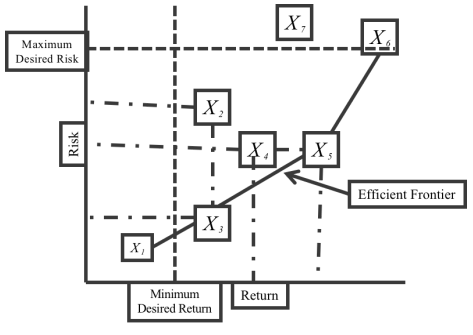
## 2. Project Selection

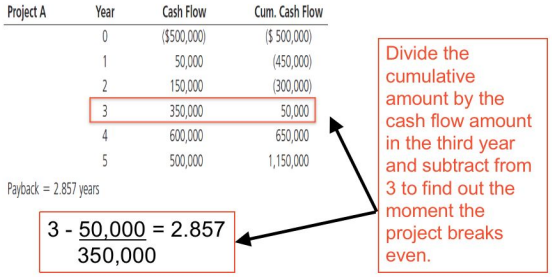
- **Realism:** An effective screening model should reflect organizational objectives and be capable of picking “winners” from a large set of potential projects.
- **Capability:** Flexible enough to respond to changes in conditions under which projects are carried out. Can be used in a wide range of project types.
- **Flexibility:** Can be easily modified if trial applications require changes. (To adapt to changes in tax laws, and so forth.)
- **Ease of use:** Simple enough to be used by people in all areas of the organization. (100 input parameters vs 5 input parameters)
- **Cost:** Inexpensive to use (e.g., require less data input).
- **Comparability:** Broad enough to be applied into multiple projects. If the screening model is too narrowly focused, it may be biased toward some projects.

### Approaches of project screening:

- **Checklist model:** a list of criteria applied to possible projects
  - Requires agreement on criteria
  - Assumes all criteria are equally important
  - Checklists are valuable for recording opinions and stimulating discussion.
- **Simplified scoring models**: each project receives a score that is the weighted sum of its grade on a list of criteria.
  - Relative scores can be misleading!
  - requirements:
    - Agreement on criteria
    - Agreement on weights for criteria
    - A score assigned for each criteria
- **Analytic hierarchy process**
  - Unlike the simple scoring model, these scores can be compared
  - steps:
    - Construct a hierarchy of criteria and subcriteria
    - Allocate weights to criteria
    - Assign numerical values to evaluation dimensions
    - Determine scores by summing the products of numeric evaluations and weights.
  - **Limitations:**
    - It doesn’t adequately account for “negative utility”
      - Counter measure: use AHP score divided by the investment cost
    - All criteria must be fully disclosed and accounted for a the beginning of the selection process
      - Powerful members can influence the process of assigning weights and determining criteria.
    -
- **Profile models**



- **Financial models:**
  - **Payback period = investment/Annual Cash Savings**
    - Determines how long it takes for a project to reach a breakeven point, a lower payback period is better (faster payback).




  - **NPV: Net present value - higher NPV is better**
    - $NPV = I_0 + \sum \frac{F_t}{(1+r+p_t)^t}$, $F_t = net\ cash\ flow\ for\ period\ t,\ r = required\ rate\ of\ return,$

      $I_0 = initial\ cash\ investment\ at\ period\ 0,\ p_t = inflation\ rate\ during\ period\ t,$

      $discount\ rate\ = r + p_t$
    - EXCEL: = initial investment+NPV(Discount Rate, Cells of cash flows)
    - Different duration of projects (refer to tut Q3.5):
      - Find the T - minimum common multiplier of all projects' duration -> repeat project k times where k=(T/project duration) -> use cash flows over Tperiods to determine NPV -> choose project having higher NPV
  - **Discounted payback period**
  - **IRR: Internal rate of return - higher IRR is better**
    - $0 = -I_0 + \sum_{i=1}^{T} \frac{ACF_t}{(1+IRR)^t} \rightarrow I_0 = \sum_{i=1}^{T} \frac{ACF_t}{(1+IRR)^t}$
    - If with a discount rate of 15% the difference between total NPV and cash investment >0 , the project meets 15% requirement and should be considered further.
    - EXCEL: =IRR(Cells of all cash flows including initial investment)

**Project portfolio management:** systematic process of selecting, supporting, and managing the firm's collections of projects.

- **Requirements:** decision making, prioritization, review, realignment, reprioritization of projects.
- **Designing a project portfolio system:**
  - Classification of a project
  - Selection criteria depending upon classification
  - Sources of proposals
  - Evaluating proposals
  - Managing the portfolio of projects
- **Portfolio of projects by type:**
  - **Compliance (must do) project:** need to meet regulatory conditions
    - Selection criteria: safety, quality, cost time
  - **Operational projects:** need to support current operations (sustainable project)
    - performance , time, cost, user satisfaction
  - **Strategic projects:** support the organisations' long run missions (e.g. R&D)
    - Market share, new opportunities, new technologies
- **Keys to successful project portfolio management:** 1. ***Flexible structure*** and freedom of communication; 2. ***Low-cost*** environmental scanning; 3. ***Time-paced*** transition

- **Maximize benefits** of project portfolio by linear programming:
  - Objective: $max\{50u_1 + 80u_2 + ... + 60u_{10}\}$
  - Constraints: decision variables $\{u_i\}$ are binary: project i is chosen when $u_i$=1, otherwise project i is not chosen.
  - Dependency constraints: $u_1 = u_4;\ u_3 + u_7 \leq 1;\ u_{10} \leq u_9$
  - Budgets constraints: $2u_1 + 10u_2 + ... + 18u_{10} \leq 30$

| Index | Project | Benefits | Dependency |
|---|---|---|---|
| 1 | Downtown | 50 | With 4 |
| 2 | Housing | 80 | |
| 3 | Flood | 85 | Not with 7 |
| 4 | Street | 60 | With 1 |
| 5 | Wireless | 75 | |
| 6 | Library | 25 | |
| 7 | Water | 50 | Not with 3 |
| 8 | Waste | 35 | |
| 9 | Facilities | 65 | |
| 10 | Parking | 60 | Only if 9 is picked |

