CERTIFIED ESTIMATING PROFESSIONAL (CEP)®

REFRESHING COURSE

By

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CEP
Certification Requirements

1. **Experience requirements:** 8 years - 4 years may be substituted by university degree
2. **Application and Fees:**

   US$500 Members - US$625 Non-Members
3. **Submit experience/education documentation**
4. **Pass the examination:** overall passing score of 70%

Exam Structure

- 120 questions
- 5 hours
- Multiple choice
- Simple & composite questions
- Basics & practice
- Memo > 300 words

Supporting Skills & Knowledge

1. **Elements of cost**
   1. Cost
   2. Cost dimensions
   3. Cost classifications
   4. Cost types
   5. Pricing
2. **Elements of analysis**
   1. Statistics & probability
   2. Economics & financial analysis
   3. Optimization
   4. Physical measurements
3. **Enabling knowledge**
   1. Enterprise in society
   2. People & organization in enterprises
   3. Information management
   4. Quality management
   5. Value management
   6. Environment, health, Safety

ELEMENTS of COST

- Cost
- Cost dimensions
- Cost classifications
- Cost types
- Pricing

Cost

- Resources
- Time
- Cost

Cost Dimensions

- Lifecycle
- Process
- Responsibility
- Valuation
- Influence
- Legal issues

Life-Cycle Cost

LCC are associated with an asset and extend the cost management information beyond the acquisition of the asset to the use and disposal of the asset.

Process Cost

- Product & Project
- Product cost
- Project cost
- Co-products
- By-products

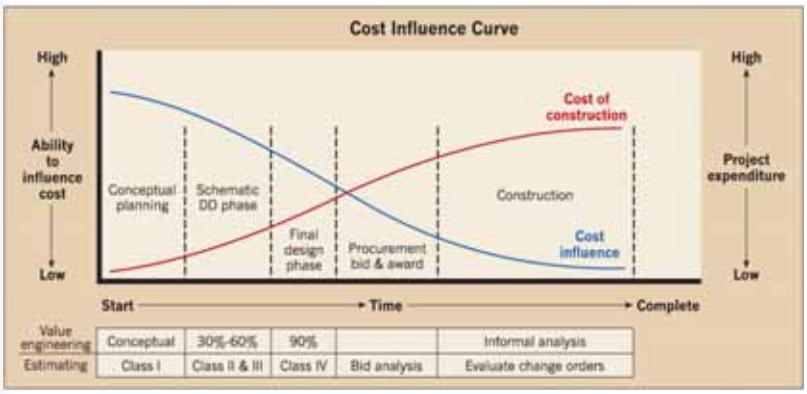
Responsibility

- Owner responsibilities
- Contractor responsibilities

Valuation

- Cost
- Expenditure
- Monetary
- Economy
- Opportunity

Influence



Legal issues

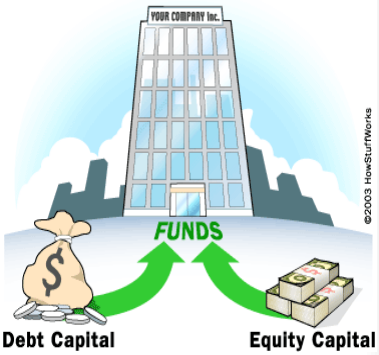
- Forensic
- Cost
- Schedule
- Planning
- Control
- Unethical practices

Cost Classification

- **Capital**
- **Operation**
- **Expenses**
- **Depreciation**
- **Amortization**
- **Accrual**
- **Fixed & Variable**
- **Direct & Indirect**
- **Activity-Based Costing (ABC)**
- **Job costing**

Capital

- This includes the assets through which business is done or the cash that makes this possible.



OPERATING COST

The expenses incurred during the normal operation of a facility, or component, including labor, materials, utilities, and other related costs.

Includes all fuel, lubricants, and normally scheduled part changes in order to keep a subsystem, system, particular item, or entire project functioning.

