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NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 01

Introduction of Project Management

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Project Management Fundamentals
Project evaluation methods
Project Integration and scope Management
Project Planning and Scheduling
Project networking
PERT/CPM techniques
Project scheduling with resources
Project risk management
Project contract and materials management
Cost management and Cost estimation
Quality Assurance and Quality Control
Computer Based Project Management

Project Management Course Objectives:

- To understand the importance of project management in today's world.
- To establish the importance of projects in implementing organization strategy
- To understand the rules for creating a Work Breakdown Structure for a project
- To demonstrate the importance of WBS to the management of projects and how it serves as a database for planning and control
- To develop a network diagram for a project

- To understand why estimating project times and costs are the foundation for project planning and control

- To understand the intricacies of project earned value analysis

- To illustrate approaches for risk identification, analysis, and assessment
- To understand the procurement process and the risks involved in different contracts

- To identify key characteristics of a high-performance project team
- To understand the critical success factors in project management

- To understand project closure process

•Cement Project, power project, refinery project, fertilizer project, etc.

•Term project is common - plants are not. In each case the project is for the plant but as soon as the plant is operational, the project is deemed to be completed.

•Project for method improvement.

•The explicit use of the term "project" is not always necessary - elections, admission process, road-dam-building construction.

•A project, therefore, is not a **physical object, nor it is the end result** – it has something to do with **the going - on in between**, which must be the same, whether we build a high technology process plant or merely hold an election, to deserve a common name and to be termed as a project.

A project is, thus, initiated to achieve the mission-whatever the mission may be. A project is completed as soon as the mission is fulfilled.

A combination of **human and non human recourses** pooled together to in a **temporary organization** to serve **specific purpose**.

What is project success??

A project is “a temporary endeavor undertaken to create a unique product, service, or result.”

Operations is work done to sustain the business.

A project ends when its objectives have been reached, or the project has been terminated.

Projects can be large or small and take a short or long time to complete.

What is a project??

- A group of tasks (activities) performed within a definable time period (schedule) in order to meet a specific set of goals/objectives (performance) within a budget (cost plan)
- A project generally exhibits most of the following conditions:
  - It is ***unique***
  - A project is ***finite***
  - Usually ***complex***
  - A project is ***heterogeneous***
  - ***Non-repetitive***
  - Requires ***multiple resources*** from a finite resource pool

- **Fixed set of objectives**
- **Team work**
- **Life cycle**
- **Made to order**
- **Multi skilled staff required**
- **Subcontracting**
- **Risk and uncertainty**

It is a one shot, time limited, **goal directed**, major undertaking, requiring the commitment of **varied skills and resources**.

A project is defined to be a **task** which has a definite **beginning-definite end time** and which consists of several activities or jobs.

SMART project

- Specific: project should be targeting specific aim or goal.
- Measurable: It should be **quantifiable**.
- Attainable: It should be attainable with resources available.
- Realistic: It should be realistic in nature, dreaming is fine, but we certainly can not manage the dreams. We need some real things to be managed.
- Time-limited: As mentioned earlier there is fixed time limit for any project.

Examples of projects include, but are not limited to:

- Developing a **new product** or service
- Effecting a change in **structure**, staffing, or style of an **organization**
- Designing a new **transportation** vehicle
- Developing or acquiring a new or modified **information system**
- Constructing a **building** or facility
- Building a **water system** for a community
- Running a **campaign** for political office
- **Implementing** a new business procedure or process

Various elements of project: Based on set of definitions

Projects are **complex, one time** processes

Projects **are limited by budget ,schedule, and resources**

Projects are developed to resolve a clear **goal or set of goals**

Projects are **customer focused**

Process & Project Management

Process	Project
1. Repeat process or product	1. New process or product
2. Several objectives	2. One objective
3. On-going	3. One shot – limited life
4. People are homogeneous	4. More heterogeneous
5. Systems in place	5. Systems must be created
6. Performance, cost, & time known	6. Performance, cost & time less certain
7. Part of the line organization	7. Outside of line organization
8. Bastions of established practice	8. Violates established practice
9. Supports status quo	9. Upsets status quo

	Project Management	Operations Management
Repetition	Non repetitive	Repetitive
Work force required	Multi-skilled or very highly specialized for short durations	Limited skills, a huge learning effect
Revenues	No revenues	Revenues and profit/losses
Objective	Scope, performance, time, cost	Profits generated, cost reduced, quality of products or services
Equipments needed	Special purpose equipments for a short durations	Same equipments are continuously used
Subcontracting	Essential, involves many subcontracting agencies	Generally avoid use of subcontracting agencies
Risk	Very high risk as generally no chance of recursion	Risk is less as chances of improvement always there

	Project Management	Operations Management
Duration	Fixed, ceases with attainment of objective	Continuous in nature, ceases in special situations like divestment.
Improvement	Radical improvement to face the existing competitor	Incremental improvement to reduce cost or add to value
Major impact	future	present
goal	Creation of new thing	Maintenance of existing thing

What is project management??

Project management is “the application of knowledge, skills, tools, and techniques (KSTT) to project activities to meet project requirements.”*

Project Management

- Project Management are the management activities of **planning, directing, and controlling resources** (???????) to meet the **technical, cost, and time constraints** of a project.

Importance of PM??????

Importance of PM??????

Fast technological changes: Electronic goods

Narrow product launch windows:

High entropy of system: Expasion

Short life cycle of products: s/w,moblile.

Globalization impact:BRICS

Large organizations:

Customer focus

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Project Success

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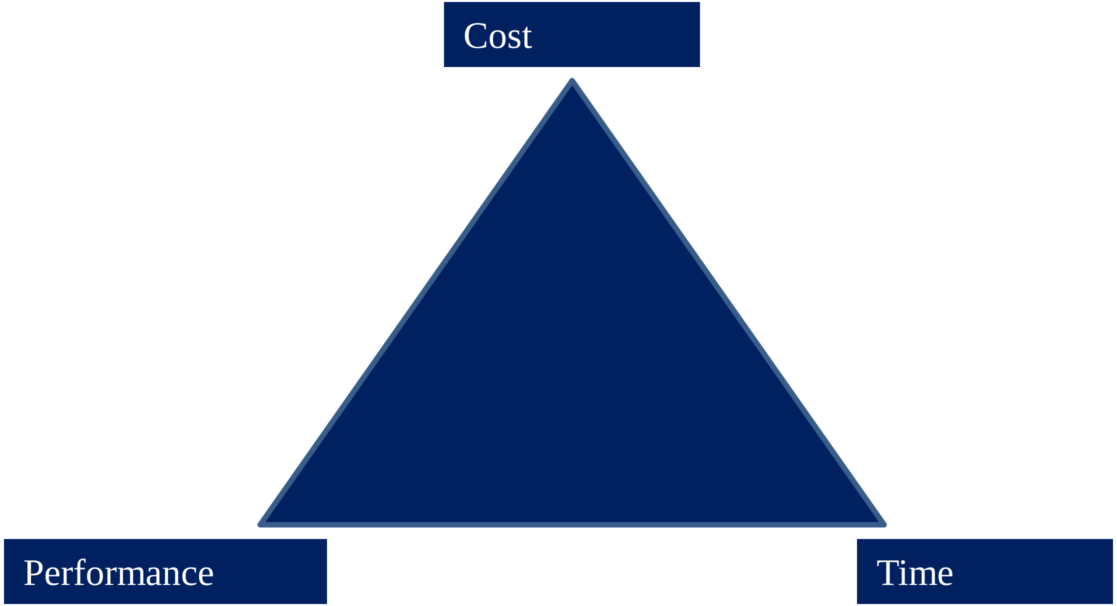
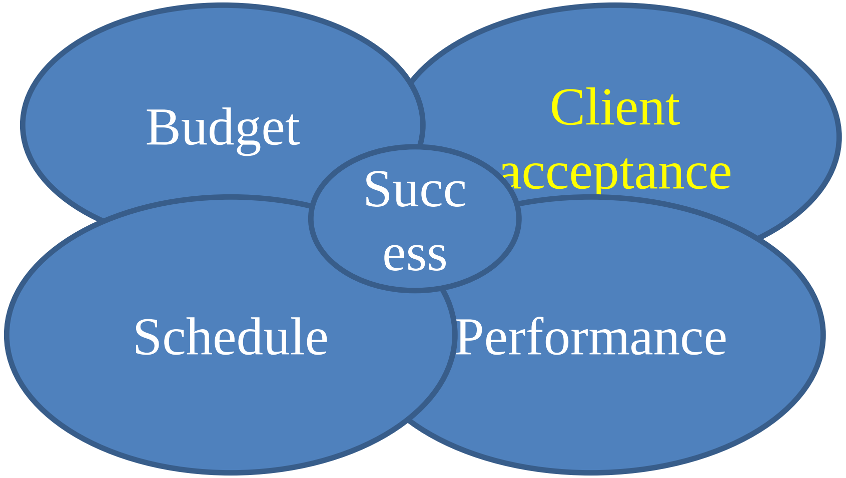
Determinants of project success??????



Iron triangle

The new quadruple approach



Objectives of PM/ Determinants of project success

1. **Scope-**cricket, badminton, tennis players have boundaries. People live in slums (No of family, no of family members, their income, etc) .

2. **Performance (technical)-** Water treatment plant- to clean 10000 lts/day.

3. **Time-** a project has fixed time, completion should be in time.

4. **Cost/ Budget-** f(P,T,S)

5. **Client acceptance**

Key indicators of IT project success ???????

1.**System quality**- easy to use, and they supply quality information.

2.**Information quality-** the information generated by the implemented IT project must be the info required by users and be of significant quality **that it is ‘actionable**”.

3.**Use-** IT system must be, problem solving, decision aiding, and networking mechanism.

4.**User satisfaction-** team must determine user satisfaction.

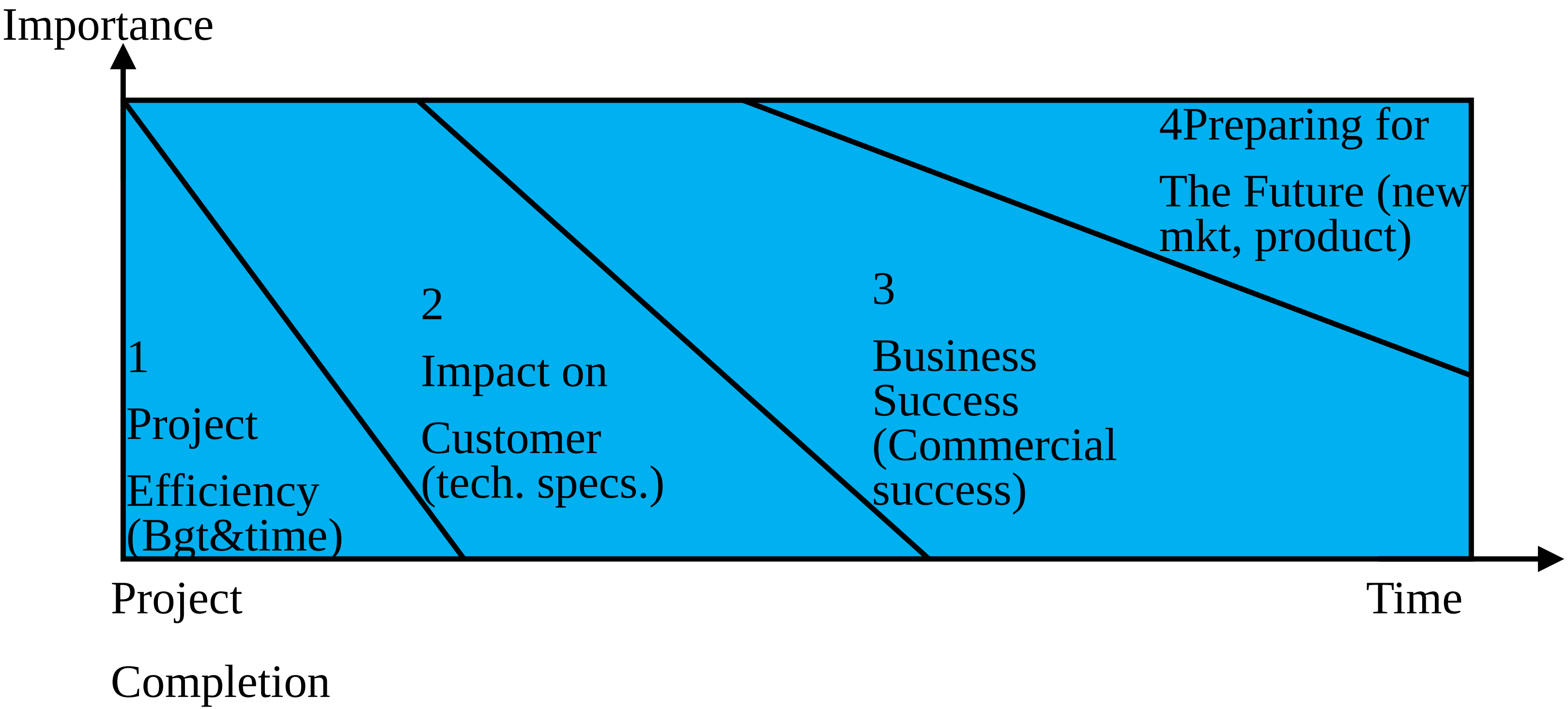
5.**Individual impact-** is decision making faster and more accurate. Is info. more retrievable and more affordable, and assimilated.

6.**Organisational impact-** positive impact on entire organization.

Information Technology Project “Success”

- Software & hardware projects **fail** at **a 65% rate**
- Over **half of** all IT projects become **runaways**
- Up to **75% of** all software projects are **cancelled**
- Average **cost overrun is 45%;** schedule overrun **is 63%;** with only 67% of originally contracted features
- **47% of IT** projects delivered but not used, **29% paid for but not delivered; 19% abandoned**

Four Dimensions of Project Success



Benefits (organization)

Improved efficiency

Improved effectiveness

Increased profit

Strategic goals

Organization learning

Reduced waste

Benefits (stakeholders)

Satisfied users

Social and environmental impact

Personal development

Professional learning

Capital supplier

Project team

Impact on surrounding community

Understanding success criteria

Iron triangle	Information system	Benefits (organization)	Benefits (stakeholders)
Cost	Maintainability	Improved efficiency	Satisfied users
Quality	Reliability	Improved effectiveness	Social and environmental impact
Time	Validity	Increased profit	Personal development
	Information Quality	Strategic goals	Professional learning
	Use	Organization learning	Capital supplier
		Reduced waste	Project team
			Impact on surrounding community

Project Management Maturity Model (PMMM):

PMMM allow an organization **to benchmark the best practices of successful PM firms.**

Developing Project Management Maturity

Project management maturity models: 4 models

- SEI's (Software Engineering Institute –Carnegie Mellon University) capability maturity model integration
- Center for business practices
- Kerzner's project management maturity model
- ESI (Education Service Institute) International's project framework

Development of PM maturity

PMMM allow an organization **to benchmark the best practices of successful PM firms**

Level of sophistication is different - practices (Boeing, L&T)

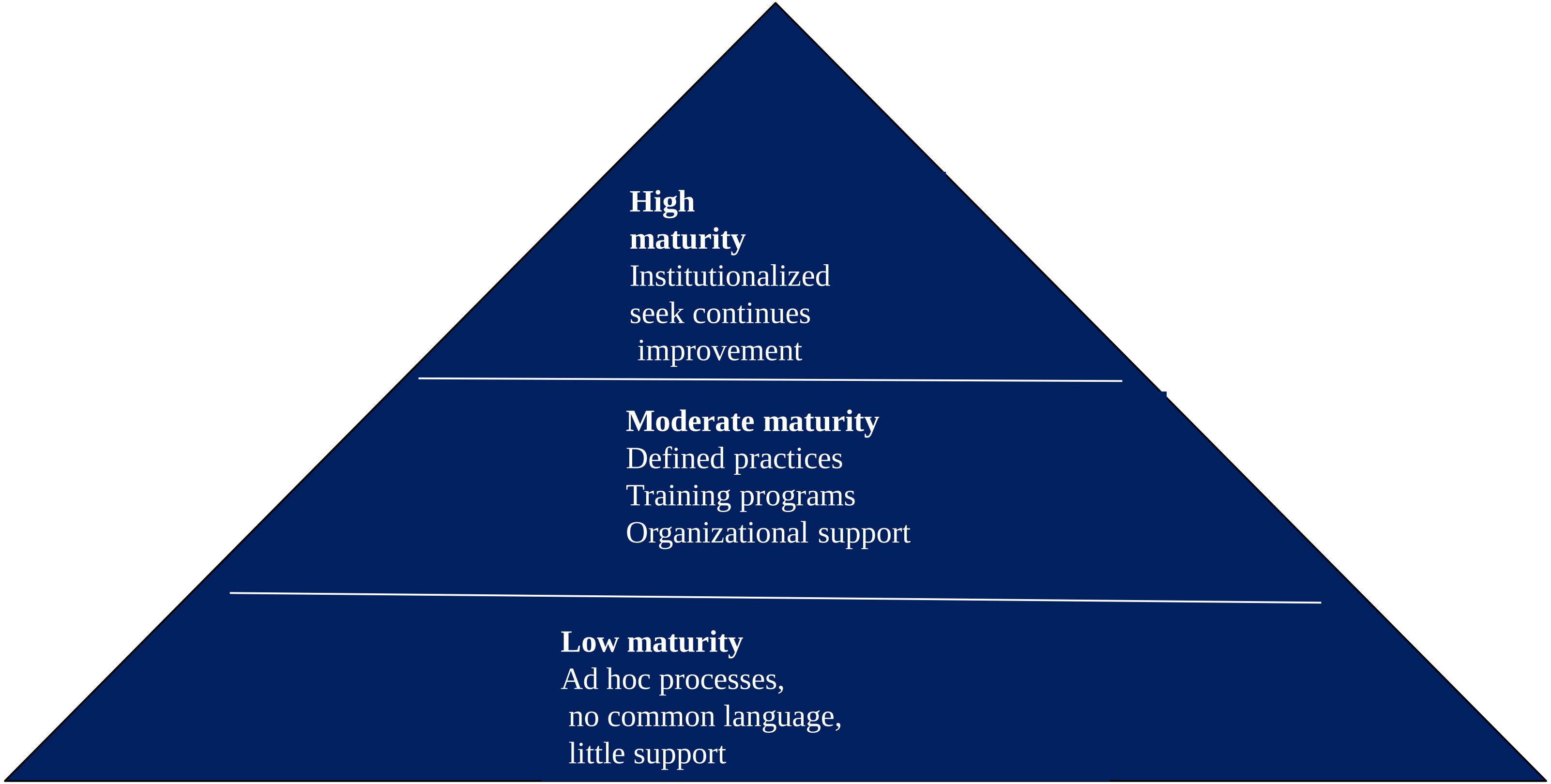
Purpose of Benchmark- process improvements of project delivery

New organizations – where to start?

MM – provide necessary frame work to first, **analysis and evaluate** current practices, and second **compare them** with chief competitor ? Industry standards, and third, define a **systematic route** for improving these practices

MM- continuous improvement in practices, MM offer the **template** for defining and then achieving such a progressive **improvement.**

MM charts both – set of **standards** currently accepted and as well as **process** for achieving significant movement towards these benchmarks.


High maturity
Institutionalized
seek continues
improvement
Moderate maturity
Defined practices
Training programs
Organizational support
Low maturity
Ad hoc processes,
no common language,
little support

Success is contextual: Depends on

(1) Strategy

(2) Structure

(3) Organizations' culture

What is **strategy: ?????????????????**

Project and organizational strategy: (strategic mgt) SM is the science of:

Formulating,

Implementing and,

Evaluating cross functional decisions that enable them to achieve its **Objectives**.

SM consists of

Developing vision statement and mission statement: where you want to be.

Formulating, implementing, and evaluating: based on SWOT, and resources.

Making cross functional decisions: All the departments.

Achieving objectives: market leadership through cost, innovative product, superior quality, other means.

Projects Reflect Strategy

Projects are ***stepping stones*** of corporate strategy

The firm's strategic development is a ***driving force*** behind project development

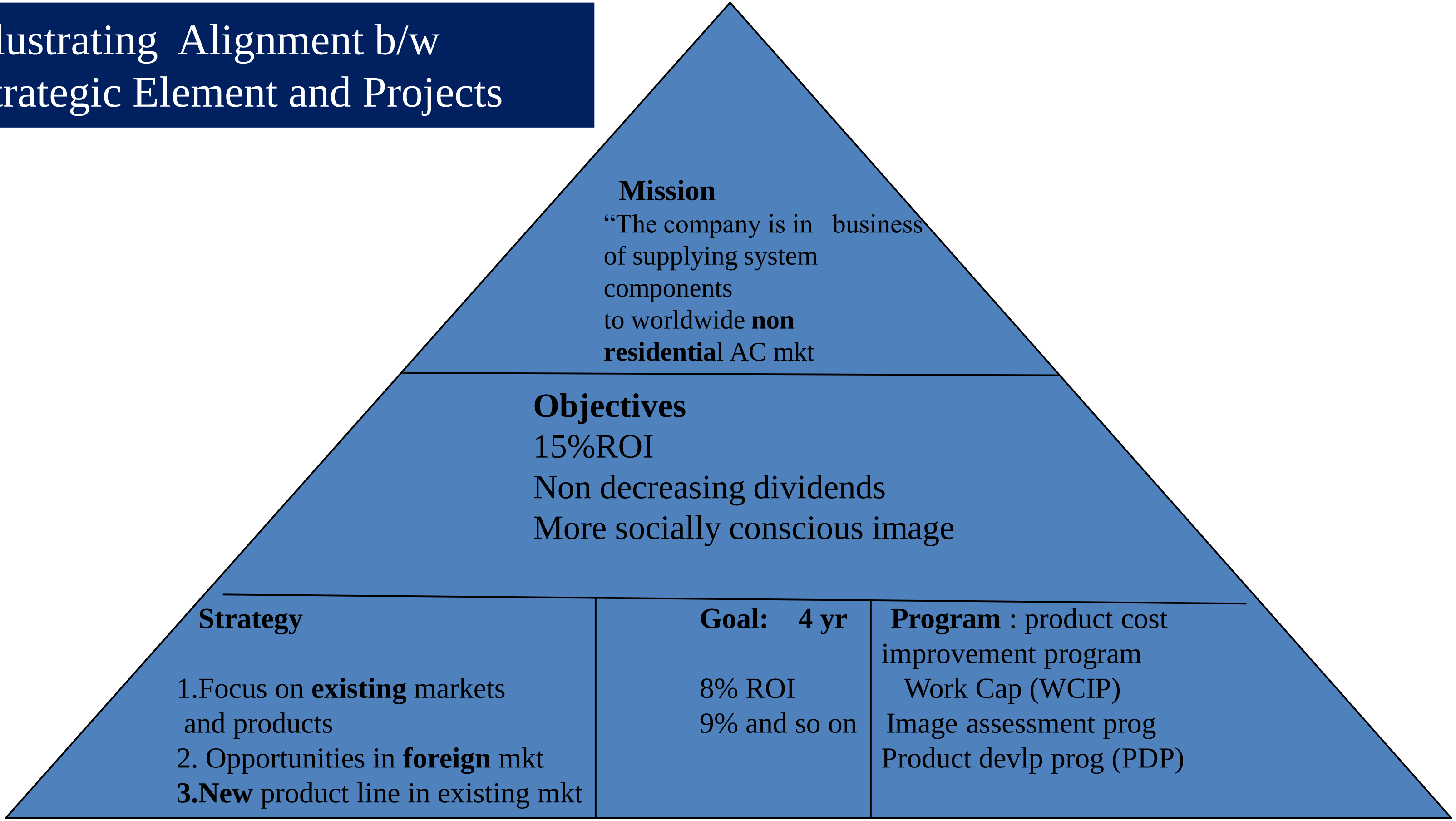
Some examples include:

A firm wishing to…	**…may have a project**
redevelop products or processes	to reengineer products or processes.
changes strategic direction or product portfolio configuration	to create new product lines.
improve cross-organizational communication & efficiency	to install an enterprise IT system.

Strategy	Project
Redevelopment of products for greater mkt. share	R E P
New business processes for greater streamlining	REP
Creation of new strategic alliances	SCM
Improving cross org. communication	???
New distribution strategy	???

Relationship of strategic elements

Illustrating Alignment b/w Strategic Element and Projects



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Lec – 03

Types of Structure Organizations

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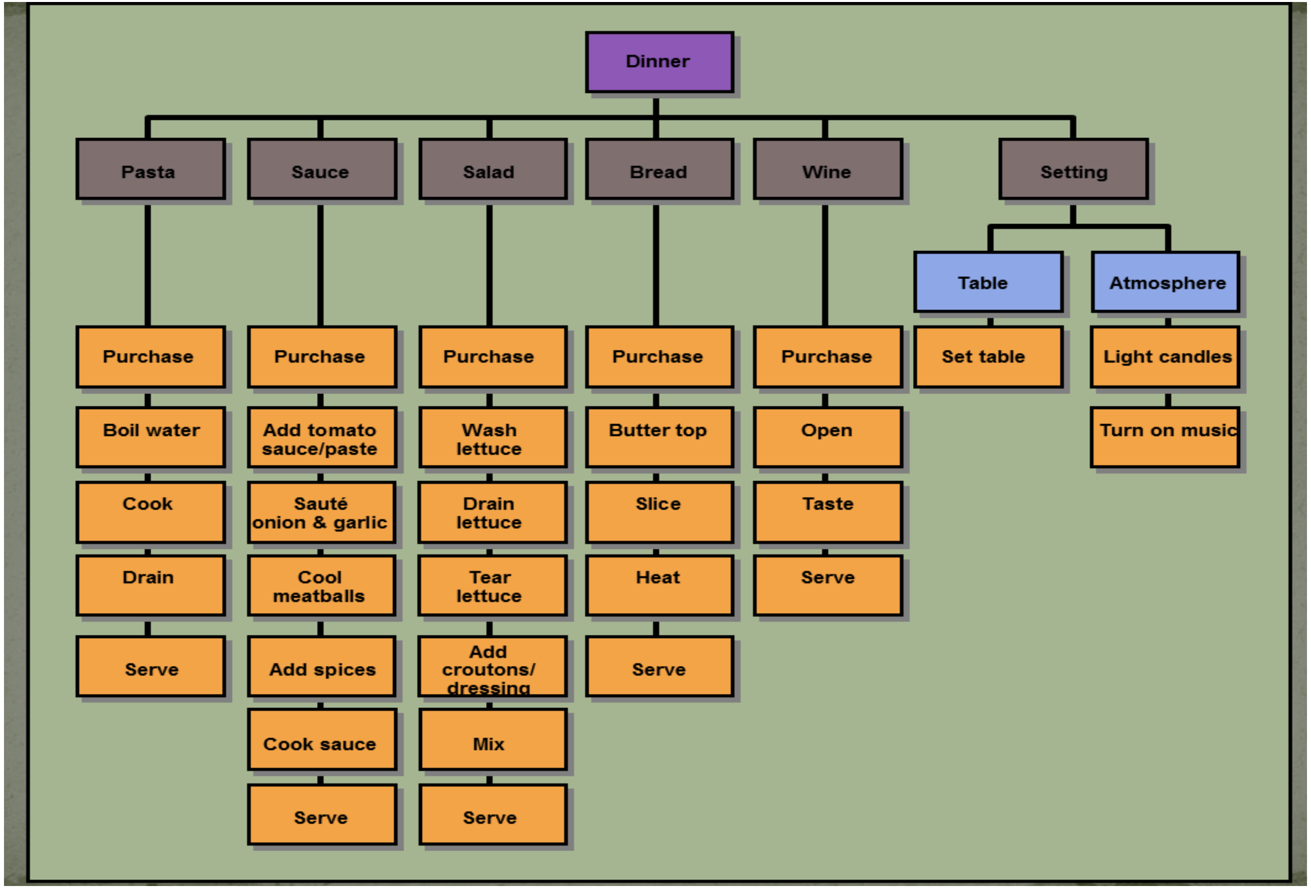
Work Breakdown Structure

- ✓ Hierarchical organization of work to be done on a project
- ✓ Project broken down into modules
- ✓ Modules subdivided into subcomponents, activities, and tasks
- ✓ Identifies individual tasks, workloads, and resource reirements

Plan	National/ Corporate plan with targets for growth.
Programme	Health programme, education programme, Sc&Tech. prog.
Project	Hospitals, schools, power plants
Work packages	Water supply & distn , power supply and distrn packages
Task	Award of water supply contract, construction of foundations.
Activity	Excavation, laying of cable, preparation of drawings,and sepcs.

Project Family Tree

- Final Assembly
  - Sub-assembly
  - Sub-assembly
    - Component
      - Element
        - Material
        - Material
      - Element
    - Component


Dinner
Pasta
Sauce
Salad
Bread
Wine
Setting
Table
Atmosphere
Purchase
Boil water
Cook
Drain
Serve
Purchase
Add tomato sauce/paste
Sauté onion & garlic
Cool meatballs
Add spices
Cook sauce
Serve
Purchase
Wash lettuce
Drain lettuce
Tear lettuce
Add croutons/ dressing
Mix
Serve
Purchase
Butter top
Slice
Heat
Serve
Purchase
Open
Taste
Serve
Set table
Light candles
Turn on music

Organization structure consists of three key elements

1. Organizational structure (OS) designates formal **reporting relationship**, including **no of levels**, **span of control** of managers and supervisors.
2. OS identifies the grouping together of **individuals into departments** and departments into total origination.
3. OS includes the design of systems to ensure **effective communication, coordination, and integration of efforts** across departments.

Forms of organizational structure

Internal and external organization environment?

Functional organization: grouping people performing **similar** activities into departments

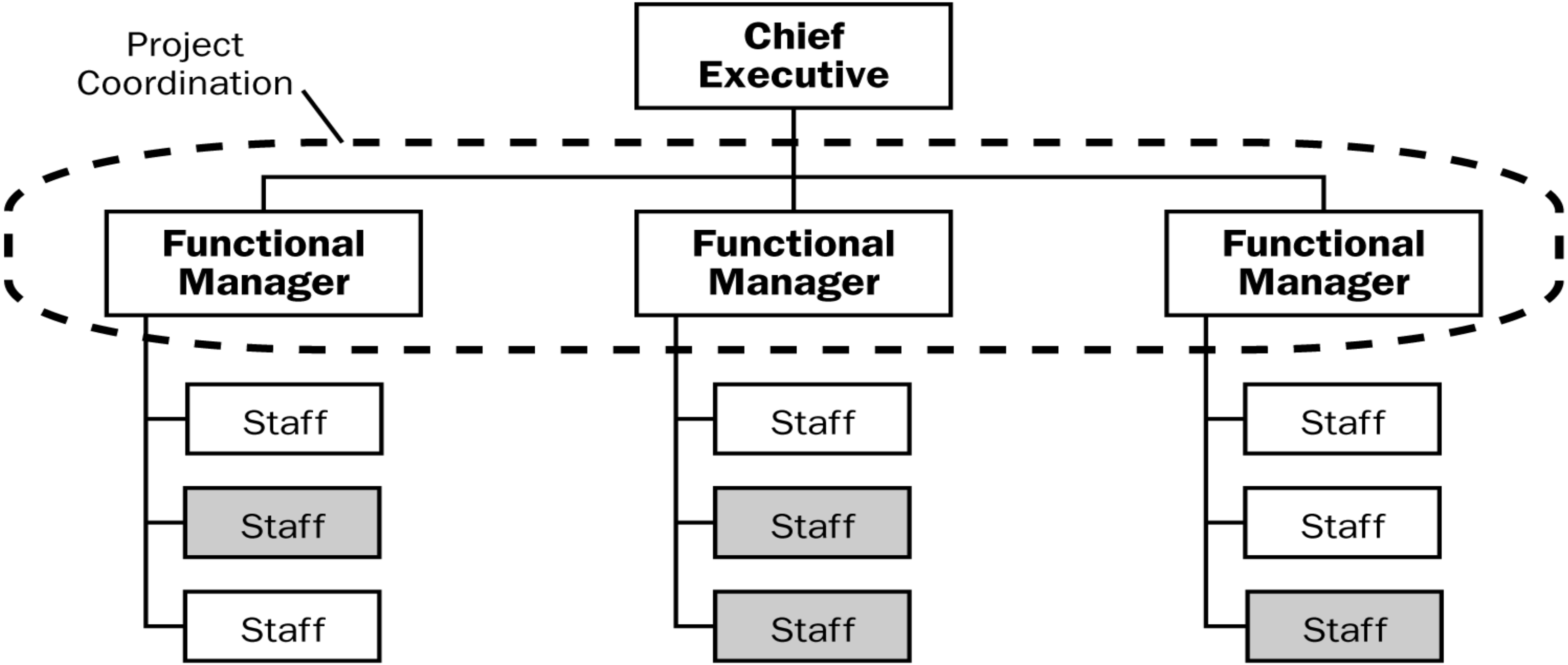
Project organization: grouping people into project teams on **temporary assignments**

Matrix organization: companies are structured by creating a **dual hierarchy in which functions and project have** equal prominence.

Functional organization

- Board of Directors
  - CEO
    - VP Marketing
      - MR
      - Sales
      - After sales service
      - Advertising
    - VP Production
      - Logistics
      - Outsourcing
      - Distribution
      - Warehousing
      - Mfg
    - VP Finance
      - ????????
    - VP R&D
      - NPD
      - Testing
      - Quality

Functional Organization

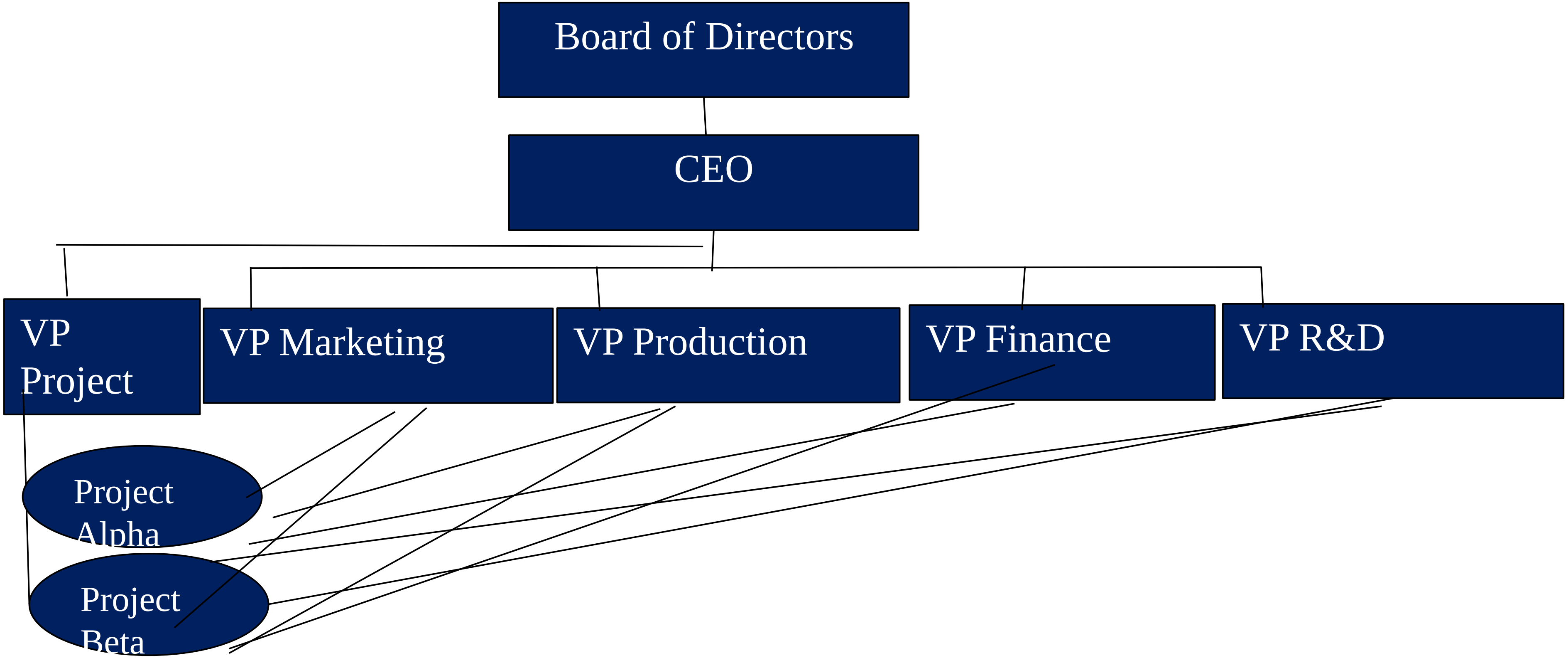


(Gray boxes represent staff engaged in project activities.)

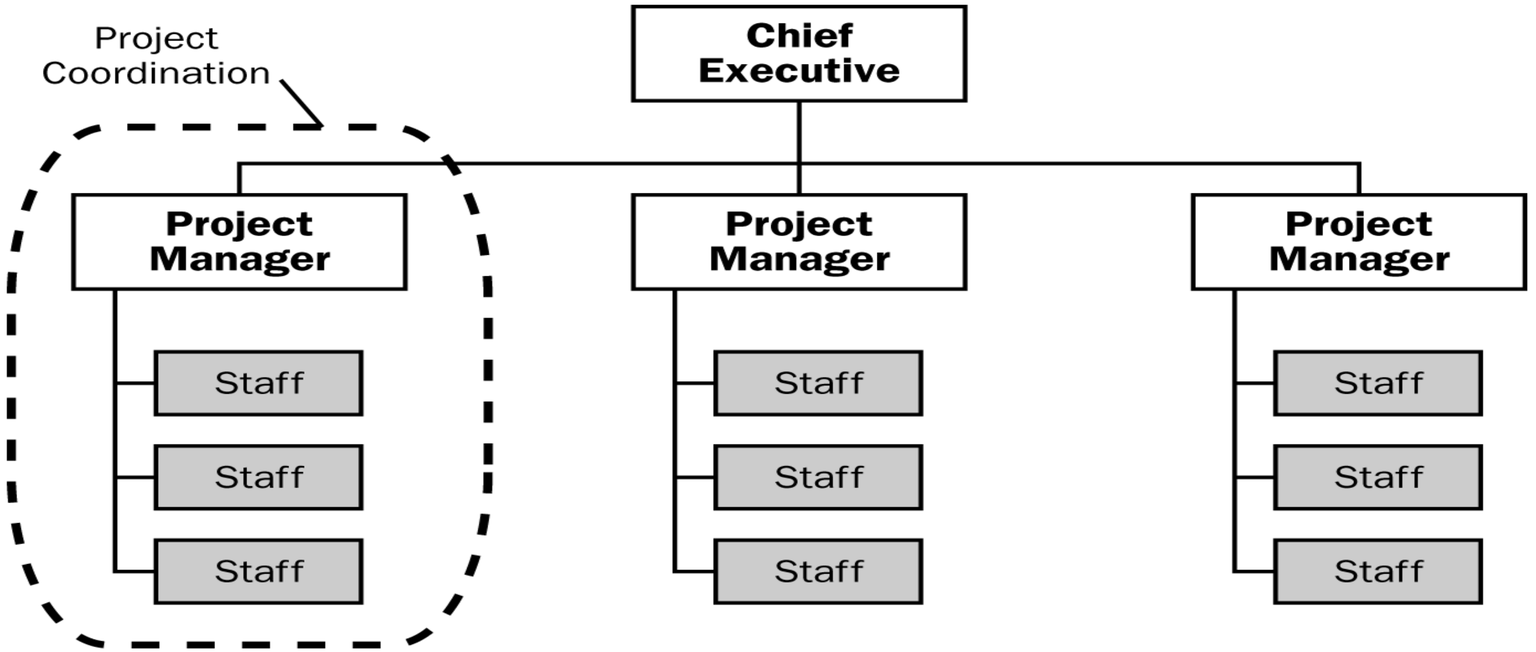
Functional organization

Strengths	Weaknesses
No change is required in firm's design	Siloing – difficult to achieve cross functional **cooperation**
Enables the development of **in-depth** knowledge	Lack of **customer focus**
Allows for standard **career paths**	Long time – due to structure problems, lack of **ownership**, slower communication
	Project may be **sub optimize** due to varying interest or commitment

Project organization



Project Organization



(Gray boxes represent staff engaged in project activities.)

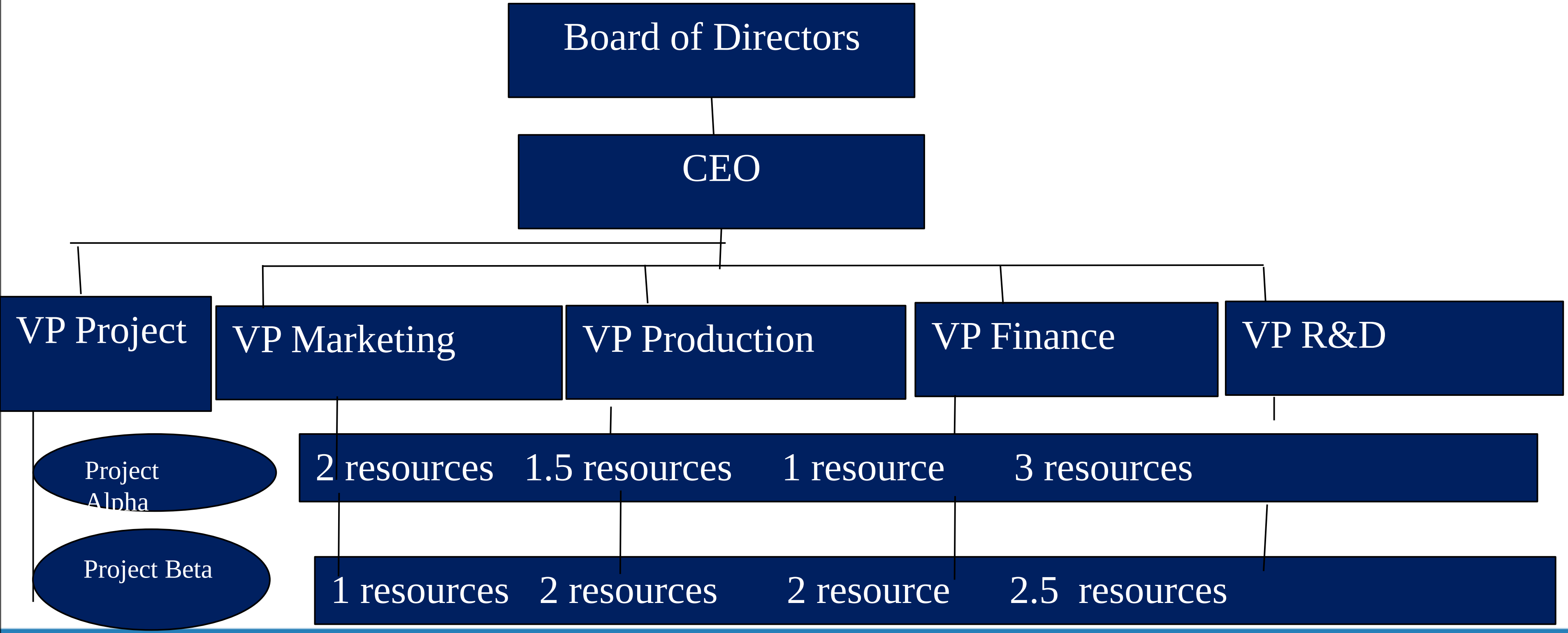
Project organization

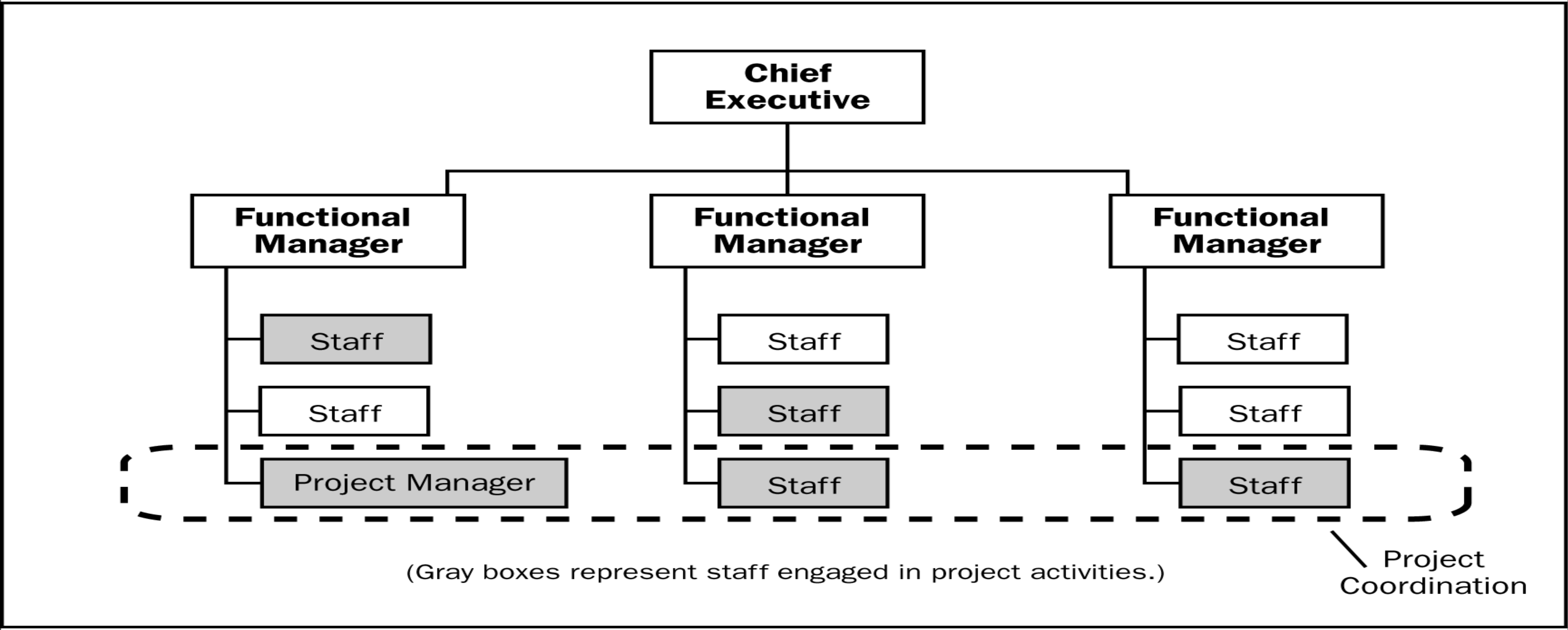
Strengths?????	Weaknesses????

Project organization

Strengths	Weaknesses
Assign **authority** to solely project manager	Setting up of maintaining **teams** can be expensive
Improved **communication** – across functions	**Loyalty to project** not to originations
Effective and speedy **DM**	Difficult to **maintain pool** of intellectual capital
Promotes creation of **cadres** of PM experts	Concern @ future after project gets over
Rapid **response** to **market**	

Matrix: We crate a dual authority where there is a balance b/w functional and pure project origination, VP projects deals with CEO and other VPs





Balanced Matrix Organization

Matrix

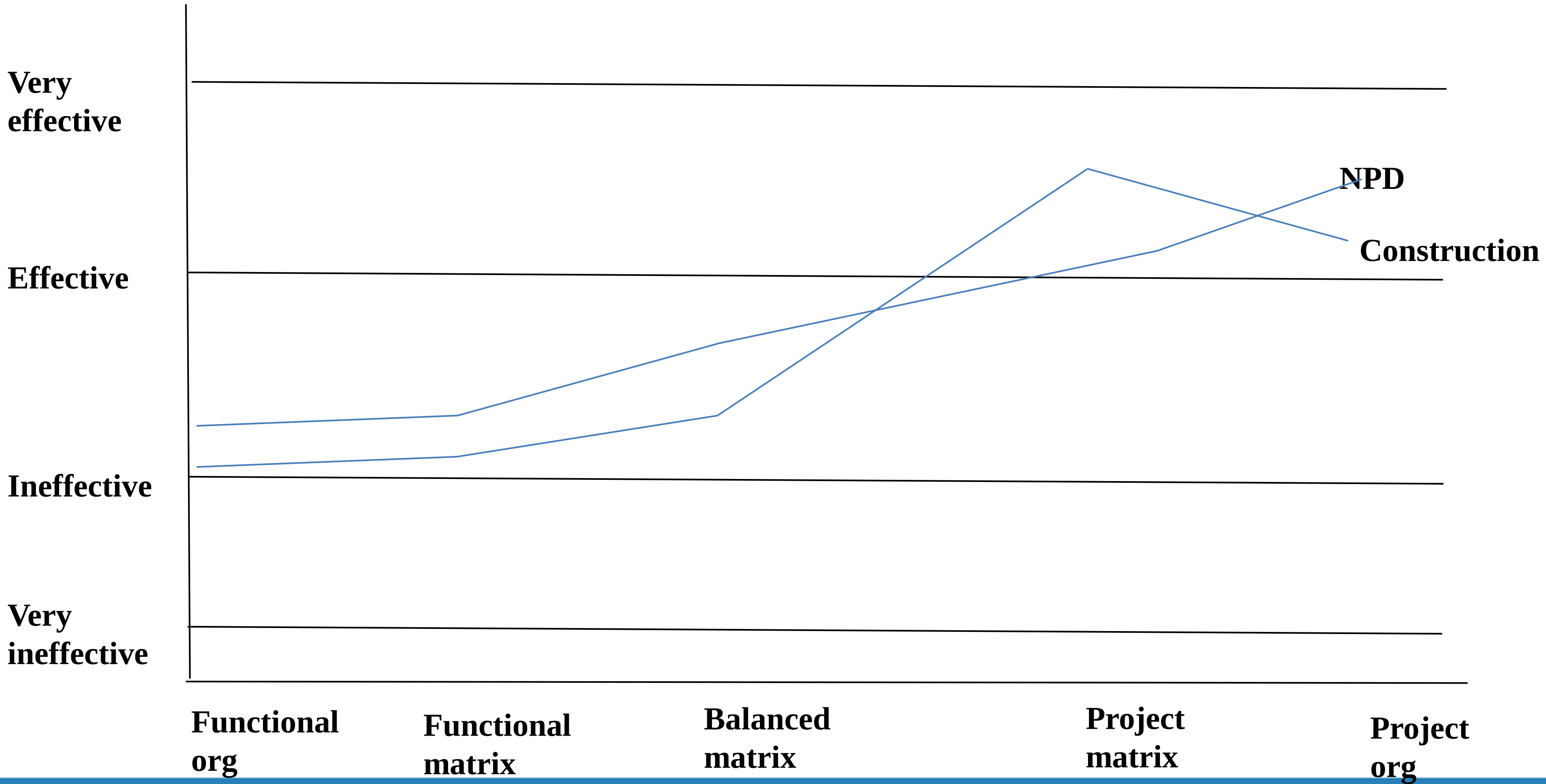
Strengths???????	Weaknesses?????

Matrix

Strengths	Weaknesses
Suited to **dynamic** environment	**Two bosses**
Emphasizes the dual importance of project management and functional efficiency	Sometime **difficult** to **share resources**
Promotes **coordination** across functions	**Frustrating** – caught b/w project and functional requirements
Use of **scares** recourses on competing basis	

Project Characteristics \ Organization Structure	*Functional*	*Matrix*			*Projectized*
		Weak Matrix	**Balanced Matrix**	**Strong Matrix**	
Project Manager's Authority	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Resource Availability	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Who controls the project budget	Functional Manager	Functional Manager	Mixed	Project Manager	Project Manager
Project Manager's Role	Part-time	Part-time	Full-time	Full-time	Full-time
Project Management Administrative Staff	Part-time	Part-time	Part-time	Full-time	Full-time

Organizational Structure Influences on Projects



Very effective
Effective
Ineffective
Very ineffective
NPD
Construction
Functional org
Functional matrix
Balanced matrix
Project matrix
Project org

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Project Management Office

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Organizational culture is the **collective behavior** of **humans** that are part of an organization.

It is also the pattern of such collective behaviors and assumptions that are **taught to new organizational members** as a way of perceiving, and even thinking and feeling.

Organizational culture affects the **way people and groups interact** with each other, with clients, and with stakeholders.

Organizational culture?????
How do cultures form???????

A man kills another man and marries woman
Women kills a man and marries other man
Woman marries a man and second man is brother
All live happily together
Men don’t talk to each other – not introduced

The ***unwritten rules*** of behavior, or norms that are used to ***shape and guide behavior*** (Speed of work) is shared by ***some subset of organization*** (Marketing Vs Finacne) members and is ***taught to all new members*** of the company.

How do cultures form?

- Technology: high–low
- Environment: global-regional
- Geographical location: ???
- Reward systems:
- Rules and procedures:
- Key organizational members (Govt org. vs CEO of IT firm):
- Organization values, visions, working language, systems, symbols, beliefs, and habits.

Project and Program Managers- Difference???

Project and Program Managers

- Project managers work with **project sponsors, project teams, and other people** involved in projects to meet project goals.
- Program: "A **group of related projects** managed in a coordinated way to obtain **benefits and control** not available from managing them individually."
- Program managers oversee programs and often act as **bosses for project managers**.

  Ex. A new car model program (engine, transmission, interior decoration)

Portfolios and Portfolio Management

A portfolio is a **collection of projects** or programs and other work that are **grouped together** to facilitate **effective management** of that work to meet strategic business objectives.

The projects or programs in the portfolio may not necessarily be **interdependent or directly** related.

Subprojects

Projects are frequently divided into **more manageable components** or **subprojects**. Subprojects are often contracted to **an external enterprise** or to another functional unit in the performing organization.

Examples include:

•Subprojects based on the project process, such as a single phase in the project **life cycle**.

•Subprojects according to human resource skill **requirements**, such as **plumbers or electricians** needed on a construction project.

•Subprojects involving **specialized technology**, such as the automated testing of computer programs on a software development project (WLL, VLSI, etc..)

•On very **large projects**, the subprojects can consist of a series of even smaller subprojects (Ganga project- KM project) .

Let us talk about PMO ?????

Project Management Office: A project management office (PMO) is an organizational unit to **centralize and coordinate** the management of projects.

"program management office"

"project office" or

"program office"

- Oversees the management **of projects, programs, or both.**
- Coordinated **planning, prioritization and execution** of projects and subprojects.
- **Resource leveling and variance reporting?????**.
- **Central repository of lesson learned**.
- New **PM improvements** are first identified, tested refined and passed.
- **Training**, **software**, **standardized policies**, and **procedures**.

- **Shared and coordinated** resources across all projects are administered by the PMO.

- Identification and development of project management **methodology, best practices, and standards.**

- **Clearinghouse** and management for project **policies, procedures, templates**, and other shared documentation.

- **Centralized repository** and management for both **shared and unique risks for all projects.**

- Central office for operation and **management of project tools**, such as enterprise-wide project management software.

- Central coordination of **communication management across projects.**

- A **mentoring** platform for project **managers.**

- Central monitoring of all PMO project **timelines and budgets**, usually at the enterprise level.

- Coordination of **overall project quality** standards between the project manager and any internal or external quality personnel or standards organization.

Is PMO required????

Critics of PMO:

All eggs in one basket - one location of professionals.

Another layer of oversight and bureaucracy in organization

Differences between project managers and a PMO ??????

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Lec – 05

Stakeholders Management

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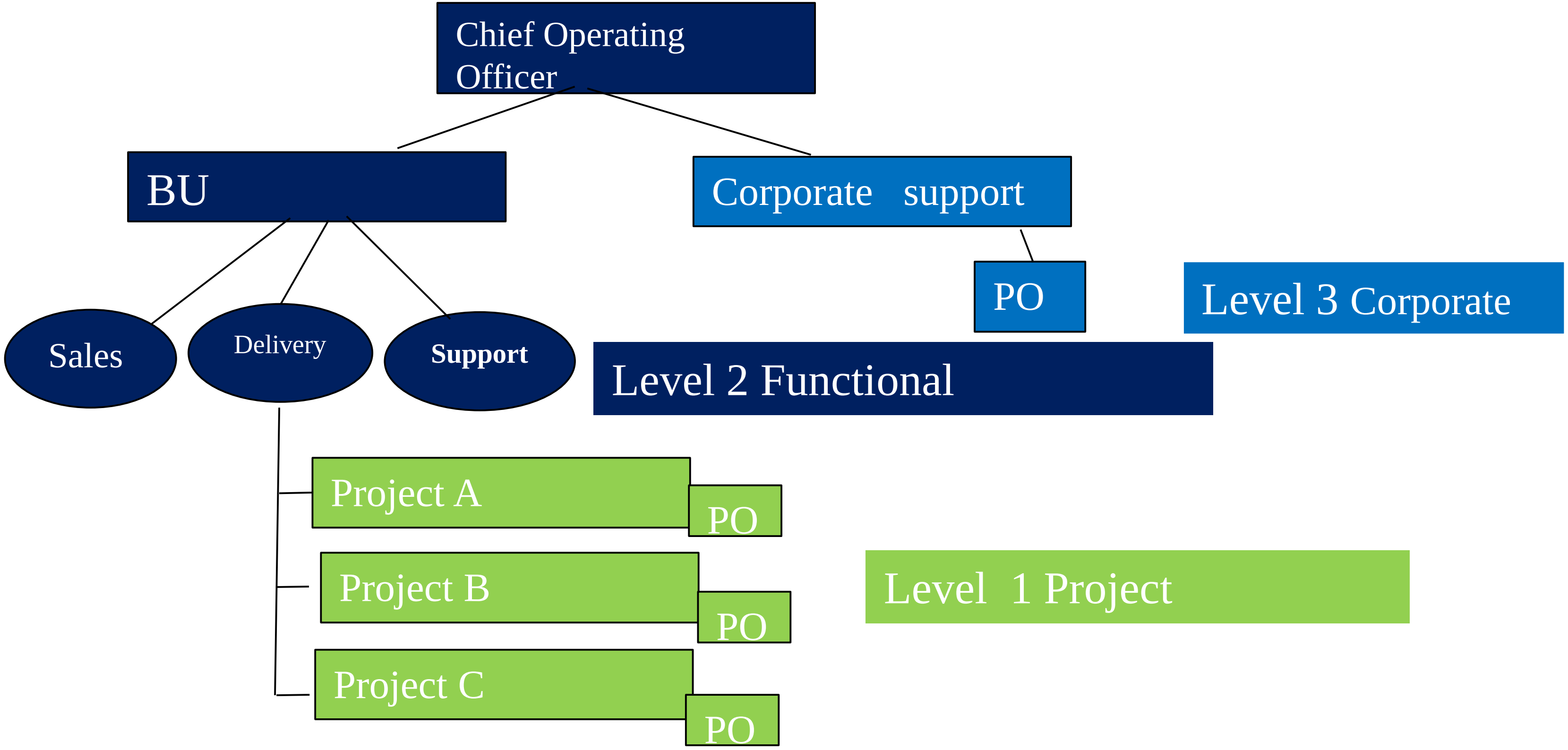
Differences between project managers and a PMO may include the following:

Project Manager	PMO
Responsible for delivering **specific project objectives** (within constraints),	PMO is an organizational structure with specific mandates that can include an **enterprise-wide perspective**. PMO manages major program to better achieve **business objectives**.
Controls the assigned **project resources** to best meet project objectives.	While the PMO optimizes the use of **shared** organizational resources across all projects.
Project manager manages **the scope, schedule, cost, and quality** of the products of the work packages.	While the PMO manages **overall risk, overall opportunity, and the interdependencies among projects.**
The project manager **reports** on project progress and other project specific information.	PMO provides **consolidated reporting** and an enterprise view of projects under its purview

Location of PMO



PMO

Weather station:
(tracking and monitoring status)

-milestones achieved

-diff b/w plan and actual progress

-budget warning signal

-money paid

- status of major project risks

-update contingency plan

-report to top mgt.

Control tower: (development of PM skills, find and resolve shortcomings, directly support to manager and team)

-establish **standards** for managing projects (uniform methodology-budget-risk mgt, etc)

-consult how to follow standards

-enforces the standards- awards-refusal.

-improve standards

Resource pool:
To maintain and provide a cadre of trained and skilled professionals

Stakeholders Management

Who is a stakeholder????

All individuals or groups who have an active stake in project and can influence either **positively or negatively** its development

Team members must identify them (**How?**). Their **need and expectations**. Manage and influence expectations to complete the project.

- Internal/External

-Internal

Top mgt

Accountant

Other functional managers

Project team members

-External

Client

Competitors (lessons to be learned, status of project)

Suppliers

Environmental , political, consumer, and other intervener groups (like???)

- Owners/funders
- Suppliers /contractors
- Team members and their families
- Govt/Media outlets
- Temporary/permanent lobbying organizations
- Society at large

Stakeholders Management

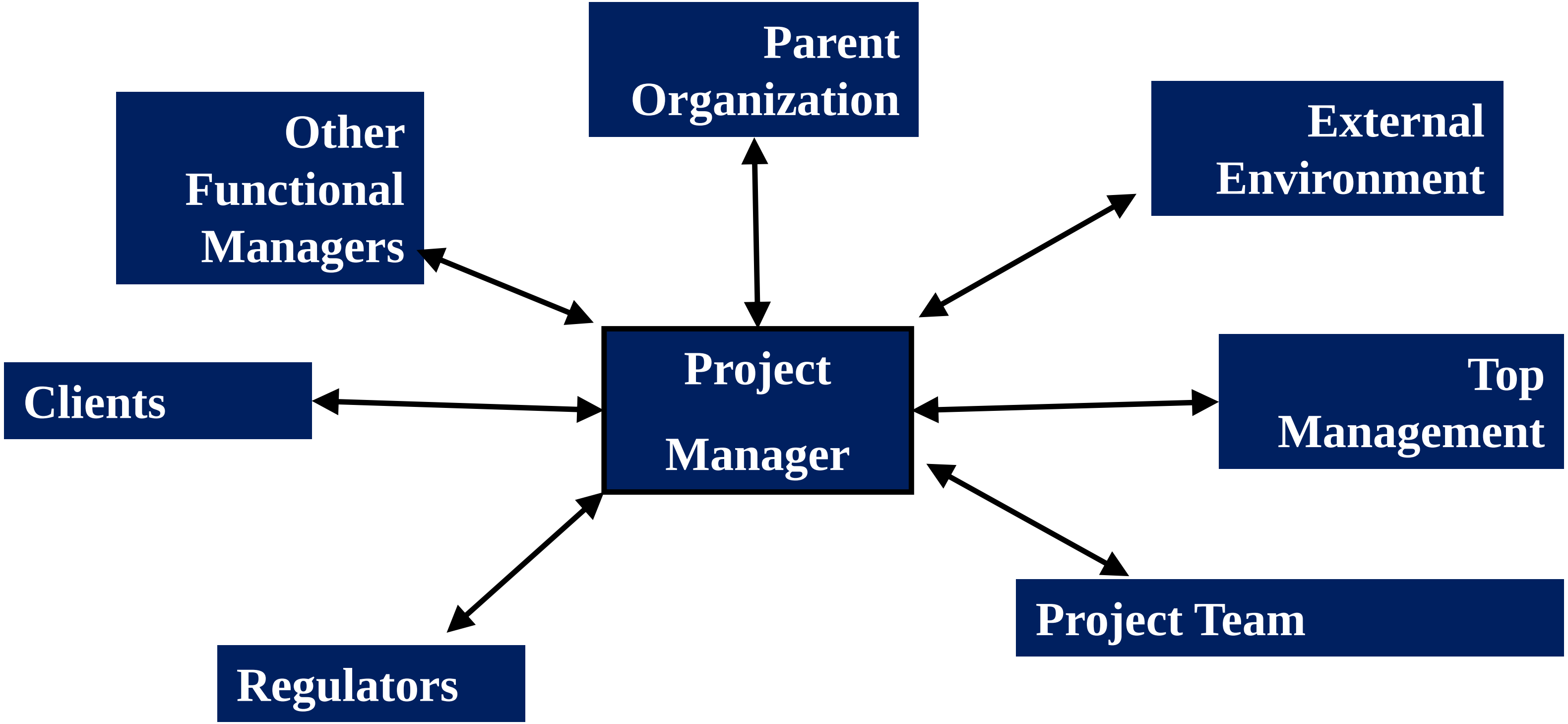
Identify Stakeholders

Plan Stakeholders Management

Manage Stakeholders Engagement

Control Stakeholders Engagement

Project Stakeholder Relationships



Managing stakeholders

Simplified stakeholder management process: planning, organizing, directing, motivating, and controlling the resources necessary to deal with various **internal** and **external** groups.

Managing stakeholders

1. Assess the environment (market research)
2. Identifying the goal of principal actors (low cost software- cost data base, follow up business- mind device, look for hidden agendas)

   Manager- low cost MIS

   System architect- technical excellence

   Programming contractor-Max profit

New product success at electronics firm

VP (Research)-State- of- the art technology

VP (Mfg.)- World class practices

VP (Mkt)- No. of new feature

Estate development project

Owner- Timely delivery

Local Govt- More taxes

Environmental group-Minimum impact

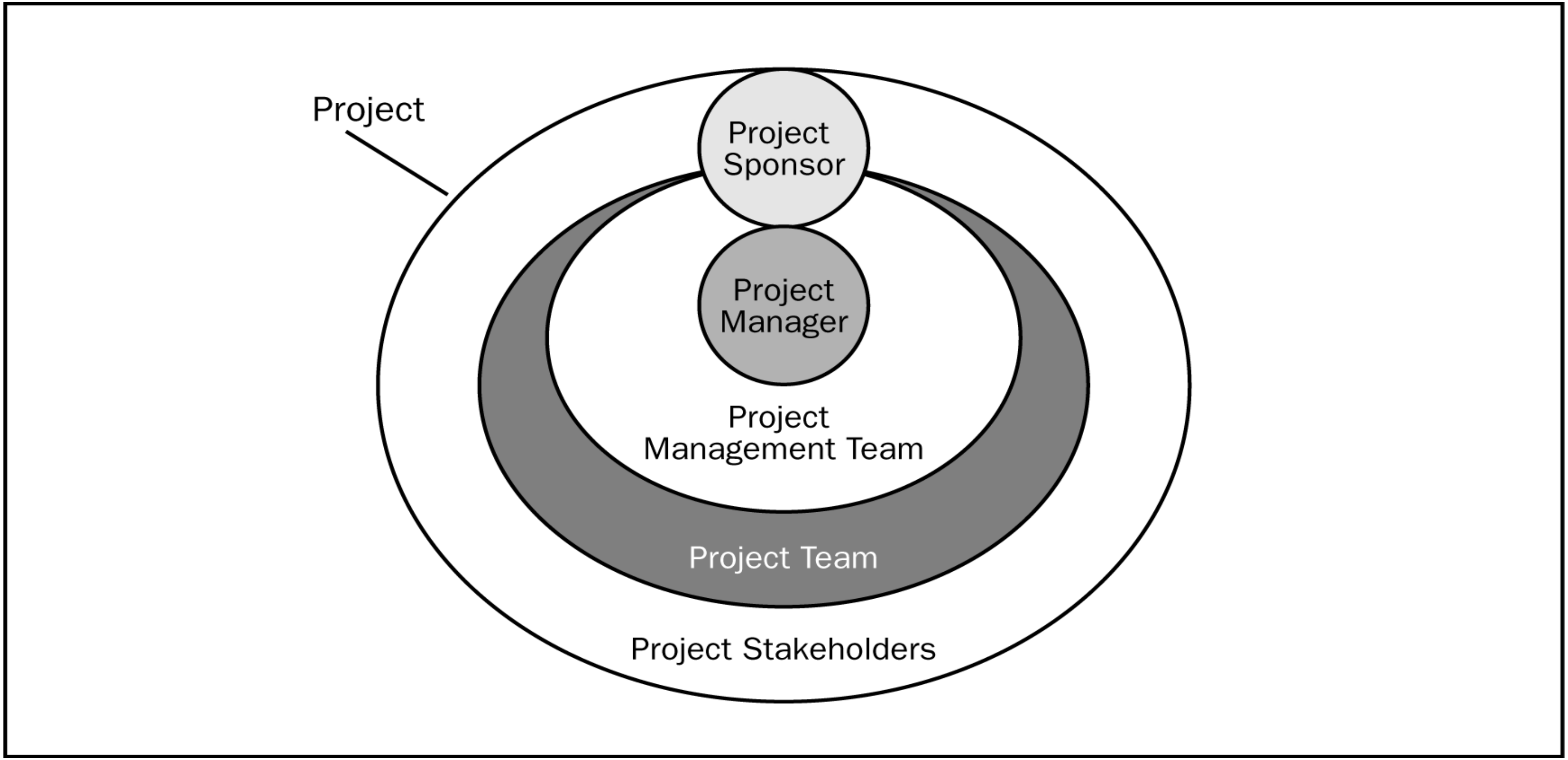
Nearby residents- Relocation

Managing stakeholders

3. Assess your own capabilities: tech, political (parties-consultants?), financial, etc.
4. Develop solution: for needs of stakeholders by creating action plans.
5. Test and refine the solution.

Project Stakeholder Management Cycle

Project Stakeholder Management Cycle (By D.I Cleland)



The Relationship Between Stakeholders and the Project

Types of projects

1. Personal : exam, vacation, book writing, getting dressed, wedding, etc.

2. Local: school function, cleanliness drives

3. Organizational : NPD, new highway, dam, etc.

4. National: Poverty, satellite, annual budget, census.etc.

5. Industrial and non industrial

6. Type of partnership

Types of projects

7. European Organization for Nuclear Research (French: Organisation européenne pour la recherche nucléaire), known as CERN .

8. High and low tech

Types of Projects

a)Based on duration: Long term 10 +, medium ?, short less than ?.

b)Based on investment: High 200m and above, medium 30-200m, low between 5-30m, cottage 5m. (Limits may vary according to States,Departments,Products)

MSMEs in India

Classification	Manufacturing enterprises*	Service enterprises**
Micro	Rs 25 lac	Rs 10 lac
Small	Rs 5 crore	Rs 2 crore
Medium	Rs 10 crore	Rs 5 crore

* Plant and machinery ** Equipment

Types of Projects

c)Based on ownership: Govt, public sector, corporate, cooperative???, proprietorship, partnership (PPP).

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Project Management for Managers

Lec – 06

Types of Projects and Project Life Cycle

Dr. M.K. Barua
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Types of Projects

a)Based on duration: Long term 10 +, medium ?, short less than ?.

b)Based on investment: High 200m and above, medium 30-200m, low between 5-30m, cottage 5m. (Limits may vary according to States,Departments,Products)

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Types of Projects

c)Based on ownership: Govt, public sector, corporate, cooperative???, proprietorship, partnership (PPP).

d)Based on risk:

- Projects
  - Greenfield
  - Brownfield
    - Expansion
    - Vertical integration
      - Downward
      - Upward
    - Diversification
      - Concentric
      - Conglomerate
  - Divestment
  - Modernization /Replacement

d)Based on risk:

1.Greenfield project/grass root project- new venture by fresh entrepreneur/ promoter.

2.Brown field projects- existing promoter company or existing projects goes for **addition of product/capacity.**

Brown field projects

Expansion projects- add capacity through mkt intensification or mkt development.

Vertical integration **projects-degree** to which a firm owns its **upstream suppliers** and **down stream customers** is called vertical integration .

Vertical integration

Forward integration:?????

Backward integration: ?????

Vertical integration

Forward integration: **downward** expansion is called forward integration, ex.- steel industry moves for manufacturing of steel pipes (ONGC?).

Backward integration: **upstream** expansion is called backward integration, pipe manufacturer makes its own steel.

Diversification Project: Financial synergy may obtained by combining two firms – lower tech and high financial.

Concentric diversification project: firm adds related products: cars??

Conglomerate diversification project: Unrelated areas (TATA, Birla, Ambani, Adaani, etc, IFFCO-TOKIO)

3.Divestment: Retrenchment of some or all of the activities in a given business of the firm or sell out some of the businesses as such.

Obsolescence-Mobiles

Competition

Failure

Concentration on new product

Better opportunity of investment.

4.Modernization/Replacement: New technology, etc.

Project Life Cycle (PLC)

The Project Life Cycle (PLC)

Project managers or the organization **can divide projects into phases** to provide **better management control** with appropriate links to the ongoing operations of the performing organization.

Collectively, **these phases are known as the project life cycle**. Many organizations identify a specific set of life cycles for use on all of their projects.

Project life cycles generally define:

- **What technical work** to do in each phase (for example, in which phase should the architect’s work be performed?).

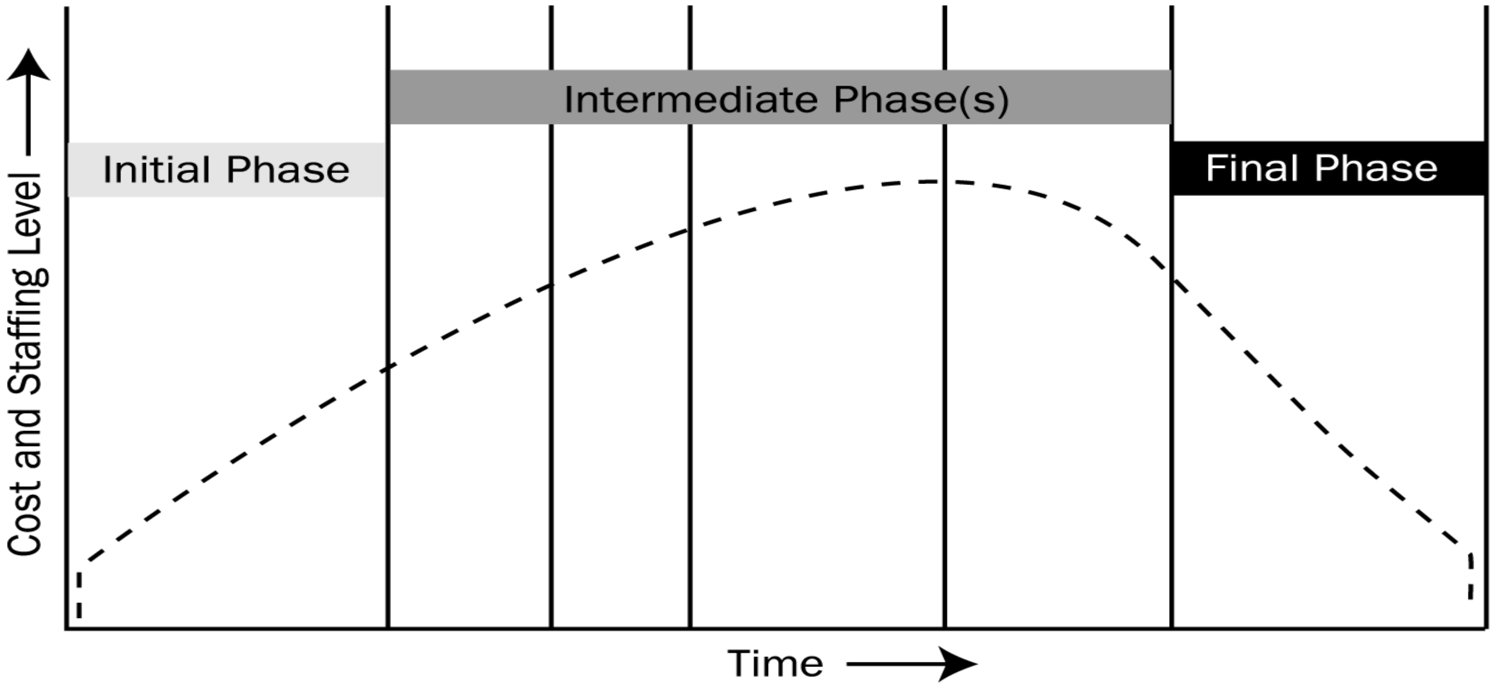
- **When** the **deliverables** are to be **generated** in each phase and how each deliverable is reviewed, verified, and validated.

- **Who is** involved in each phase (for example, **concurrent engineering** requires that the implementers be involved with requirements and design (D for D).

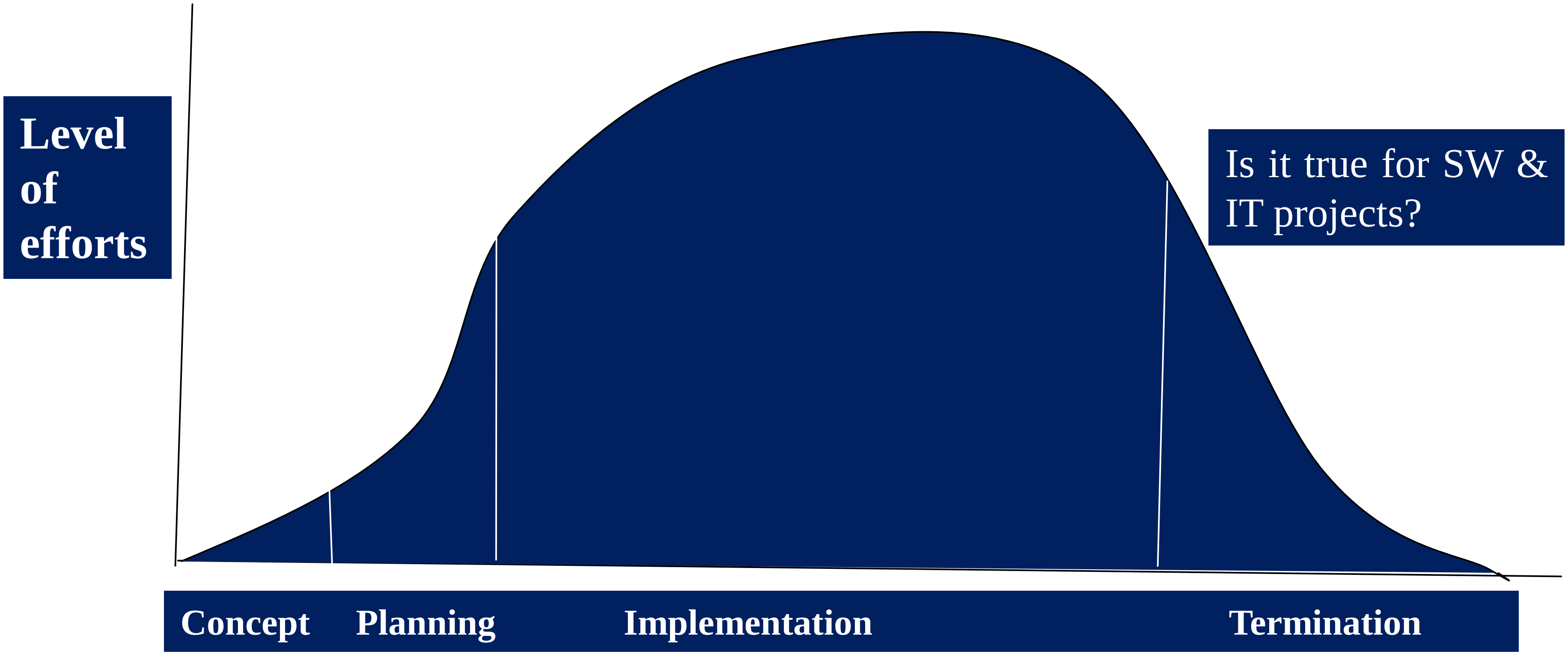
- How to **control and approve** each phase.

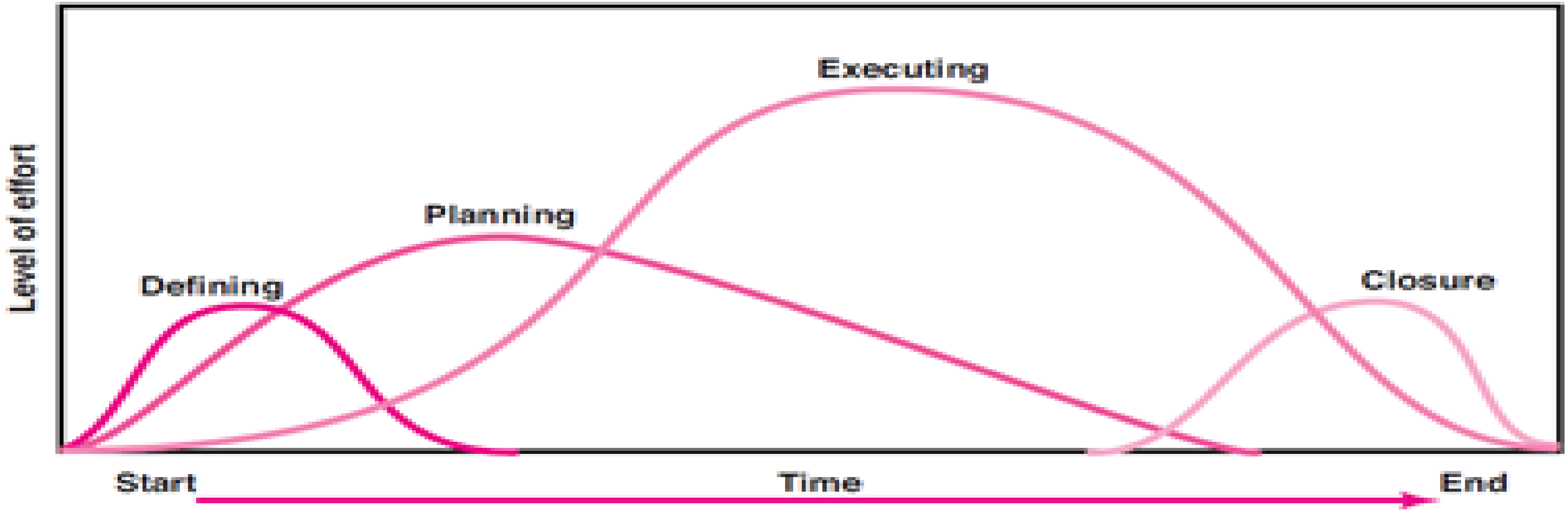
Most project life cycles **share a number of common** characteristics:

- Phases are generally **sequential (????)** and are usually defined by some form of technical information transfer or technical component handoff.
- Cost and staffing levels are low at the start, peak during the intermediate phases, and drop rapidly as the project draws to a conclusion (Depends on project).



Typical Project Cost and Staffing Level Across the Project Life Cycle


Level of efforts
Is it true for SW & IT projects?
Concept
Planning
Implementation
Termination



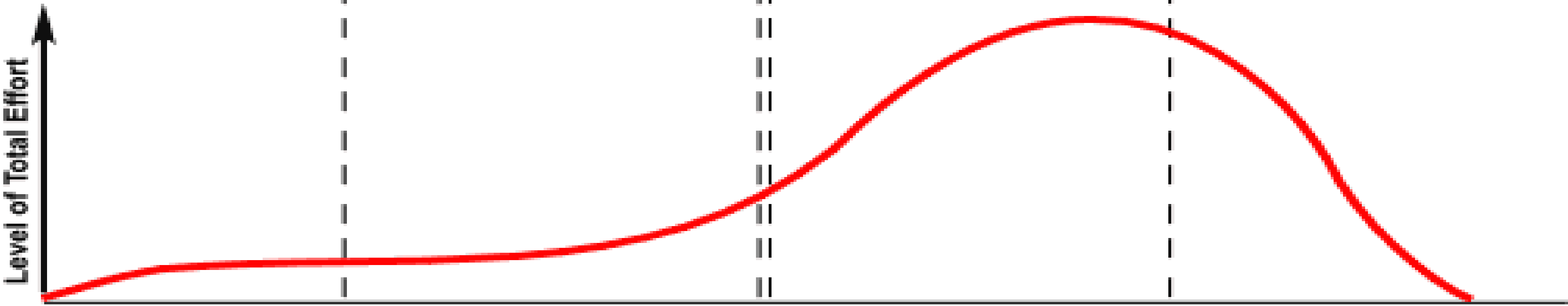
Defining
1. Goals
2. Specifications
3. Tasks
4. Responsibilities

Planning
1. Schedules
2. Budgets
3. Resources
4. Risks
5. Staffing

Executing
1. Status reports
2. Changes
3. Quality
4. Forecasts

Closure
1. Train customer
2. Transfer documents
3. Release resources
4. Evaluation
5. Lessons learned

Phase 1 Concept



- Gather data
- Identify need
- Goals
- Practicality
- Economics
- Resources
- Strategies
- Risks
- Alternatives
- Sell concept
- Approvals

Phase 2 Development

- Feasibility:
  Objectives/rationale
  Program, schematics
  Sketches/outline drawings
  WBS
  Resources, team
  Schedule
  Budget
  Cash flow
  Financing
- Re-assess risks, alternatives
- Present Project Charter/Brief

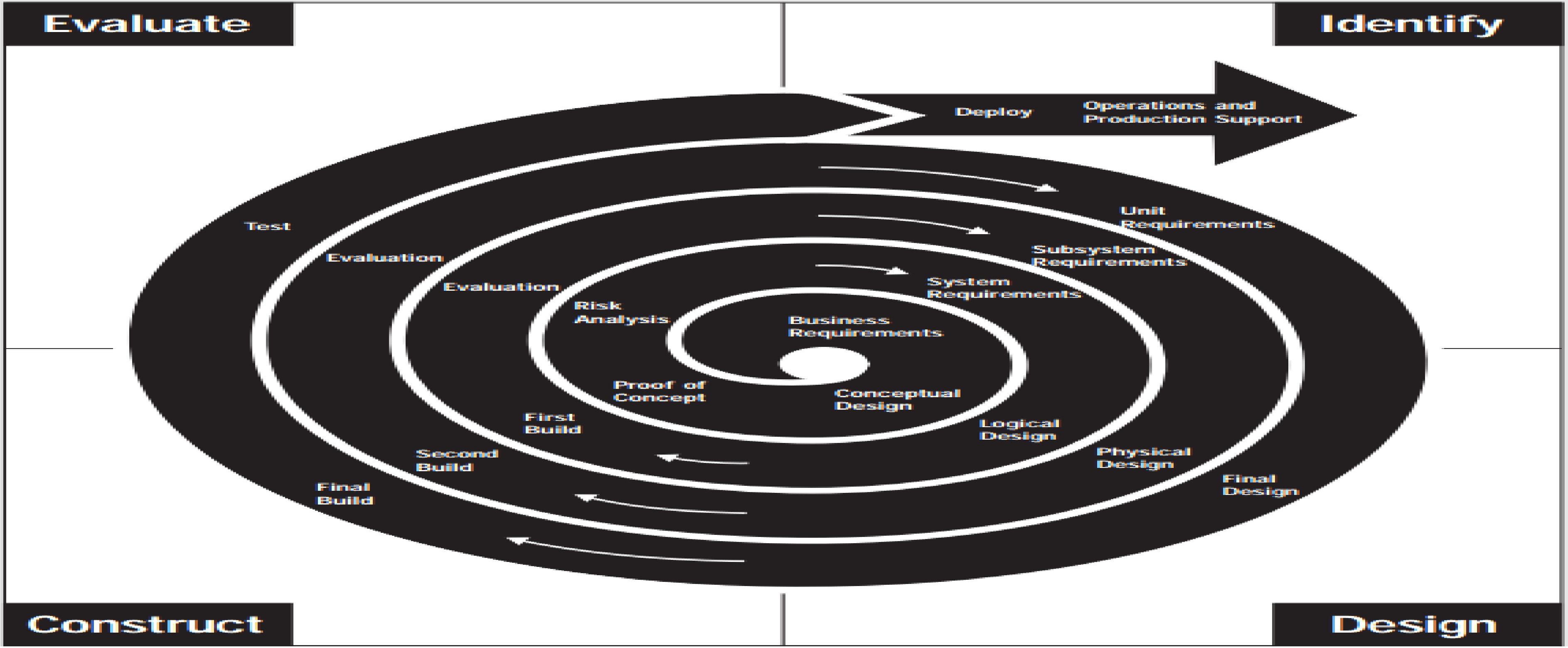
Phase 3 Execution

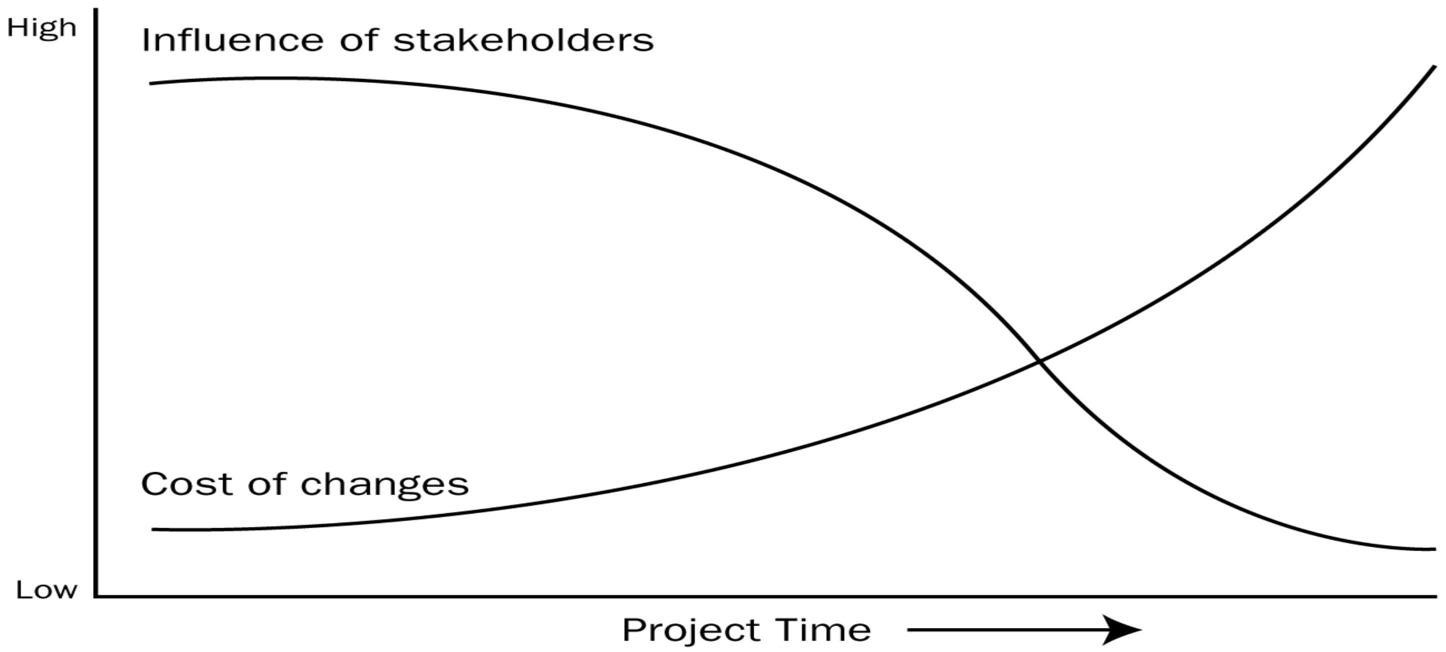
- Mobilize team
- Planning & scheduling
- Technical requirements
- Work packages
- Detail design & specs
- Procurement
- Execute the work
- Testing
- Resolve issues
- Progress monitoring
- Forecasts
- Reports

Phase 4 Transfer

- Assemble start-up team
- Training
- Finalize/test all systems
- Reviews & Acceptances
- Transfer responsibility
- Settle all accounts
- Project review
- Re-assign remaining team
- Archive lessons learned
- Close all records
- Deliver Final Report

Representative Software Development life Cycle





Stakeholders’ Influence Over Time

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Project Management for Managers

Lec – 07

Project Life Cycle Phases & Project Appraisal

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Project life cycle phases

1a.Conception phase
1b.Definition phase

Initiation phase or Selection of a project

2. Planning and organizing
3. Implementation
4. Project clean-up phase

1. **<u>Project selection</u>** : Major decision of top mgt. **(How to select a project ??????).** Project selection can be divided into two major activities:

Project identification

Project appraisal

Project identification: Brainstorming (structured–sequential, 20-30 ideas,) and unstructured.