### Challenges in project selection

- Information asymmetry and conflicting interests give rise to moral hazard (e.g. hidden action) and adverse selection (e.g. hidden information)
  - To illustrate, consider a simple example as follows. The subsidiary has two projects to propose. Each project generates a subsidiary project X and a headquarters' profit Y. The consolidated profit is then X+Y. Suppose that the Headquarters does not observe the attributes of the available projects. Due to limited capital, only one project can be undertaken. The subsidiary can pretend that project B is the only available project. The lost consolidated profit equals 26-18=8.

| Project ID | Subsidiary Profit X | Headquarters' Profit Y |
|---|---|---|
| A | 10 | 16 |
| B | 15 | 3 |

  - ***How do companies design a project selection system to mitigate the inefficiency caused by information asymmetry?***
    - **Incentives(激励措施)** when cash transfer is permitted: e.g. link the reward to subsidiary to the consolidated profit rather than the subsidiary project using shares
    - Appropriate **selection standard** when cash transfer is not permitted or infeasible:
      - e.g. pre-announce that an approvable project must produce a Headquater's profit that is at least 5. So project B is strategically banned.
      - e.g. IRR measures the quality of a project. To avoid undertaking a low quality project that consumes a large amount of cash, any proposed project must meet the minimum requirement on IRR. Such minimum requirement on IRR is called hurdle rate.

## 3. Project network

Project network: a slow chart that graphically depicts the sequence, interdependencies, and start and finish times of the project job plan of activities that is the critical path through the network.

**Usage of project network:**

- Provides the basis for scheduling labor and equipment
- Enhances communication among project participants
- Provides an estimate of the project's duration
- Highlights activities that are "critical" and can not be delayed
- Help managers get and stay on plan

### Rules of project network

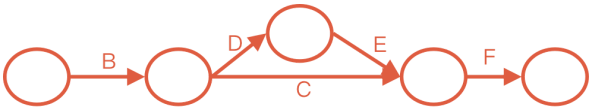
- Newworks flow from left to right
- An activity cannot begin until all of its activities are complete
- Arrows indicate precedence and flow and can cross over each other
- Identify each activity with a unique number, this number must be greater than its predecessors

    - Numbering is done after the project network is complete (to allow addition or deletion of activities)
- Looping is not allowed
- Conditional statements are not allowed
- Use common start and stop nodes

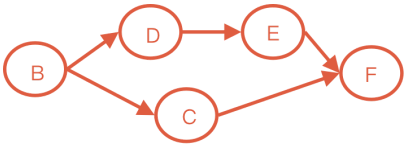
## Project network terminology

- **Activity:** an element of the project that requires time.
- **Merge activity:** an activity that has two or more preceding activities on which it depends.
- **Parallel / concurrent activities:** activities that can occur independently and, if desired, not at the same time.
- **Path:** a sequence of connected, dependent activities.
- **Critical path:** the longest path through the activity network that allows for the completion of all project-related activities; the shortest expected time in which the entire project can be completed. Delays on the critical path will delay completion of the entire project.
- **Event:** a point in time when an activity is started or completed. It does not consume time.
- **Burst activity:** an activity that has more than one activity immediately following it (has more than one predecessors).

**AOA:**




**AON:**

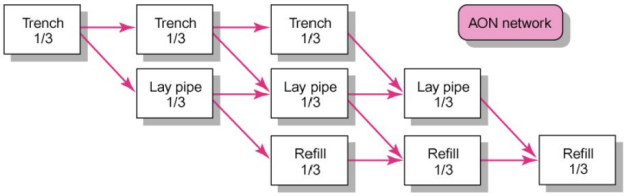



| | | |
|---|---|---|
| Early start | Identifier number | Early finish |
| Activity float | Activity descriptor | |
| Late start | Activity duration | Late finish |

- **Total slack:** the amount of time an activity can be delayed without affecting the project duration. (TS=LS-ES)
- **Free slack:** the amount of time an activity can be delayed from its early start (ES) without affecting the early start of any activity immediately following it. (FS=ES of next node - EF of current node)

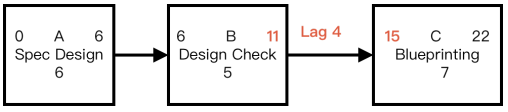
**Laddering:** activities are broken into segments so the following activity can begin sooner and ot delay the work.

- Limitations: more resources such as workers and machines might be needed for parallel activities.




**Lags:** the minimum amount of time a dependent activity must be delayed to begin or end

- Finish to Start lag (FS lag):




### Reducing project duration

- **Reasons:**
    - Time-to-market pressures
    - Unforeseen delays
    - Incentive contracts
    - Imposed deadlines and contract commitments
- Procedures:
    - Resources not constrained
        - Adding resources
        - Outsourcing project work
        - Scheduling overtime
        - Establishing a core project team
    - Resource constrained
        - Fast-tracking
        - Reducing project scope
        - Compromise quality

### Project cost:

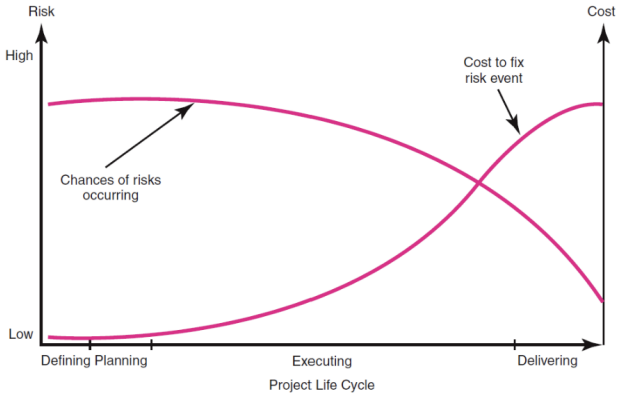
- **Indirect costs:**
    - cannot be associated with any particular work package or project activity(e.g. Supervision, administration, consultants, and interest)
    - Costs that vary with time - reducing project time directly **reduces** indirect costs.
- **Direct costs:** can be assigned directly to a specific work package (e.g. labor, materials, equipment, and subcontractors)
    - **Crashing** activities increases direct costs

## 4. Risk management

**Risk:** uncertain or chance events that planning can not overcome or control.

**Risk management:** a proactive attempt to recognize and manage internal events and external treats

- Risk event: what can go wrong?
- Consequences: how to minimize the risk event's impact?
- Anticipation: what can be done before an event occurs?
- Contingency plans: what to do when an event occurs?