Expenses

- Actual cash payments (such as wages and salaries),
- A computed expired portion (depreciation),
- An amount taken out of earnings (such as bad debts).

Whereas all expenses are costs, not all costs (such as those incurred in acquisition of income generating assets) are expenses.

Depreciation

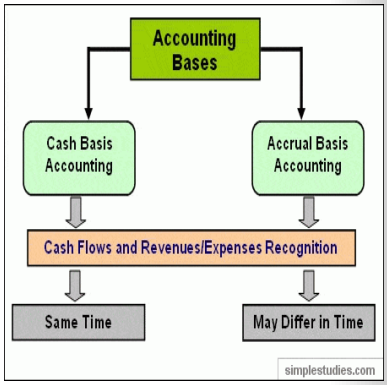
- Decline in value of a capitalized asset
- Form of capital recovery applicable to a property with a life span of more than one year, in which an appropriate portion of the asset's value is periodically charged to current operations.

Amortization

- *Amortization* is a term which is applied to writing off or recovering any portion of the initial capital expense which is intangible in nature and as such has no definable useful life.

Accruals

- The term *accrual* is used as an abbreviation for the terms **accrued expense** and **accrued revenue** that have the opposite economic / accounting characteristics.
- Accrued revenue: revenue is recognized before cash is received.
- Accrued expense: expense is recognized before cash is paid out.

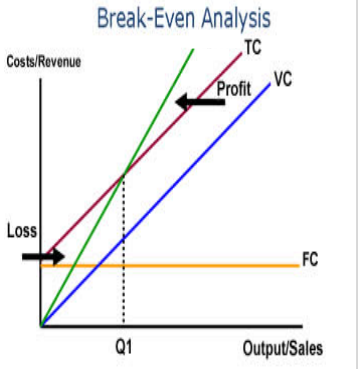


Fixed Costs

- Fixed cost are those costs independent of short term variations in output of the system under consideration.
- Includes such costs as maintenance; plant overhead; and administrative, selling and research expense.

Variable Costs

- Variable costs are a function of production, eg., raw materials costs, by-product credits, and those processing costs that vary with plant output (such as utilities, catalysts and chemical, packaging, and labor for batch operations).



Direct Costs

- In construction, cost of installed equipment, material and labor directly involved in the physical construction of the permanent facility.
- In manufacturing, the portion of operating costs that is generally assignable to a specific product or process area.

Indirect Costs

In construction, all costs which do not become a final part of the installation, but which are required for the orderly completion of the installation.

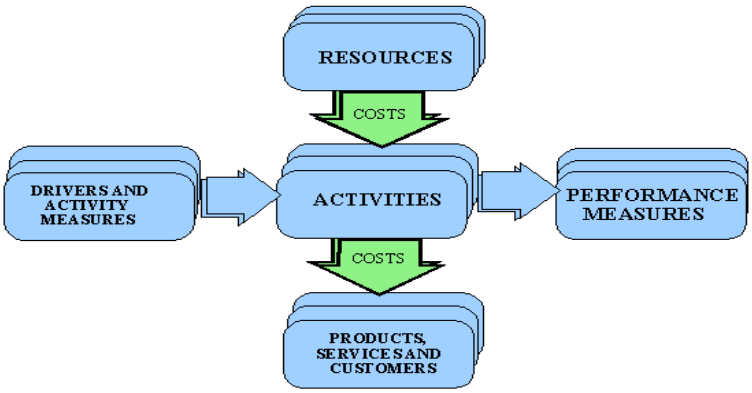
Indirect Costs

- In manufacturing, costs not directly assignable to the end product or process, such as overhead and general purpose labor, or costs of outside operations.
- Indirect manufacturing cost sometimes includes insurance, property taxes, maintenance, depreciation, packaging, warehousing and loading.

Activity-Based Costing (ABC)

- **Activity-based costing** (**ABC**) is a costing methodology that identifies activities in an organization and assigns the cost of each activity with resources to all products and services according to the actual consumption by each.
- This model assigns more indirect costs (overhead) into direct costs compared to conventional costing.

