successfully Use EV

…what's needed:

1. Complete Requirements
2. Complete WBS
3. Integrated & Correct Project Plan
4. Change Management Process
5. Effective Cost System
6. Accurate Reported Progress

Conclusion

- Earned Value is a methodology that, if used properly, provides project performance measurement
- EV requires complete requirements, scope definition and a Project Plan!
- Properly used, Earned Value is a flexible process that provides timely information on the project health