### Project risk vs business risk

- Business risk: selecting the right project.
- Project risk: managing uncertainty to meet the stakeholders' objectives.

### Risk management process

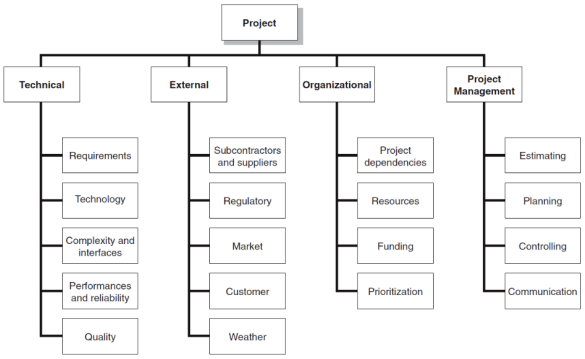
1. **Risk identification:** generate a list of possible risks through brainstorming, problem identification and risk profiling.
    a. Macro risks first then specific events
2. **Risk assessment:** scenario analysis for event probability and impact

a. Techniques: risk assessment matrix, Failure Mode and Effects Analysis (FMEA), probability analysis (Decision trees, NPV, PERT), semiquantitative scenario analysis.

3. **Risk response development**
   a. **Mitigating risk:**
      i. reducing likelihood an adverse event will occur
      ii. Reducing impact of adverse event
   b. **Avoiding risk:** Changing the project plan to eliminate the risk or condition
   c. **Transferring risk:**
      i. Paying a premium to pass the risk to another party
      ii. Requiring Build-Own-Operate-Transfer provisions
   d. **Retaining risk:** making a conscious decision to accept the risk
4. **Risk response control**
   a. **Risk control:** 1)Execution of the risk response strategy; 2) Monitoring of triggering events; Initiating contingency plans; 3) Watching for new risks
   b. Establishing a **Change Management System**: 1) Monitoring, tracking, and reporting risk; 2)Fostering an open organization environment; 3)repeating risk identification / assessment exercises assigning and documenting responsibility for managing risk; 4) assigning and documenting responsibility for managing risk

## Risk assessment techniques:

- **Risk breakdown structure (RBS)**




- **risk profile for product development**

**Technical Requirements**
Are the requirements stable?
**Design**
Does the design depend on unrealistic or optimistic assumptions?
**Testing**
Will testing equipment be available when needed?
**Development**
Is the development process supported by a compatible set of procedures, methods, and tools?
**Schedule**
Is the schedule dependent upon the completion of other projects?
**Budget**
How reliable are the cost estimates?
**Quality**
Are quality considerations built into the design?
**Management**
Do people know who has authority for what?
**Work Environment**
Do people work cooperatively across functional boundaries?
**Staffing**
Is staff inexperienced or understaffed?
**Customer**
Does the customer understand what it will take to complete the project?
**Contractors**
Are there any ambiguities in contractor task definitions?

- **Defined conditions for impact scales of a risk on major project objectives**

| | Relative or Numerical Scale | | | | |
|---|---|---|---|---|---|
| **Project Objective** | 1 Very Low | 2 Low | 3 Moderate | 4 High | 5 Very High |
| **Cost** | Insignificant cost increase | < 10% cost increase | 10–20% cost increase | 20–40% cost increase | > 40% cost increase |
| **Time** | Insignificant time increase | < 5% time increase | 5–10% time increase | 10–20% time increase | > 20% time increase |
| **Scope** | Scope decrease barely noticeable | Minor areas of scope affected | Major areas of scope affected | Scope reduction unacceptable to sponsor | Project end item is effectively useless |
| **Quality** | Quality degradation barely noticeable | Only very demanding applications are affected | Quality reduction requires sponsor approval | Quality reduction unacceptable to sponsor | Project end item is effectively useless |

- **Likelihood ratings**

| Description | Definition | Probability |
|---|---|---|
| Almost certain | Event is expected to occur in most circumstances | 91-100% |
| Likely | Event will probably occur in most circumstances | 61-90% |
| Possible | Event should occur at some time | 41-60% |
| Unlikely | Event could occur at some time | 10-40% |
| Rare | Event will only occur in exceptional circumstances | 0-10% |

**Risk assessment form**

| Risk Event | Likelihood | Impact | Detection Difficulty | When |
|---|---|---|---|---|
| Interface problems | 4 | 4 | 4 | Conversion |
| System freezing | 2 | 5 | 5 | Start-up |
| User backlash | 4 | 3 | 3 | Postinstallation |
| Hardware malfunctioning | 1 | 5 | 5 | Installation |

- Failure Mode and Effects Analysis (FMEA): $Impact \times Probability \times Detection = Risk\ value$

## Types of risks

- **Costs risks:**
  - Costs increase when problems take longer to solve than expected
  - Should avoid to use the schedule to solve cash flow problems
  - Price protection risks (a rise in input costs) increases if the duration of a project increases
- **Funding risks:** changes in the supply of funds can dramatically affect the likelihood of implementation or successful completion of a project.
- **Technical risks:**
  - Backup strategies if chosen technology fails
  - Assessing whether technical uncertainties can be resolved
- **Schedule risks:**
  - Use of alck increases the risk of a late project finish
  - Imposed duration date (absolute project finish date)
  - Compression of project schedules due to a shortened project duration date.