Activity-Based Costing (ABC) vs. ledger



Job Costing

- **Job Costing** involves the calculation of costs involved in a construction "job" or the manufacturing of goods done in discrete batches.
- These costs are recorded in ledger accounts throughout the life of the job or batch and are then summarized in the final trial balance before the preparing of the job cost or batch manufacturing statement.

Cost Types

- Materials
  1. Material types
  2. Purchase costs
  3. Materials management cost
  4. Capital equipment
  5. Temporary equipment
- Labor
  1. Labor wage rate
  2. Benefits & burdens
  3. Overhead & profit
  4. Union

Material Types

1. Raw materials
2. Bulk materials
3. Fabricated materials
4. Engineered or designed materials
5. Consumables

Raw Materials

- Raw materials are those materials utilized in a production or fabrication process that require a minimum amount of processing to be useful.

Bulk Materials

- Bulk materials in common sizes are typically readily available with minimal lead times for order and delivery.

Fabricated Materials

- Fabricated materials are bulk materials transformed into custom-fit items for a particular product or project.
- As an example, the bulk material of steel pipe.

Engineered Materials

- Engineered or designed materials constitute a category requiring substantial working in order to attain their final form.
- These engineered materials may consist of many components and subcomponents that end with a completed product.

Consumables

- Consumables are products that consumers buy *recurrently*, i.e., items which "get used up" or discarded.
- Supplies and materials used up during construction. Includes utilities, fuels and lubricants, welding supplies, worker's supplies, medical supplies, etc.
- This is in contrast to the **capital goods** or **durable goods**.

Purchase Costs

- Market pricing
- Order quantity
- Taxes & duties
- Carrying charges
- Cancellation charges
- Demurrage
- Hazardous material regulations
- Warranties, maintenance, & service

Negotiated bid

- Unlike the design-bid-build approach, a general contractor and an architect are selected at the project's inception.
- These firms work together throughout the design phase.
- When design documents are complete, the final construction costs are negotiated by the general contractor through bids from subcontractors on various scopes of work.

Economic Order Quantity (EOQ)

$$EOQ = \sqrt{\frac{2 \times D \times P}{S}}$$

D = annual demand
P = purchase order costs
S = storage / carrying cost

EOQ example

- A garden tractor manufacturer has a demand for 15,000 engines per year.
- The engines each cost $75.
- The order cost for a purchase order is $250.
- The storage costs for the engine are $12 per year which includes space costs and financing costs.

EOQ solution

$$EOQ = \sqrt{\frac{2 \times 15{,}000 \times 250}{12}} = 790 \; engines$$

Reorder Point (RP)

$$RP = (O \times R) + I$$

RP = reorder point
O = order time
R = production rate
I = minimum inventory level or safety stock

RP example

- Production process uses 60 engines per day for the 60 garden tractors produced per day.
- Lead time for an order is 5 days, and the safety stock level is 180 engines (minimum level).

RP solution

RP = *(5 days x 60 units/day) + 180 units*

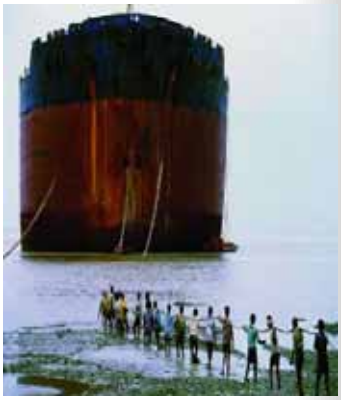
= *480 units*

Carrying Charges

- The **cost of carry** or **carrying charge** is the cost of storing a physical commodity, such as lumber or metals, over a period of time.
- The carrying charge includes insurance, storage and interest on the invested funds as well as other incidental costs

Demurrage

- Demurrage is a delay in delivery of a product via delivery truck.
- When a delay occurs with product delivery, the delivery party can elect to claim a no fault delay by submitting a demurrage charge.