Create a new product/ services through brainstorming.???????????????

Ways to create new product development through brainstorming

Kodak - informal sessions- engineer and designer with customers- problems & needs.

-Allow time off: scouting time- for technical people to putter in their own, pet projects.

-Survey your customers.

-Use iterative models: customers group discussing problems- technical people in another room listening and solving.

-Set up an idea vault.

-Interaction b/w technical people and supplier - through visits .

Forces fighting new ideas

I have got great idea

Forces fighting new ideas

It wont work here

Forces fighting new ideas

We have tried it before

Forces fighting new ideas

This is not the right time

Forces fighting new ideas

It can’t be done

Forces fighting new ideas

It's not the way we do things

Forces fighting new ideas

We have done all right without it

Forces fighting new ideas

It will cost too much

Forces fighting new ideas

Let us discuss in our next meeting

During brainstorming activity: management has to be:

Receptive
Vision for future growth
Keep long term objectives in mind
SWOT

Perform preliminary project analysis to assess whether a project proposal is worthwhile or not.

Documents like: **project / product documents** (characteristics of project), **feasibility document** (constraints), **project concept** document (what, how, why – is to be done), **project charter** (it formally communicates the initiation of the project, scope, authority, KSF)

Ex: Reduce vehicular pollution in your city

1.
2.
3.
.
.
.
N

Criteria for screening ideas

Effectiveness to achieve objectives

Cost of the proposal

Ease of implementation

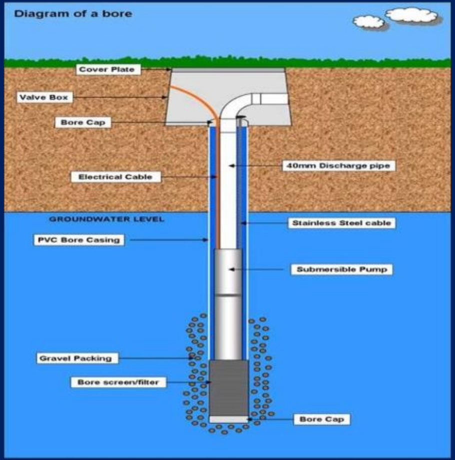
Time needed

Project appraisal

Market appraisal: customer (who-needs), mkt share, current and future competitors- their mkt share, aggregate demand, possible pricing options.

Project appraisal

Technical : Engineering aspects, location , size, process, etc. (bore well)



Financial factor?????

Project appraisal

Financial appraisal: Cost of project and means of sources, impact on financial position of the firm, working capital, cash flows over time, profitability, BEP, net present worth, IRR, PBP, Risk.

Project appraisal

Ecological: **Environmental damage (air, water, noise) restoration measures**

Economic?????????

Project appraisal

Economic: Impacts of project on society. Benefits and costs, distribution of income in society, level of saving and investments, employment, etc.

Project appraisal

Production factors: **<u>Time</u>** to complete project, availability of **<u>resources</u>**, flexibility of **<u>operations</u>**, connection with existing **<u>production</u>** line, **<u>energy</u>** requirements and its sources. Expected **quality** of product.

Personal factors:??????

Legal factors:???????

2. Planning and organizing

3.Project implementation :?????????????

3.Project implementation:

- Organization of project **team** and allocation of **work**
- Monitoring – cost, value and time
- Effective control action to minimize time and cost overruns
- Updating of project schedules (time and cost)
- Provisioning of financial and other resources needed in the project
- Coordination
- Awarding of contracts-vendors, sub contactor
- Procure and erecting of equipment and services

4. Project completion and Review?????

4. Project completion and Review

Disbanding project team

Handing over

Accounting and report writing

Learning from experience

What else ???????

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Project Management for Managers

Lec – 08

Methods of Project Selection - I

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Model for project selection: Methods for selection run on continuum, from highly **qualitative or judgmental to quantitative**. The screening models should have:

Model for project selection: Methods for selection run on continuum, from highly qualitative or **judgmental to quantitative**. The screening models should have:

1. **Realism**: organization's objectives, constraints on money and resources.
2. **Capability**: flexible enough to respond to changes in conditions under which projects are carried out. Comparison of projects should be there (time, technology, commercial aspects).

3. **Flexibility**: model should allow tax rate and tax laws, building codes.

4. **Ease of use**: simple enough, help people involved in project roles and functional roles

5. **Cost**: model should be cost effective

6. **Comparability**: broad enough to be applied to multiple projects

Methods of project selection/evaluation

- Sacred cow: Senior and powerful people
- Operating necessity: Shortage of power - power generation unit, effluent disposal issue – effluent treatment plant
- BCG
- CE/McKINSEY
- SPACE diagram

Methods of project selection/evaluation

Boston Consulting Group (BCG) Matrix: is a four celled matrix (2 * 2 matrix) developed by BCG, USA.

It is the most renowned corporate **portfolio analysis tool**.

It provides a graphic representation for an organization to **examine different businesses in it's portfolio** on the basis of their **related market share and industry growth rates.**

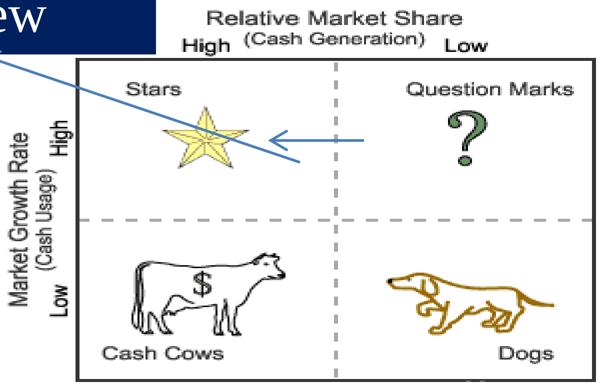
It is a two dimensional analysis on management of SBU's (Strategic Business Units). In other words, it is a comparative analysis of **business potential and the evaluation of environment.**

According to this matrix, business could be **classified as high or low** according to their industry growth rate and relative market share.

Market Share???(Reltv)? = SBU Sales this year / leading competitors sales this year.

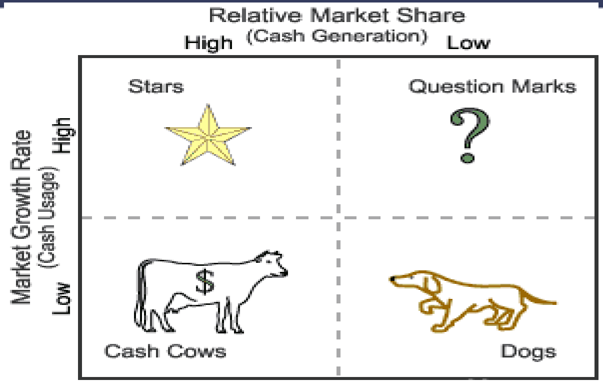
Market Growth Rate = Industry sales this year/ Industry Sales last year.

Select few



Stars- Stars represent business units having **large market share** in a **fast growing** industry. They may generate cash but because of fast growing market, stars **require huge investments to maintain their leads**. Net cash flow is usually modest.

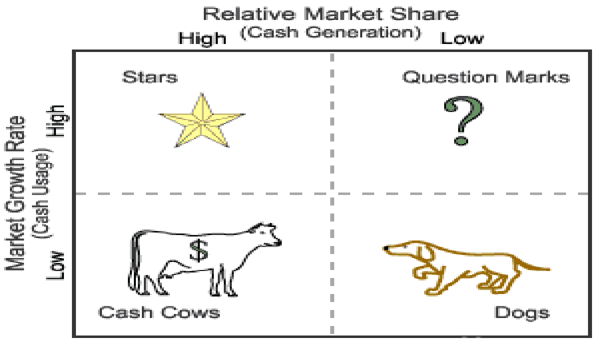
SBU's located in this cell are attractive as they are located in a robust industry and these business units are highly competitive in the industry. **If successful, a <u>star will become a cash cow</u> when the industry matures.**



Cash Cows- Cash Cows represent business units having a **large market share in a mature, slow growing industry**.

Cash cows **require little investment** and generate cash that can be utilized for **investment in other business units**. These SBU's/products are the corporation's key source of cash, and are specifically the core business.

They are the base of an organization. **These businesses usually follow <u>stability strategies</u>.** When **cash cows loose their appeal** and move towards deterioration, then a **retrenchment** policy may be pursued.



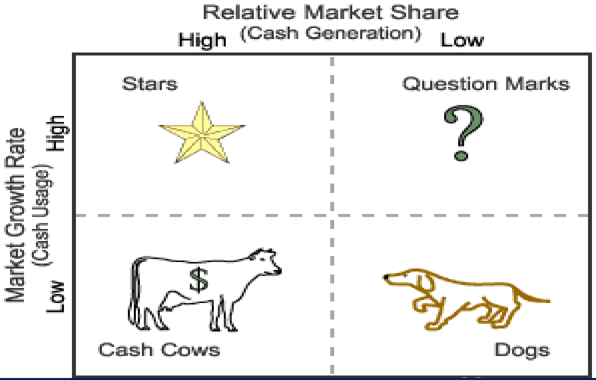
Divest others

Question Marks- They **require huge amount of cash** to maintain or gain market share. They require attention to determine if the venture can be viable.

If the firm thinks it has **dominant market share**, then it can adopt **expansion** strategy, else **retrenchment** strategy can be adopted.

Most **businesses start as question marks** as the company tries to enter a high growth market in which there is already a market-share.

If ignored, then question marks may become dogs, while if huge investment is made, then they have potential of becoming stars.



Liquidate

Dogs- Dogs represent businesses having weak market shares in low-growth markets. **They neither generate cash nor require huge amount of cash.** Due to low market share, these business units face **cost disadvantages**. Generally **retrenchment strategies are adopted** because these firms can gain market share only at the expense of competitor's/rival firms.

These business firms have **weak market share because of high costs, poor quality, ineffective marketing, etc**. Unless a dog has some other strategic aim, it should be liquidated if there is fewer prospects for it to gain market share. **Number of dogs should be avoided and minimized in an organization.**

As a particular industry **matures and its growth slows**, all business units become either ***cash cows* or *dogs***.

The **natural cycle** for most business units is that they start **as *question marks*, then turn into *stars*.**

Eventually the market stops growing thus the business unit becomes a ***cash cow*.**

At the end of the cycle the cash cow turns into a ***dog*.**

BCG looks at only growth–share, ignores other elements.

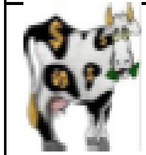
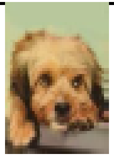
RELATIVE MARKET SHARE

HIGH — Cash Generation — LOW

MARKET GROWTH RATE — Cash Usage (HIGH / LOW)

	HIGH	LOW
HIGH	**STARS** Earnings: *low, stable, growing* Cash flow: *neutral* Strategy: *invest for growth*	**QUESTION MARKS** Earnings: *low, unstable, growing* Cash flow: *negative* Strategy: *invest ,if has potential, otherwise sell*
LOW	**CASH COWS** Earnings: *high & stable* Cash flow: *high & stable* Strategy: *invest to maintain current level or harvest*	**DOGS** Earnings: *low, unstable* Cash flow: *neutral or negative* Strategy: *divest*

Relative market share

Business Growth Rate	High	Low
High	 Safari Dicor, Indica Vista, Starbus, Ace, Manza, Winger, Magic, Tata Prima, Other LCE's	 Nano, OneCat, Versa, Essota & other new inventions
Low	 Safari, Sumo, Indigo CS, Indigo XL	 Indigo Sedan, Safari, Sierra, Estate


Star
Agri Business
Hotels
Paperboards & Packaging
Question mark
FMCG-Foods
ITC Infotech
Cash Cow
FMCG-Cigarettes
Dog
Branded Apparels
Packaged foods
High
Low
MARKET GROWTH
High
Low
MARKET SHARE

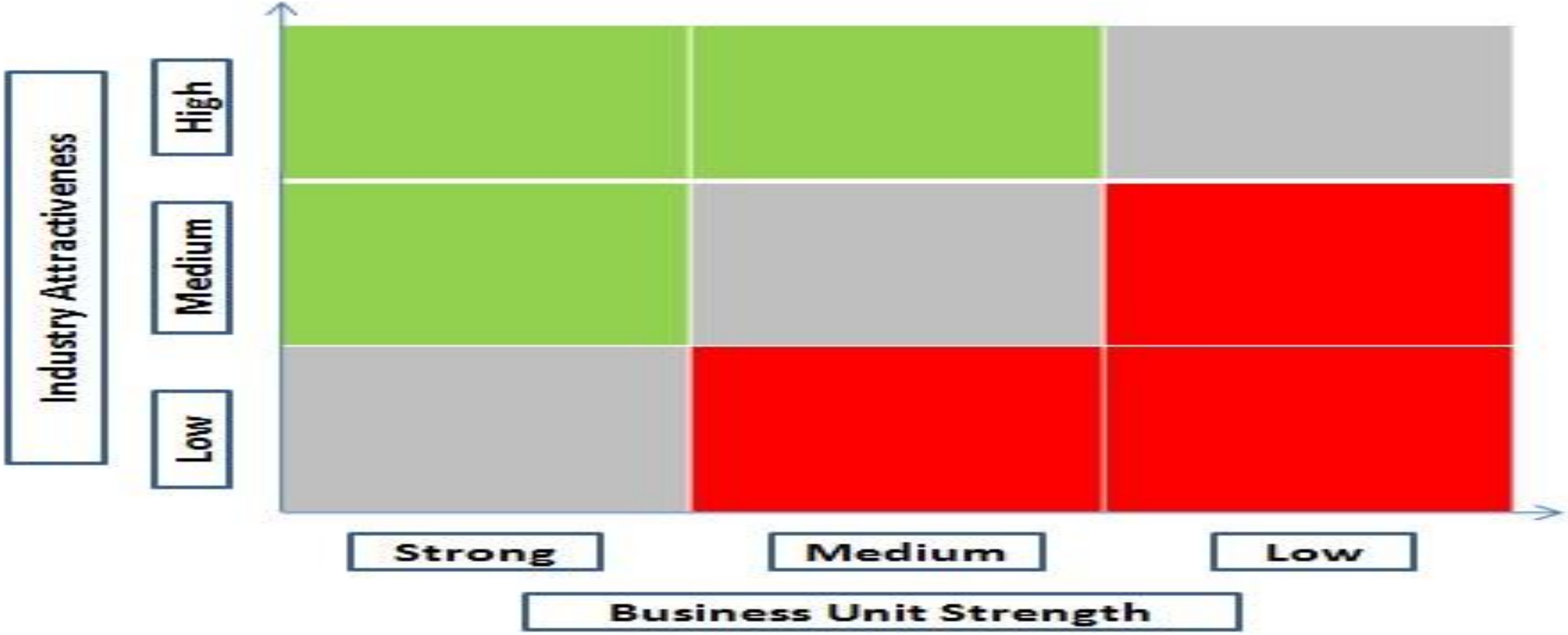
McKINSEY/GE Matrix:

GE / McKinsey Matrix is an extension of the BCG Matrix. This tool compares different businesses on "**Business Strength**" and “**Industry/ Market Attractiveness**" .

This Matrix is divided **into nine cells** - nine alternatives for positioning of any SBU or product offering. **Based on the strength of the business and its market attractiveness each SBU will have a different position in the matrix.**

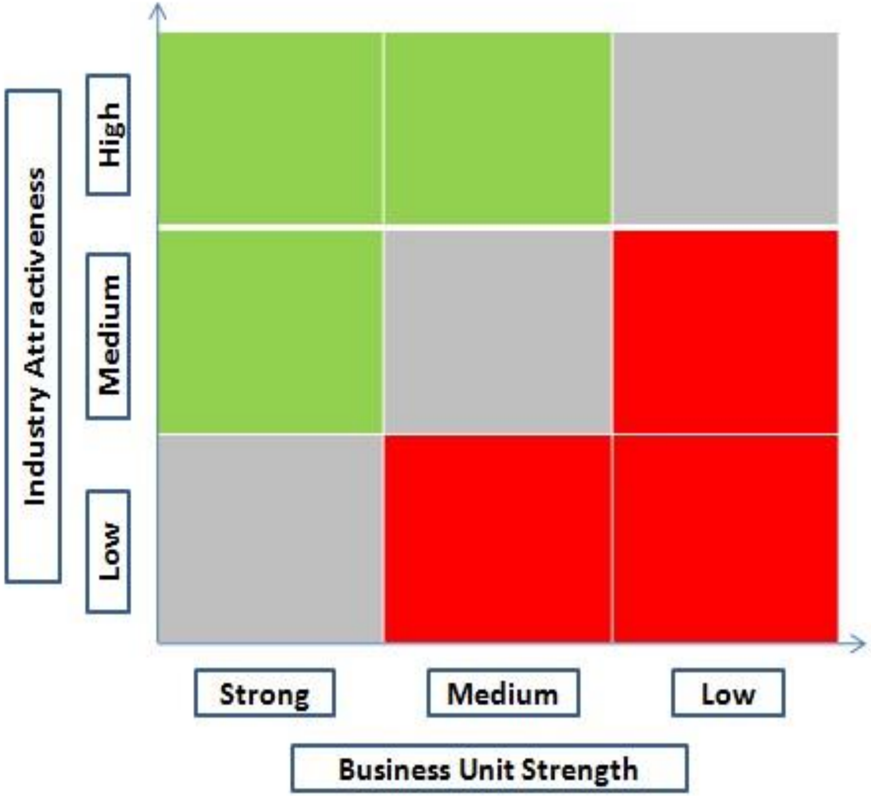
Industry Attractiveness??????

Business Unit Strength??????



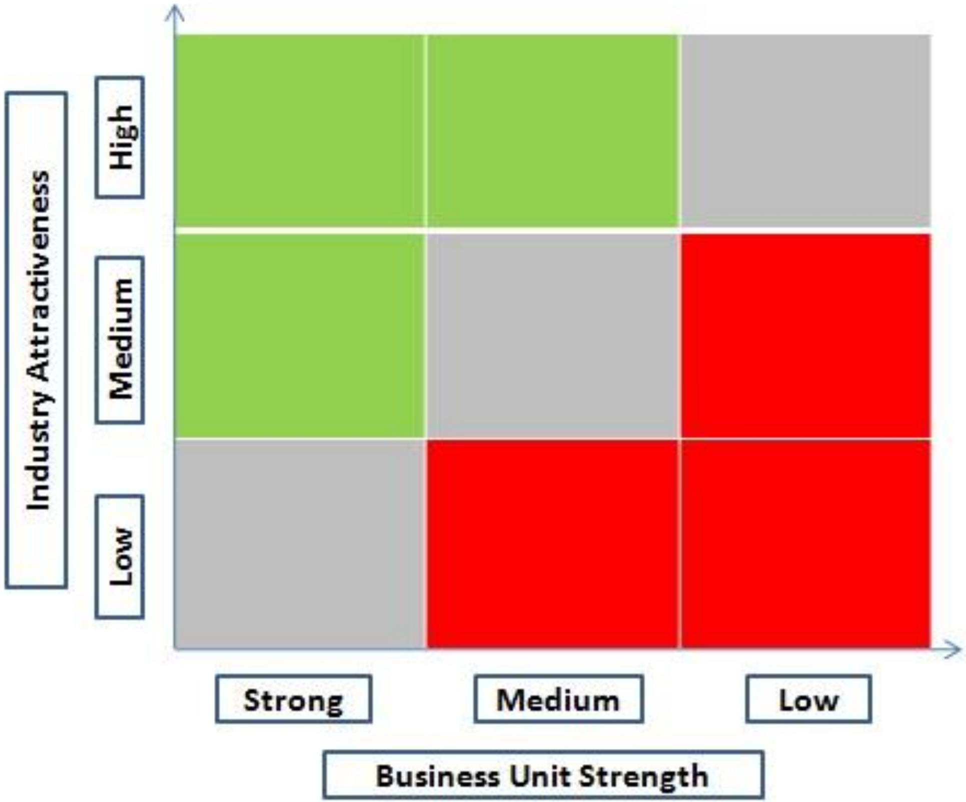
Industry Attractiveness

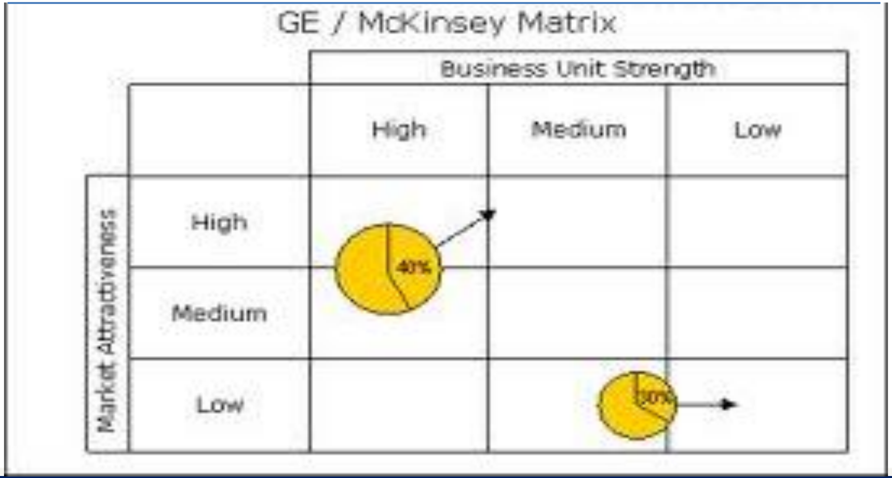
- Market size
- Market growth rate
- Govt support (????)
- Global opportunities
- Industry profitability
- Industry rivalry
- Demand variability
- Macroenvironmental factors



Business Unit Strength

- Market share
- Growth in market share
- Customer loyalty
- Brand equity
- Distribution channel access
- Production capacity
- Profit/cost margins relative to competitors
- Financial and channels' strength



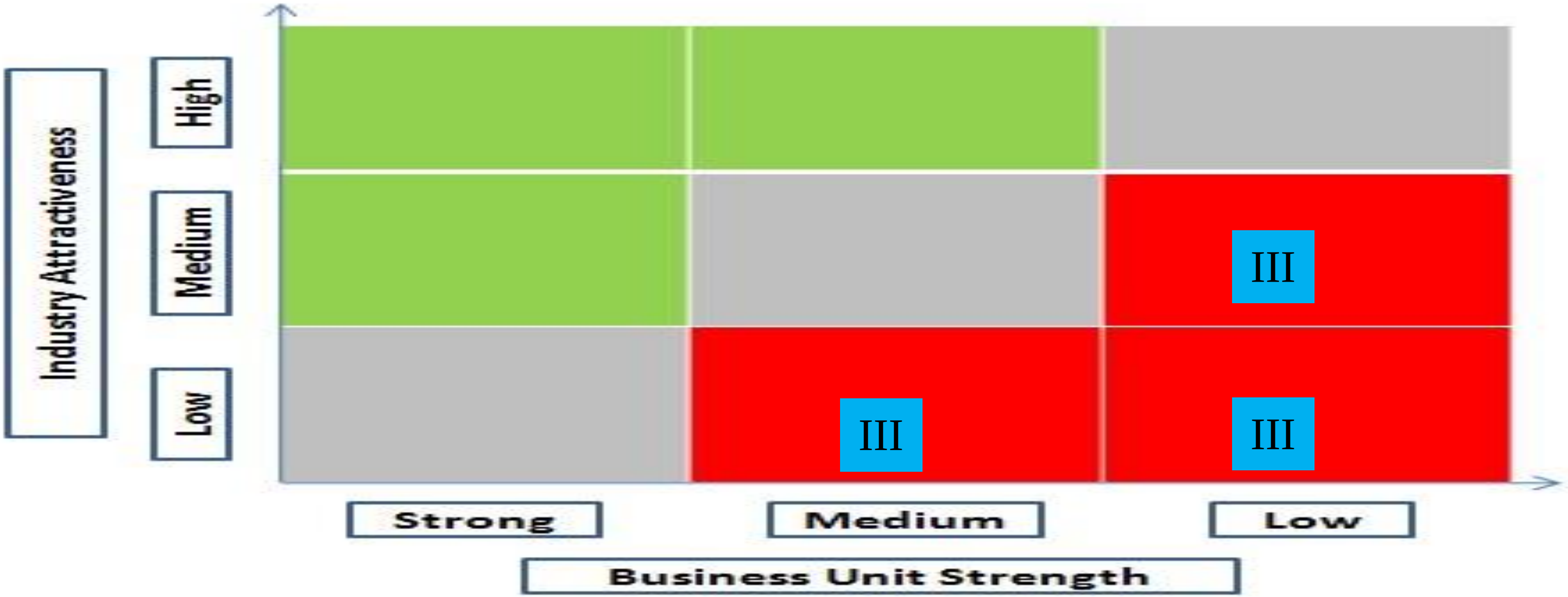


Plotting the Information: Each **business unit can be portrayed as a circle** plotted on the matrix, with the information conveyed as follows:

- Market **size** is represented by the size of the circle.
- Market **share** is shown by using the circle as a **pie chart**.
- The expected future position of the circle is portrayed by means of an arrow.

Segment I: This is the **best segment**. The business is strong and the market is attractive. The company should **allocate resources in this business and focus on growing the business and increase market share. (Similar to which cell of BCG????)**

Segment II: The **business** is either **strong but the market is not attractive or** the **market is strong** and the **business is not strong** enough to pursue potential opportunities. **Decision makers should make judgment on how to further deal with these SBUs**. Some of them may consume to much resources and are not promising while others may need additional resources and better strategy for growth. (**Similar to which cell of BCG????)**



Segment III: This is the **worst segment**. Businesses in this segment are **weak and their market is not attractive**. Decision makers should consider either **repositioning these** SBUs into a different market segment, develop **better cost-effective offering**, or **get rid of these SBUs** and invest the resources into more promising and attractive SBUs. (**Similar to which cell of BCG????)**

GE matrix

Industry attractiveness — Size, Market Growth, Pricing, Mkt. Diversity Competitive Structure, Industry Profitability

Business strength - Size - Growth - Share - Position - Profitability - Margins - Tech. Position - Image - People		**High**	**Medium**	**Low**
	High	Investment and growth (G) SWIFT	Investment and growth (G) ALTO	Selectivity/ Earnings A STAR
	Medium	Investment and growth (G) SWIFT DEZIRE	Selectivity/ Earnings SX4	Harvest BALENO
	Low	Selectivity/ Earnings WAGON R	Harvest VERSA	Harvest OMNI

Prepare GE Matrix of ITC ?????

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Project Management for Managers

Lec – 09

Methods of Project Selection - II

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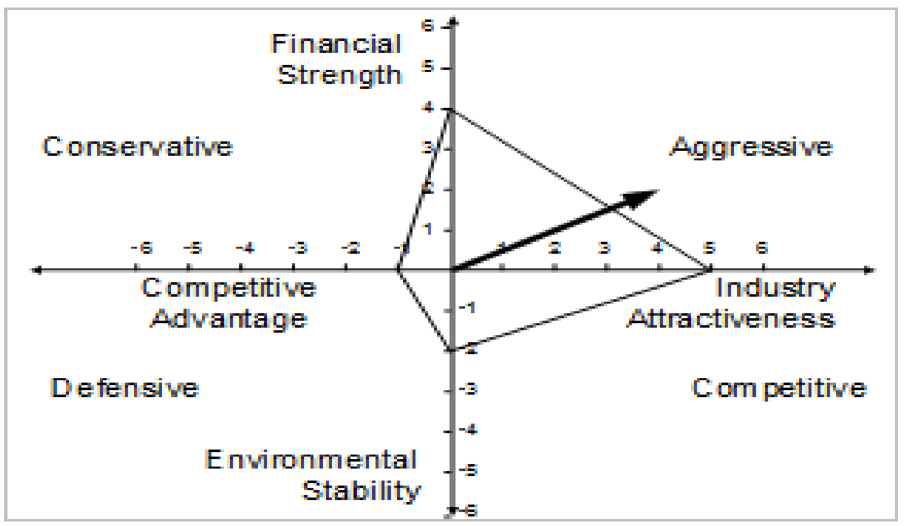
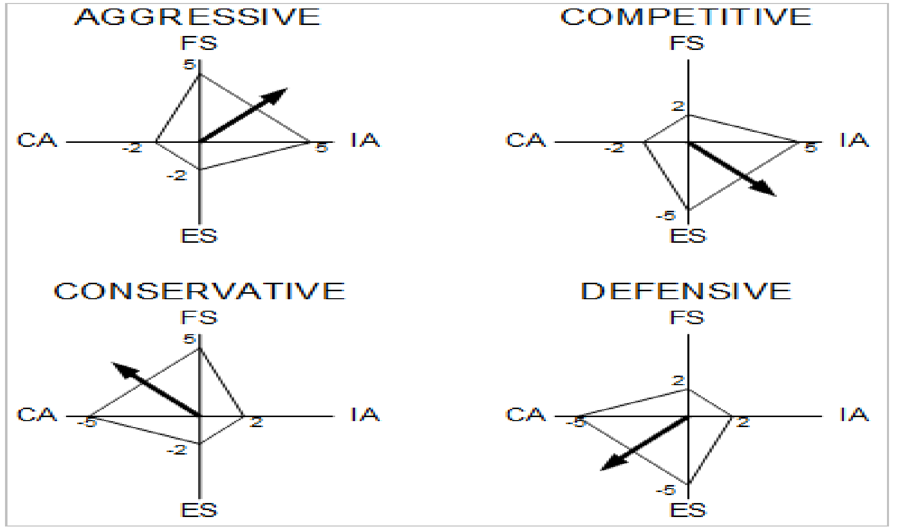
SPACE : (Strategic Position and Action Evaluation diagram: A management tool to **analyse a company and decide its future strategy**.

A set of variables should be selected to define:

- **Financial strength,**
- **Competitive advantage,**
- **Environmental stability, and**
- **Industry attractiveness.**

Internal
and External???





The set of variables could be as follows:Internal Dimensions

Financial Strength

- Return of investment
- Ability to raise funds
- Liquidity
- **Working capital**
- Cash flows

Competitive Advantage

- Market share
- Capacity utilization
- **Location advantage**
- Brand image
- Product **Quality**
- Product life cycle
- Customer preference
- Technological **innovation**
- **Sound** supply chain

The set of variables could be as follows: **External Dimensions**

Environmental Stability
- Technological changes
- Inflation
- **Demand elasticity**
- Competitor's price ranges
- Barriers to entry
- Competitive pressure
- **Ease of exit**
- Price elasticity of demand
- Risk exposure

Industry attractiveness
- Growth potential
- Profit potential
- Financial stability
- Resource availability
- **Ease of entry**
- Capacity utilization

Criteria

Tangible: Rs, %, Rs/year

Intangible: (Not measurable on a well defined scale)

Commensurate

Incommensurate (Rs for investment & years for PBP)

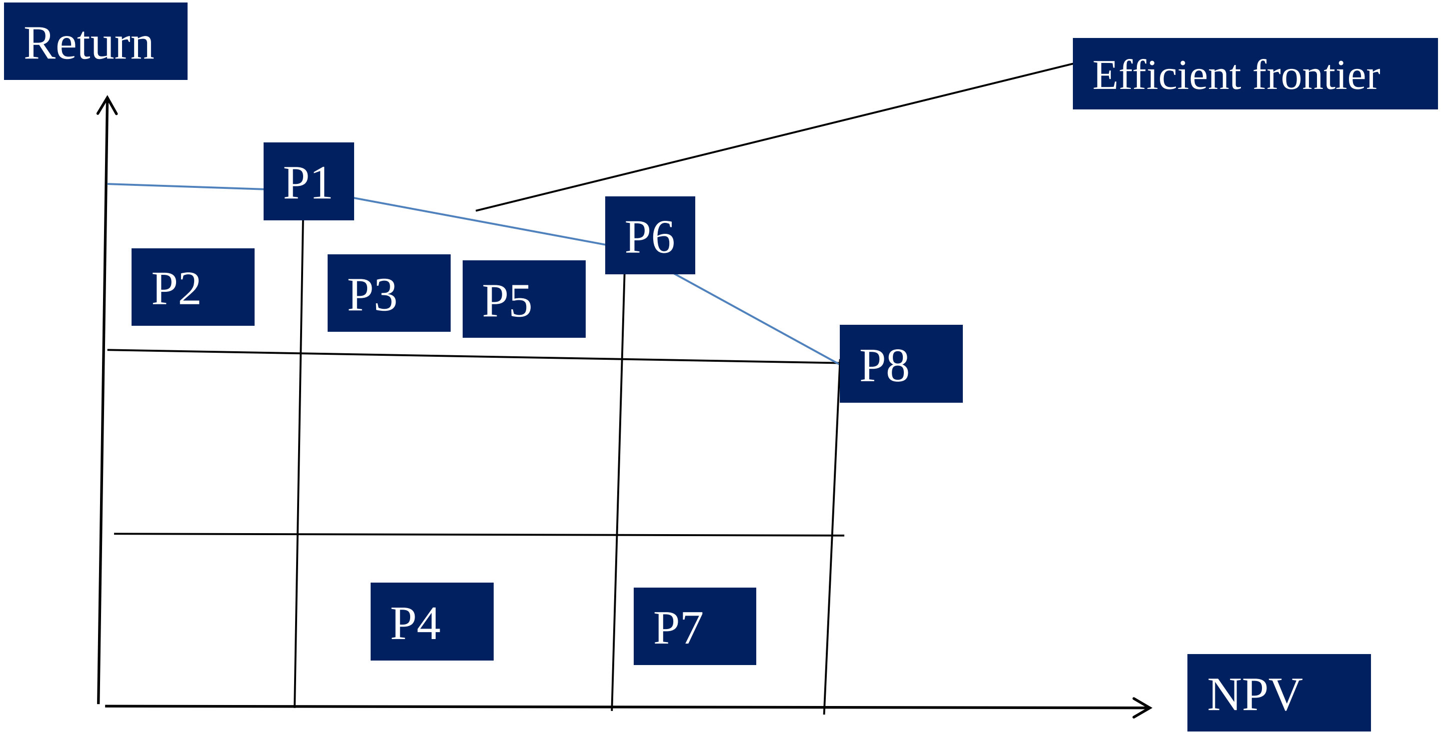
(Not measurable – Score on a subjective scale ?????)

Projects

Dominance

Non dominance/Pareto optimal set

Non dominance/Pareto optimal set



Selection method: (un-weighted)/ Dominance

Project	Criteria	Performance on criteria		
		High	Medium	Low
Alpha	Cost	x		
	Profit potential			x
	Time to market		x	
	Development risk			x
Beta	Cost		x	
	Profit potential		x	
	Time to market	x		
	Development risk		x	
Gamma	Cost	x		
	Profit potential	x		
	Time to market			x
	Development risk	x		
Delta	Cost			x
	Profit potential			x
	Time to market	x		
	Development risk		x	

Maximize : which is the best project based on maximizing all the criteria?

SIMPLIFIED SCORING MODEL (WEIGHTED)

Project	Criteria	Performance on criteria		
		High	Medium	Low
Alpha	Cost	x		
	Profit potential			x
	Time to market		x	
	Development risk			x
Beta	Cost		x	
	Profit potential		x	
	Time to market	x		
	Development risk		X	
Gamma	Cost	X		
	Profit potential	x		
	Time to market			x
	Development risk	x		
Delta	Cost			x
	Profit potential			x
	Time to market	x		
	Development risk		x	

	Weight
Cost	1
Profit potential	2
Time to market	3
Development risk	2

Low-1 Medium-2 High-3

SIMPLIFIED SCORING MODEL (WEIGHTED)

Project	Criteria	Performance on criteria		
		High	Medium	Low
Alpha	Cost	3		
	Profit potential			1
	Time to market		2	
	Development risk			1
Beta	Cost		2	
	Profit potential		2	
	Time to market	3		
	Development risk		2	
Gamma	Cost	3		
	Profit potential	3		
	Time to market			1
	Development risk	3		
Delta	Cost			1
	Profit potential			1
	Time to market	3		
	Development risk		2	

	Weight
Cost	1
Profit potential	2
Time to market	3
Development risk	2

Low-1 Medium-2 High-3

Alpha:3*1+1*2+2*3+1*2=13

Beta:2*1+2*2+3*3+2*2=19

Gamma:3*1+3*2+1*3+3*2=18

Delta:1*1+1*2+3*3+2*2=16

Optimization Techniques

Linear Programming: ????????????

Optimization Techniques

Linear Programming: Optimization of a function of variables know as objective function, subject to a set of linear equations and/or inequalities known as constraints.

Ex:

	Mobile	**Laptop**	
Assembly	6	3	90hrs
Finishing	3	6	72hrs
Profit	120	90	

Determine the best combination of mobile and laptops to realize maximum profit.

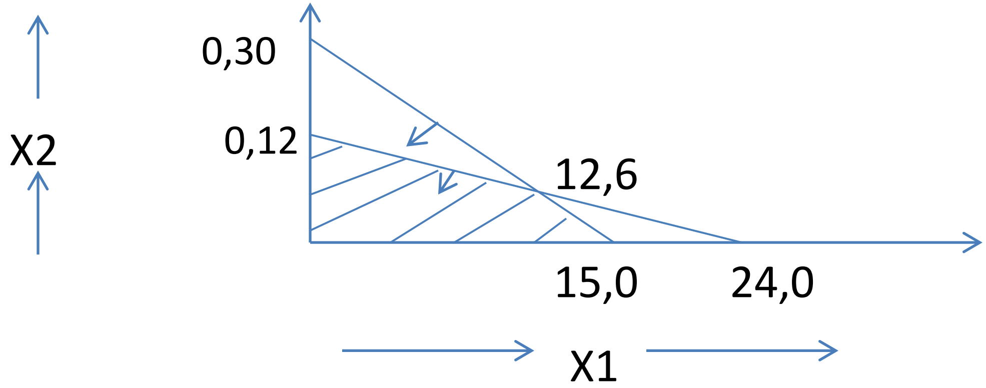
Maximize $Z = 120x1 + 90x2$

ST $6x1 + 3x2 <= 90$

$3x1 + 6x2 <= 72$

$x1, x2, <= 0$

Answer: x1= 12 and x2= 6. Total profit = 1980



Integer programming

A company is planning its capital spending for the **next T periods**.

There are **N projects** that compete for the limited **capital Bi,** available for investment in **period "i".**

Each project requires a certain investment in each period once it is selected.

Let "aij" be the required investment in project j for period i.

The value of the project is **measured in terms of NPV**. Let, Vj is NPV of project j.

The problem is to select the **proper project** for investment that will **maximize total NPV.**

Integer programming : A company is planning its capital spending for the next T periods,. There are N projects that compete for the limited capital Bi, available for investment in period "i". Each project requires a certain investment in each period once it is selected. Let "aij" be the required investment in project j for period i. The value of the project is measured in terms of NPV. Let , Vj is NPV of project j. The problem is to select the proper project for investment that will maximize total NPV.

$x_j = 1$ if project j is selected

$x_j = 0$ if project j is not selected

Max $Z = \sum v_j x_j$ ($j=1$ to N)

ST $\sum a_{ij} x_j \le B_i$, for $i=1$ to T

$0 \le x_j \le 1$, x_j a binary and for all $j = 1$ to N

	Project 1	Project 2	Project 3	Project 4
Profit	105	140	80	100
Cash flow (first year)	60	108	200	90
Cash flow (second year)	160	40	150	70
Cash flows in first and second year should not exceed 600 and 700.				
Project 1 and 3 are mutually exclusive.				
Company wants to maximize profit.				

$$\text{Max } Z = 105x1+140x2+80x3+100x4$$

$$\text{ST} \quad 60x1+108x2+200x3+90x4 <=600$$

$$160x1+40x2+150x3+70x4 <=700$$

$$x1+x3=1,$$

$$\text{All } 0<= xi<=1$$

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Project Management for Managers

Lec – 10

Methods of Project Selection (MCDM – I)

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MCDM

1) Multi-Attribute Utility Theory,
2) Analytic Hierarchy Process,
3) Fuzzy Set Theory,
4) Case-based Reasoning,
5) Data Envelopment Analysis,
6) SMART (Simple Multi-Attribute Rating Technique),
7) Goal Programming,
8) ELECTRE (ELimination and Choice Translating Reality),
9) PROMETHEE (Preference ranking organization method for enrichment evaluation
10) Simple Additive Weighting, and
11) TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)

Goal programming??:

In LP, only one dimension of (Z), organizations often have several objectives (conflicting) and not measured in same units.

GP asks mgt to rank objectives.

GP tries to **minimize deviations** from the targets .

Ex:

	Mobile	**Laptop (lt)**	
Assembly	6	3	90hrs
Finishing	3	6	72hrs
Profit	120	90	

If profit is Rs120 per mobile and Rs 90 per laptop, **determine the best combination of** mobile **and laptop to realize a profit of Rs 2100.**

This is a single goal (profit) problem. Let

Du = Amount by which profit goal is underachieved.

Do = Amount by which profit goal is overachieved.

Minimize Z = Du (underachievement of profit goal)

ST $120x_1 + 90x_2 + Du - Do = 2100$

$6x_1 + 3x_2 <= 90$

$3x_1 + 6x_2 <= 72$

$x_1, x_2, Du, Do >= 0$

$6x_1 + 3x_2 + s_1 = 90$

$3x_1 + 6x_2 + s_2 = 72$

$x_1, x_2, s_1, s_2 >= 0$

This is a single goal (profit) problem. Let

Du = Amount by which profit goal is underachieved.

Do = Amount by which profit goal is overachieved.

Minimize Z = Du (underachievement of profit goal)

ST 120x1 +90x2+Du-Do = 2100

6x1+ 3x2<=90

3x1+ 6x2<=72

x1,x2,Du,Do >=0

6x1+ 3x2+s1 =90

3x1+ 6x2+s2=72

x1,x2,s1,s2>=0

	c_j	0	0	0	0	1	0	
c_B	Basis	x_1	x_2	s_1	s_2	D_u	D_o	b
1	D_u	0	0	$-50/3$	$-20/3$	1	-1	120
0	x_1	1	0	$2/9$	$-1/9$	0	0	12
0	x_2	0	1	$-1/9$	$2/9$	0	0	6
	Z_j	0	0	$-50/3$	$-20/3$	1	-1	
	$\bar{c}_j$	0	0	$50/3$	$20/3$	0	1	

$D_{u\,min}$ *Optimal basic feasible solution*

After using simplex method, x1= 12, x2=6, Du =120, Means actual profit earned is Rs= 2100-120=1980, underachieved by Rs 120.

Ex: If the company sets **two equally ranked goals, one to reach a profit of Rs 1500** and the other to meet the **mobile goal of 10 units,** find the optimal solution.?????????

Solution:

Dup= Amount by which profit goal is underachieved

Dop= Amount by which profit goal is overachieved

Dum= Amount by which mobile goal is underachieved

Dom= Amount by which mobile goal is overachieved

Minimize Z =Dup+Dum

ST $\quad 120x1 + 90x2 + Dup - Dop = 1500$

$x1 + Dum - Dom = 10$

$6x1 + 3x2 <= 90$

$3x1 + 6x2 <= 72$

$x1, x2, Dup, Dop, Dum, Dom >= 0$

Solution:

Dup= Amount by which profit goal is underachieved

Dop= Amount by which profit goal is overachieved

Dum= Amount by which mobile goal is underachieved

Dom= Amount by which mobile goal is overachieved

Minimize Z =Dup+Dum

ST 120x1 +90x2+Dup-Dop = 1500

x1+Dum-Dom = 10

6x1+ 3x2<=90

3x1+ 6x2<=72

x1,x2,Dup,Dop,Dum,Dom >=0

	c_j	0	0	0	0	1	0	1	0	
c_B	Basis	x_1	x_2	s_1	s_2	D_{up}	D_{op}	D_{ur}	D_{or}	b
0	D_{or}	0	$3/4$	0	0	$1/120$	$-1/120$	-1	1	$5/2$
0	x_1	1	$3/4$	0	0	$1/120$	$-1/120$	0	0	$25/2$
0	s_1	0	$-3/2$	1	0	$-1/20$	$1/20$	0	0	15
0	s_2	0	$15/4$	0	1	$-1/40$	$1/40$	0	0	$69/2$
z_j		0	0	0	0	0	0	0	0	
$\bar{c}_j$		0	0	0	0	1	0	1	0	

Optimal b.f.s.

After using simplex method, x1=25/2, Dom = 5/2, Means profit goal of Rs= 1500 achieved, since both Dup and Dop do not appear in final table.

Analytic Hierarchy Process (AHP)

- Analytic Hierarchy Process is a multi-criteria decision making (MCDM) technique was developed by **Saaty** in 2000 year.

- The analytic hierarchy process (AHP) is also a structured technique for helping people deal with organizing and analyzing **complex decisions**.

- AHP is also a measurement theory that priorities the hierarchy and **consistency of judgmental data** provided by a group of decision makers.

- The AHP provides a **comprehensive and rational** framework **for structuring a problem**, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions

i. Establish the hierarchy structure

ii. Various hierarchies' elements weight computation

✓ Establishment of pair-wise comparison matrix

- ✓ The relative importance of two elements is rated using a scale with the values 1, 3, 5, 7, and 9.

Equally Preferred	Moderately Preferred	Strongly Preferred	Extremely Preferred	Absolutely Preferred
1	3	5	7	9

- ✓ 2, 4, 6, and 8 indicate intermediate value.

$$A = [a_{ij}] = \begin{array}{cc} & \begin{array}{cccc} C_1 & C_2 & & C_n \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ \vdots \\ C_n \end{array} & \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \end{array}$$

Where $a_{ij} = 1$ and $a_{ij} = 1/a_{ji} = 1, 2, ...n.$

$$A = [a_{ij}] = \begin{array}{cc} & \begin{array}{cccc} C_1 & C_2 & & C_n \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ \vdots \\ C_n \end{array} & \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_1 \\ \vdots & \vdots & & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} \end{array}$$

Where $W_i / W_j = a_{ij}$

- Eigen value and eigen vector calculation

$$\lambda_{max} = \sum_{j=1}^{n} a_{ij} \frac{W_j}{W_i}$$

- Consistency test

CI (Consistency Index) = $\frac{\lambda max - n}{n - 1}$

CR (Consistency Ratio) = $\frac{CI}{RI}$

✓ Random index values were already given by Saaty where

n=1	n=2	n=3	n=4	n=5	n=6	n=7	n=8
RI=0	RI=0	RI=0.52	RI=0.89	RI=1.11	RI=1.25	RI=1.35	RI=1.4

iii. Overall hierarchy weight computation

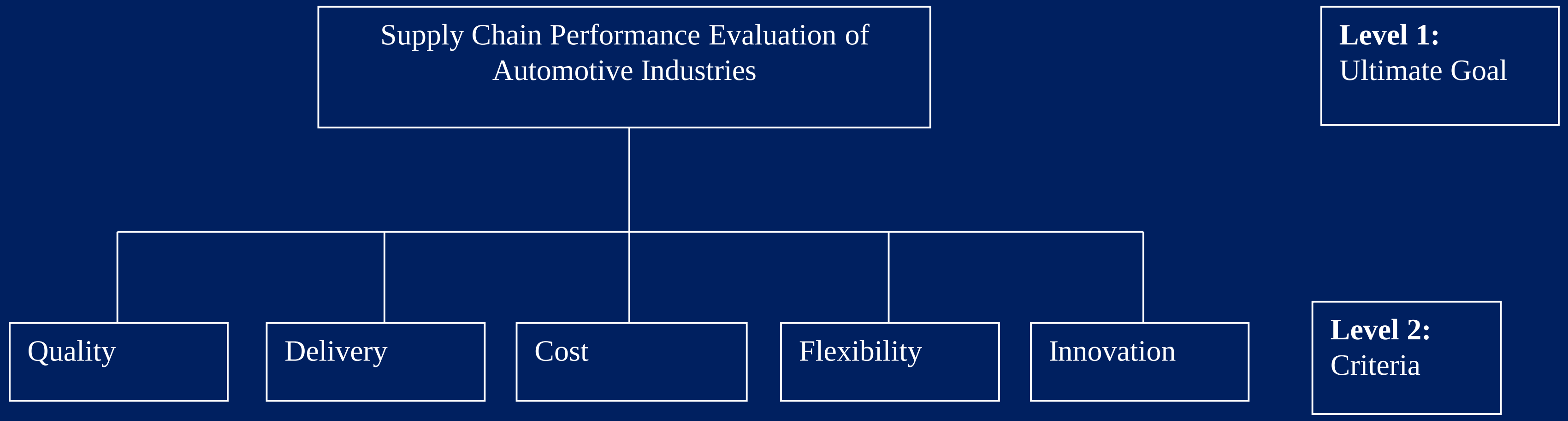


Figure : Hierarchical structure to evaluate the supply chain performance evaluation of automotive industries

	Quality	Delivery	Cost	Flexibility	Innovation
Quality	1	3	1	1/3	9
Delivery		1	1/3	1/5	6
Cost			1	1/4	7
Flexibility				1	8
Innovation					1

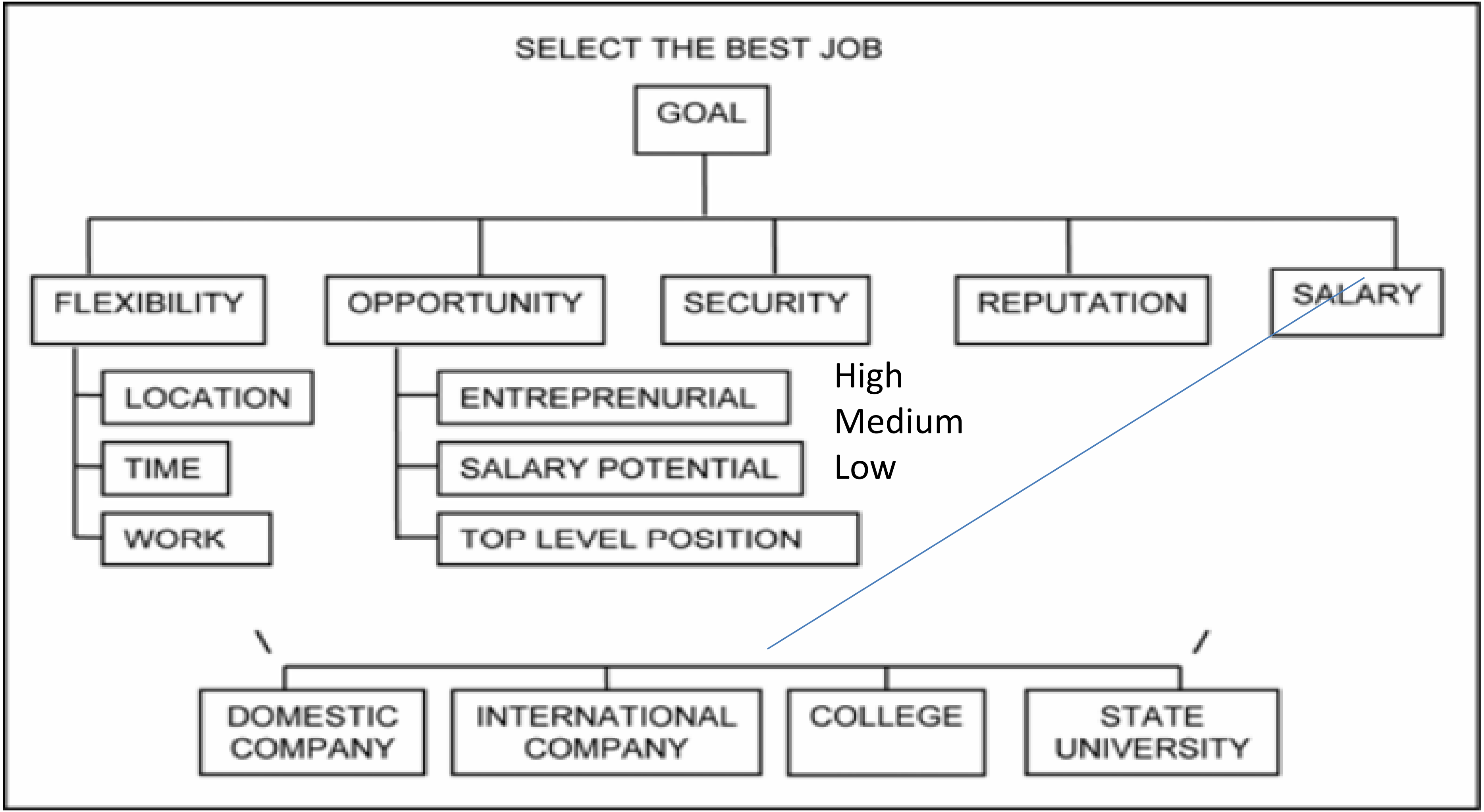
Pair-wise comparison matrix of respondents (Either consensus or highest frequency) for all criteria.

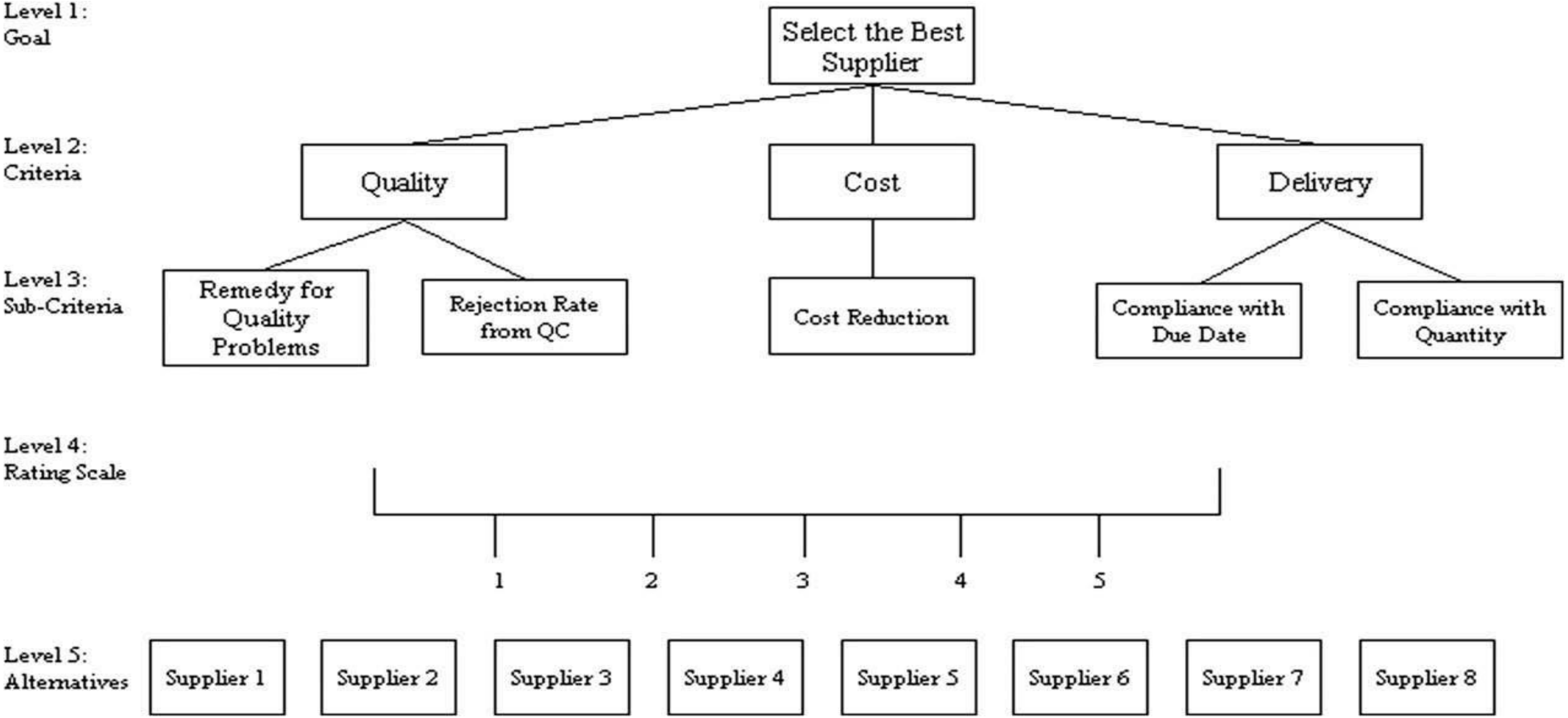
Respondents	CI	CR	Respondents	CI	CR
R_1	0.07749	0.06918	R_9	0.08364	0.07467
R_2	0.07986	0.07131	R_{10}	0.06853	0.06119
R_3	0.06862	0.06127	R_{11}	0.03277	0.02926
R_4	0.09214	0.08227	R_{12}	0.08052	0.07189
R_5	0.08884	0.07933	R_{13}	0.10024	0.08950
R_6	0.09095	0.08120	R_{14}	0.08556	0.07640
R_7	0.11118	0.09927	R_{15}	0.04887	0.04363
R_8	0.10366	0.09255	R_{16}	0.09692	0.08653

Table : Consistency index (CI) and consistency ratio (CR) of all respondents

Criteria	*Weights of Criteria*	*Rank*
Quality = C_1	0.2937	2
Delivery = C_2	0.1995	3
Cost = C_3	0.1533	4
Flexibility = C_4	0.3036	1
Innovation = C_5	0.0499	5

Table : Relative weights of the criteria and global priority


SELECT THE BEST JOB
GOAL
FLEXIBILITY
OPPORTUNITY
SECURITY
REPUTATION
SALARY
LOCATION
TIME
WORK
ENTREPRENURIAL
SALARY POTENTIAL
TOP LEVEL POSITION
High
Medium
Low
DOMESTIC COMPANY
INTERNATIONAL COMPANY
COLLEGE
STATE UNIVERSITY


Level 1:
Goal
Select the Best Supplier
Level 2:
Criteria
Quality
Cost
Delivery
Level 3:
Sub-Criteria
Remedy for Quality Problems
Rejection Rate from QC
Cost Reduction
Compliance with Due Date
Compliance with Quantity
Level 4:
Rating Scale
1
2
3
4
5
Level 5:
Alternatives
Supplier 1
Supplier 2
Supplier 3
Supplier 4
Supplier 5
Supplier 6
Supplier 7
Supplier 8

Project Management for Managers

Lec – 11

Methods of Project Selection (MCDM – II)

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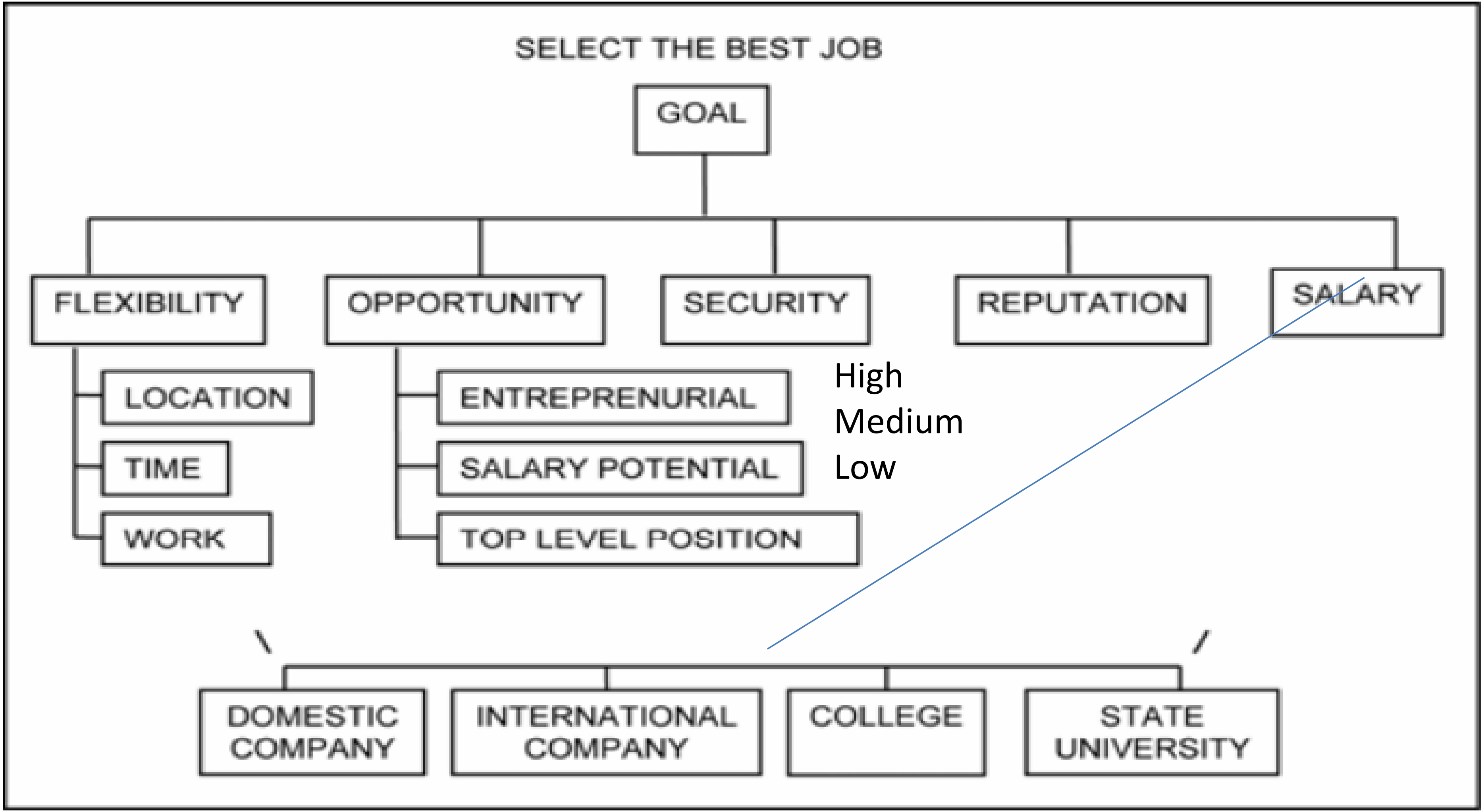
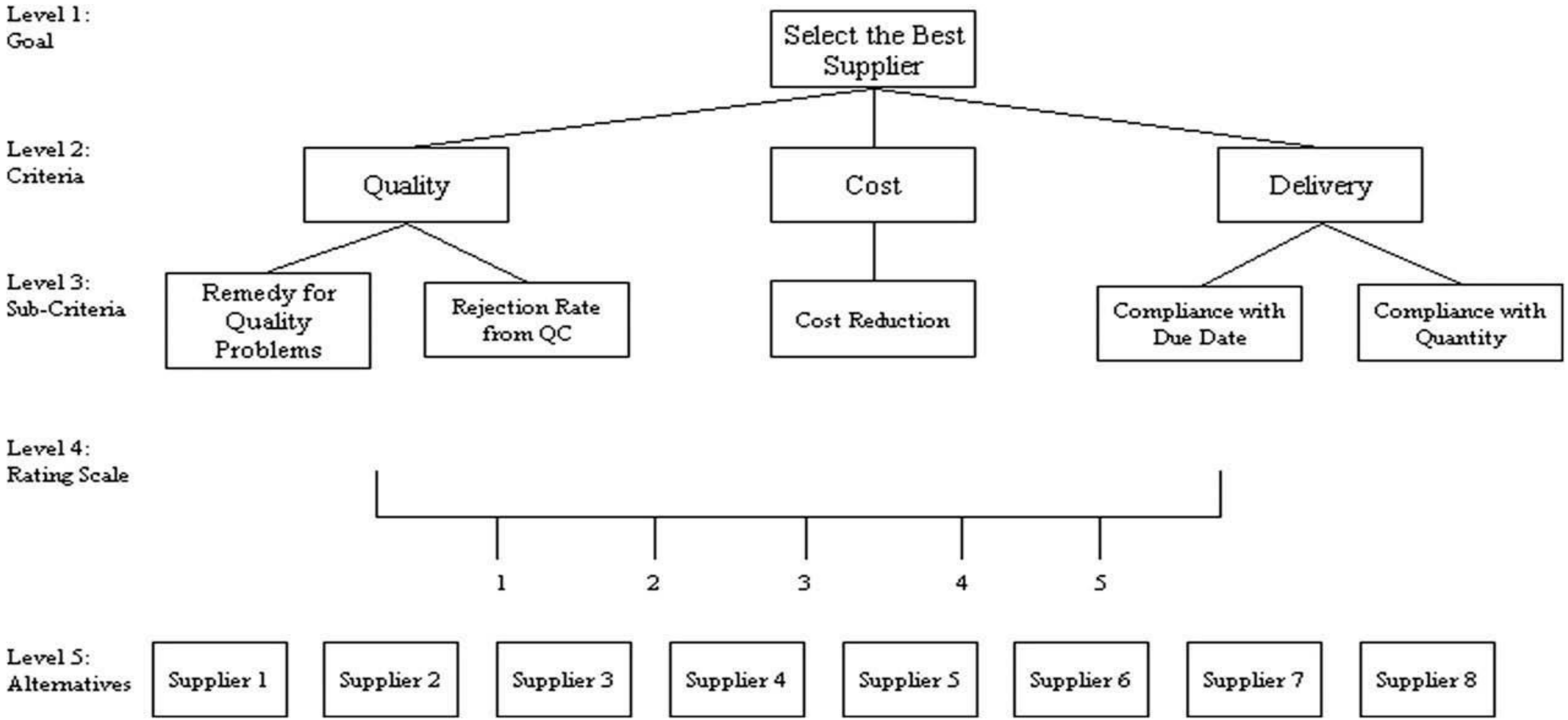

SELECT THE BEST JOB
GOAL
FLEXIBILITY
OPPORTUNITY
SECURITY
REPUTATION
SALARY
LOCATION
TIME
WORK
ENTREPRENURIAL
SALARY POTENTIAL
TOP LEVEL POSITION
High
Medium
Low
DOMESTIC COMPANY
INTERNATIONAL COMPANY
COLLEGE
STATE UNIVERSITY


Level 1:
Goal
Select the Best Supplier
Level 2:
Criteria
Quality
Cost
Delivery
Level 3:
Sub-Criteria
Remedy for Quality Problems
Rejection Rate from QC
Cost Reduction
Compliance with Due Date
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1
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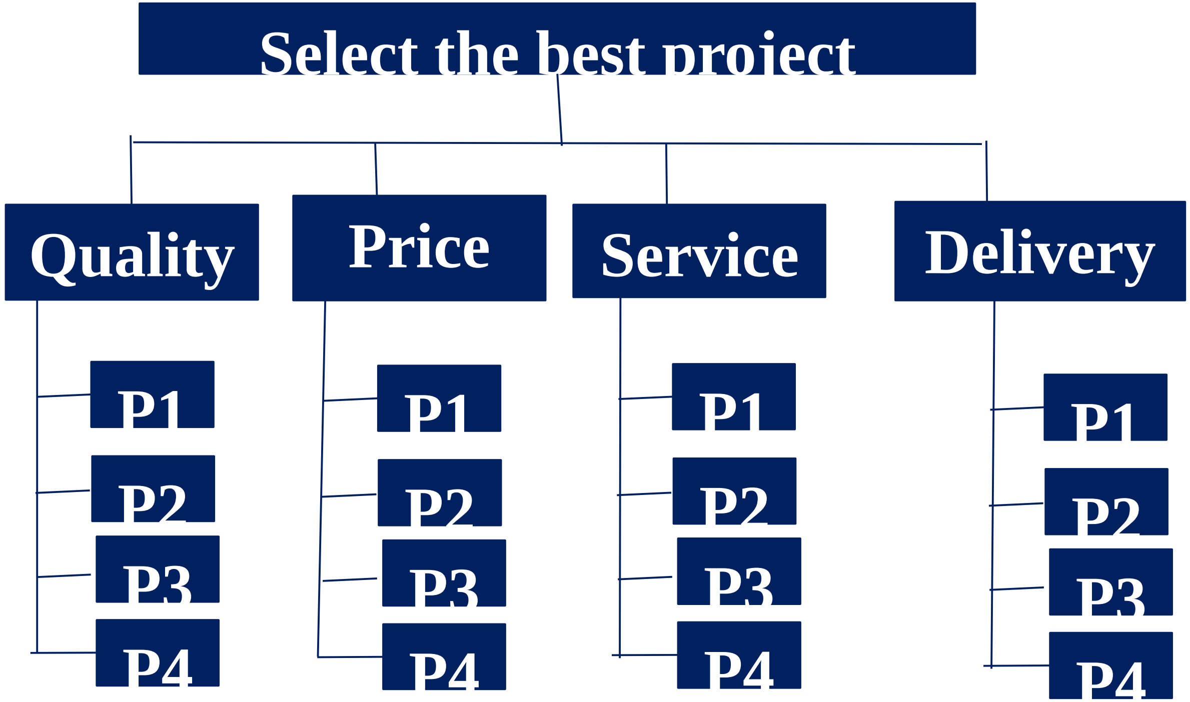
4
5
Level 5:
Alternatives
Supplier 1
Supplier 2
Supplier 3
Supplier 4
Supplier 5
Supplier 6
Supplier 7
Supplier 8


Select the best project
Quality
Price
Service
Delivery
P1
P2
P3
P4
P1
P2
P3
P4
P1
P2
P3
P4
P1
P2
P3
P4

Pair wise comparison matrix and computations: evaluation criteria

Original matrix	**Quality**	**Price**	**Service**	**Delivery**
Quality	1	2	4	3
Price		1	3	3
Service			1	2
Delivery				1

Pair wise comparison matrix and computations: evaluation criteria

Original matrix	**Q**	**P**	**S**	**D**
Q	1	2	4	3
P	½	1	3	3
S	¼	1/3	1	2
D	1/3	1/3	1/2	1
Column total	25/12	11/3	17/2	9

Adjusted matrix	Q	P	S	D	Weights (row avg.)
Q	12/25	6/11	8/17	3/9	0.457
P	6/25	3/11	6/17	3/9	0.300
S	3/25	1/11	2/17	2/9	0.138
D	4/25	1/11	1/17	1/9	0.105
				Total	1.0

Supplier pair wise comparison matrices and priorities

A: wrt quality

	P1	P2	P3	P4	Wts
P1	1	5	6	1/3	?
P2		1	2	1/6	?
P3			1	1/8	?
P4				1	?

A: wrt price

	P1	P2	P3	P4	Wts
P1	1	1/3	5	8	?
P2		1	7	9	?
P3			1	2	?
P4				1	?

Supplier pair wise comparison matrices and priorities

A: wrt service

	P1	P2	P3	P4	Wts
P1	1	5	4	8	?
P2		1	1/2	4	?
P3			1	5	?
P4				1	?

A: wrt delivery

	P1	P2	P3	P4	Wts
P1	1	3	1/5	1	?
P2		1	1/8	1/3	?
P3			1	5	?
P4				1	?

Calculation of the weights A: wrt quality

	P1	P2	P3	P4
P1	1.00	5.00	6.00	0.33
P2	0.20	1.00	2.00	0.17
P3	0.17	0.50	1.00	0.13
P4	3.00	6.00	8.00	1.00
Column total	4.37	12.50	17.00	1.63

	P1	P2	P3	P4
P1	1/4.37	5.00/12.50	6.00/17	0.33/1.63
P2	0.20/4.37	1.00/12.50	2.00//17	0.17/1.63
P3	0.17/4.37	0.50/12.50	1.00//17	0.13/1.63
P4	3.00/4.37	6.00/12.50	8.00//17	1.00/1.63

	P1	P2	P3	P4	Row Sum	Normalized
P1	0.229008	0.4	0.352941	0.205128	1.187077	0.296769
P2	0.045802	0.08	0.117647	0.102564	0.346013	0.086503
P3	0.038168	0.04	0.058824	0.076923	0.213915	0.053479
P4	0.687023	0.48	0.470588	0.615385	2.252996	0.563249

A wrt Price

	P1	P2	P3	P4
P1	1.00	0.33	5.00	8.00
P2	3	1	7	9
P3	0.166667	0.142857	1	2
P4	0.125	0.111111	0.5	1
Column Sum	4.29	1.59	13.50	20.00

	P1	P2	P3	P4	Row Sum	Normailzed
P1	0.23301	0.21	0.37037	0.4	1.213380079	0.30334502
P2	0.699029	0.63	0.518519	0.45	2.297547645	0.574386911
P3	0.038835	0.09	0.074074	0.1	0.302909026	0.075727256
P4	0.029126	0.07	0.037037	0.05	0.186163251	0.046540813

Supplier pair wise comparison matrices and priorities

A: wrt quality

	P1	P2	P3	P4	Wts
P1	1	5	6	1/3	0.297
P2		1	2	1/6	0.08
P3			1	1/8	0.53
P4				1	0.563

A: wrt price

	P1	P2	P3	P4	Wts
P1	1	1/3	5	8	0.303
P2		1	7	9	0.573
P3			1	2	0.078
P4				1	0.046

A: wrt service

	P1	P2	P3	P4	Wts
P1	1	5	4	8	0.597
P2		1	1/2	4	0.140
P3			1	5	0.214
P4				1	0.050

A: wrt delivery

	P1	P2	P3	P4	Wts
P1	1	3	1/5	1	0.151
P2		1	1/8	1/3	0.060
P3			1	5	0.638
P4				1	0.151

Computation of weights: supplier alternatives

Adjusted matrix	Weights (row avg.)
Quality	0.457
Price	0.300
Service	0.138
Delivery	0.105

	Quality	Price	Service	Delivery	Wts (Q*P*S*D)
P1	.457*.297	.300*.303	.138*.597	.105*.151	.325
P2	.457*.087	.300*.573	.138*.140	.105*.060	.237
P3	.457*.053	.300*.078	.138*.214	.105*.638	.144
P4	.457*.563	.300*.046	.138*.050	.105*.151	.294

TOPSIS METHOD

TOPSIS METHOD

Technique of Order Preference by Similarity to Ideal Solution

This method considers three types of attributes or criteria

- Qualitative **benefit** attributes/criteria
- Quantitative **benefit** attributes/criteria
- **Cost** attributes or criteria

- In this method **two artificial alternatives** are hypothesized:

- **Ideal** alternative: the one which has the **best level** for all attributes considered.

- **Negative** ideal alternative: the one which has the worst attribute values.

- TOPSIS selects the alternative that is **closest** to the **ideal** solution and **farthest** from **negative** ideal alternative.

Input to TOPSIS

- TOPSIS assumes that we have m **alternatives** (options) and n **criteria** and we have the **score** of each option with respect to each criterion.
- Let x_{ij} score of option i with respect to criterion j

  We have a matrix $X = (x_{ij})$ $m \times n$ matrix.
- Let J be the set of **benefit attributes** or criteria (more is better???)
- Let J' be the set of **negative attributes** or criteria (less is better???)

Steps of TOPSIS

- Step 1: Construct **normalized** decision matrix.

- This step transforms various attribute dimensions **into non-dimensional attributes**, which allows comparisons across criteria.

- Normalize scores or data as follows:

$$r_{ij} = x_{ij} / (\Sigma x^2_{ij}) \quad \text{for } i = 1, \ldots, m; \ j = 1, \ldots, n$$

- Step 2: Construct the **weighted normalized** decision matrix.
- Assume we have a set of weights for each criteria w_j for $j = 1,\ldots n$.
- Multiply each column of the **normalized decision matrix** by its associated **weight**.
- An element of the new matrix is:

$$v_{ij} = w_j \, r_{ij}$$

- Step 3: Determine the **ideal and negative** ideal solutions.

- **Ideal** solution.

$$A^* = \{ v_1^*, \ldots, v_n^* \}, \text{ where}$$

$$v_j^* = \{ \max_i (v_{ij}) \text{ if } j \in J \, ; \; \min_i (v_{ij}) \text{ if } j \in J' \}$$

- **Negative** ideal solution.

$$A' = \{ v_1', \ldots, v_n' \}, \text{ where}$$

$$v' = \{ \min_i (v_{ij}) \text{ if } j \in J \, ; \; \max_i (v_{ij}) \text{ if } j \in J' \}$$

- Step 4: Calculate the **separation** measures for each alternative.

- The separation from the **ideal** alternative is:

$$S_i^* = \Big[\sum_j (v_j^* - v_{ij})^2 \Big]^{1/2} \qquad i = 1, \ldots, m$$

- Similarly, the separation from the **negative ideal** alternative is:

$$S'_i = \Big[\sum_j (v_j' - v_{ij})^2 \Big]^{1/2} \qquad i = 1, \ldots, m$$

- Step 5: Calculate the **relative closeness** to the ideal solution C_i^*

$$C_i^* = S'_i / (S_i^* + S'_i) \quad , \qquad 0 < C_i^* < 1$$

Select the option with C_i^* closest to 1.

Applying TOPSIS Method to Example

Weight	0.1	0.4	0.3	0.2
	Style	Reliability	Fuel Eco.	Cost
Civic	7	9	9	8
Saturn	8	7	8	7
Ford	9	6	8	9
Mazda	6	7	8	6

Applying TOPSIS to Example

- $m = 4$ alternatives (car models)
- $n = 4$ attributes/criteria

- x_{ij} = score of option i with respect to criterion j
  $X = \{x_{ij}\}$ 4×4 score matrix.
- J = set of **benefit** attributes: style, reliability, fuel economy (more is better)
- J' = set of **negative** attributes: cost (less is better)

Steps of TOPSIS

- Step 1(a): calculate $(\Sigma x_{ij})^{1/2}$ for each column

	Style	Rel.	Fuel	Cost
Civic	49	81	81	64
Saturn	64	49	64	49
Ford	81	36	64	81
Mazda	36	49	64	36
Σx_{ij}	230	215	273	230
$(\Sigma x)^{1/2}$	15.17	14.66	16.52	15.17

Steps of TOPSIS

- Step 1 (b): divide each column by $(\Sigma x^2_{ij})^{1/2}$ to get $\mathbf{r_{ij}}$

	Style	Rel.	Fuel	Cost
Civic	0.46	0.61	0.54	0.53
Saturn	0.53	0.48	0.48	0.46
Ford	0.59	0.41	0.48	0.59
Mazda	0.40	0.48	0.48	0.40

????

Steps of TOPSIS

- Step 1 (b): divide each column by $(\Sigma x^2_{ij})^{1/2}$ to get $\mathbf{r_{ij}}$

	Style	Rel.	Fuel	Cost
Civic	0.46	0.61	0.54	0.53
Saturn	0.53	0.48	0.48	0.46
Ford	0.59	0.41	0.48	0.59
Mazda	0.40	0.48	0.48	0.40

- Step 2 : multiply each column by w_j to get v_{ij}.

Weight	0.1	0.4	0.3	0.2
	Style	Rel.	Fuel	Cost
Civic	0.046	0.244	0.162	0.106
Saturn	0.053	0.192	0.144	0.092
Ford	0.059	0.164	0.144	0.118
Mazda	0.040	0.192	0.144	0.080

- Step 3 (a): determine ideal solution A*.

$$A^* = \{0.059, 0.244, 0.162, 0.080\}$$

	Style	Rel.	Fuel	Cost
Civic	0.046	0.244	0.162	0.106
Saturn	0.053	0.192	0.144	0.092
Ford	0.059	0.164	0.144	0.118
Mazda	0.040	0.192	0.144	0.080
		↑		↓

- Step 3 (a): find negative ideal solution A'.

A' = {0.040, 0.164, 0.144, 0.118}

	Style	Rel.	Fuel	Cost
Civic	0.046	0.244	0.162	0.106
Saturn	0.053	0.192	0.144	0.092
Ford	0.059	0.164	0.144	0.118
Mazda	0.040	0.192	0.144	0.080
		↓		↑

- Step 4 (a): determine separation from ideal solution

$A^* = \{0.059, 0.244, 0.162, 0.080\}$

$S_i^* = [\Sigma (v_j^* - v_{ij})^2]^{½}$ for each row

	Style	Rel.	Fuel	Cost
Civic	$(.046-.059)^2$	$(.244-.244)^2$	$(.162-.162)^2$	$(.106-.080)^2$
Saturn	$(.053-.059)^2$	$(.192-.244)^2$	$(.144-.162)^2$	$(.092-.080)^2$
Ford	$(.059-.059)^2$	$(.164-.244)^2$	$(.144-.162)^2$	$(.118-.080)^2$
Mazda	$(.040-.059)^2$	$(.192-.244)^2$	$(.144-.162)^2$	$(.080-.080)^2$

- Step 4 (a): determine separation from ideal solution S_i^*

	$\Sigma(v_j^* - v_{ij})^2$	$S_i^* = [\Sigma (v_j^* - v_{ij})^2]^{½}$
Civic	**0.000845**	**0.029**
Saturn	**0.003208**	**0.057**
Ford	**0.008186**	**0.090**
Mazda	**0.003389**	**0.058**

- Step 4 (b): find separation from negative ideal solution $A' = \{0.040, 0.164, 0.144, 0.118\}$

$$S_i' = \left[\sum_j (v_i' - v_{ij})^2 \right]^{1/2} \text{ for each row}$$

	Style	Rel.	Fuel	Cost
Civic	**$(.046-.040)^2$**	**$(.244-.164)^2$**	**$(.162-.144)^2$**	**$(.016-.0118)^2$**
Saturn	**$(.053-.040)^2$**	**$(.192-.164)^2$**	**$(0)^2$**	**$(.092-.118)^2$**
Ford	**$(.059-.040)^2$**	**$(.164-.164)^2$**	**$(0)^2$**	**$(0)^2$**
Mazda	**$(.040-.040)^2$**	**$(.192-.164)^2$**	**$(0)^2$**	**$(.080-.118)^2$**

- Step 4 (b): determine separation from negative ideal solution S_i'

	$\Sigma(v_j' - v_{ij})^2$	$S_i' = [\Sigma(v_j' - v_{ij})^2]^{1/2}$
Civic	**0.006904**	**0.083**
Saturn	**0.001629**	**0.040**
Ford	**0.000361**	**0.019**
Mazda	**0.002228**	**0.047**

- Step 5: Calculate the relative closeness to the ideal solution $C_i^* = S'_i / (S_i^* + S'_i)$

	$S'_i / (S_i^* + S'_i)$	C_i^*		
Civic	**0.083/0.112**	**0.74**	←	**BEST**
Saturn	**0.040/0.097**	**0.41**		
Ford	**0.019/0.109**	**0.17**		
Mazda	**0.047/0.105**	**0.45**		

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Project Management for Managers

Lec – 12

Methods of Project Selection (MCDM – III)

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Solve by TOPSIS

Fighter Aircraft Selection

	Speed	Range	Payload	Cost	Reliability	Maneuverability
	X1	X2	X3	X4	X5	X6
A1	2	1500	20000	5.5	5	9
A2	2.5	2700	18000	6.5	3	5
A3	1.8	2000	21000	4.5	7	7
A4	2.2	1800	20000	5.5	5	5

Data available

	Speed	Range	Pay load	Cost	Reliability	Maneuverability
	X1	X2	X3	X4	X5	X6
A1	2	1500	20,000	5.5	5	9
A2	2.5	2700	18,000	6.5	3	5
A3	1.8	2000	21,000	4.5	7	7
A4	2.2	1800	20,000	5	5	5

m = 4 alternatives (Aircraft models)
n = 6 attributes/criteria

Step 1: Obtain the decision matrix

- **In-order to make calculations easier, replace the higher values with its equivalent power**

	Speed	Range(x10^3)	Pay load (x10^4)	Cost	Reliability	Maneuverability
	X1	X2	X3	X4	X5	X6
A1	2.0	1.5	2.0	5.5	5	9
A2	2.5	2.7	1.8	6.5	3	5
A3	1.8	2.0	2.1	4.5	7	7
A4	2.2	1.8	2.0	5.0	5	5

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 1(a): calculate $(\Sigma x^2_{ij})^{1/2}$ for each column

	X1	X2	X3	X4	X5	X6
A1	4.0	2.25	4.0	30.25	25	81
A2	6.25	7.29	3.2	42.25	9	25
A3	3.24	4.0	4.4	20.25	49	49
A4	4.84	3.24	4.0	25.0	25	25
Σx_{ij}^2	18.33	16.78	15.65	117.75	108.00	180.00
$(\Sigma x^2)^{1/2}$	**4.28**	**4.096**	**3.956**	**10.851**	**10.392**	**13.416**

Step 1 (b): divide each column by $(\Sigma x^2_{ij})^{1/2}$ to get $\mathbf{R_{ij}}$

	X1	X2	X3	X4	X5	X6
A1	0.4672	0.3662	0.5056	0.5063	0.4811	0.6708
A2	0.5839	0.6591	0.4550	0.5983	0.2887	0.3727
A3	0.4204	0.4882	0.5308	0.4143	0.6736	0.5217
A4	0.5139	0.4392	0.5056	0.4603	0.4811	0.3727

Step 2 : Obtain the weighted decision matrix V_{ij} by multiplying each column of R_{ij} by the corresponding weight

$$V_{ij} = W_{ij} \times R_{ij}$$

Weight	0.2	0.1	0.1	0.1	0.2	0.3
	X1	**X2**	**X3**	**X4**	**X5**	**X6**
A1	0.0934	0.0366	0.0506	0.0506	0.0962	0.2012
A2	0.1168	0.0659	0.0455	0.0598	0.0577	0.1118
A3	0.0841	0.0488	0.0531	0.0414	0.1347	0.1565
A4	0.1028	0.0439	0.0506	0.046	0.0962	0.1118

Ideal and Negative Ideal solution

- Step 3: Obtain the ideal (A*) and the negative ideal (A-) solutions from the weighted decision matrix V.