**Contingency plan:** an alternative plan that will be used if a possible foreseen risk event actually occurs, which will reduce or mitigate the negative impact of a risk event.

- **Risk of not having a contingency plan**
  - Slow managerial response
  - Decisions made under pressure can be potentially dangerous and costly
- **Contingency funds**
  - Funds to cover project risks which are identified and unknown - size of funds reflects overall risk of a project
  - Budget reserves: are linked to the identified risks of specific work packages
  - Management reserves: are large funds to be used to cover major unforeseen risks (e.g., change in project score) of the total project
- **Time buffers:** amounts of time used to compensate for unplanned delays in the project schedule
  - Severe risk, merge, noncritical, and scarce resource activities

## Opportunity management

- **Exploit:** seeking to eliminate the uncertainty associated with an opportunity to ensure that it definitely happens
- **Share:** allocate some or all of the ownership of an opportunity to another party who is best able to capture the opportunity for the benefit of the project
- **Enhance:** take action to increase the probability and/or the positive impact of an opportunity
- **Accept:** be willing to take advantage of an opportunity if it occurs, but not taking action to pursue it.

**Risk response matrix**

| Risk Event | Response | Contingency Plan | Trigger | Who Is Responsible |
|---|---|---|---|---|
| Interface problems | Mitigate: Test prototype | Work around until help comes | Not solved within 24 hours | Nils |
| System freezing | Mitigate: Test prototype | Reinstall OS | Still frozen after one hour | Emmylou |
| User backlash | Mitigate: Prototype demonstration | Increase staff support | Call from top management | Eddie |
| Equipment malfunctions | Mitigate: Select reliable vendor Transfer: Warranty | Order replacement | Equipment fails | Jim |

## Change management control:

- **Source:**
  - Project scope changes
  - Implementation of contingency plans
  - Improvement changes
- **Change control system process:** 1) Identify proposed changes. 2) List expected effects of proposed changes on schedule and budget. 3) Review, evaluate, and approve or disapprove of changes formally. 4) Negotiate and resolve conflicts of change, condition, and cost. 5) Communicate changes to parties affected. 6) Assign responsibility for implementing change. 7) Adjust master schedule and budget. 8) Track all changes that are to be implemented
- **Benefits:** 1) Inconsequential changes are discouraged by the formal process. 2) Costs of changes are maintained in a log. 3) Integrity of the WBS and performance measures is maintained. 4) Allocation and use of budget and management reserve funds are tracked. 5)Responsibility for implementation is clarified. 6) Effect of changes is visible to all parties involved. 7)Implementation of change is monitored. 8) Scope changes will be quickly reflected in baseline and performance measures.

**PERT:** Program evaluation review technique assumes each activity duration has a range that statistically follows a beta distribution

## Calculate probability of completing the project in scheduled time:

- Weighted average activity time (expected time):
  $t_e = \frac{a+4m+b}{6},\ a = optimistic\ time,\ m = most\ likely\ time,\ b = pessimistic\ \ time$
- variance of expected time $\sigma_{t_e} = \frac{b-a}{6}$
- Standard deviation for the project: $\sigma_{T_E} = \sqrt{\sum \sigma_{t_e}^2}$
- Probability of completing the project in scheduled time:
  $Z = \frac{T_S - T_E}{\sqrt{\sum \sigma_{te}^2}},\ T_E = critical\ path\ duration,\ T_S = scheduled\ project\ duration$

  $probability = NORM.S.DIST(Z, TRUE)$

## Manage risks with PERT:

- Conduct a **risk audit**
- Take actions to **avoid or minimize** risk
  - Alter the project scopel take positive steps to prevent risks from escalating into full-blown crises

- Develop **contingency plans** for unavoidable and uncontrollable risks.
    - A good contingency plan prepares the project and company to deal quickly and effectively with adverse situations. When disaster strikes, managers and project members with a plan can act immediately; they don't have to spend time trying to figure out what they should do or how they will find the funds to deal with their new situation.

## 5. Project scheduling

### Heuristic leveling procedure:

- Minimum slack
- Smallest duration
- Lowest activity identification number

| Activities | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|---|
| A | 2T | 2T | 2T | | |
| B | | | | | |
| C | 1T | 1T | | | |
| D | | | | | |
| Total Requirement | | | | | |

For day 1, activities A, B, and C are eligible to be scheduled. Because A has the smallest slack (0 slack actually), we first load A into the schedule. This would use up 2T on Day 1-3. We have 1T left. Then B and C are eligible. We continue to apply the smallest slack rule. C is preferred to B because of shorter slack. We load C. After that, all resources are used up. We are done for days 1 and 2.

### With resource constraints, the optimal schedule may:

- Dependency between tasks may be altered
- Increases scheduling complexity
- Increases criticality of events
- make the traditional critical path no longer meaningful
- Can break sequence of events
- May cause parallel activities to become sequential and critical activity with slack to become noncritical.