Hazardous Material Regulations

- Material safety data sheets (MSDS)
- Occupational Safety & Health Administration (OSHA)
- Resource Conservation And Recovery Act (RCRA)
  1. Generators,
  2. Transporters, and
  3. Owners and operators of Treatment, Storage, and Disposal (TSD) facilities.

Materials Management Costs

- Delivery schedule
- Packing
- Shipping and freight
- Freight forwarding
- Handling
- Storage and inventory
- Agent cost
- Surveillance or inspection
- Expediting
- Losses (shrinkage, waste, theft, damage)
- Spare parts (inventory or start-up)
- Surplus materials

Capital Equipment

Any equipment used by an organization to produce other commodities.

- Fabricated
- Engineered
- Rent
- Lease
- Purchase

Lease vs. Rent

	Lease	Rent
Meaning	It is a contract renting land, buildings, etc.,	Renting is an agreement where a payment is made for the temporary use of a good
Flexibility	Not flexible	It is flexible
Time	Long term	Short term
Agreement	Pre determined and cannot be broken without breaking the lease	Pre determined and terms can be changed
Mode of agreement	Written	Oral / Written
Stability	Both landlord and tenant have stability	Not much stability

Valuation

- Reproduction cost
- Replacement cost
- Fair value
- Market value
- Book value
- Residual value
- Operating life

Reproduction Cost

- The cost of reproducing substantially the identical item or facility at a price level as of the date specified.

Replacement Cost

1. The cost of replacing the productive capacity of existing property by another property of any type, to achieve the most economical service, at prices as of the date specified.

2. Facility component replacement and related costs, included in the capital budget, that are expected to be incurred during the study period.

Fair Value

That estimate of the value of a property that is reasonable and fair to all concerned, after every proper consideration has been given due weight.

Market Value

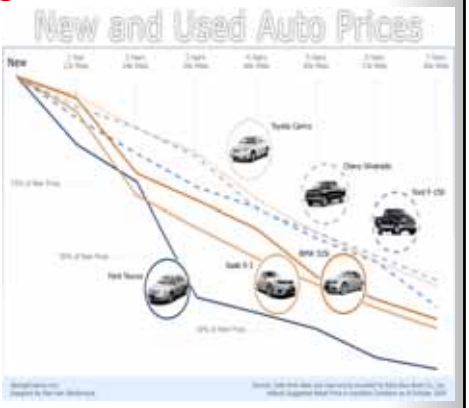
- The monetary price upon which a willing buyer and a willing seller in a free market will agree to exchange ownership, both parties knowing all the material facts but neither being compelled to act.
- The use of the term market suggests the idea of barter. When numerous sales occur on the market, the result is to establish fairly definite market prices as the basis of exchanges.

Book Value

1. Current investment value on the books calculated as original value less depreciated accruals.
2. New asset value for accounting use.
3. The value of an outstanding share of stock of a corporation at any one time, determined by the number of shares of that class outstanding.

Residual Value

- Residual or Economic Value is the value of property in view of all its expected economic uses, as distinct from its value in view of any particular use.
- Also, economic value reflects the importance of a property as an economic means to an end, rather than as an end in itself.



Operating vs. Economic Life

- **Operating Life Cycle**: The length of time during which a machine, tool, or other property can be operated before breakdown.
- **Economic Life Cycle**: That period of time over which an investment is considered to be the least-cost alternative for meeting a particular objective.

Labor

- Labor wage rate
- Benefits & burdens
- Overhead & profit
- Union

Labor Wage Rate

- Exempt & non-exempt
- Effective wage rate
- Overtime premium
- Shortened shift time
- Travel time
- Show-up pay

Exempt & Non-Exempt

- Certain types of employees, who are classified as exempt employees, are not entitled to overtime pay as guaranteed by the Fair Labor Standards Act (FLSA).
- Administrative, executive, and professional employees, outside salespeople and certain computer employees may be classified as exempt if they meet the following criteria:

1. Employees are paid on a salary rather than an hourly basis.
2. Employees earn at least $455 per week.

Travel Time

- Under the Fair Labor Standards Act (FLSA), time spent traveling during normal work hours is considered work time and employees must be paid for this travel time. Generally, time spent commuting is not work time.