	X1	X2	X3	X4	X5	X6
A1	0.0934	**0.0366**	0.0506	0.0506	0.0962	**0.2012**
A2	**0.1168**	**0.0659**	**0.0455**	**0.0598**	**0.0577**	**0.1118**
A3	**0.0841**	0.0488	**0.0531**	**0.0414**	**0.1347**	0.1565
A4	0.1028	0.0439	0.0506	0.046	0.0962	0.1118

- A* = (0.1168, 0.0659, 0.0531, 0.0414, 0.1347, 0.2012)
- A- = (0.0841, 0.0366, 0.0455, 0.0598, 0.0577, 0.1118)

Step 4 : **Separation Measures**

Determine **separation** from ideal solution

A* = (0.1168, 0.0659, 0.0531, 0.0414, 0.1347, 0.2012)

$S_i^* = [\,\Sigma\,(v_j^* - v_{ij})^2\,]^{½}$ for each row

Ideal solution	**Ideal solution**
S1* = 0.0545	S1- = 0.0983
S2* = 0.1197	S2- = 0.0439
S3* = 0.0580	S3- = 0.0920
S4* = 0.1009	S4- = 0.0458

Step 5: Relative closeness to the Ideal Solution

For each alternative, calculate the relative closeness to the ideal solution

$$C_i^* = S'_i / (S_i^* + S'_i)$$

$S'_i / (S_i^* + S'_i)$	C_i^*	
0.0983/(0.0545+0.0983)	**0.6433**	← **BEST**
0.0439/(0.1197+0.0439)	**0.2683**	
0.092/(0.058+0.092)	**0.6133**	
0.0458/(0.1009+0.0458)	**0.3122**	

Ranking/Preference Order

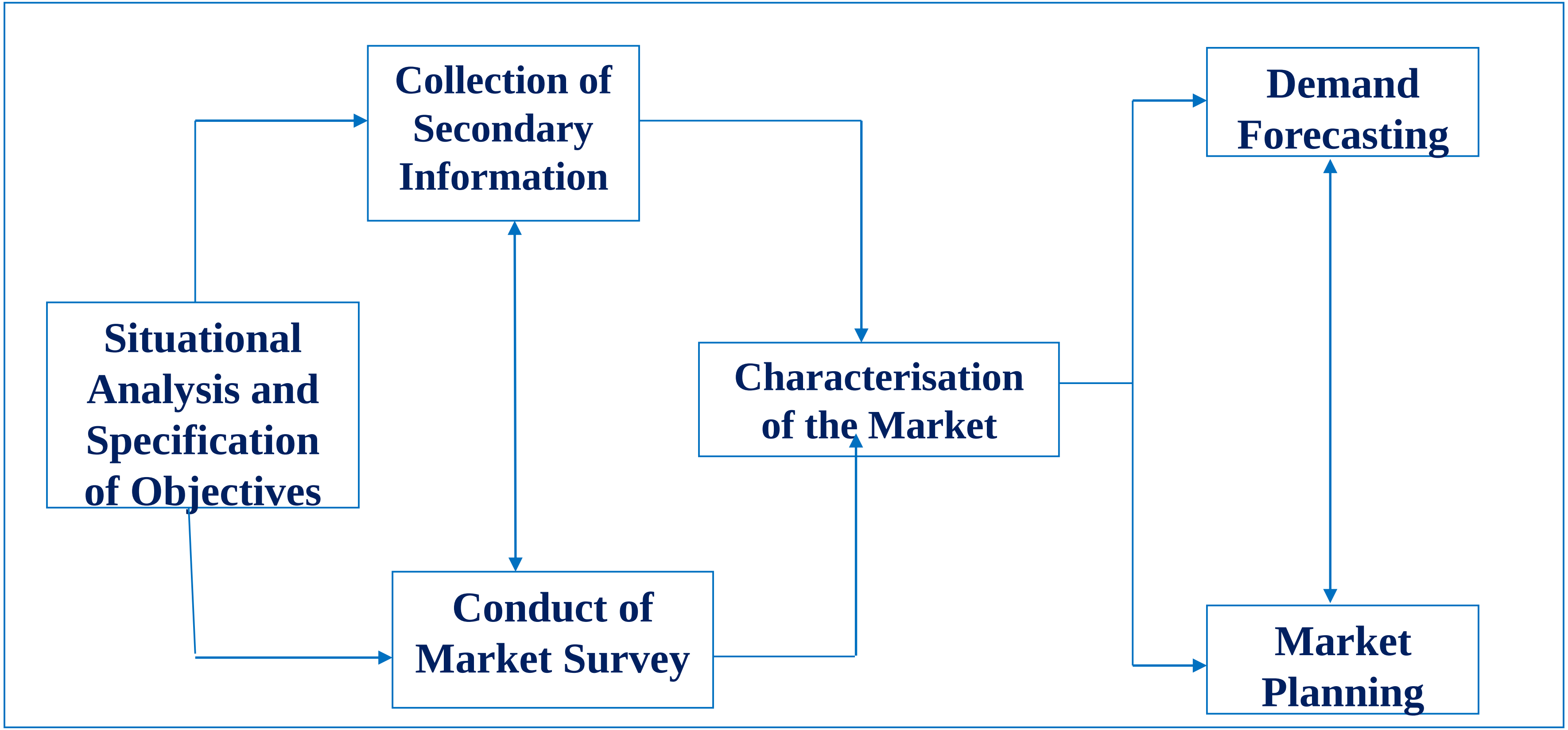
NOTE : The closeness rating is a number between **0** and **1**, with **0 being the worst possible** and **1 the best possible solution**)

Thus the ranks for the alternatives in the fighter aircraft selection problem using TOPSIS as

A1, A3, A4, A2

Market and Demand Analysis

Key Steps in Market and Demand Analysis and their Inter-relationships



Situational Analysis

In order to get a "feel" of the relationship between the product and its market, the project analyst may informally talk to customers, competitors, middlemen, and others in the industry.

Wherever possible, he may look at the experience of the company to learn about the preferences and purchasing power of customers, actions and strategies of competitors, and practices of the middlemen.

Collection of Secondary Information

- Secondary information is information that has been gathered in some other context and is readily available.

- Secondary information provides the base and the starting point for the market and demand analysis. It indicates what is known and often provides leads and cues for gathering primary information required for further analysis.

Sources of secondary data????????????

Evaluation of Secondary Information

Criteria	Issues	Remarks
Specifications & Methodology	Data collection method, response rate, quality & analysis of data, sampling technique & size, questionnaire design, fieldwork.	Data should be reliable, valid, & generalizable to the problem.
Error & Accuracy	Examine errors in approach, research design, sampling, data collection & analysis, & reporting.	Assess accuracy by comparing data from different sources.
Currency	Time lag between collection & publication, frequency of updates.	Census data are updated by syndicated firms.
Objective	Why were the data collected?	The objective determines the relevance of data.
Nature	Definition of key variables, units of measurement, categories used, relationships examine	Reconfigure the data to increase their usefulness.
Dependability	Expertise, credibility, reputation, & trustworthiness the source.	Data should be obtained from an original source.

Evaluation of Secondary Information

While secondary information is available economically and readily (provided the market analyst is able to locate it), its reliability, accuracy, and relevance for the purpose under consideration must be carefully examined.

Market Survey

- Secondary information, though useful, often does not provide a comprehensive basis for market and demand analysis.
- It needs to be supplemented with primary information gathered through a market survey.
- The market survey may be a census survey or a sample survey; typically it is the latter.

What Information is Sought in a Market Survey?????

Information Sought in a Market Survey

The information sought in a market survey may relate to one or more of the following:

- Total demand and rate of growth of demand
- Demand in different segments of the market
- Income and price elasticities of demand
- Motives for buying
- Purchasing plans and intentions
- Satisfaction with existing products
- *Unsatisfied needs*
- Attitudes toward various products
- Distributive trade practices and preferences
- Socio-economic characteristics of buyers

Steps in a Sample Survey

Typically, a sample survey involves the following steps:

1. Define the <u>target</u> population (elements, sampling unit, extent,time: Men's DO).
2. Select the sampling <u>scheme</u> and sample <u>size</u>.
3. Develop the <u>questionnaire</u>.
4. Recruit and train the <u>field</u> investigators.
5. Obtain <u>information</u> as per the questionnaire from the sample of respondents.
6. <u>Scrutinize</u> the information gathered.
7. <u>Analyze</u> and interpret the information.

Characterization of the Market

Based on the information gathered from secondary sources and through the market survey, the market for the product/service may be described in terms of the following:

- **Effective demand in the past and present**
- **Breakdown of demand**
- **Price**
- **Methods of distribution and sales promotion**
- **Consumers**
- **Supply and competition**
- **Government policy**

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Project Management for Managers

Lec – 13

Market and Demand Analysis - I

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Methods of Demand Forecasting

I Qualitative Methods : These methods rely essentially on the judgment of experts to translate qualitative information into quantitative estimates. The important qualitative methods are :

- Jury of executive method
- Delphi method

II Quantitative Methods: These methods generate forecasts on the basis of an analysis of the historical time series . The important time series projection methods are :

- Trend projection –method
- Exponential smoothing method
- Moving average method

III Causal Methods : More analytical than the preceding methods, causal methods seek to develop forecasts on the basis of cause-effect relationships specified in an explicit, quantitative manner. The important causal methods are :

- Chain ratio method
- Consumption level method
- End use method
- Leading indicator method
- Econometric method

IV Simulation

Qualitative Methods

Jury of Executive Opinion Method

This method involves soliciting the opinion of a group of managers on expected future sales and combining them into a sales estimate

Pros

- It is an expeditious method
- It permits a wide range of factors to be considered
- It appeals to managers

Cons

- The biases cannot be unearthed easily
- Its reliability is questionable

Qualitative Methods

Delphi Method

This method is ??????????????

Delphi Method

This method is used for eliciting the opinions of a group of experts with the help of a mail survey. The steps involved in this method are :

1. A group of experts is sent a questionnaire by mail and asked to express their views.

2. The responses received from the experts are summarised without disclosing the identity of the experts, and sent back to the experts, along with a questionnaire meant to probe further the reasons for extreme views expressed in the first round.

3. The process may be continued for one or more rounds till a reasonable agreement/disagreement emerges in the view of the experts.

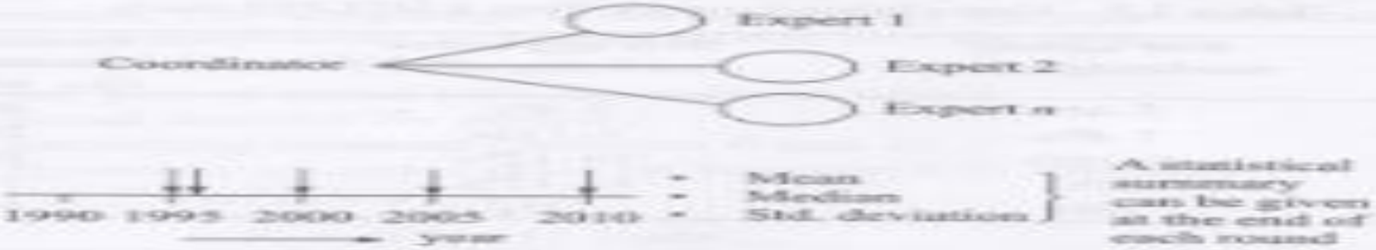

Fig. 3.2 Composition of a DELPHI panel with initial responses.

Fig. 3.3 DELPHI panelists moving successively towards consensus.

Fig. 3.4 Emergence of diverging viewpoints in DELPHI.

Pros

- It is intelligible to users
- It seems to be more accurate and less expensive than the traditional face-to-face group meetings

Cons

There are some question marks: What is the value of the expert opinion? What is the contribution of additional rounds and feedback to accuracy?

Quantitative Methods

Trend Projection Method

The trend projection method involves:

(a) determining the trend of consumption by analysing past consumption statistics and

(b) projecting future consumption by extrapolating the trend.

Trend Projection Method

Linear relationship: $Yt = a + bt$

Exponential relationship: $Yt = ae^{bt}$

Polynomial relationship: $Yt=a_0+a_1t+ a_2t^2 \ldots\ldots a_n t^n$

Cobb Douglas relationship: $Yt = at^b$

Age (x)	Repair expenses (y)
5	7
3	7
3	6
1	4

What would be expenses for a 4 years old truck.

	Age (x)	**Repair expenses (y)**	**xy**	**x^2**
	5	7	35	25
	3	7	21	9
	3	6	18	9
	1	4	4	1
Total	12	24	78	44

$\overline{x}=3$, $\overline{y}=6$

$a = \overline{Y} - b\overline{X}$ = 3.75

$b = \dfrac{\sum XY - n\overline{X}\overline{Y}}{\sum X^2 - n\overline{X}^2}$ = 0.75

$$Y=3.75+0.75\,(4) = 6.75$$

<u>Moving Average Method</u>

As per the moving average method of sales forecasting, the forecast for the next period is equal to the <u>average</u> of the sales for <u>several</u> preceding periods.

In symbols,

$$F_{t+1} = \frac{S_t + S_{t-1} + \ldots + S_{t-n+1}}{n}$$

Where F_{t+1} = forecast for the next period

S_t = sales for the current period

n = period over which averaging is done

Moving Average

Year	Demand	4 MA
2010	32	
2011	36	
2012	40	
2013	35	
2014	32	35.75
2015	35	35.75
2016	45	35.5
For 2017		36.75

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Project Management for Managers

Lec – 14

Market and Demand Analysis - II

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Exponential Smoothing Method

In exponential smoothing, forecasts are modified in the light of observed errors. If the forecast value for year t, Ft , is less than the actual value for year t, St, the forecast for the year t+1, Ft+1, is set higher than Ft. If Ft> St , Ft+1 is set lower than Ft. In general.

$$F_{t+1} = F_t + \alpha\, e_t$$

where Ft + 1 = forecast for year t + 1

α = smoothing parameter (which lies between 0 and 1)

et = error in the forecast for year t = St - Ft

Determine the forecast for 2017 by exponential smoothing method. Given $\alpha = 0.6$. Assume forecast for 2010 as 32.

Year	Demand
2010	32
2011	36
2012	40
2013	35
2014	32
2015	35
2016	45

Determine the forecast for 2017 by exponential smoothing method. Given α = 0.6

Year	Demand	Forecast	Error (e)	e*α
2010	32	32	0	0
2011	36	32	4	2.4
2012	40	34.4	5.6	3.36
2013	35	37.76	-2.76	-1.66
2014	32	36.10	-4.10	-2.46
2015	35	33.64	1.36	.82
2016	45	34.46	10.54	6.33
For 2017		34.46+6.33=40.79		

32+2.4=34.4

Measures of Forecast Error

- Forecast error = $E_t = F_t - D_t$
- Mean squared error (MSE)

  $MSE_n = (Sum_{(t=1 \text{ to } n)}[E_t^2])/n$

MSE - estimates the variance of the error

- Absolute deviation = $A_t = |E_t|$
- Mean absolute deviation (MAD)

  $MAD_n = (Sum_{(t=1 \text{ to } n)}[A_t])/n$

- Mean absolute percentage error (MAPE)- is the **average absolute error as a % of demand** and is as follows

MAPE by SA

Year	Demand	4MA	Error (e)	Absolute error	MAD	% Error (Abs Error/Demand) *100	MAPE
2008	32						
2009	36						
2010	40						
2011	35						
2012	32	35.75	-3.75	3.75	3.75	11.71	11.71
2013	35	35.75	-0.75	0.75	2.25	2.14	6.92
2014	45	35.5	9.5	9.5	4.66	21.11	**11.65**
For 2015		36.75					

MAPE by SES

Year	Demand	Fore cast	Error (e)	Absolute error	MAD	% Error (Abs Error/Demand) *100	MAPE
2008	32	32	0	0	0	0	0
2009	36	32	4	4	2	11.11	5.55
2010	40	34.4	5.6	5.6	3.2	14	8.37
2011	35	37.76	-2.76	2.76	3.1	7.8	8.22
2012	32	36.10	-4.10	4.10	3.3	12.8	9.14
2013	35	33.64	1.36	1.36	3	3.8	8.25
2014	45	34.46	10.54	10.54	4.1	23.42	**10.41**
For 2015		34.46+6.33 =40.79					

Example: Sales of wrist watches 25,32,24,28,26,27

Answers:

26,26,26 (Avg last 3,trend, outlier)

27,27 (avg of all, weights (1,2,3) to last 3)

28, (last 2 data show increase)

30 (population is increasing)

Depending on trends, use appropriate method and select the one which gives minimum error.

Causal Methods

Chain Ratio Method

The potential sales of a product may be estimated by applying a series of factors to a measure of aggregate demand. For example, a company estimated the potential sales for a new product, a freeze-fried instant coffee (Maxim), in the following manner :

Total amount of coffee sales	: 174.5million units
Proportion of coffee used at home	: 0.835
Coffee used at home	: 145.7 million units
Proportion of non-decaffeinated coffee used at home	: 0.937
Non-decaffeinated coffee used at home	: 136.5 million units
Proportion of instant coffee	: 0.400
Instant non-decaffeinated coffee used at home	: 54.6 million units
Estimated long-run market share for Maxim	: 0.08
Potential sales of Maxim	: 4.37 million units

Population: 130 crore

Proportion of Male:51%

Proportion of adult: 63%

Proportion of adults not shaving: 10%

Proportion of people using premium quality shaving blades : 20.5%

No of shaving per year:183

No of shaving per blade: 3

What is the demand of premium quality shaving blades?

Consumption Level Method

The method estimates consumption level on the basis of elasticity coefficients, the important ones being the income elasticity of demand and the price elasticity of demand.

Income Elasticity of Demand

The income elasticity of demand reflects the responsiveness of demand to variations in income. It is measured as follows :

$$E_I = \frac{Q_2 - Q_1}{I_2 - I_1} \times \frac{I_1 + I_2}{Q_2 + Q_1}$$

where E_I = income elasticity of demand

Q_1 = quantity demanded in the base year

Q_2 = quantity demanded in the following year

I_1 = income level in the base year

I_2 = income level in the following year.

Income Elasticity of Demand

Example: **The following information is available on quantity demanded and income level: $Q_1 = 50$, $Q_2 = 55$, $I_1 = 1{,}000$ and $I_2 = 1{,}020$. What is the income elasticity of demand? The income elasticity of demand is :**

Income Elasticity of Demand

Example The following information is available on quantity demanded and income level: $Q_1 = 50$, $Q_2 = 55$, $I_1 = 1{,}000$ and $I_2 = 1{,}020$. What is the income elasticity of demand? The income elasticity of demand is :

$$E_I = \frac{55 - 50}{1{,}020 - 1{,}000} \times \frac{1{,}000 + 1{,}020}{55 + 50} = 4.81$$

Price Elasticity of Demand

The price elasticity of demand measures the responsiveness of demand to variations in price. It is defined as :

$$E_p = \frac{Q_2 - Q_1}{P_2 - P_1} \times \frac{P_1 + P_2}{Q_2 + Q_1}$$

where E_p = price elasticity of demand

Q_1 = quantity demanded in the base year

Q_2 = quantity demanded in the following year

P_1 = price per unit in the base year

P_2 = price per unit in the following year

Price Elasticity of Demand

Example The following information is available about a certain product :

P_1= Rs.600, Q_1 = 10,000, P_2 = Rs. 800, Q_2 = 9,000.

What is the price elasticity of demand? The price elasticity of demand is :

Price Elasticity of Demand

Example **The following information is available about a certain product :**

P_1= Rs.600, Q_1 = 10,000, P_2 = Rs. 800, Q_2 = 9,000. What is the price elasticity of demand? The price elasticity of demand is :

$$E_p = \frac{9{,}000 - 10{,}000}{600 - 800} \times \frac{600 + 800}{9{,}000 + 10{,}000} = -0.37$$

End Use Method

Suitable for estimating the demand for intermediate products, the end use method, also referred to as the consumption coefficient method, involves the following steps:

1. Identify the possible uses of the product.
2. Define the consumption coefficient of the product for various ses.
3. Project the output levels for the consuming industries.
4. Derive the demand for the product.

End Use Method

Projected Demand for Indchem

This method may be illustrated with an example. A certain industrial chemical, Indchem is used by four industries Alpha, Beta,Gamma, and Kappa.

The consumption coefficients for these industries, the projected output levels for these industries for the year *X*, and the projected demand for Indchem as shown in the following slide

	Consumption Coefficient *	*Projected Output in year X*	*Projected Demand for Indchem in year X*
Alpha	**2.0**	**10,000**	**20,000**
Beta	**1.2**	**15,000**	**18,000**
Kappa	**0.8**	**20,000**	**16,000**
Gamma	**0.5**	**30,000**	**15,000**
		Total	***69,000***

- This is expressed in tonnes of Indchem required per unit of output of the consuming industry

Leading Indicator Method

Leading indicators are variables which change ahead of other variables, the lagging variables. Hence, observed changes in leading indicators may be used to predict the changes in lagging variables.

For example, the change in the level of urbanisation (a leading indicator) may be used to predict the change in the demand for air conditioners (a lagging variable)

Ex: Temperatures- Demand of invertors.

Leading Indicator Method

Two basic steps are involved in using the leading indicator method:

(i) First, identify the appropriate leading indicator(s).

(ii) Second, establish the relationship between the leading indicator(s) and the variable to be forecast.

The principal merit of this method is that it does not require a forecast of an explanatory variable. Its limitations are that it may be difficult to find appropriate leading indicator(s) and the lead-lag relationship may not be stable over time.

Econometric Method

- **An econometric model is a mathematical representation of economic relationship(s) derived from economic theory.**

  The primary objective of econometric analysis is to <u>forecast the future behavior of the economic variables</u> **incorporated in the model.**

- **Two types of econometric models are employed: the <u>single</u> equation model and the <u>simultaneous</u> equation model.**

Single Equation Model

The single equation model assumes that one variable, the dependent variable (also referred to as the explained variable), is influenced by one or more **independent variables (also referred to as the explanatory variables)**. In other words, one-way causality is postulated. An example of the single equation model is given below:

$$D_t = a_0 + a_1 P_t + a_2 N_t$$

where D_t = demand for a certain product in year t

P_t = price for the product in year t

N_t = income in year t

Simultaneous Equation Model

The simultaneous equation model portrays economic relationships in terms of two or more equations. Consider a highly simplified three-equation econometric model of Indian economy.

$$GNP_t = G_t + I_t + C_t$$
$$I_t = a_0 + a_1 GNP_t$$
$$C_t = b_0 + b_1 GNP_t$$

where GNP_t = gross national product for year t

I_t = gross investment for year t

C_t = consumption for year t

Gt = governmental purchases for year t

Strategic advantage approach:

International price / Domestic Price — Export potential

Domestic Price / International price — Import threat

Price
Quality
Value addition
Brand image

Uncertainties in Demand Forecasting

Demand forecasts are subject to error and uncertainty which arise from ?????????

Uncertainties in Demand Forecasting

- **Data about past and present market:** Lack of standardization, few observations, influence of abnormal factors

- **Methods of forecasting:** Inability to handle unquantifiable factors, Unrealistic assumptions, Excessive data requirements.

- **Environmental change:** technological change, shift in Govt. policy, development of international scene (OPEC), discovery of sources of raw material, quality of Monsoon.

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Project Management for Managers

Lec – 15

Financial Analysis

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Financial Analysis

Financial Feasibility : Ratio Analysis

Return on investment: This measures overall return on overall investments.

ROI = (EBIT – Tax) / (Investment)

EBIT= Earning before interest and taxes.

Return on equity: This measures return for shareholders.

ROE = (EAT - Preferential dividend) / (Equity)

EAT= Earning after tax

Operating profit margin: This measures the profitability in its gross terms.

OPM = EBIT/ Sales

Net profit margin: This measures profitability in its true terms.

NPM = EAT /Sales

Rs.1000 today or next month.

Ex: 1000 today or next month.

Ex: 1000 today or next month if "interest rate" = 20 %

Time value of money: Money available today is more than tomorrow.

Compound amount = Principal $(1+ r)^n$ or

Principal = Compound amount / $(1+ r)^n$ or

Present value of money = future value * present value factor

where PVF = $1/(1+ r)^n$

r = Discount factor,

n = No of periods

Capital budgeting, or **investment appraisal**, is the planning process used to determine whether an organization's **long term investments such** as

- new **machinery**,
- **replacement** machinery,
- new **plants**,
- new **products**, and
- research **development** projects

are worth the **funding of cash** through the firm's capitalization structure.

CAPITAL BUDGETING TECHNIQUES

- **Non discounting**
  - **PBP**
  - **ARR**
- **Discounting**
  - **Discounted PBP**
  - **NPV**
  - **Profitability index**
  - **Internal rate of return**

Discounting techniques **take time value of money** into account.

Non-discounting techniques are those techniques which do **not consider time value of money**.

PBP ?????????

PBP = Time period in which investor gets back his invested money in fixed assets from the project

Example (PBP)

Initial investment	300000
Annual cost of operation	20000
Expected annual revenues	
first two years	100000
next three years	200000
Planning horizone	5 yrs

Find : PBP ??

PBP= Y0 - (CuCF0)/(CF1)

Y0 = is the year just before the pay back period is attained

CuCF0= cumulative cash flow of Y0

CF1= cash flow of pay back year

Initial investment		300000
Annual cost of operation		20000
Expected annual revenues		
	first two years	100000
	next three years	200000
Planning horizon		5 yrs

Year	Cash flow	CuCF0
0	-300	-300
1	80	-220
2	80	-140
3	180	40
4	180	220
5	180	400

PBP= (interpolated as the year when CCF becomes zero) = 2- (-140/180)=2.78 yrs

Payback Period

Payback period is the length of time required to recover the initial outlay on the project

XYZ Enterprise's Capital Project

Year	Cash flow	Cumulative cash flow
0	-100	-100
1	34	- 66
2	32.5	-33.5
3	31.37	- 2.13
4	30.53	28.40

Find PBP

$$PBP = 3 - (-2.13/30.53) = 3.06 \text{yrs}$$

Example: Projected cash flow 30 lac in first year, CF is going to increase by 10 lac for next 3 years, and then decreases by 15 lac and closes in 5th year. Initial investment 140 lac, working capital requirement is 20 lac. The company foresees to fetch a net salvage value of 35 lac after 5 years. **Find PBP??**

Example: Projected cash flow 30 lac in first year, CF is going to increase by 10 lac for next 3 years, and then decreases by 15 lac and closes in 5 year. Initial investment 140 lac, working capital requirement is 20 lac. The company foresees to fetch a net salvage value of 35 lac after 5 years. **Find PBP??**

Year	Cash flow	CuCF0
0	-140	-140
1	30	-110
2	40	-70
3	50	-20
4	60	40
5	45	85

BPB= 3 – (-20/60)=3.33 yrs or 3 yrs 4months

Example: Compare following projects using PBP

Year	Project A (CuCF0)	Project B (CuCF0)	Project C (CuCF0)
0	-110	-110	-110
1	20	20	0
2	30	30	0
3	40	40	90
4	30	30	30
5	20	20	20
6	20	10	20

Which project is best and why???

Project A			Project B			Project C		
Year	Cash flow	(CuCF0)	Year	Cash flow	(CuCF0)	Year	Cash flow	(CuCF0)
0	-110	-110	0	-110	-110	0	-110	-110
1	20	-90	1	20	-90	1	0	-110
2	30	-60	2	30	-60	2	0	-110
3	40	-20	3	40	-20	3	90	-20
4	30	10	4	30	10	4	30	10
5	20	30	5	20	30	5	20	30
6	20	50	6	10	40	6	20	50

PBP = 3- (-20/30) = 3.33yrs

Project A			Project B			Project C		
Year	Cash flow	Cum CF	Year	Cash flow	Cum CF	Year	Cash flow	Cum CF
0	-110	-110	0	-110	-110	0	-110	-110
1	20	-90	1	20	-90	1	0	-110
2	30	-60	2	30	-60	2	0	-110
3	40	-20	3	40	-20	3	90	-20
4	30	10	4	30	10	4	30	10
5	20	30	5	20	30	5	20	30
6	20	50	6	10	40	6	20	50

A better than B, additional 10 lac, PBP is same for all three projects 3yrs and 8 months

A better than C, **early recovery**. 20lac in first year will fetch interest for 2 years and 30 lac (second year) will fetch interest for 1 year. An example depicts drawback of PBP

Pros

- Simple
- Rough and ready method for dealing with risk
- Emphasizes earlier cash inflows

Drawbacks of PBP

1. Does not consider WC and salvage value
2. Does not consider cash flows after the PBP
3. Does not consider time value of money
4. No consideration for risk
5. Ignores cost of capital
6. It measures project's <u>capital recovery, not profitability</u>

Average rate of return (ARR):Considers cash flows after PBP, working capital and salvage value

ARR = average return / average investment

Average return = Sum of all CFs/n,

Average investment

=1/2 (initial investment + terminal cash flow)

=1/2 {(fixed investment +WC) + (WC+SV)}

= WC + ½ (FI+SV)

FI= fixed investment, WC =working capital, SV =salvage value

Ex. Projected cash flow 30 lac in first year, CF is going to increase by 10 lac for next 3 years, and then decreases by 15 lac and closes in 5 year. Initial investment 140 lac, working capital requirement is 20 lac. The company foresees to fetch a net salvage value of 35 lac after 5 years.

Find :ARR

Example:- Let us determine the ARR for the following 2 alternative investments:

		Machine A:	Machine B:
Cost		56,125	58,125
Annual estimated income after depreciation & tax			
	Year 1	3,375	11,375
	Year 2	5,375	9,375
	Year 3	7,375	7,375
	Year 4	9,375	5,375
	Year 5	11,375	3,375
Total earnings		36,875	36,875
Estimated life		5 years	5 years
Estimated salvage value		3,000	3,000

Which investment is better????

$$ARR = \frac{\text{Annual average net earnings after taxes X 100}}{\text{Average investment over the life of the project}}$$

Average earnings = Total earnings / Estimated life in years

For machines A:- 36,875 / 5 = 7,375
For machines B:- 36,875 / 5 = 7,375

Average investment = (Initial investment - Salvage Value) / 2 + Working capital + Salvage value.

For Machine A: (56,125 - 3000) / 2 + 0 + 3000 = 29,562.50
For Machine B: (58,125 - 3000) / 2 + 0 + 3000 = 30,562.50

ARR for Machine A : 7375/29562.50 * 100 = 24.95% or 25%
ARR for Machine B : 7375/30,562.50 * 100 = 24.13% or 24%.

Machine A would be preferred as ARR is higher. However, if we use previous method , then machine B is better.

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Capital Budgeting techniques- I

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$$D : \frac{\text{Average income after tax but before interest}}{\text{Average investment}}$$

$$E : \frac{\text{Average income before interest and taxes}}{\text{Initial investment}}$$

$$F : \frac{\text{Average income before interest and taxes}}{\text{Average investment}}$$

$$G : \frac{\text{Total income after tax but before depreciation} - \text{Initial investment}}{(\text{Initial investment} / 2) \;\; x \;\; \text{years}}$$

Year	Investment (Book value)	Depreciation	Income before Interest and Taxes	Interest	Income before Tax	Tax	Income after Tax
1	1.00	0.20	0.30	0.10	0.20	0.100	0.100
2	0.80	0.20	0.35	0.10	0.25	0.125	0.125
3	0.60	0.20	0.40	0.10	0.30	0.150	0.150
4	0.40	0.20	0.40	0.10	0.30	0.150	0.150
5	0.20	0.20	0.35	0.10	0.25	0.125	0.125
Sum	3.00	1.00	1.80	0.50	1.30	0.650	0.650
Average	**0.60**	**0.20**	**0.36**	**0.10**	**0.26**	**0.130**	**0.130**

Year	Investment (Book value)	Depreciation	Income before Interest and Taxes	Interest	Income before Tax	Tax	Income after Tax
1	1.00	0.20	0.30	0.10	0.20	0.100	0.100
2	0.80	0.20	0.35	0.10	0.25	0.125	0.125
3	0.60	0.20	0.40	0.10	0.30	0.150	0.150
4	0.40	0.20	0.40	0.10	0.30	0.150	0.150
5	0.20	0.20	0.35	0.10	0.25	0.125	0.125
Sum	3.00	1.00	1.80	0.50	1.30	0.650	0.650
Average	0.60	0.20	0.36	0.10	0.26	0.130	0.130

Measures

A: $$\frac{\text{Average income after tax}}{\text{Initial investment}} = \frac{0.13}{1.00} = 13.0\%$$

B: $$\frac{\text{Average income after tax}}{\text{Average investment}} = \frac{0.13}{0.60} = 21.7\%$$

C: $$\frac{\text{Average income after tax but before interest}}{\text{Initial investment}} = \frac{0.13 + 0.10}{1.0} = 23.0\%$$

D: $$\frac{\text{Average income after tax but before interest}}{\text{Average investment}} = \frac{0.13 + 0.10}{0.60} = 38.3\%$$

E: $$\frac{\text{Average income before interest and tax}}{\text{Initial investment}} = \frac{0.36}{1.0} = 36\%$$

F: $$\frac{\text{Average income before interest and tax}}{\text{Average investment}} = \frac{0.36}{0.60} = 60\%$$

G: $$\frac{\text{Total income after tax but before depreciation} - \text{Initial investment}}{(\text{Initial investment} / 2) \times \text{years}} = \frac{0.65 + 1.00 - 1.00}{1/2 \times 5} = 26.0\%$$

De-merits of ARR method:

Like the pay-back period method, this method **ignores** the **time value of money.**

This method takes into account the accounting **profits** rather than the cash inflows and hence **ignores the fact that the actual cash flows can be re-invested**.

It is the discretion of the management to choose the **arbitrary cut-off rate of return** in choosing the projects. This may not always ensure the right selection.

The concept of average investment and average earnings **differ widely** and hence may produce different results.

CAPITAL BUDGETING TECHNIQUES

Discounting

- Discounted PBP
- Profitability index
- NPV
- Internal rate of return

Time value of money: Money available today is more than tomorrow.

Compound amount = Principal $(1+ r)^n$

or , Principal = Compound amount / $(1+ r)^n$

or , present value of money = future value * present value factor

where PVF = $1/(1+ r)^n$

r = Discount factor,

n = No of periods

Present value: Any **value that occurs at the beginning of the problem** is a present value. As zero is good baseline, **all cash flows are converted into their present value for analysis**.

PVF is the ratio of PV and future value and is available in the form of table.

Future value: ????????????

Future value: The **last cash flow** is generally called future value, it can be understood as the **cash transaction taking place after certain duration of time**. If the **same amount is transacted after a regular interval,** it is termed annuity.

Annuity payment: ????????????????????

Annuity payment: As per literary meaning, an annuity payment means the **yearly payment that occurs every year for more than one year.**

But in financial terms, the duration may not be yearly, it may be less as well, say quarterly, monthly, weekly etc., but the **duration b/w two successive payments remains constant**.

Each **payment, if taken alone, is a future value**, but together they make an annuity.

Discount factor: DF is the **expected** **returns per unit of period** **over the life of the project or investment**.

It is necessary to understand that **if annuity is for** **quarterly** **payment or transactions**, the **annual expected** **return** **should be reduced to** **one quarter** for computational purpose, similarly 1/12, if it is monthly.

Number of periods: The total no. of periods in any annuity is very important as they **define the value of annuity**.

It should again be noted that **if transactions are done yearly**, it is the no. of years, but in the situation of **quarterly payments, the no. of periods should be quadrupled the no. of years.**

Ex: Mr Sharma wishes to invest some money for future need of 5 lac after 5 yrs. @ 9 %, how much money should he deposit in Bank.

If interest is paid semi annually, then how much money should he deposit in Bank.

Ex: Mr Sharma wishes to invest some money for future need of 5 lac after 5 yrs, @ 9 %, how much money should he deposit in Bank

Present value = $500000/(1+0.09)^5$

$= 325000$

What if interest is paid semi annually?

Present value = $500000/(1+0.045)^{10} = 318712$

Ex: Mr X wants to receive 120,000 every year for next 10 years (starting from next year from now).How much should he deposit now ? If interest rate is 10%.????

Ex: Mr X wants to receive 120,000 every year for next 10 years (starting from next year from now). How much should he deposit now? If interest rate is 10%.

Present value of an annuity of ₹ 1 paid for period t at a rate $k = [1 - 1/(1+k)^t]/k$																				
	Rate																			
Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870

Solution:120000*6.145 (from table) = 737400.

Discounted PBP: while evaluating projects with DPBP method, **present values of cash flow are considered instead of cash flow itself** as in the case of PBP method.

DPBP is **length of time required to recover the initial cash outflow** from the discounted future cash flow.

DPBP = Y0- (Cu.PV0)/(CF1)

Y0 = is the year just before the pay back period is attained

CuPV0 = cumulative present value of Y0

CF1 = cash flow of pay back year

Ex: Find DPBP ????, if discount factor is 10%

Year	Cash flow
0	-140
1	30
2	40
3	50
4	60
5	45

DPBP= Y0- (Cu.PV0)/(CF1),

Y0 = is the year just before the pay back period is attained

CuPV0 = cumulative present value of Y0

CF1= cash flow of pay back year

Ex: FIND DPBP, if discount factor is 10%

Year	Cash flow	PVF	PV	CuPV
0	-140	1	-140	-140
1	30	$1/(1+0.10) = 0.90$	27	-113
2	40	$1/(1+0.10)^2 = 0.82$	33.04	-79.96
3	50	$1/(1+0.10)^3 = 0.75$	37.55	-42.41
4	60	$1/(1+0.10)^4 = 0.68$	40.98	-1.43
5	45	$1/(1+0.10)^5 = 0.62$	27.94	26.51

DPBP = 4 - (-1.43/27.94) = 4.05 yrs

Ex: Find DPBP ????, if DF=10%

Year	Cash flow
0	-300
1	80
2	80
3	180
4	180
5	180

Net Present Value

NPV: NPV is the most common approach used in the filed of financial investment analysis.

It is very **simple** to use and evaluate on the basis of **wealth maximization objective**.

It is defined as the **difference b/w the present value of cash inflows and present value of cash outflows .**

Advantages of NPV

1. Considers all cash flows.
2. Considers time value of money.
3. Computes contribution towards wealth creation.
4. Allows expected changes in cost of capital.

The limitation of NPV

1. Requires pre-determination of DF.
2. Does not consider risk factors.

Determine PI and NPV, assuming DF as 10%, should we accept this project??

Year	Cash flow
0	-160
1	30
2	40
3	50
4	60
5	100

Determine PI and NPV, assuming DF as 10%

Year	Cash flow	PVF (10%)	PV	
	-160	1	-160	
1	30	$1/(1+0.10) = 0.9091$	27.27	
2	40	$1/(1+0.10)^2 = 0.826$	33.06	
3	0	$1/(1+0.10)^3 = 0.751$	37.57	200.56
4	60	$1/(1+0.10)^4 = 0.683$	40.57	
5	100	$1/(1+0.10)^5 = 0.621$	62.09	
		Total	**40.56**	

PI = 200.56/160 = 1.25

NPV = 200.56-160 = 40.56,

We should accept project.

Ex: **Determine PI and NPV, assuming DF as 10%**

Year	Cash flow
0	-140
1	30
2	40
3	50
4	60
5	45

Should we accept this project????

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Project Management for Managers

Lec – 17

Capital Budgeting techniques- II

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Ex: Find DPBP ????, if discount factor is 10%

Year	Cash flow
0	-140
1	30
2	40
3	50
4	60
5	45

DPBP= Y0- (Cu.PV0)/(CF1),

Y0 = is the year just before the pay back period is attained

CuPV0 = cumulative present value of Y0

CF1= cash flow of pay back year

Ex: FIND DPBP, if discount factor is 10%

Year	Cash flow	PVF	PV	CuPV
0	-140	1	-140	-140
1	30	$1/(1+0.10) = 0.90$	27	-113
2	40	$1/(1+0.10)^2 = 0.82$	33.04	-79.96
3	50	$1/(1+0.10)^3 = 0.75$	37.55	-42.41
4	60	$1/(1+0.10)^4 = 0.68$	40.98	-1.43
5	45	$1/(1+0.10)^5 = 0.62$	27.94	26.51

DPBP = 4 - (-1.43/27.94) = 4.05 yrs

Ex: Find DPBP ????, if DF=10%

Year	Cash flow
0	-300
1	80
2	80
3	180
4	180
5	180

Ex: Find DPBP, if DF=10%

Year	Cash flow	PVF	PV	CuPV
0	-300	1	-300	-300
1	80	0.909	72.72	-227.28
2	80	0.826	66.08	-161.2
3	180	0.751	135.18	-26.02
4	180	0.683	122.94	96.92
5	180	0.621	111.78	208.7

DPBP = 3 - (-26.02/122.94) = 3.21yrs

Profitability index

Profitability index (PI) : PI is the **ratio of sum of cash inflows to sum of cash outflow,** a necessary condition for a project to be feasible is that PI should **be more than 1**.

PI= (sum of cash **i**nflows)/(sum of cash **o**utflow)

Net profitability index = PI-1

Net Present Value

NPV: NPV is the most common approach used in the filed of financial investment analysis.

It is very **simple** to use and evaluate on the basis of **wealth maximization objective**.

It is defined as the **difference b/w the present value of cash inflows and present value of cash outflows .**

Advantages of NPV

1. Considers all cash flows.
2. Considers time value of money.
3. Computes contribution towards wealth creation.
4. Allows expected changes in cost of capital.

The limitation of NPV

1. Requires pre-determination of DF.
2. Does not consider risk factors.

Determine PI and NPV, assuming DF as 10%, should we accept this project??

Year	Cash flow
0	-160
1	30
2	40
3	50
4	60
5	100

Determine PI and NPV, assuming DF as 10%

Year	Cash flow	PVF (10%)	PV	
	-160	1	-160	
1	30	$1/(1+0.10) = 0.9091$	27.27	
2	40	$1/(1+0.10)^2 = 0.826$	33.06	
3	0	$1/(1+0.10)^3 = 0.751$	37.57	200.56
4	60	$1/(1+0.10)^4 = 0.683$	40.57	
5	100	$1/(1+0.10)^5 = 0.621$	62.09	
		Total	**40.56**	

PI = 200.56/160 = 1.25

NPV = 200.56-160 = 40.56,

We should accept project.

Ex: **Determine PI and NPV, assuming DF as 10%**

Year	Cash flow
0	-140
1	30
2	40
3	50
4	60
5	45

Should we accept this project????

Ex: **Determine PI and NPV, assuming DF as 10%**

Year	Cash flow	PVF	PV
0	-140	1	-140
1	30	1/1.10 = 0.90	27
2	40	$1/(1.10)^2=0.82$	33.04
3	50	0.75	37.55
4	60	0.68	40.98
5	45	0.62	27.94
		Total	**26.51**

166.51

PI = 166.51/140 = 1.189

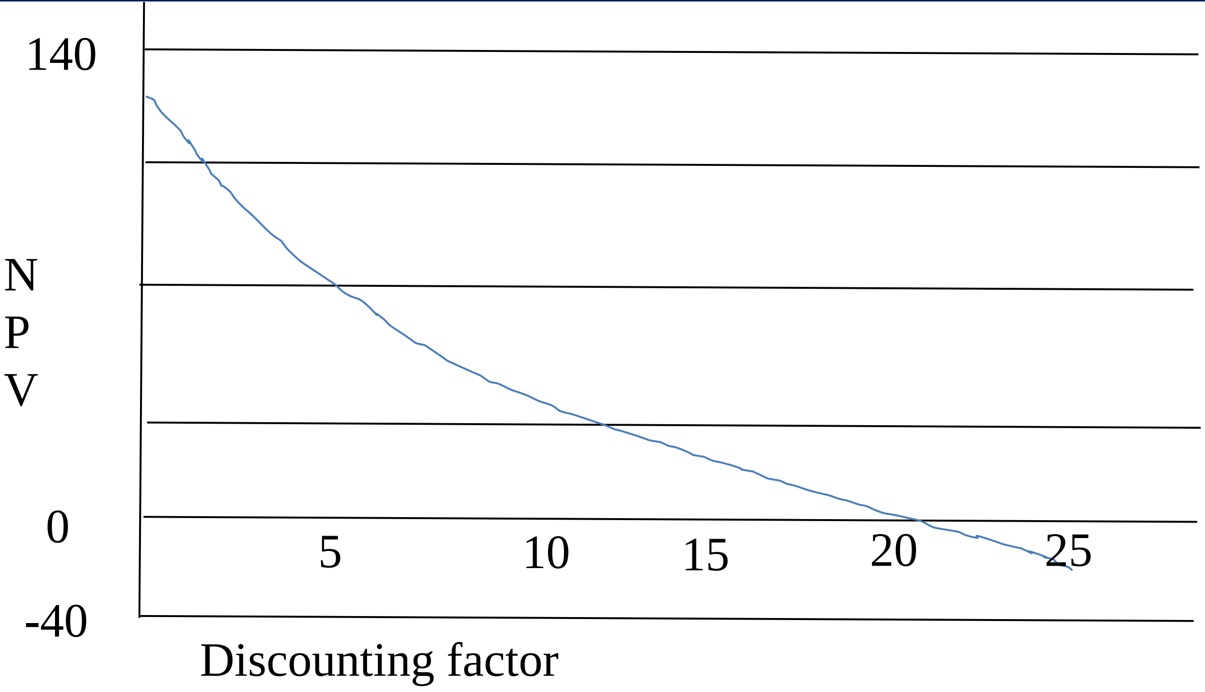
NPV = 166.51-140 = 26.51. Should we accept project????

Internal Rate of Return (IRR): IRR is defined as the **discounting rate** which delivers a Net Present Value equal to zero.

A simple criterion can be stated to **accept a project if its rate of <u>return</u> exceeds the <u>cost</u> of capital** and **rejected if this IRR is less than cost of capital**.

IRR may result in number of complexities: Neglects the **size** of the project and **assumes** that cash flows are **reinvested at constant rate**.

The relationship b/w discounting rates and NPV is not a linear, and for calculation of exact IRR, this should be linear, can be assumes linear, if we take small piece.



Calculating IRR is a **tedious process**. It should be done with the help of **trial and error method**.

Continue **increasing** "r" to **decrease NPV till it reaches negative**.

And then interpolate b/w the consecutive "r" values where it is positive and negative, respectively.

The interpolation formula:

IRR = r_o + (NPV_o)/ (NPV_1-NPV_o), Where

r_o = is the rate at which NPV is just positive,

NPV_o = is just positive NPV,

NPV_1 = is just negative NPV

Calculate IRR??

Year	Cash flow
0	-160
1	30
2	40
3	50
4	60
5	100

Let us try at 18% and then 17% , at18% NPV is just negative.

		18%		17 %	
Year	**Cash flow**	**PVF**	**PV**	**PVF**	**PV**
0	-160	1	-160	1	-160
1	30	1/1.18=.847	25.42	.855	25.64
2	40	$1/(1.18)^2$. = 718	28.73	.731	29.22
3	50	.609	30.43	.624	31.22
4	60	.516	30.95	.534	32.02
5	100	.437	43.71	.456	45.61
Total			**-0.76**		**3.71**

IRR = r_o + (NPVo)/ (NPV1-NPVo),

IRR= 17+3.71/(3.71-(-0.76)) = 17.83%

Discount rate 8%

Year	Cash Flow	**PVF**	**PV**
0	-1,000,000	1	-1,000,000
1	450,000	$1/(1+0.08)=0.92$	414000
2	400,000	$1/(1+0.08)^2=0.85$	340000
3	350,000	$1/(1+0.08)^3=0.79$	276500
4	300,000	$1/(1+0.08)^4=0.73$	219000
5	250,000	$1/(1+0.08)^5=0.68$	170000
		NPV	**419500**

In the above example if you replace the 8% with a 25% the NPV will become zero, and that's your IRR. **Hence, the statement that IRR is the discount rate at which the NPV of a project becomes zero is true.**

Discount rate 25%

Cash flow			PVF	PV
-10,00,000	1	1	1	-1000000
4,50,000	1	1.25	0.8	360000
4,00,000	1	1.5625	0.64	256000
3,50,000	1	1.953125	0.512	179200
3,00,000	1	2.44140625	0.4096	122880
2,50,000	1	3.051757813	0.32768	81920
NPV				0

Selection of capital budgeting technique (NPV vs IRR) : In capital budgeting , there are number of **different approaches** that can be used to **evaluate** any given project, and each approach has its own distinct **advantages and disadvantages** as discussed earlier.

All other things being equal, using IRR and NPV measurements to evaluate projects often results in the **same findings**.

- **Over time, discounted cash flow methods have gained importance and internal rate of return is one of the most popular evaluation methods.**

- **Firms typically use multiple evaluation methods.**

- **Accounting rate of return and payback period are widely employed as supplementary evaluation methods.**

However, there are number of projects for which **using IRR is not as effective as using NPV** to discount cash flows.

While **ranking** the various techniques, **NPV stands on top priority**, followed by IRR.

Why IRR is not as good as NPV is?

-IRR presumes that the same rate of return is available in other projects as well.

-If cash flows are not normal, IRR may arrive at multiple solutions.

Assessment of Basic Evaluation Methods

	Net present value	*IRR*	*Payback period*	*Accounting rate of return*
***Theoretical** considerations*				
1. Does the method consider **all cash flows**	Yes	Yes	No	?
2. Does the method **discount** cash flows at the opportunity cost of funds ?	Yes	No	No	No
3. Does the method satisfy the principle of value additivity ?	Yes	No	?	?
4. From a set of mutually exclusive projects, does the method choose the project which **maximize shareholder wealth ?**	Yes	No	?	?

Assessment of Basic Evaluation Methods

	Net present value	*Internal rate of return*	*Payback period*	*Accounting rate of return*
***Practical** considerations*				
1. Is the method **simple** ?	Yes	Yes	Yes	Yes
2. Can the method be used with **limited** information ?	No	No	Perhaps	Yes
3. Does the method give a **relative** measure ?	No	Yes	No	Yes

Survey: Evaluation Techniques in India

- Internal rate of return
- Payback period
- Net present value
- Break-even analysis
- Profitability Index

Financing of Projects

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Financing of Projects

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The two broad sources of finance available to a firm are : shareholders' funds (equity funds) and loan funds (debt funds).

Basic Differences between Equity and Debt?????????????????????????

Equity

- Equity shareholders have a **residual** claim on the income and the wealth of the firm

- Equity ordinarily has **indefinite** life

- Equity investors enjoy the prerogative to **control** the **affairs of the** firm

. Dividend paid to equity shareholders **is not a tax** deductible payment

Debt

- Creditors (suppliers of debt) have a fixed claim in the form of interest and principal payment

- Debt has a **fixed maturity**

- Debt investors play a passive role – of course, they impose certain restrictions on the way the firm is run to protect their interest

- Interest paid to creditors is a **tax deductible payment**

Key Factors in Determining the Debt - Equity Ratio

The key factors in determining the debt-equity ratio for a project are:

- **Cost:** lenders require a lower rate of return compared to equity share holder. **Debt is cheaper but riskier source of finance, whereas equity is a costlier but safer source of finance**.
- **Nature of assets:** (tangible-electricity-more of debt, intangible-brand & software-less of debt)
- **Business risk:** Refers to the variability of earring power (demand variability, price variability, variability of input prices, proportion of fixed operating cost (of the total cost –risk is higher))

The key factors in determining the debt-equity ratio for a project are:

Norms of lenders: DER= 2:1, 1:1, for high capital incentive project (power) 2.33:1

Control considerations: Capital structure depends on **extent of equity stake** want by **promoters**. If cost of project is 10000, promoters can invest 2000. If they want minimum 50% of stake in the equity of the project, **the total equity cannot exceed 4000**. Hence, balance 6000 in debt form (1.5:1). If they want a minimum stake of 40% in the equity of the project, **the total equity cannot exceed 5000 (1:1).**

Market conditions: if equity mkt is **buoyant** and equity shares can be issued at an attractive premium the project may rely more **on equity**. If e**quity mkt is depressed**, the project may depend on **debt**.

A Checklist

Use more equity when	Use more debt when
The **corporate tax rate applicable is negligible**	The corporate tax rate applicable is **high**
Business risk exposure **is high**	Business risk exposure **is low**
Dilution **of control** is **not an** important issue	Dilution of control is an issue
The **assets** of the project are mostly **intangible**	The assets of the project are mostly tangible
The project has many valuable **growth options**	The project has **few growth** options

Sources of Finance

Part A

Sources of Finance

- Internal Accruals
- Securities
  - Equity
  - Preference
  - Bonds
- Term loans
- Working capital advances
- Miscellaneous sources

Part B

Sources of Finance

- Equity
  - Equity
  - Preference
  - Internal accruals
- Debt
  - Bonds
  - Term loans
  - Working capital advances
  - Miscellaneous sources

Public and Private Sources of Capital: A firm can raise **equity and debt capital** from both **public and private sources**. Capital raised form public sources is in the form of **securities offered to public** through **an offer document field with SEBI.**

Private capital comes either in the form of loans given by banks and financial institution or in the form of issue of securities like shares, preference shares, and debentures which are privately places with a small group of sophisticated investors like PE funds, VC firms, financial institutions, insurance companies, mutual funds, and wealthy individuals.

The typical pattern of financing: When a company is formed, it first issues equity shares to the promoters (founders) and also, in most cases, to a select group of investors.

As the company grows, it may rely on the following methods of raising equity capital: initial public offering, seasoned offering, rights issue, private placement, and preferential allotment.

Internal Accruals

Internal accruals of a firm consist of depreciation amortization, and retained earnings (that portion of equity earning which are ploughed back in the firm) (part of equity earnings- 30 to 80% of profit after tax for financing growth)

Ex. Cost of m/c 10,000, life 5 yrs, no salvage value after 5 yrs, annual depreciation charges 2,000, Each year a deprecation cost of Rs 2,000 will be shown in PLA. It is non-cash charge.

Pros

- **Readily** available (management need not talk to shareholder or lenders)
- No dilution of control

Cons

- Opportunity cost of retained earning is **high as it** is equal to the cost of equity –remember the retained earnings, in essence, **dividend forgone by equity shareholders**.
- Limited amount.

Equity Capital

Equity capital represents ownership capital as equity shareholders collectively own the company. They enjoy the rewards and bear the risks of ownership

Authorized, Issued, Subscribed, and Paid up Capital:

The amount of capital that a company can potentially issue, as per its memorandum, represents the *authorized* capital.

The amount offered by the company to the investors is called the *issue* capital.

The part of issued capital which has been subscribed by the investors represents the *subscribed* capital.

The actual amount paid up by the investors is called the *paid up* capital-typically the Issued, Subscribed, and Paid-up are the same .

Rights of Equity Shareholders

- Right to Income: PAT-preferred dividend
- Right to Control: Select board of directors, right to vote on a resolution, etc
- Pre-emptive Right: Shareholders maintain their proportional ownership by purchasing the additional equity shares issued by the firm . (Ex. 1000,000 outstanding shares, proposes to issue 200,00, equity SH has 100 shares has right to …..)
- Right in Liquidation: As in case of income, equity shareholders have a residual claim over assets of the firm , after settling claims of (Debenture holders, secured and unsecured lender, other creditors, preferred share holders).

Advantages of equity capital:

1. **Long** term source of finance.
2. In case of **insufficient** cash - no need to pay **dividend**.
3. Presently, equity dividends are tax-exempt in the hands of investors.
4. Equity capital **has no maturity** date and hence the firm has no obligation to redeem.

Disadvantages equity capital :

1. Sale of equity shares to outsider dilutes the control of existing owners.
2. The cost of equity capital is high, **usually the highest**. The rate of return required by equity SH is higher than the rate of return required by any other investors.
3. The cost of **issuing equity shares is generally higher** than the cost of issuing other types of securities. Underwriting commission, brokerage costs, and other issue expenses are high for equity issues.

Preference Capital

Preference capital represents **a hybrid form of financing**. It partake some characteristics of **equity** and some attributes of **debt**.

It resembles **equity**

(i) preference dividend is payable only out of distributable profits

(ii) preference dividend **is not an obligatory payment**

(iii) preference dividend **is not a tax deductible** payment

It resembles **debenture**

(i) the **dividend rate** of preference capital is **fixed**

(ii) the claim of preference SHs is **prior** to the claim of equity SHs

(iii) preference SHs **do not normally enjoys the right to vote.**

Preference Capital

Pros

- No legal obligation to pay dividends
- Enhances creditworthiness
- No dilution of control

Cons

- **Costly source**
- Skipping preference dividends adversely affects image
- **Voting rights under certain conditions**

Debentures (or Bonds)???????

For large publicly traded firms, debentures are a viable alternative to term loan. Akin to promissory notes, debentures are instruments for raising debt finance. Debenture holders are the creditors of the company. The obligation of a company toward its debenture holders is similar to that of a borrower who promises to pay **interest and principal at specified times**. Debentures often provide **more flexibility than term loans** as they offer greater choice with respect to **maturity, interest rate, security, repayment, and special features.**

- **Trustee:** Appointed through deed, bank, or FI or Insurer, the borrowing firm will fulfill contractual obligations.

- **Security:** Debenture issues in India are typically secured by **mortgage/charges on the immovable properties** of the company and a floating charge on its other assets. Occasionally, companies issue **unsecured debentures**, not backed by specific assets of the firm, but by its general credit.

- **Maturity:** Corporate debt may be short term , medium term (1- 5 yrs) or long term (5-12 yrs) . Corporate debt of **less** than one year is called **commercial** paper .

- **Redemption**: Debentures are typically redeemable in nature.

- **Fixed rate vs. floating rate:** Debenture may carry fixed or floating or zero rate of interest.

- **Embedded options:** Debenture may carry a "**call**" feature (redemption at certain price before maturity period), "**put**" feature (at specified time and predetermined prices)

Advantages and Disadvantages of Debt Financing

Advantages

- Interest on debt is a tax deductible expense, whereas equity and preference dividends are paid out of profit after tax.
- No **dilution** of control: because debt holder are not entitled to vote
- **Lower** issue costs
- Debt servicing burden is generally fixed in nominal terms
- Tailor-made maturity: to the needs of borrowing firm

Advantages and Disadvantages of Debt Financing

Disadvantages

- Fixed **interest and principal repayment obligation, failure to this may lead to bankruptcy**.
- Debt financing increases financial leverage which, according to CAPM, raises the cost of equity to the firm.
- Debt contracts impose restrictions that limit the borrowing firm's financial and operating flexibility, which may impair firm's ability to resort to value maximizing behavior.

The following are the main difference between a debenture and a share:

1. A person having the debentures is called debenture holder whereas a person holding the shares is called shareholder.

2. Debenture holder is a creditor of the company and cannot take part in the management of the company while a shareholder is the owner of the company. It is the basic distinction between a debenture and a share.

3. Debenture holders will get interest on debentures and will be paid in all circumstances, whether there is profit or loss will not affect the payment of interest on debentures.

4. Shareholder will get a portion of the profits called dividend which is dependent on the profits of the company. It can be declared by the directors of the company out of profits only.

5. Shares cannot be converted into debentures whereas debentures can be converted into shares.

The following are the main difference between a debenture and a share:

6.Debentures will get priority in getting the money back as compared to shareholder in case of liquidation of a company.

7.There are no restriction on issue of debentures at a discount, whereas shares at discount can be issued only after observing certain legal formalities.

8.Convertible debentures which can be converted into shares at the option of debenture holder can be issued whereas shares convertible into debentures cannot be issued.

9. There can be mortgage debentures i.e. assets of the company can be mortgaged in favour of debenture holders. But there can be no mortgage for shares. Assets of the company cannot be mortgaged in favour of shareholders.

Methods of Offering

There are different ways in which a company may raise finances in the primary market

Public offering: **Sale of security to the members of the public. IPO (The first public offering of equity shares of a company , which is followed by a listing of its shares on the stock market.).**

Benefits	*Costs*
• **Access to a larger pool of capital**	• Dilution
• **Respectability**	• Loss of flexibility
• **Lower cost of capital** compared to private placement	• Disclosures and accountability
• **Liquidity**	• Periodic costs

Methods of Offering

Seasonal equity offering (as companies need more finances, they are likely to make further trip to capital market also called secondary offerings) .

Bond offering (similar to IPO with some differences- the prospectus for a bond offering typically emphasis on a company 's stable cash flow whereas prospectus for an equity offering highlights the company's growth prospects., etc)

Methods of Offering

There are different ways in which a company may raise finances in the primary market

Rights issue: Involves selling securities in the primary market by issuing rights to the existing SHs.

When a company issues **additional equity capital** , it has to be offered in the first instance to the existing SHs on pro rata basis.

SHs may forfeit this right, partially or fully , to enable company to issue additional capital to public.

Methods of Offering

Private placement: Issue of securities to a select group of persons not exceeding 49. Private placement of **shares and convertible debentures** by a listed company can be of two types.

Preferential allotment: When a company issues shares or debentures to select group of in terms of provisions persons (pricing, disclosures, lock-in period) of chapter XIII of SEBI (DIP) guidelines.

Qualifies Institutional Placement (QIP): A QIP is an issue of equity shares or convertible securities to Qualified Institutional Buyers in terms of the provisions of Chapter XIIIA of SEBI (DIP) guidelines.

Summary Comparison of the Various Methods

	Public Issue	Rights Issue	Private Placement	Preferential Allotment
• Amount that can be raised	Large	Moderate	Moderate	Moderate
• Cost of issue	High	Negligible	Negligible	Negligible
• Dilution of control	Yes	No	Yes	Depends
• Degree of underpricing	Large	Irrelevant	Small	No
• Market perception	Negative	Neutral	Neutral	Neutral

Term Loans

Term loans, also referred to as term finance, represent a source of **debt finance which is generally repayable in less than 10 years**.

Features of term loans (IFCI, ICICI, IDBI, SFCs, Commercial Banks)

1. **Currency:** Rupee (for land , building, miscellaneous fixed assets, margin money for working capital, etc) and foreign currency.

2. **Security:** Term loans typically represent secured borrowings. Usually the assets, which are financed with the term loan, provide the prime security .

3. **Inters payment and principal repayment:** Are definite obligations that are payable irrespective of the financial situation of the firm.

4. **Restrictive covenants:** Term loan providers put certain conditions; Broad-base its board of directors and team in consultations with them, bring additional funds in the form of unsecured loans, refrain from undertaking new projects, obtain clearances and NOCs from respective agencies, seek their consent if going for extra borrowings)

Working Capital Advances

WC advance by commercial banks represents the most important source for financing current assets.

- **Cash credits / overdrafts:** a predetermined limit is for borrowing is specified by the bank. A borrower can draw as often as required subject to a limit and adequate security. Interest is charged on running balance not on the limit sanctioned.
- **Loans :** These are advances of fixed amounts to the borrower. Interest is on entire amount irrespective of how much he draws.
- **Purchase / discount of bills:** A bill usually arises out of transaction. The seller of goods draws the bill on the purchaser . On acceptance of the bill by the purchaser , the seller offers it to the bank for discount/purchase. When the bank discount/purchases the bill, it releases the funds to the seller. The bank presents the bill to the purchase on the due date and gets its payment
- **Letter of credit:** A letter of credit is an arrangement whereby a bank helps its customer to obtain a credit from its (suppliers). Bank undertakes responsibilty to honor the obligation of its customer, should the customer fail to do so.

Miscellaneous Sources

- Deferred credit: When supplier of machinery offers deferred credit facility, a bank guarantee should be furnished by the buyer.

- Lease and hire purchase finance:

•Lasing (The lessee cannot claim depreciation. The entire lease rental is a tax – deductible expense for the lessee. The lessee, not being the owner of the asset, does not enjoy the salvage value of the asset.)

•Hire-Purchase (The hirer is entitled to claim depreciation. Only the interest component of the hire purchase installment is a tax-deductible expense for the hirer. The hirer, being the owner of the asset, enjoys the salvage value of the asset)

- Unsecured loans and deposits: Are typically provided by the promoters to fill the gap between the promoters' contribution required by the financial institutions and the equity capital subscribed by the promoters.

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Project Management for Managers

Lec – 19

Risk Management- I

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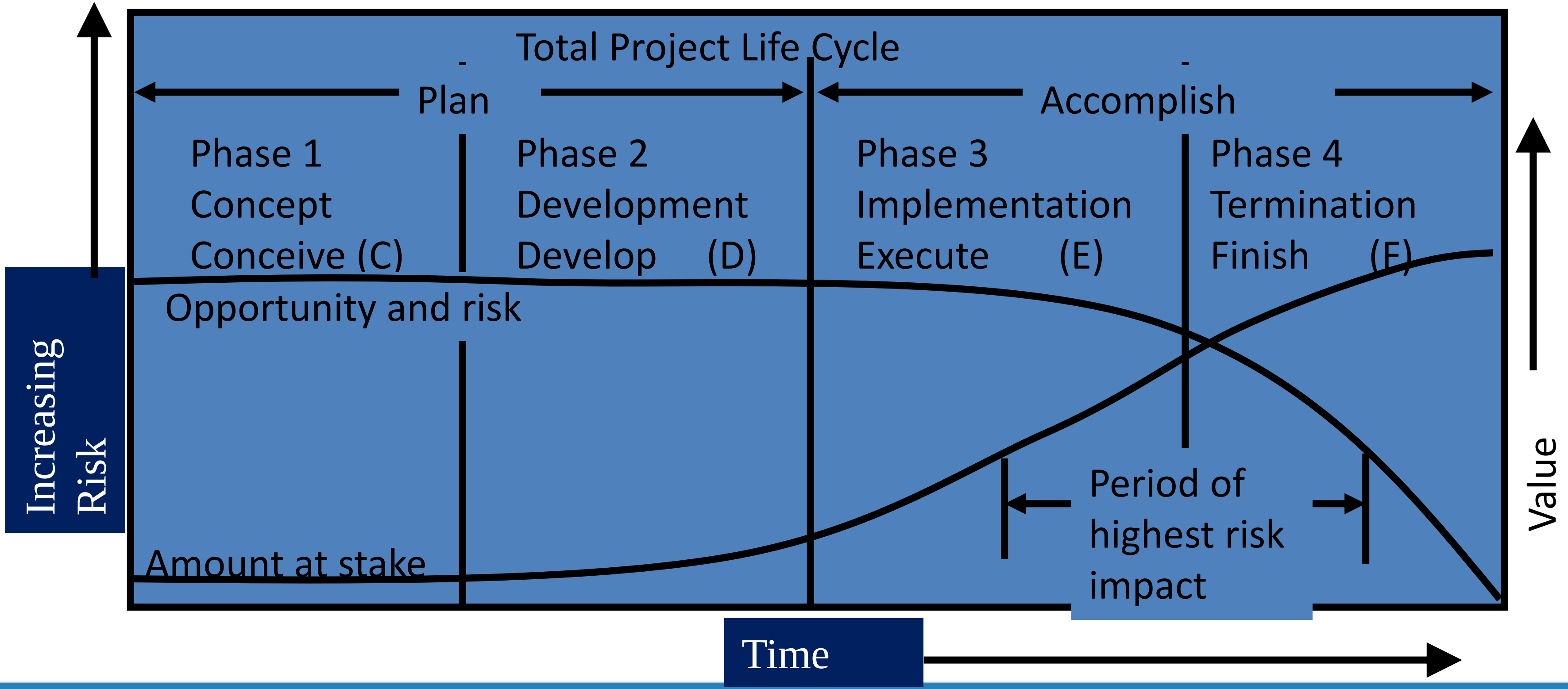
Process of Risk Management

- What is likely to happen? (The probability and impact)
- What can be done to minimize probability or impact of these events?
- What are the warning signs (clues one should look for?)
- What are the likely outcomes of these problems and my actions?

Project Risk = (Probability of Event)(Consequences of Event)

Risk Vs Amount at Stake



Four Stages of Risk Management

1. Risk **identification: determine specific risk factors.**

2. Analysis of probability and consequences: the potential impact of these risk factors, determined by how likely they are to occur and the effect they would have on the project if they did occur.

3. Risk **mitigation** strategies: steps to minimize the potential impact of those risks.

4. Control and documentation: creating a knowledge base for future projects based on lesson learned.

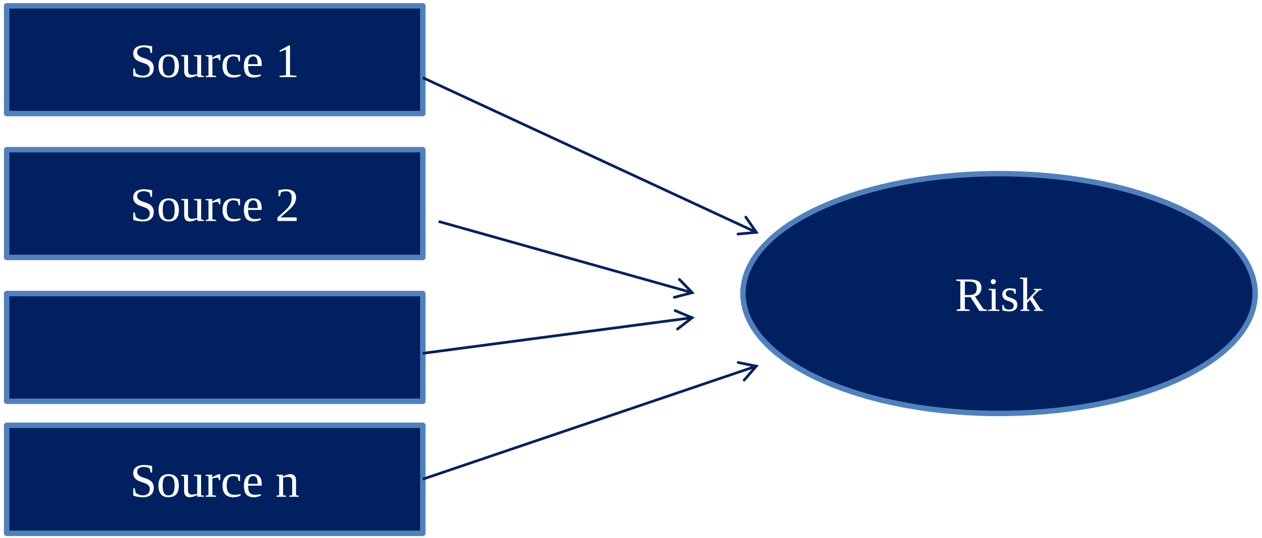
Risks commonly fall into one or more of the following classification Clusters

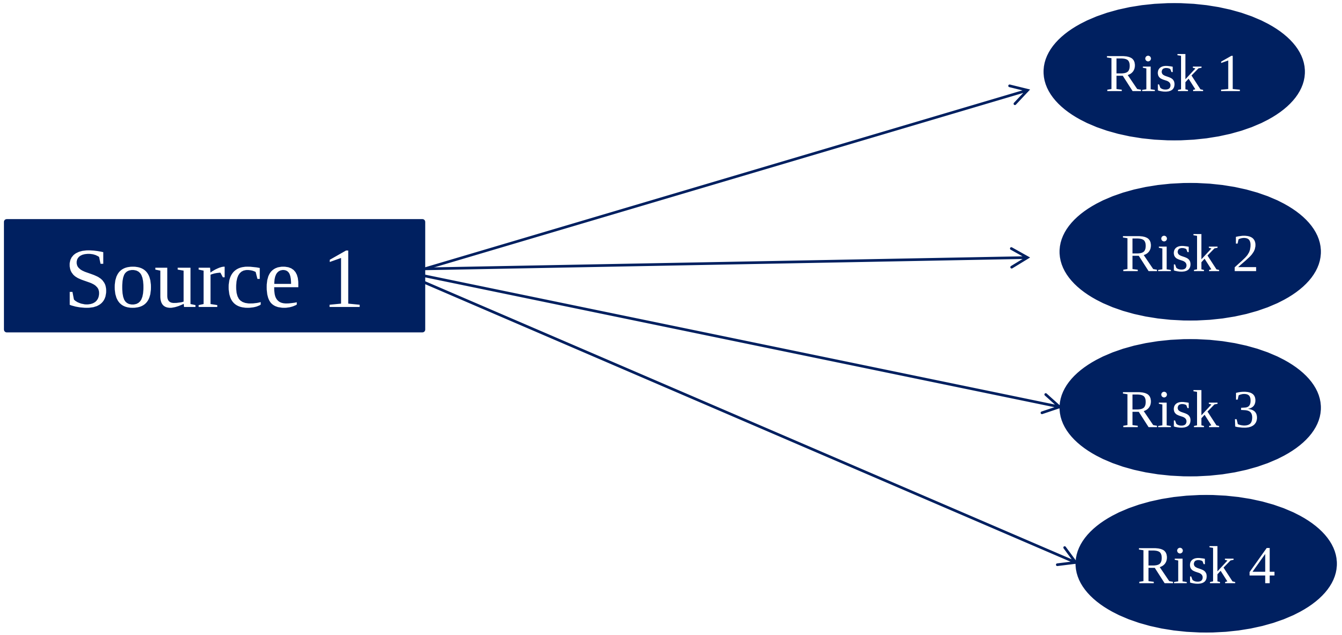
- Financial
- Technical
- Contractual/Legal
- Common Types
  - Absenteeism
  - Resignation
  - Staff pulled away
  - Time overruns

- Commercial
- Execution
  - Skills unavailable
  - Ineffective Training
  - Specs incomplete/initial specs poorly specified
  - Change orders

1. Risk Factor Identification

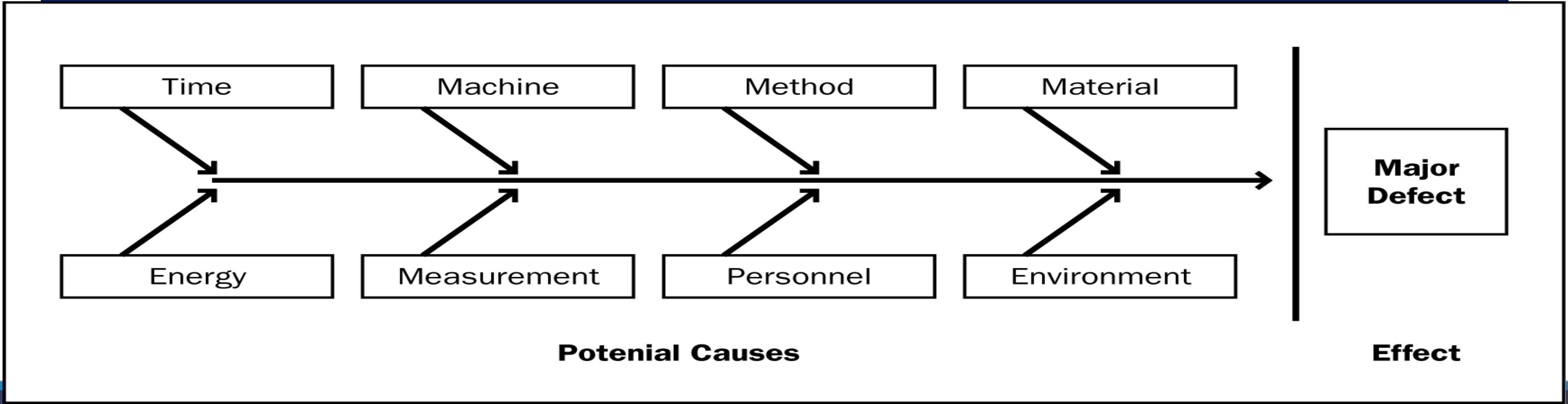
- Brainstorming meetings
- Expert opinion (or Delphi)
- Past history
- Multiple (team based) assessments


Source 1
Source 2
Source n
Risk

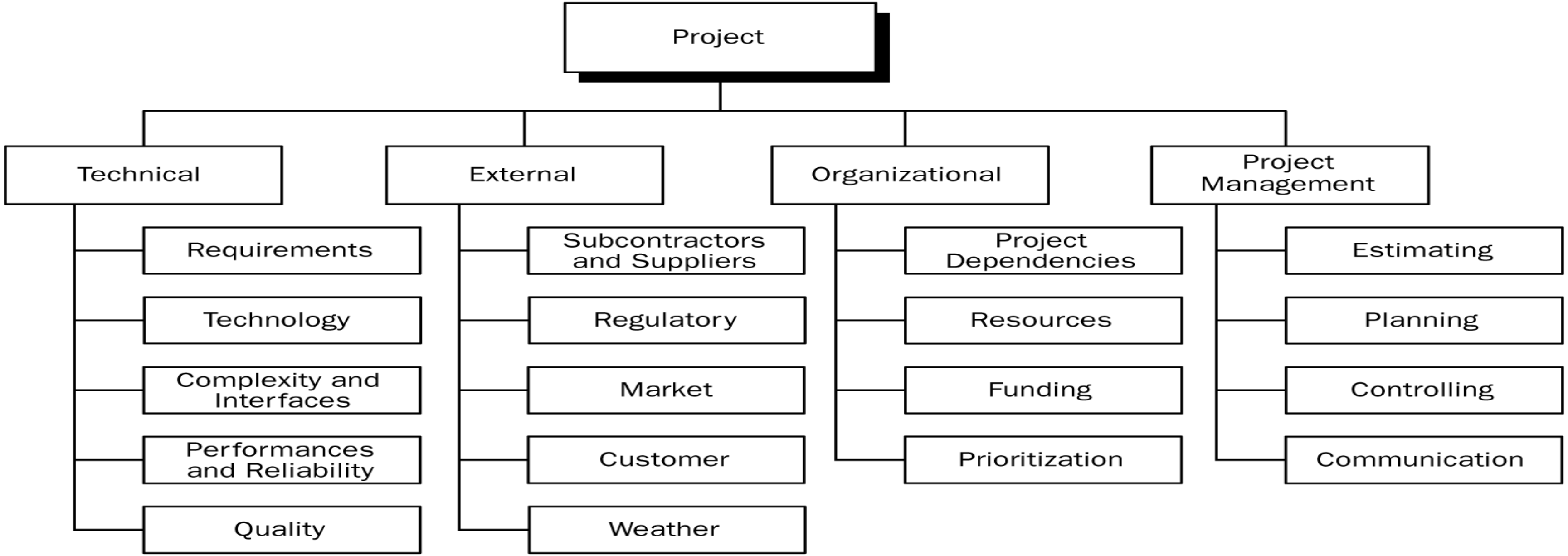

Source 1
Risk 1
Risk 2
Risk 3
Risk 4

1. Risk Factor Identification

- Documentation Reviews
- Sensitivity analysis
- Assumptions Analysis
- Decision tree analysis
- Simulation
- Diagrammatic technique



Similar to WBS



The Risk Breakdown Structure (RBS) lists the categories and sub-categories within which risks may arise for a typical project. Different RBSs will be appropriate for different types of projects and different types of organizations. One benefit of this approach is to remind participants in a risk identification exercise of the many sources from which project risk may arise.

2.Risk Management Assessment Matrix

Likelihood	Consequences: Low	Consequences: High
Low		FDI policy
High	RM (Soya bean - high production cost) but less impact on oil	Raw material from abroad

Can be a 3*3 matrix also or more. Consequences can be sever, moderate, and slight.

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Project Management for Managers

Lec – 20

Risk Management- II

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A firm developing a new software product for the retail market.

The scenario considers both the probability of failure and consequences of failure.

In probability of failures, we are interested in identifying any factors that can significantly affect the probability that the new product can be successfully completed.

The potential causes of failure are:

1.Maturity of the software design- It is a new product or based on existing software platform.

2.Complexity of the product: Is the design relatively simple or it is highly complex in structure.

3.Dependency- Can the product be developed independently on any system currently in place in the company or is it slaved to current operating systems or practices.

Under the consequences of failures, we are concerned with the issues that will highlight the effects of project failure; that is, consequences of failure require us to critically evaluate the results of project's success or failure along a number of key dimensions.

1. **Cost -** budget adherence versus overruns
2. **Schedule -** on time verses severe delay
3. **Reliability -** the usefulness and quality of finished product and
4. **Performance -** how well it is performing

Probability of Failure (P_f)

Score	Maturity	Complexity	Dependency
Low (0.1)	Existing software	Simple design	Not limited to existing system or clients. No external or uncontrollable events are likely to impact the project.
Minor (0.3)	Minor redesign	Minor increase in complexity	Schedule or performance depend on an existing system. Effect on cost or schedule is minor.
Moderate (0.5)	Major change	Moderate increase	Moderate risk to schedule or performance due to dependence on existing system, facility, or processes. Effect on cost is moderate.
Significant (0.7)	Technology is available, but complex design	Significant increase	Schedule or performance depend on new system or process. Significant cost or schedule risk.
Major (0.9)	State of art, some research complete	Extremely complex	Schedule and performance depend on new system and process. Very high cost or schedule risk.

		Consequence of Failure (C_f)		
Score	Cost	Schedule	Reliability	Performance
Low (0.1)	Budget estimate not exceeded	Negligible impact on program, no impact on critical path	Minimal or no reliability consequence	Minimal or no performance consequence.
Minor (0.3)	Cost estimate exceeds budget by < 5%	Minor slip in schedule (less than 5%)	Small reduction in reliability	Small reduction in system performance
Moderate (0.5)	Cost estimate exceeds budget by < 15%	Small slip in schedule starting to impact critical path	Some reduction in reliability performance	Some reduction in system. performance May require moderate debugging.
Significant (0.7)	Cost estimate exceeds budget by < 30%	Development time slips in excess of 1 month, requires readjustment of critical path	Significant degradation in reliability performance	Significant degradation in system performance. Guarantees are at risk. Serious debugging required.
Major (0.9)	Cost estimate exceeds budget by > 50%	Large schedule slips ensure the system will miss client timeframe	Reliability goals cannot be achieved under current plan	Performance goals cannot be achieved. Results may not be usable.

Project Risk Scoring

1. Identify factors and assess the probability (P_f) and consequences (C_f) of failure
2. Calculate overall probability & consequence

$$P_f = \frac{\sum_n P_i}{n}$$

$$C_f = \frac{\sum_m C_i}{m}$$

3. Calculate overall risk factor

$$RF = P_f + C_f - (P_f)(C_f)$$

Rule of thumb

Low risk RF< 0.30

Medium risk = 0.30 to 0.70

High risk >0.70

Probability of Failure (P_f)

Score	Maturity	Complexity	Dependency	
Low (0.1)	**0.10**	**0.15**	**0.13**	**0.38/3 = 0.12**
Minor (0.3)	0.30	0.20	0.25	= 0.25
Moderate (0.5)	0.50	0.45	0.40	=0.45
Significant (0.7)	0.72	0.75	0.65	=0.70
Major (0.9)	0.95	0.92	0.90	=.92

Consequence of Failure (C_f)

Score	Cost	Schedule	Reliability	Performance	
Low (0.1)	**0.11**	**0.18**	**0.15**	**0.18**	**0.15**
Minor (0.3)	0.32	0.25	0.25	0.29	0.27
Moderate (0.5)	0.52	0.47	0.44	0.49	0.48
Significant (0.7)	0.75	0.70	0.60	0.72	0.69
Major (0.9)	0.95	0.92	0.90	0.93	0.92

0.10	**0.15**	**0.13**	**0.38/3 = 0.12**
0.30	0.20	0.25	= 0.25
0.50	0.45	0.40	=0.45
0.72	0.75	0.65	=0.70
0.95	0.92	0.90	=.92
			0.48

0.11	**0.18**	**0.15**	**0.18**	**0.15**
0.32	0.25	0.25	0.29	0.27
0.52	0.47	0.44	0.49	0.48
0.75	0.70	0.60	0.72	0.69
0.95	0.92	0.90	0.93	0.92
				.50

$$RF = P_f + C_f - (P_f)(C_f)$$

Rule of thumb
Low risk RF< 0.30
Medium risk = 0.30 to 0.70
High risk >0.70

RF = 0.48+0.50- (0.48*0.50) =0.74 (high risk)

3.Risk Mitigation Strategies

- Accept - minor in nature, occurrence and consequences both are small.
- Minimize - next option is minimize risk. Boeing – millions of parts from thousands of vendors, direct contact of vendors with quality assessment team of Boeing. Right to intervene in the production process of vendors.

3.Risk Mitigation Strategies

- Share - ??????????.

3.Risk Mitigation Strategies

- Share - Risk may be allocated proportionately among **multiple** members of the project. European Space Agency and Airbus consortium - (huge capital and technical skills). BOOT is another example.
- Transfer - Insurance. Fixed price contacts (fixed price for the project upfront and if overruns builder will bear).

3.Risk Mitigation Strategies

- Use of Contingency Reserves: Depends on project. 10-15 % in construction projects.(Funds).
  - Task contingency (use to offset budget cutbacks, schedule overruns, or other unforeseen circumstances accruing to individual tasks or project work packages).
  - Managerial contingency (client asks for changes which require change in technology, or acts of God).
- Mentoring of project managers and tam members.
- Cross training- one can handle other members duties.

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Project Management for Managers

Lec – 21

Risk Management (Control & Documentation)

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4. Control & Documentation

Help managers classify and codify risks, responses, and outcomes.

Customer	**Project name**
Budget No	Project team
Date of Most Recent Evaluation	
Risk Description	
Risk Assessment	Risk Factor
Discussion	
Risk Reduction Plan	Owner
Timeframe to net assessment	
Expected outcome	

Risk Management Report Form

Control & Documentation

Change management report system answers

- What?: Source of risk
- Who?: Assign a team member
- When?:Time frame to mitigate the risk
- Why?: Find reasons/causes of the risk
- How?: Plan to abate the risk. Charting of method for closing a particular "risk window".? Do they seem reasonable or far-fetched?. Too expensive in terms of money of time.

Project Risk Analysis & Management (PRAM): An integrated Approach

The Eurasian Association for PM has developed an integrated program of risk management, based on efforts to extend risk management to cover a project's entire life cycle.

This program, known as Project Risk Analysis and Management (PRAM).