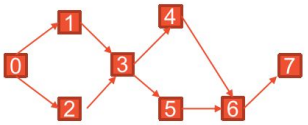
### Time-constrained scheduling:

- Reduce time by **crashing**
- Objective: **minimize cost**
- Must increase the resources; otherwise the time cannot be reduced if the resource is limited

### Linear programming for scheduling:

- Decision variables: Let $X_i$ be the time when the event of node i is completed, where $i = 1, 2, 3, ..., n$
- Objective: $Minimize\ X_n$
- Constraints: $X_i - X_j \geq event\ duration$
    - If FS lag exists:
      $X_i - X_j \geq event\ duration$ +Lag
- Use **binding constraints** to find critical path
- Report the **project duration** and **critical path**: the binding constraints include 0-2, 1-3, 2-3, 3-4, 4-6, 5-6, 6-7. The critical path is B-D-E-H-I *(NB: 1-3, 5-6 are not in the critical path)*.

| Arc | Event ID | Length of Arc | Constraints |
|---|---|---|---|
| 0-1 | A | 2 | $x_1$-$x_0$≥2 |
| 0-2 | B | 5 | $x_2$-$x_0$≥5 |
| 1-3 | C | 5 | $x_3$-$x_1$≥5 |
| 2-3 | D | 3 | $x_3$-$x_2$≥3 |
| 3-4 | E | 9 | $x_4$-$x_3$≥9 |
| 3-5 | F | 2 | $x_5$-$x_3$≥2 |
| 5-6 | G | 6 | $x_6$-$x_5$≥6 |
| 4-6 | H | 7 | $x_6$-$x_4$≥7 |
| 6-7 | I | 2 | $x_7$-$x_6$≥2 |




## 6. Project monitoring

### Project progress report format:

- Progress since last report
- Current status of project: schedule, cost scope

- Cumulative trends
- Problems and issues since last report: 1) actions and resolution of earlier problems; 2) new variances and problems identified
- Corrective action planned

### Project control steps:

- **Control:** the process of comparing actual performance against plan.
- **Tools:** tracking and baseline Gantt charts, control charts

1. Setting a baseline plan
2. Measuring progress and performance
3. Comparing plan against actual
4. Taking action

### Monitoring systems:

- **Time-Phased Baseline Plan:** connect a project's actual performance to its schedule and forecast budget.
- **Earned Value Cost / Schedule System:** uses a time-phased budget baseline to compare actual and planned schedule and costs based on the earned value concept.

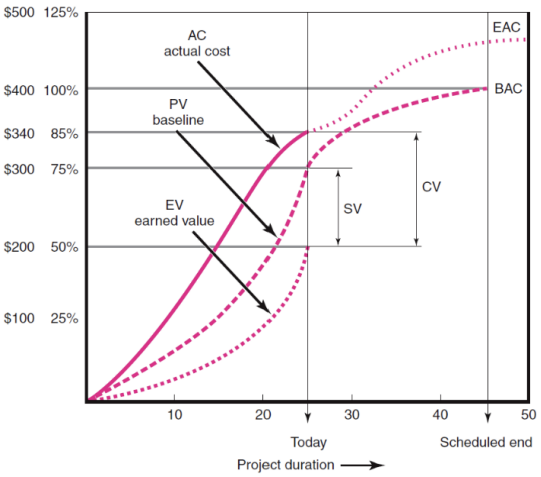
| | |
|---|---|
| **EV** | **Earned value for a task is simply the percent complete times its original budget. Stated differently, EV is the percent of the original budget that has been earned by actual work completed.** |
| **PV** | **The planned time-phased baseline of the value of the work scheduled. An approved cost estimate of the resources scheduled in a time-phased cumulative baseline [BCWS—budgeted cost of the work scheduled].** |
| **AC** | **Actual cost of the work completed. The sum of the costs incurred in accomplishing work. [ACWP—actual cost of the work performed].** |
| **CV** | **Cost variance is the difference between the earned value and the actual costs for the work completed to date where CV = EV – AC.** |
| **SV** | **Schedule variance is the difference between the earned value and the baseline line to date where SV = EV – PV.** |
| **BAC** | **Budgeted cost at completion. Total budgeted cost of the baseline or project cost accounts.** |
| **EAC** | **Estimated cost at completion.** |
| **ETC** | **Estimated cost to complete remaining work.** |
| **VAC** | **Cost variance at completion. VAC indicates expected actual over- or under-run cost at completion.** |

### Develop project baselines

- **Purposes of a Baseline (PV): to measure performance**
  - planned cost and expected schedule vs actual cost and schedule
  - A basis for cash flows and awarding progress payments
  - A summation of time-phased budgets along a project timeline
- **Costs included in baselines:** labor, equipment, materials, project direct overhead costs
- **Rules for placing costs** in baselines
  - Costs are placed exactly as they are expected to "earned" in order to track their origin
  - Percent Complete Rule: costs are periodically assigned to a baseline as units of work are completed over the duration of a work package.

## Methods of variance analysis:

- Comparing **Earned value** with the **expected schedule value** and the **actual costs**.
- **Assessing status of a project:**
  - Using PV, EV, AC
  - **Calculate schedule and cost variances:** a positive variance indicates a desirable condition while a negative variance suggests problems
- **Cost variance (CV):** the difference between the actual **cost** and the budgeted **cost** - CV=EV-AC
- **Schedule variance (SV):** indicates whether a project schedule is ahead or behind and is typically used within Earned Value Management (EVM) - SV=EV-PV




## Status report assumptions:

- Each cost account has only one work package, and each cost account will be represented as an activity on the network.
- The project network early start times will serve as the basis for assigning the baseline values.
- From the moment work an activity begins, some actual costs will be incurred each period until the activity is completed.

## Indexes to monitor progress

- **Cost performance index (CPI):** measures the cost efficiency of work accomplished to date - **CPI=EV/AV**
  - CPI>1: Under cost, CPI=1: On cost, CPI<1: Over cost
- **Scheduling performance index (SPI):** measures scheduling efficiency - **SPI=EV/PV**
  - SPI>1: Ahead of schedule, SPI=0: On schedule, SPI<0: Behind schedule
- **Percent complete indexes:** indicates how much of the work accomplished represents of the total budgeted (BAC) and actual (AC) dollars to date - **PCIB=EV/BAC; PCIC=AC/EAC**

## Earned value rules applied to short-duration / small-cost activities

- **0/100 percent rule:** assumes 100% of budget credit is earned at once and only when the work is completed.
- **50/50 rule:** allows for **50%** of the value of the work package budget to be earned when it's started and **50%** to be earned when the package is completed.
- Percent complete with weighted monitoring gates

## Forecasting final project cost:

- $EAC_{re}$: allows experts to change original baseline durations and costs because new information tells them the original estimates are not accurate.
- $EAC_f$: uses actual costs-to-date plus an efficiency index to project final costs in large projects where the original budget is unreliable.