Show-up Pay

- Sometimes when you arrive for work, at the time your employer directed you to be there, you are sent home before you perform any work. The FLSA does not require an employer to consider any of this time as hours worked or to give you show-up pay.
- However, some employers and employees have informal or contractual agreements (Collective Bargaining Agreements) which require a set number of hours be considered hours worked.

Benefits & Burdens

- Retirement – Social Security
- Unemployment insurance
- Workers compensation
- Insurance
- Paid-time off (sick- vacation –holiday)
- Industrialized vs. non-industrialized countries
- Populated vs. remote areas

Overhead & Profit

Home Office Support such as; Legal Assistance, Procurement, Human Resources, Senior Management review, Corporate Computer Support, Estimating and Business Development, etc.

Fringe Benefits

Paid Time Off (PTO)

- For example, an engineer gets:
  - 5 days of sick time
  - 10 days of vacation
  - 10 holidays per year
- base salary is $28.85 per hour.

Fringe Benefits: PTO

- Sick time: 5 days at 8 hours / day @ $28.85 = $1,154 / year
- Vacation: 10 days at 8 hours / day @ $28.85 = $2,308 / year
- Holiday: 10 days at 8 hours / day @ $28.85 = $2,308 / year
- Total adders: $5,770 / year
- Engineer working hours= 52 weeks x 40 hours / week - 25 days x 8 hours =1,880 hours / year.
- Hourly cost = $28.85 base wage + ($5,770 ÷ 1,880 hours) = $31.92 total.

Fringe Benefits:
Medical & Life Insurance

- If the firm contributes $400 per month for medical insurance:

  $400 / month x 12 months = $4,800 / year divided by 1,880 hours = $2.55 / hour

- If the company contributes $300 to 401ks and other retirement plans :

  $300 / month x 12 months = $ 3,600 / year divided by 1,880 hours = $1.91 / hour

Government Mandated Benefits

- Retiremt. (6.2%) = .062 x $28.85 =$ 1.79
- Retiremt. medical (1.35%) = .0135 x $28.85 =$ 0.39
- State unemployment (1.0%) = .01 x $28.85 =$0.29
- Total government mandated benefits = $ 2.47

		Per Hour	
Base Salary Working		1,880 hrs/yr	= $28.85
Fringe Benefits:			
	company retirement contributions		= $1.91
	PTO (holidays, vacation, sick time)		= $3.07
	company medical and life insurance		= $2.55
	government mandadted benefits (retirement, etc.)		= $2.47
Total Cost Per Hour			
Benefits Adder		= ($38.85 - $28.85)	= $10.00
		= $10.00/28.85	=$34.7%

Overtime Wages

- Overtime can range from straight time pay to 1.5 and 2.0 times the regular pay.
  - For example, a craft worker earning $25.00 per hours is working overtime at 1.5 times his base rate at $ 37.50.
  - Federal retirement and medical is included at 7.55%, which equals $2.83 (0.0755 x 37.50).
  - The total cost per hour for 1.5 overtime is $40.33.

Weighted Average Rate

Civil Engineering Design Team

No.	Classification	Hourly Base Wage	Extension
2	Engineering Aides	$14.00	$28.00
2	Junior Engineers	$20.00	$40.00
4	Engineers	$25.00	$100.00
2	Senior Engineers	$30.00	$60.00
1	Eng. Supervisor	$35.00	$35.00
11	Total		$263.00*

*Average cost for the group = $263.00/ 11 = $23.91/hour with benefits adder of 34.7% = $32.21/hour.

OT calculations

- If the concrete crew of *nine* works *10 hours* per day for *two weeks* and *10 hours* a day on *two Saturdays*, how much extra will it cost him?