PRAM: Is logical and sequential method for analyzing and addressing risk.

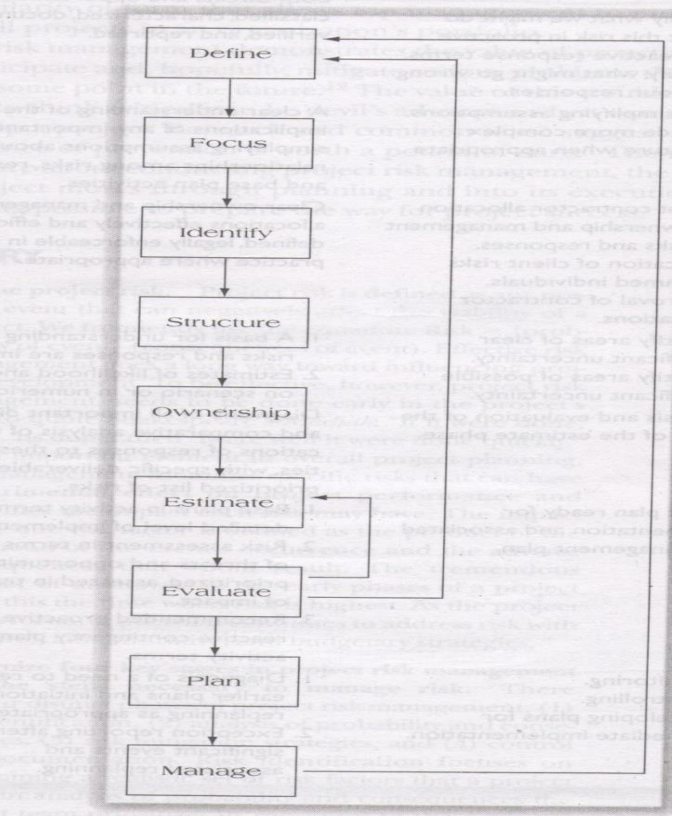
Key Features of PRAM

Risk management follows a **life cycle**

Risk management **strategy changes** over the project life cycle

Synthesized, coherent approach, tools of RM to be used as they are needed.

Nine Phases of Risk Assessment



PRAM Structure Flowchart

Define	**Project is well defined, deliverables, statement of work, project scope**
Focus	Begin to plan the risk management process as a project in its own right. Apply best methods for addressing risk
Identify	Sources of risk and their responses, prioritize risks
Structure	Find out commonalities across sources of risks , so that it can be handled separately.
Clarify ownership of risks	Whether project origination or clients risks
Estimate	The impact of risk and solution proposed
Evaluate	Critically evaluate the results of the estimate phase to determine the most likely plan for realizing potential risks
Plan	Produce risk mgt plan that proactively offers risk mitigation straggles
Manage	Respond to any variance in theses plans

A Generic Risk Management Process (RMP) Following the PRAM Methodology

Phases	Purposes	Deliverables
Define	Consolidate relevant existing information about the project.	A clear, unambiguous, shared understanding of all key aspects of the project documented, verified, and reported.
Focus	1. Scope and provide a strategic plan for the RMP 2. Plan the RMP at an operational level.	A clear, unambigucus, shared understanding of all relevant key aspects of the RMP, documented, verified, and reported.
Identify	1. Identify where risk might arise. 2. Identify what we might do about this risk in proactive and reactive response terms. 3. Identify what might go wrong with our responses.	All key risks and responses identified; both threats and opportunities classified, characterized, documented, verified, and reported.
Structure	1. Test simplifying assumptions. 2. Provide more complex structure when appropriate.	A clear understanding of the implications of any important simplifying assumptions about relationships among risks, responses, and base plan activities.
Ownership	1. Client contractor allocation of ownership and management of risks and responses. 2. Allocation of client risks to named individuals. 3. Approval of contractor allocations.	Clear ownership and management allocations effectively and efficiently defined, legally enforceable in practice where appropriate.

A Generic Risk Management Process (RMP) Following the PRAM Methodology

Phases	Purposes	Deliverables
Estimate	1. Identify areas of clear significant uncertainty. 2. Identify areas of possible significant uncertainty.	1. A basis for understanding which risks and responses are important. 2. Estimates of likelihood and impact on scenario or in numeric terms.
Evaluate	Synthesis and evaluation of the results of the estimate phase.	Diagnosis of all important difficulties and comparative analysis of the implications of responses to these difficulties, with specific deliverables like a prioritized list of risks.
Plan	Project plan ready for implementation and associated risk management plan.	1. Base plans in activity terms at the detailed level of implementation. 2. Risk assessment in terms of threats and opportunities prioritized, assessed in terms of impact. 3. Recommended proactive and reactive contingency plans in activity terms.
Manage	1. Monitoring. 2. Controlling. 3. Developing plans for immediate implementation.	1. Diagnosis of a need to revisit earlier plans and initiation of replanning as appropriate. 2. Exception reporting after significant events and associated replanning.

Stand- Alone Risk Analysis

Techniques for Risk Analysis

- Analysis of Stand-Alone Risk
  - Sensitivity Analysis
  - Scenario Analysis
  - Break-even Analysis
  - Hillier Model
  - Simulation Analysis
  - Decision tree Analysis
- Analysis of Contextual Risk
  - Corporate Risk Analysis
  - Market Risk Analysis

Perspectives on Risk

Standalone risk: For that project at hand only.

Firm risk: Risk of a project in context of firm.

Market risk :Risk of a project in context of market.

Sources of Risk

- Project specific risk: **Earning** and **cash** flows down (estimation **error** or quality of management)
- Competitive risk: Earning and cash flows down (unanticipated action of **competitors**)
- Industry-specific risk: Unexpected **technological** development and **regulatory** changes that are specific to industry to which the project belongs.
- Market risk: Changes in **macroeconomic** factors (GDP, Interest rates, inflation)
- International risk : In case of foreign projects (**exchange** rates)

Measures of Risk

Risk refers to variability. It is a complex and multi-faceted phenomenon. A variety of measures have been used to capture different facets of risk. The more important ones are:

- Range
- Standard deviation
- Coefficient of variation
- Semi - variance

NPV	**Probability**
200	0.3
600	0.5
900	0.2
What is the final NPV???	
Find Range???	
Find Standard Deviation???	
Find risk?	

NPV	Probability
200	0.3
600	0.5
900	0.2
What is the final NPV: 200*.3+600*.5+900*.2 = 540	
Find Range: 900-200 = 700	
Find Standard Deviation = $\{.3\,(200-540)^2 + .5\,(600-540)^2 + .2(900-540)^2\}^{1\backslash 2} = 249.8$	
Variance = (249.8) * (249.8) = 62400	

Coefficient of variation (CV) : SD is not adjusted for scale.

NPV = 10 and SD 4 would be more risky than
NPV = 1 and SD 2.

CV= SD/ Expected value = 249.8/540 = 0.46

Semi variance = Another problem with SD is, it considers positive and negative variations, but we have to worry about only negative variations.

SV= $\{0.3\ (200-540)^2\}^{1\backslash 2}$

$= 186$

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Project Management for Managers

Lec – 22

Stand-Alone Risk Analysis- I

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Sensitivity Analysis :

Since future is uncertain, we want to know the effect of input on output

Sensitivity Analysis

('000)

	YEAR 0	YEARS 1 - 10
1. INVESTMENT	(20,000)	
2. SALES		18,000
3. VARIABLE COSTS (66 2/3 % OF SALES)		12,000
4. FIXED COSTS		1,000
5. DEPRECIATION		2,000
6. PRE-TAX PROFIT		3,000
7. TAXES		1,000
8. PROFIT AFTER TAXES		2,000
9. CASH FLOW FROM OPERATION		4,000
10. NET CASH FLOW	(20,000)	4,000

Find NPV? Given Salvage Value =0, and cost of capital = 12%

Present value of an annuity of ₹ 1 paid for period t at a rate $k = [1 - 1/(1 + k)^t]/k$																				
	Rate																			
Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870

Sensitivity Analysis

('000)

	YEAR 0	YEARS 1 - 10
1. INVESTMENT	(20,000)	
2. SALES		18,000
3. VARIABLE COSTS (66 2/3 % OF SALES)		12,000
4. FIXED COSTS		1,000
5. DEPRECIATION		2,000
6. PRE-TAX PROFIT		3,000
7. TAXES		1,000
8. PROFIT AFTER TAXES		2,000
9. CASH FLOW FROM OPERATION		4,000
10. NET CASH FLOW	(20,000)	4,000

NPV = -20,000,000 + 4,000,000 (5.650) = 2,600,000

If we change sales from 18 to 15, and keep Investment 20, variable cost 66.67% of sales , FC = 1000.

Sensitivity Analysis

('000)

	YEAR 0	YEARS 1 - 10
1. INVESTMENT	(20,000)	
2. SALES		18,000
3. VARIABLE COSTS (66 2/3 % OF SALES)		12,000
4. FIXED COSTS		1,000
5. DEPRECIATION		2,000
6. PRE-TAX PROFIT		3,000
7. TAXES		1,000
8. PROFIT AFTER TAXES		2,000
9. CASH FLOW FROM OPERATION		4,000
10. NET CASH FLOW	(20,000)	4,000

NPV = -20,000,000 + 4,000,000 (5.650) = 2,600,000

RS. IN MILLION

	RANGE			*NPV*		
KEY VARIABLE	*PESSIMISTIC*	*EXPECTED*	*OPTIMISTIC*	*PESSIMISTIC*	*EXPECTED*	*OPTIMISTIC*
INVESTMENT (RS. IN MILLION)	24	20	18	-0.65	2.60	4.22
SALES (RS. IN MILLION)	15	18	21	-1.17	2.60	6.40
VARIABLE COSTS AS A PERCENT OF SALES	70	66.66	65	0.34	2.60	3.73
FIXED COSTS	1.3	1.0	0.8	1.47	2.60	3.33

Merits:

1. How robust or vulnerable the project is.
2. It indicates where future work may be done. If NPV is highly sensitive to the changes in some factor, it may be worthwhile to explore how the variability of the critical factors may be contained.

Shortcomings:

- Only one variable is considered.
- Subjectivity in interpretation of different projects.
- Shows change in NPV, does not show how likely that change would be.

Scenario Analysis: More then one variable can be changed simultaneously.

How many scenarios???

Scenario Analysis

Procedure

1. Select the factor around which scenarios will be built.
2. Estimate values of each of the variables for each Scenario
3. Calculate NPV / IRR under each scenario

Merits:

1. Better than sensitivity analysis.

2.Many variables can be considered.

Demerits:

1.Economy can not always be recession, stability and boom (no discrete scenario).It varies on continuum.

2. If 10 inputs, then the analysis has to estimate 3*10=30 scenario analysis

Break Even Analysis

As a manager you should know how much should be produced and sold at a minimum to ensure that the project does nor loose money. Point of no profit no loss.

BEA: Two types (1) Accounting BEA (2) Financial BEA

In the example we know that ratio of variable cost to sales is 0.667 (12/18).

This means that every rupee of sales makes a profit of Re 0.333 .

Break-Even Analysis

- Accounting Break –Even Analysis level for sales will be

$$\frac{\text{Fixed Costs + Depreciation}}{\text{Contribution margin ratio}} = \frac{1 + 2}{0.333} = \text{Rs. 9 million}$$

		(‘000)
	Year 0	Year 1 - 10
1. Investment	(20,000)	
2. Sales		18,000
3. Variable costs ($66\,^{2}/_{3}$% of sales)		12,000
4. Fixed costs		1,000
5. Depreciation		2,000
6. Pre-tax profit		3,000
7. Taxes		1,000
8. Profit after taxes		2,000
9. Cash flow from operation		4,000
10. Net cash flow	(20,000)	4,000

Financial BEA: The focus is on NPV not on accounting profit.

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Project Management for Managers

Lec – 23

Stand-Alone Risk Analysis- II

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Simulation Analysis

Sensitivity analysis indicates the sensitivity of the criterion of merit (NPV, IRR or any other) to variations in basic factors.

Though useful, such information may not be adequate for decision making.

The decision maker would also like to know *the likelihood of such occurrences.*

This information can be generated by simulation analysis which may be used for developing the probability profile of a criterion of merit by *randomly combining values of variables that have a bearing on the chosen criterion*.

Before explaining Hillier’s model

As risk is the outcome of probability and its consequence, any technique applied to measure the **risk** involved should necessarily measure the **probability of outcomes.**

There are two major categories of probabilistic distributions, continuous and discontinuous probability.

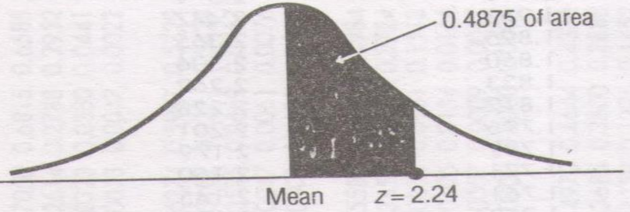
An example of risk with **discontinuous probability** is when there are three outcomes with some expected probability in each event as given below.

	Probability	Profit
Favourable situation	20%	40 lacs
Average situation	50%	20 lacs
Unfavourable situation	30%	–10 lacs
Expected profit ?????		

	Probability	Profit	Probability * Profit
Favourable situation	20%	40 lacs	8 lacs
Average situation	50%	20 lacs	10 lacs
Unfavourable situation	30%	–10 lacs	–3 lacs
Expected profit ?????			15 lacs

An example of risk with **continuous probability** is normal distribution where **average profit is 15 lacs** with a **standard deviation of 6 lacs**.

The probability of earning at least 10 lacs can be calculated as ???



Appendix Table 1

Areas under the Standard Normal Probability Distribution between the Mean and Positive Values of z

Example:
To find the area under the curve between the mean and a point 2.24 standard deviations to the right of the mean, look up the value opposite 2.2 and under 0.04 in the table; 0.4875 of the area under the curve lies between the mean and a **z** value of 2.24.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

An example of risk with continuous probability is normal distribution where average profit is 15 lacs with a standard deviation of 6 lacs.

The probability of earning at least 10 lacs can be calculated as 50+29.67= 79.67%.

Hillier Model

It can be used for both **continuous** and **discontinuous** probabilistic events.

Discontinuous probabilistic events: The **probability** of individual year's cash flow is **multiplied** with the corresponding **cash flow** and **summed** to determine the average cash flow for the year and then overall Net Present Value (NPV) is determined with standard deviation, making it **continuous type probabilistic outcome.**

A project with the initial investment of 100 lacs with a lifespan of four years has the following probabilistic outcomes in different years.

Year 1		Year 2		Year 3		Year 4	
NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.
50	20%	60	25%	70	40%	60	30%
30	50%	40	50%	40	50%	40	55%
10	30%	10	25%	–10	10%	20	15%

Determine the expected net present value of the project and its standard deviation.

Also, determine the probability of (i) positive NPV of 30 lacs and (ii) loss. Assume 10% as discounting factor.

Solution:

Year 1		Year 2		Year 3		Year 4	
NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.
50	20%	60	25%	70	40%	60	30%
30	50%	40	50%	40	50%	40	55%
10	30%	10	25%	–10	10%	20	15%

Projected cash flow of first year = 50 * 20% + 30 * 50% + 10 * 30% = ***28 lacs***

Projected cash flow of second year = 60 * 25% + 40 * 50% + 10 * 25% = 37.5 lacs

Projected cash flow of third year = 70 * 40% + 40 * 50% - 10 * 10% = 47 lacs

Projected cash flow of fourth year = 60 * 30% + 40 * 55% + 20 * 15% = 43 lacs

NPV = $(28/1.1) + (37.5/\{1.1\}^2) + (47/\{1.1\}^3) + (43/\{1.1\}^4) - 100$ = **21.13**

$\sigma_1^2 = 0.2(50 - 28)^2 * 0.5(30 - 28)^2 * 0.3(10 - 28)^2 = 196$

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Project Management for Managers

Lec – 24

Hillier Model

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A project with the initial investment of 100 lacs with a lifespan of four years has the following probabilistic outcomes in different years.

Year 1		Year 2		Year 3		Year 4	
NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.
50	20%	60	25%	70	40%	60	30%
30	50%	40	50%	40	50%	40	55%
10	30%	10	25%	–10	10%	20	15%

Determine the expected net present value of the project and its standard deviation.

Also, determine the probability of (i) positive NPV of 30 lacs and (ii) loss. Assume 10% as discounting factor.

Solution:

Year 1		Year 2		Year 3		Year 4	
NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.	NCF (lacs)	Prob.
50	20%	60	25%	70	40%	60	30%
30	50%	40	50%	40	50%	40	55%
10	30%	10	25%	–10	10%	20	15%

Projected cash flow of first year = 50 * 20% + 30 * 50% + 10 * 30% = ***28 lacs***

Projected cash flow of second year = 60 * 25% + 40 * 50% + 10 * 25% = 37.5 lacs

Projected cash flow of third year = 70 * 40% + 40 * 50% - 10 * 10% = 47 lacs

Projected cash flow of fourth year = 60 * 30% + 40 * 55% + 20 * 15% = 43 lacs

$$NPV = (28/1.1) + (37.5/\{1.1\}^2) + (47/\{1.1\}^3) + (43/\{1.1\}^4) - 100 = \mathbf{21.13}$$

$$\sigma_1^2 = 0.2(50 - 28)^2 * 0.5(30 - 28)^2 * 0.3(10 - 28)^2 = 196$$

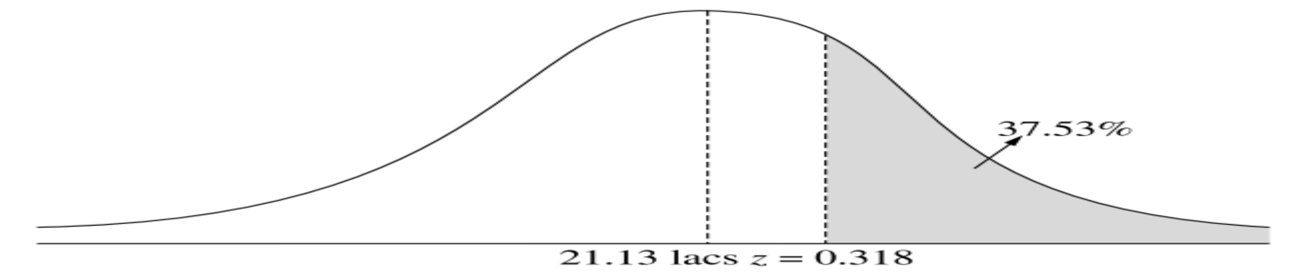
Similarly, $\sigma_2^2 = 318$, $\sigma_3^2 = 561$, $\sigma_4^2 = 171$

$$\sigma(\text{NPV}) = \left[\sum \frac{\sigma_t^{\,2}}{(1+i)^{2t}}\right]^{1/2}$$

$\sigma(\text{NPV}) = (196/\{1.1\}^2) + (318/\{1.1\}^4) + (561/\{1.1\}^6) + (171/\{1.1\}^8)$ = **27.86**

(i) Prob of positive NPV of 30 lacs and more

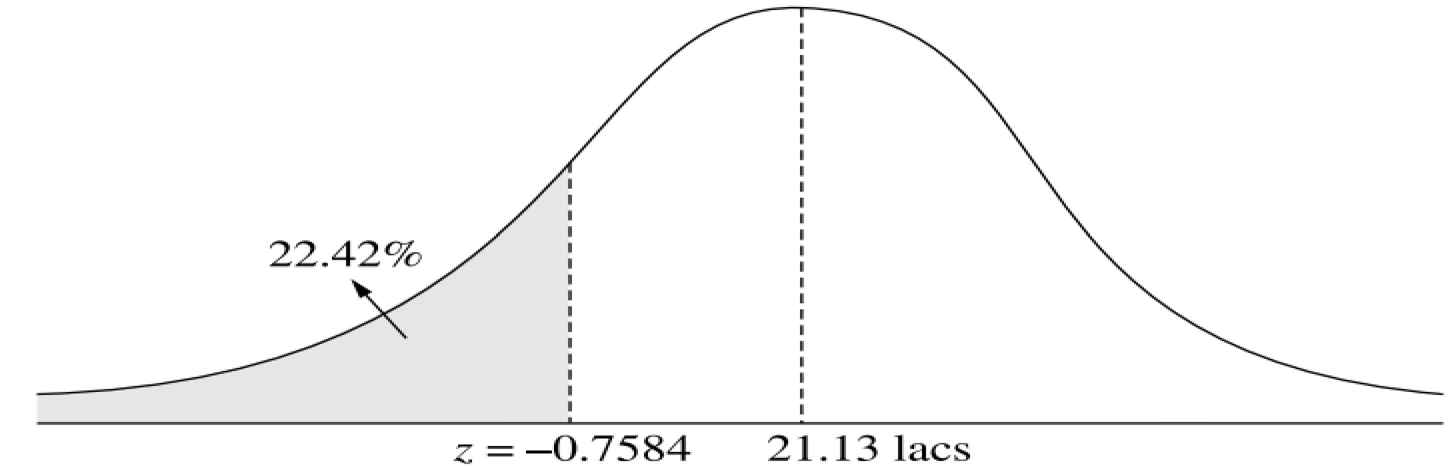
Z= (30 - 21.13) / 27.86 = 0.318 , area under curve is 0 .12



37.53%

(ii) probability of loss

Z= (0 - 21.13) /27.86 = -0.75 (area under curve .2734)



Determine the expected NPV and the probability of earning at least ₹ 50 lacs and the probability of making at least no loss with the following information. Initial investment is ₹ 150 lacs and discounting factor is 12%.

Year	1	2	3	4	5
Expected cash flow(in lacs)	40	60	80	70	50
Standard deviation(in lacs)	6	8	10	9	7

Determine the expected NPV and the probability of earning at least ₹ 50 lacs and the probability of making at least no loss with the following information. Initial investment is ₹ 150 lacs and discounting factor is 12%.

Year	1	2	3	4	5
Expected cash flow(in lacs)	40	60	80	70	50
Standard deviation(in lacs)	6	8	10	9	7

Solution

$$\text{NPV} = \frac{40}{1.12} + \frac{60}{(1.12)^2} + \frac{80}{(1.12)^3} + \frac{70}{(1.12)^4} + \frac{50}{(1.12)^5} - 150 = ₹\ 63.34 \text{ lacs}$$

$$\sigma\ (\text{NPV}) = \left[\frac{6}{(1.12)} + \frac{8}{(1.12)^2} + \frac{10}{(1.12)^3} + \frac{9}{(1.12)^4} + \frac{7}{(1.12)^5}\right] = ₹\ 28.40 \text{ lacs}$$

Probability of earning at least 50 lacs

$$z = \frac{(50 - 63.34)}{28.4} = -0.468$$

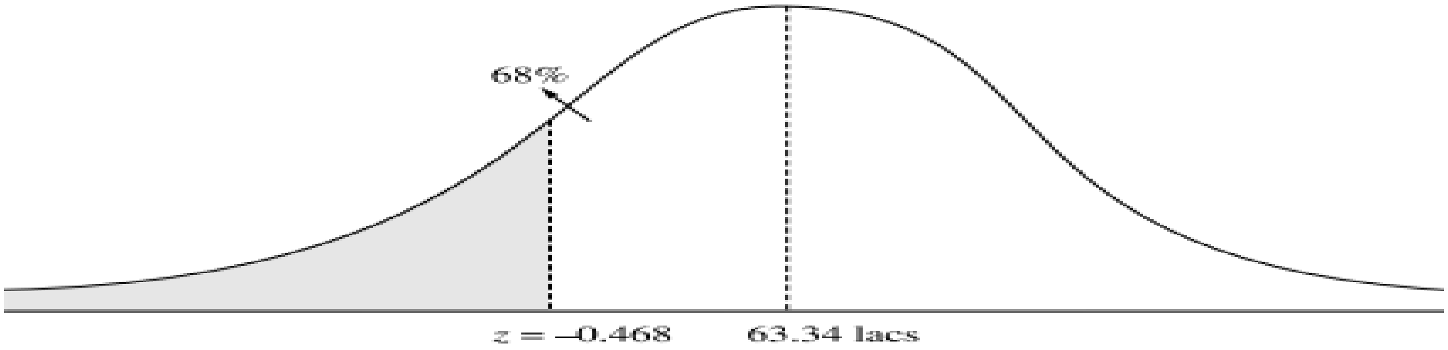


Figure 9.3(a) Solution to Example 9.2(a).

Corresponding probability of earning ₹ 50 lacs is .68 or 68%.

Probability that the project will not suffer a loss.

$$z = \frac{(0 - 63.34)}{28.4} = -2.23$$

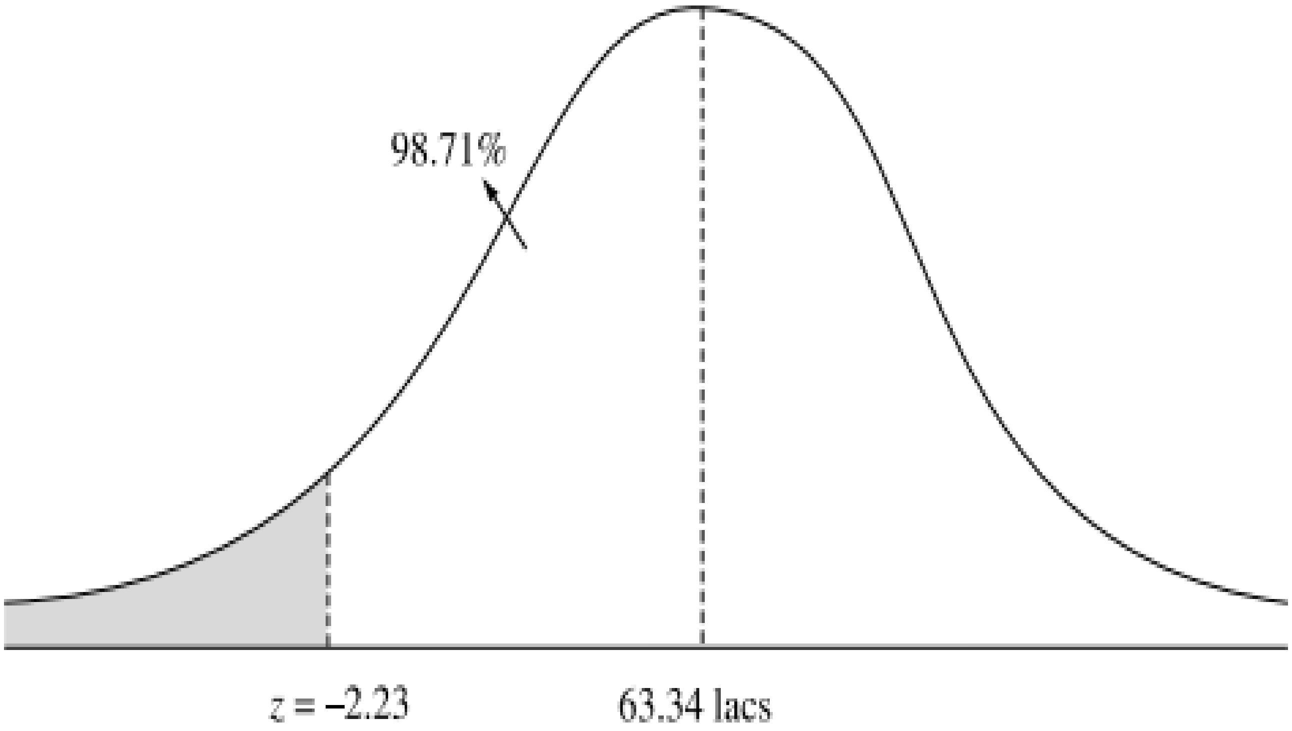


Figure 9.3(b) Solution to Example 9.2(b).

Corresponding probability of at least making no loss is 98.71%.

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Project Management for Managers

Lec – 25

Simulation Analysis

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Simulation Analysis

Sensitivity analysis indicates the sensitivity of the criterion of merit (NPV, IRR or any other) to variations in basic factors.

Though useful, such information may not be adequate for decision making.

The decision maker would also like to know *the likelihood of such occurrences.*

This information can be generated by simulation analysis which may be used for developing the probability profile of a criterion of merit by *randomly combining values of variables that have a bearing on the chosen criterion*.

Procedure:

1. Model the project-How NPV is related to parameters (variables held constant by decision makers) and exogenous variables (stochastic in nature and not controllable).
2. Specify the value of parameter and probability exogenous variables.
3. Select a value, at random, from Probability Distribution of exogenous variable.
4. Determine the value of NPV for set parameter and exogenous variable generated randomly.
5. Repeat steps 4and 5 a number of times.
6. Plot frequency distribution of NPV.

$$NPV = \text{Sum } t = 1 \text{ to } n \left\{ \frac{\text{Annual cash flow}}{(1+\text{ risk free return})^t} - \text{In.Invs} \right\}$$

Risk free return = 10% initial investment = 13000.

The exogenous variable having following probability distribution

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Project Management for Managers

Lec – 26

Decision Tree Analysis- I

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Techniques for Risk Analysis

- Analysis of Stand-Alone Risk
  - Sensitivity Analysis
  - Scenario Analysis
  - Break-even Analysis
  - Hillier Model
  - Simulation Analysis
  - Decision tree Analysis
- Analysis of Contextual Risk
  - Corporate Risk Analysis
  - Market Risk Analysis

Decision Tree Analysis

- Decision tree analysis is a tool for analysing situations where sequential decision making in face of risk is involved.

-New molecule-pilot production-test market-mfg – small and large plant ,etc.

- The key steps in decision tree analysis are:

1.Identifying the problem and alternatives- Imaginative efforts –risk and uncertainty

2.Delineating the decision

3.Specifying probabilities and monetary outcomes

4.Evaluating various decision alternatives

Decision Tree

The decision tree, exhibiting the anatomy of the decision situation,shows :

- The decision points (also called decision forks) and the alternative options available for experimentation and action at these decision points.
- The chance points (also called chance forks) where outcomes are dependent on a chance process and the likely outcomes at these points.

The decision tree reflects in a diagrammatic form the nature of the decision situation in terms of alternative courses of action and chance outcomes which have been identified in the first step of the analysis.

Decision Tree

A decision tree can easily become very complex and cumbersome if an attempt is made to consider the myriad possible future events and decisions. Such a decision tree, however, is not likely to be a very useful tool of analysis. Over-elaborate, it may obfuscate the critical issues.

Hence an effort should be made to keep the decision tree somewhat simple so that the decision makers can focus their attention on major future alternatives without being drowned in a mass of trivia

Specification of Probabilities and Monetary Value of Outcomes

Once the decision tree is delineated, the following data have to be gathered :

- Probabilities associated with each of the possible outcomes at various chance forks, and
- Monetary value of each combination of decision alternative and chance outcome.

Specification of Probabilities and Monetary Value of Outcomes

The probabilities of various outcomes may sometimes be defined objectively. For example, the probability of a good monsoon may be based on objective, historical data. More often, however, the possible outcomes encountered in real life are such that objective probabilities for them cannot be obtained. How can you, for example, define objectively the probability that a new product like an electric moped will be successful in the market? In such cases, probabilities have to be necessarily defined subjectively.

Evaluation of Alternatives

Once the decision tree is delineated and data about probabilities and monetary values gathered, decision alternatives may be evaluated as follows :

1. Start at the right-hand end of the tree and calculate the expected monetary value at various chance points that come first as we proceed leftward.
2. Given the expected monetary values of chance points in step 1, evaluate the alternatives at the final stage decision points in terms of their expected monetary values.

Evaluation of Alternatives

3. At each of the final stage decision points, select the alternative which has the highest expected monetary value and truncate the other alternatives. Each decision point is assigned a value equal to the expected monetary value of the alternative selected at that decision point.
4. Proceed backward (leftward) in the same manner, calculating the expected monetary value at chance points, selecting the decision alternative which has the highest expected monetary value at various decision points, truncating inferior decision alternatives, and assigning values to decision points, till the first decision point is reached.

case

The scientists at a comapny have come up with an electric moped. The firm is ready for pilot production and test marketing. This will cost Rs.20 million and take six months. Management believes that there is a 70 percent chance that the pilot production and test marketing will be successful. In case of success, company can build a plant costing Rs.150 million. The plant will generate an annual cash inflow of Rs.30 million for 20 years if the demand is high or an annual cash inflow of Rs.20 million if the demand is moderate. High demand has a probability of 0.6; Moderate demand has a probability of 0.4. To analyse such situations where sequential decision making is involved decision tree analysis is helpful.

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Project Management for Managers

Lec – 27

Decision Tree Analysis- II

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case

The scientists at a comapny have come up with an electric moped. The firm is ready for pilot production and test marketing. This will cost Rs.20 million and take six months. Management believes that there is a 70 percent chance that the pilot production and test marketing will be successful. In case of success, company can build a plant costing Rs.150 million. The plant will generate an annual cash inflow of Rs.30 million for 20 years if the demand is high or an annual cash inflow of Rs.20 million if the demand is moderate. High demand has a probability of 0.6; Moderate demand has a probability of 0.4. To analyse such situations where sequential decision making is involved decision tree analysis is helpful.

Present value of an annuity of ₹ 1 paid for period t at a rate $k = [1 - 1/(1 + k)^t]/k$																				
	Rate																			
Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870

Airways Limited Case

Airways Limited has been set up to run an air taxi service in western India. The company is debating whether it should buy a turboprop aircraft or a piston engine aircraft. The turboprop aircraft costs 4000 and has a larger capacity. It will serve if the demand turns out to be high.

The piston engine aircraft costs 1800 and has a smaller capacity. It will serve if the demand is low, but it will not suffice if the demand is high.

The company believes that the chances of demand being high and low in year 1 are 0.6 and 0.4. If the demand is high in year 1, there is an 80 percent chance that it will be high in subsequent years (year 2 onward) and a 20 percent chance that it will be low in subsequent years.

Airways Limited Case

The technical director of Airways Limited thinks that if the company buys a piston engine aircraft now and the demand turns out to be high the company can buy a second-hand piston engine aircraft for 1400 at the end of year 1. This would double its capacity and enable it to cope reasonably well with high demand from year 2 onwards.

The payoffs associated with high and low demand for various decision alternatives are shown as. The payoffs shown for year 1 are the payoffs occurring at the end of year 1 and the payoffs shown for year 2 are the payoffs for year 2 and the subsequent years, evaluated as of year 2, using a discount rate of 12 percent which is the weighted average cost of capital for Airways Limited.

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Project Management for Managers

Lec – 28

Abandonment Analysis

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Every project has a useful life, after which it is expected to end. But, sometimes, a project is ended before its useful life is over. Deciding to abandon the project before its planned life is called abandonment. This can be due to various reasons. The reasons are generally related to variables of project life, selling price, selling quantity, raw material availability and its price, salvage value, expected rate of return, etc

Product may loose charm- sale may decline- customer taste or some other reasons like competition or regulations.

Raw material non availability – spectrum , import regulations, reduced cultivation.

Offered price for the project may be lucrative for the project owner to abandon the project and he may feel beneficial to sell the project instead of continuing with it.

An <u>increase in expected return </u>also leads to abandonment. The increase in expected returns may be due to increased rate of interest or availability of better prospects for investment.

For example, a company expects a return of 14% from a project and the expected return <u>was 12%, </u>it will be a beneficial project but if due to some economic conditions like **increase in interest** rate which results in increase in expected **returns (16%),** then the project loses its feasibility and the firm may decide to abandon the project

Another common reason is availability of more <u>lucrative project</u> with higher returns. For example, an investor has invested money to yield a return of 10% with a bank and another bank offers 12% return.

There are some other reasons for abandonment. For example, a firm may decide to decrease its product line to concentrate on fewer products.

The question arises, when should a firm abandon a project or how to evaluate whether abandonment should be done?

We can certainly apply NPV method to evaluate the various alternatives and take the right decision.

The simple rule is, consider the offered abandon price as investment and consider only future cash flows of remaining project life and apply the current expected return as discounting factor.

The resultant NPV, if positive, means that the project should be continued rather than abandoned and vice versa. The past data should be ignored in abandonment analysis

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Project Management for Managers

Lec – 29

Technical Analysis

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Outline

- Manufacturing process / technology
- Technical arrangements
- Materials and inputs
- Product mix
- Plant capacity
- Location and site
- Machineries and equipments
- Structures and civil works
- Environmental aspects
- Project charts and layouts
- Project implementation schedule
- Need for considering alternatives

Manufacturing Process/Technology

For manufacturing a product / service often two or more alternative technologies are available (Steel – Bessemer process or open hearth, Cement- Dry or wet, Soap – semi or fully boiled process).

Choice of Technology

The choice of technology is influenced by a variety of considerations:

·Plant capacity (relationship b/w capacity and technology???)

·Principal inputs: (quality of limestone – dry or wet process)

·Investment outlay and production cost (effect of alternative technologies on these two should be observed)

·Use by other units (how it is yielding profits)

·Product mix

·Latest developments (obsolescence should be minimized)

·Ease of absorption (high end tech may take long time and trained people)

Should we always use latest technology?

Appropriate:

Evaluate technology in terms of :

1. **Whether it utilizes local raw material and manpower**
2. **Whether it protects ecological balance**
3. **Whether it is harmonious with social and cultural conditions.**

Technical Arrangements

When collaboration is sought, the following aspects of the agreement must be worked out in detail??????.

Technical Arrangements

- The nature of support to be provided by the collaborators during the designing of the project, selection and procurement of equipment, installation and erection of the plant, operation and maintenance of the plant, and training of project personnel

- Process and performance guarantees in terms of plant capacity, product quality, and consumption of raw materials and utilities.

- The price of technology in terms of one time licensing fee and periodic royalty fee
- The continuing benefit of research and development work being done by the collaborator.
- The period of collaboration agreement
- The assistance to be provided and the restrictions to be imposed by the collaborator with respect to exports
- If the technical collaboration is backed by financial collaboration, the level of equity participation and the manner of sharing management control.
- Assignment of the agreement by either side in case of change of ownership
- Termination of the agreement or other remedies when either party fails to meet its obligation

Material Inputs and Utilities

An important aspect of technical analysis is concerned with defining the materials and utilities required, specifying their properties in some detail, and setting up their supply programme.

Materials and utilities may be classified into four broad categories:

- Raw materials (Agricultural products, mineral products, livestock or forest products, and marine product)
- Processed industrial materials and components (parts, components, sub-assemblies)
- Auxiliary materials and factory supplies (chemicals, packaging matl, oils, grease, paint, varnishes)
- Utilities (power, water, steam, fuel)

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Project Management for Managers

Lec – 30

Product Mix and Plant Capacity Analysis

Dr. M.K. Barua
Department of Management
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Product Mix

- The choice of product mix is guided by market requirements. In the production of most of the items, variations in size and quality are aimed at satisfying a broad range of customers.

- While planning the production facilities of the firm, some flexibility with respect to the product mix must be sought.

Plant Capacity

- Plant capacity (also referred to as production capacity) refers to the volume or number of units that can be manufactured during a given period.

- Plant capacity may be defined in two ways : feasible normal capacity and nominal maximum capacity (Installed capacity)

- Several factors have a bearing on the capacity decision:

Plant Capacity

- **Investment cost: (The investment cost per unit of capacity decreases as the plant capacity increases)**

$$C2 = C1\ (Q2/Q1)^{\alpha}$$

Where C2 is derived cost for Q2 units, C1 is the known cost for Q1 units of capacity, and α is factor reflecting capacity – cost relationship.

Ex: For 5000 units, the investment is Rs.1000,000. What would be the investment for 10,000 units. Given $\alpha = 0.6$.

Ex: For 5000 units, the investment is Rs.1000,000. What would be the investment for 10,000 units. Given $\alpha = 0.6$.

$C2 = 1000,000\ (2)^{0.6}$

Plant Capacity

- Technological requirement (cement plant – capacity of 300 tones per day- rotary kiln method, other wise use vertical shaft method for lower capacity)
- Input constraints: (power supply, raw material/ labor availability, etc.
- Market conditions: If favorable, then higher capacity of plant.
- Resources of the firm: Managerial and financial limit the capacity decision.
- Governmental policy :

Location and Site

Location refers to a broad area; site refers to a specific piece of land. The choice of location is influenced by a variety of considerations:

- **Proximity to raw materials and markets**
- **Availability of infrastructure**
- **Labour situation**
- **Governmental policies**
- **Other factors** (climate conditions, general living conditions, proximity to ancillary, ease in coping up with pollution)

Machineries and Equipment

- The requirement of machineries and equipment is dependent on production technology and plant capacity. It is influenced by the type of project.
- For a process-oriented industry, like a petrochemical unit, machineries and equipments required should be such that the various stages are matched well.
- The choices of machineries and equipment for a manufacturing industry is somewhat wider.

Structures and Civil Works

Structures and civil works may be divided into three categories:

- **Site preparation and development**: (leveling, gardening, removal of existing structures, relocation of existing pipelines, cables, power lines, roads, reclamation of swamp, and draining and removal of standing water, connection of electric power, water, communication)

- **Buildings and structures:** (Factory building, stores, warehouse, laboratory, administrative building, staff welfare building, cafeteria, medical, etc)

- **Outdoor works:** (Handling and treatment of emission, wastages, effluents, transportation and traffic signals, out door lighting, boundary wall, fencing, gates, security posts)

Environmental Aspects

The environmental aspects of projects have to be properly examined. The key issues that need to be considered in this respect are:

- **What are the types of effluents and emissions generated ?**
- **What needs to be done for proper disposal of effluents and treatment of emissions ?**
- **Will the project be able to secure all environmental clearances and comply with all statutory requirements ?**

Project Charts and Plant Layout

Once data is available on the principal dimensions (market size, plant capacity, production technology, building and civil works, etc.) of the project, project charts and layout may be prepared.

The important charts and layout drawings are :

(i) general functional layout,
(ii) material flow diagrams,
(iii) production line diagram,
(iv) transport layout,
(v) utility consumption points layout,
(vi) communication layout
(vii) organisational layout, and
(viii) plant layout

Plant Layout

The important considerations in preparing the plant layout are:

- Consistency with production technology
- Smooth flow of goods from one stage to another
- Proper utilisation of space
- Scope for expansion
- Minimisation of production cost
- Safety of personnel

Schedule of Project Implementation

As part of technical analysis, a project implementation schedule is also usually prepared. For preparing the project implementation schedule the following information is required:

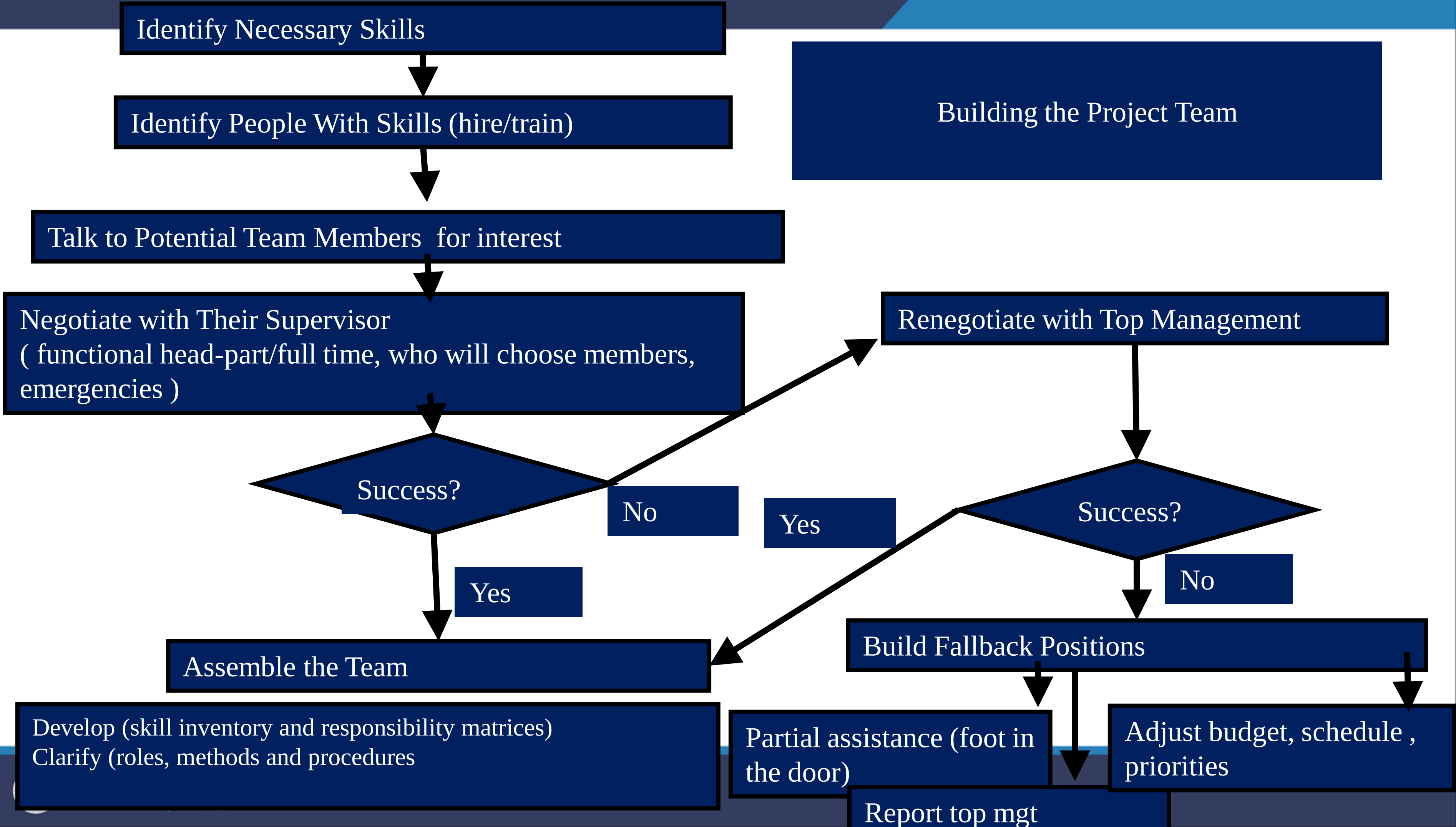
- List of all possible activities from project planning to commencement of production
- The sequence in which various activities have to be performed
- The time required for performing various activities
- The resources normally required for performing various activities
- The implications of putting more resources or less resources than are normally required.

The Need for Considering Alternatives

There are alternative ways of transforming an idea into a concrete project. These alternatives may differ in one or more of the following aspects:

- Nature of project
- Production process
- Product quality
- Scale of operation and time phasing
- Location

Project Team Building, Conflict, and Negotiation


Identify Necessary Skills
Building the Project Team
Identify People With Skills (hire/train)
Talk to Potential Team Members for interest
Negotiate with Their Supervisor
(functional head-part/full time, who will choose members, emergencies)
Renegotiate with Top Management
Success?
No
Yes
Success?
Yes
No
Assemble the Team
Build Fallback Positions
Develop (skill inventory and responsibility matrices)
Clarify (roles, methods and procedures
Partial assistance (foot in the door)
Adjust budget, schedule , priorities
Report top mgt

Effective Project Teams Should Have

- **Clear Sense of Mission:** Understanding of objectives.
- **Productive Interdependency:** degree of joint activity among team members required to complete project. (MIS,Engg, A/c,mkt, admin- give importance to interrelatedness of each others' efforts)
- **Cohesiveness:** Degree of mutual attraction that team members hold for each other and their task.
- **Trust:** Tam's **comfort level** with each individual member. How to build trust – PM – "what happens here stay here" (divulging of views and confidence betrayed). It takes time. It is 1 or 0, trust worthy or not (nothing like slightly trustworthy). Trust occurs at professional level, integrity level, and emotional level.

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Project Management for Managers

Lec – 31

Project Team Building, Conflict and Negotiation

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- **Enthusiasm:** Is the key to creating the **energy and spirit** that drives effective project efforts. Project should be challenging, personally rewarding, supportive (each other).
- **Results Orientation:** Commitment to achieve project's goal.

Reasons Why Teams Fail

- **Poorly developed or unclear goals:** (a) Multiple interpretations, (b) member interprets in most advantageous way, (c) increase conflict.
- **Poorly defined project team roles & interdependencies:**
- **Lack of project team motivation:**
- **Poor communication:**

Reasons Why Teams Fail

- **Poor leadership:**
- **Turnover among project team members:** Should be low.
- **Dysfunctional behavior:** Disruptive acts of some team members due to personality issues, hidden agendas, or interpersonal problems.

Stages in Group Development???????

Stages in Group Development??????

1. **Forming** – Members become **acquainted**, members **unsure** about project's **goals**, may not **know** each other, **confused** about own assignments.
2. **Storming** – Conflict begins, they test **limits and constraints** placed on their **behavior**. **Leadership, reporting relationship, norms of work** and interpersonal behavior are challenged.
3. **Norming** – A norm is unwritten rule of behavior, members reach **agreement**, level of **openness and trust** they should have with each other, how conflicts will be resolved.
4. **Performing** – Members work together, in this stage team relationships are characterized by **high level of trust**, a mutual **appreciation** for one another's performance and contributions, and a **willingness to actively seek to collaborate**.
5. **Adjourning** – Group disbands

Virtual Project Teams

use electronic media to link members of a geographically dispersed project team

How Can Virtual Teams Be Improved?

- ✓ Use face-to-face communication when possible
- ✓ Don’t let team members disappear
- ✓ Establish a code of conduct
- ✓ Keep everyone in the communication loop
- ✓ Create a process for addressing conflict

Conflict Management: What % of time is spent on this

Conflict *is a* ***process*** *that begins when you* ***perceive*** *that someone has frustrated or is about to frustrate a major concern of yours.*

Categories or types of conflict : ?????

Categories of conflict

- **Goal-oriented:** Often results from multiple perceptions. Disagreement about **end results, scope, performance, priorities, specifications.**
- **Administrative:** Arises through management hierarchy, organizational structure or company philosophy. Example is matrix origination having two bosses.
- **Interpersonal:** Occurs due to personality differences between project team members and important ant stakeholders. Interpersonal conflict sources include- **difference in work ethics, behavioral styles, egos, and personalities of team members.**

Views

Traditional: Conflicts will have **negative** effects on origination, conflict is **bad**, should be **avoided and resolved** quickly and painlessly as possible when it does occur. Emphasis is on **suppression and elimination.**

Views

Behavioral: Views conflicts as **natural and inevitable** part of organization life. So, **manage conflicts effectively** rater than attempt to **suppress or eliminate them.**

Views

Interactionist: View **encourages** conflict to develop., it prevents originations to become **too stagnant and apathetic**. Conflict actually introduces an **element of tension that produces innovation, creativity, and higher productivity**.

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Project Management for Managers

Lec – 32

HRM Issues and Time Management

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Sources of Conflict

Organizational:

- Reward systems: competitive processes, how evaluation is being done.
- Scarce resources:
- Uncertainty: over lines of authority.
- Differentiation: mind set, attitudes, time frame, value systems are different from department to department.

Interpersonal:

- Faulty communication
- Personal grudges & prejudices

Conflict Resolution

1. **Mediate** – defusion (focus is less on source of conflict, but is on **mutual acceptable solution**) / confrontation (look for **root cause** of conflict, more effective in long run)

Conflict Resolution

2.Arbitrate – PM imposes **impersonal judgment** on the warring parties.

Conflict Resolution

3.Control – cool down period

Conflict Resolution

4. Accept – unmanageable - even after project gets over.

Conflict Resolution

5. Eliminate – transfer the guilty person

Conflict is often evidence of progress!

	Conflict Intensity Ranking	
SOURCES OF CONFLICT	Thamhain & Wilemon	Posner
Conflict over project priorities	**2**	3
Conflict over administrative procedures	5	7
Conflict over technical opinions and performance trade-offs	4	5
Conflict over human recourses	**3**	4
Conflict over cost and budget	**7**	**2**
Conflict over schedules	**1**	**1**
Personality conflicts	6	6

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Project Management for Managers

Lec – 33

Project Time Management - Introduction

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PROJECT TIME MANAGEMENT

Project Time Management includes the processes required to manage the **timely completion** of the project.

1 Plan Schedule Management—The process of establishing the policies, procedures, and documentation for *planning*, *developing*, *managing*, *executing*, and *controlling* the project **schedule.**

2 Define Activities—The process of identifying and documenting the specific actions to be performed to produce the project deliverables.

3 Sequence Activities—The process of identifying and documenting relationships among the project Activities.

4 Estimate Activity **Resources—The** process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity.

5 Estimate Activity **Durations—The** process of estimating the number of work periods needed to complete individual activities with estimated resources.

6 Develop Schedule—The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model.

7 Control Schedule—The process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan.

Project Time Management Overview

1 Plan Schedule Management

- .1 Inputs
  - .1 Project management plan
  - .2 Project charter
  - .3 Enterprise environmental factors
  - .4 Organizational process assets
- .2 Tools & Techniques
  - .1 Expert judgment
  - .2 Analytical techniques
  - .3 Meetings
- .3 Outputs
  - .1 Schedule management plan

2 Define Activities

- .1 Inputs
  - .1 Schedule management plan
  - .2 Scope baseline
  - .3 Enterprise environmental factors
  - .4 Organizational process assets
- .2 Tools & Techniques
  - .1 Decomposition
  - .2 Rolling wave planning
  - .3 Expert judgment
- .3 Outputs
  - .1 Activity list
  - .2 Activity attributes
  - .3 Milestone list

3 Sequence Activities

- .1 Inputs
  - .1 Schedule management plan
  - .2 Activity list
  - .3 Activity attributes
  - .4 Milestone list
  - .5 Project scope statement
  - .6 Enterprise environmental factors
  - .7 Organizational process assets
- .2 Tools & Techniques
  - .1 Precedence diagramming method (PDM)
  - .2 Dependency determination
  - .3 Leads and lags
- .3 Outputs
  - .1 Project schedule network diagrams
  - .2 Project documents updates

4 Estimate Activity Resources

- .1 Inputs
  - .1 Schedule management plan
  - .2 Activity list
  - .3 Activity attributes
  - .4 Resource calendars
  - .5 Risk register
  - .6 Activity cost estimates
  - .7 Enterprise environmental factors
  - .8 Organizational process assets
- .2 Tools & Techniques
  - .1 Expert judgment
  - .2 Alternative analysis
  - .3 Published estimating data
  - .4 Bottom-up estimating
  - .5 Project management software
- .3 Outputs
  - .1 Activity resource requirements
  - .2 Resource breakdown structure
  - .3 Project documents updates

5 Estimate Activity Durations

- .1 Inputs
  - .1 Schedule management plan
  - .2 Activity list
  - .3 Activity attributes
  - .4 Activity resource requirements
  - .5 Resource calendars
  - .6 Project scope statement
  - .7 Risk register
  - .8 Resource breakdown structure
  - .9 Enterprise environmental factors
  - .10 Organizational process assets
- .2 Tools & Techniques
  - .1 Expert judgment
  - .2 Analogous estimating
  - .3 Parametric estimating
  - .4 Three-point estimating
  - .5 Group decision-making techniques
  - .6 Reserve analysis
- .3 Outputs
  - .1 Activity duration estimates
  - .2 Project documents updates

6 Develop Schedule

- .1 Inputs
  - .1 Schedule management plan
  - .2 Activity list
  - .3 Activity attributes
  - .4 Project schedule network diagrams
  - .5 Activity resource requirements
  - .6 Resource calendars
  - .7 Activity duration estimates
  - .8 Project scope statement
  - .9 Risk register
  - .10 Project staff assignments
  - .11 Resource breakdown structure
  - .12 Enterprise environmental factors
  - .13 Organizational process assets
- .2 Tools & Techniques
  - .1 Schedule network analysis
  - .2 Critical path method
  - .3 Critical chain method
  - .4 Resource optimization techniques
  - .5 Modeling techniques
  - .6 Leads and lags
  - .7 Schedule compression
  - .8 Scheduling tool
- .3 Outputs
  - .1 Schedule baseline
  - .2 Project schedule
  - .3 Schedule data
  - .4 Project calendars
  - .5 Project management plan updates
  - .6 Project documents updates

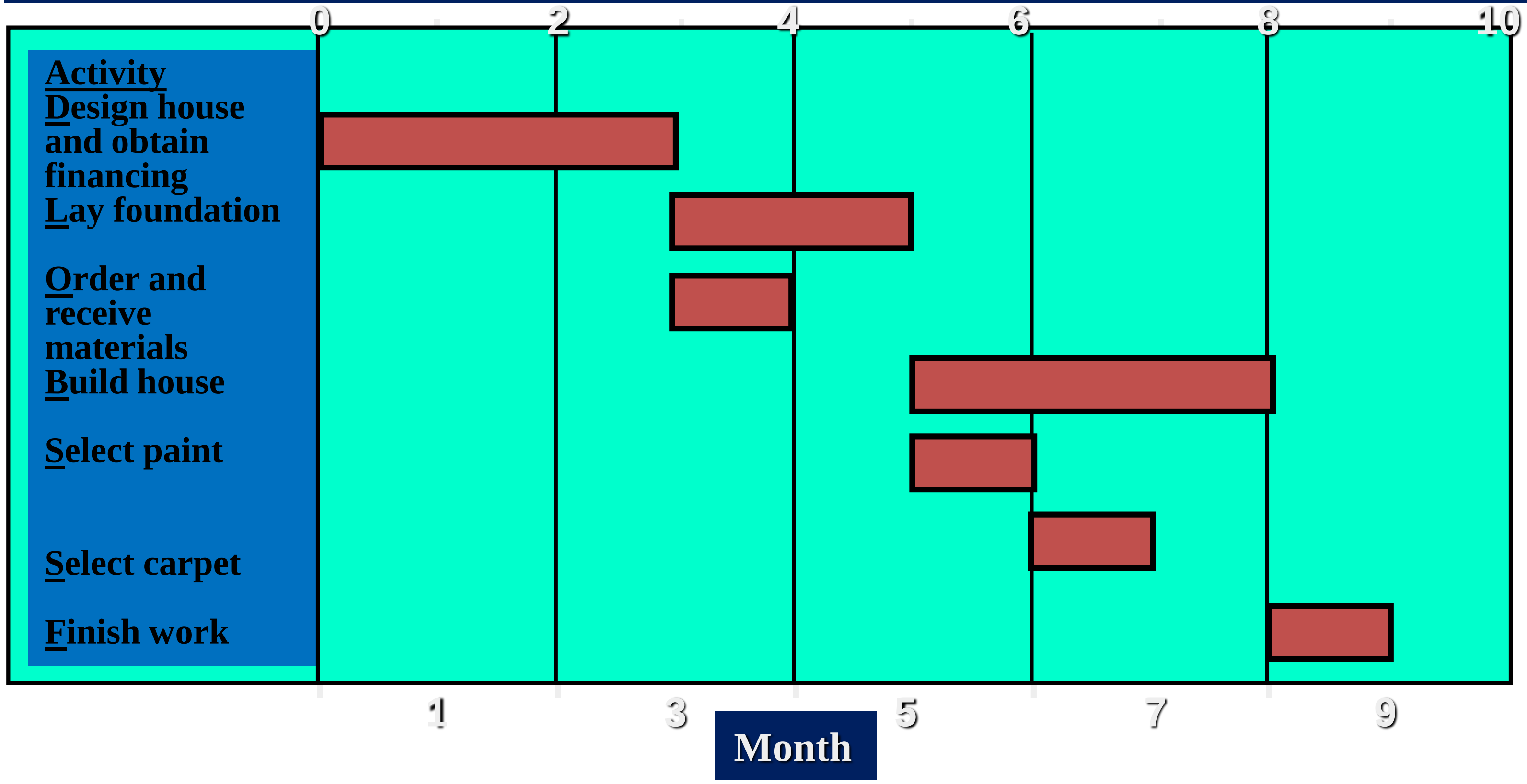
7 Control Schedule

- .1 Inputs
  - .1 Project management plan
  - .2 Project schedule
  - .3 Work performance data
  - .4 Project calendars
  - .5 Schedule data
  - .6 Organizational process assets
- .2 Tools & Techniques
  - .1 Performance reviews
  - .2 Project management software
  - .3 Resource optimization techniques
  - .4 Modeling techniques
  - .5 Leads and lags
  - .6 Schedule compression
  - .7 Scheduling tool
- .3 Outputs
  - .1 Work performance information
  - .2 Schedule forecasts
  - .3 Change requests
  - .4 Project management plan updates
  - .5 Project documents updates
  - .6 Organizational process assets updates

Project scheduling and controlling techniques

1. Bar charts
2. Life cycle curves
3. Line of balance (LOB)
4. Network techniques (PERT/CPM)

A Gantt / Bar Chart



Gantt Charts

- ✓ Establish a time-phased network
- ✓ Can be used as a tracking tool

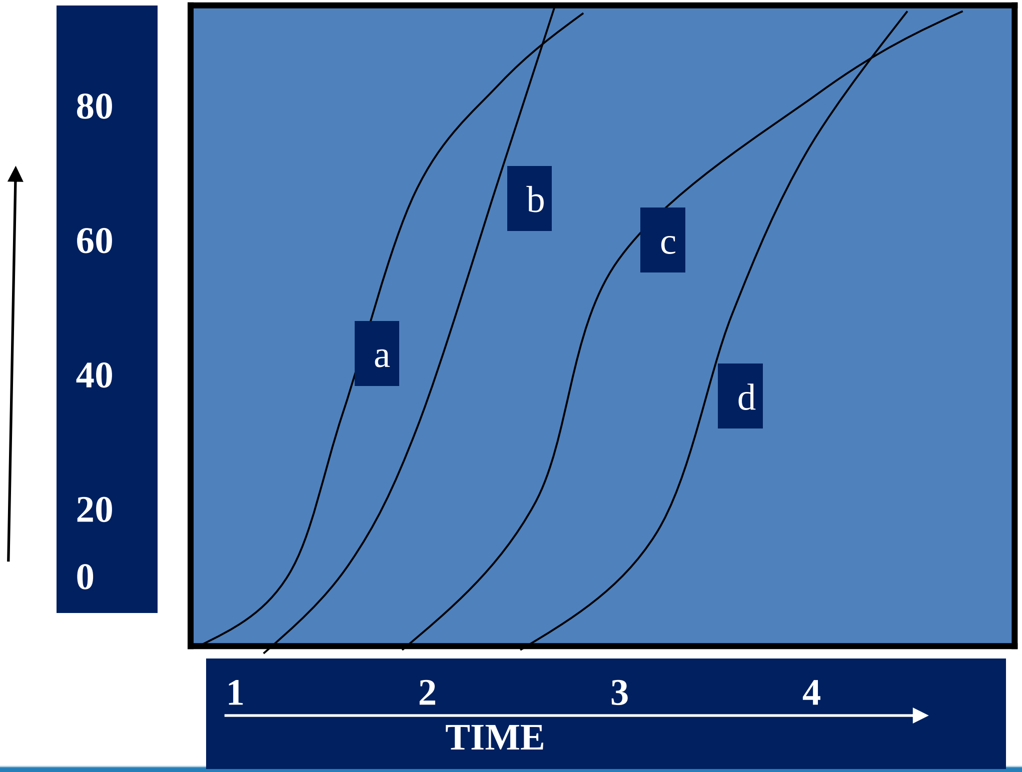
<u>Benefits of Gantt charts</u>

1. **Easy** to create and comprehend
2. Identify the schedule **baseline** network
3. Allow for **updating** and **control**
4. Identify **resource needs**

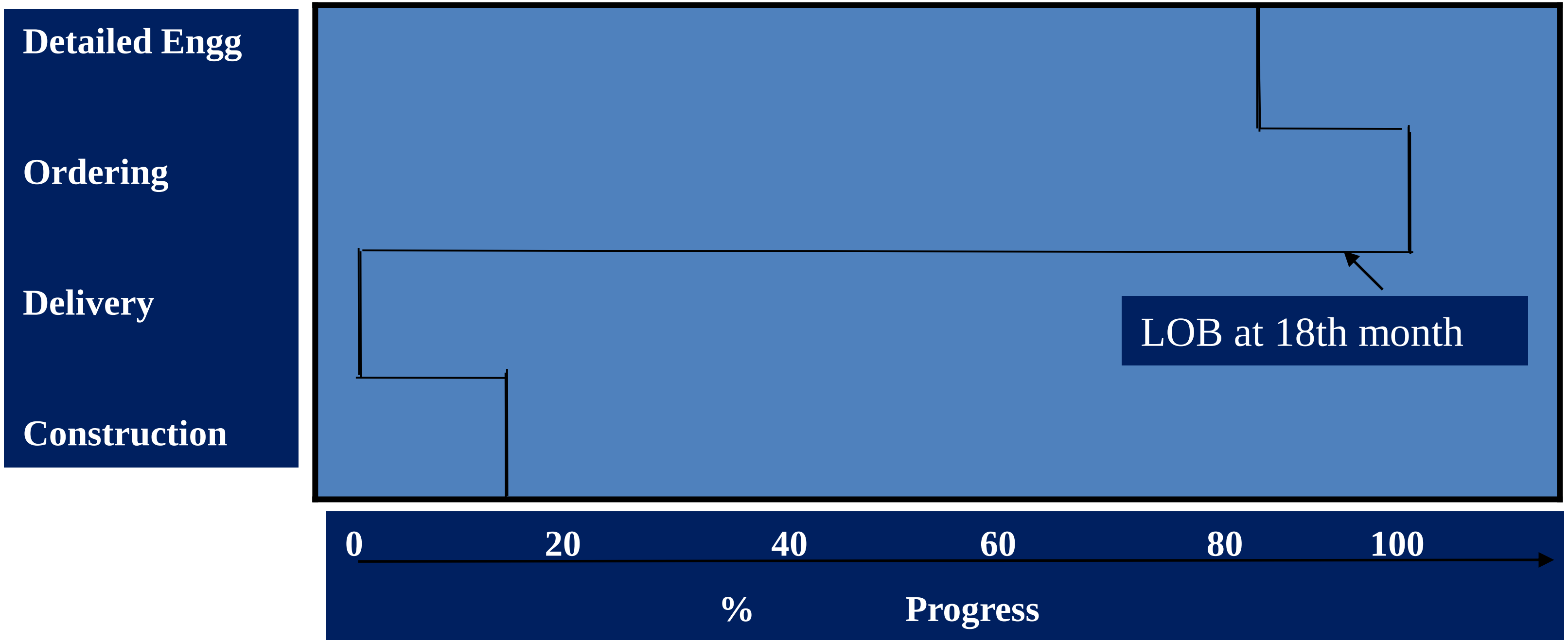
Create a Gantt chart based on the activities listed in the table.

Task	Time	Pred
Z	8	--
Y	5	Z
X	8	Z
W	4	Y,X
V	5	W
U	3	W
T	6	V
S	7	U,T
R	9	S

Life cycle curves



LINE OF BALANCE

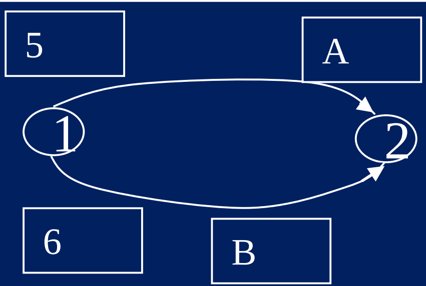


Network : We represent activities of a project through networks. It takes care of precedence relationships.

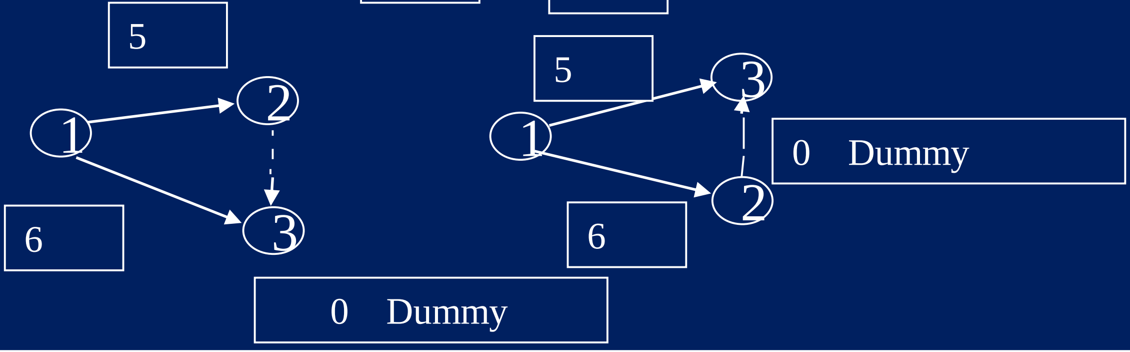
CPM	PERT
1.The time durations are **deterministic** (MBA degree).	1.The time durations are **probabilistic** (Ph. D. degree, DRDO,ISRO, CSIR Labs)
2.The duration of the project is fixed. And for a fixed duration it gives the most economical schedule.	2.There is expected duration of the project.
2.Looping and probabilistic events are not allowed in the network.	3.Simulation can be used to PERT network.

1. Each activity must be represented by one and only one arrow, an activity (i-j) " i" is the staring node and "j" is terminal node.

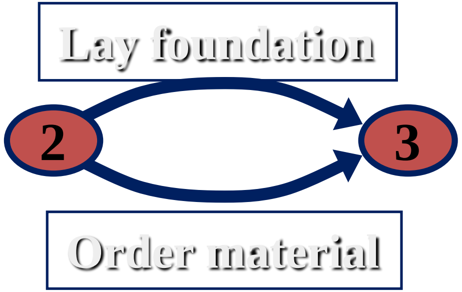
2. No two activities should not have the same initial and same terminal nodes.



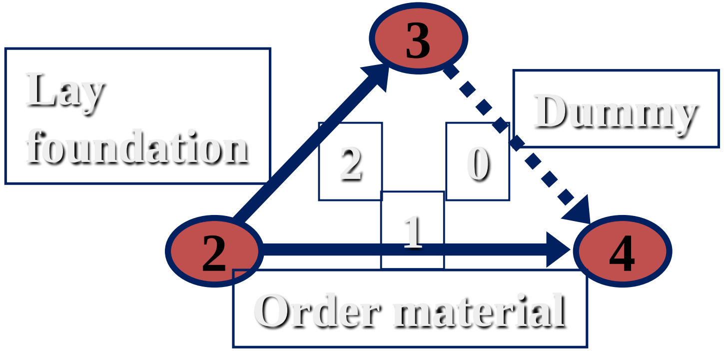
Dummy activity: does not consume time and resource



No two activities should have the same initial and same terminal nodes.



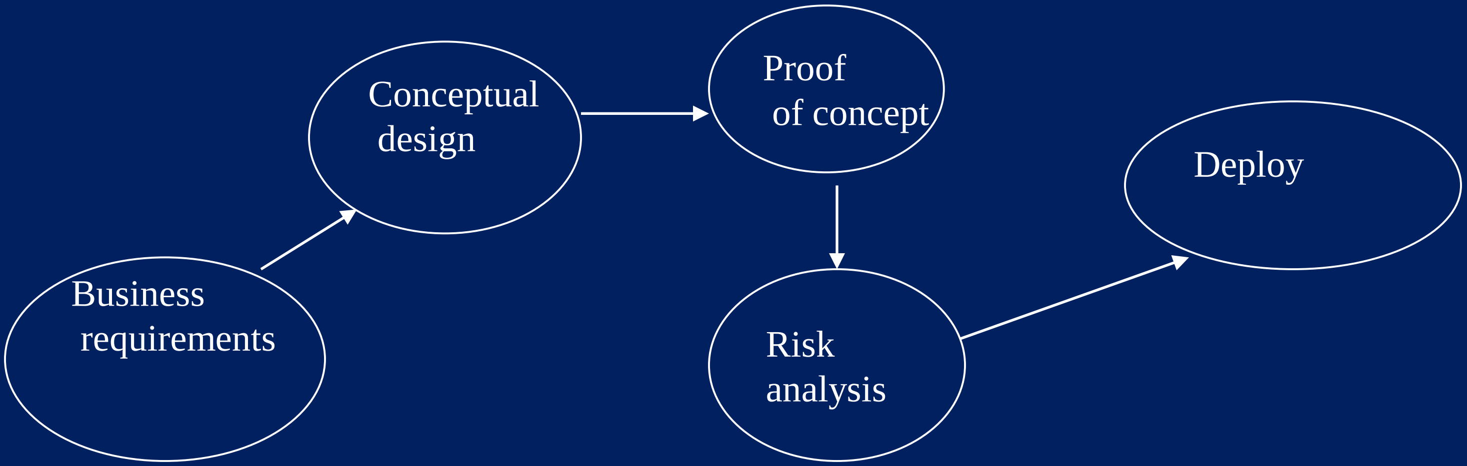
(a) Incorrect precedence relationship



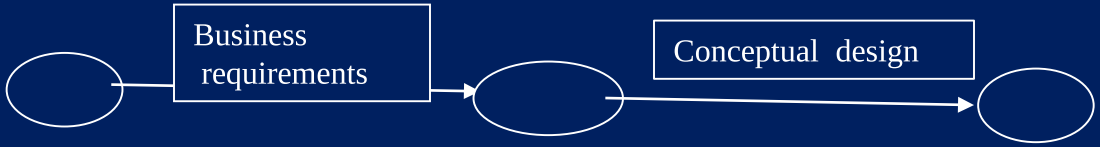
(b) Correct precedence relationship

Software Project

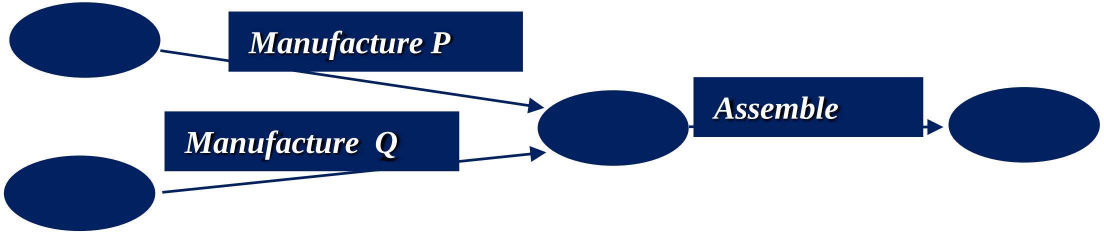
Number	Event
1	Business requirements
2	Conceptual design
3	Proof of concept
4	Risk analysis
5	System requirements
6	Logical design
7	First build
8	Evaluation
9	Subsystem requirements
10	Physical design
11	Second build
12	Evaluation
13	Unit requirements
14	Final design
15	Final build
16	Test
17	Deploy



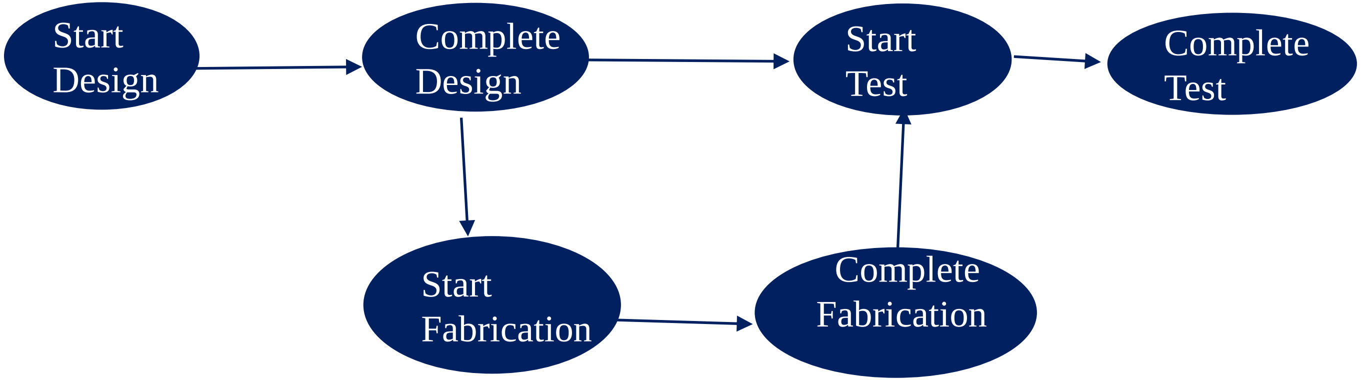
Event based network (PERT)



Activity based network (CPM)



Activity based network

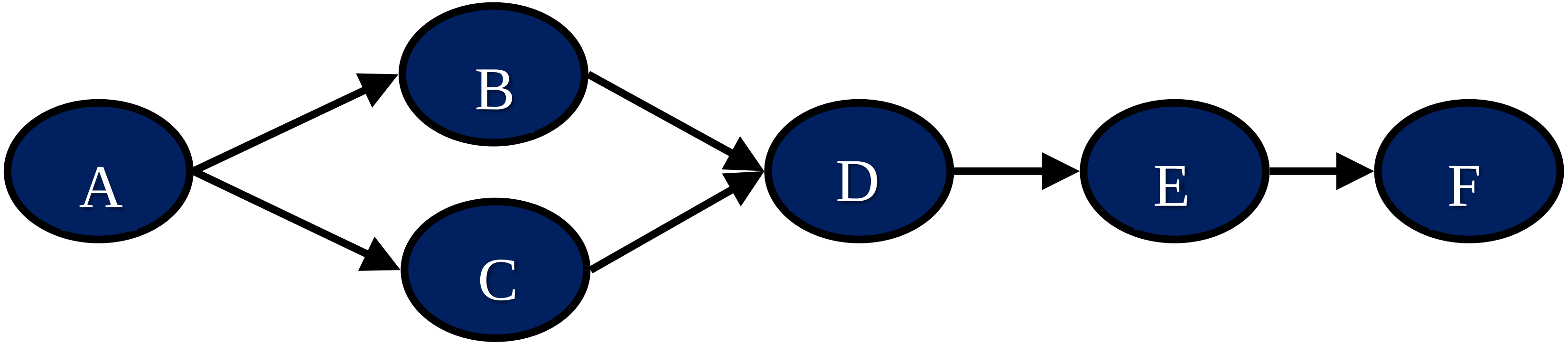


Event based network (PERT)

Project Scheduling Terms

- Successors
- Predecessors
- Network diagram
- Serial activities
- Concurrent activities

- Merge activities
- Burst activities
- Node
- Path



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Project Management for Managers

Lec – 34

Project Time Management (Project Scheduling)

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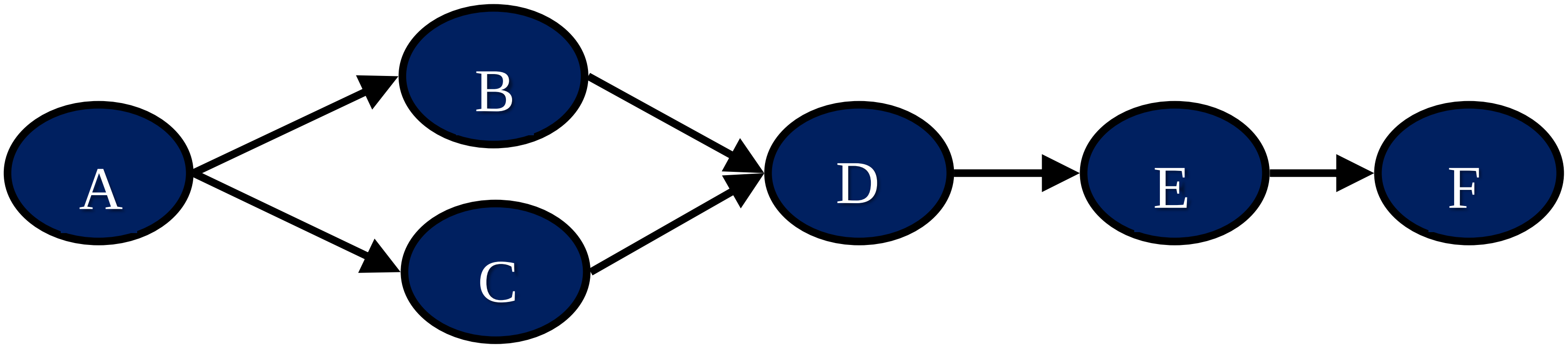
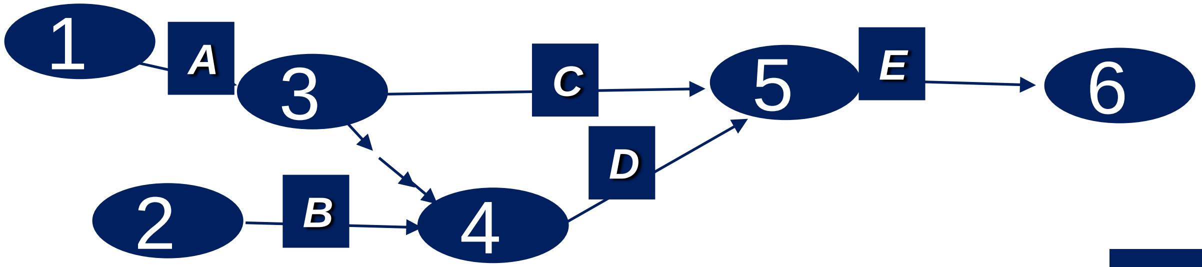


Types of dummy activities

Job	Immediate predecessors
A	-
B	-
C	A
D	A,B
E	C,D

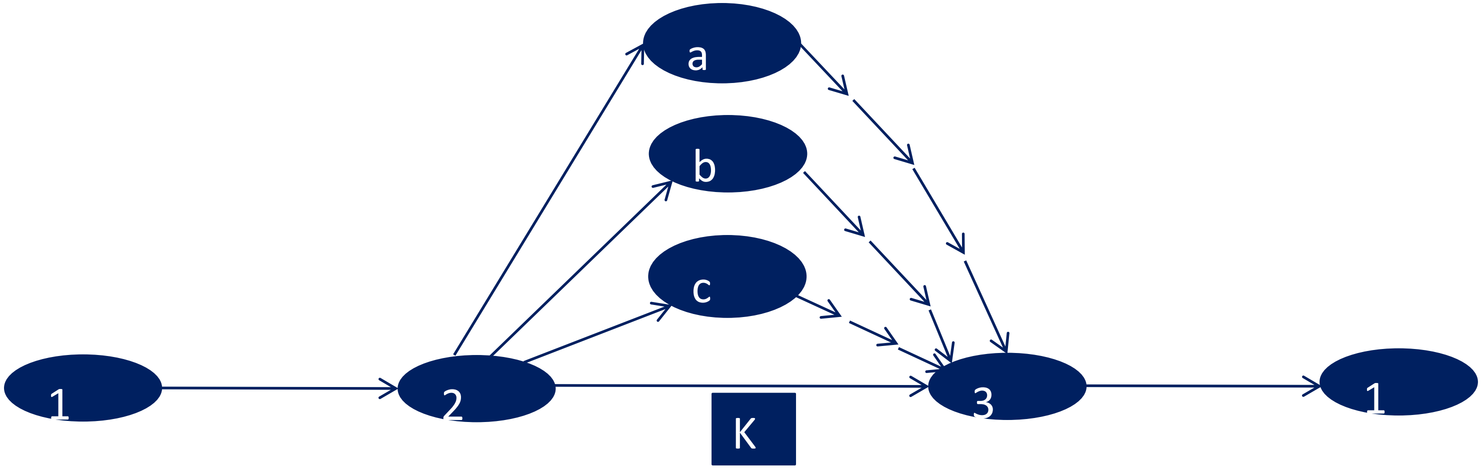


3-4 is a logical dummy activity

Apart from logical dummies one may be faced with situations where two or more activities have identical sets of predecessors and successors.

In this situation, the activities can be done in parallel or concurrently and their unique identification by referring to node numbers is *not* possible.

In such a situation , k parallel activities are modeled using k-1 dummies. The dummies so inserted are not logical dummies, but perform the function of dummies for unique representation



Dummies for unique representation of parallel activates

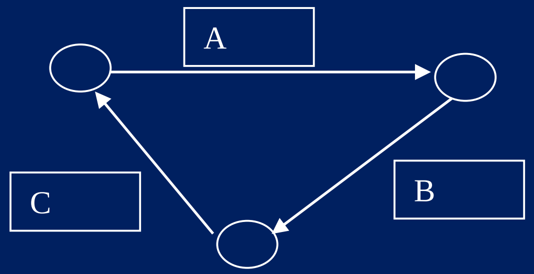
Another use of dummies is for creating a single source or single sink in a network which has multiple sources and/or sinks.

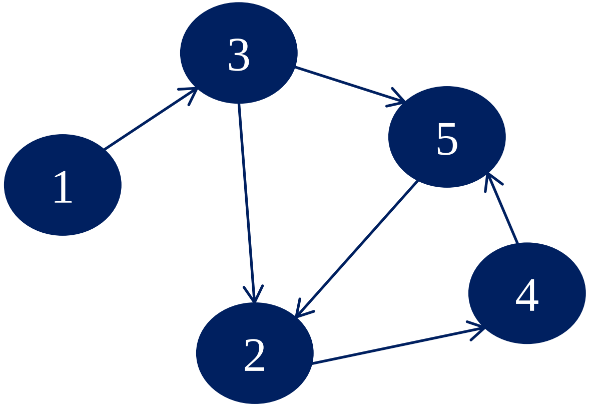
Dummies added for single source and sink

Types of network representation : A-O-N and A-O-A

It may be noted that if we use the A-O-N mode of representation where <u>each activity is represented as a node</u>, there is <u>no need of adding any dummy activities to represent precedence or parallelism</u> in activities since <u>each activity would be well taken care of with suitable predecessors</u>.

3. The arrow heads should not form a close loop/ consistency in project network





Adjacency matrix M

From node “i”to node “j”	1	2	3	4	5
1	0	0	1	0	0
2	0	0	0	1	0
3	0	1	0	0	1
4	0	0	0	0	1
5	0	1	0	0	0

M^2

From node "i"to node "j"	1	2	3	4	5
1	0	1	0	0	1
2	0	0	0	0	1
3	0	1	0	1	0
4	0	1	0	0	0
5	0	0	0	1	0

M^2 has all zeros on the diagonal, we compute M^3

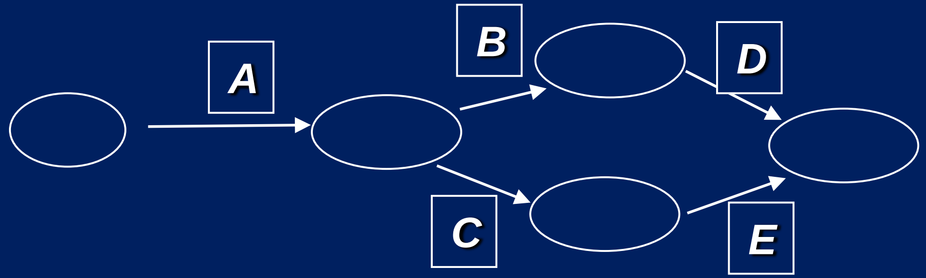
From node "i"to node "j"	**1**	**2**	**3**	**4**	**5**
1	**0**	**1**	**0**	**1**	**0**
2	**0**	**1**	**0**	**0**	**0**
3	**0**	**0**	**0**	**1**	**1**
4	**0**	**0**	**0**	**1**	**0**
5	**0**	**0**	**0**	**0**	**1**

The appearance of 1^s to diagonal elements of nodes 2,4,5 indicates presence of loop and inconsistency . The loop is (2-4-5).

Hints for drawing networks:

Example 1

- ‘A’ precedes ‘B’ and ‘C’ or ‘B’ and ‘C’ follow ‘A’ or ‘B ‘and ‘C’ depend on ‘A’
- ‘D’ follows ‘B’
- E follows C
- D and E are terminal activities.