The equation for this forecasting model:

$$EAC_f = ETC + AC$$

$$EAC = \frac{\text{Work remaining}}{CPI} = \frac{BAC - EV}{EV/AC}$$

where $EAC_f$ = estimated total cost at completion.
ETC = estimated cost to complete remaining work.
AC = cumulative actual cost of work completed to date.
CPI = cumulative cost index to date.
BAC = total budget of the baseline.
EV = cumulative budgeted cost of work completed to date.

### Scope creep

- **Definition:** the tendency for the project scope to expand over time, usually by changing requirements, specifications, and priorities.
- **Avoid scope creep: scope management**
- Scope creep affects the organization, the project team and project suppliers. It also relates to change management

## 7. Project scope

**Project scope:** a definition of the end result or mission of the project

**Scope management:** the function of controlling a project in terms of its goals and objectives and consists of : 1) conceptual development; 2) Scope statement; 3) Work authorization; 4) Scope reporting; 5) Control systems; 6) Project closeout

### Purpose of scope statement

- To clearly define the deliverables for the end user
- To focus the project on successful completion of its goals
- To be used by the project owner and participants as a planning tool and for measuring project success
- Manage expectation and establish agreement

### Product scope vs project scope

- **Product scope** consists of the features and performance specifications;
- **Project scope** is all the work necessary to meet project objectives

### Definition of success:

- On time: the deliverable is delivered according to schedule.
- On budget: the project meets forecasted cost estimates.
- High quality: the outcome of the project must meet the customers' expectations for use
- Client acceptance

### Scope statement structure

1. **Project objective:** define the overall object to meet customers's needs. Objectives should exhibit the SMART characteristics, and clearly and unambiguously describe the goal of the project
2. **Deliverables:** the expected outputs over the life cycle of the project
3. **Milestones:** A significant event in a project that occurs at a point in time. The milestone schedule is built using the deliverables as a platform to identify the major segments of work and an end date.
4. **Technical requirements**
5. **Limits and exclusions**
6. **Reviews with customer:** to avoid misunderstanding - "Is the customer getting what he/she desires in deliverables?, "Does the project scope statement identify key accomplishments,budgets, timing, and performance requirements?"

### Actions after creating project scope statement:

1. Establishing project priorities
2. Creating the work breakdown structure
3. Integrating the WBS with the organization

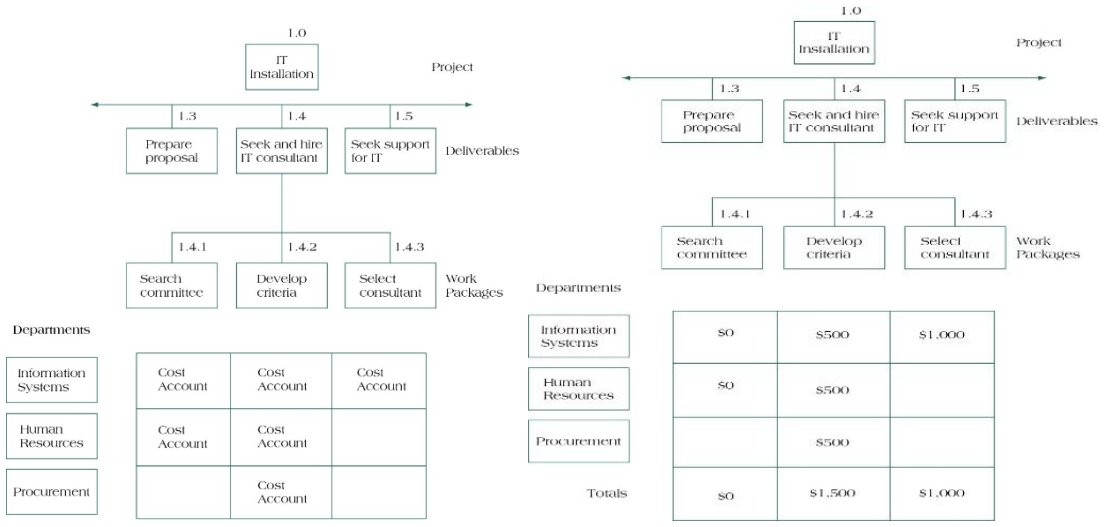
4. Coding the WBS for the information system

## Project charter

- **Definition:** a document issued by the project initiator or sponsor formally sanctioning the existence of the project and authorizing project managers to begin applying organizational resources to project activities. It demonstrates formal company approval of the project.
- ***Consists of:*** 1) The project's mission statement; 2) An outline of the roles and responsibilities that people will play, including the name of the project sponsor; 3) The scope of the project; 4) A concise description of project deliverables; 5) The relationship between the project's goals and higher organizational goals; 6) The expected time frame of the work and milestones.'
- **Value:**
    - without a formal charter, a project can head off in a direction that jeopardizes organizational objectives
    - A project can also suffer from scope creep as stakeholders demand more and more from it.
    - A good project charter indicates the desired outcomes of the effort but not the means to achieve those ends.

**Organization breakdown structure (OBS):** allows 1) Work definition; 2) Owner assignment of work packages; 3) Budget assignment to departments

### WBS and OBS




## Work package

- Forms lowest level in WBS
- Has a deliverable result
- Has one owner
- May be considered by its owner as a project in itself
- May include several milestones
- Should fit the organizational procedures and culture.
- The optimal size of a work package may be expressed in terms on labor hours, calendar time, cost, reporting period and risks.