Normal wage rate =	$23.83 / hour
1.5 normal wage rate =	$29.58 / hour
2.0 normal wage rate =	$39.44 / hour

OT calculations

- Monday thru Friday = 2 hours per day = 10
- Saturday = 8 hours
- Total 1.5 time = 18 hours
- Saturday Double time = 2 hours
- Crew Cost (1.5 time) = $29.58 / hour x 9 workers x 18 hours x 2 weeks = $ 9,584
- Crew Cost (2 time) = $ 39.44 / hour x 9 workers x 2 hours x 2 weeks = $ 1,420
- Total = $11,004

Indirect Labor

Indirect Positions	Duration On-Site (months)	No. of Positions	Worker Months	Monthly Rate*	Estimate
warehouse workers	12	2	24	$3,500	$84,000
	6	2	12	$3,500	$42,000
accounting clerks	12	1	12	$3,800	$45,600
	6	1	6	$3,800	$22,800
payroll supervisor	8	1	8	$4,500	$36,000
first aid person	12	1	12	$4,000	$48,000
safety engineer	10	1	10	$4,600	$46,000
office manager	12	1	12	$5,200	$62,400
clerical support	12	1	12	$3,000	$36,000
	6	1	6	$3,000	$18,000
On-site computer support	11	1	11	$5,000	$55,000
Project Manager	10	1	10	$8,000	$80,000
Total Indirect Labor					**$575,800**

* monthly rate includes benefits

Indirect Labor

- Use historical job percentages to determine an appropriate allowance for indirect labor.
- For example, Estimated Direct Costs = $360, 000
- Indirect Costs at 25% = $90,000

or

- Estimated Direct Labor = $250,000
- Indirect Labor at 30% = $ 75,000

Estimating Work Hours

- Estimating work hours is usually done at least with Class 3 estimate.
- A Class 3 estimate when major equipment has been identified, layout drawings are available, and rough quantities are available for many of the major elements (such as cubic yards of concrete, linear feet of pipe, etc.).

Estimating Work Hours

- Area = 200 ft x 100 ft;
- The slab will be our example, and it is 1 foot thick
- The quantity of concrete in the slab is; 200 ft x 100 ft x 1 ft = 20,000 cubic ft = 741 CY.
- From Means: 0.026 labor hours per cf.
- This equals 20,000 cf x .026 = 520 labor hours.

Factors Affecting Productivity (Cost)

Jobsite Conditions		
	Good	+ 3% to 5%
	Average	+ 6% to 8%
	Poor	+ 9% to 15%
Worker Skill Level		
	High	+ 2% to 5%
	Average	+ 6% to 10%
	Poor	+ 11% to 20%
Temperature		
	Below 40 degrees or above 85 degrees add 1% per degree of variance	
Work Weeks in excess of 40 hours		
	40 to 48 hours	+ 5%b to 10%
	49 to 50 hours	+ 11% to 15%
	51 to 54 hours	+ 16% to 20%
	55 to 59 hours	+ 21% to 25%
	60 to 65 hours	+ 26% to 30%
	66 to 72 Hours	+ 31% to 40%

Factors Affecting Productivity (Cost)

Example Calculation:

The standard labor cost for 100 LF of footing 8 inches by 12 inches = $130.90

The jobsite conditions are as follows

Adders		
Jobsite conditions	Good	+ 4%
Worker Skill	Average	+ 8%
Temperature	95 degrees	+10%
Work week = 40 hours		+ 0 %
Total adders =		+22%