Hints for drawing networks:

Example 2

-‘A’ and ‘B’ start immediately

- ‘C’ follows both ‘A’ and ‘B’

- D follows A

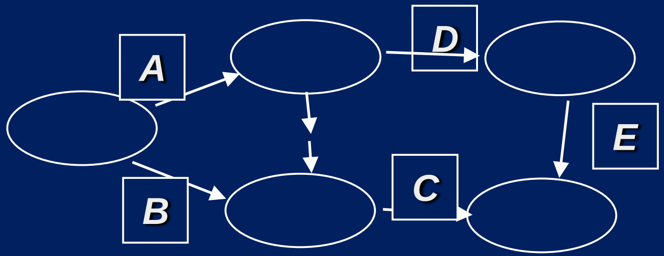
- E follows D

- The project is complete when C and E are done

Hints for drawing networks:

Example 2

- *'A' and 'B' start immediately*
- *'C' follows both 'A' and 'B'*
- *D follows A*
- *E follows D*
- *The project is complete when C and E are done*



Hints for drawing networks:

Example 3

- *‘A’ starts immediately*

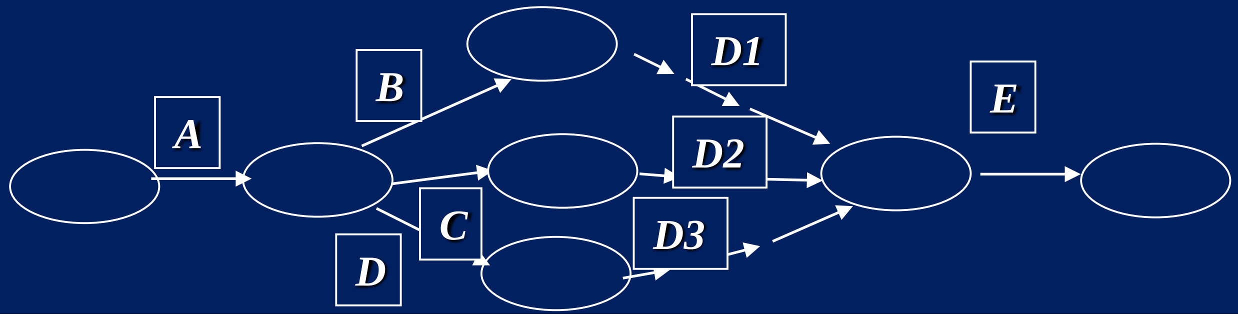
- *‘B’, ‘C’ and ‘D’ follow ‘A’*

- *E follows B, C, and D*

Hints for drawing networks:

Example 3

- *'A' starts immediately*
- *'B', 'C' and 'D' follow 'A'*
- *E follows B, C, and D*



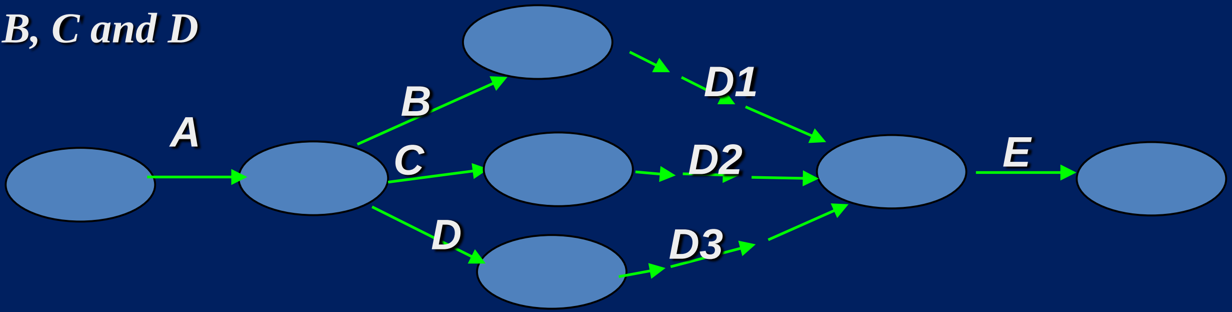
Hints for drawing networks:

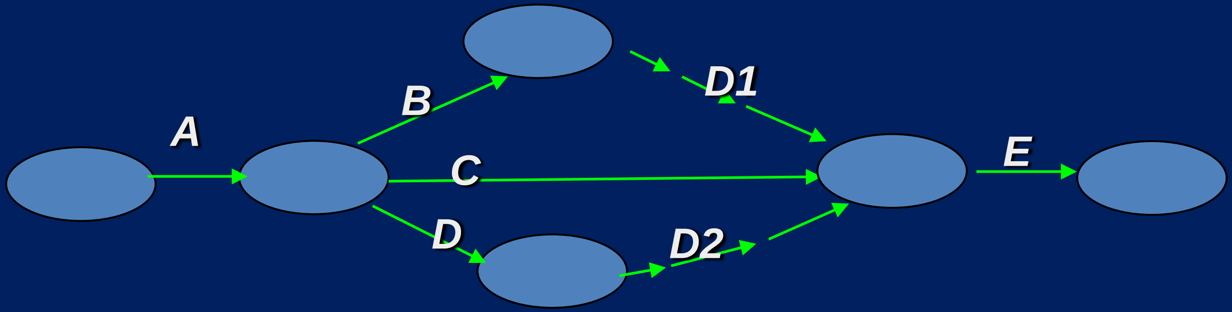
Example 3 Contd……

-‘A’ starts immediately

- ‘B’, ‘C’ and ‘D’ follow ‘A’

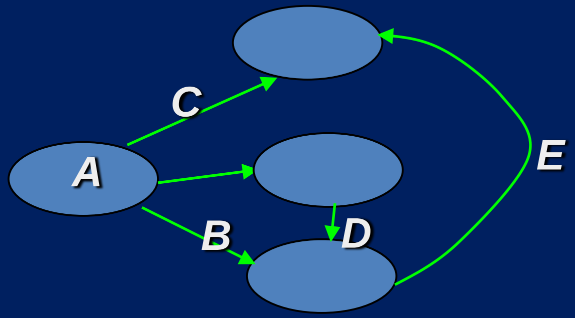
- E follows B, C and D





4. The arrows representing activities should be <u>straight not curved</u>.

- *A,B and C start immediately*
- *D follows A*
- *E follows B and D*
- *C and E are terminal activities*



The arrows representing activities should be __straight not curved__.

- *A, B and C start immediately*
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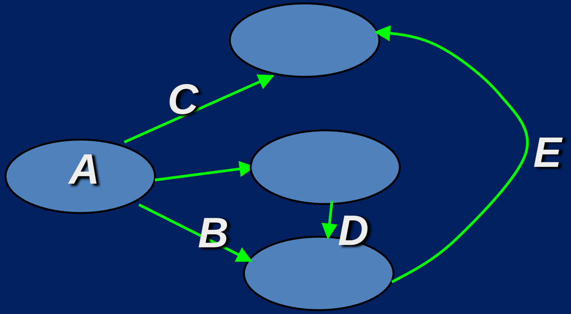
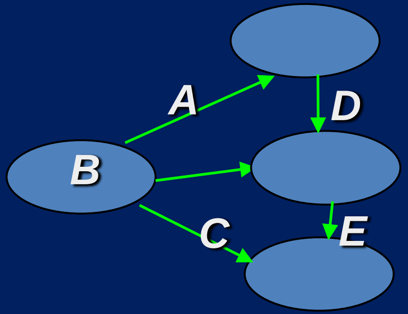
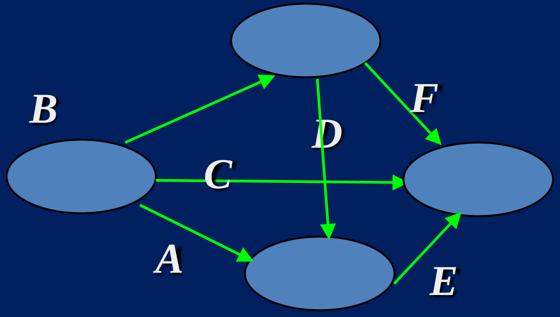
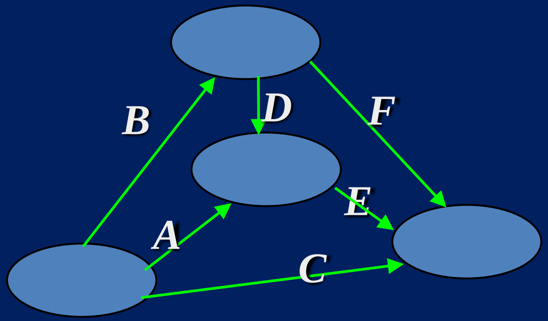




5. *Avoid crossover of activities whenever possible.*





Construct a network

- *A and B are the first activities of the project start immediately,*
- *A precedes C and F,*
- *B precedes D and E ,*
- *F and D precede G and H,*
- *C and G precede I ,*
- *E , H and I are terminal activities.*

Construct a network

- A and B are the first activities of the project start immediately,
- A precedes C and F,
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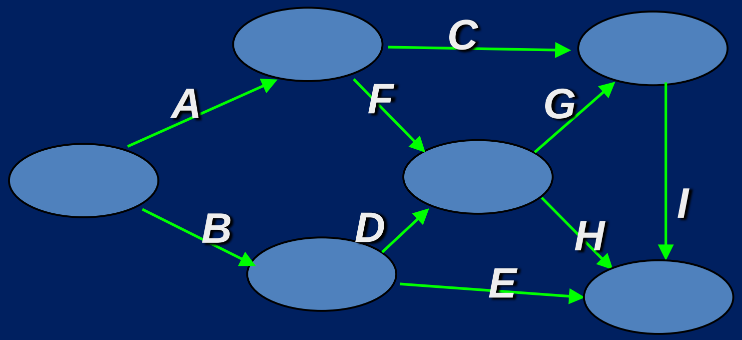
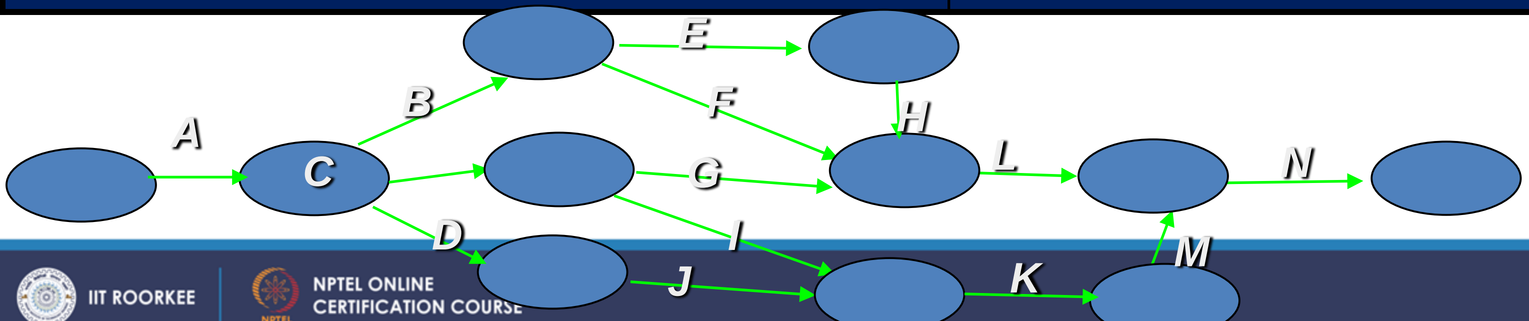


Construct a network

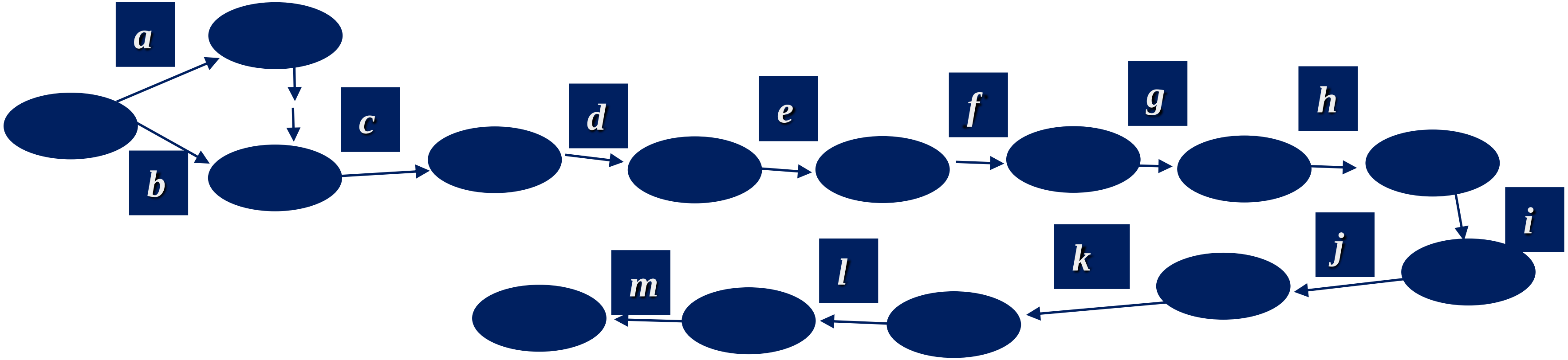
Activity	Depends on
A	None
B	A
C	A
D	A
E	B
F	B
H	E
G	C
I	C
J	D
K	I and J
L	F, G and H
M	K
N	L and M

Activity	*Depends on*
A	*None*
B	*A*
C	*A*
D	*A*
E	*B*
F	*B*
H	*E*
G	*C*
I	*C*
J	*D*
K	*I and J*
L	*F, G and H*
M	*K*
N	*L and M*



a-review houses,
b-finalize requirements,
c-engage architect,
d-evaluate alternate designs,
e-finalize contractor,
f-foundations,
g-brickwork,
h-RCC,
i-plumbing,
j-wooden work,
k-organize party,
l-shift luggage,
m-settling in new house

Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l



Activity on Arrow Network (A-O-A)

Activity on Node Network (A-O-N): Activities are represented on nodes and the arrows represent the precedence relation

a-review houses,
b-finalize requirements,
c-engage architect,
d-evaluate alternate designs,
e-finalize contractor,
f-foundations,

g-brickwork,
h-RCC,
i-plumbing,
j-wooden work,
k-organize party,
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m-settling in new house

Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l

Activity on Node Network (A-O-N): Activities are represented on nodes and the arrows represent the precedence relation

a-review houses,
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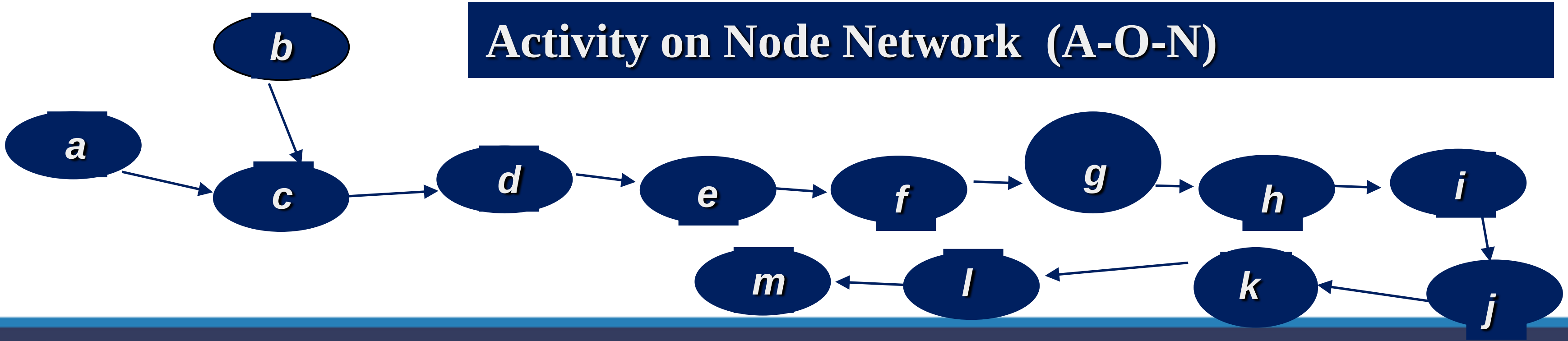
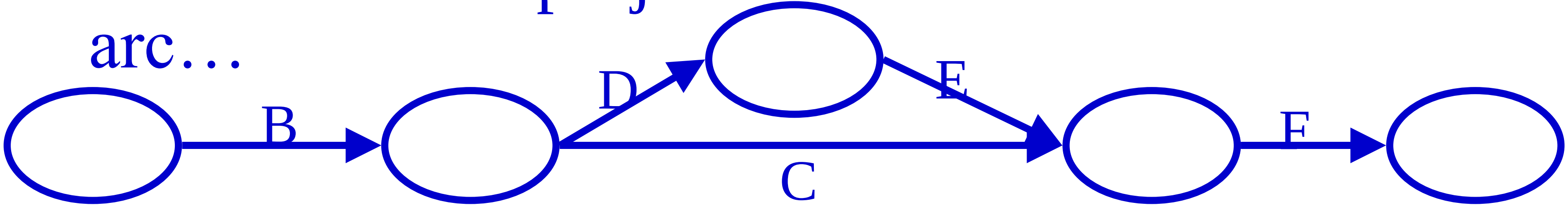
Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l

Activity on Node Network (A-O-N)

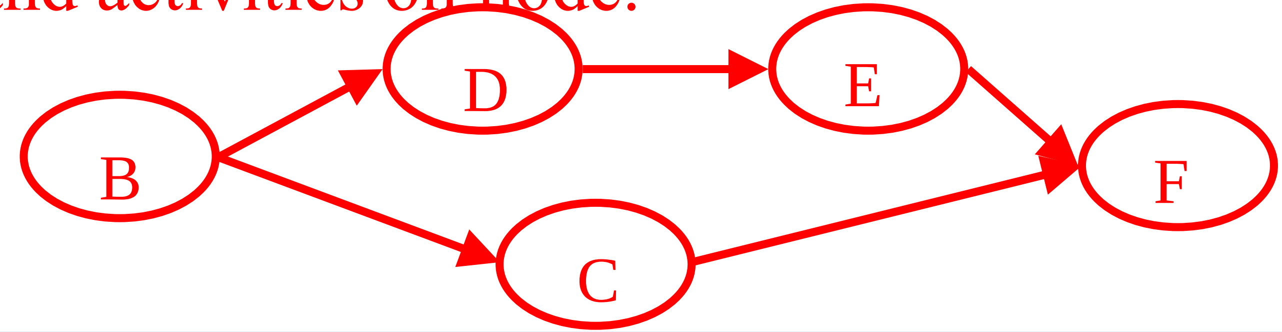


AOA Vs. AON

The same mini-project is shown with activities on arc…



…and activities on node.



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Project Management for Managers

Lec – 35

Project Time Management – Numbering of Nodes

Dr. M.K. Barua

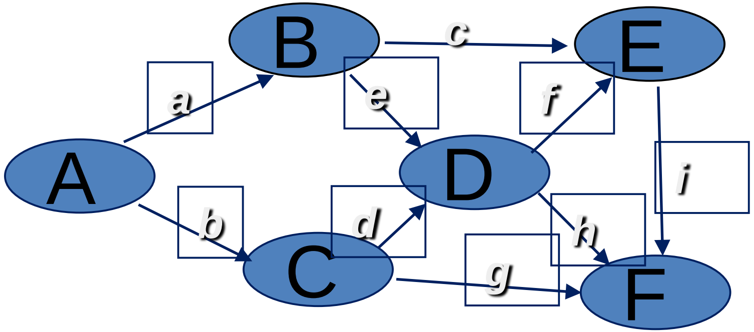
Department of Management

Indian Institute of Technology Roorkee

Node Label

Early Start	ID Number	Early Finish
Activity Float	Activity Descriptor	
Late Start	Activity Duration	Late Finish

Numbering of events



Numbering the events : D. R . Fulkerson rule.

1. *An initial event is one which has arrows coming out of it and none entering it . In any network there will be one such event . Number it "1".*

2. *Delete all arrows emerging from event 1. This will create at least one more*

' initial event'.

3. *Number these initial events as 2,3,…….*

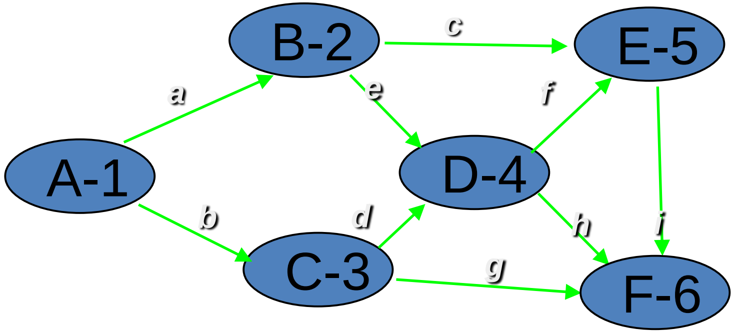
4. *Delete all emerging arrows from these numbered events which will create new initial events.*

5. *Follow step (3).*

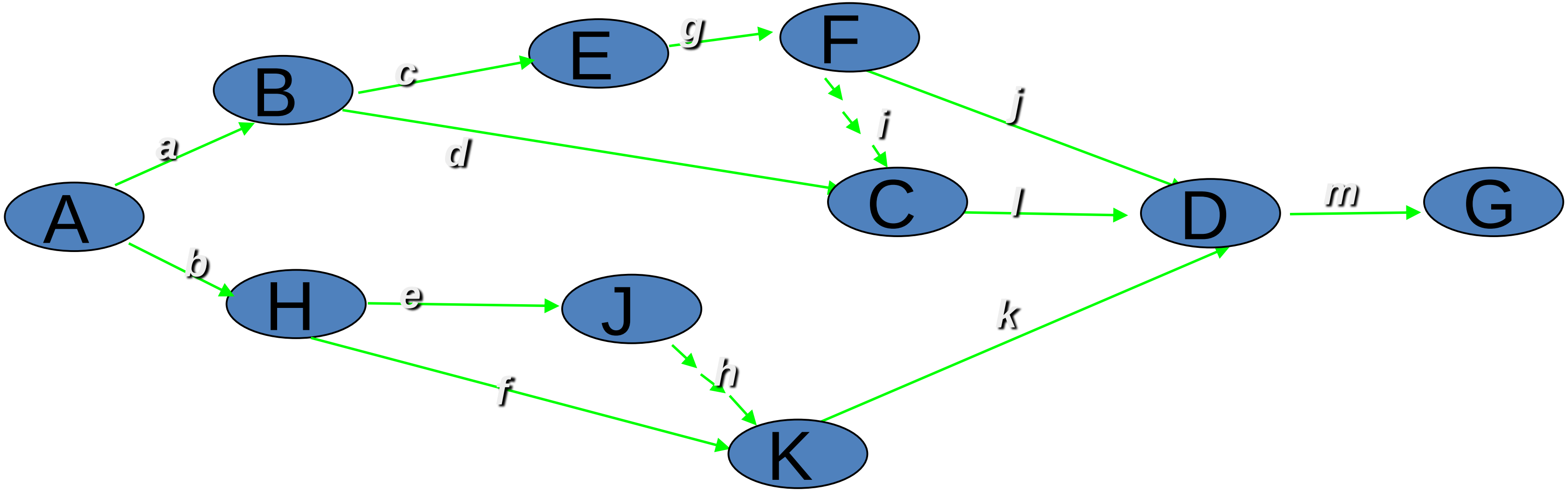
6. *Continue until last event which has no arrows emerging from it is obtained.*

NUMBERING THE EVENTS

1. Number event A as 1, there is no incoming arrow.
2. Delete arrows a and b. Which will result in events B and C. Number B as 2 and C as 3.
3. Delete arrows c & e and d & g. Which will result in events E, D and F. But events E and F have incoming arrows , number event D as 4.
4. Delete arrows f & h. Which will result in events E and F. But event F has an incoming arrow , number event E as 5.
5. Delete i, number F as 6.



NUMBER THE EVENTS ??????????????



NUMBERING THE EVENTS

1. Number event A as 1, which has no incoming arrows.

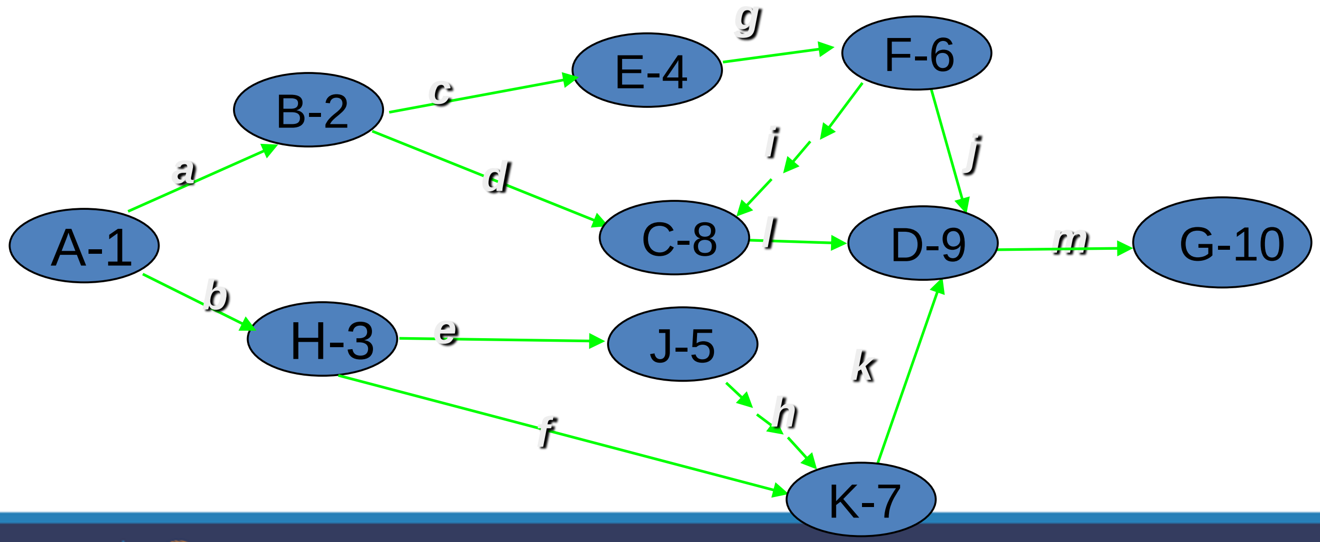
2. Delete arrows 'a' and 'b'. We will have events B and H, both do not have incoming arrows, number event B as 2 and event H as 3.

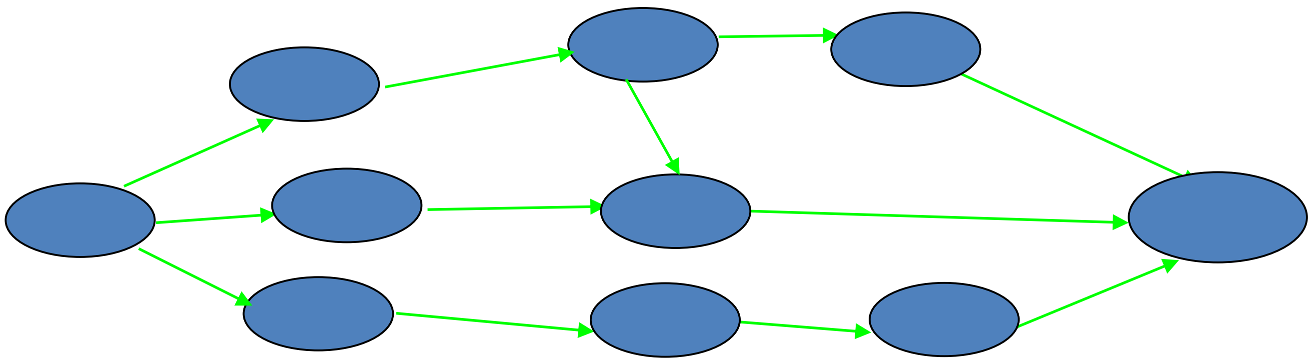
3. Delete arrows c, d, and e, f. Which will result in E & C and J &K , but events C and K have incoming arrows . Number events E as 4, and event J as 5

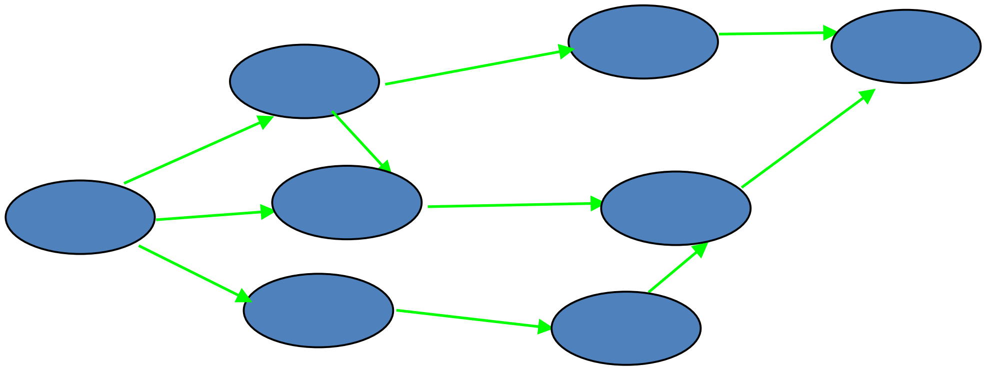
4. Delete arrows g, h . Which will result in events F and K . Number event F as 6 and K as 7 .

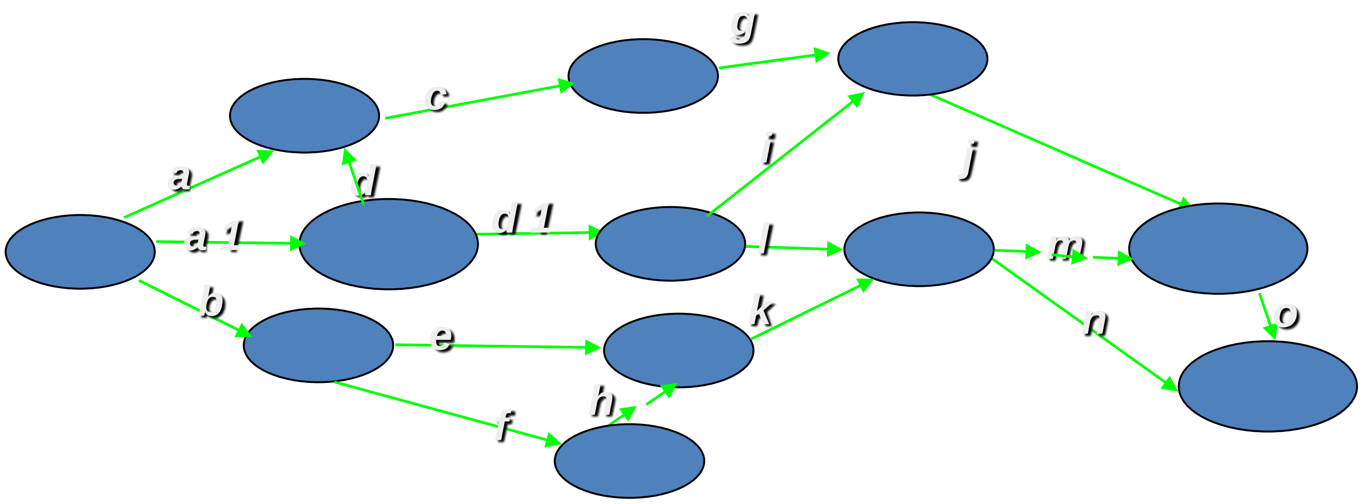
5. Delete arrows i, j, k . Which will result in event C and D, number C as 8 and D as 9.

6. Delete arrow m, number event G as 10.



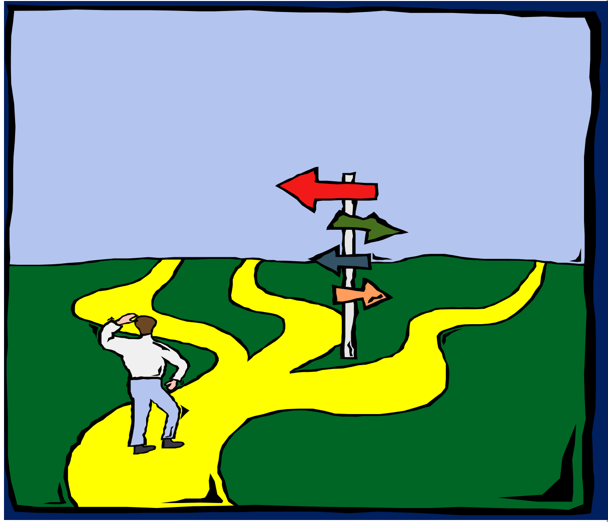





g
c
a
d
i
j
a 1
d 1
l
m
b
k
o
e
n
h
f

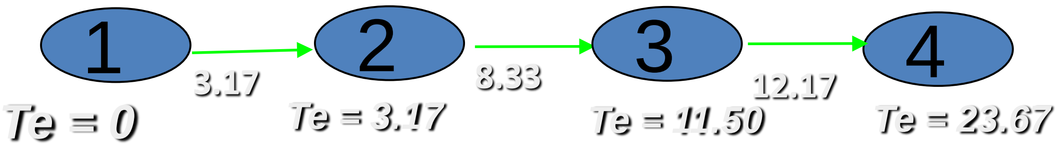
Critical Path

- ✓ ***A path is a sequence of connected activities running from start to end node in network***
- ✓ ***The critical path is the path with the longest duration in the network***
- ✓ ***Project cannot be completed in less than the time of the critical path***



To find critical path in a large network we compute two time estimates for every event.

Earliest expected time / Earliest start time (Te) : *Refers to the time when an event can be expected to start as early as possible. It is computed by adding the te's of the activity paths leading to that event*



We calculate "Te" in forward pass.

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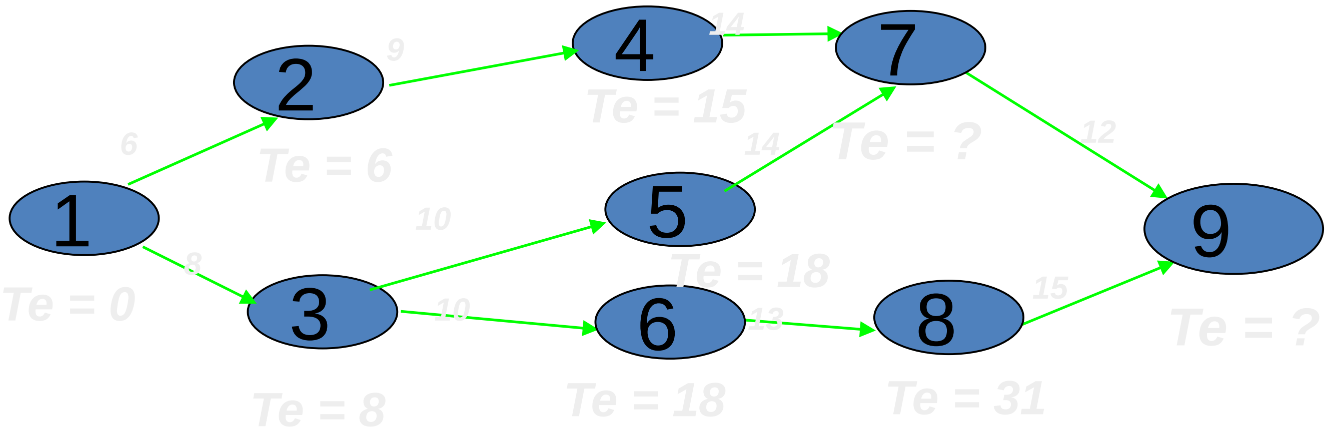
Project Management for Managers

Lec – 36

Project Time Management – PERT Networks

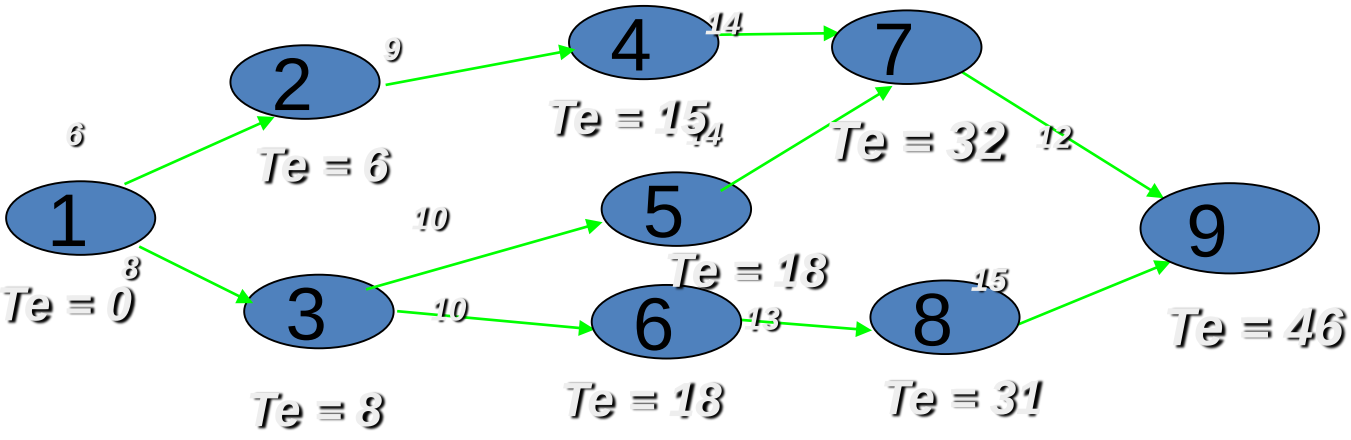
Dr. M.K. Barua
Department of Management
Indian Institute of Technology Roorkee

Earliest expected time/ Earliest start time (Te).



We calculate "Te" in forward pass.

Earliest expected time/ Earliest start time (Te).

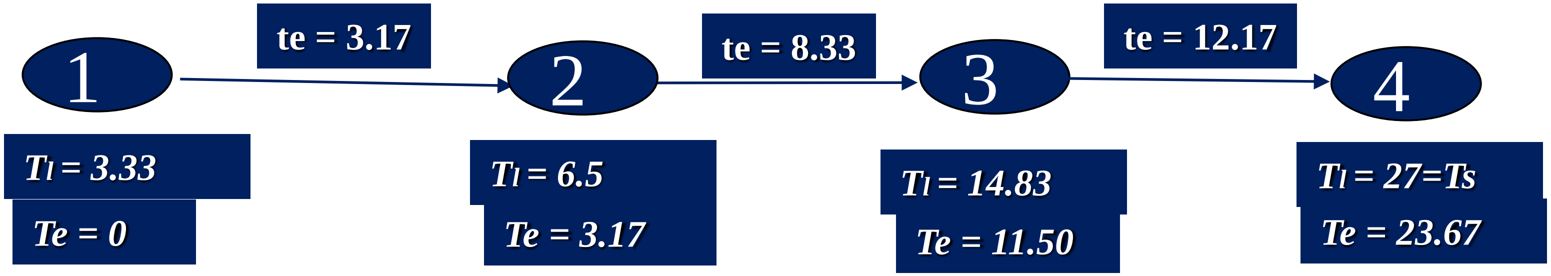


We calculate "Te" in forward pass.

Latest allowable occurrence time (Tl) / Latest completion time:

The latest time by which an event must occur to keep the project on schedule is known as latest allowable occurrence time.

To explain this, consider contractual obligation time (Ts)= 27



We calculate "Tl" in Backward pass.

Single Vs. Multiple Time Estimate.

Networks used in process and construction industries where vast experience has provided the basis for reliable and accurate time estimates, a single time estimate appears to be more reasonable.

We can appreciate the multiple time estimates in projects where research and development (cryogenic, nano tech, bio medical,) activities, technological breakthroughs have a considerable effect.

PERT Network and Time Estimates.

1. The Optimistic Time Estimate: This is the estimate of the shortest possible time in which an activity can be completed under ideal condition. (better than normal conditions are assumed to prevail during the execution of the project). This is represented by ‘to”.

2. The Pessimistic Time Estimate: This is the maximum possible time it could take to accomplish the job. If everything went wrong and abnormal situations prevailed, this would the time estimate for that activity. This is represented by‘tp’.

3. The Most Likely Time Estimate: This is the time estimate which lies between the optimistic and the pessimistic time estimates. This is represented by ‘tm’.

Multiple Time Estimate- By experts

Optimistic (to)

Pessimistic time(tp)

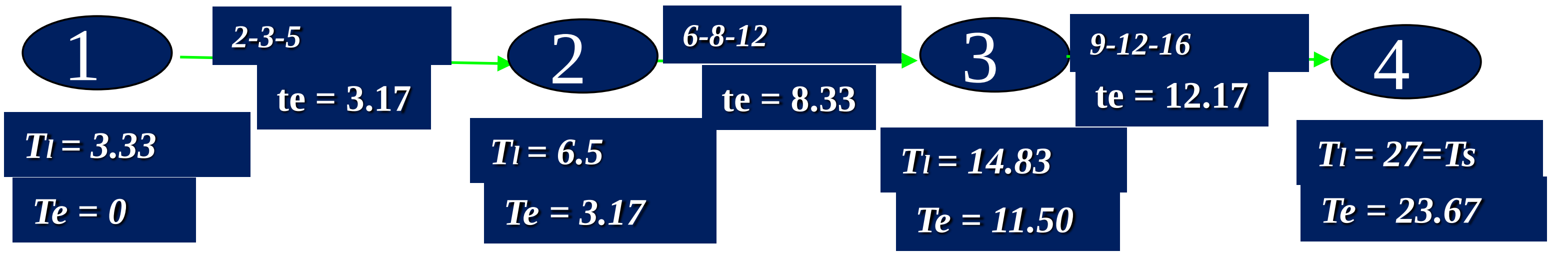
Most likely time(tm)

$$te = (to + 4tm + tp)/6$$

Latest allowable occurrence time (Tl) / Latest completion time:

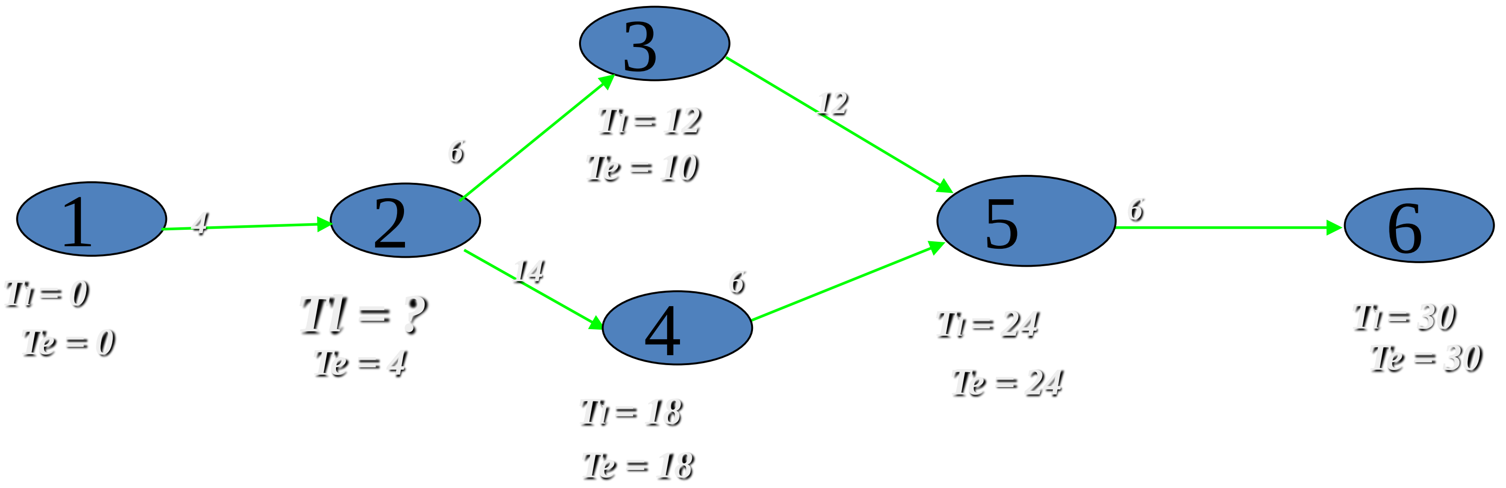
The <u>latest time</u> by which an event must occur to keep the project on schedule is known as latest allowable occurrence time.

To explain this, consider contractual obligation time (Ts)= 27



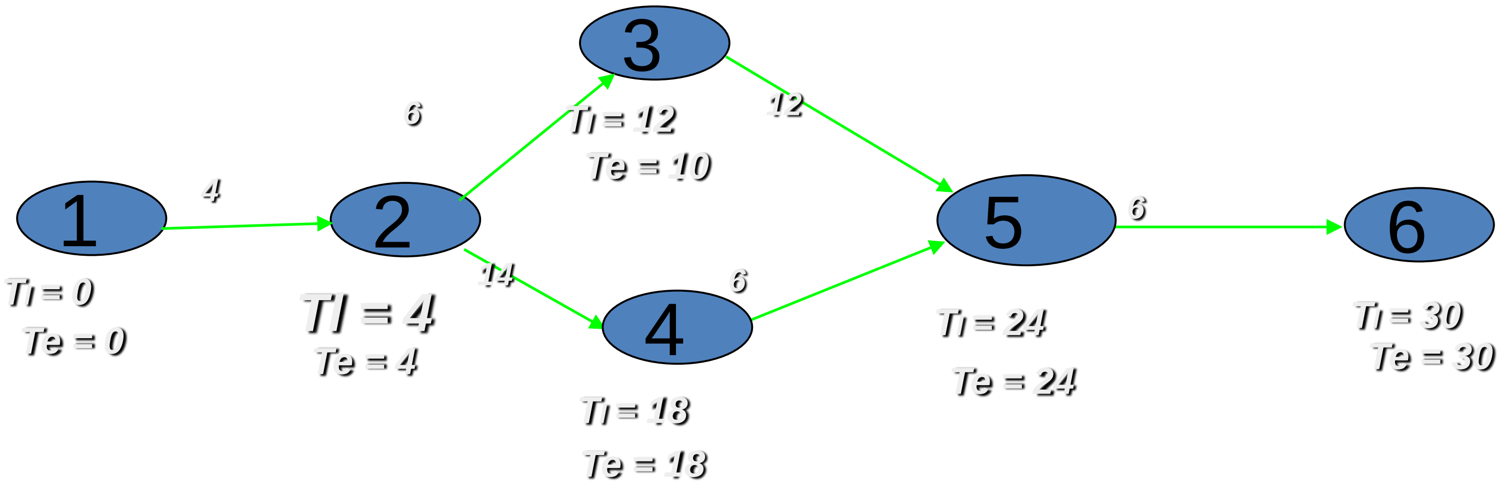
We calculate "Tl" in Backward pass.

Latest allowable occurrence time / Latest completion time (T_l).



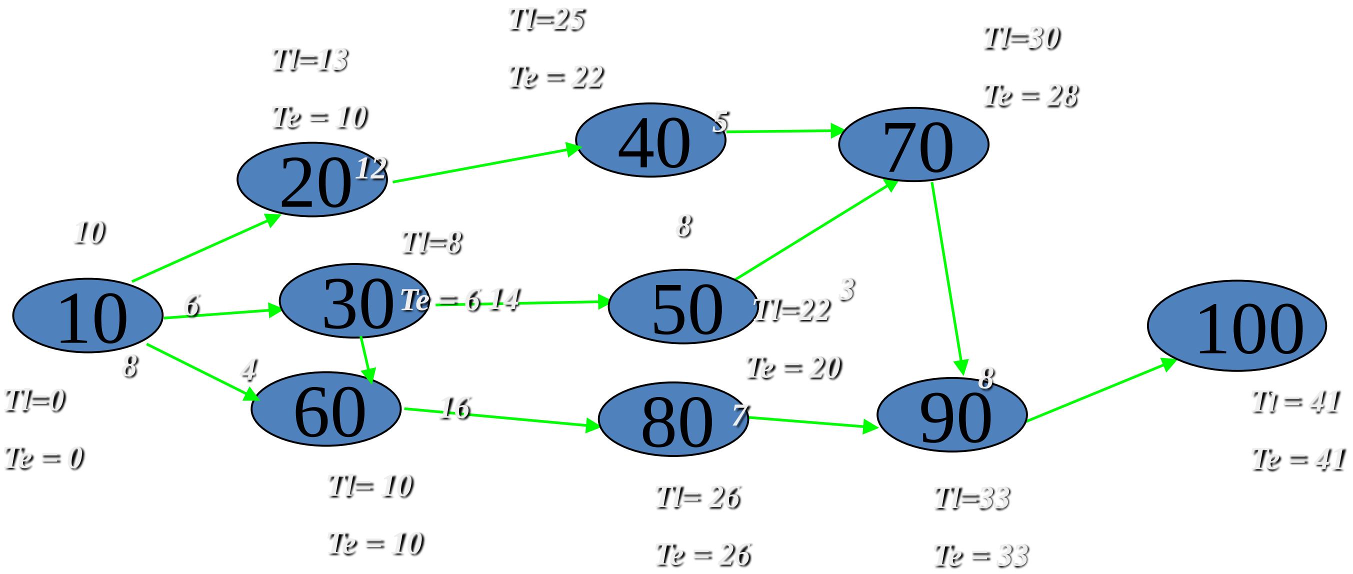
We calculate "Tl" in Backward pass.

Latest allowable occurrence time / Latest completion time (T_l).



We calculate "Tl" in Backward pass.

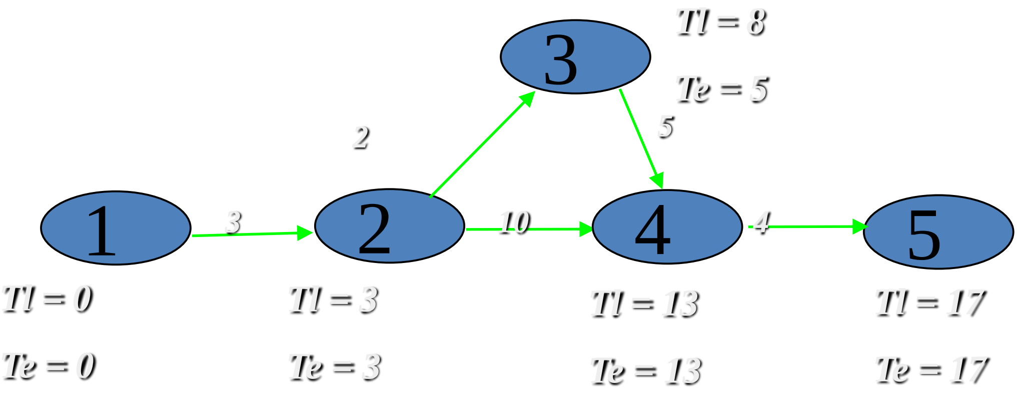
Example.



Nodes with Te = Tl form a critical path.

Critical path: Where Tl=Te

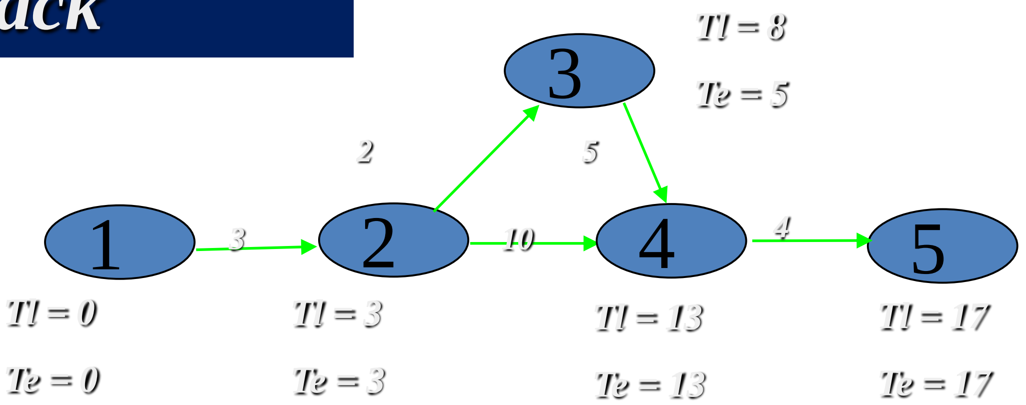
Slack - PERT



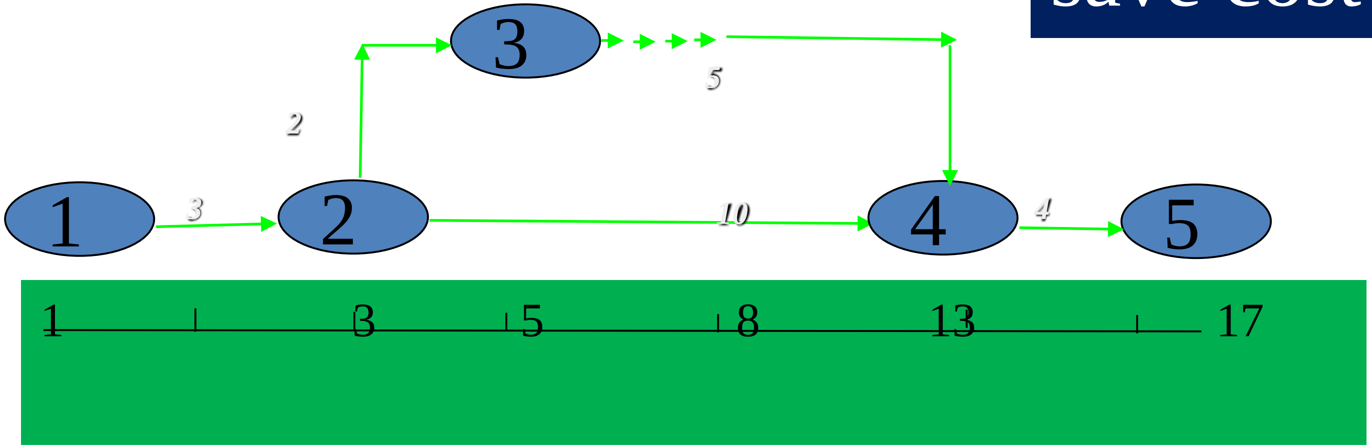
Node	Slack = Tl-Te
1	0
2	0
3	3
4	0
5	0

Critical path with zero slack

Slack



One can level men power and save cost also.



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Lec – 37

Project Time Management – CPM

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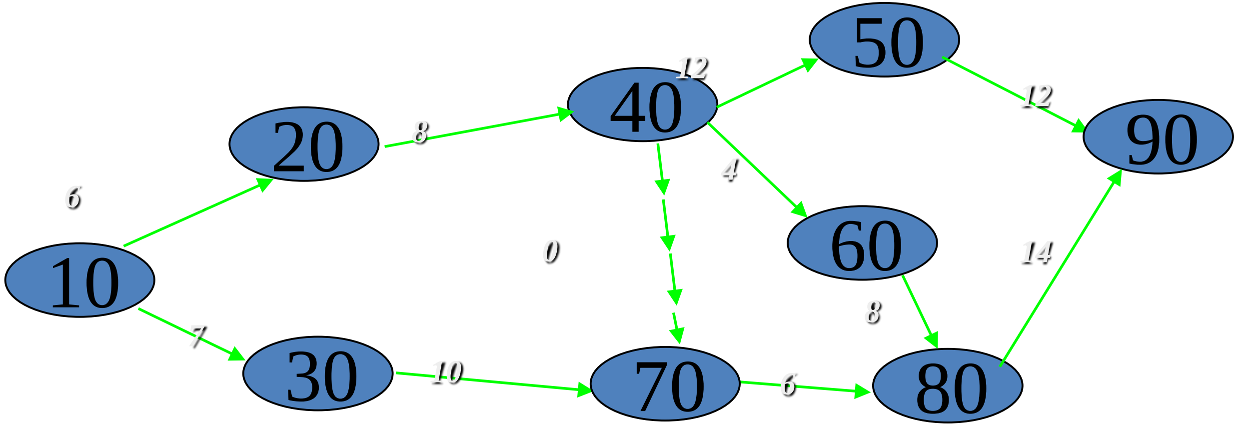
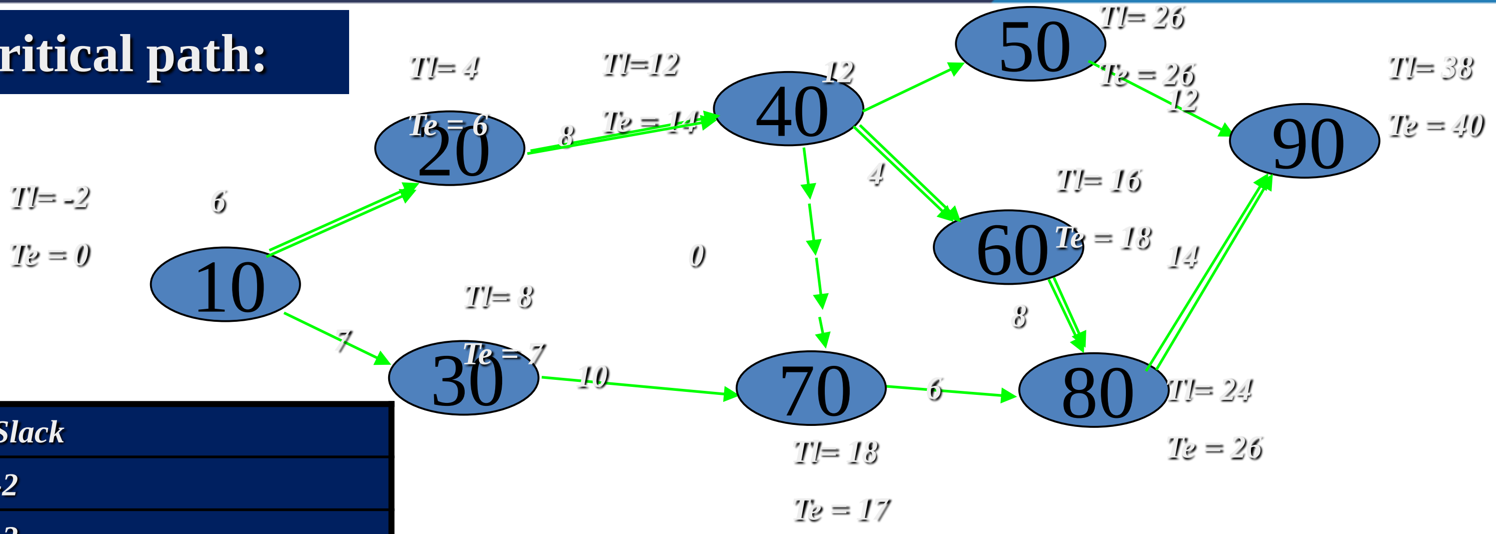
Indian Institute of Technology Roorkee



Find critical and Semi critical paths:

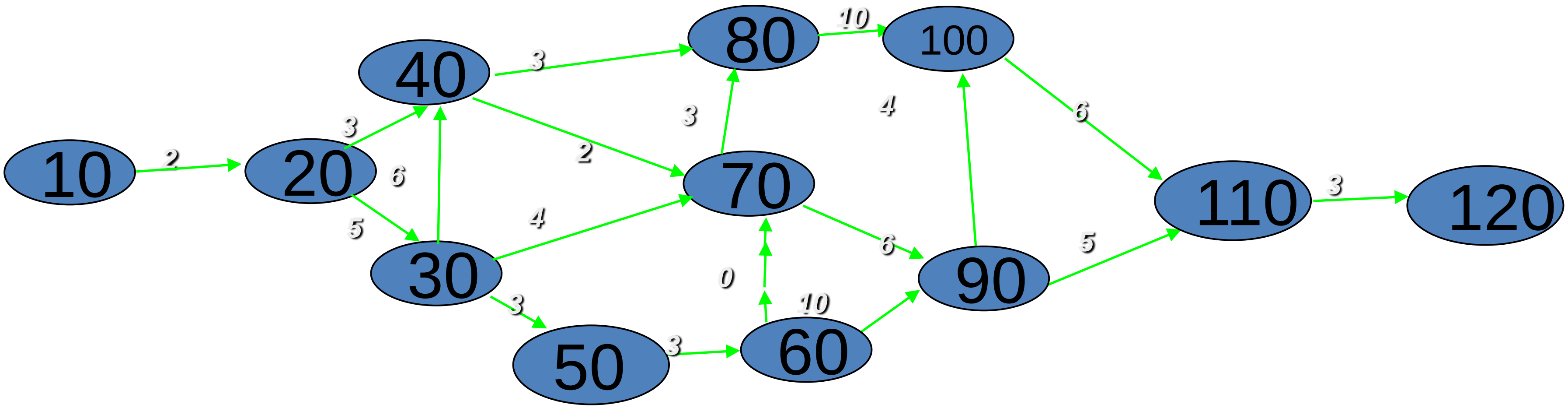
Semi critical path:



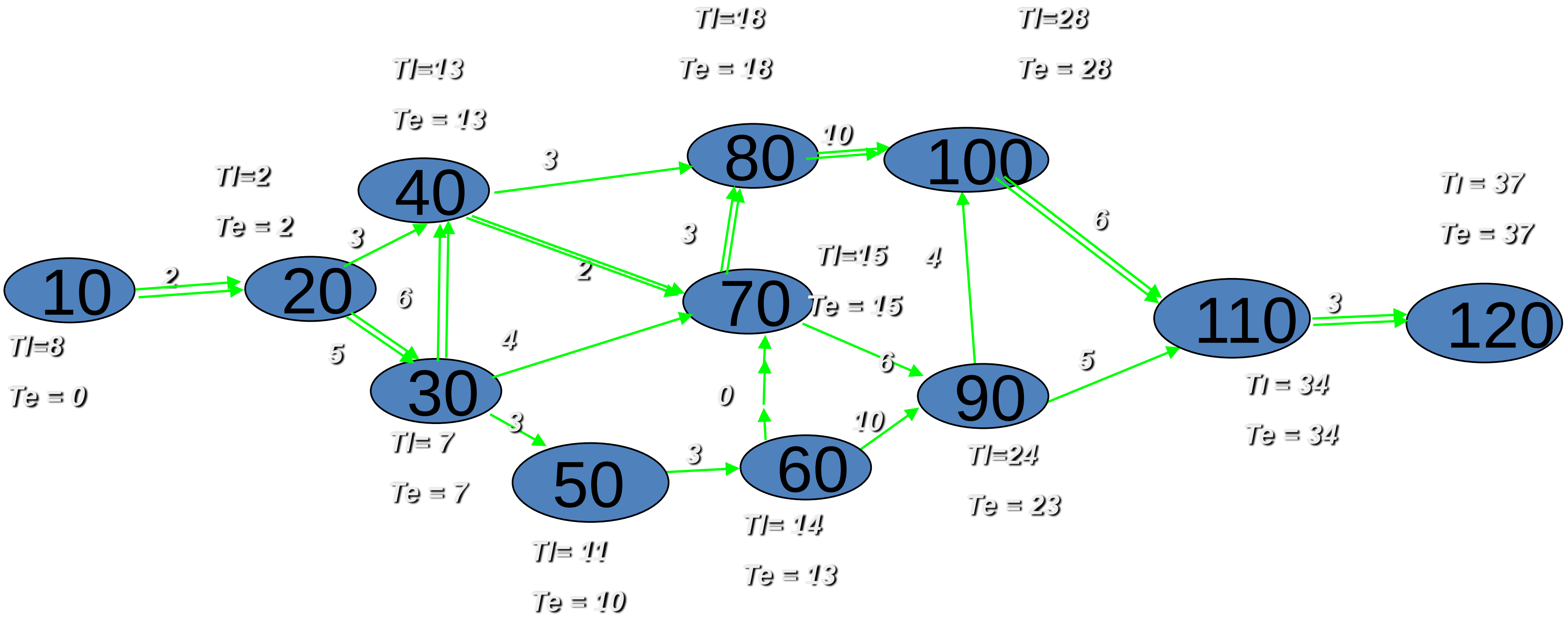
Node	Slack
10	-2
20	-2
30	1
40	-2
50	0
60	-2
70	1
80	-2
90	-2

Semi critical path: *Slack at node 50 is 0, which is connected to node 40 and 90. Semi critical path is 40-50-90.*

The other semi critical path is 30-70



Find critical and semi critical paths??



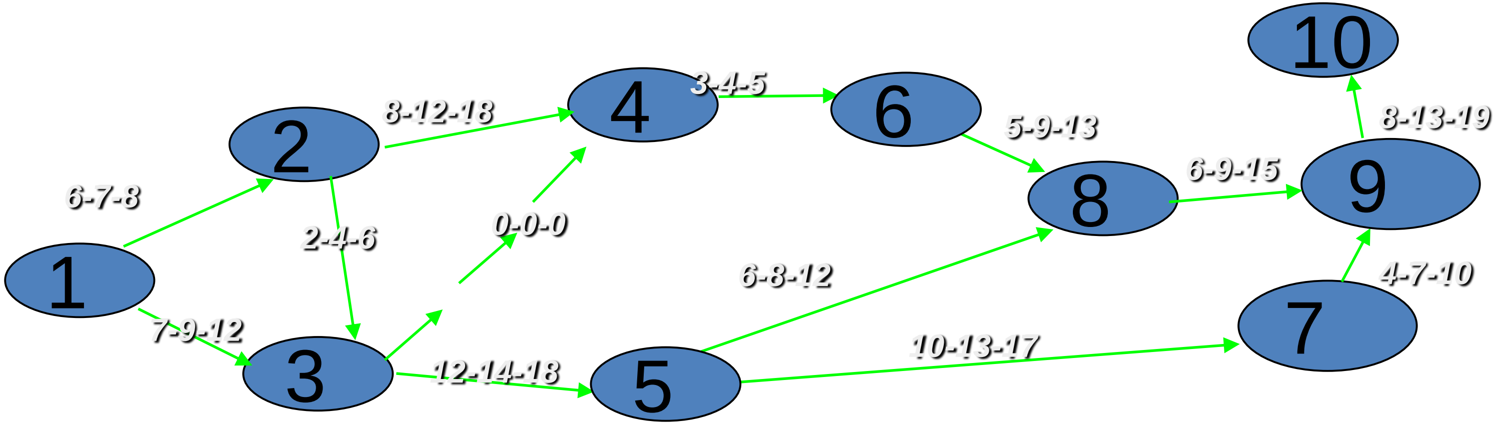
Tl=18
Te = 18
Tl=28
Te = 28
Tl=13
Te = 13
Tl=2
Te = 2
Tl = 37
Te = 37
Tl=15
Te = 15
Tl=8
Te = 0
Tl= 7
Te = 7
Tl= 11
Te = 10
Tl= 14
Te = 13
Tl=24
Te = 23
Tl = 34
Te = 34
10
20
30
40
50
60
70
80
90
100
110
120
2
3
5
6
4
3
2
3
10
3
0
10
6
4
6
5
3
3

PERT Network and Time Estimates.

1. The Optimistic Time Estimate:

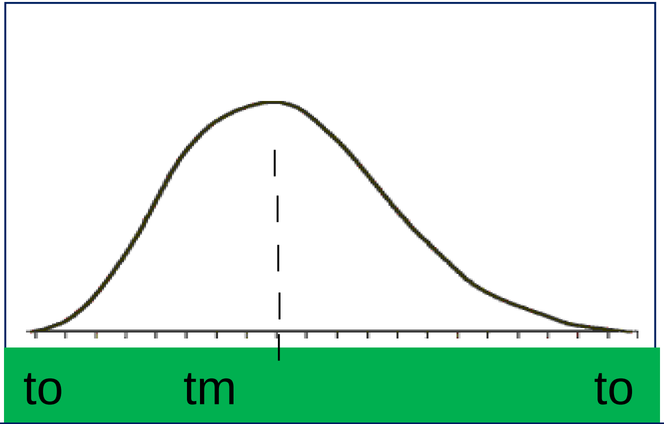
2. The Pessimistic Time Estimate:

3. The Most Likely Time Estimate:



Find critical and semi critical paths??

The Beta Distribution: The PERT analysts have found that the beta distribution curve happened to give fairly satisfactory results for most of the activities. (skewed to right- positively skewed curve- tails off toward high end of the scale)



For distribution of this type, the standard deviation is approximately one-sixth of the range.

$\sigma = (tp\text{-}to) / 6$

$(\sigma)^2 = ((tp\text{-}to) / 6)^2$

The Beta Distribution:

Consider the time estimates for two persons, x and y , for the execution of a particular job.

	to	tm	tp
Estimate by x	6	8	10
Estimate by y	5	7	11

Who is more uncertain.???????????

The Beta Distribution:

Consider the time estimates for two persons, x and y , for the execution of a particular job.

	to	tm	tp
Estimate by x	6	8	10
Estimate by y	5	7	11

Who is more uncertain.

$$(\sigma x)^2 = ((tp - to) / 6)^2 = 0.44$$

$$(\sigma y)^2 = ((tp - to) / 6)^2 = 1$$

EXPECTED TIME OR AVERAGE TIME.

After finding SD and variance, let us find average time taken for completion of a job.

In PERT, average time is called as expected time. There is 50-50 chance of getting the job done within that time.

$$te = 1/6\,(to) + 2/3\,(tm) + 1/6\,(tp)$$

$$= (to+4tm+tp)/\,6$$

Lags in Precedence Relationships

The logical relationship between the start and finish of one activity and the start and finish of another activity.

<u>Four logical relationships between tasks</u>

1. Finish to Start
2. Finish to Finish
3. Start to Start
4. Start to Finish

Finish to Start Lag: A **finish to start** lag of 4 days between completion of activity B and the start of activity C, as shown in figure. Three activities (A,B,C), activity C cant be started , as activity B is to be done by external supplier.

- Most common type of sequencing
- Shown on the line joining the nodes
  - Added during forward pass
  - Subtracted during backward pass

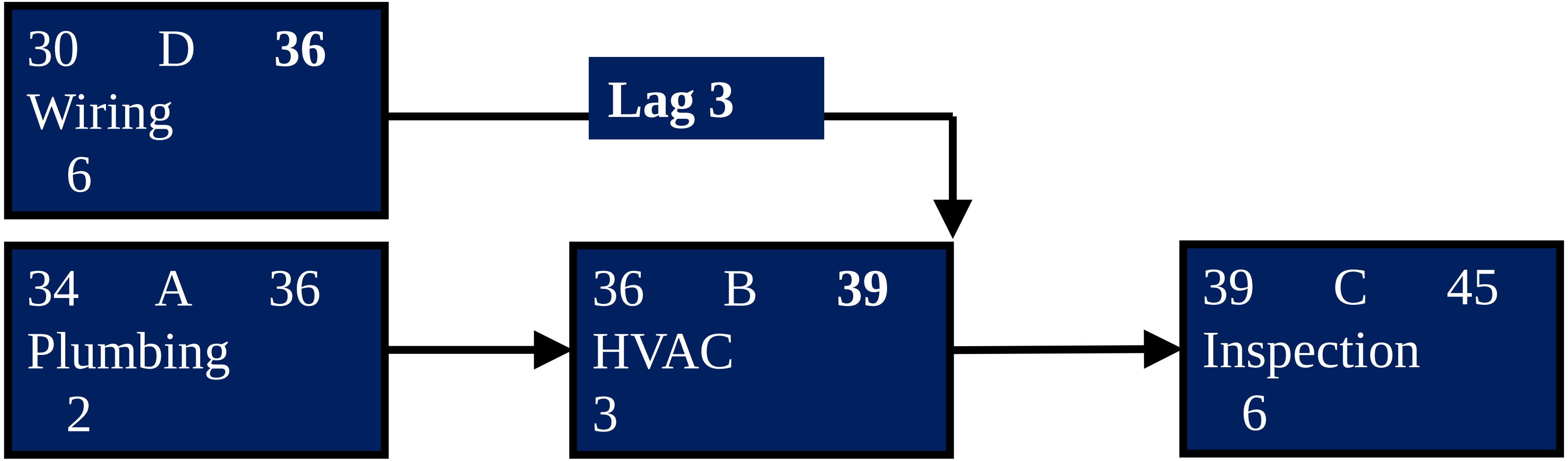
This lag is not the same as activity slack 15-11 =4

0 A 6	→	6 B **11**	Lag 4 →	**15** C 22
Spec Design		Design Check		Blueprinting
6		5		7

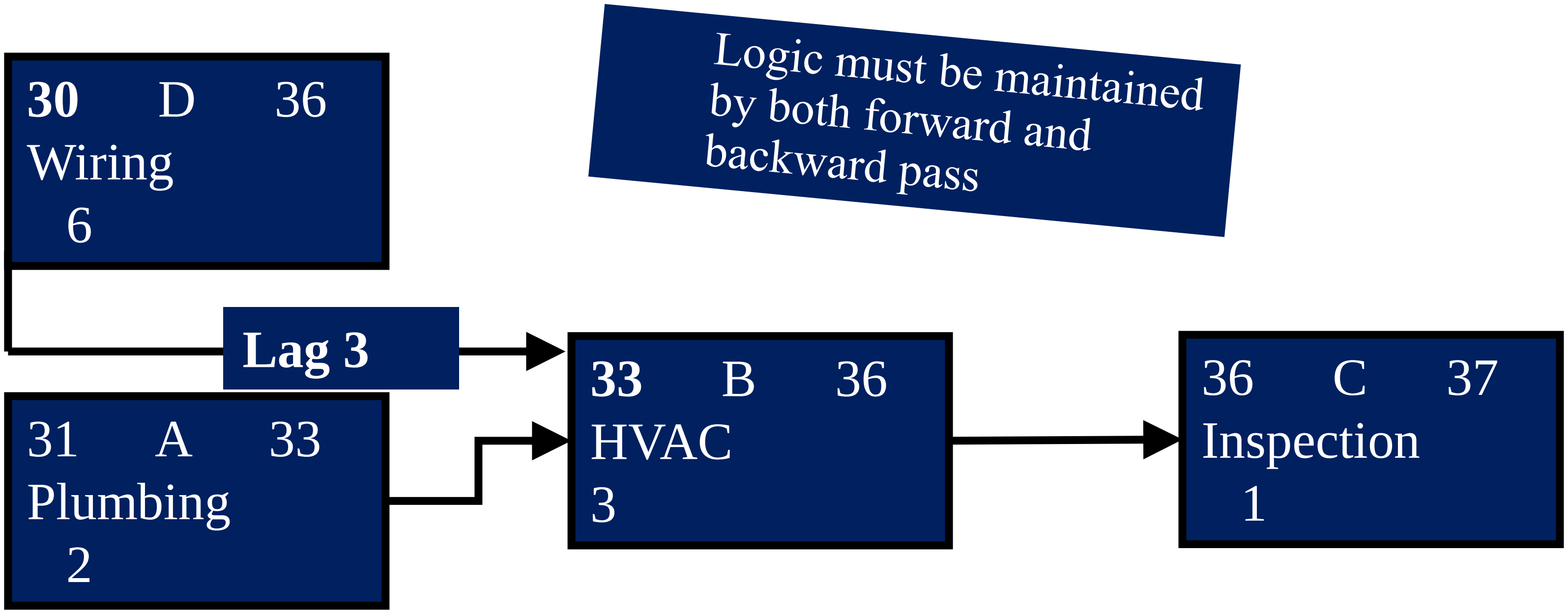
Finish to Finish Lag:

Two activities share a similar completion point

- The mechanical inspection cannot happen until wiring, plumbing, and HVAC installation are complete

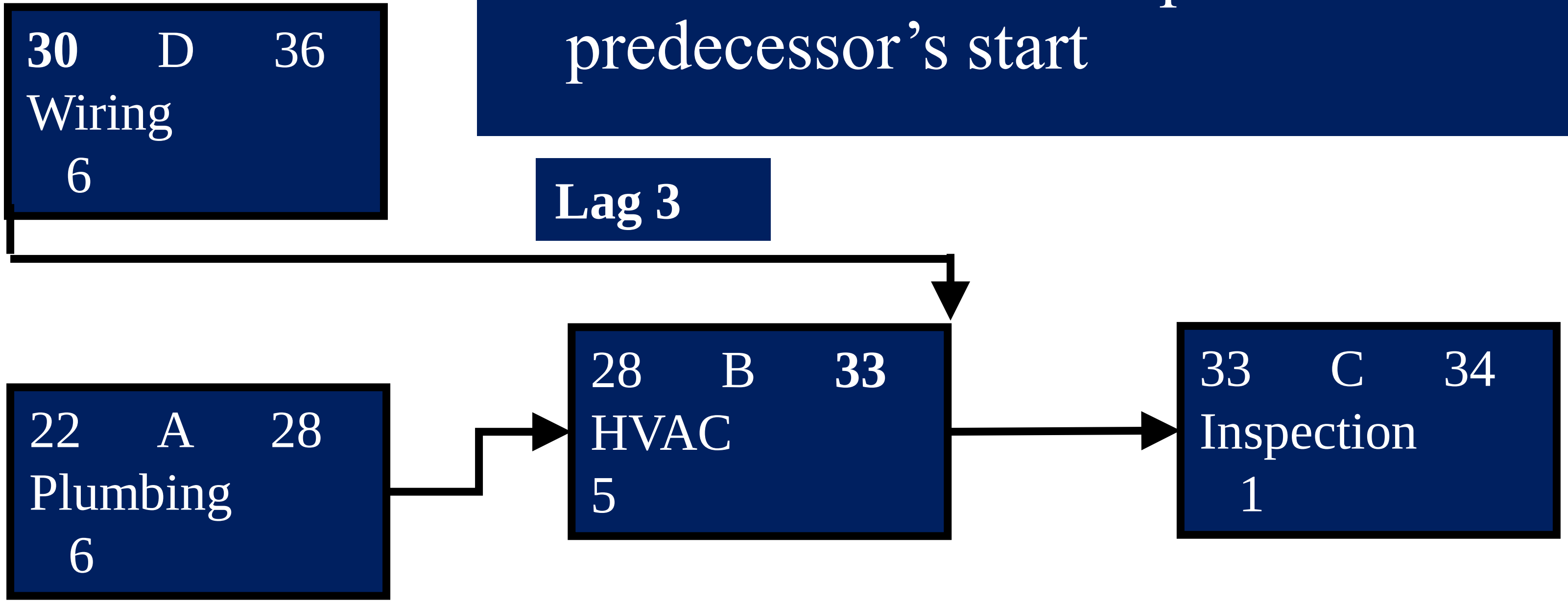


Start to Start Lag

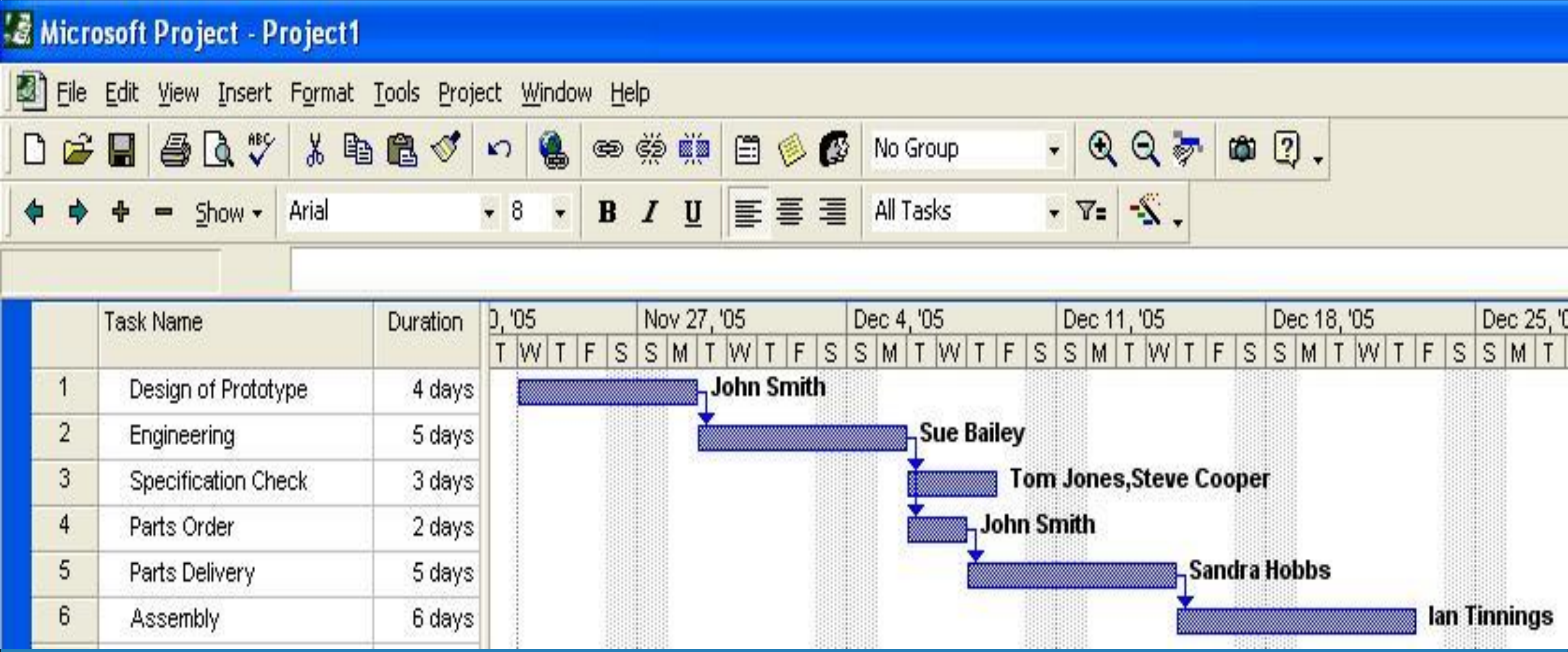


Start to Finish Lag

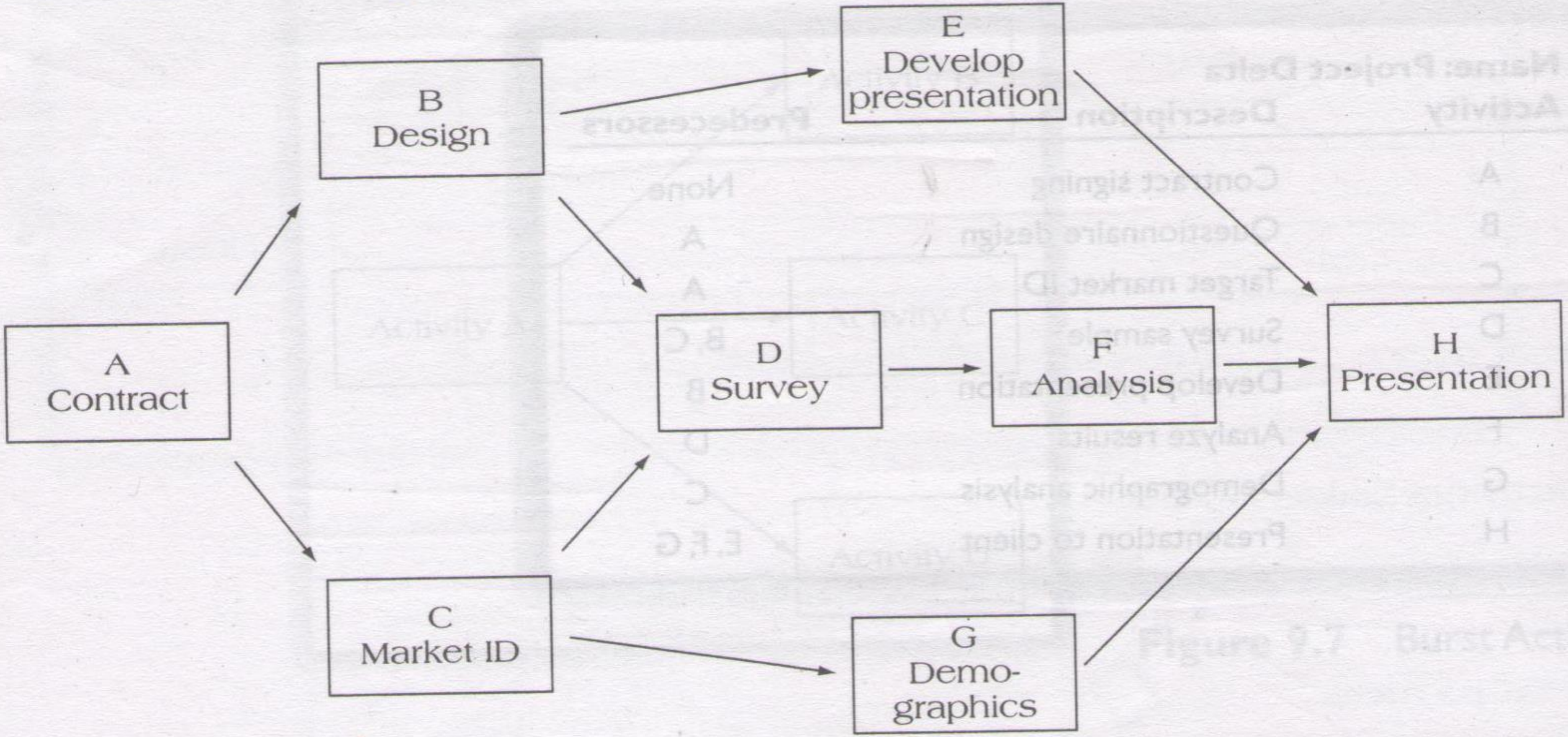
- Least common type of lag relationship
- Successor’s finish dependent on predecessor’s start