**Project management trade-offs: Quality = Time + Cost - change any one of these variables can change the other two as well.**

- All stakeholders should be informed of any changes in the project's objectives and understand the

consequences of changes in terms of quality, time, and cost. Otherwise they may end up surprised and dissatisfied.

- **Priority matrix:**
  - Constrain: the original parameters are fixed - the project must meet the completion date, specifications, and budget.
  - Enhance: the project team takes the opportunity to optimise some of the parameters such as cost and time.
  - Accept: the project team determines which parameter is allowed not to meet the original specifications

| | Time | Performance | Cost |
|---|---|---|---|
| Constrain | | √ | |
| Enhance | √ | | |
| Accept | | | √ |

- **Avoid scope creep:** make sure stakeholders understand what're the consequences and ensure that they accept responsibility for those consequences.

### Sample scope statement

**Case:** You are in charge of organizing a dinner-dance concert for a local charity. You have reserved a hall that will seat 30 couples and have hired a jazz musical band. Develop a scope statement for this project that contains examples of all the elements. Assume that the event will occur in 4 weeks and provide your best guess estimate of the dates for milestones.

**Project objective:** Organize a dinner dance for 30 couples by November 1 at a cost not greater than $500 to raise money for a local charity

**Deliverables:** 1) 60 Catered dinners; 2) Jazz combo; 3) Rented hall; 4) Tickets

**Milestones:**

1. Rent hall by 14 October
2. Sell 30 tickets by 28 October
3. Arrange caterer by 30 October

**Technical requirements:**

- Halls has sufficient space for tables and dance floor
- Convenient parking available
- Hall has infrastructure to support catered dinner and jazz combo
- Meals include vegetarian option

**Limits and exclusions:**

- Caterer responsible for preparing, serving, and clean-up
- Ticket price set to generate at least $50 profit per couple
- Jazz combo responsible for sound system
- Event transpired between 7:00-12:00am

**Customer review:** charity official

## 8. Project estimate

**Factor influencing the quality of estimates:** 1) Planning horizon;2 ) Project duration; 3) People; 4) Project structure and organization; 4) Padding estimates; 5) Organization culture; 6) Other nonproject factors.

### Estimating projects

- Projects are **unique**. The more unique they are, the more difficult they are to estimate
- Skills and knowledge of the project team members affect the accuracy of estimate
- New technology and learning curve affect the reliability of estimate
- Incorrect estimate costs money

### Estimate guidelines

1. Have people familiar with the tasks make the estimate.
2. Use several people to make estimates.
3. Base estimates on normal conditions, efficient methods, and a normal level of resources.
4. Use consistent time units in estimating task times.
5. Treat each task as independent, don't aggregate.
6. Don't make allowances for contingencies.
7. Adding a risk assessment helps avoid surprises to stakeholders.

**Common sources of project cost:** labor, materials, subcontractors, equipment & facilities, travel

### Types of costs:

- Direct vs Indirect
- Recurring vs non-recurring
- Fixed vs variable
- Normal vs expedited

**TABLE 8.2** Cost Classifications

| | Type | | Frequency | | Adjustment | | Schedule | |
|---|---|---|---|---|---|---|---|---|
| Costs | Direct | Indirect | Recurring | Nonrecurring | Fixed | Variable | Normal | Expedited |
| Direct Labor | X | | X | | X | | X | |
| Building Lease | | X | X | | X | | X | |
| Expediting Costs | X | | | X | | X | | X |
| Material | X | | X | | | X | X | |

### Cost estimation

- Ballpark $\pm 30\%$: used when information or time is scarce
- Comparative estimate $\pm 15\%$: based on historical data about similar projects
- Feasibility estimate $\pm 10\%$: based on real numbers after the preliminary design is completed
- Definitive $\pm 5\%$: given only when most of the design work is completed.

**Problems with cost estimation:** 1) Low initial estimates; 2) Unexpected technical difficulties; 3) Lack of definition; 4) Specification changes; 5) External factors

**Budget:** the financial blueprint or action plan for the project. It translates the project plan into measurable expenditures and anticipated returns over a certain period of time.

- **Personnel:** usually the largest part of the budget and include full time & temporary workers.
- **Training:** any travel expenses? Any outside contractor to provide training?
- **Supplies:** office equipment and any unusual equipment.
- **Space:** how much room & money will it require to relocate people?
- **Research:** research performed by the team itself and that needed to be bought, at what cost?
- **Professional services:** cost of these services.
- **Capital expenditures:** Are there any more expensive equipment needed? Will they be covered by capital expenditures?and how?

### Types of estimates

- **Top-down (macro) estimates:** Are made by top managers who are not familiar with the processes of the projects.
    - Used for: 1) Strategic decision making; 2) High uncertainty; 3) Internal, small project; 4) Unstable scope.

    - **Apportion:** used when projects closely follow past projects in features and costs. The WBS/OBS need to be developed.
        - **Weaknesses:**
            - It requires good, realistic historical data.
            - If the total cost estimate is off, all other costs will be off (i.e., there is a perfect positive correlation amongst all items).
            - Projects must be very similar to past projects for subdeliverables to be useful.
- **Bottom-up (micro) estimates:** are made by front-line managers who are familiar with the work packages in the WBS.
    - **Used for:** 1) Cost and time important; 2) Fixed-price contract; 3) Customer wants details;
    - Requires the most effort but is the most accurate as all detailed tasks are estimated and then combined.
    - It is not always used because of the additional time and/or the lack of information for the entire project life cycle.
- **Activity-based costing:** 1) Assign costs to activities that use resources; 2) Identify cost drivers associated with this activity;  3) Compute a cost rate per cost driver unit or transaction; 4) Multiply the cost driver rate times the volume of cost units used y the project

**Differences between top-down and bottom-up? Under what condition would you prefer one over the other?**

Top-down estimates are typically used in the project conceptual phase, and depend on surrogate measures such as weight, square feet, ratio. Top-down estimates are good for rough estimates and can help select and prioritize projects.