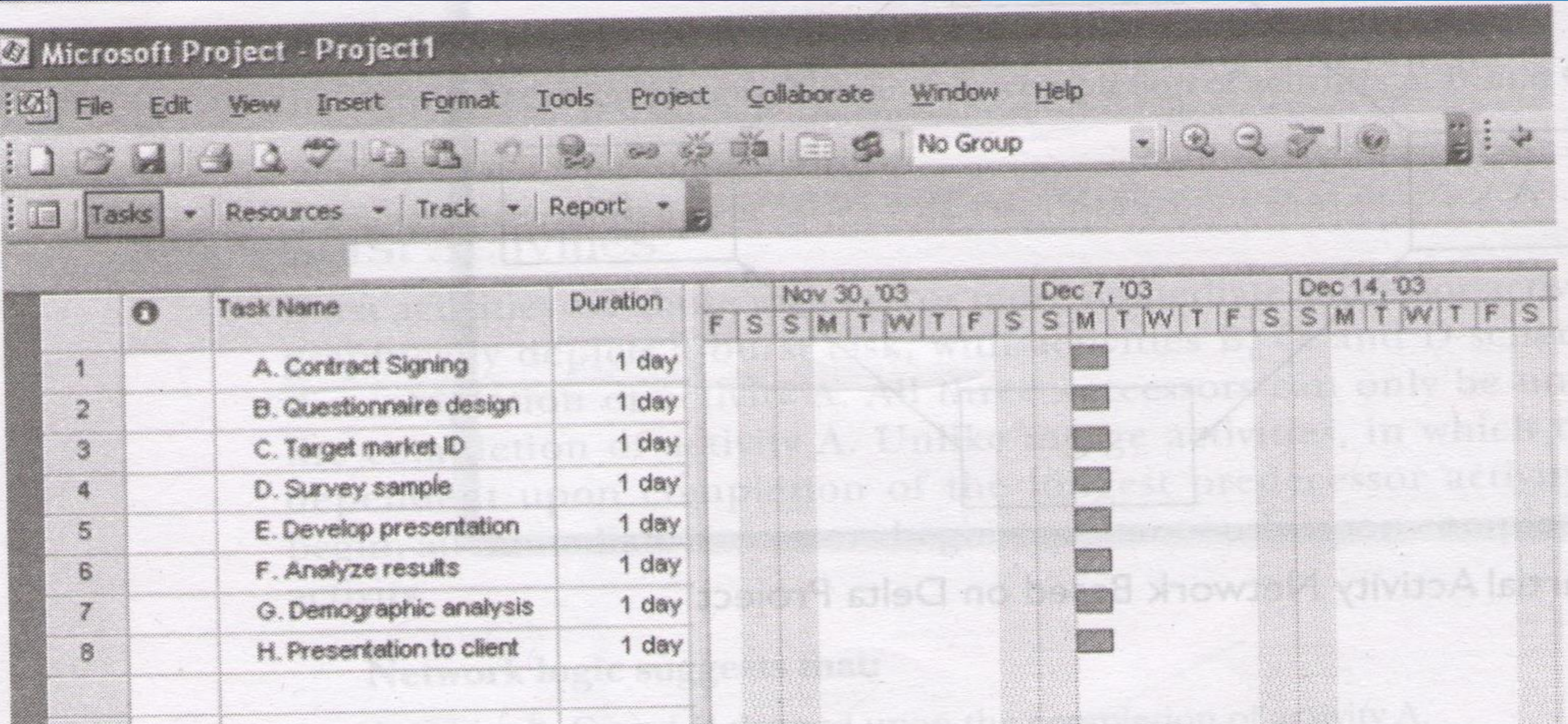


Gantt Chart With Resources in MS Project

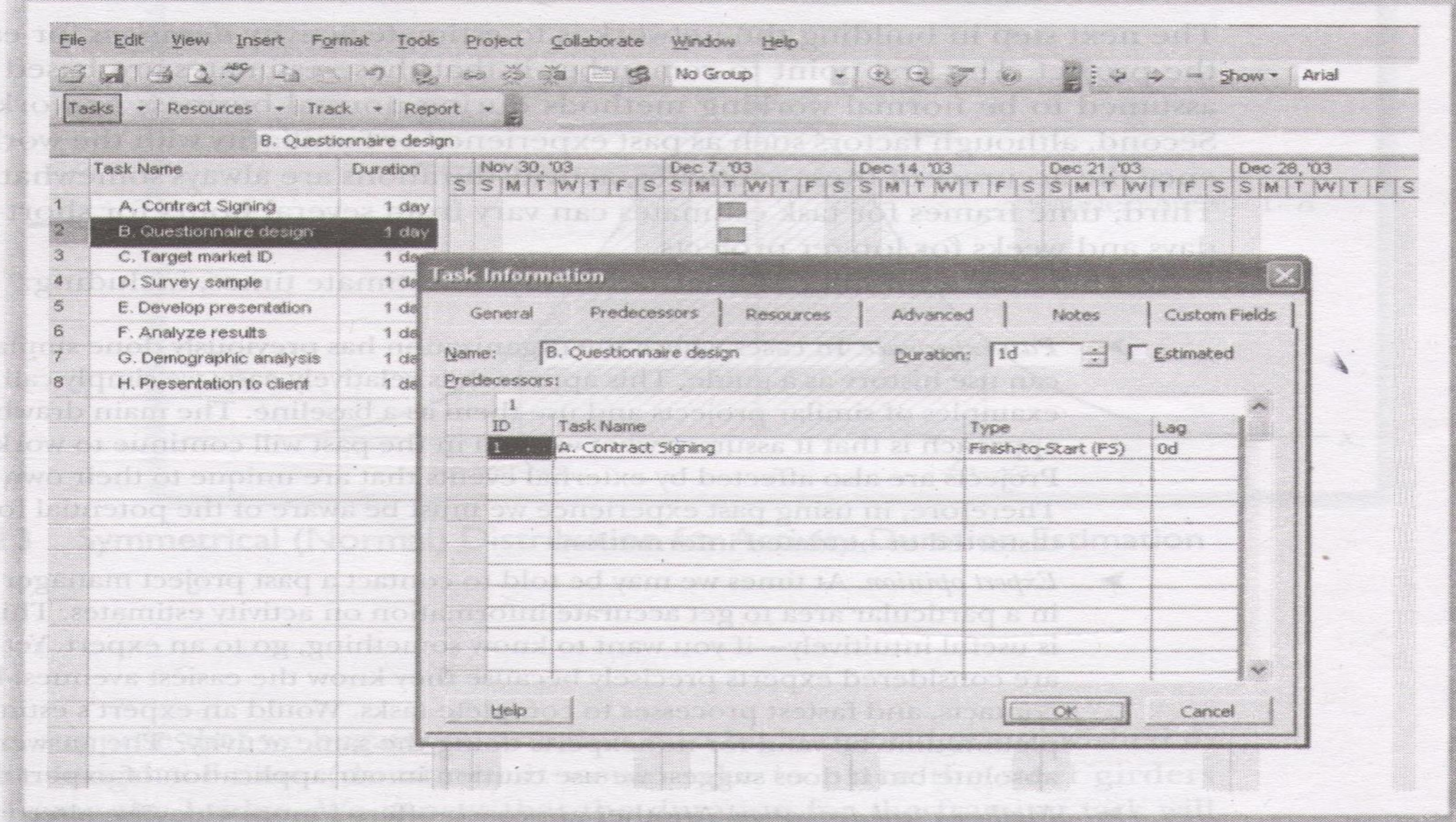


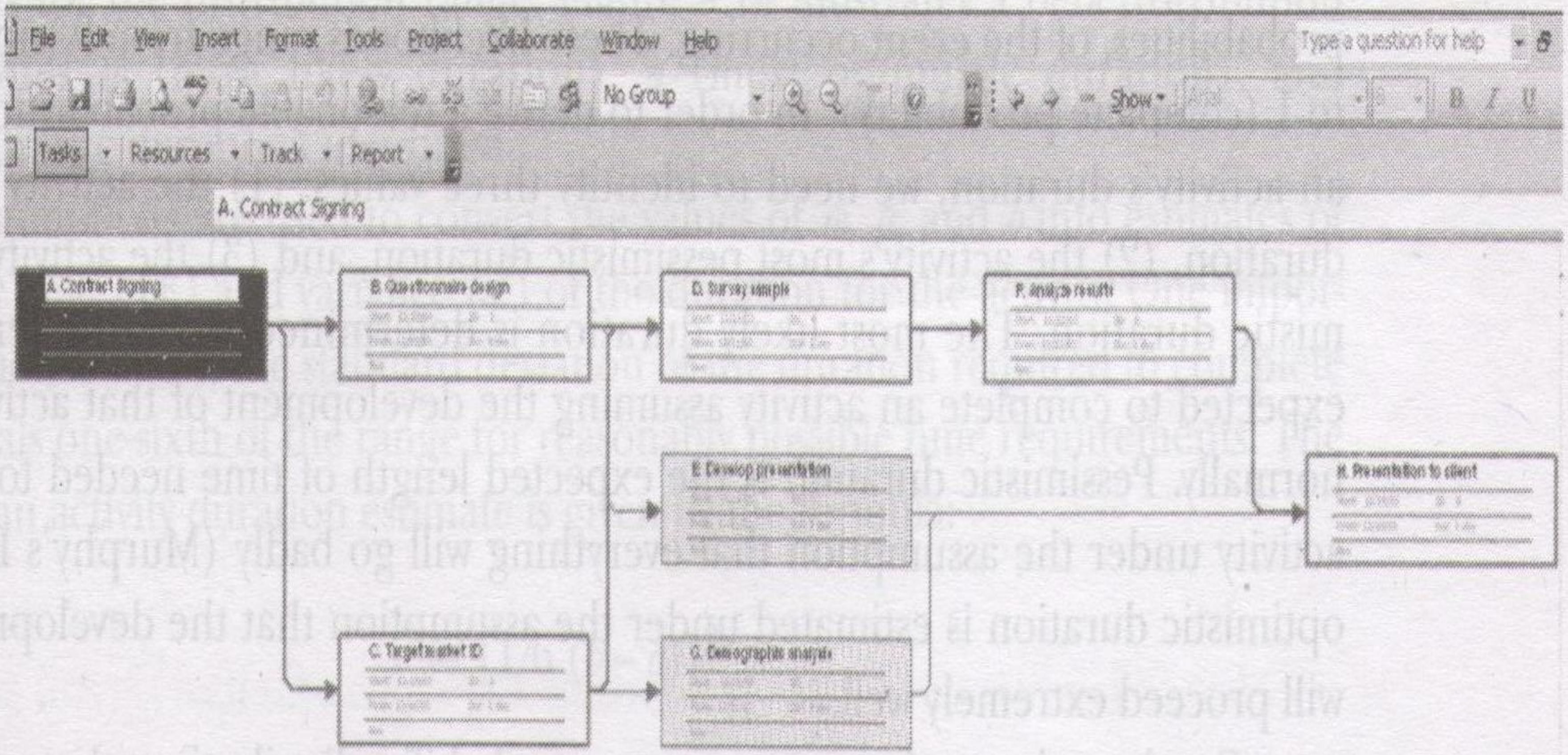
Activity	Description	Predecessors
A	Contract signing	None
B	Questionnaire design	A
C	Target market	A
D	Survey sample	B,C
E	Develop presentation	B
F	Analyze results	D
G	Demographic analysis	C
H	Presentation to client	E,F,G


E
Develop
presentation
B
Design
A
Contract
D
Survey
F
Analysis
H
Presentation
C
Market ID
G
Demo-
graphics



Duration is one day by default


File Edit View Insert Format Tools Project Collaborate Window Help
No Group
Show
Arial
Tasks Resources Track Report
B. Questionnaire design
Task Name
Duration
Nov 30, '03
Dec 7, '03
Dec 14, '03
Dec 21, '03
Dec 28, '03
1 A. Contract Signing 1 day
2 B. Questionnaire design 1 day
3 C. Target market ID
4 D. Survey sample
5 E. Develop presentation
6 F. Analyze results
7 G. Demographic analysis
8 H. Presentation to client
Task Information
General
Predecessors
Resources
Advanced
Notes
Custom Fields
Name: B. Questionnaire design
Duration: 1d
Estimated
Predecessors:
ID
Task Name
Type
Lag
1 A. Contract Signing Finish-to-Start (FS) 0d
Help
OK
Cancel


File Edit View Insert Format Tools Project Collaborate Window Help
Type a question for help
No Group
Show
Tasks Resources Track Report
A. Contract Signing
A. Contract Signing
B. Questionnaire design
D. Survey sample
F. Analyze results
E. Develop presentation
H. Presentation to client
C. Target market ID
G. Demographic analysis

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Project Management for Managers

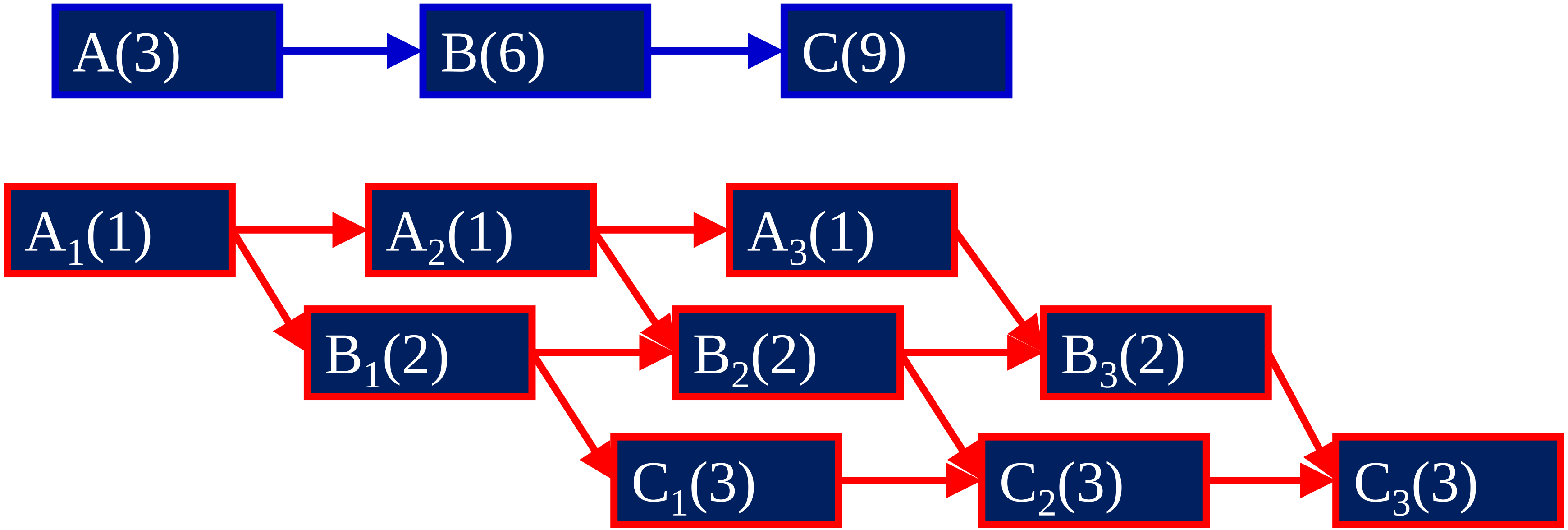
Lec – 38

Project Time Management – Laddering in PERT/CPM

Dr. M.K. Barua
Department of Management
Indian Institute of Technology Roorkee

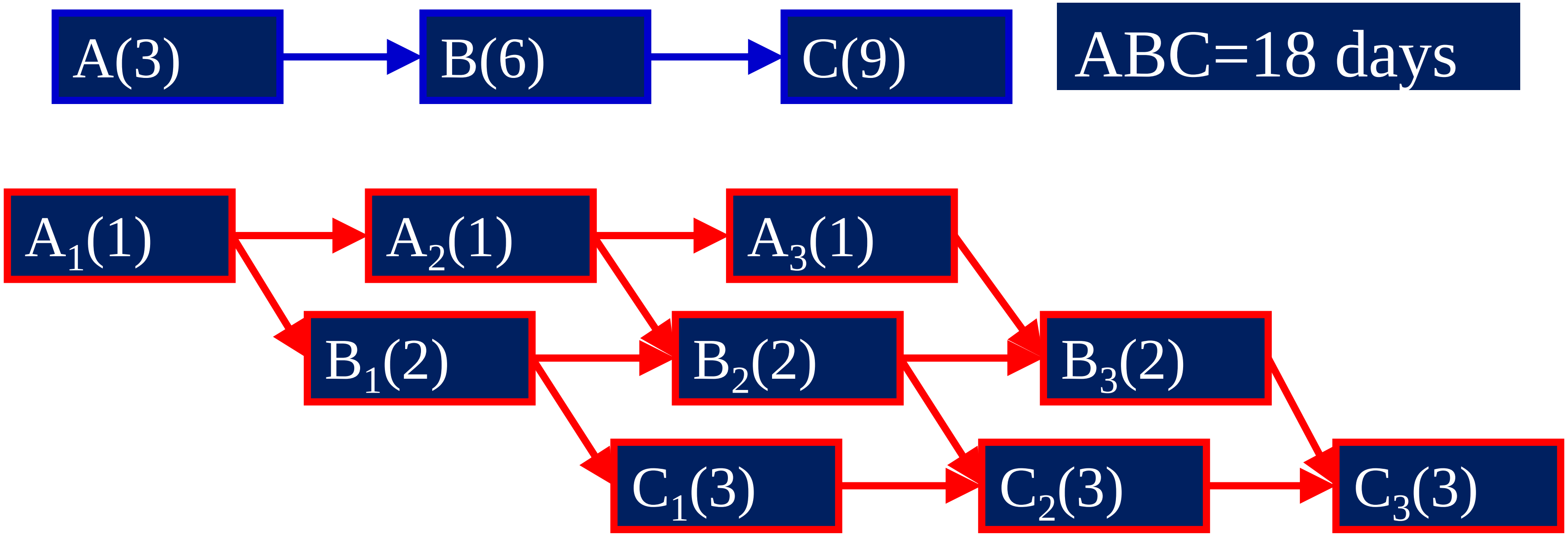
Laddering: Laddering is a technique that allows us to redraw the activity network to more closely sequence **project subtasks** to make the overall network **sequence more efficient**. It also helps in keeping project **resources fully employed.**

Project ABC (Design, Coding , Debugging) can be completed more efficiently if subtasks are used.



Laddered ABC=???? days

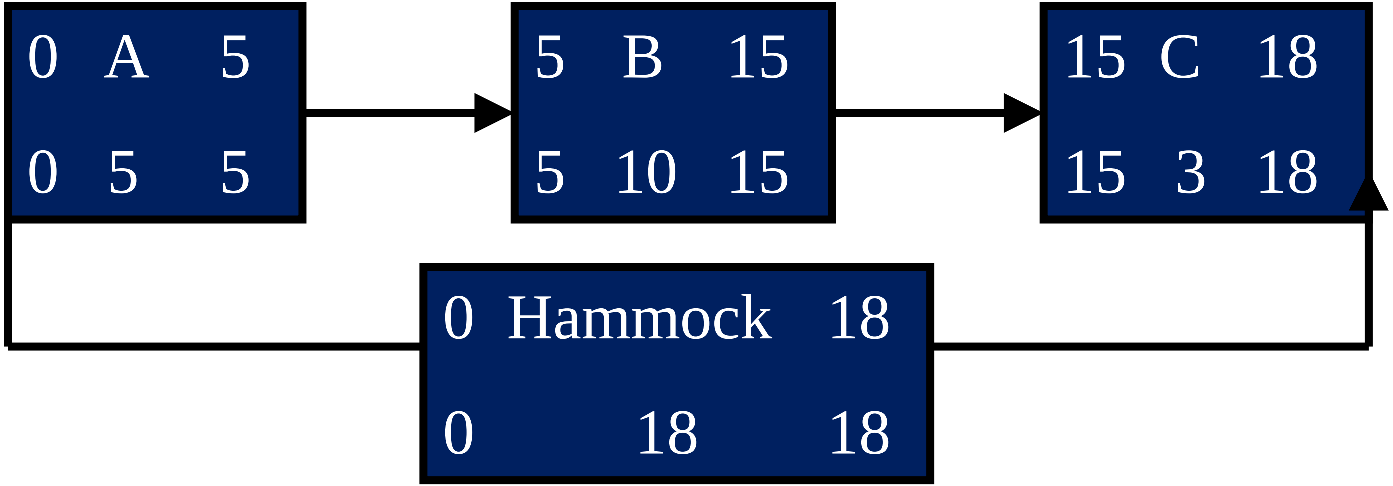
Project ABC (Design, Coding , Debugging) can be completed more efficiently if subtasks are used



Laddered ABC=C1 can be only be started on 4 day (after 3 days)

= 3+3+3+3=12

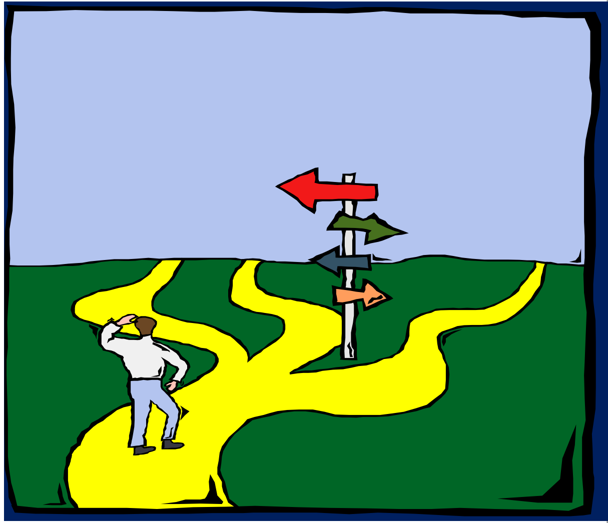
Hammock Activities: Can be used to summaries for some **subset of the activities** identified in the overall project network. It summarize tasks ,duration, and cost. The hammock is so named because it hangs **below**

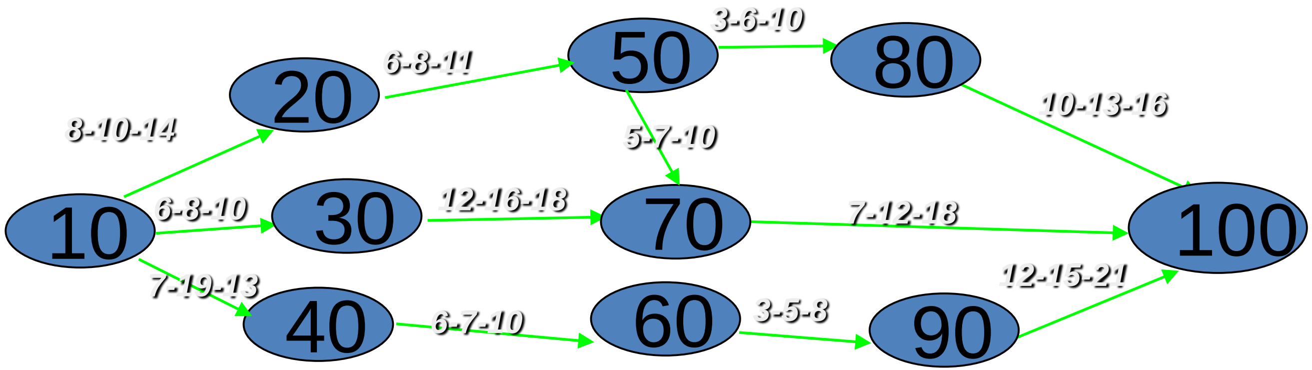


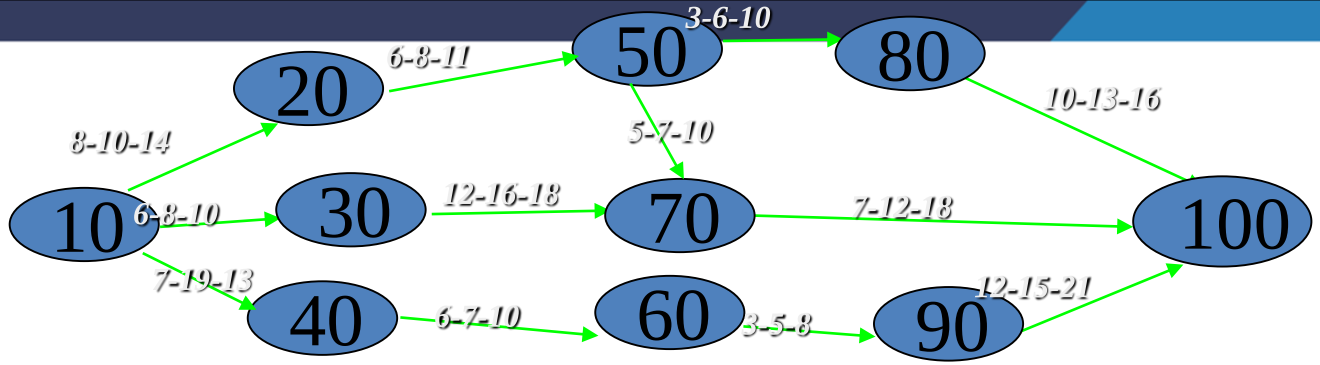
Useful with a complex project or one that has a shared budget

Critical Path

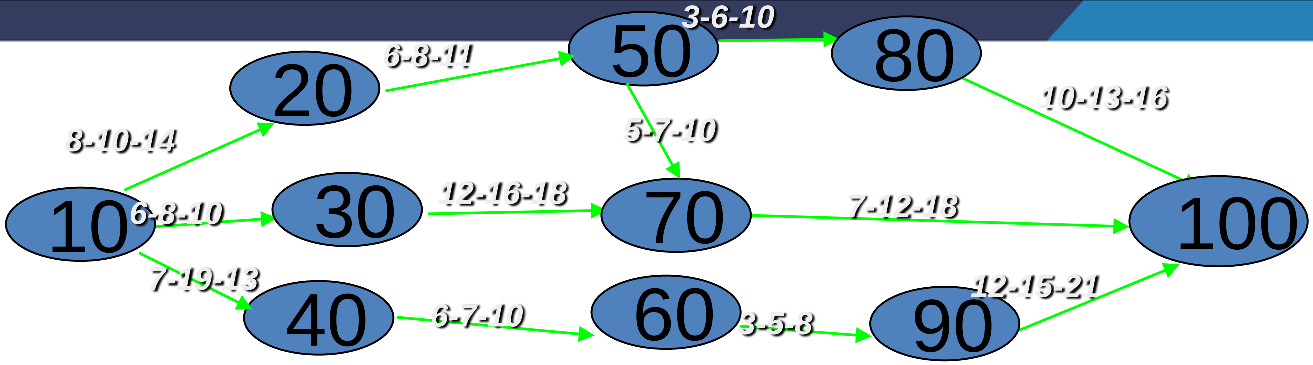
- ✓ ***A path is a sequence of connected activities running from start to end node in network***
- ✓ ***The critical path is the path with the <u>longest duration</u> in the network***
- ✓ ***Project cannot be completed in <u>less than the time</u> of the critical path***



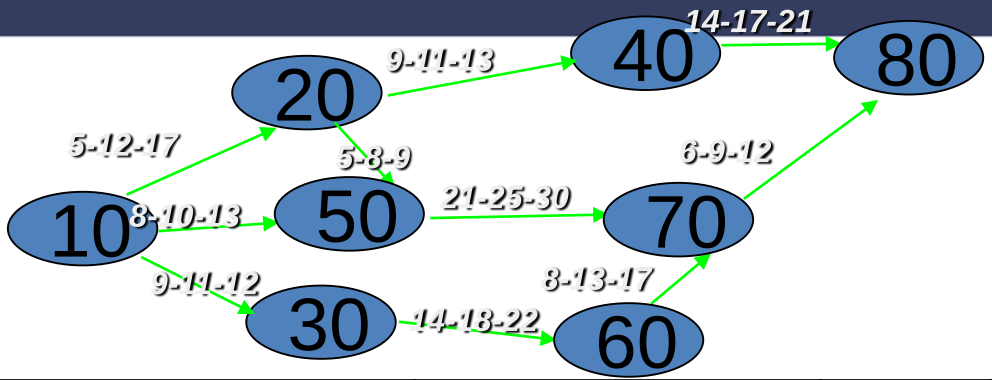

10
20
30
40
50
60
70
80
90
100
8-10-14
6-8-10
7-19-13
6-8-11
12-16-18
6-7-10
3-6-10
5-7-10
3-5-8
10-13-16
7-12-18
12-15-21



	Activity	to	tm	tp	te	Sum of - te's
Path - A	10-20	8	10	14	?	?
	20-50	6	8	11	?	
	50-80	3	6	10	?	
	80-100	10	13	16	?	
Path - B	10-20	8	10	14	?	?
	20-50	6	8	11	?	
	50-70	5	7	10	?	
	70-100	7	12	18	?	
Path - C	10-30	6	8	10	?	?
	30-70	12	16	18	?	
	70-100	7	12	18	?	
Path- D	10-40	7	9	13	?	?
	40-60	6	7	10	?	
	60-90	3	5	8	?	
	90-100	12	15	21	?	



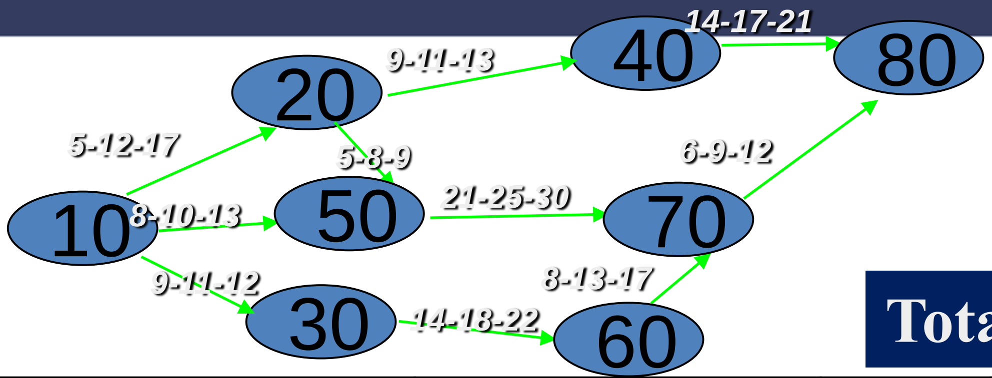
	Activity	*to*	*tm*	*tp*	*te*	*Sum of - te's*
Path - A	*10-20*	*8*	*10*	*14*	*10.33*	*37.67*
	20-50	*6*	*8*	*11*	*8.17*	
	50-80	*3*	*6*	*10*	*6.17*	
	80-100	*10*	*13*	*16*	*13.00*	
Path - B	*10-20*	*8*	*10*	*14*	*10.33*	***37.84*** ***(Critical Path)***
	20-50	*6*	*8*	*11*	*8.17*	
	50-70	*5*	*7*	*10*	*7.17*	
	70-100	*7*	*12*	*18*	*12.17*	
Path - C	*10-30*	*6*	*8*	*10*	*8.00*	*35.84*
	30-70	*12*	*16*	*18*	*15.67*	
	70-100	*7*	*12*	*18*	*12.17*	
Path- D	*10-40*	*7*	*9*	*13*	*9.34*	*37.34*
	40-60	*6*	*7*	*10*	*7.33*	
	60-90	*3*	*5*	*8*	*5.17*	
	90-100	*12*	*15*	*21*	*15.50*	



$$te = (to+4tm+tp)/6$$

$$(\sigma)^2 = ((tp-to)/6)^2$$

Predecessor event	*Successor event*	*to*	*tm*	*tp*	*te*	$(\sigma)^2$
10	***20***	*5*	*12*	*17*	***?***	*?*
10	*30*	*9*	*11*	*12*	***?***	*?*
10	*50*	*8*	*10*	*13*	***?***	*?*
20	*40*	*9*	*11*	*13*	***?***	*?*
20	***50***	*5*	*8*	*9*	***?***	*?*
30	*60*	*14*	*18*	*22*	***?***	*?*
40	*80*	*14*	*17*	*21*	***?***	*?*
50	***70***	*21*	*25*	*30*	***?***	*?*
60	*70*	*8*	*13*	*17*	***?***	*?*
70	***80***	*6*	*9*	*12*	***?***	*?*



$$te = (to+4tm+tp)/6$$

$$(\sigma)^2 = ((tp-to)/6)^2$$

Total "te" along critical path??

Predecessor event	Successor event	to	tm	tp	te	(σ)2
10	20	5	12	17	11.66	4
10	30	9	11	12	10.83	.25
10	50	8	10	13	10.17	.69
20	40	9	11	13	11	.44
20	50	5	8	9	7.67	.44
30	60	14	18	22	18	1.78
40	80	14	17	21	17.17	1.36
50	70	21	25	30	25.18	2.25
60	70	8	13	17	12.83	2.25
70	80	6	9	12	9	1

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Project Management for Managers

Lec – 39

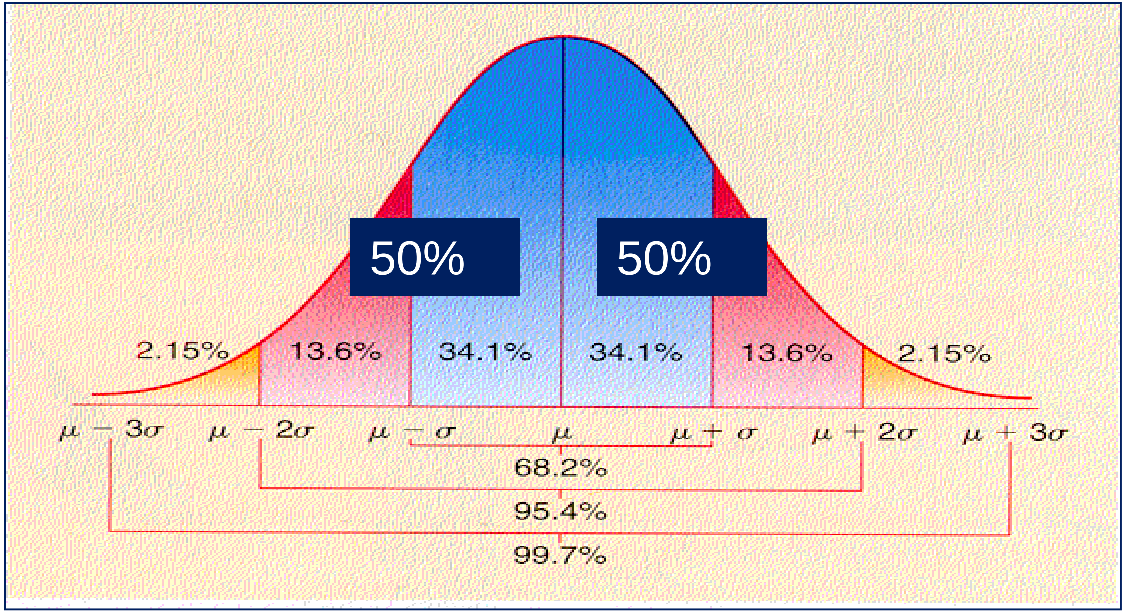
Probability Models in Networks - I

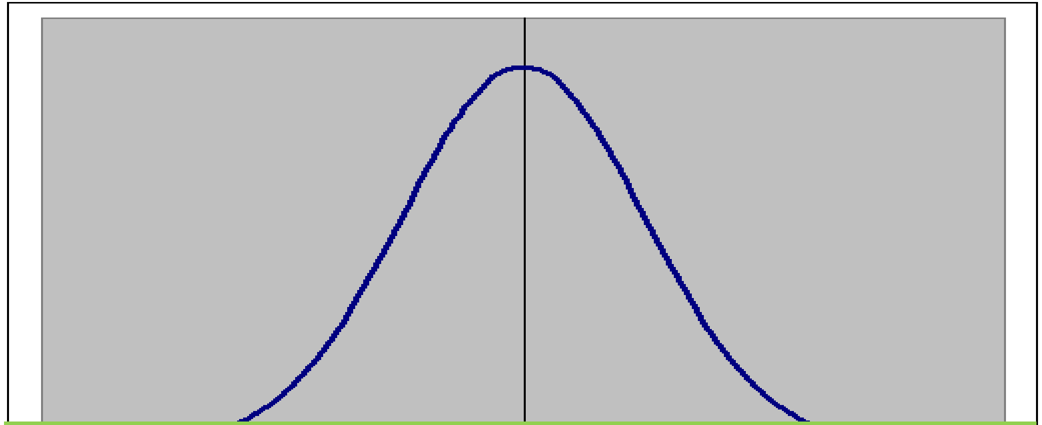
Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

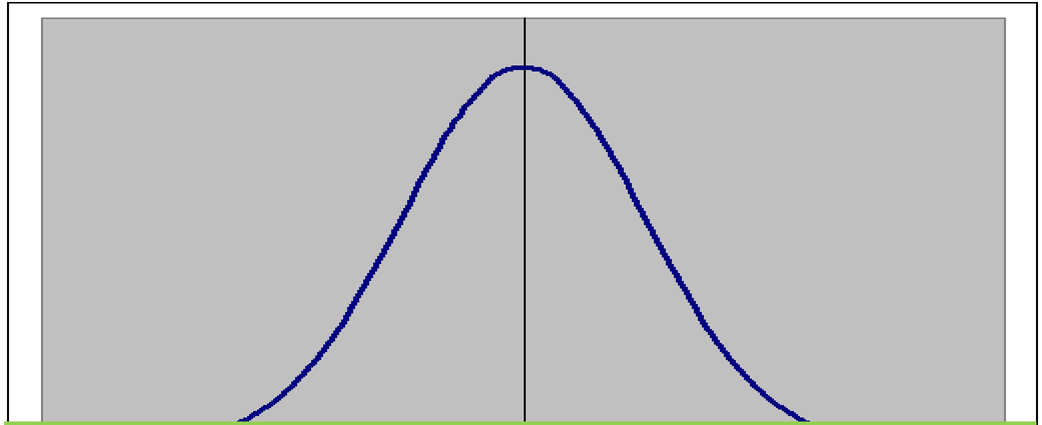
Probability of achieving a project on completion date.:





Te = Ts

If Ts as “"1 σ” towards left of Te than the area under curve would be ????and if it is “1 σ” towards right of Te, the areas would be ?????%.

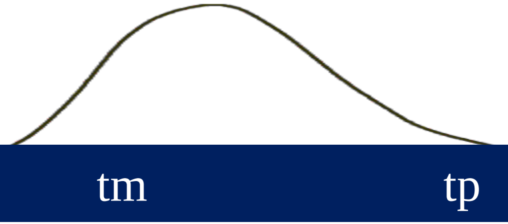


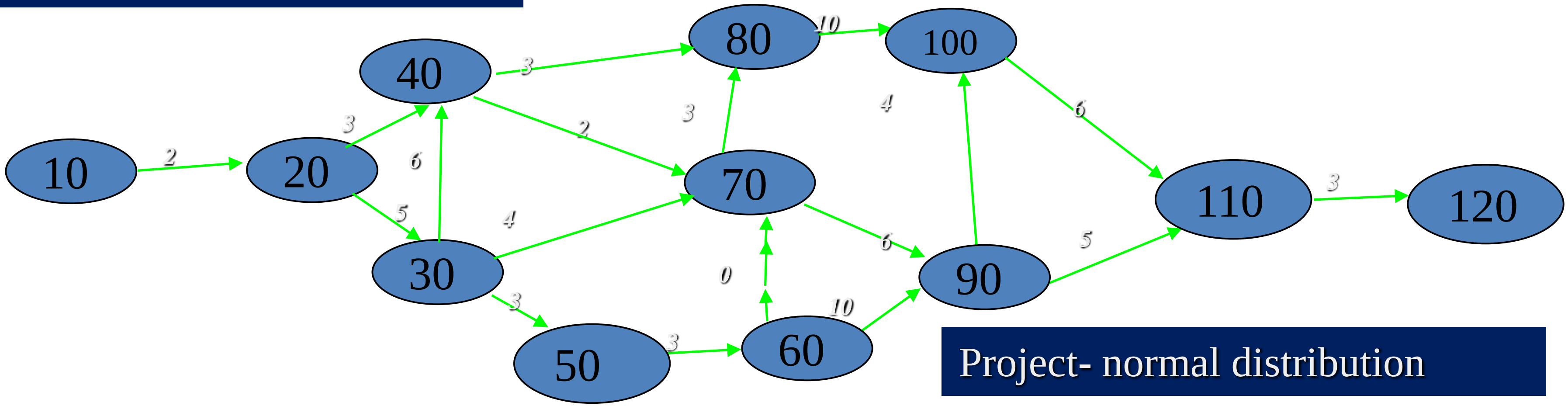
Te= Ts

If Ts as 1 σ towards left of Te than area under the curve would be 15.9% and if it is 1 σ towards right of Te, the areas would be 84.1%.

Central limit theorem: Relationship b/w shape of population distribution and shape of sampling distribution of mean is called CLT.

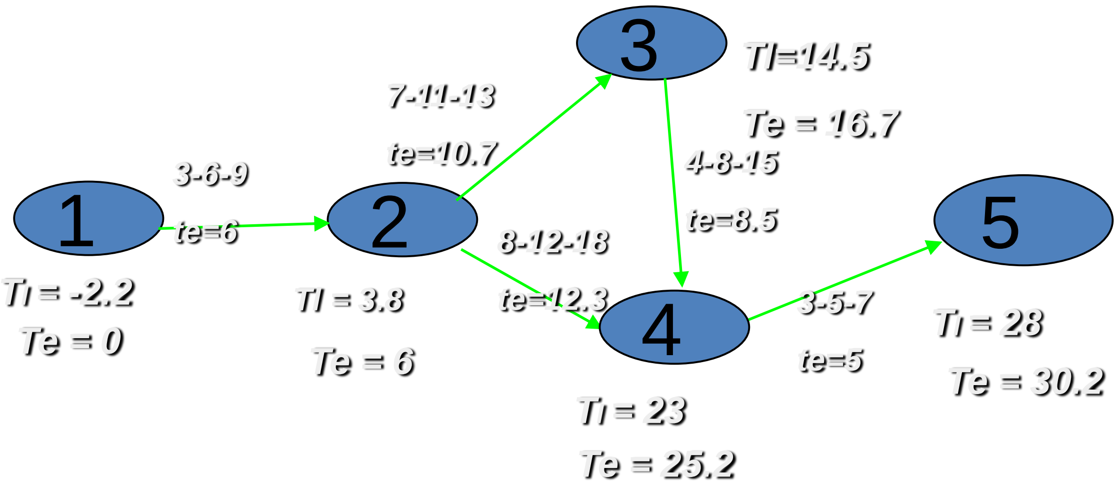
Activity –β distribution

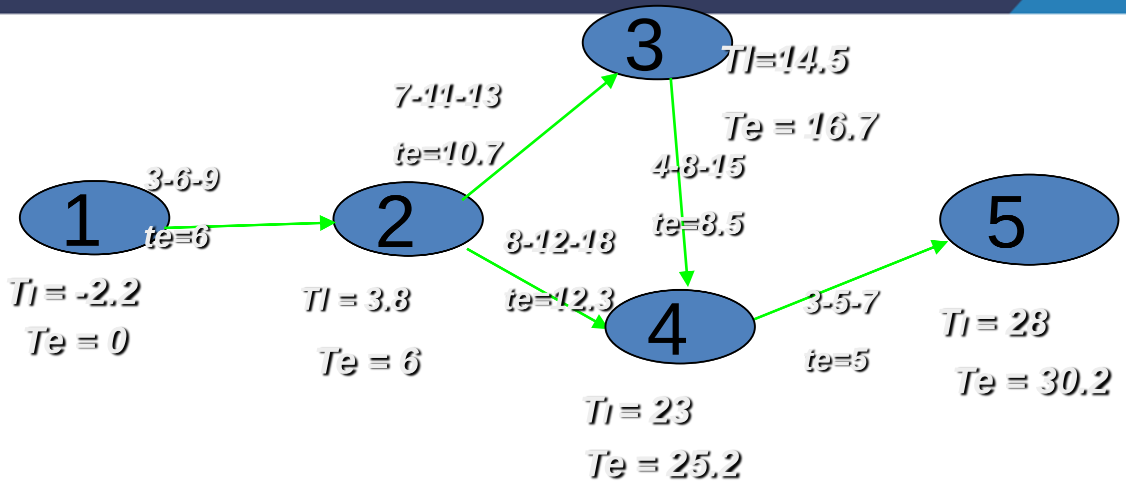




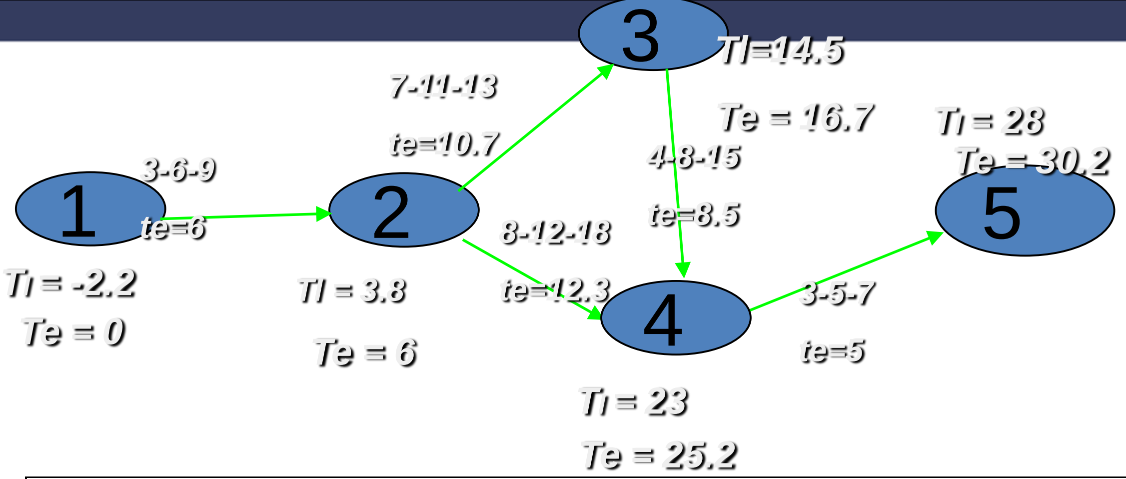
Project- normal distribution

Find critical path and variance along critical path. What is the probability that the project will be completed in 28 days?.

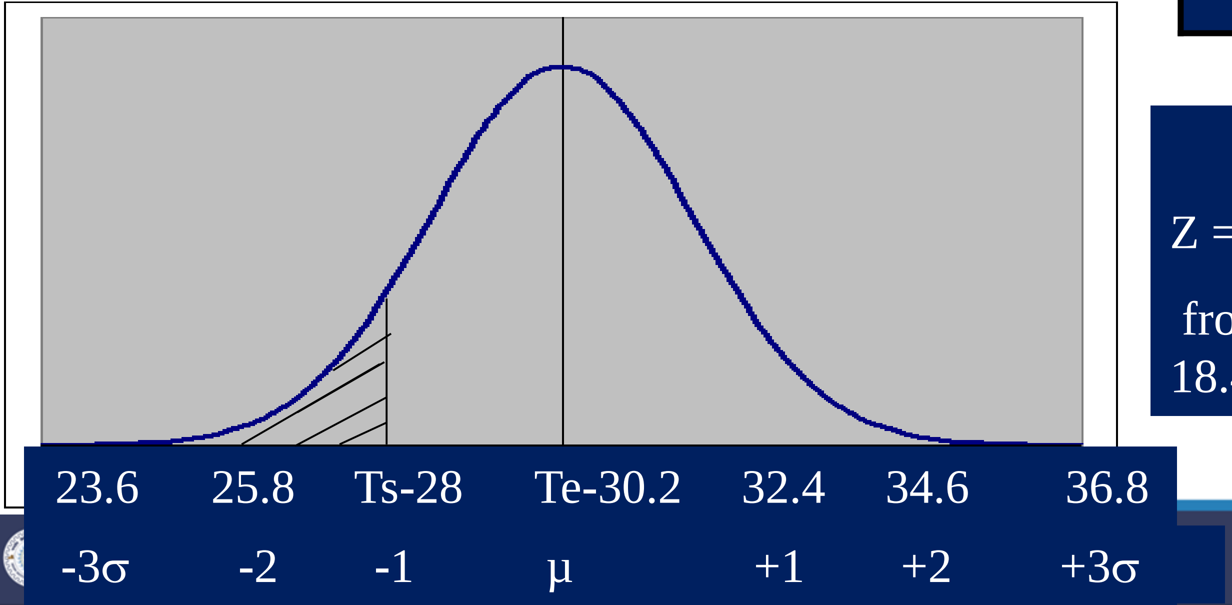




Activity	to	tp	$(\sigma)^2$
1-2	3	9	1
2-3	7	13	1
3-4	4	15	3.36
4-5	3	7	.44
Variance along Critical Path			5.8

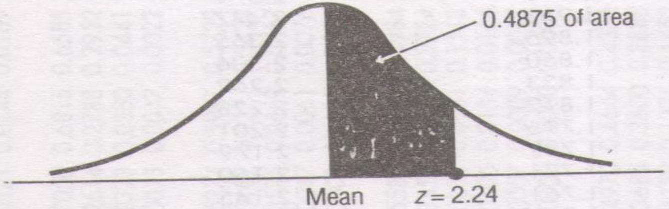


Activity	to	tp	(σ) 2
1-2	3	9	1
2-3	7	13	1
3-4	4	15	3.36
4-5	3	7	.44
Variance along Critical Path			5.8



Z = Ts-Te/ (σ) = -2.2/2.41 = -0.91

from z table the area under curve is 18.4%.



Appendix Table 1

Areas under the Standard Normal Probability Distribution between the Mean and Positive Values of z

Example:
To find the area under the curve between the mean and a point 2.24 standard deviations to the right of the mean, look up the value opposite 2.2 and under 0.04 in the table; 0.4875 of the area under the curve lies between the mean and a **z** value of 2.24.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

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Project Management for Managers

Lec – 40

Probability Models in Networks - II

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The distributions of durations of different activities, as assessed by project incharge are as follows.

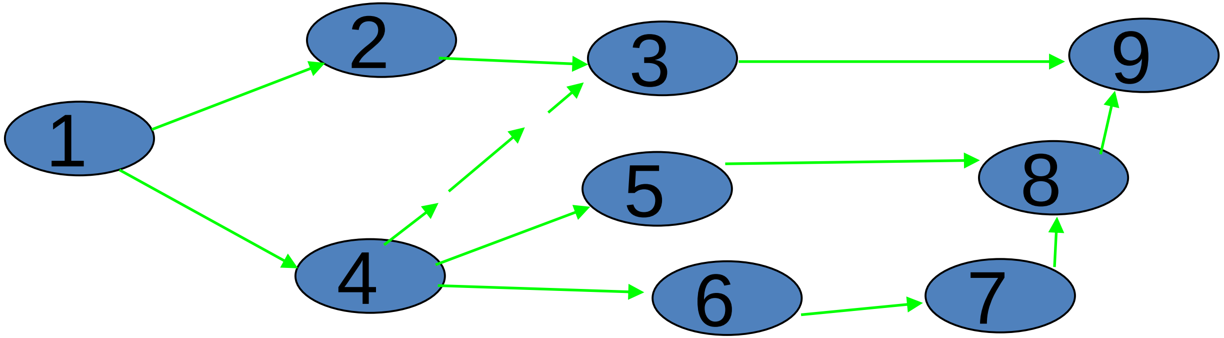
T12	**has normal distribution with to = 3 and tp =9**
T23	**has normal distribution with to = 4 and tp =16**
T39	**has normal distribution with to = 8 and tp =16**
T46	**has normal distribution with to = 4 and tp =10**
T58	**has constant distribution (duration) with 5 days.**
T89	**has constant distribution (duration) with 4 days.**
T34	**is a dummy activity.**

T45	Prob.
3	.2
4	.3
5	.4
6	.1

T14	Prob.
16	.25
17	.50
18	.25

T67	Prob.
4	.5
5	.5

T78	Prob.
5	.4
6	.6



Find critical path variance along it.

What is the probability that the project will be completed in less than or 40 days.

Find out <u>expected</u> value and <u>variance</u> for all the activities.

If we have an activity (i,j) assumed to have a normal distribution with tp = 9 and to = 3, then we fit normal distribution to the activity.

$\mu = E(X) = (tp+to)/2$ and $\sigma = (tp-to)/6$.

T12 has normal distribution with to = 3 and tp =9

Expected duration of $E(T12) = 6$ and $\sigma^2 = (9-6)/6 = 1$.

Similarly,

expected duration of $E(T23)$ (4,16) = 10 and $\sigma^2 = 4$

expected duration of $E(T39)$ (8,16) = 12 and $\sigma^2 = 16/9$

expected duration of $E(T46)$ (4,10) = 7 and $\sigma^2 = 1$

For the activities with constant duration, we have

$E(T58) = 5$ and $\sigma^2 = 0$.

$E(T89) = 4$ and $\sigma^2 = 0$, and for dummy $E(T43) = \sigma^2 = 0$,

Now find expected value and variance of an activity with discrete distribution.

$E(T14) = 16*.25+17*.50+18*.25 = 17$

T14	Prob.
16	.25
17	.50
18	.25

After finding E (T14) = 17, the variance of T14 is

$$V^2\,14 = E\,(T14 - E(T14))^2$$

$$= E\,(T14 - 17)^2$$

$$= E\,(16-17)^2 = 1$$

$$= E\,(17-17)^2 = 0$$

$$= E\,(18-17)^2 = 1$$

$(T14-17)^2$:	1	0	1
Prob.:	.25	.5	.25

$$(V14)^2 = 1*.25+0*.5+1*.25 = 0.5$$

T14	Prob.
16	.25
17	.50
18	.25

$E(T45) = .6 + 1.2 + 2 + .6 = 4.4$

$V^2\ 45 = E\,(T45 - E(T45))^{2}$

$= E\,(T45 - 4.4)^2$

$= E\,(3 - 4.4)^2 = 1.96$

$= E\,(4 - 4.4)^2 = .16$

$= E\,(5 - 4.4)^2 = .36$

$= E\,(6 - 4.4)^2 = 2.56$

T45	Prob.
3	.2
4	.3
5	.4
6	.1

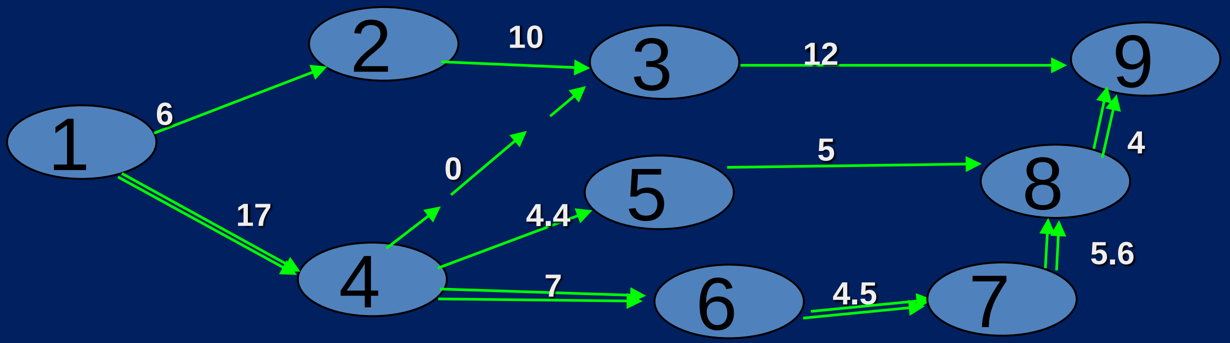
$(T45-4.4)^2$:	1.96	.16	.36	2.56
Prob.:	.2	.3	.4	.1

$V^2\ 45 = 1.96 * .2 + .16 * .3 + .6 * .4 + 2.56 * .1 = .84$

For activity 6-7, E(67) and V2 (67) = 4.5 and .25 and

for activity 7-8 , E(78) and V2 (78) = 5.6 and .24

After finding expected values and variance for all the activities find critical path.



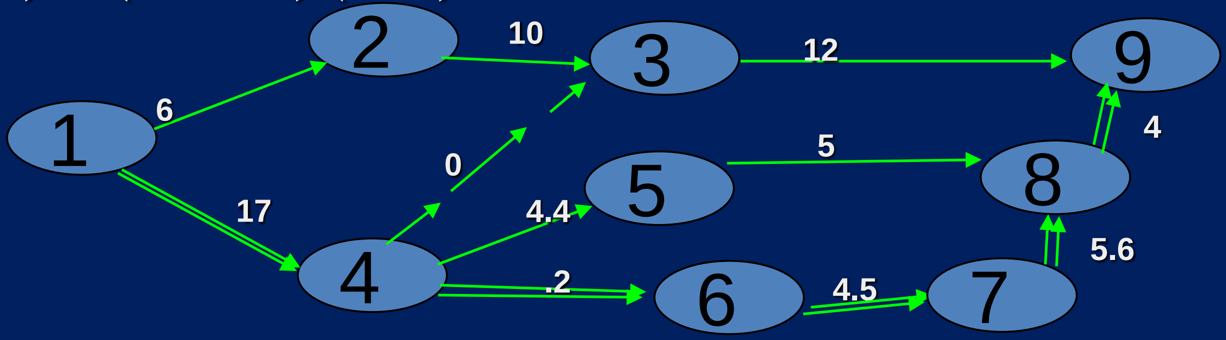
The project duration is 38.1

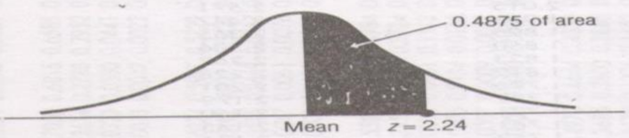
he project duration is : 1-4-6-7-8-9= 17+7+4.5+5.6+4= 38.1 and

Variance: 1-4-6-7-8-9

0.5+1+.25+0.24+0 =1.99 and Std Dev = 1.41

P (T<= 40) = (40-38.1)/(1.41) = 1.35





Appendix Table 1

Areas under the Standard Normal Probability Distribution between the Mean and Positive Values of z

Example: To find the area under the curve between the mean and a point 2.24 standard deviations to the right of the mean, look up the value opposite 2.2 and under 0.04 in the table; 0.4875 of the area under the curve lies between the mean and a z value of 2.24.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

.50+0.4115=0.91 =91%

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Probability Models in Networks - III

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Probability Models in Networks - IV

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Lec – 43

Simulation of Networks- I

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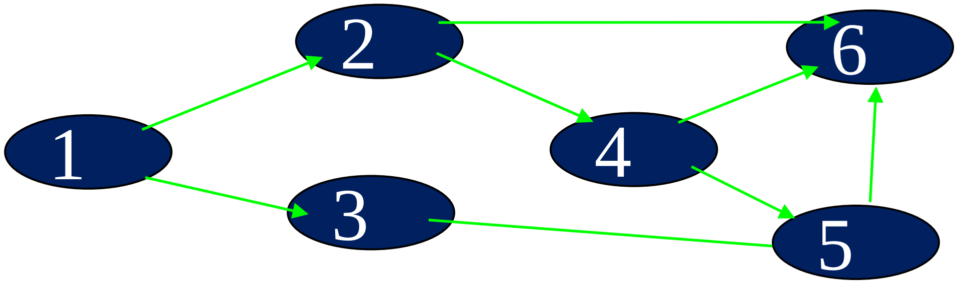
Simulation of PERT network.



The person in charge of the activity feels there is

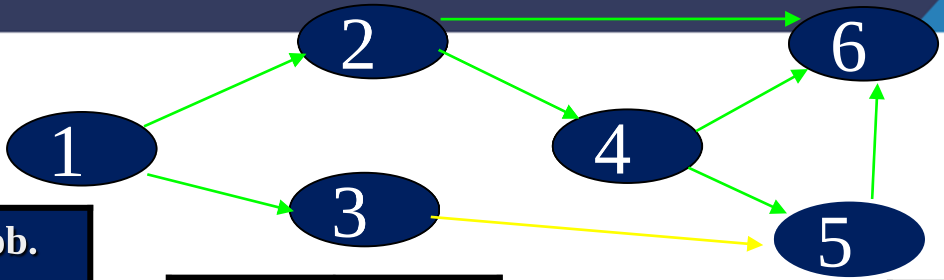
a chance of 20 % that the activity 1-2 will be over in 5 days,

and a 30% chance of completion in 6 days,

a 30% chance of completion in 7 days and

a 20% chance of completion in 8 days.

Let $T_{1\text{-}2}$ be the random variable which denotes the duration of activity 1-2. The probability distribution of $T_{1\text{-}2}$ is shown in table.



Find the duration of this project?

1-2	Prob.
5	0.2
6	0.3
7	0.3
8	0.2

4-5	Prob.
6	0.3
7	0.6
8	0.1

1-3	Prob.
12	.05
13	0.2
14	0.5
15	0.2
16	0.05

2-4	Prob.
6	0.2
7	0.6
8	0.2

3-5	Prob.
4	0.15
5	0.7
6	0.15

5-6	Prob.
7	0.3
8	0.4
9	0.3

2-6	Prob.
8	0.1
9	0.4
10	0.4
11	0.1

4-6	Prob.
13	0.1
14	0.2
15	0.5
16	0.1
17	0.1

Now we generate random sample for Tij. Let F ij(x) denote the cumulative distribution function (cdf) of Tij that is

$F_{ij}(x) = P(T_{ij} \le x)$

1-2	Prob.
5	0.2
6	0.3
7	0.3
8	0.2

From table we find that

$$F_{12}(x) = \begin{cases} 0 & x<5 \\ .2 & 5 \le x < 6 \\ .5 & 6 \le x < 7 \\ .8 & 7 \le x < 8 \\ 1.0 & 8 \le x \end{cases}$$

Equation (1)

Let "u" be the random variable which is distributed uniformly over (0,1). Since F ij(x) is uniformly distributed over (0,1) it can be proved that equation (1) implies

$0 \le u < .2$	corresponds to Tij = 5
$.2 \le u < .5$	corresponds to Tij = 6
$.5 \le u < .8$	corresponds to Tij = 7
$.8 \le u < 1$	corresponds to Tij = 8

.07	.01	.85	.24	.44	.72	.16	.11	.79	.18
.13	.62	.32	.74	.20	.96	.03	.96	.82	.82

The following will the times for activity 1-2 .

5	5	8	6	6	7	5	5	7	5
5	7	6	7	6	8	5	8	8	8

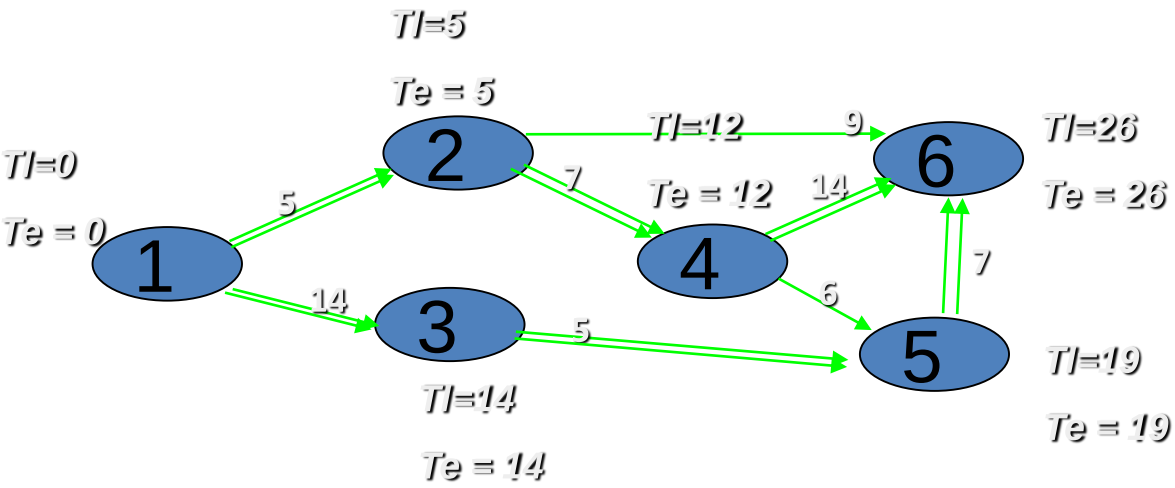
Similarly generate times for other activities.

SN	RN	T12
1	.07	5
2	.01	5
3	.85	8
4	.24	6
5	.44	6
6	.72	7
7	.16	5
8	.11	5
9	.79	7
10	.18	5
11	.13	5
12	.62	7
13	.32	6
14	.74	7
15	.20	6
16	.96	8
17	.03	5
18	.96	8
19	.82	8
20	.82	8

SN	RN	T12	RN	T13	RN	T24	RN	T35	RN	T26	RN	T45	RN	T46	RN	T56
1	.07	5	.54	14	.41	7	.19	5	.34	9	.09	6	.17	14	.21	7
2	.01	5	.26	14	.78	7	.19	5	.96	11	.23	6	.29	14	.33	8
3	.85	8	.26	14	.69	7	.34	5	.89	10	.71	7	.55	15	.89	9
4	.24	6	.62	14	.56	7	.90	6	.96	11	.10	6	.93	17	.88	9
5	.44	6	.90	15	.27	7	.17	5	.96	11	.07	6	.38	15	.88	9
6	.72	7	.53	14	.98	8	.76	5	.55	10	.60	7	.31	15	.21	7
7	.16	5	.34	14	.73	7	.94	6	.28	9	.62	7	.17	14	.47	8
8	.11	5	.83	15	.87	8	.15	5	.23	9	.27	6	.26	14	.72	9
9	.79	7	.44	14	.52	7	.54	5	.13	9	.99	8	.56	15	.75	9
10	.18	5	.82	15	.14	6	.30	5	.37	9	.73	7	.25	14	.44	8
11	.13	5	.99	16	.73	7	.33	5	.94	11	.71	7	.57	15	.39	8
12	.62	7	.26	14	.90	8	.02	4	.12	9	.08	6	.29	14	.04	7
13	.32	6	.89	15	.43	7	.38	5	.80	10	.00	6	.97	17	.44	8
14	.74	7	.53	14	.33	7	.73	5	.65	10	.99	8	.50	15	.27	7
15	.20	6	.42	14	.29	7	.37	5	.11	9	.23	6	.71	15	.58	8
16	.96	8	.38	14	.66	7	.81	5	.69	10	.63	7	.76	15	.98	9
17	.03	5	.55	14	.36	7	.77	5	.98	11	.09	6	.16	14	.71	9
18	.96	8	.63	14	.46	7	.37	5	.12	9	.41	7	.59	15	.59	8
19	.82	8	.91	15	.83	8	.42	5	.37	9	.98	8	.75	15	.71	9
20	.82	8	.59	14	.49	7	.79	5	.01	8	.06	6	.34	15	.78	9

For each case we find critical path and duration of completion of project.

SN	RN	T12	RN	T13	RN	T24	RN	T35	RN	T26	RN	T45	RN	T46	RN	T56
1	.07	5	.54	14	.41	7	.19	5	.34	9	.09	6	.17	14	.21	7



For serial no. 1 , the critical paths are 1-2-4-6 and 1-3-5-6 and the duration is 26. When we do it for 20 runs, we will find next table.

Critical paths for sr. no. 1 are :1-2-4-6 and 1-3-5-6

Sr.No.	1-2	1-3	2-4	3-5	2-6	4-5	4-6	5-6	T
1	1	1	1	1			1	1	26
2		1		1				1	27
3	1		1			1		1	31
4	1		1				1		30
5		1		1				1	29
6	1		1				1		30
7		1		1				1	28
8		1		1				1	26
9	1		1			1		1	31
10		1		1				1	28
11		1		1				1	29
12	1		1				1		29
13	1		1				1		30
14	1		1			1	1	1	29
15	1		1				1		28
16	1		1			1		1	31
17		1		1				1	28
18	1		1			1	1	1	30
19	1		1			1		1	33
20	1		1			1	1	1	30
Crit Ind.	.65	.40	.65	.40	.00	.35	.45	.75	Avg:29.3

Average duration of the project is 29.3 days .The critical index of the activity 5-6 is 0.75, it means that, if we under take this project 100 times, then 75 % of the times it will be a critical activity. From previous table.

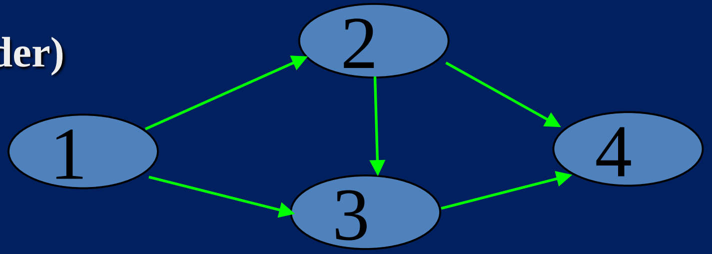
T (Days)	26	27	28	29	30	31	32	33
Prob.	2/20	1/20	4/20	4/20	5/20	3/20	0/20	1/20

P (project will take more than 29 days) = 9/20.

This approach is better than traditional PERT approach.

Gives information about critical and semi critical activities.

A PERT network consists of five activities (1,2),(1,3),(2,3),(2,4) and (3,4) with following details.



Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

<u>Simulate the network for five times</u> and find

(a) Distribution of T the project duration,

(b) E (T) ,

(c) $P(T \leq 14)$ and

(d) Critical indexes of all the activities.

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Simulation of Networks- II

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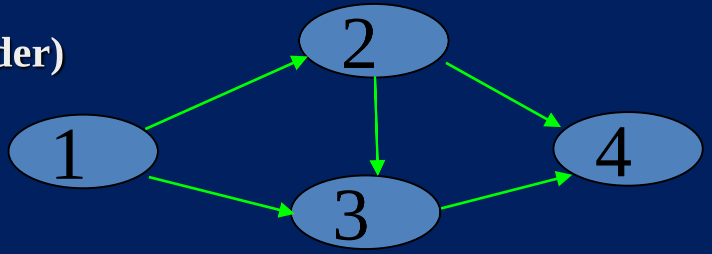
A PERT network consists of five activities (1,2),(1,3),(2,3),(2,4) and (3,4) with following details.



Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

<u>Simulate the network for five times</u> and find

(a) Distribution of T the project duration,

(b) E (T) ,

(c) $P(T \leq 14)$ and

(d) Critical indexes of all the activities.

First of all we find the relations connecting Tij to random numbers.

For T23 : 3/.3 4/.4 5/.3

$0 \leq u < .3$	corresponds to T23 = 3
$.3 \leq u < .7$	corresponds to T23 = 4
$.7 \leq u < 1$	corresponds to T23 = 5

Similarly,

For T24: 6/.3 7/.5 8/.2

$0 \leq u < .3$	corresponds to T24 = 6
$.3 \leq u < .8$	corresponds to T24 = 7
$.8 \leq u < 1$	corresponds to T24 = 8

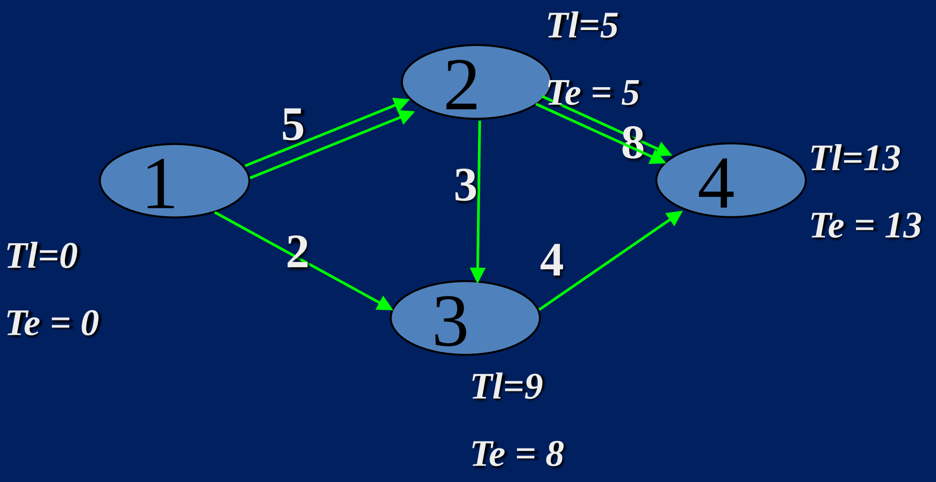
and

For T34: 3/.2 4/.7 5/.1

$0 \leq u < .2$	corresponds to T34 = 3
$.2 \leq u < .9$	corresponds to T34 = 4
$.9 \leq u < 1$	corresponds to T34 = 5

Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

1st Simulation: T12 = 5, T13= 2, first random number for T23 is .2, the duration would be 3 days, similarly for T24 and T34 the durations would be 8 and 4 days.



$0 \leq u < .3$	corresponds to T23 = 3
$.3 \leq u < .7$	corresponds to T23 = 4
$.7 \leq u < 1$	corresponds to T23 = 5

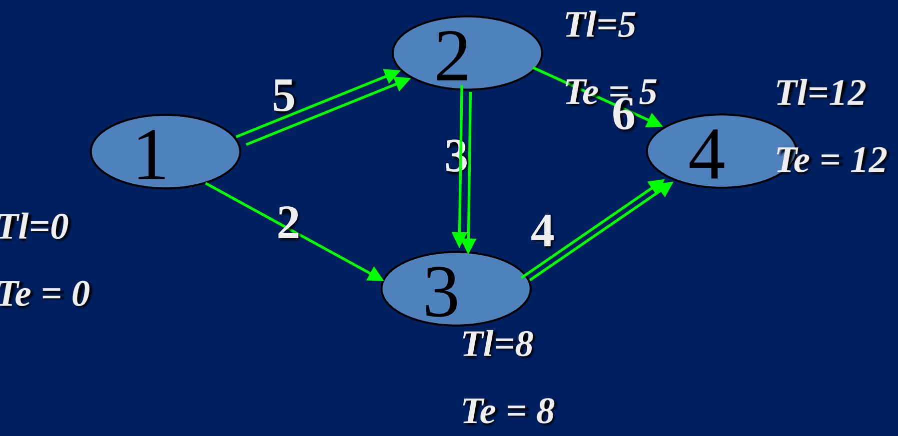
$0 \leq u < .3$	corresponds to T24 = 6
$.3 \leq u < .8$	corresponds to T24 = 7
$.8 \leq u < 1$	corresponds to T24 = 8

$0 \leq u < .2$	corresponds to T34 = 3
$.2 \leq u < .9$	corresponds to T34 = 4
$.9 \leq u < 1$	corresponds to T34 = 5

The critical path is 1-2-4 and the duration is 13.

Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

2nd Simulation: T12 = 5, T13= 2, second random number for T23 is .1, the duration would be 3 days, similarly for T24 and T34 the durations would be 6 and 3 days.

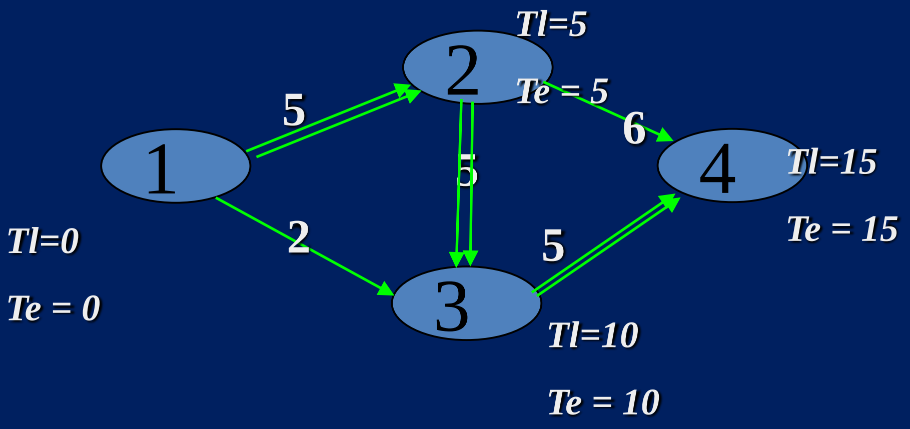


$0 \leq u < .3$	corresponds to T23 = 3
$.3 \leq u < .7$	corresponds to T23 = 4
$.7 \leq u < 1$	corresponds to T23 = 5
$0 \leq u < .3$	corresponds to T24 = 6
$.3 \leq u < .8$	corresponds to T24 = 7
$.8 \leq u < 1$	corresponds to T24 = 8
$0 \leq u < .2$	corresponds to T34 = 3
$.2 \leq u < .9$	corresponds to T34 = 4
$.9 \leq u < 1$	corresponds to T34 = 5

The critical path is 1-2-3-4 and the duration is 12.

Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

3rd Simulation: **T12 = 5, T13= 2, third random number for T23 is .9, the duration would be 5 days, similarly for T24 and T34 the durations would be 6 and 5 days.**



$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 \le u < 1$	corresponds to T23 = 5

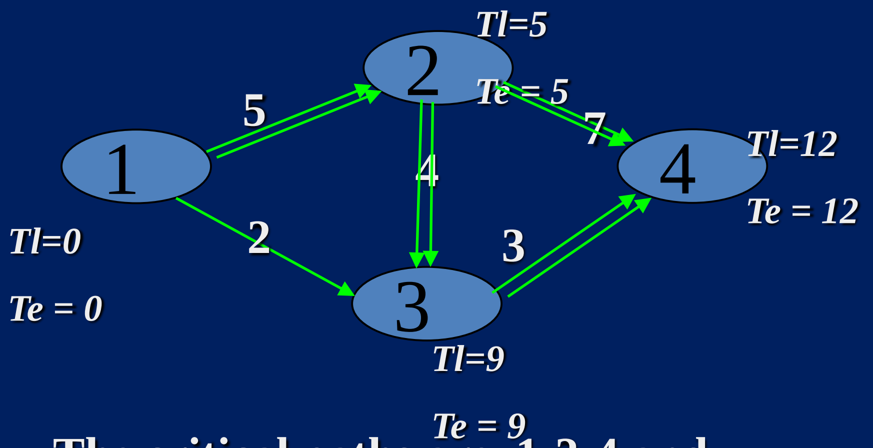
$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8

$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

The critical path is 1-2-3-4 and the duration is 15.

Activity	Description			RN(to be used in order)
1-2	Constant with duration 5			
1-3	Constant with duration 2			
2-3	3/.3	4/.4	5/.3	.2, .1, .9, .3, .2
2-4	6/.3	7/.5	8/.2	.9, .0, .1, .5, .6
3-4	3/.2	4/.7	5/.1	.6, .2, .9, .1, .1

4th Simulation: T12 = 5, T13= 2, fourth random number for T23 is .3, the duration would be 4 days, similarly for T24 and T34 the durations would be 7 and 3 days.

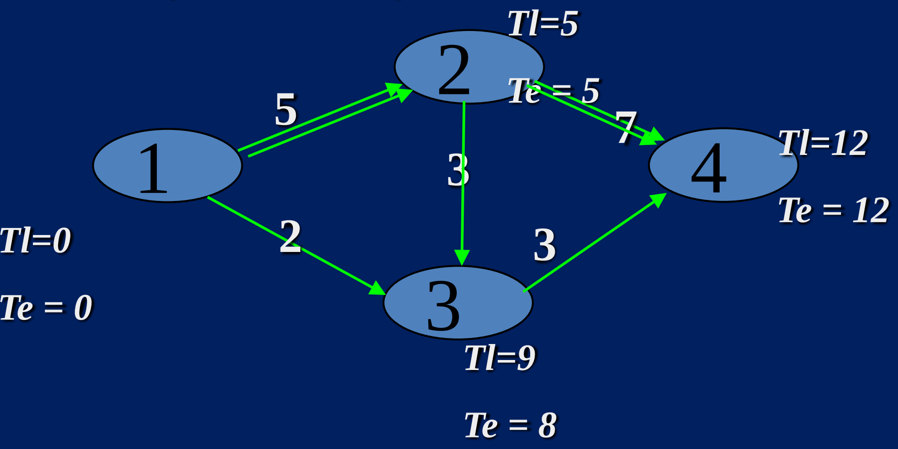


The critical paths are 1-2-4 and 1-2-3-4 the duration is 12.

$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 < u < 1$	corresponds to T23 = 5
$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8
$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1

5th Simulation: $T12 = 5$, $T13= 2$, fifth random number for T23 is .2, the duration would be 3 days, similarly for T24 and T34 the durations would be 7 and 3 days.



The critical paths are 1-2-4 and

the duration is 12.

$0 \leq u < .3$	corresponds to $T23 = 3$
$.3 \leq u < .7$	corresponds to $T23 = 4$
$.7 \leq u < 1$	corresponds to $T23 = 5$
$0 \leq u < .3$	corresponds to $T24 = 6$
$.3 \leq u < .8$	corresponds to $T24 = 7$
$.8 \leq u < 1$	corresponds to $T24 = 8$
$0 \leq u < .2$	corresponds to $T34 = 3$
$.2 \leq u < .9$	corresponds to $T34 = 4$
$.9 \leq u < 1$	corresponds to $T34 = 5$

From above

(a) Distribution of T is

T	12	13	15
Prob.	3/5=.6	1/5=.2	1/5=.2

(b) E(T)

$$12^* \,.6+13^* \,.2+15^* \,.2 = 12.8$$

(c) P (T ≤ 14)

$$.6+.2 = .8$$

(d) Critical index.

SN	1-2	1-3	2-3	2-4	3-4	T
1	1			1		13
2	1		1		1	12
3	1		1		1	15
4	1		1	1	1	12
5	1			1		12
Critical Index	1	0	.6	.6	.6	12.8

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Project Management for Managers

Lec – 45

Slacks & Floats- I

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Slack is the maximum delay possible for an event without affecting its overall duration.

Floats for activities are the same as slacks are for events.

So, we can define float as maximum delays possible for an activity without changing the project duration.

There are four types of floats:

1. Total float: It is the maximum delay possible for an activity without considering any delay in its precedence or succeeding activity.

2. Free float: It is the maximum delay possible for activities which will **not a**ffect the float of the successor activity.

3. Independent float: It is the maximum delay possible for an activity with used floats of preceding activities and will not affect the floats of succeeding activities.

4. Safety float: Let the preceding job finish at its latest possible time and the succeeding job finish as late as possible time.

The characteristics of float are:

Independent float <=Free float <=Total float

Only independent float can be negative, the rest two floats are always positive or zero.

Activities with all floats = 0 are critical activities.

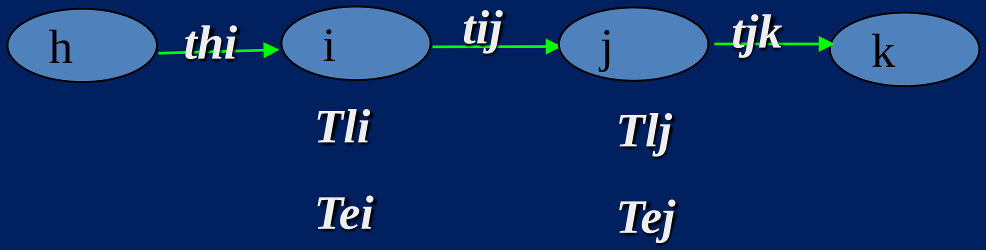
The applications of floats are as follows:

1. It identifies the critical activities as well as quantify maximum delays possible for all not critical activities.

2. It is very important in crashing of a network (reducing the time and/or cost of overall project).

3. It helps in resource allocation and smoothing.

Float: We can define following for a given activity i-j.



<u>Earliest start time</u> (Tei): This is the earliest occurrence time for the event from which the activity arrow originates.

<u>Earliest finish time</u> : Tei + tij

<u>Latest finish time:</u> The latest occurrence time for the node at which the activity arrow terminates, Tlj

<u>Latest start time :</u> Tlj - t Ij

Maximum time available = Tlj – Tei

Total float:= Total float for job i-j is the difference between maximum time available and the actual time it takes.

TF =Tlj – Tei – tij

Free float: This is based on the possibility that all events occur at their earliest times, i.e. all activities start as early as possible. It is the difference between earliest finish time and earliest start time.

FF= Tej-Tei – tij

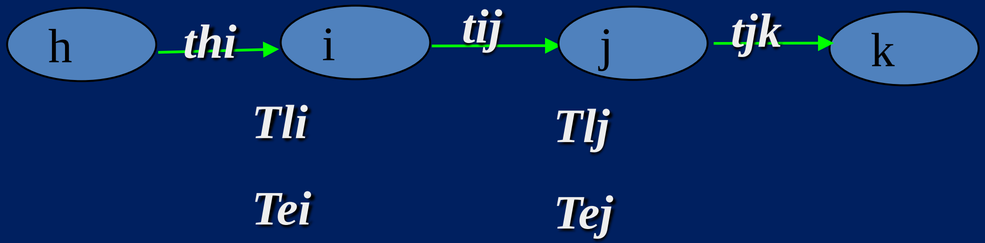
Successor

Predecessor

	Early	**Late**
Early	Free	Total
Late	Independent	Safety

Independent float: Let the preceding job h-i finish at its latest possible time Tli and the succeeding job j-k start at its earliest possible time , which is Tej.

IF= Tej-Tli-tij.



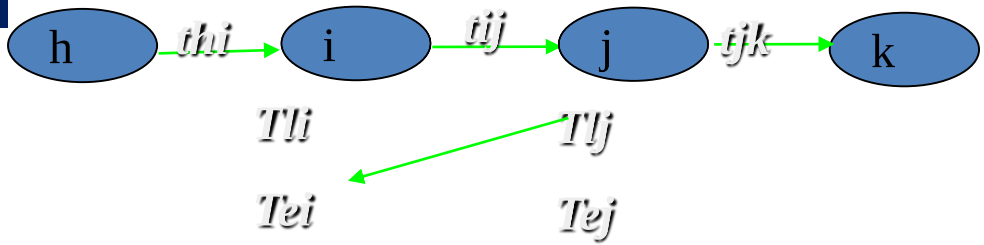
Successor

Predecessor

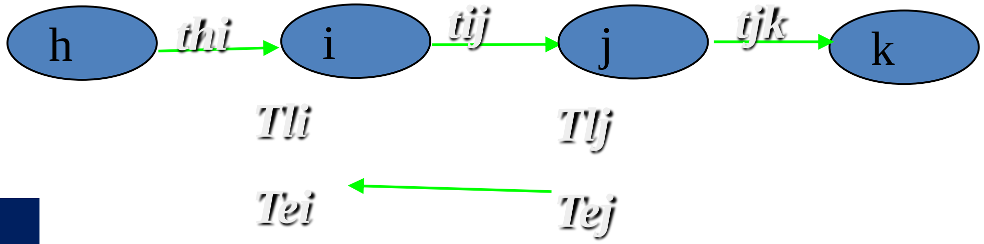
	Early	**Late**
Early	Free	Total
Late	Independent	Safety

Safety float: Let the preceding job finish at its latest possible time and the succeeding job finish as late as possible time.

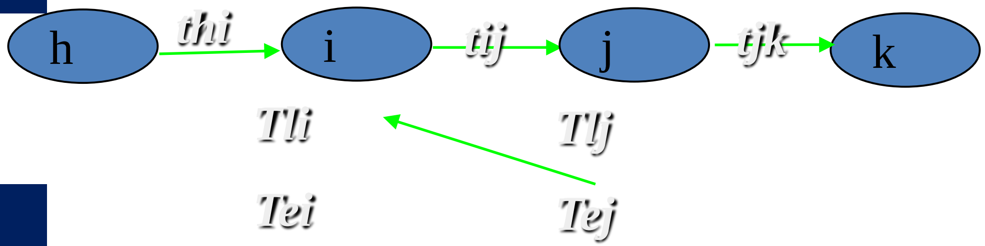
Total float



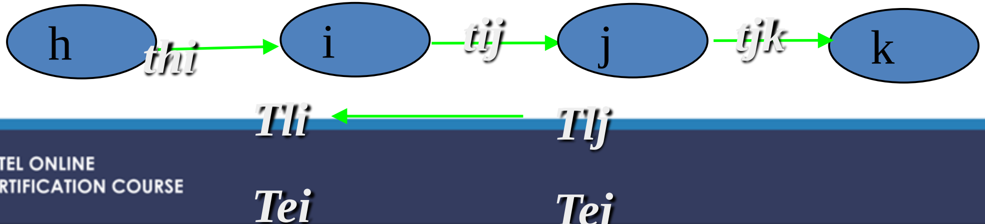
Free float

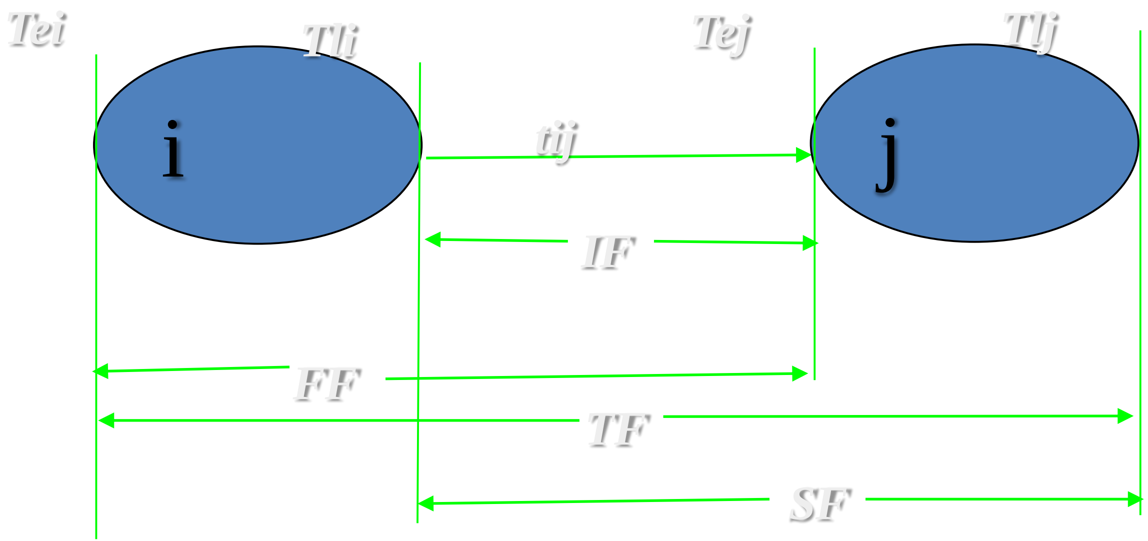


Independent float



Safety float





TF =Tlj – Tei – tij

FF= Tei-Tei – tii

IF= Tej-Tli-tij

SF=Tlj-Tli-tij

		Successor	
		Early	**Late**
Predecessor	Early	Free	Total
	Late	Independent	Safety

Ex: Work out couple of examples

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Lec- 46

Slacks & Floats- II

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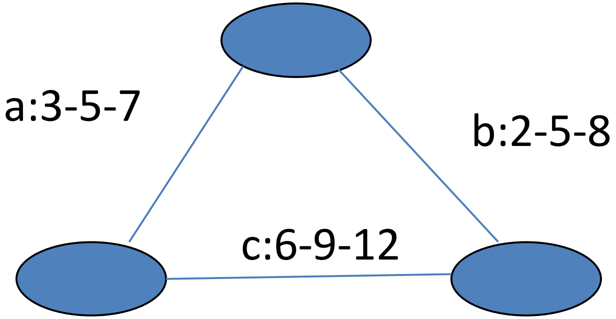
Limitations of Networks: There are some assumptions in networks, which may not be practical. Some of them are: **No activity can be repeated**, though at times many activities have to be repeated, when scope is not met or quality of work is not satisfactory.

All immediate precedence activities have to be completed before starting the activity; although at **times even after completion of few precedence activities, the later activity can start and go concurrently** with predecided precedence activity.

This is common in the situation of a research project or when some other adjustment is made due to delay situations. The critical path is the longest path, but in the situations of probabilistic times, **many paths with little slack become critical path** because there time becomes pessimistic and critical path activities are completed in estimated time or in another situation when activities of critical path are completed in optimistic times, but the activity on a non-critical path are completed in estimated times. Generally, this situation arrives when there is a minor difference between time of critical path and other noncritical path.

Let us understand this through an example as depicted by a network in Figure below. Limitations of PERT. The critical path is a-b in normal circumstance but if activity ‘c’ is finished in pessimistic time of 12 days and activities ‘a’ and ‘b’ are completed in estimated time, then path c will become critical



It is assumed that in probabilistic events, it will follow **beta distribution** but it may not follow the beta distribution and then the average time will be in accordance with the **distribution**.

It is assumed that a project will have only one **ending event**, but there are chances of **partial success** which may lead to more than one ending events.

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Project Management for Managers

Lec – 47

Time and Cost Relationship

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Time and Cost Relationship

Crashing : Process of reducing time of the project.

Elements of costs

(i)Material
(ii)Labour
(iii) Expenses

Material

Direct : Raw material and components

Indirect: consumable stores, lubricants, cotton waste, cleaning material, stationary , etc.

(ii) Labour

Direct : Employees engaged in manufacturing/activity of a project.

Indirect: Store clerk, material handling staff, supervisors, foremen, works manager etc.

(iii) Expenses :

Direct- Payments made to consultants, designers, hiring charges of m/cs, cost of rework.

Indirect- Rent of building, telephone bills, insurance, lighting expenses.

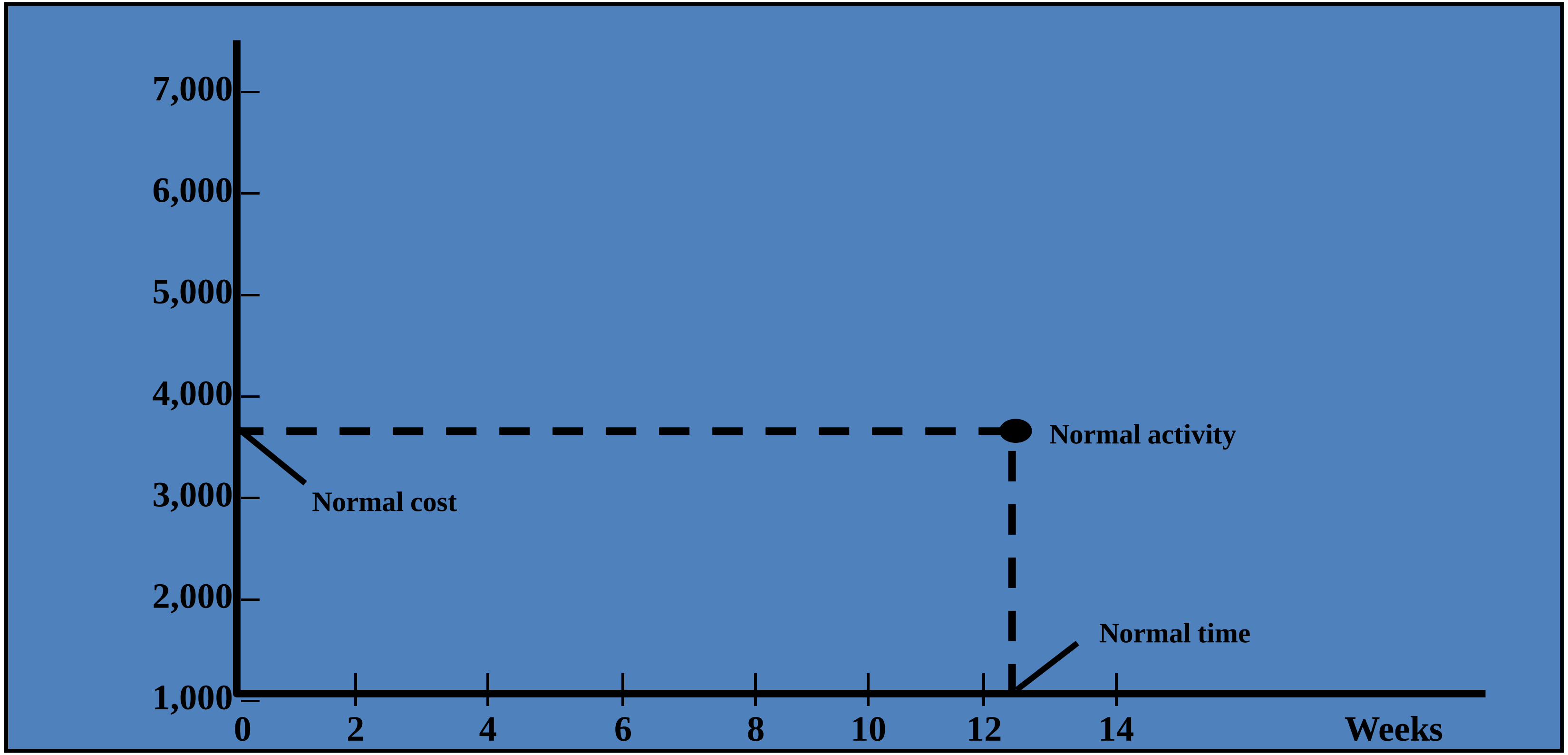
Crashing of a Project

Crashing : Process of reducing time of the project.

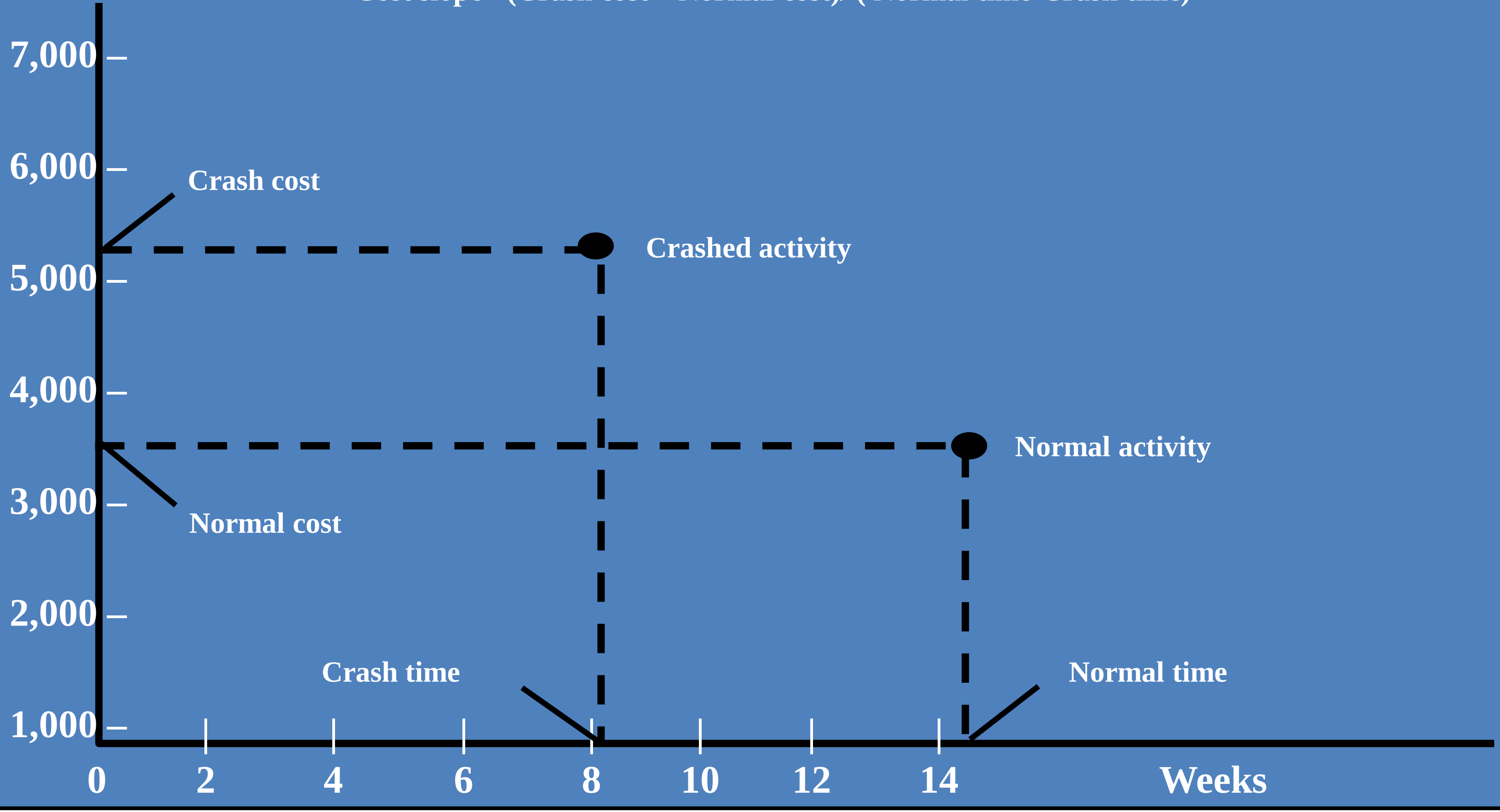
Direct cost: Cost of resources required to for an activity (men, material, etc).

Indirect cost: Indirect costs associated with material , labor and expenses.

Crashing of a Project

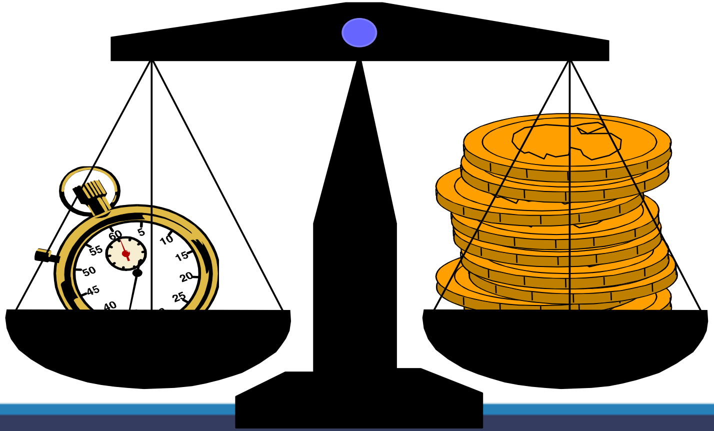


Cost slope= (Crash cost – Normal cost)/ (Normal time-Crash time)

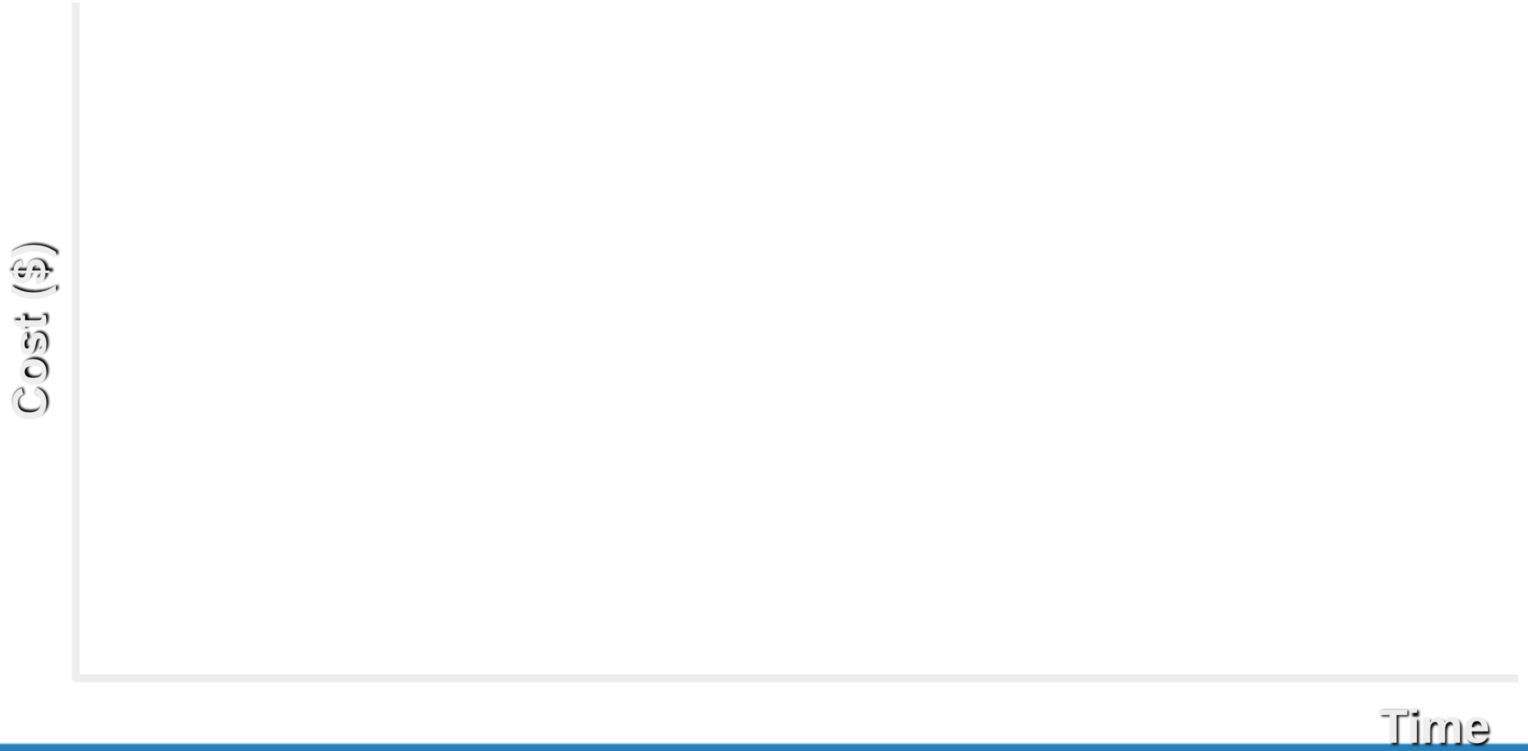


Time-Cost Relationship

- ✓ *Direct costs increase as project duration decreases*
- ✓ *Indirect costs increase as project duration increases and vice versa*
- ✓ *Reduce project length as long as crashing costs are less than indirect costs*

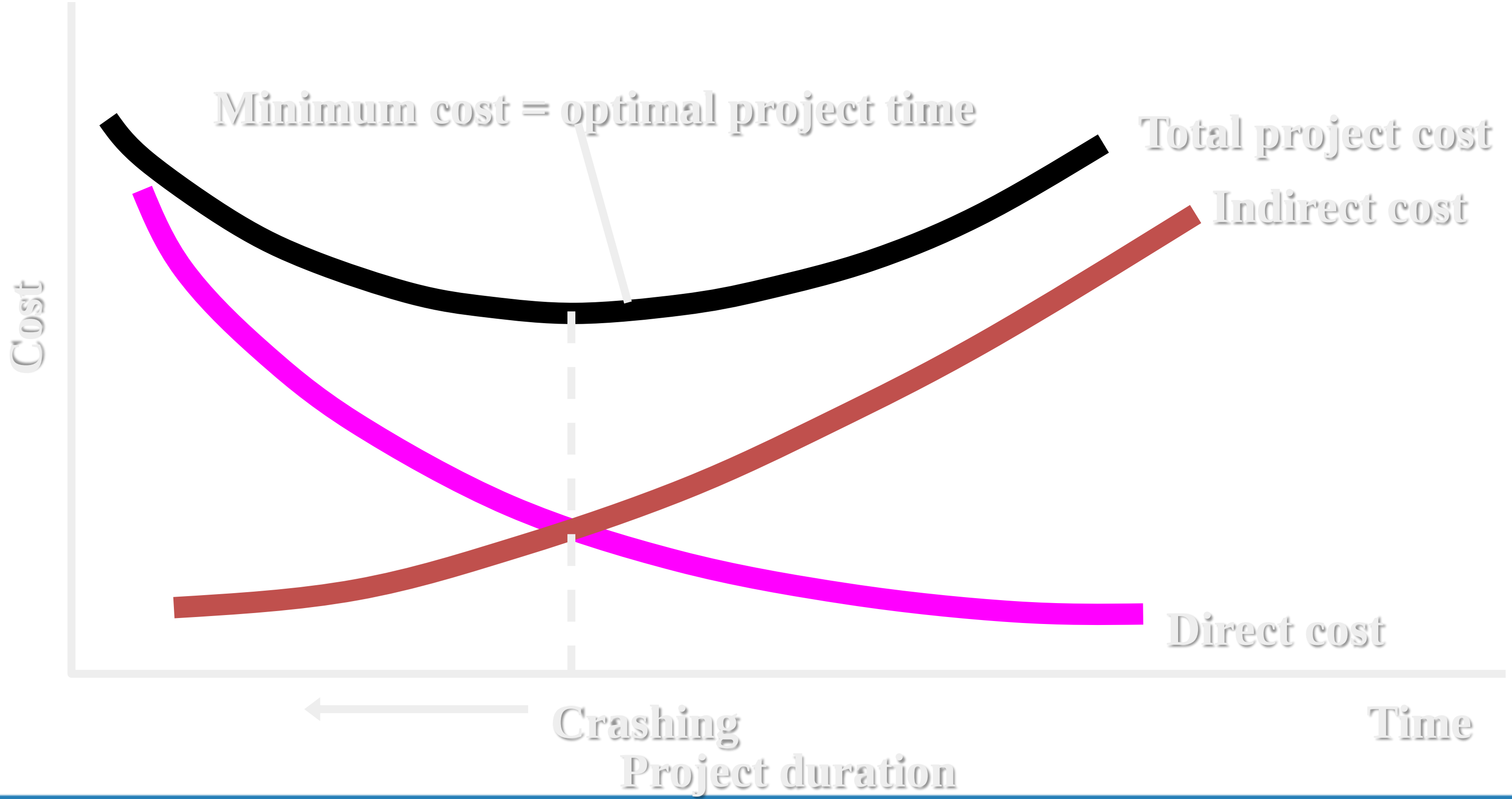


Time-Cost Tradeoff



Project duration

Time-Cost Tradeoff



Rule 1: Crash only those activities whose **slope** (increased direct cost/unit time) is more than **indirect cost per unit time**. Now suppose **painting** is not a critical activity. Then the overall project duration would not decrease by decreasing activity time for painting as project duration is the sum total of duration of critical activities.

So, we reach the second rule for crashing.

Rule 2: Crash only those activities which **are on critical path**. There are many activities which are critical in a project, which qualify the second rule. There may many of them which follow the first rule as well. Now the question arises which activity should be preferred for crashing. This is given by third rule. Rule 3: Preference should be given to the activity with the **least slope**.

There may be situations where two or more critical activities have the **same** slope.

Then we should use a subsidiary rule.

Subsidiary rule 1: Preference should be given to the activity with the **least additional** cost in the situation when there is a tie between slopes of critical activities.

Another situation can be seen when there **is more than one critical path**. Then we can use another subsidiary rule. Subsidiary rule 2: Preference should be given to **common activity** on the critical path if there is more than one critical path.

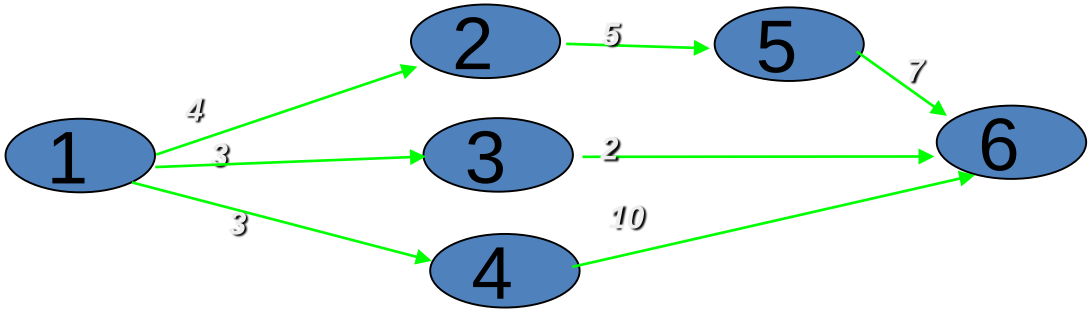
In the absence of any qualifying activity, which is common to all the critical paths, we should stick to the rule **of lowest slope** amongst all critical activities

Example: Find optimum schedule.

Activity	Normal		Crash	
	Time	Cost	Time	Cost
1-2	4	100	1 (up to 1 day)	130
1-3	3	140	1	160
1-4	3	200	1	240
2-5	5	100	2	200
3-6	2	50	1	80
4-6	10	150	9	180
5-6	7	200	5	250

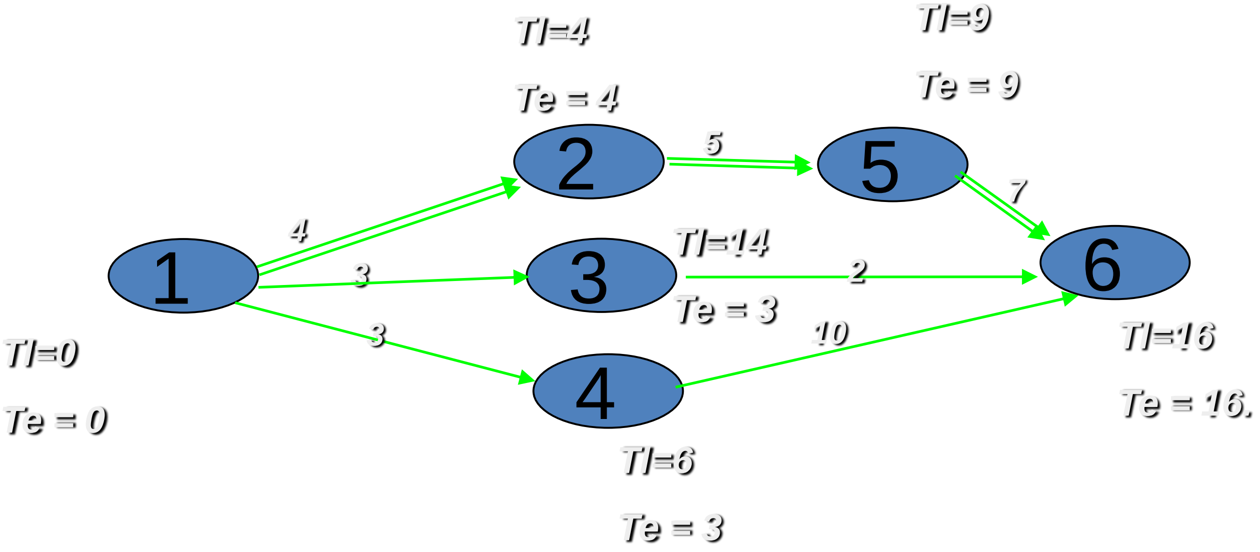
Indirect cost = 50 per day.

Activity	Time
1-2	4
1-3	3
1-4	3
2-5	5
3-6	2
4-6	10
5-6	7



Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	4	100	1	130	3	30	10
1-3	3	140	1	160	2	20	10
1-4	3	200	1	240	2	40	20
2-5	5	100	2	200	3	100	34
3-6	2	50	1	80	1	30	30
4-6	10	150	9	180	1	30	30
5-6	7	200	5	250	2	50	25
		940					

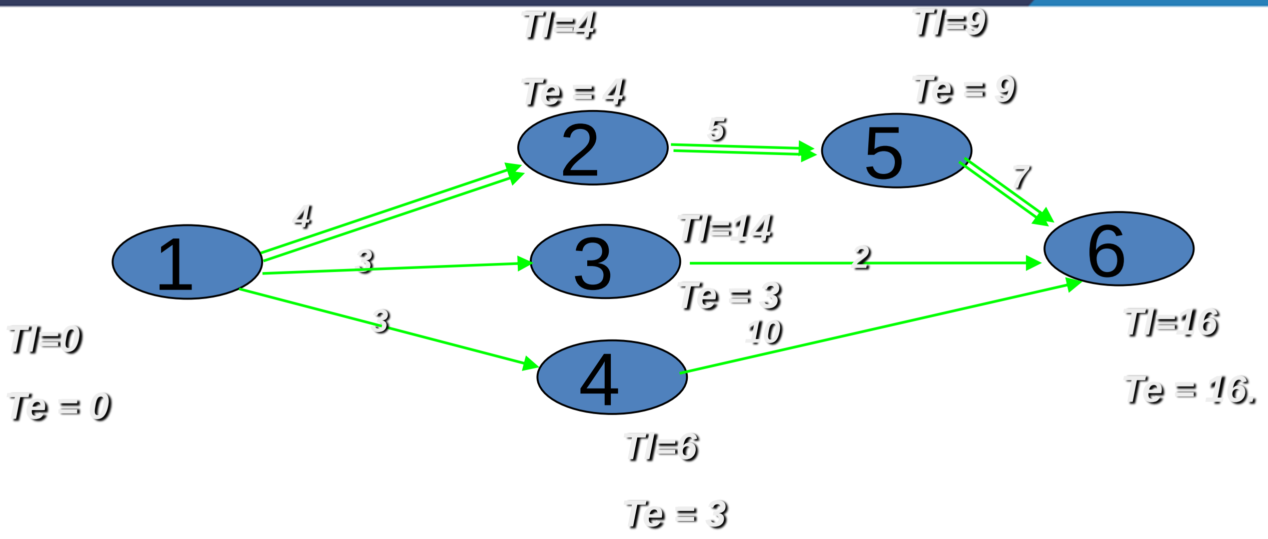
Indirect cost = 50 per day.



Critical path: 1-2-5-6

Direct Cost = ???, Indirect cost =????

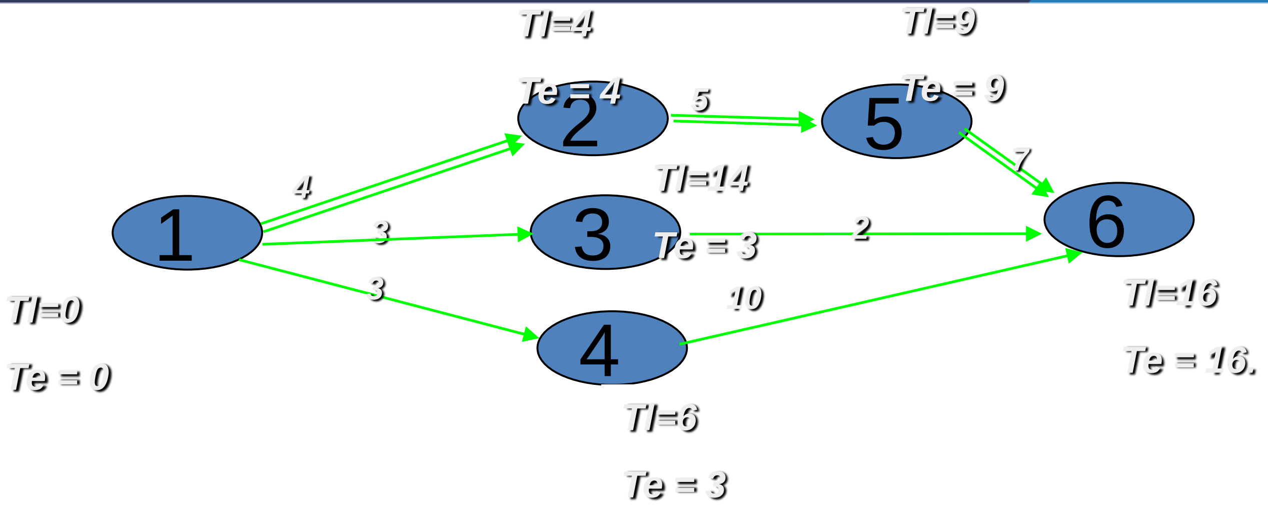
Total time = 16



Critical path: 1-2-5-6

Direct Cost = 940, Indirect cost = 50*16 =800

Total time = 16

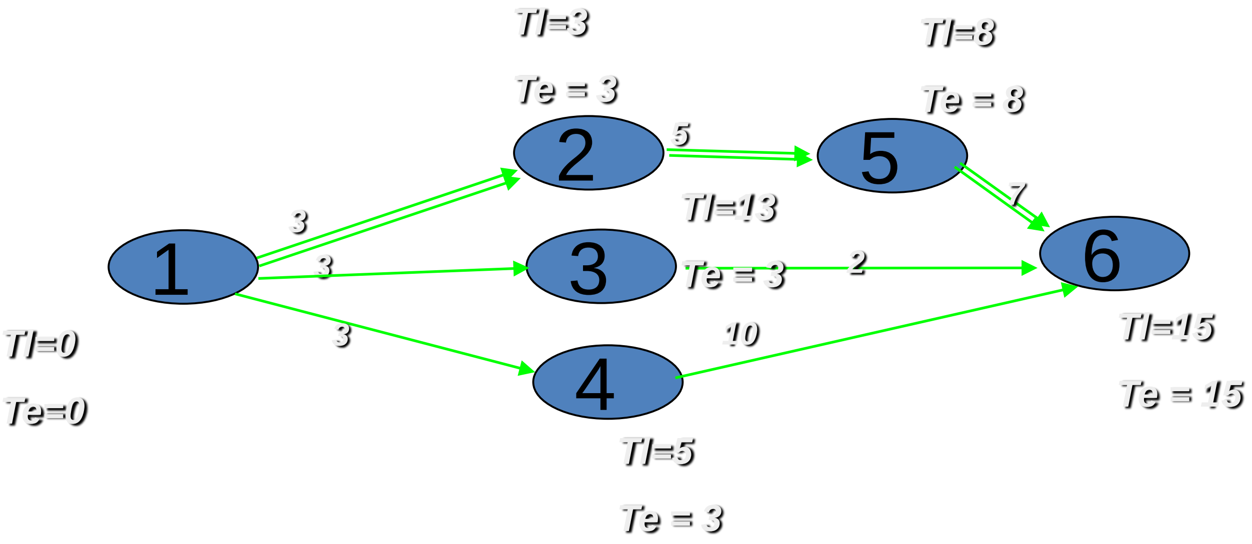


To reduce the duration of the project, reduce critical activities by one time unit. Select that critical activity which has the least slope.

Critical path : 1 2 5 6

Cost slope : 10 34 25

Crash Limit : 3 3 2



Critical path: 1-2-5-6
Direct Cost : 940+10=950
Total time = 15

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Crashing of Networks- I

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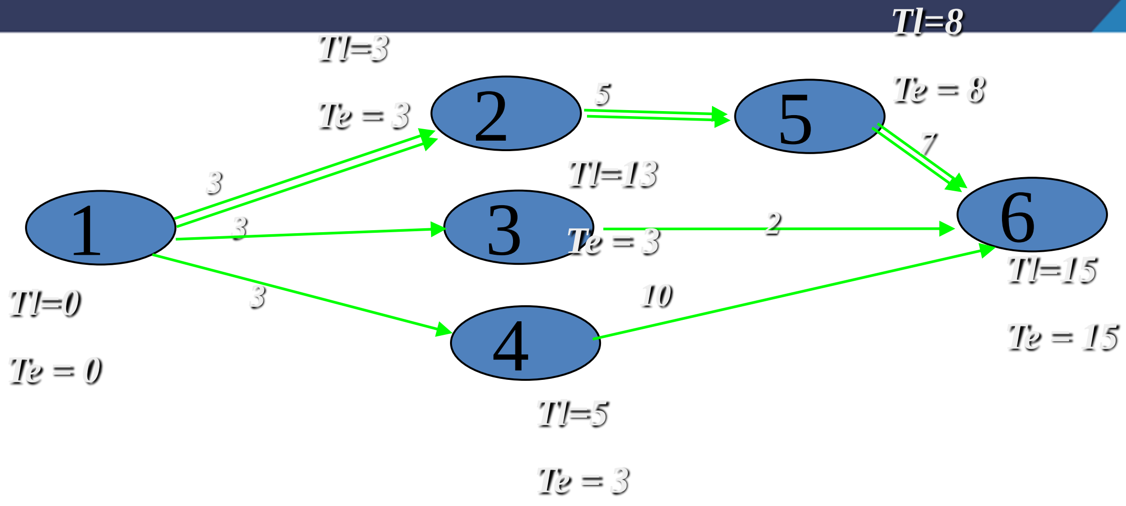
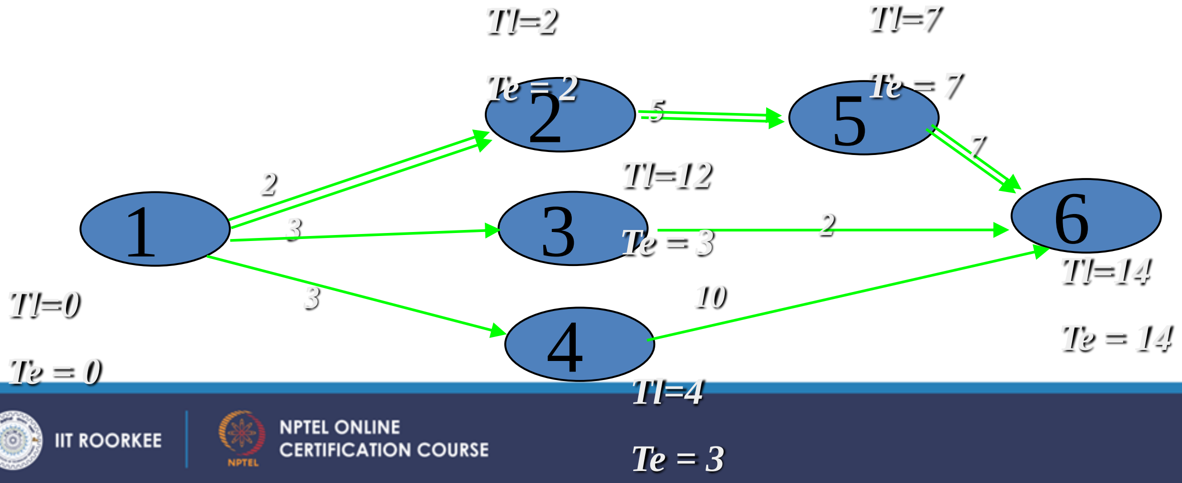


Critical path: 1-2-5-6

Direct Cost : 950

Total time = 15

Again reduce activity 1-2 by one unit.



Critical path: 1-2-5-6

Direct Cost : 960

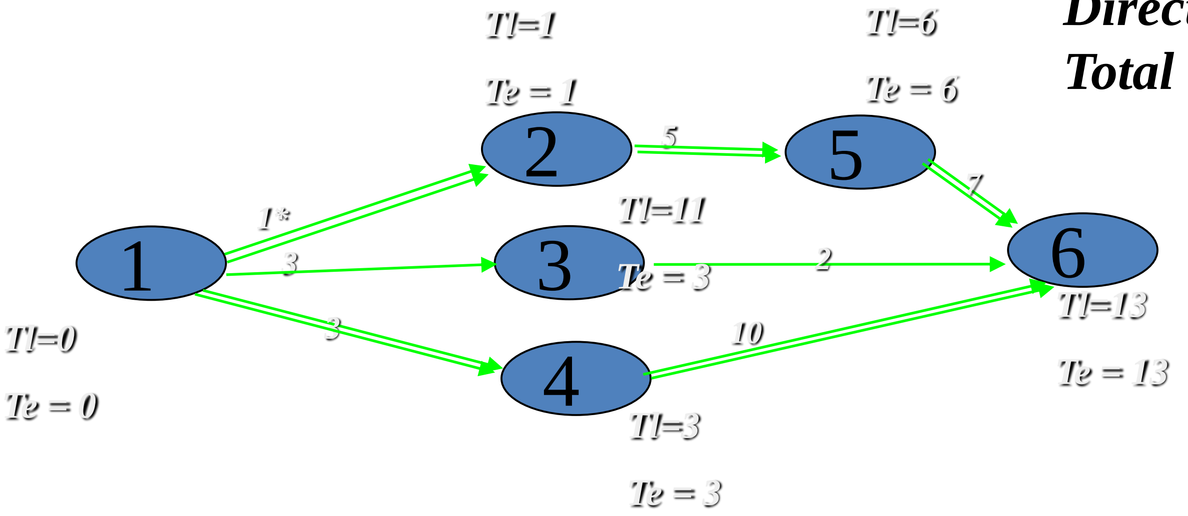
Total time = 14

Again reduce activity 1-2 by one unit.

Critical path: 1-2-5-6&1-4-6

Direct Cost : 970

Total time = 13



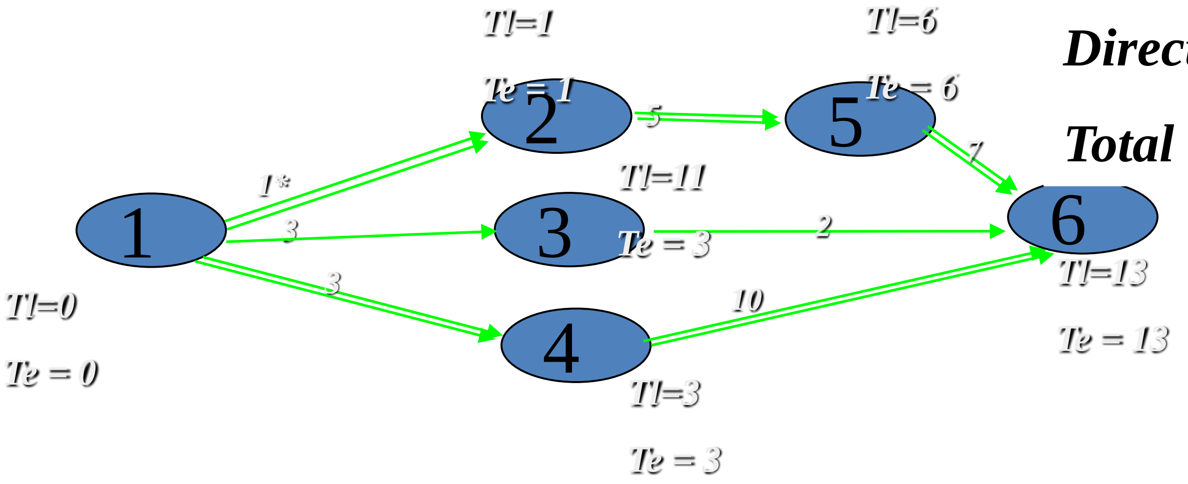
Two critical paths ??????????,

Again reduce activity 1-2 by one unit.

Critical path: 1-2-5-6 &1-4-6

Direct Cost : 970

Total time = 13



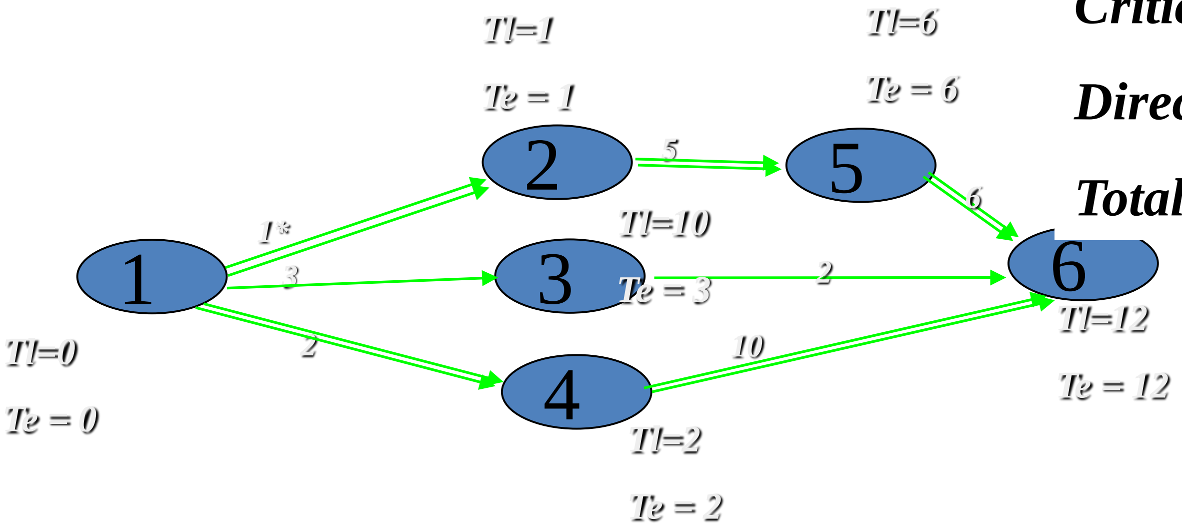
Two critical paths, reduce them simultaneously,

Critical paths : 1 2 5 6 and 1 4 6

Cost slope : 10 34 25 20 30

Crash Limit : 0 3 2 2 1

Reduce activities 5-6 and 1-4 by 1 day.



Critical path: 1-2-5-6 &1-4-6

Direct Cost : 970 +45=1015

Total time = 12

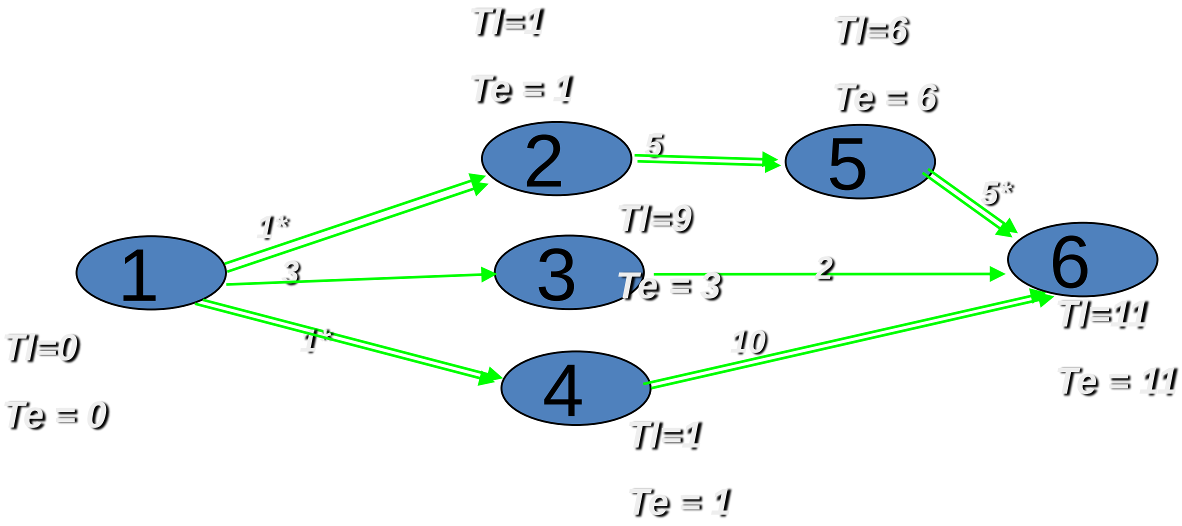
Two critical paths, reduce them simultaneously,

Critical path : 1 2 5 6 and 1 4 6

Cost slope : 10 34 25 20 30

Crash Limit : 0 3 1 1 1

Reduce activities 5-6 and 1-4 by 1 day again.



Critical path: 1-2-5-6&1-4-6

Direct Cost : 1015+45=1060

Total time = 11

Two critical paths, reduce them simultaneously,

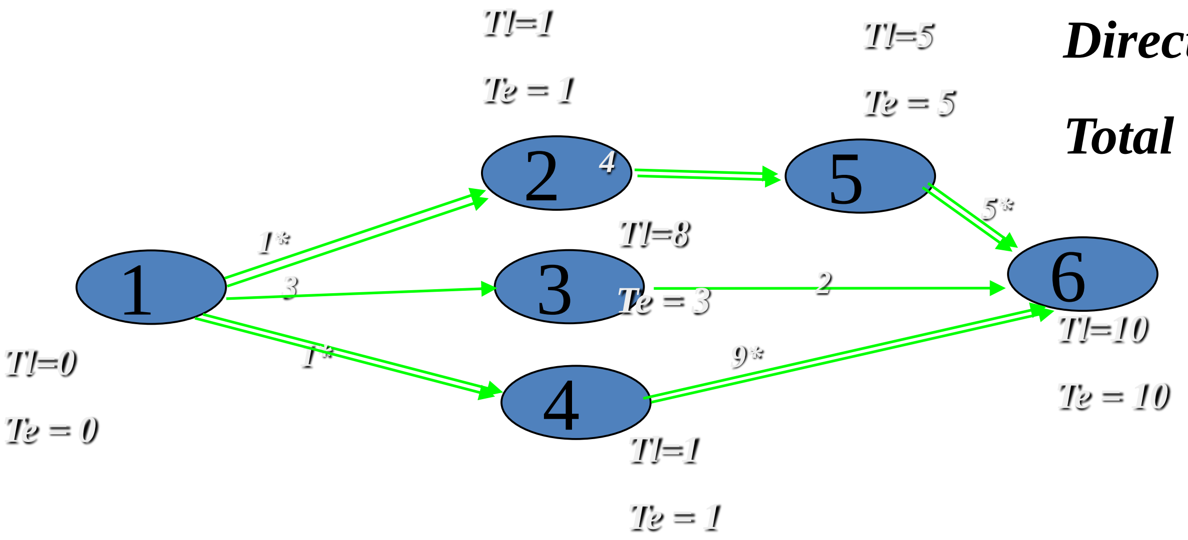
Critical path :	***1***	***2***	***5***	***6***	***and***	***1***	***4***	***6***
Cost slope :	***10***	***34***	***25***			***20***	***30***	
Crash Limit :	***0***	***3***	***0***			***0***	***1***	

Reduce activities 2-5 and 4-6 by 1 day.

Critical path: 1-2-5-6&1-4-6

Direct Cost : 1060+64=1124

Total time = 10



Critical paths can not be reduced further.

Optimum schedule:

Days	*DC*	*IDC*	*TC*
16	*940*	*800*	*1740*
15	*950*	*750*	*1700*
14	*960*	*700*	*1660*
13	*970*	*650*	*1620*
12	*1015*	*600*	*1615*
11	**1060**	**550**	**1610**
10	**1124**	**500**	**1624**

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Project Management for Managers

Lec – 49

Crashing of Networks- II

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Example 1: Find optimum schedule by FF method?

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					

Float: ***We can define following for a given activity i-j.***

<u>Earliest start time</u> (Tei): This is the earliest occurrence time for the event from which the activity arrow originates.

<u>Earliest finish time</u> : Te i + t i-j

<u>Latest finish time:</u> The latest occurrence time for the node at which the activity arrow terminates, Tl j

<u>Latest start time :</u> Tl j - t I j

Maximum time available = Tlj – Tei

Total float: Total float for job i-j is the difference between maximum time available and the actual time it takes.

TF =Tlj – Tei – tij

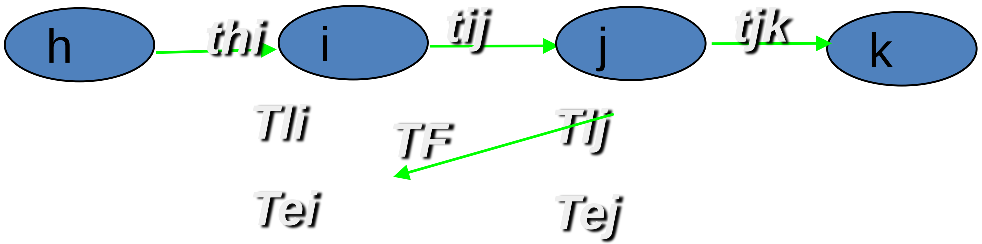
Free float: This is based on the possibility that all events occur at their earliest times, i.e. all activities start as early as possible. It is the difference between earliest finish time and earliest start time.

FF= Tej-Tei – tij

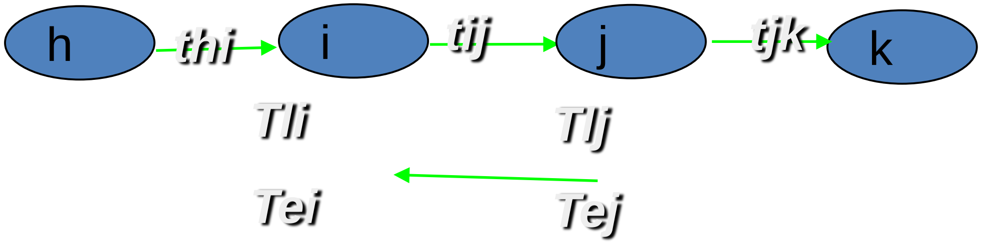
Independent float: Let the preceding job h-i finish at its latest possible time Tli and the succeeding job j-k start at its earliest possible time , which is Tej.

IF= Tej-Tli-tij.

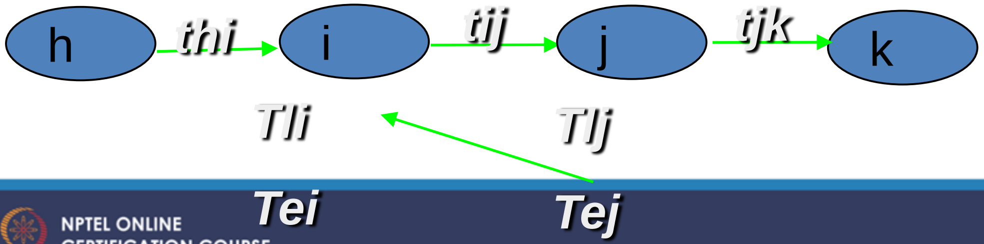
Total float



Free float

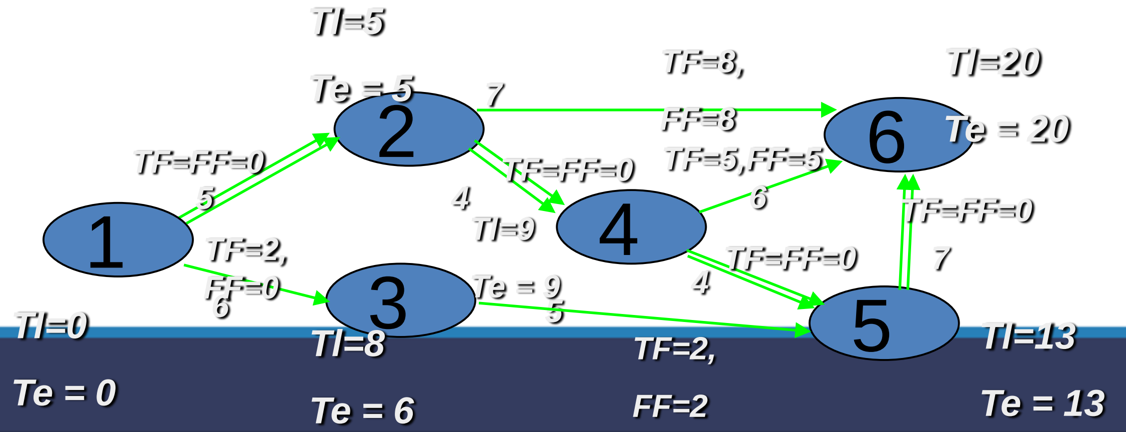


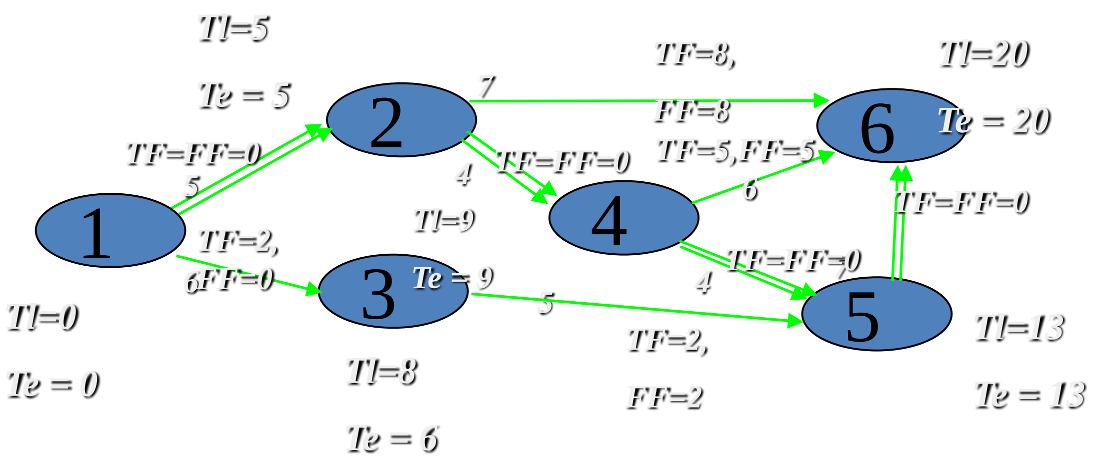
Independent float



Example 1: Find optimum schedule by FF method? If indirect cost is 40 per day

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					

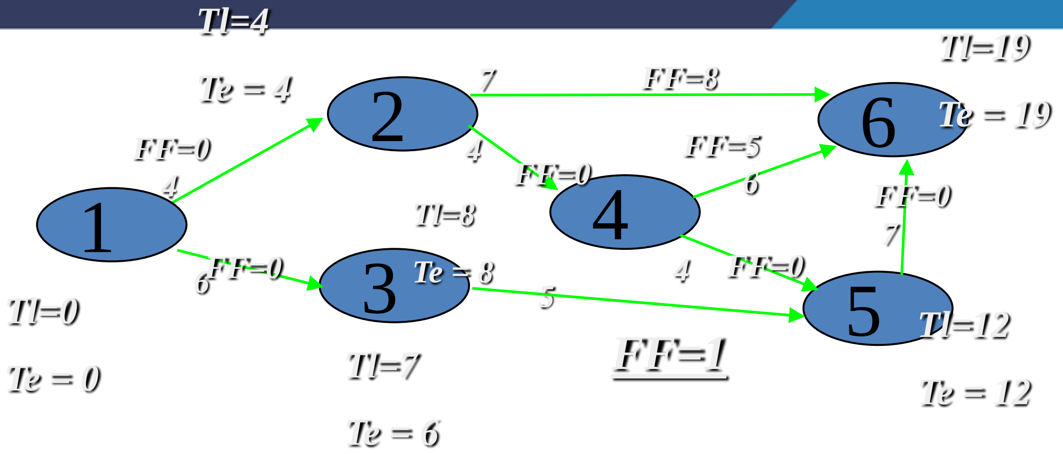




Critical path is a path having TF=0. Find FF for all the activities.

Critical path : 1 2 4 5 6
Slope : 20 40 40 30
Crash limit : 3 2 2 3
The decision is to compress 1-2. Initially by one day and see the change in values of FF of non critical activities.

Test step : ***Which non critical activities are associated with activity 1-2.***



When we reduced activity 1-2 by one unit , ***FF of non critical activity 3-5 reduced from 2 to 1****, if we reduce activity 1-2 by 2 units then* ***FF of 3-5 will become zero*** *and a new critical path may develop.*

FF guards against a ***non critical activity becoming critical****.*

It is better to find crash limit first .

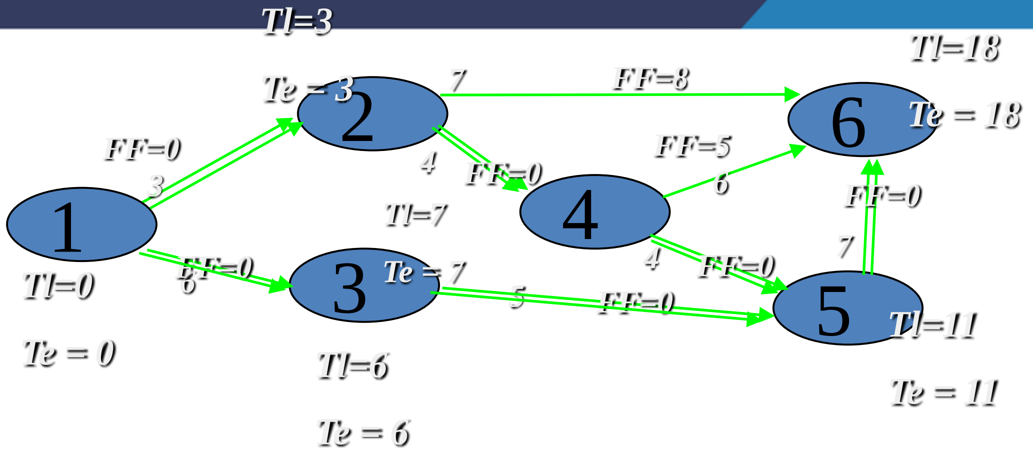
FF limit *of the activity 1-2 = Min (FF 3-5) = Min (2) = 2*

and the ***crash limit*** *(CL) is 5 – 2 =3*

Compression limit *is Min of FF and CL = Min (2,3)= 2.*

Take a decision to compress activity 1-2 by 2 days.

1-2	20
1-3	30
2-4	40
2-6	50
3-5	20
4-5	40
4-6	40
5-6	30



When we have reduced activity 1-2 by 2 days. A new critical path has developed 1-3-5-6.
Now to reduce total project duration reduce both the paths simultaneously.

Critical paths: 1 2 4 5 6 and 1 3 5 6

Slope : <u>20</u> 40 40 30 30 <u>20</u> 30

Crash limit 1 2 2 3 3 2 3

Either crash activities 1-2 and 3-5 simultaneously (Rs 40) or common activity 5-6 (Rs.30). <u>Take 5-6 common</u> activity for compression, its crash limit is 3 , we need a test step (reduce it by one day and see the FF of non critical activates).

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Project Management for Managers

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Crashing of Networks- III (Free Float Method)

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Project Management for Managers

Lec – 51

Crashing of Networks

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Project Management for Managers

Lec – 52

Introduction to Project Cost Management

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Cost Estimating

.1 Inputs
- .1 Enterprise environmental factors
- .2 Organizational process assets
- .3 Project scope statement
- .4 Work breakdown structure
- .5 WBS dictionary
- .6 Project management plan
  - Schedule management plan
  - Staffing management plan
  - Risk register

.2 Tools and Techniques
- .1 Analogous estimating
- .2 Determine resource cost rates
- .3 Bottom-up estimating
- .4 Parametric estimating
- .5 Project management software
- .6 Vendor bid analysis
- .7 Reserve analysis
- .8 Cost of quality

.3 Outputs
- .1 Activity cost estimates
- .2 Activity cost estimate supporting detail
- .3 Requested changes
- .4 Cost management plan (updates)

Cost Budgeting

.1 Inputs
- .1 Project scope statement
- .2 Work breakdown structure
- .3 WBS dictionary
- .4 Activity cost estimates
- .5 Activity cost estimate supporting detail
- .6 Project schedule
- .7 Resource calendars
- .8 Contract
- .9 Cost management plan

.2 Tools and Techniques
- .1 Cost aggregation
- .2 Reserve analysis
- .3 Parametric estimating
- .4 Funding limit reconciliation

.3 Outputs
- .1 Cost baseline
- .2 Project funding requirements
- .3 Cost management plan (updates)
- .4 Requested changes

Cost Control

.1 Inputs
- .1 Cost baseline
- .2 Project funding requirements
- .3 Performance reports
- .4 Work performance information
- .5 Approved change requests
- .6 Project management plan

.2 Tools and Techniques
- .1 Cost change control system
- .2 Performance measurement analysis
- .3 Forecasting
- .4 Project performance reviews
- .5 Project management software
- .6 Variance management

.3 Outputs
- .1 Cost estimate (updates)
- .2 Cost baseline (updates)
- .3 Performance measurements
- .4 Forecasted completion
- .5 Requested changes
- .6 Recommended corrective actions
- .7 Organizational process assets (updates)
- .8 Project management plan (updates)

Project Cost Management is primarily concerned with the cost of the resources needed to complete schedule activities

Different stakeholders will measure project costs in different ways and at different times. (Purchase decision, placing order, arrived,)

Cost estimates are generally expressed in **units of currency** (dollars, euro, yen, etc.) to facilitate comparisons both within and across projects.

In some cases, the estimator can use units of measure to estimate cost, **such as staff hours (men hour) or staff days,** along with their cost estimates, to facilitate appropriate management control.

Cost estimates can benefit from **refinement during the course** of the project to reflect the additional detail available. Initially **Rough order of magnitude** (ROM) estimate may be -50% to 100% later -10 to 50%.

Cost included is not limited to, labor, materials, equipment, services, and facilities, as well as special categories such as an **inflation** allowance or a contingency cost.

Cost Estimating: Inputs

1 Enterprise Environmental Factors

Marketplace conditions. What products, services, and results are available in the marketplace, from whom, and under what terms and conditions .

Commercial databases. Info @ standard costs for material and equipment. **Published seller** price lists are another source.

3 Project Scope Statement: describes the business need, justification, requirements, and current boundaries for the project.

4 Work Breakdown Structure: the project's work breakdown structure (WBS) provides the **relationship among all the components of the project** and the project deliverables.

5 Project Management Plan: provides the **overall plan for executing, monitoring, and controlling the project, and includes subsidiary plans that provide guidance and direction for cost management planning and control**.

Cost Estimating: Tools and Techniques

1. **Analogous Estimating:** Analogous cost estimating means **using the actual cost of previous**, similar projects as the basis for estimating the cost of the current project. It uses **expert judgment**. It is **less costly** than other techniques, but it is also **generally less accurate.**

2. **Determine Resource Cost Rates:** The persons must know the unit cost rates, **such as staff cost per hour and bulk material cost per cubic yard**, for each resource to estimate schedule activity costs.

Cost Estimating: Tools and Techniques

3. Bottom-up Estimating??????????

4. Parametric Estimating: ????????????????

Cost Estimating: Tools and Techniques

3. Bottom-up Estimating: estimating the cost of individual work packages or individual schedule activities with the lowest level of detail. This detailed cost is then summarized or "**rolled up**" to higher levels for reporting and tracking purposes.

4. Parametric Estimating: Parametric estimating is a technique that uses a **statistical relationship between historical data and other variables** (e.g., square footage in construction, lines of code in software development, required labor hours) to calculate a **cost estimate** for a schedule activity resource.

5. **Project Management Software:** Project management software, **such as cost estimating software applications, computerized spreadsheets, and simulation and statistical tools**, are widely used to assist with cost estimating.

6. **Vendor Bid Analysis:** Other cost estimating methods include **vendor bid analysis** and an analysis of what the project should cost.

7. **Reserve Analysis:** Many cost estimators **include reserves**, also called **contingency allowances**, as costs in many schedule activity cost estimates.

8. **Cost of Quality:** Cost of quality can also be used to prepare the schedule activity cost estimate.

Cost Estimating: Outputs

1. Activity Cost Estimates: An activity cost estimate is a **quantitative assessment** of the likely **costs of the resources** required to complete schedule activities. This includes, but is not limited to, **labor, materials, equipment, services, facilities, information technology, and special categories such as an inflation allowance or cost contingency reserve.**

2. Activity Cost Estimate Supporting Detail: Regardless of the level of detail, the **supporting documentation should provide a clear, professional, and complete picture by which the cost estimate was derived**.

Supporting detail for the activity cost estimates should include:

- Description of the schedule activity's project scope of work
- Documentation of **the basis for the estimate** (i.e., how it was developed)
- Documentation of **any assumptions made**
- Documentation **of any constraints**
- Indication of the range **of possible estimates** (e.g., $10,000 (-10% / +15%) to indicate that the item is expected to cost between $9,000 and $11,500).

3. Requested Changes: The Cost Estimating process may **generate requested changes that may affect the cost management plan, activity resource requirements**, and **other components of the project management plan.**

4. Cost Management Plan (Updates): If approved change requests result from the Cost Estimating process, then the **cost management plan component of the project management plan is updated** if those approved changes impact the management of costs.

Cost Budgeting: Cost budgeting involves **aggregating the estimated costs of individual schedule activities** or work packages to establish a **total cost baseline for measuring project performance.**

Cost Budgeting: Inputs

1. Project Scope Statement

2. Work Breakdown Structure

3. WBS Dictionary: The WBS dictionary is a primary input to schedule activity definition.

4. Activity Cost Estimates: The **cost estimates for each schedule activity** within a work package are aggregated to obtain a cost estimate for each work package.

5. Activity Cost Estimate Supporting Detail

6. **Project Schedule:** The project schedule includes planned **start and finish dates for the project's schedule activities, schedule milestones, work packages, planning packages, and control accounts.** This information is used to aggregate costs to the calendar periods when the costs are planned to be incurred.

7. **Resource Calendars**

8. **Contract:** information related to what products, services, or results have been purchased — and their costs — are used in developing the budget.

9. **Cost Management Plan:** The cost management plan component of the project management plan and other subsidiary plans are considered during cost budgeting.

Cost Budgeting: Tools and Techniques

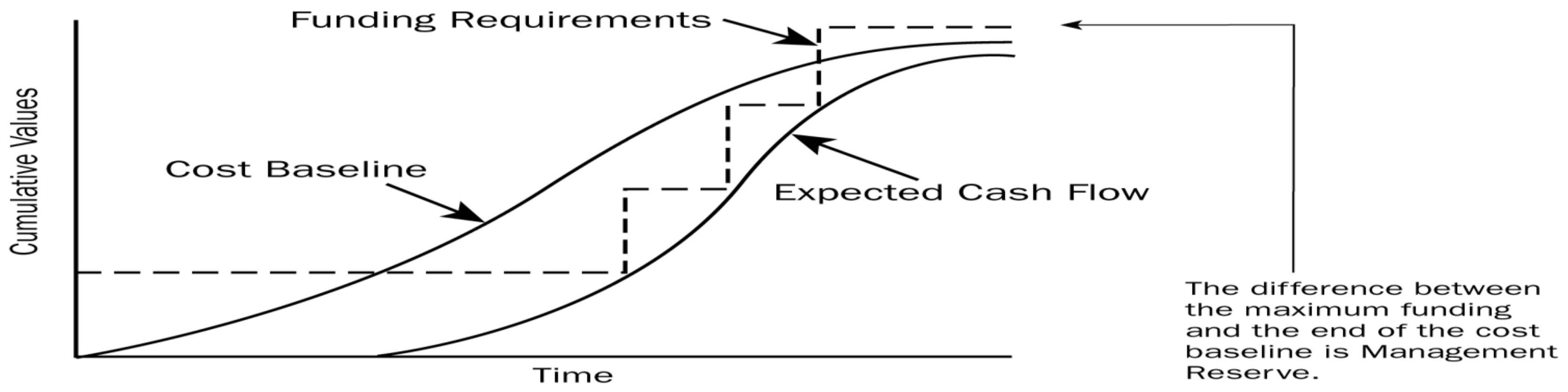
1. Cost Aggregation: Schedule activity cost estimates are aggregated by work packages in accordance with the WBS.

2. Reserve Analysis: Reserve analysis establishes contingency reserves, such as the management **contingency** reserve, that are allowances for **unplanned**, but potentially required, changes.

3. Parametric Estimating: The parametric estimating technique involves using project characteristics (parameters) in a **mathematical model** to predict total project costs. Both the cost and accuracy of parametric models vary widely.

Cost Budgeting: Outputs

1. **Cost Baseline:** The cost baseline is a time-phased **budget** that is used as a basis against which to measure, 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 an S-curve,** as illustrated in Figure .
2. **Project Funding Requirements:** Funding requirements, total and periodic (e.g., annual or quarterly), are **derived from the cost baseline** and can be established to exceed, usually by a margin, to allow for either early progress or cost overruns. Funding usually occurs in incremental amounts that are not continuous, and, therefore, appears as a step function in Figure



3 . Cost Management Plan (Updates): If approved change requests result from the Cost Budgeting process, then the cost management plan component of the project management plan is updated if those approved changes impact the management of costs.

4 . Requested Changes: The Cost Budgeting process can generate requested changes that affect the cost management plan or other components of the project management plan. Requested changes are processed for review and disposition through the Integrated Change Control process.

Cost Control??????????????

Cost Control

Project cost control includes:

- Influencing **the factors that create changes** to the cost **baseline**

- Ensuring **requested changes are agreed** upon

- Managing the actual changes when and as they occur

- Assuring that potential **cost overruns do not exceed the authorized funding** periodically and in total for the project

• Monitoring cost performance **to detect and understand variances from the cost baseline**

• Recording all appropriate changes accurately **against the cost baseline**

• **Preventing incorrect, inappropriate, or unapproved changes from being included in the reported cost** or resource usage

• **Informing appropriate stakeholders of approved changes**

• **Acting to bring expected cost overruns within acceptable limits**.

Cost Control: Inputs

1 . Cost Baseline

2 . Project Funding Requirements

3. Performance Reports: Performance reports **provide information on cost and resource performance** as a **result of actual work progress.**

4. Work Performance Information: Work performance information pertaining to the **status and cost of project activities being performed is collected**. This information Includes, but is not limited to:

- **Deliverables that have been completed** and those not yet completed
- **Costs authorized and incurred**
- Estimates to complete the schedule activities
- **Percent physically complete** of the schedule activities.

5. Approved Change Requests

6. Project Management Plan

Cost Control: Tools and Techniques

1. **Cost Change Control System:** A cost change control system, documented in the cost management plan, defines the **procedures by which the cost baseline can be changed**. It includes the **forms, documentation, tracking systems, and approval levels** necessary for authorizing changes.

Cost Control: Tools and Techniques

2. **Performance Measurement Analysis:** Performance measurement techniques help to assess the **magnitude of any variances** that will invariably occur.

   The earned value technique (EVT) compares the value of the **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.

An **<u>important part of cost control is to determine</u>** the **cause of a variance**, the **magnitude** of the variance, and to decide if the variance **requires corrective action.**

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Project Management for Managers

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Cost Control Tools and Techniques

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Cost Control: Tools and Techniques

2. Performance Measurement Analysis: Performance measurement techniques help to assess the **magnitude of any variances** that will invariably occur.

The earned value technique (EVT) compares the value of the **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.

An **important part of cost control is to determine** the **cause of a variance**, the **magnitude** of the variance, and to decide if the variance **requires corrective action.**

The earned value technique involves developing these key values for each schedule activity, work package, or control account:

- **Planned value (PV):** PV is the **budgeted cost for the work scheduled <u>to be completed</u>** on an activity or WBS component.
- **Earned value (EV):** EV is the **budgeted amount for the work actually <u>completed</u>** on the schedule activity or WBS component.

•**Actual cost (AC):** AC is the **total cost incurred** in accomplishing work on the schedule activity or WBS component. This AC must correspond in definition and coverage to whatever was budgeted for the PV and the EV (e.g., direct hours only, direct costs only, or all costs including indirect costs).

•**Budgeted cost at completion (BAC):** This represents the total budget for a project.

The **PV, EV, and AC** values are used in **combination to provide performance measures** of whether or not work is being **accomplished** as **planned** at any given point in time.

The most commonly used measures are **cost variance (CV) and schedule variance (SV).**

Cost variance (CV): CV equals earned value (EV) minus actual cost (AC). The cost variance at the end of the project will be the **difference between the budget at completion (BAC) and the actual amount spent.**

Formula: CV= EV – AC

• **Schedule variance (SV): SV equals earned value (EV) minus planned value (PV).** Schedule variance **will ultimately equal zero when the project is completed because all of the planned values will have been earned.**

Formula: SV = EV – PV

These two values, the CV and SV, can be **converted to efficiency indicators** to **reflect the cost and schedule performance of any project.**

Cost performance index (CPI): A CPI value less than 1.0 indicates a <u>cost overrun</u> of the estimates. A CPI value greater than 1.0 indicates a **<u>cost underrun</u>** of the estimates.

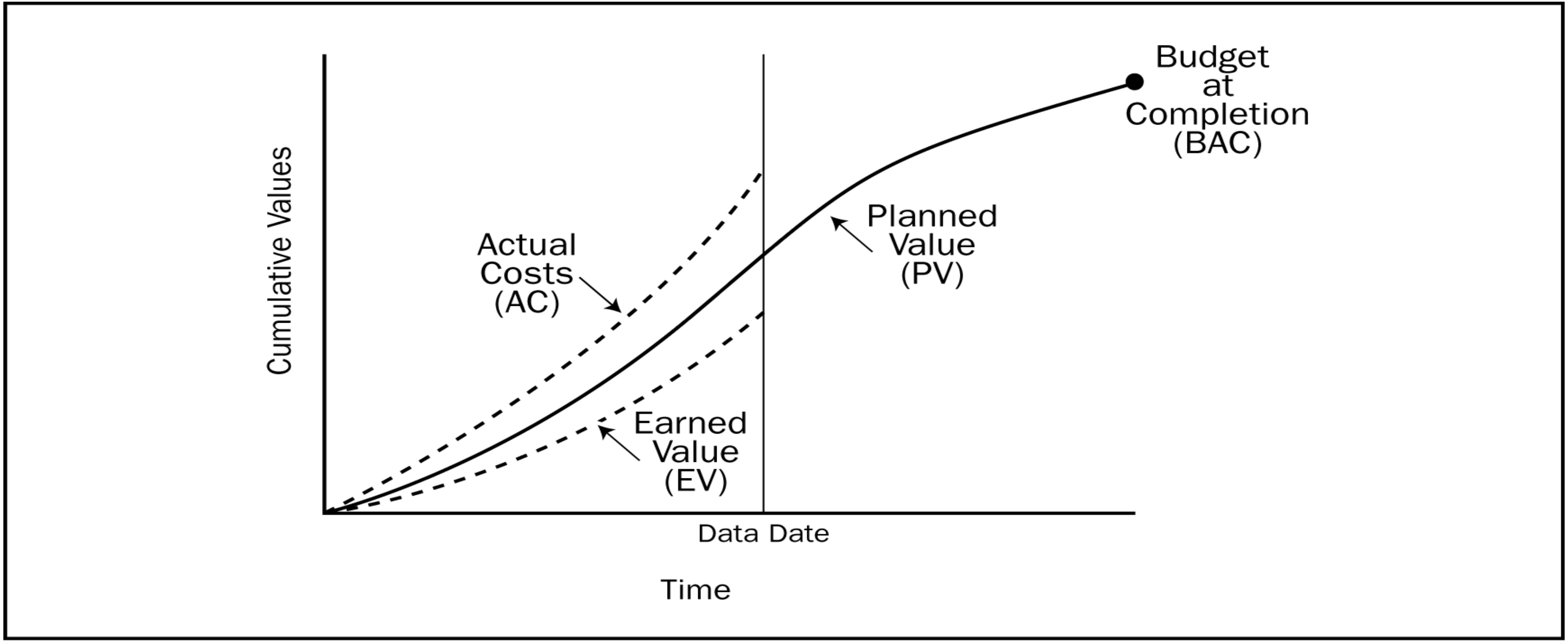
The CPI is the most **commonly used cost-efficiency indicator**.

Formula: **CPI = EV/AC**

Schedule performance index (SPI): The SPI is used, in addition to the schedule status, **to predict the completion date** and **is sometimes used in conjunction with the CPI to forecast the project completion estimates**.

Formula: **SPI = EV/PV**

Figure uses S-curves to display EV data for a project that is over budget and behind the work plan.



Cost Control: Tools and Techniques

3.Forecasting: Forecasting includes **making estimates or predictions of conditions in the project's future based on information** and knowledge available at the time of the forecast.

4.Project Performance Reviews: Performance reviews **compare cost performance over time, schedule activities or work packages overrunning and under running budget** (planned value), **milestones due, and milestones met**.

5. Project Management Software: Project management software, **such as computerized spreadsheets, is often used to monitor PV versus AC,** and to forecast the effects of changes or variances.

6. Variance Management: The cost management plan describes **how cost variances will be managed, for example, having different responses to major or minor problems**. The amount of variance tends to **decrease as more work is accomplished**.

Cost Control: Outputs

1 Cost Estimates (Updates)

2 Cost Baseline (Updates)

3 Performance Measurements

4 Forecasted Completion

5 Requested Changes

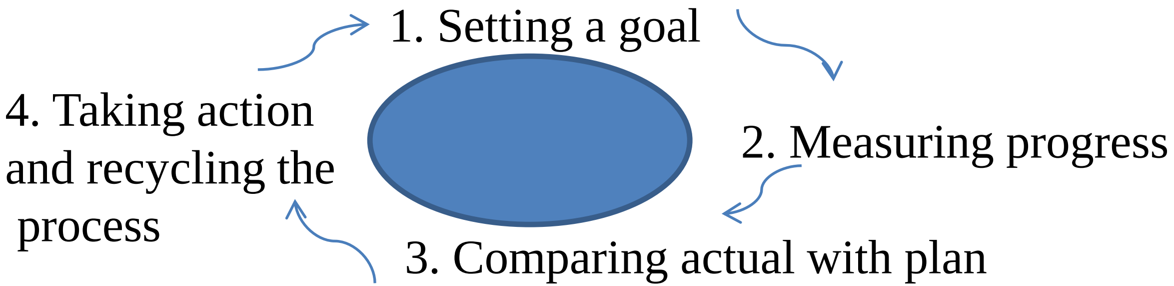
6 Recommended Corrective Actions

7 Organizational Process Assets (Updates)

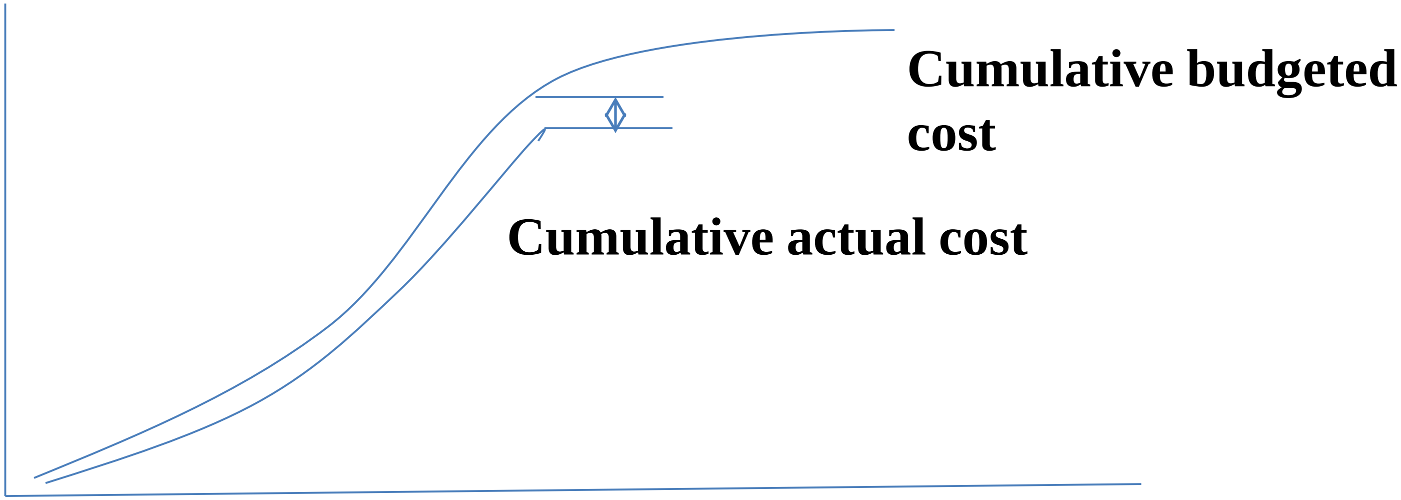
8 Project Management Plan (Updates)

For project control: What information concerning the project should be measured, and when are the best times to measure it.

Project Control Cycle : A general model

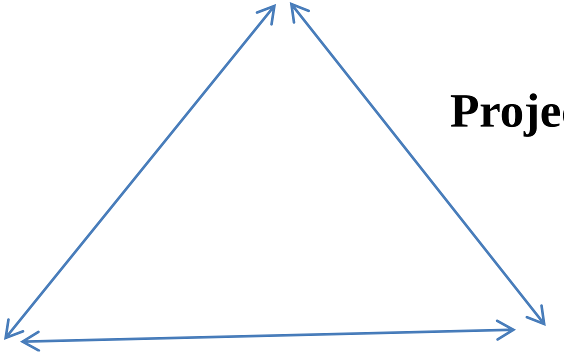


The project S curve:



S- curve drawback : It does not give cause of variance.

Cost



Project S- curve

Performance

Schedule

Monitoring Project Performance

Another method of monitoring project progress **is millstone analysis**. **A milestone is an event or stage of the project that represents a significant accomplishment** on the road to the project's completion.

Completion of a deliverable, an **important activity on** the project's critical path, or even a **calendar date** can all be milestones.

They are reactive control system.

The tracking Gantt Chart: Future **projection of project's status** and **reasons of delay are not known** are the drawbacks of this method.

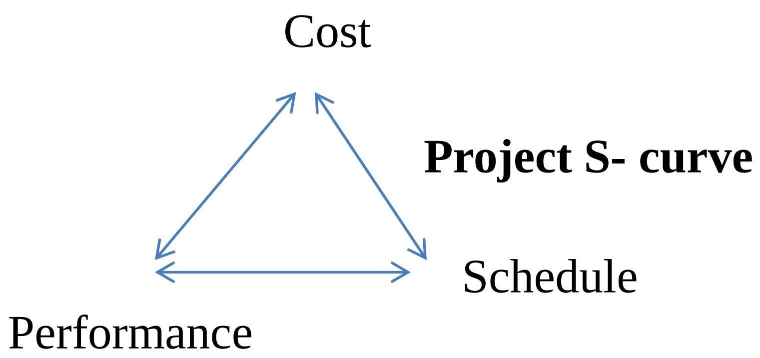
Earned Value Management: Unlike previous project tracking approaches , **EVM recognizes that it is necessary to jointly consider the impact of time, cost,** and **project performance** on any analysis of current project status.

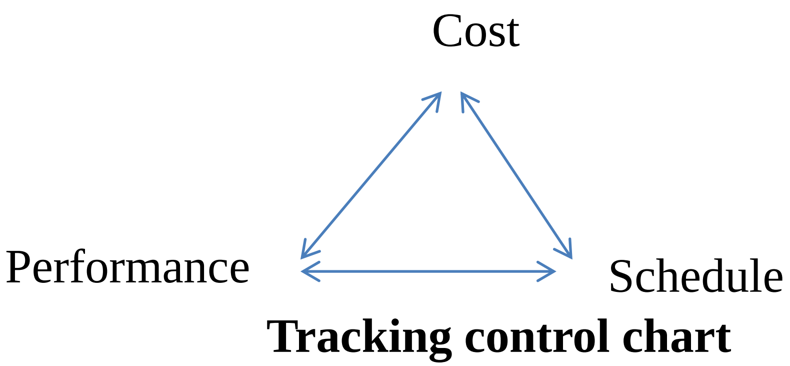
Put another way: Any monitoring system that **only compares actual against budget cost numbers** ignores the fact that the client is spending that money to accomplish something –create a project. Therefore, EVM reintroduces and stresses the importance of **analyzing the time element** in the project status updates.

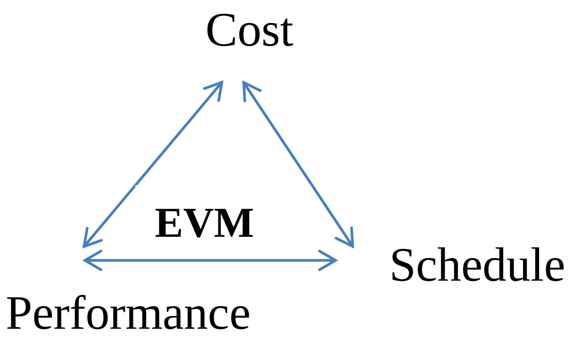
EVM also allows the project team to **make future projections of the project status** based on its current status.

Earned value, directly links **all three project success matrices** (cost, schedule, and performance)

Earned value, directly **links all three project success matrices** (cost, schedule, and performance) . This methodology allows for regular updating of a time phased budget to determine schedule and cost overruns

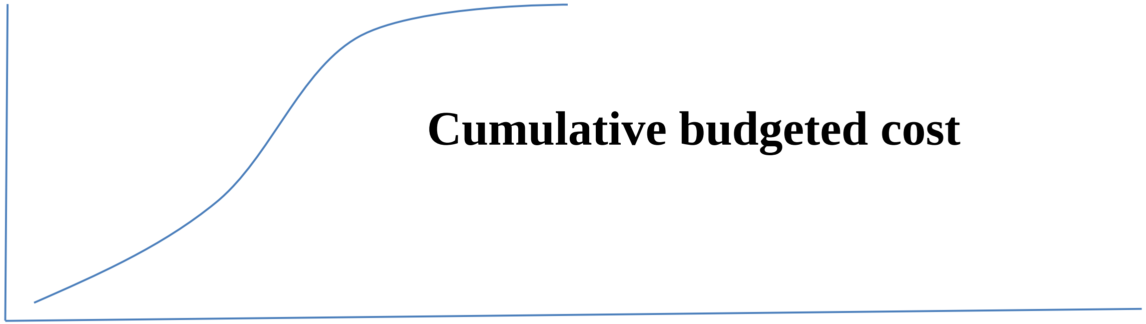






Budgeted cost for a project

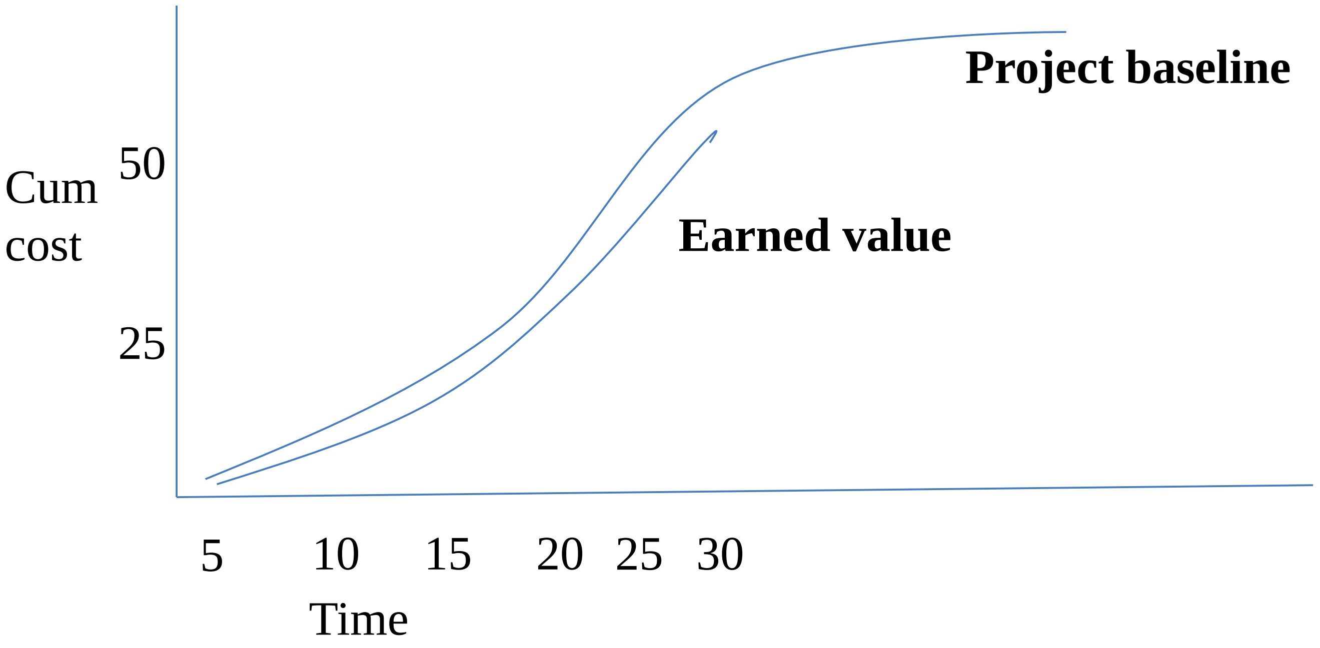
Duration (in weeks)									
	5	10	15	20	25	30	35	40	45
Design	6	2							
Engineering		4	8	8	8				
Installation				4	20	6			
Testing						2	6	4	2
Total	6	6	8	12	28	8	6	4	2
Cumulative	6	12	20	32	60	68	74	78	80



Percentage of tasks completed for above project: Suppose that on 30th week, design and engineering are 100% complete and installation is 50% complete.