Bottom-up time and cost estimates are usually tied directly to the WBS and a work package. These estimates are made by people familiar with the task, which helps to gain buy-in on the validity of the estimate. Use of several people should improve the accuracy of the estimate. Bottom-up estimates should be preferred if time to estimate is available, estimating cost is reasonable, and accuracy is important.

**Budget contingencies:** allocation of extra funds to cover uncertainties and improve the chance of finishing on time.

- **Reason** of allocating bouquet contingencies: 1) Project scope may change; 2) Murphy's Law is present; 3) Cost estimate must anticipate interaction costs; 4) Normal conditions are rarely encountered.
- **Benefits** to contingency funding: 1) Recognizes future contains unknowns; 2) Adds provision for company plans for an increase in project cost; 3) Applies contingency fund as an early warning signal to potential overdrawn budget.

**Time estimation:**

- **Using experience:** Base estimate on experience,  use the average expected time to perform a task.
- **Keeping estimates as estimate:** don't change estimate into firm commitments as estimates aren't guarantees
- **Clarifying assumptions:** Make sure stakeholders understand the assumptions and variables behind when presenting estimates.
- **Padding:** an acceptable way of reducing the risk that a task will take longer than the schedule allows. But make sure stakeholders know any expectations which the estimate bases and what the consequences of not meeting the expectations would be.

**Adjusting estimates:** time & cost estimates of specific activities are adjusted as the risks, resources, and situation particulars become more clearly defined.

- Reasons: 1) interaction costs are hidden in estimates; 2) Normal conditions don't apply; 3) Things go wrong on projects; 4) Changes in project scope and plans.

## 9. Virtual project

### Why virtual team is prevalent:

- The need of distance working during a pandemic outbreak
- Advancement in IT technologies enabling virtual teams
- Global outsourcing involves suppliers in different continents

### Challenges of virtual project management:

- Developing trust: it is difficult to establish when project team members cannot interact fact-to-face.
- Effective communication: time zone difference, e-mails don't allow real-time communication

### Deal with lack of trust?

- Hold **face-to-face** meetings in the beginning of the project if possible - PM should encourage the exchange of social information.
- Set **clear roles** for each team member - assign specific tasks to each team member so that they can make contributions immediately.
- PM displays **enthusiasm** and **action-oriented spirit** - trust in virtual projects grows through team member reliability, consistency, and responsiveness,

### Manage communications

- When to **email**: distribute important information and news in a one-to-one or one-to many frame of reference.
- When to use **electronic discussion boards**: to encourage discussion and flush out diversity of opinion on issues
- When to **video conferencing**: a video conferencing enables the PM to see each other's face and expressions. It is important during the early stage of a project to build relationships and common understanding of what needs to be done. Use it when working on critical decisions or contentious issues.
- When to use a **conference call**: when people in different locations are working with common documents, presentations, and sketches. Use it for status reports or to sustain social camaraderie.
- When to **fly**: fly to build or repair trust. Use the travel budget to get all key players together early on to instil commitment to the goals of the project and to engage in team-building activities.

## 10. Outsourcing

**Approaches to solve a moral hazard model:**

- **Indirect approach:** Stackelberg game wherein the principal is the first mover who offers a contract w(x) and then the agent determines the best level of effort to exert.
- **Direct approach:** It gives rise to a set of incentive compatibility (IC) constraints that predict how the agent will react to the offered contract. The optimization problem is solved in a single-stage (without any backward induction or sequential analysis).

### Why do firms outsource project work?

- Cost savings - employment cost
- More funds available for main business growth
- Staff satisfaction / 24/7 customer-service

**Fixed-Price (FP) Contract / Lump-sum Agreement:** The contractor agrees to perform all works specified in the contract at a fixed price.

- **Disadv for buyers:** it is more difficult and more costly to prepare as they need to specify all works.
- **Disadv for contractors:** the risk of underestimating project costs
- Contract adjustment: 1) redetermination provisions; 2) performance incentives

**Cost-reimburse(plus) contracts:** The contractor is reimbursed for all direct allowable costs (materials, labor, travel) plus an additional prior-negotiated fee (set as a percentage of the total costs or a fixed amount) to cover overhead and profit.

- **Disadv for buyers: It relies on the contractor's best efforts to contain costs.**
- **Controls on contractors:** 1) performance and schedule incentives; 2) Costs-sharing clauses

### What are fundamental differences between fixed-price and cost-plus contracts?

The risk sharing between the buyer and supplier is different. Under a fixed-price contract, the buyer's risk is the lowest while the supplier's risk is the highest. Under cost-plus contract, the buyer's risk is the highest whereas the supplier's risk is the lowest.

### For what kinds of projects would you recommend a fixed-price and cost-plus contract?

A fixed-price contract is recommended when the cost is known or easy to estimate. Also when it is permitted that the project scope will not change. A cost-plus contract is recommended when the cost is hard to estimate and the project scope is highly uncertain.

### Choosing contract bid

- In the context of **buying** a service, a Vickery auction selects the bidder with the **lowest bid** as the winner and the payment to the winner is the second lowest bid.
- In the context of **selling** a good / providing a service, a Vickery auction selects the bidder with the **highest bid** as the winner and whose payment to the seller is the second highest bid.

### Linear contract

**Objective:** Z=min{f+b*35}(f>=0 and b>=0)
**Subject to:**
reservation value of 5: **f+b*35 - 8 >= 5**
Choosing C over B: **f+b*35-8>= f+b*30-6**
**(35-30)*b>=2 => 5*b>=2 => b>=0.4**
Choosing C over A: **f+b*35-8>=f+b*20-3**
**(35-20)*b>=5 => 15*b>=5 => b=> 1/3**
**=> b = 0.4 (minimum)**
**=> f+0.4*35-8>=5 => f+14-8>=5 (minimum) => f+6>=5**
**=> as f>=0 => f=0**
**=> optimal values: f=0 and b=0.4**