Duration (in weeks)										
	5	10	15	20	25	**30**	35	40	45	% completed
Design	6	2								100
Engineering		4	8	8	8					100
Installation				4	20	**6**				50
Testing						**2**	6	4	2	0
Total	6	6	8	12	28	**8**	6	4	2	
Cumulative	6	12	20	32	60	**68**	74	78	80	

Duration (in weeks)			
	Planned	% complete	Earned value
Design	8	100	8
Engineering	28	100	28
Installation	30	50	15
Testing	14	0	0
Cumulative Earned value			51


Project baseline
Cum
cost
50
Earned value
25
5
10
15
20
25
30
Time

The project has 8 months schedule and 118 budget. Calculate earned value at the end of June?.

Duration (in weeks)										
	Jan	Feb	Mar	Apr	May	**June**	July	**Plan**	**% Completed**	**Value**
Staffing	8	7						15	100	
Blueprint			4	6				10	80	
Prototype			2	8				10	60	
Full design				3	8	**10**		21	33	
Construction					2	**30**		32	25	
Transfer							10	10	0	
Punch list						**15**	5	20	0	
								$\sum$ 118		
Monthly plan	8	7	6	17	10	**55**	15			
Monthly actual	8	11	8	11	10	**30**	0			

The project has 8 months schedule and 118 budget. Calculate earned value at the end of June?.

Duration (in weeks)										
	Jan	Feb	Mar	Apr	May	**June**	July	**Plan**	**% Completed**	**Value**
Staffing	8	7						15	100	15
Blueprint			4	6				10	80	8
Prototype			2	8				10	60	6
Full design				3	8	**10**		21	33	7
Construction					2	**30**		32	25	8
Transfer							10	10	0	0
Punch list						**15**	5	20	0	0
								$\sum$ 118		**44**
Monthly plan	8	7	6	17	10	**55**	15			
Cumulative	8	15	21	38	48	**<u>103</u>**	118			
Monthly actual	8	11	8	11	10	**30**	0			
Cumulative actual	8	19	27	38	48	**78**				

Total planned budget is 118 and the value realized is 44.

Schedule variances	
Planned value (PV)	103
Earned value(EV)	44
Schedule performance index (SPI)	EV/PV =.43
Estimated time to completion	1/ (.43) * (8)=**18.60,** We are running 10 months behind schedule

Cost variances	
Actual cost of work performed (AC)	78
Earned value (EV)	44
Cost performance index (CPI)	EV/AC = .56
Estimated cost to completion	1/(.56) * 118=210

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Project Management for Managers

Lec – 54

Cost Estimation

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Cost management is extremely important for running successful projects. The management of costs, in many ways, <u>reflects</u> the project origination's <u>strategic goals, mission statement, and business plan.</u>

Some of the common sources of costs

Labor

Material

Subcontractors

Equipment and facilities

Travel

Common classification of costs

Direct and indirect (overhead costs; depreciation, health and retirements benefits, selling and general administrative expenses)

Recurring (labor, logistic, material, etc.) **and non recurring** (charges applied **once** at the beginning or end or project)

Fixed (when leasing capital equipment or other project hardware, the leasing price is likely **not to go up or down** with the amount of uses) **and Variable** (Metal cutting operation)

Normal and expedited

Costs	Type		Frequency		Adjustment		Schedule	
	Direct	Indirect	Recurring	Non-recurring	Fixed	Variable	Normal	Expedited
Direct labor								
Building lease								
Expedite costs								
Material								

Costs	Type		Frequency		Adjustment		Schedule	
	Direct	Indirect	Recurring	Non-recurring	Fixed	Variable	Normal	Expedited
Direct labor	x		x		x		x	
Building lease		x	x		x		x	
Expedite costs	x			x		x		x
Material	x		x			x	x	

Learning Curves in Cost Estimation

Let us assume, for example, **that the time necessary to code a particular software routine is estimated at 20 Hrs** of work for the first iteration. Doing the coding work **a second time requires only 15 hrs**. The **learning ratio** is 15/20 = **75%**. We can now apply that figure to estimates of cost for additional coding iterations.

When the output is doubled from the first two routines to the required four, the time needed to complete the exercise is now estimated to take

15*0.75 = 11.25 hrs.

Learning curves in cost estimation

These **time and cost estimates** follow a well defined formula, which is the time required to produce a unit of output, and is represented as:

$Yx = a (X)^b$

Where

Yx= Time required for x unit of output

a=the time required for the initial unit of out put

X =the number of units to be produced

b=the slope of the learning curve, represented as: **log decimal learning rate /log2**

Example: Worker must do 15 of these activities (fitting, riveting, and squaring). Also assume that the time estimated to perform the last iteration (steady state) is 1 hr., and we know from past experience the learning rate of this activity is 0.60.

In calculation the time necessary to complete the first activity , we would apply the above values to the formula to determine the value of “a”,.?????????????????????????

Example: Worker must do 15 of these activities (fitting, riveting, and squaring). Also assume that the time estimated to perform the last iteration (steady state) is 1 hr., and we know from past experience the learning rate of this activity is 0.60.

In calculation the time necessary to complete the first activity , we would apply the above values to the formula to determine the value of “a”,.

$b = \log 0.60 / \log 2$

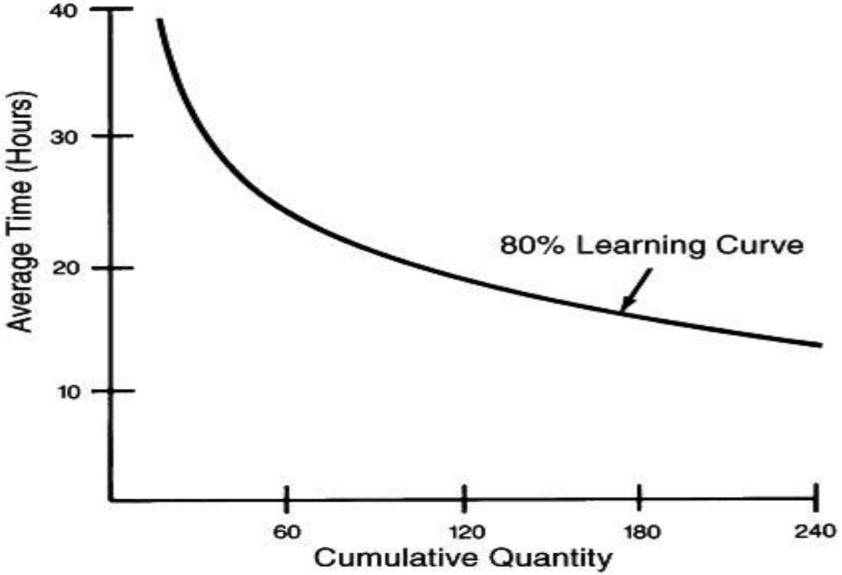
$= -0.5108/0.693$

$= -0.737$

$1 \text{ hr} = a(15)^{-0.737}$

$a = 7.358 \text{ hrs.}$

Learning curves in cost estimation: As can be seen, as production quantities double, the average time per unit decreases by 20% of its immediate previous time.



Sample project budget

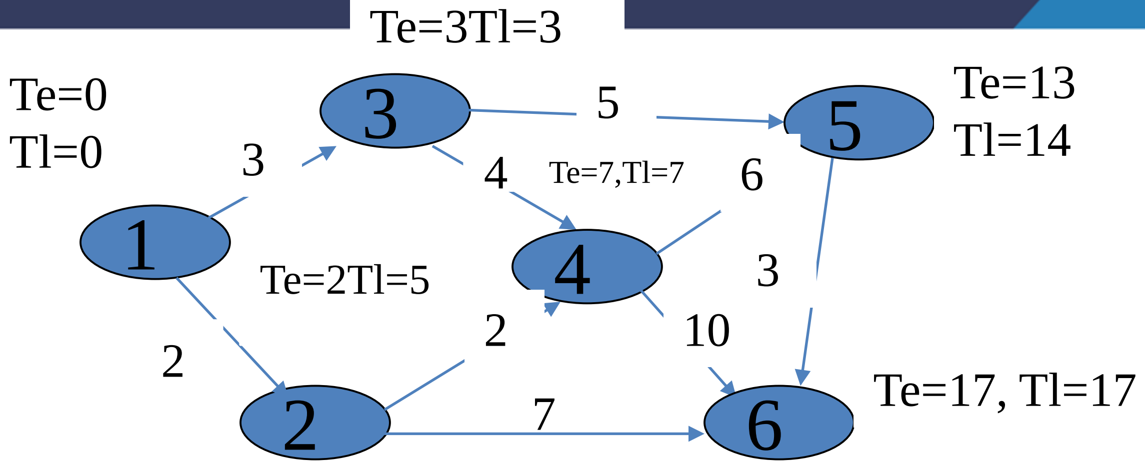
Activity	DC	Budget overhead	Total cost
Survey	3500	500	4000
Design	7000	1000	8000
Clear site	3500	500	4000
Foundation	6750	750	7500
Framing	8000	2000	10000
Plumb and wire	3750	1250	5000

Sample budget tacking planned and actual activity costs.

	Budget		
Activity	**Planned**	**Actual**	**variance**
Survey	4000	4250	250
Design	8000	8000	0
Clear site	4000	3500	-500
Foundation	7500	8500	1000
Framing	10000	11250	1250
Plumb and wire	5000	5150	150
Total	38500	40650	2150

Example of time phased budget

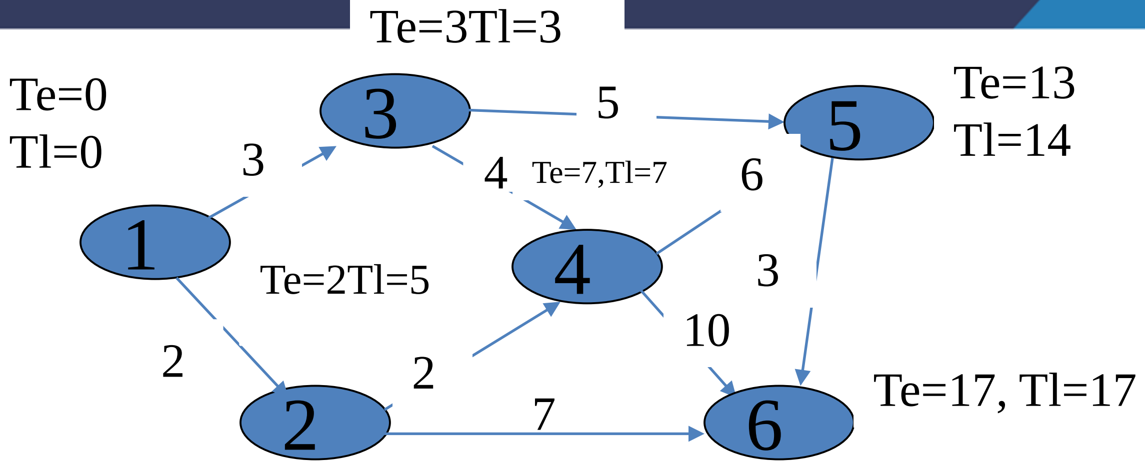
Month						
Activity	**Jan**	**Feb**	**March**	**April**	**May**	**Total by activity**
Survey	4000					**4000**
Design		5000	3000			**8000**
Clear site		4000				**4000**
Foundation			7500			**7500**
Framing				8000	2000	**10000**
Plumb and wire				1000	4000	**5000**
Monthly planned	4000	9000	10500	9000	6000	
Cumulative	4000	13000	23500	32500	38500	**38500**



Find cumulative cost by considering earliest start solution.

Activity	**Duration (months)**	**ESij**	**LSij**	**Total cost (Rs 100)**	**Cost per month**
1-2	2	0	3	1200	600
1-3	3	0	0	900	300
2-4	2	2	5	0	0
2-6	7	2	10	2800	400
3-4	5	3	3	2000	400
3-5	5	3	9	2000	400
4-5	6	7	8	3000	500
4-6	10	7	7	8000	800
5-6	3	13	14	2100	700

Day	1-2	1-3	2-4	2-6	3-4	3-5	4-5	4-6	5-6	Cum Cost
1	600	300								900
2	600	300								1800
3		300	0	400						2500
4			0	400	500	400				3800
5				400	500	400				5100
6				400	500	400				6400
7				400	500	400				7700
8				400		400	500	800		9800
9				400			500	800		11500
10							500	800		12800
11							500	800		14100
12							500	800		15400
13							500	800		16700
14								800	700	18200
15								800	700	19700
16								800	700	21200
17								800		22000

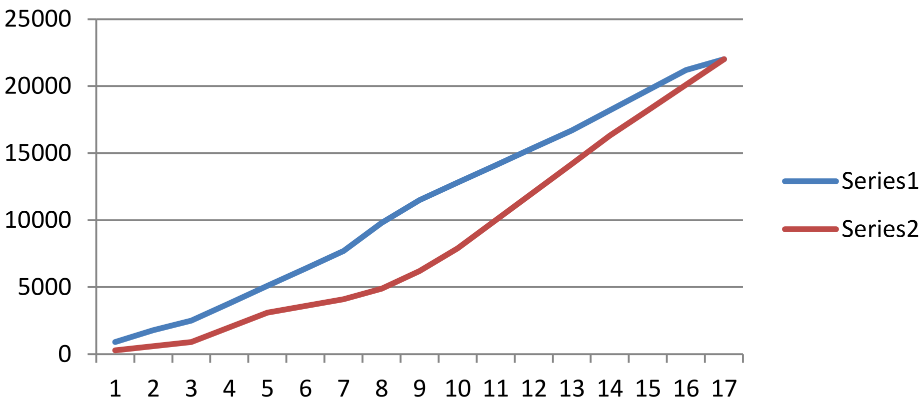


Find cumulative cost by considering latest start solution.

Activity	Duration	Esij	LSij	Total cost (Rs 100)	Cost per month
1-2	2	0	3	1200	600
1-3	3	0	0	900	300
2-4	2	2	5	0	0
2-6	7	2	10	2800	400
3-4	5	3	3	2000	400
3-5	5	3	9	2000	400
4-5	6	7	8	3000	500
4-6	10	7	7	8000	800
5-6	3	13	14	2100	700

Day	1-2	1-3	2-4	2-6	3-4	3-5	4-5	4-6	5-6	Cum Cost
1		300								300
2		300								600
3		300								900
4	600				500					2000
5	600				500					3100
6			0		500					3600
7			0		500					4100
8								800		4900
9							500	800		6200
10						400	500	800		7900
11				400		400	500	800		10000
12				400		400	500	800		12100
13				400		400	500	800		14200
14				400		400	500	800		16300
15				400				800	700	18200
16				400				800	700	20100
17				400				800	700	22000

Te	Tl
900	**300**
1800	600
2500	900
3800	2000
5100	3100
6400	3600
7700	4100
9800	4900
11500	6200
12800	7900
14100	10000
15400	12100
16700	14200
18200	16300
19700	18200
21200	20100
22000	22000



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Project Management for Managers

Lec – 55

Introduction to Quality Management

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Sugarcane extraction gears

Wrist watch gears

Airplane gears

Taguchi ????

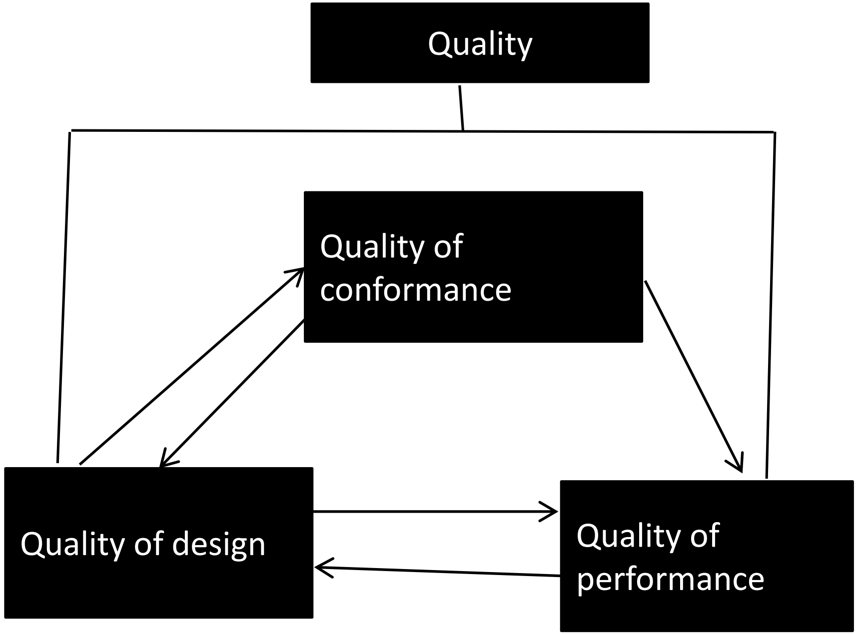
$$\text{Quality} \propto \frac{1}{\text{Variability}}$$

Dimensions of Quality

- Performance (P-Power, S/N ratio, S- Time to process a/c)
- Reliability (P-MTTF, S- Variability of time to process req.)
- Durability (P-Useful life with repairs, S-Pace with technology)
- Serviceability (how easy to repair)
- Aesthetics
- Features
- Perceived Quality (reputation of the company)
- Conformance to standards (Design)

How to remember ????

The Three aspects of quality



There are several **reasons** why the cost of quality should be **explicitly** considered in an organization.

1. The **increase** in the **cost** of quality because of the increase in the **complexity** of manufactured products associated with advances in technology.
2. Increasing awareness of life cycle costs, including **maintenance, spare parts,** and the cost of field failures.
3. Quality **engineers** and **managers** can most effectively communicate quality issues in a way that **management** understands.

Prevention costs: Prevention of non conformity

1. Quality planning and engineering
2. New products review
3. Product or process review
4. Process control
5. Burn-in: The cost of pre-shipment operation of the product to prevent early-life failures in the field.
6. Training
7. Quality data acquisition and analysis

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Project Management for Managers

Lec – 56

Cost of Quality

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Appraisal Costs: Costs associated with measuring, evaluating or auditing products, components and purchased materials to ensure conformance to the standards that have been imposed.

1. Inspection and test of incoming material
2. Product inspection and test
3. Materials and services consumed
4. Maintaining accuracy of test equipment

Internal Failure Costs: Internal failure costs are incurred when products, components, materials and services **fail to meet** quality requirements and the failure is discovered **prior to delivery** of the product to customer.

1. Scrap
2. Rework
3. Retest
4. Failure analysis
5. Down time
6. Yield losses
7. Downgrading (off-specing): Price difference

External Failure Costs: External failure costs occur when the product does not perform satisfactory after it is delivered to the customer.

1.Complaint adjustment

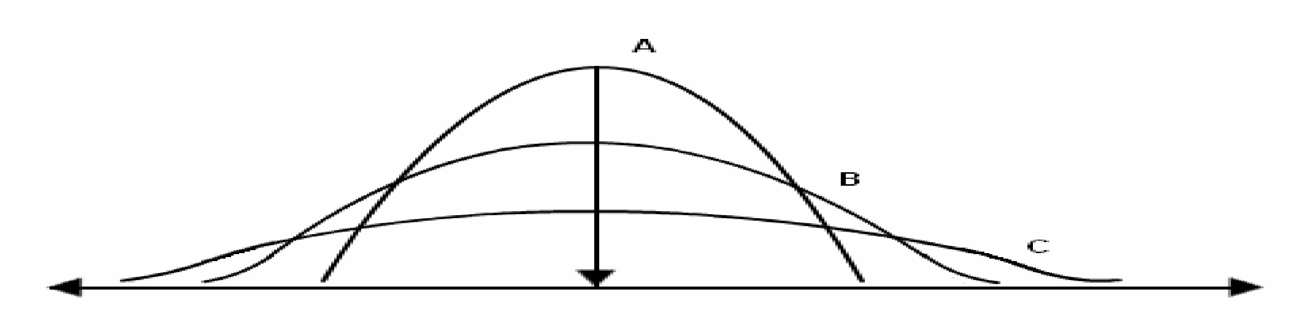
2. Returned product/material

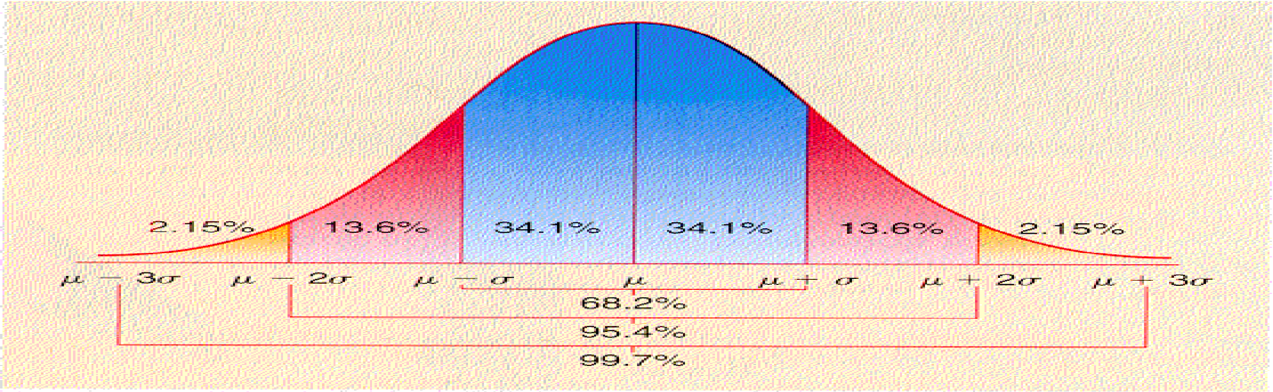
3. Warranty charges

4. Liability costs or awards incurred from product liability litigation.

5. Indirect costs: These are incurred because of customer dissatisfaction with the level of quality of delivered product.

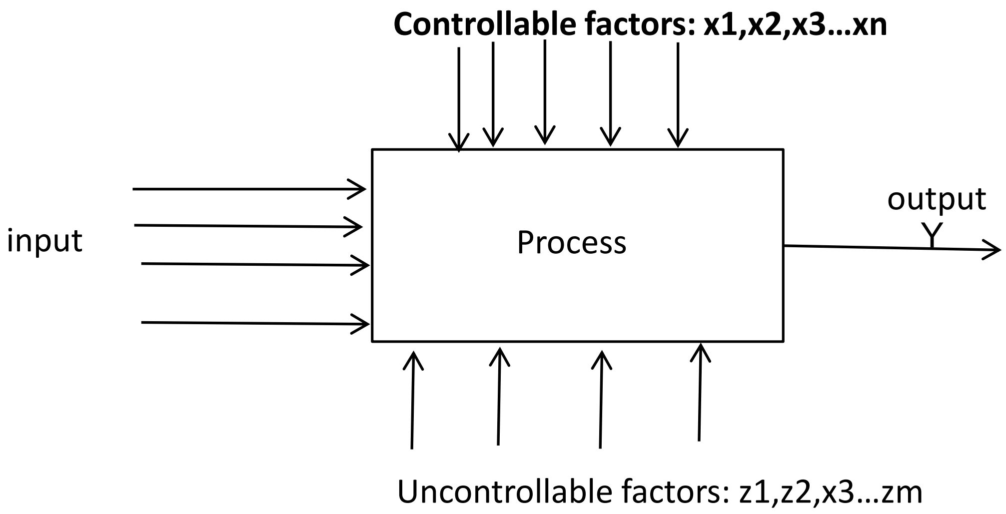
What is variability?





How to measure it : σ

Sources of variability



How to remove variability?

- Determine which variables (x’s) are most influential on the response, y
- Determine where to set the influential x’s so that y is near the nominal requirement
- Determine where to set the influential x’s so that variability is small
- Determine where to set the influential x’s so that the effects of the uncontrollable variables z are minimized

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Project Management for Managers

Lec – 57

Sources of Variability and Six Sigma

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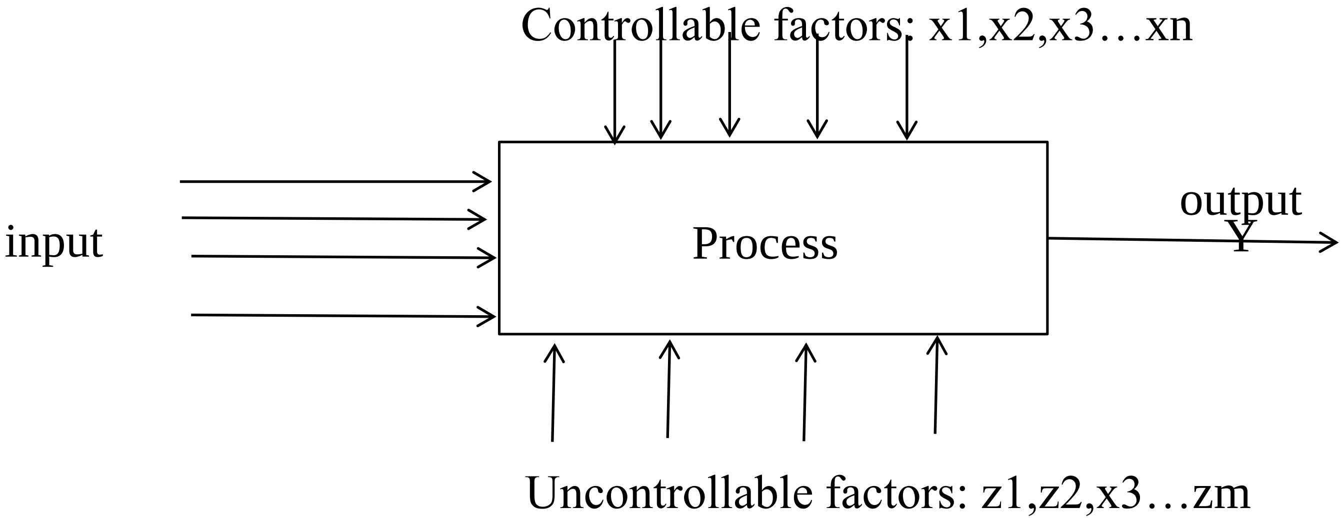
Sources of variability



How to remove variability?

– Determine which **variables** (x’s) are most **influential** on the response, y

– Determine where **to set** the influential x’s so that y is near the nominal requirement

– Determine where to set the influential x’s so that **variability** is **small**

– Determine where to set the influential x’s so that the effects of the **uncontrollable variables “z” are minimized**

Number of confirming products at 3 σ : 99.73

Ex. A product consists of 100 parts assembly, the probability that any specific unit of product is confirming.

Ex. A product consists of 100 parts assembly, the probability that any specific unit of product is confirming.

Solution: $(0.9973)^{100} = 0.7631 = 76.31\%$

If we go by 3 sigma:

20,000 wrong drug prescription each year.

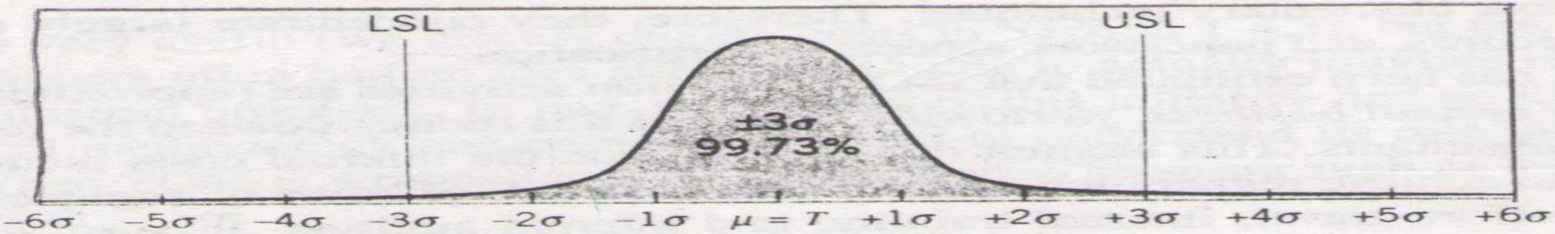
More than 15,000 babies accidently dropped by nurses and doctors each year.

500 incorrect surgical operations per week.

2000 lost pieces of mail each hour.

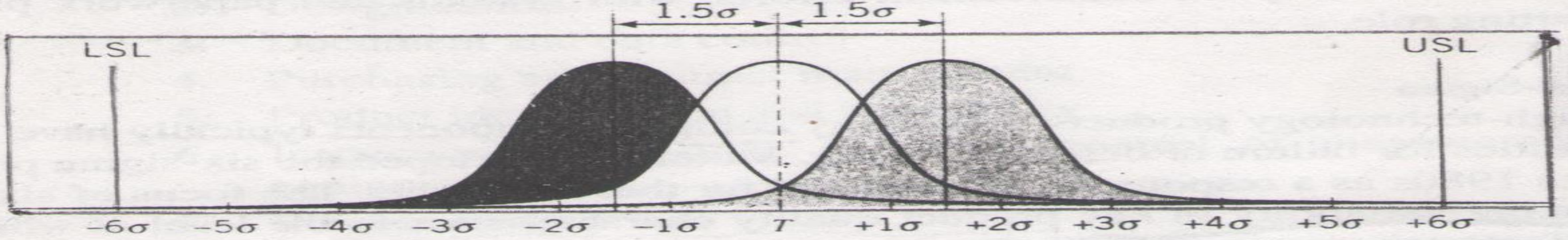
Six Sigma

The Motorola SS concept is to reduce the **variability** in the process so that specific limits are **six standard deviations away from the mean.**



Spec. Limit	Percent Inside Specs	ppm Defective
±1 Sigma	68.27	317300
±2 Sigma	95.45	45500
±3 Sigma	99.73	2700
±4 Sigma	99.9937	63
±5 Sigma	99.999943	0.57
±6 Sigma	99.9999998	0.002

(*a*) Normal distribution centered at the target (*T*)



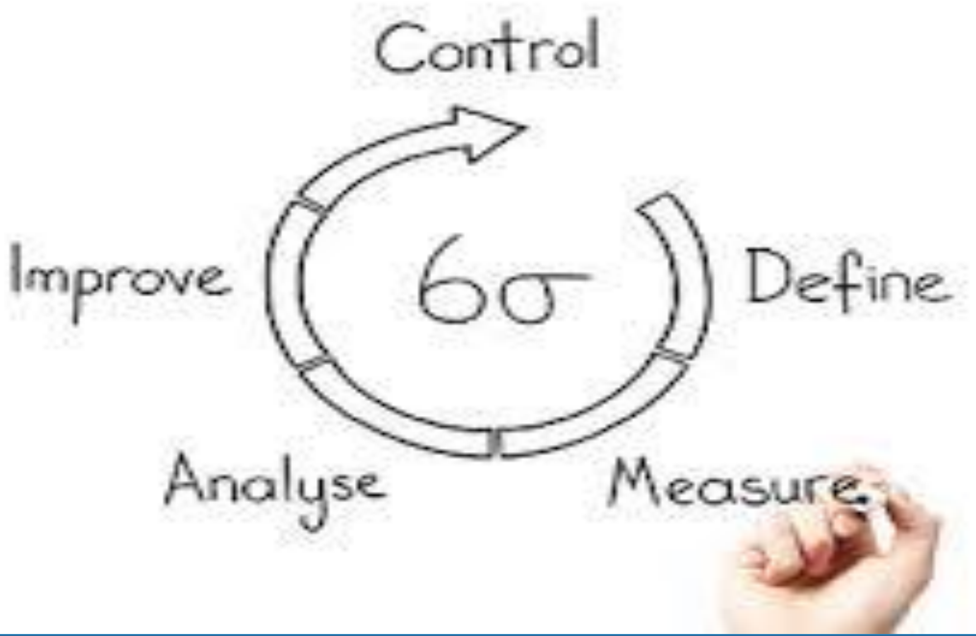
Spec. Limit	Percent Inside Specs	ppm Defective
±1 Sigma	30.23	697700
±2 Sigma	69.13	608700
±3 Sigma	93.32	66810
±4 Sigma	99.3790	6210
±5 Sigma	99.97670	233
±6 Sigma	99.999660	3.4

(*b*) Normal distribution with the mean shifted by 1.5σ from the target

The Motorola six-sigma concept.

Deming’s PDCA cycle

Six Sigma Process



Six Sigma Quality

$\pm 3\sigma$

- **A philosophy and set of methods companies use to eliminate defects in their products and processes**

- **Seeks to reduce variation in the processes that lead to product defects**

- **The name, "six sigma" refers to the variation that exists within plus or minus three standard deviations of the process outputs**

Six Sigma Quality (Continued)

- Six Sigma allows managers to readily describe process <u>performance</u> using a common metric: Defects Per Million Opportunities (DPMO)

$$DPMO = \frac{\text{Number of defects}}{\begin{bmatrix}\text{Number of} \\ \text{opportunities} \\ \text{for error per} \\ \text{unit}\end{bmatrix} \text{x No. of units}} \text{x } 1{,}000{,}000$$

Six Sigma Quality (Continued)

Example of Defects Per Million Opportunities (DPMO) calculation.

Suppose we observe 200 letters delivered incorrectly to the wrong addresses in a small city during a single day when a total of 200,000 letters were delivered. What is the DPMO in this situation?

Six Sigma Quality (Continued)

Example of Defects Per Million Opportunities (DPMO) calculation. Suppose we observe 200 letters delivered incorrectly to the wrong addresses in a small city during a single day when a total of 200,000 letters were delivered. What is the DPMO in this situation?

So, for every one <u>million</u> letters delivered this city's postal managers can expect to have 1,000 letters incorrectly sent to the wrong address.

$$DPMO = \frac{200}{[1] \times 200{,}000} \times 1{,}000{,}000 = 1{,}000$$

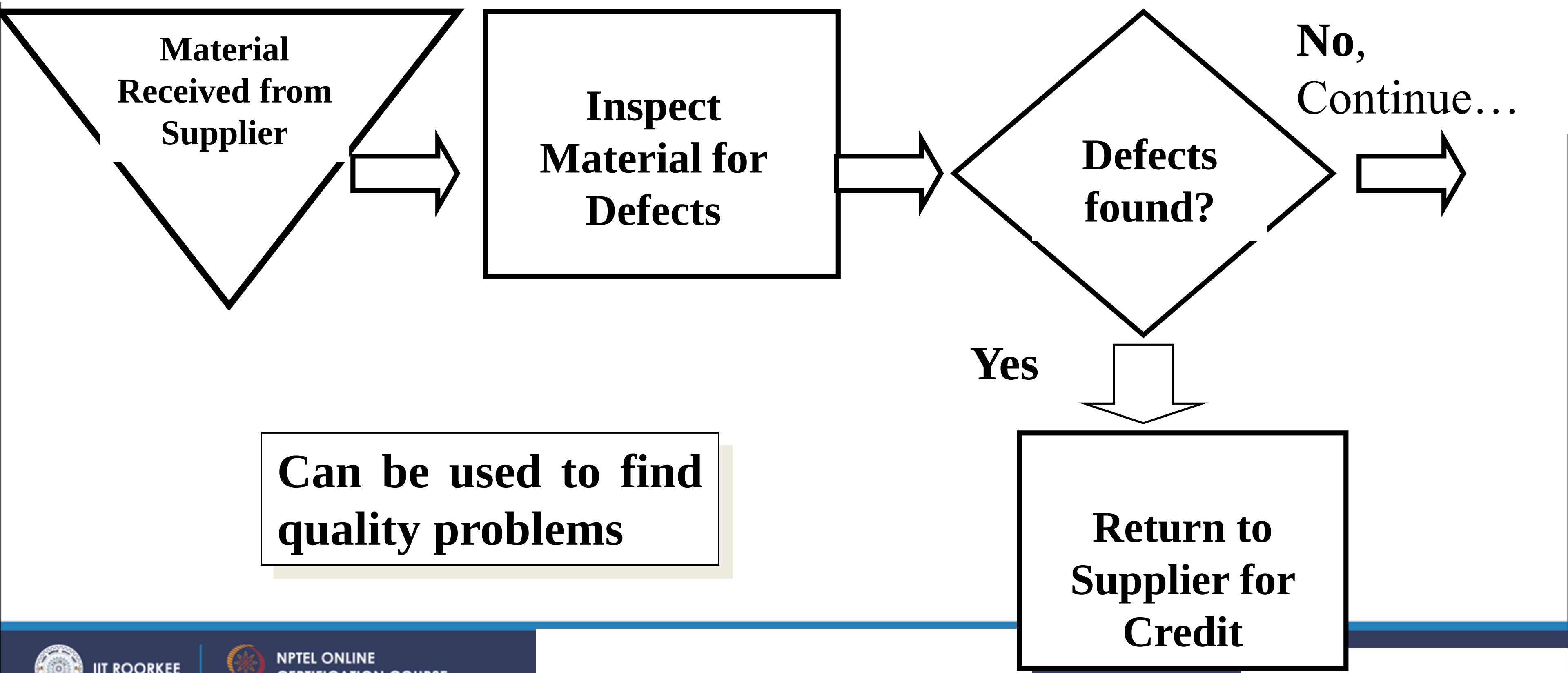
Six Sigma Quality: DMAIC Cycle

- **Define, Measure, Analyze, Improve, and Control (DMAIC)**
- **Developed by General Electric as a means of focusing effort on quality using a methodological approach**
- **Overall focus of the methodology is to understand and achieve what the customer wants**
- **DMAIC consists of five steps….**

Six Sigma Quality: DMAIC Cycle (Continued)

1. Define (D)	Customers and their priorities
↓	↓
2. Measure (M)	Process and its performance
↓	↓
3. Analyze (A)	Causes of defects
↓	↓
4. Improve (I)	Remove causes of defects
↓	↓
5. Control (C)	Maintain quality

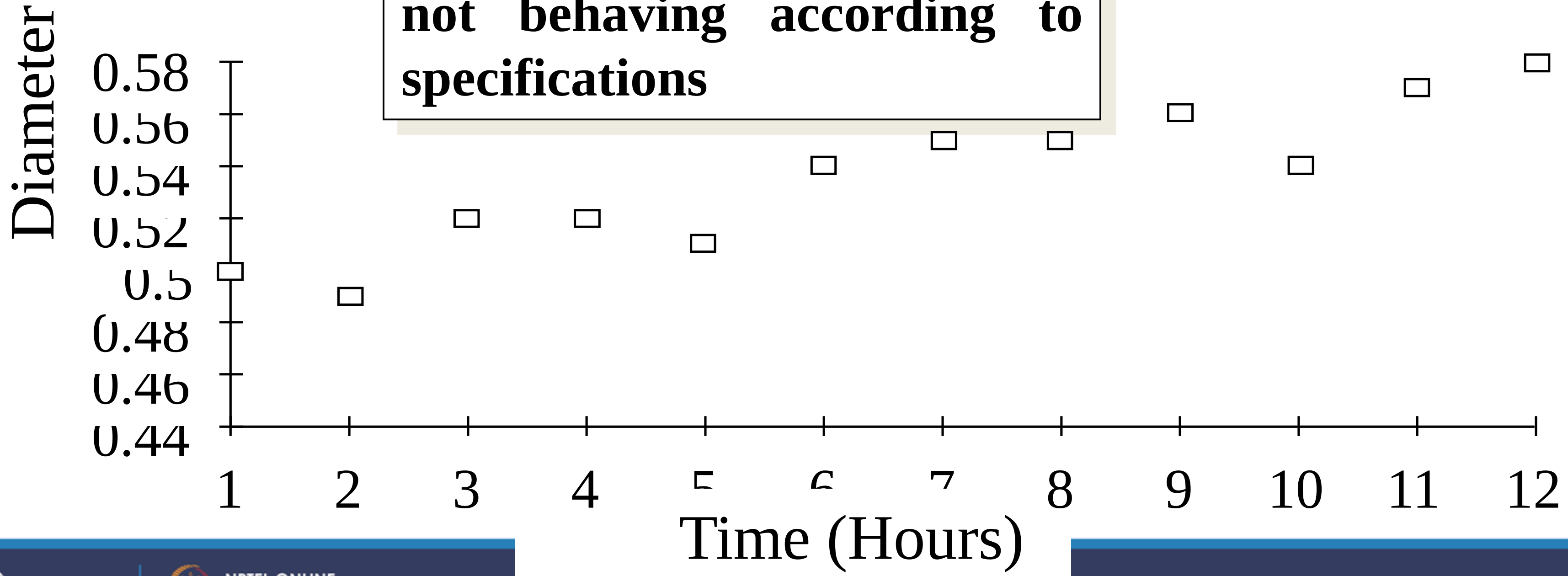
Analytical Tools for Six Sigma and Continuous Improvement: Flow Chart



Can be used to find quality problems

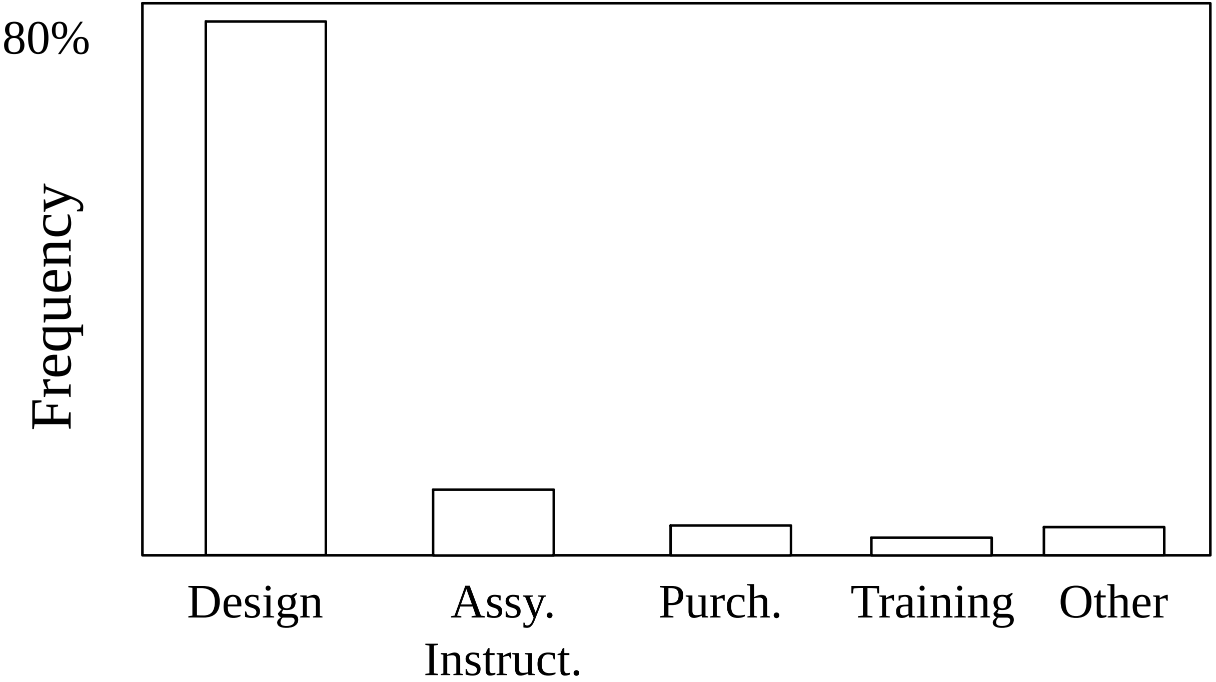
Analytical Tools for Six Sigma and Continuous Improvement: Run Chart

Can be used to identify when equipment or processes are not behaving according to specifications



Analytical Tools for Six Sigma and Continuous Improvement: Pareto Analysis

Can be used to find when 80% of the problems may be attributed to 20% of the causes



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Project Management for Managers

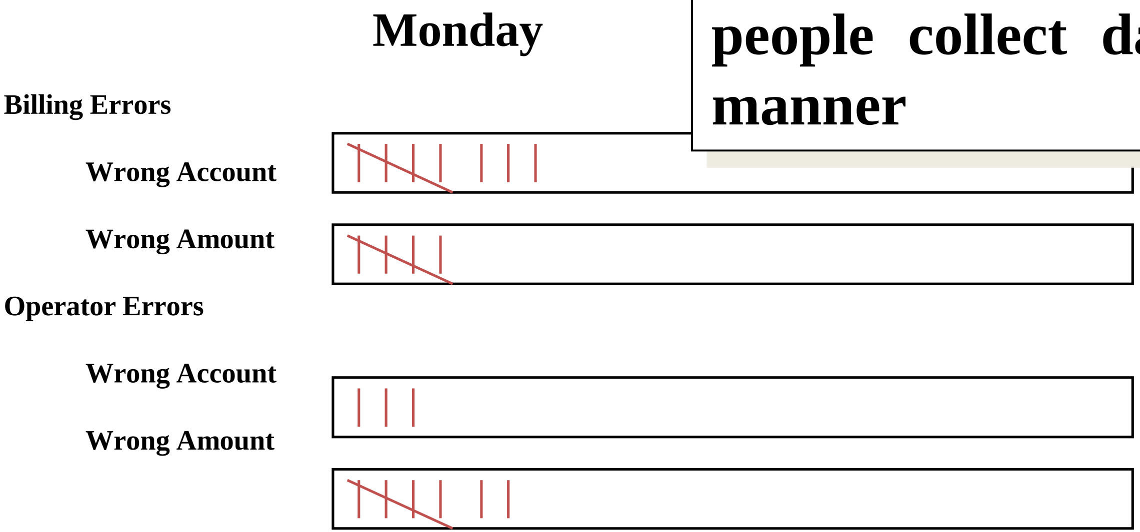
Lec – 58

Six Sigma Tools

Dr. M.K. Barua
Department of Management
Indian Institute of Technology Roorkee

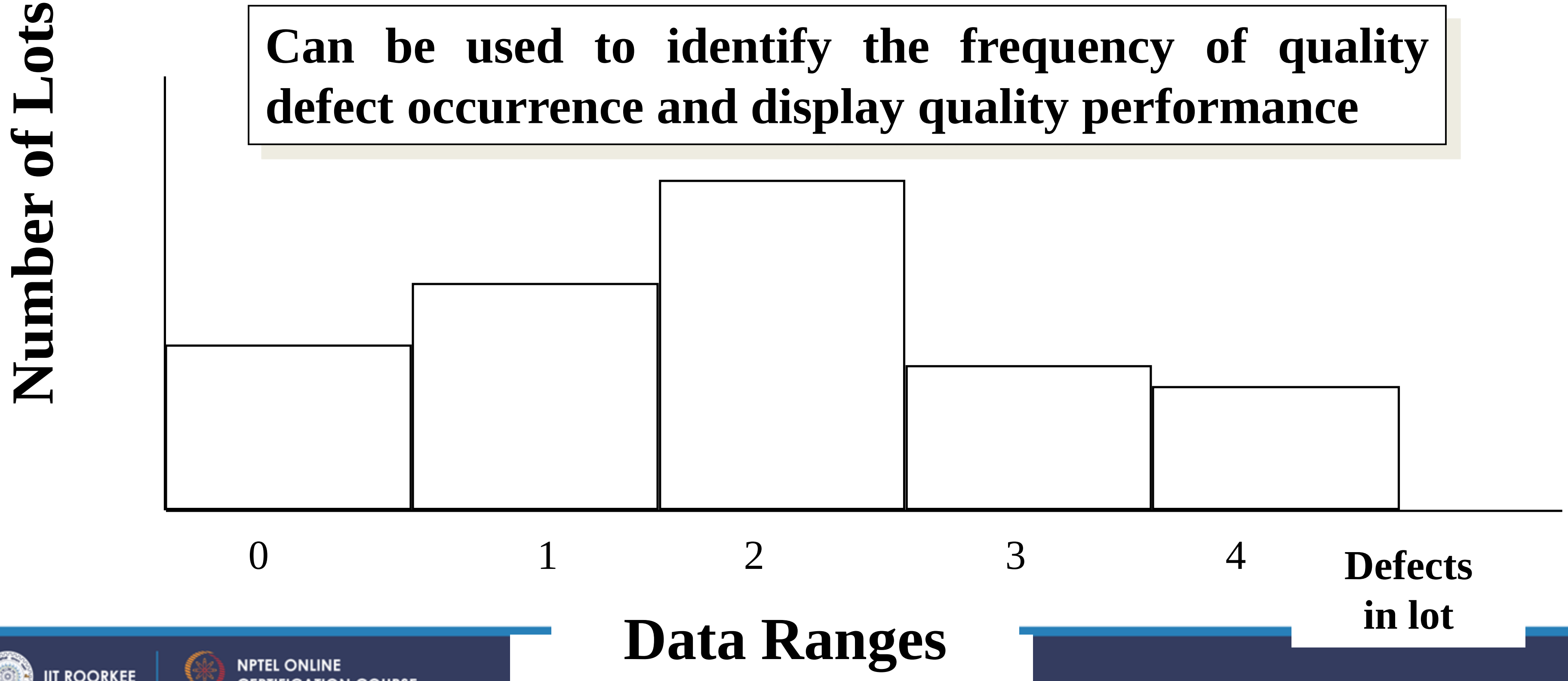
Analytical Tools for Six Sigma and Continuous Improvement: Checksheet

Can be used to keep track of defects or used to make sure people collect data in a correct manner



Analytical Tools for Six Sigma and Continuous Improvement: Histogram

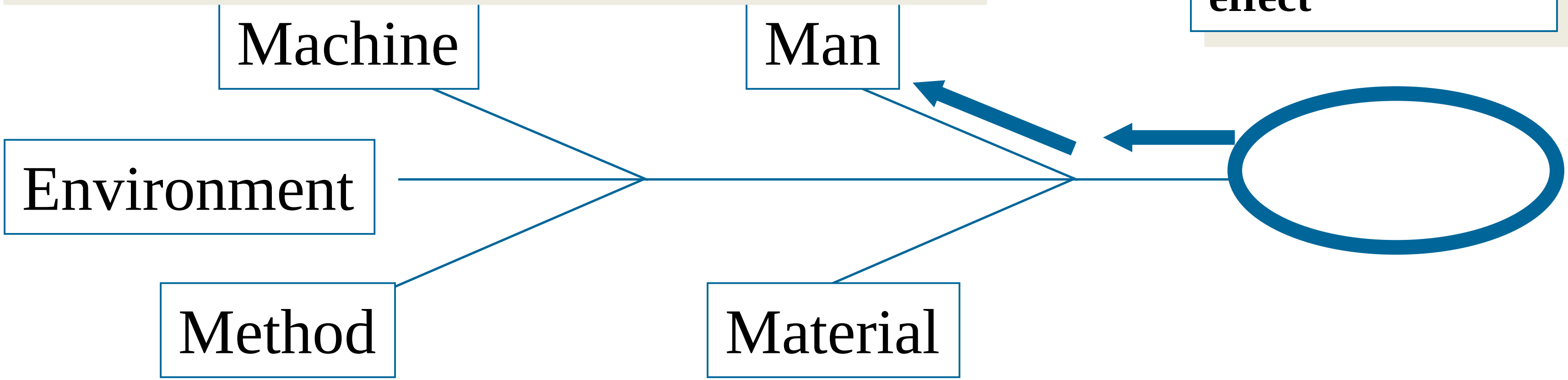
Can be used to identify the frequency of quality defect occurrence and display quality performance



Analytical Tools for Six Sigma and Continuous Improvement: Cause & Effect Diagram

Possible causes:

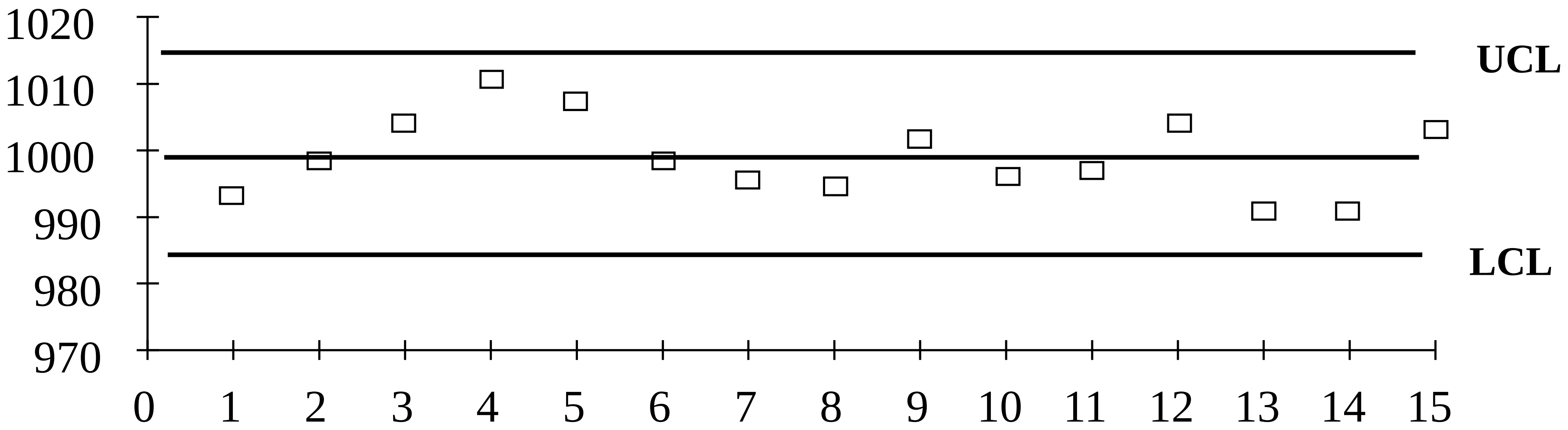
The results or effect



Can be used to systematically track backwards to find a possible cause of a quality problem (or effect)

Analytical Tools for Six Sigma and Continuous Improvement: Control Charts

Can be used to monitor ongoing production process quality and quality conformance to stated standards of quality

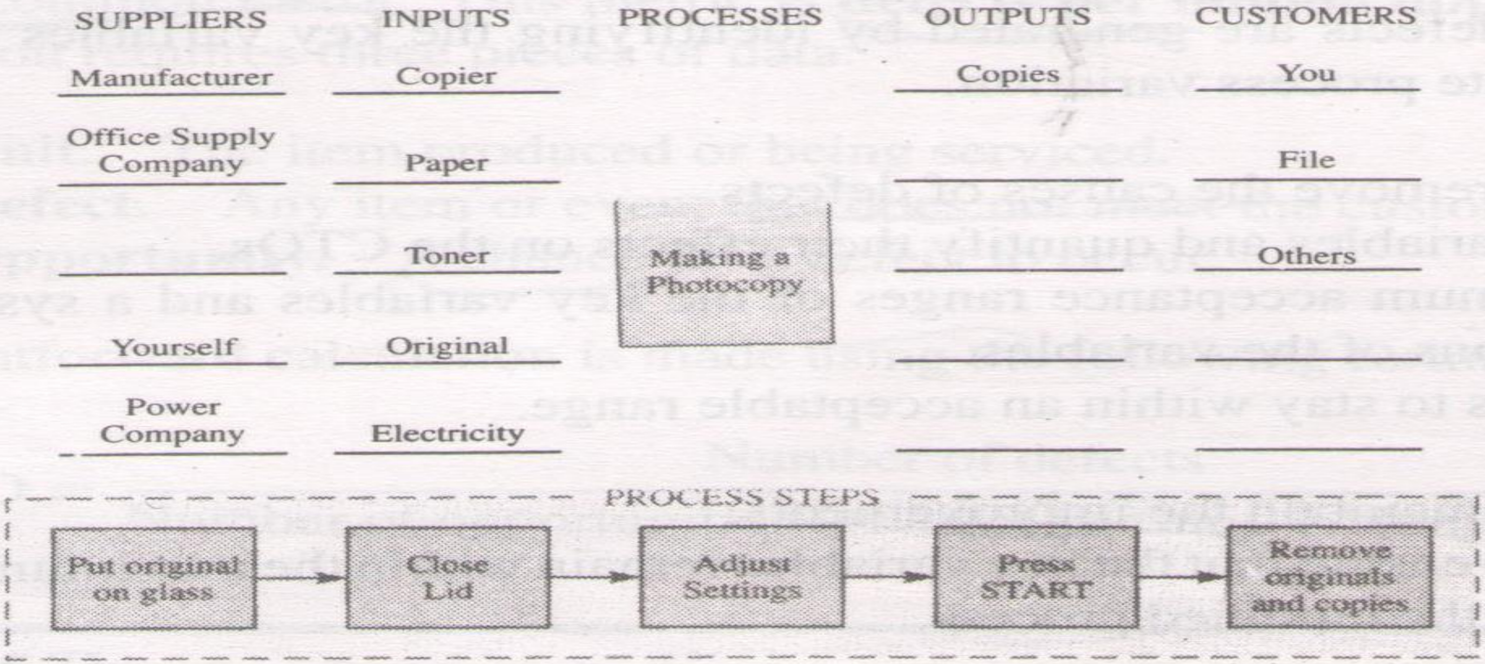


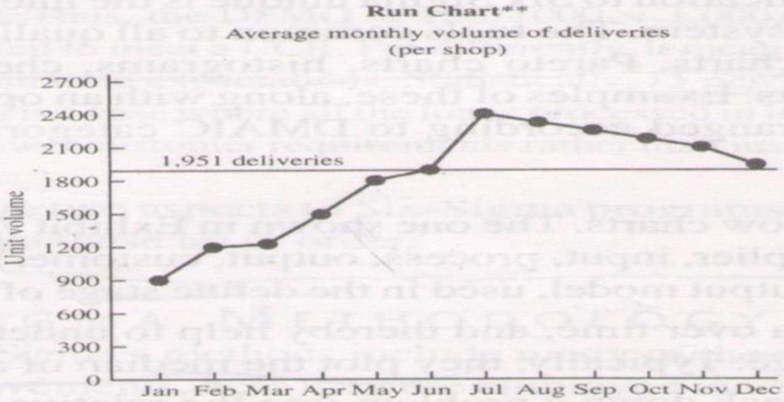
Other Six Sigma Tools

- Opportunity Flow Diagram used to graphically show those activities that add value from those that are performed (and maybe could be reduced or removed) that do not add value to the finished product
- Failure Mode and Effect Analysis (FMEA) is a structured approach to identify, estimate, prioritize, and evaluate risk of possible failures at each stage in the process
- Design of Experiments (DOE) a statistical test to determine cause-and-effect relationships between process variables and output

Flow Chart of Major Steps in a Process*

Define





DATA COLLECTION FORMS*

Checksheets are basic forms that help standardize data collection by providing specific spaces where people should record data.

Defines what data are being collected → **Machine Downtime (Line 13)**

Operator: Wendy   Date: May 19

Reason	Frequency	Comments
Carton Transport	~~IIII~~ ~~IIII~~ II	
Metal Check	IIII	
No Product	~~IIII~~ I	
Sealing Unit	II	
Barcoding	III	
Conveyor Belt		
Bad Product	~~IIII~~	Burned flakes III Low weight II
Other	II	

Lists the characteristics or conditions of interest

Includes place to put the data

May want to add space for tracking stratification factors

Has room for comments

Measure

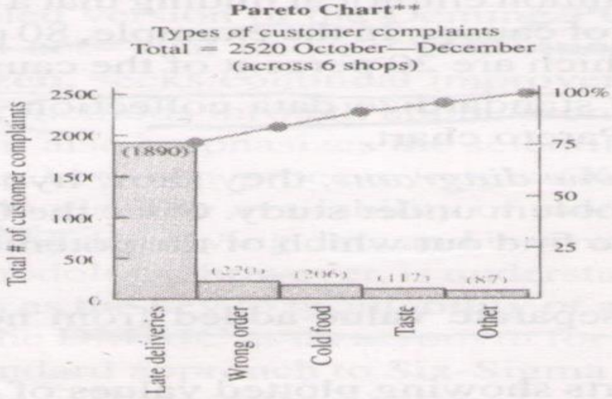
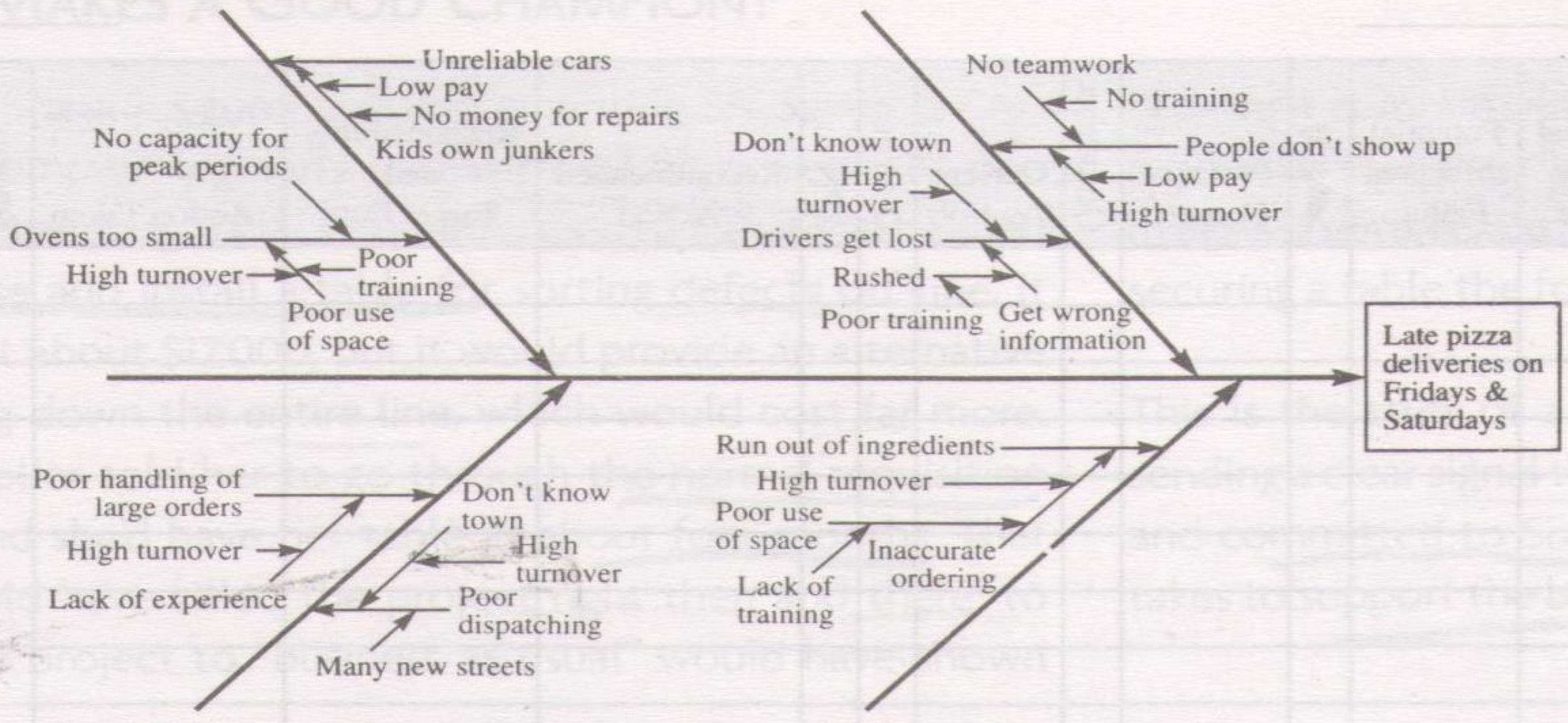


Illustration note: Delivery time was defined by the total time from when the order was placed to when the customer received it.

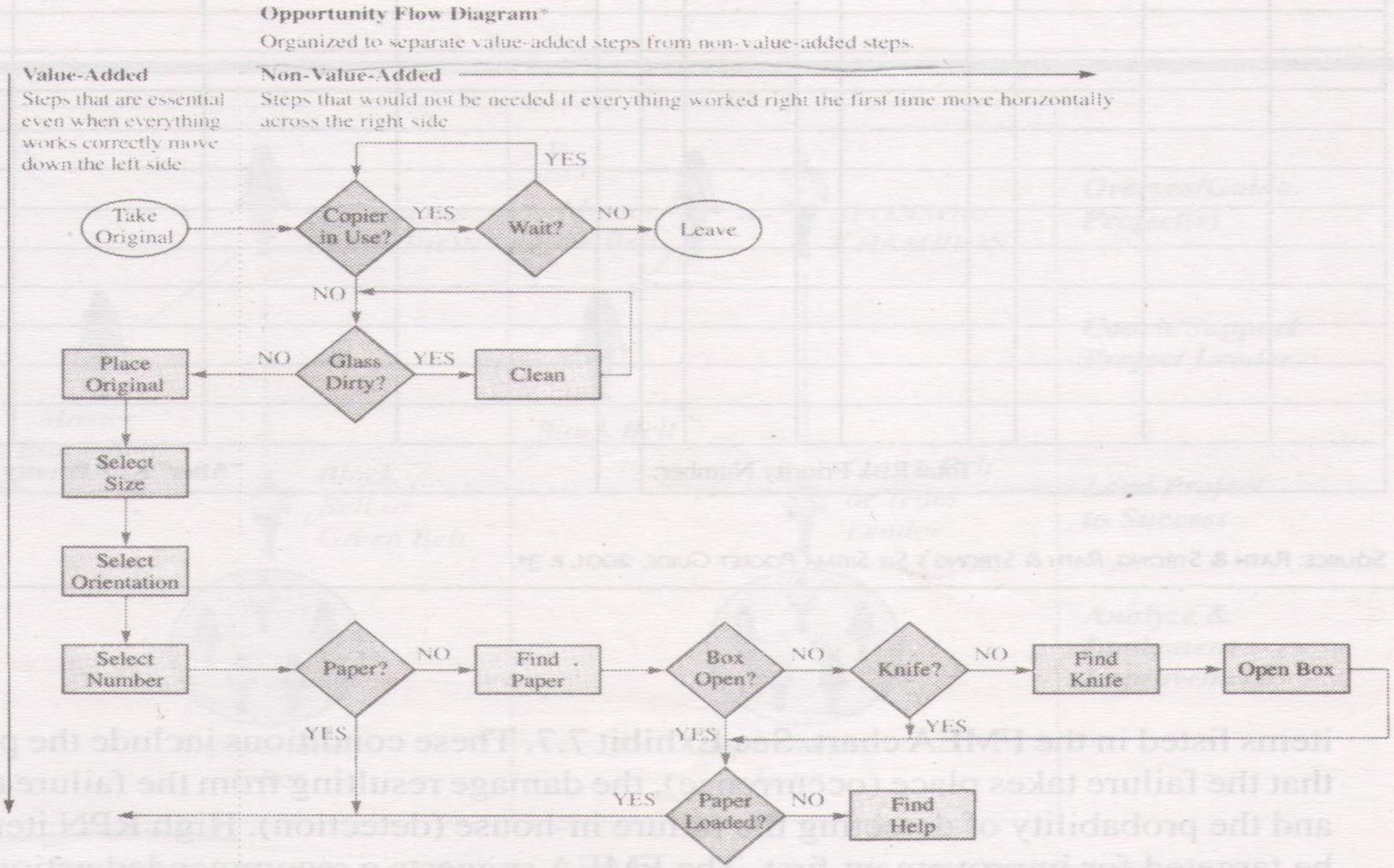
C & E/Fishbone Diagram**

Reasons for late pizza deliveries

Analyze



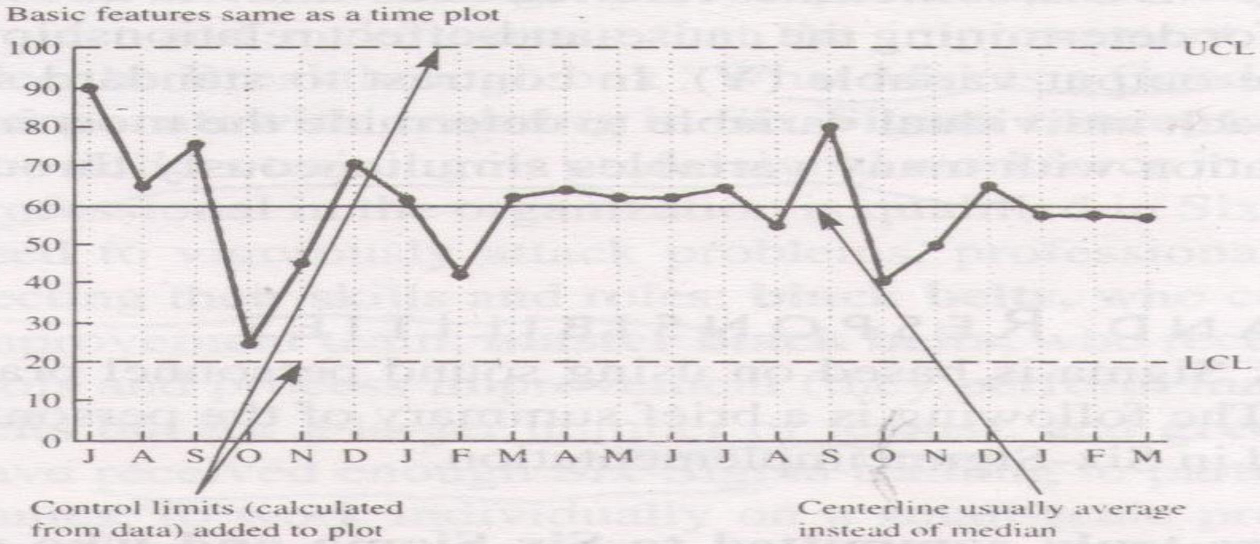
Improve



Opportunity Flow Diagram*
Organized to separate value-added steps from non-value-added steps.
Value-Added
Steps that are essential even when everything works correctly move down the left side
Non-Value-Added
Steps that would not be needed if everything worked right the first time move horizontally across the right side
Take Original
Copier in Use?
YES
Wait?
YES
NO
Leave
NO
Glass Dirty?
YES
Clean
NO
Place Original
Select Size
Select Orientation
Select Number
Paper?
NO
Find Paper
Box Open?
NO
Knife?
NO
Find Knife
Open Box
YES
YES
YES
Paper Loaded?
YES
NO
Find Help

Control

Control Chart Features*



Six Sigma Roles and Responsibilities

1. Executive leaders must champion the process of improvement: Executives and managers
2. Corporation-wide training in Six Sigma concepts and tools

   <u>Black belt:</u> who coach or leads SS improvement team

   <u>Master black belt:</u> Who receive in depth training on <u>statistical</u> tools process improvement(larger teams)

Green belt: who have received enough SS training to participate in a team or, in some companies, to work individually on a small scale project related to their own jobs.

3. Setting stretch objectives for improvement

4. Continuous reinforcement and rewards

The Shingo System: Fail-Safe Design

- **Shingo's argument:(Successive, self, source checks)**
  - SQC methods do not prevent defects
  - Defects arise when people make errors
  - Defects can be prevented by providing workers with feedback on errors
  - SMED – to cut set up time

- **Poka-Yoke includes:**
  - Checklists
  - Special tooling that prevents workers from making errors

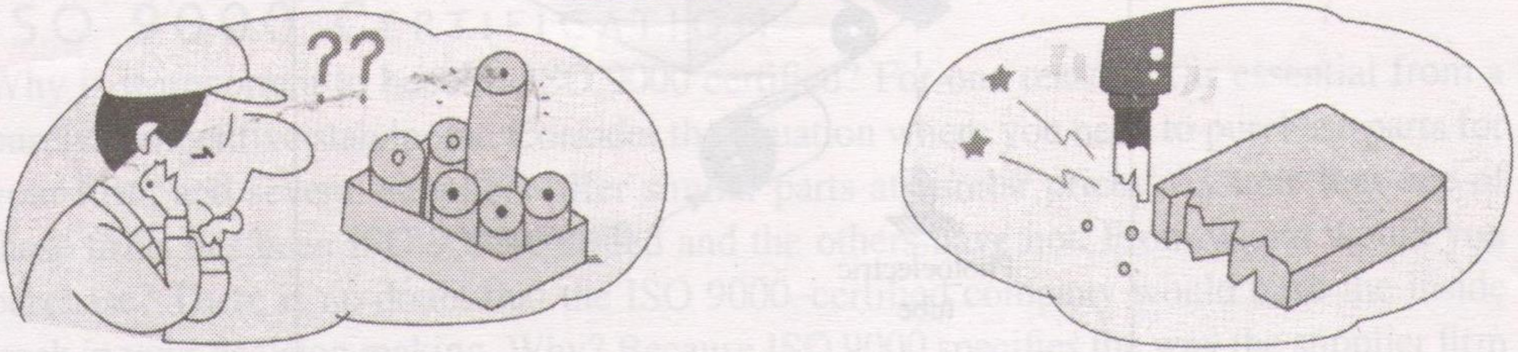
What Are the Sources of Defects?

There are various types of defects. In order of importance these are

1. Omitted processing
2. Processing errors
3. Errors setting up workpieces
4. Missing parts
5. Wrong parts
6. Processing wrong workpiece
7. Misoperation
8. Adjustment error
9. Equipment not set up properly
10. Tools and jigs improperly prepared

What are the connections between these defects and the mistakes people make?

☆ Causal connections between defects and human errors



◉ Strongly connected ○ Connected

Causes of Defects \ Human Errors	Intentional	Mis-understanding	Forgetful	Mis-identification	Amateurs	Willfull	Inadvertent	Slowness	Non-supervision	Surprise
Omitted processing	◉	○	◉	○	○	○	◉	○	○	
Processing errors	◉	◉	○	○	◉	◉	◉	◉	◉	
Errors setting up workpieces	○	○	◉	○	○		◉	○	○	
Missing parts	◉	○	○		○	○	◉		○	
Wrong parts	◉	◉	◉	◉	◉	○	◉		◉	
Processing wrong workpiece	○	◉	◉	○	○	◉	◉		○	
Misoperation			○				○		○	◉
Adjustment error	○	○	○	◉	○	◉	○	○	○	○
Improper equipment setup			○				○			◉
Improper tools and jigs			○				○			○

Source: N. K. Shimbun, Ltd./Factory Magazine (ed.), *Poka-Yoke: Improving Product Quality by Preventing Defects* (Cambridge, MA: Productivity Press, 1989), p. 14. From *Poka-Yoke: Improving Product Quality by Preventing Defects*, edited by NKS/Factory Magazine.

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NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 59

Procurement Management- Part 1

Dr. M.K. Barua
Department of Management
Indian Institute of Technology Roorkee

SELECTIVE INVENTORY CONTROL

classifying items into different categories.

ABC analysis (Annual consumption valuc)

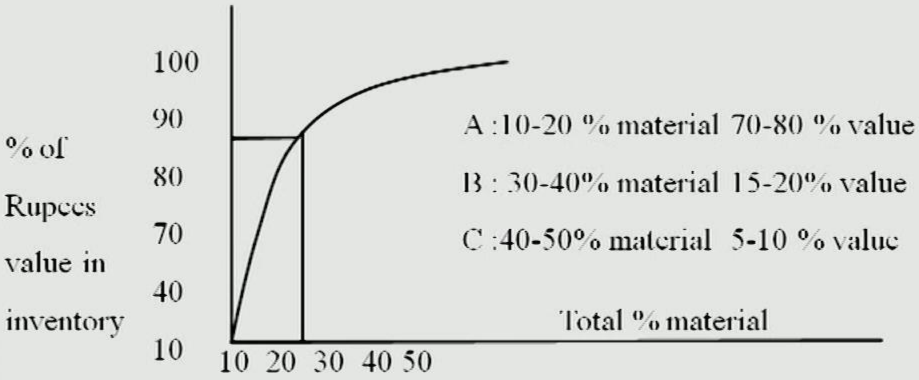
SOS

VED

GOLF

FSN

SDE (Depending on lcad time- Scarcs (Abroad),Difficult, Easy)



Item	Annual consumption (unit)	Price / unit (Rs.)
1	4000	10 /lit
2	600	10/kg
3	2000	16/pc
4	3500	1/kg
5	50	8/kg
6	6000	6/kg
7	2400	5/kg
8	4200	1/lit
9	50	10/kg
10	100	7/kg
11	80	40/kg
12	50	8/kg
13	20	10/kg
14	2000	.15/pc
15	30	6/kg
16	80	.25/kg
17	200	.50/kg
18	750	4/kg
19	350	6/kg
20	20	10/kg

Item	Annual consumption (unit)	Price / unit (Rs.)	Annual consumption (Rs)	Rank	Cum	%
1	4000	10 /lit	40000	40000	40000	27
2	600	10/kg	6000	36000	76000	51
3	2000	16/pc	32000	32000	108000	73
4	3500	1/kg	3500	12000	120000	
5	50	8/kg	400	6000		
6	6000	6/kg	36000	4200		
7	2400	5/kg	12000	3500		
8	4200	1/lit	4200	3200		
9	50	10/kg	500	3000		
10	100	7/kg	700	2100		
11	80	40/kg	3200	700		
12	50	8/kg	400	500		
13	20	10/kg	200	400		
14	2000	.15/pc	300	400		
15	30	6/kg	180	300		
16	80	.25/kg	20	200		
17	200	.50/kg	100	200		
18	750	4/kg	3000	100		
19	350	6/kg	2100	80		
20	20	10/kg	200	20	147000	

A
15%

Item	Annual consumption (unit)	Price / unit (Rs.)	Annual consumption (Rs)	Rank	Cum	%
1	4000	10 /lit	40000	40000	40000	27
2	600	10/kg	6000	36000	76000	51
3	2000	16/pc	32000	32000	108000	73
4	3500	1/kg	3500	12000	120000	
5	50	8/kg	400	6000		
6	6000	6/kg	36000	4200		
7	2400	5/kg	12000	3500		
8	4200	1/lit	4200	3200		
9	50	10/kg	500	3000		
10	100	7/kg	700	2100		
11	80	40/kg	3200	700		
12	50	8/kg	400	500		
13	20	10/kg	200	400		
14	2000	.15/pc	300	400		
15	30	6/kg	180	300		
16	80	.25/kg	20	200		
17	200	.50/kg	100	200		
18	750	4/kg	3000	100		
19	350	6/kg	2100	80		
20	20	10/kg	200	20	147000	

A
15%

Purchasing: Is the procuring of materials, supplies, machine tools and services required for the equipment, maintenance and operation of the manufacturing plant.

Growing importance of purchasing: earlier it was activity of production management.

-Higher cost of goods and services – 50 to 70% raw material, component, services in total cost.

-Escalating cost of stock outs

-Higher present day cost of capital : fixed and working capital – 60:40, around 80% of working capital is locked up in inventory of RM, WIP, FG. Interest rates are very high.

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Purchasing is not mere act of buying: it includes

- market research,
- vendor rating,
- standardisation and verity reduction,
- codification,
- indent control,
- pre-purchasing value analysis,
- price negotiation,
- inventory control,
- surplus disposal,
- purchase budget,
- import substitution,
- purchase system design.

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Objectives of scientific purchasing

- Procure material at **competitive price**
- Maintain **continuity** in supply
- Ensure **production** of goods of better quality
- Suggest better **substitution** of materials
- Assist in **standardisation**, **variety reduction**, **cost reduction**, etc
- Advice on prices
- Create **goodwill**

Functions of purchase department

Primary duties:

- **Receipt**, scrutiny of purchase intend and determination of method of buying.
- **Search** for suppliers
- Acquisition and analysis of suppliers' proposal
- **Selection** of suppliers
- **Follow-up** for timely receipt
- Performance evaluation and **feedback**
- Disposal of **surplus obsolete, and scrap material**

Purchase as profit centre:

It should be looked as a profit centre not as a cost centre.

- To earn a rupee- increase sale by Rs10
- Good to save one rupee in purchasing through **skilful negotiation**
- Purchasing and **capital** release: reduce RM, WIP and FG
- Purchasing **and life cycle** cost:
- Purchasing **and transportation** cost: Select mode of transportation carefully

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Procurement Management- Part 2 and Project Termination

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Films & TV

Purchasing policies include

Sourcing policies: help in to select suppliers **indigenous vs. Foreign**, **local vs distinct supplier**, purchase from **sister concern**.

Internal policies: petty cash purchase, cash discount, **payment for the samples**, **disposal** of defective goods, system of rejection allowance for subcontracting items.

Suppliers' relationship policies: help in **fair trading and professionalism** on part of the purchase staff e.g. Gifts

Policies and general principles:

Speculative buying: Buying objective to buy at **least cost** to prevent production hold-up, in forward buying– the intention is to **resale for profit**.

Purchase of **goods from own employees:**

Employee's purchase: Cooperative society of the company

Sale of goods to employees: surplus and obsolete items, cartons, wooden box, gunny bags, etc.

Ethics in buying:

Word ethics meaning **character or conduct** is that branch of philosophy which deals with **rightness or wrongness**, **goodness or badness** of human conduct.

Needed in **all functions** of the organisation.

Ethics: may be defined as little finest complications of **do's and don't resulting** from conflict of mind as to what a **person is tempted to do and what he ought to do .**

Typical unethical acts

Misrepresentation of facts:

- Vendor may give **wrong estimate** of requirement to buyer, he may quote **low prices to get order.**
- **Buyer** may give vendor a rosy picture of future prospects and press him to **go for small volumes/price**.
- Buyer rejects material on **flimsy** grounds, false competitive information to the sellers.

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Improprieties of bids: Buyer should not allow vendor to **submit more than one bid,** no **rebidding**, submission of bid after **due dates**, all bidders must be **appraised**.

Price disclosure: Competitive price information should be treated confidential.

Unearned discounts: Buyers make payment through cheques even after the due dates .

Cancellation of orders : without valid reasons

Thrusting decisions on suppliers: thrust prices on smaller vendors , forcing vendors to mfg products in a way not interested buy seller.

Personal Requirements: ex-get materials for home/vehicle.

Samples and estimates: buyer asks to prepare drawings, samples, but does not pay for it.

Development work at the cost of vendor: Gives orders to others on the basis of learning of first vendor.

Discourteous behaviour:

There are code of conduct by Indian Association of Material Management (AIMM).

What does a supplier want form buyer:???????

Timely payment

Non-cancellation of orders:

Minimisation of unscheduled deliveries and rush orders:

Avoidance of force price reductions:

Avoidance of unnecessary rejections:

Avoidance of harassment:

Right quantity: EOQ, Replenishment system and buying methods.

Right quality: design, material, chemical composition, properties like mechanical electrical , etc.

Quality of design, conformance, performance.

Right price: right price does not mean lowest price but the price which **minimises** the **overall cost**. The techniques are negotiation tendering , and learning curve.

Right Time:

Right source: only right source can give other 4 Rs

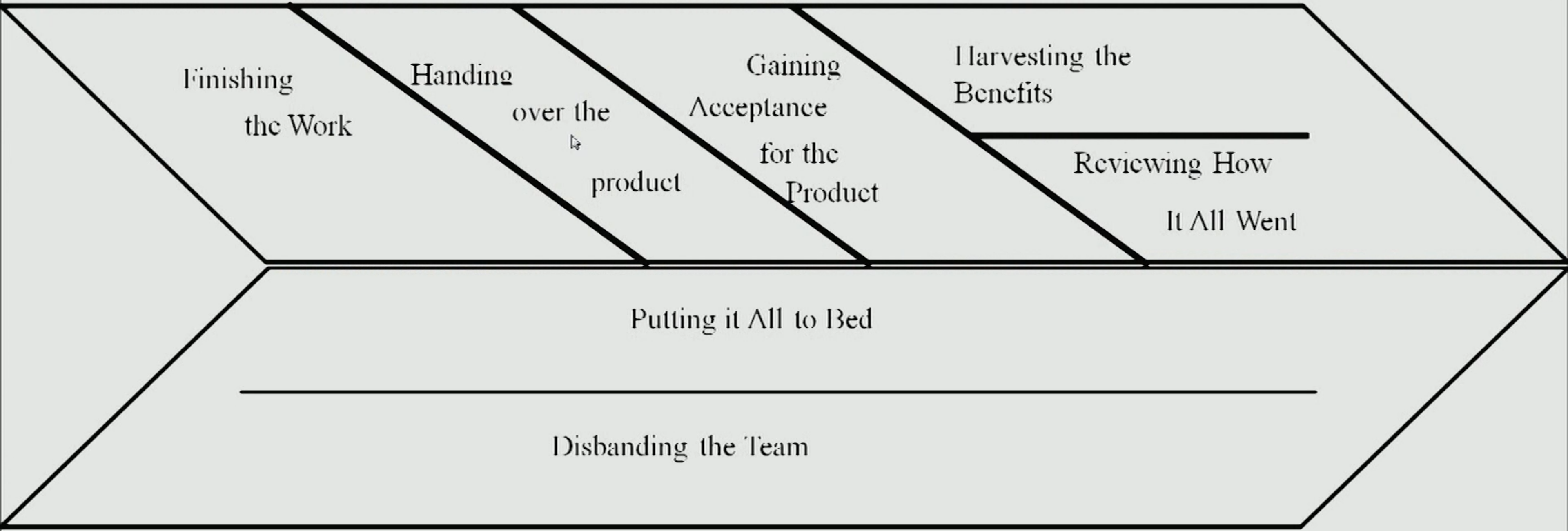
Project Termination

All **activities consistent with closing out the project**. Acceptance of project by sponsor, completion of records, final revision and issue of documentation to reflect its final condition.

Types of project termination

- **<u>Extinction</u>** : Project is **stopped** due to either its **successful or unsuccessful conclusion**. Auditing, team on new assignment, assets transferred as per policy.
- **<u>Addition</u>** : Success of the project is added to organization structure.
- **<u>Integration</u>**: Resources and team members are **reintegrated** within the organization's existing structure. Team members leave parent originations.
- **<u>Starvation:</u>** Due to budget or any other reasons.

Elements of Project Closeout Management



Finishing the work: Final "polish". Members loose focus, think of new assignment, challenge is to keep the team "zeroed in".

Handing over the project: Transferring project to client with **technical details and drawings, training**, etc.

Gaining acceptance: Over a period of **time** projects get acceptance from clients.

Harvesting Benefits: Project are initiated to **find or solve problems/ find opportunities**. Increased productivity, higher market share or profit, etc.