Unit Rate = $130.90 x 1.22 = $159.70

Estimates Adjustments

		Chicago, Illinois[1]			Los Angeles, California[2]		
		Matl	Inst	Total	Matl	Inst	Total
02	Site Construction	86.0	91.0	89.8	89.5	109.0	104.5
03	Concrete (Summary)	100.6	134.6	117.6	108.2	115.6	111.9
04	Masonry	93.9	131.5	117.0	97.8	116.5	109.3
05	Metals	96.4	123.7	106.3	111.2	99.3	106
06	Woods & Plastics	103.3	128.9	116.5	99.6	117.3	108.7
07	Thermal & Moisture Protection	99.3	128.7	113.3	114.2	114.6	114.4
08	Doors & Windows	104.1	136.4	111.9	99.1	114.8	102.9
09	Finishes	89.4	129.9	110.1	108.5	116.6	112.7
Total (10-14) *(Define)*		100.0	123.7	105.0	100.0	114.5	103.1
15	Mechanical	100.0	124.5	111.3	100.2	114.0	106.6
16	Electrical	101.1	130.7	121.4	109.8	113.6	112.4
	Weighted Average	98.2	125.4	111.4	104.3	112.9	108.5

Union

- An organization of wage earners formed for the purpose of serving the members' interests with respect to compensation and working conditions.
- In the case of construction craft that may work for many employers during a given period, wages are usually paid into a fund managed by their union or trade organization who distributes the salary for PTO.

Subcontract

- Reimbursable vs. non-reimbursable costs
- Overhead & profit
- License, fees, royalties
- Bonds (bid – payment – performance)
- Retainage
- Performance guarantee
- Liquidated damage

Overhead

A cost or expense inherent in the performing of an operation, which cannot be charged to or identified with a part of the work, product or asset and, therefore, must be allocated on some arbitrary base believed to be equitable, or handled as a business expense independent of the volume of production.

Profit

1. **GROSS PROFIT**: Earnings from an on-going business after direct and project indirect costs of goods sold have been deducted from sales revenue for a given period.
2. **NET PROFIT**: Earnings or income after subtracting miscellaneous income and expenses (patent royalties, interest, capital gains) and federal income tax from operating profit.
3. **OPERATING PROFIT**: Earnings or income after all expenses (selling, administrative, depreciation) have been deducted from gross profit.

Royalties

Payments a company receives to allow others to use a design or concept the company has researched and developed to commercialization.

1. Paid-up royalties where a lump sum payment is made;
2. Running royalties where continuous payments are made, usually based on actual production or revenues.

Surety

- **Payment Bond:** A bond that is executed in connection with a contract and which secures the payment of all persons supplying labor and material in the prosecution of the work provided for in the contract.
- **Performance Bond:** A bonding company licensed to conduct business which guarantees the owner that the contract will be completed.

Retainage

- Retainage – retention: Usually refers to a percent of contract value retained by the purchaser until work is finished and testing of equipment is satisfactorily completed

Liquidated Damage

- An amount of money stated in the contract as being the liability of a contractor for failure to complete the work by the designated time(s).
- Liquidated damages ordinarily stop at the point of substantial completion of the project or beneficial occupancy by the owner.
- Also can apply to contract defined output performance.

Cost of Money

- Escalation
- Inflation
- Currency exchange rate

Escalation

A provision in costs or prices for uncertain changes in technical, economic, and market conditions over time. Inflation (or deflation) is a component of escalation.

Inflation

A persistent increase in the level of consumer prices, or a persistent decline in the purchasing power of money, caused by an increase in available currency and credit beyond the proportion of available goods and services.

Risk & Uncertainty

- Contingency
- Allowance
- Reserve

Contingency

- Contingency is a cost element of the estimate used to cover the uncertainty and variability associated with a cost estimate, and unforeseeable elements of cost within the defined project scope.

Allowance

Resources included in estimates to cover the cost of known but undefined requirements for an individual activity, work item, account or sub-account.

Reserve

An amount added to an estimate to allow for discretionary management purposes outside of the defined scope of the project, as otherwise estimated.

May include amounts that are within the defined scope, but for which management does not want to fund as contingency or that cannot be effectively managed using contingency.

Pricing

- Cost vs. Price
- Price strategy
- Business strategy & market force
- Owner & contractor
- Benefit vs. price
- Contract vs. price

Introduction

The required tools and techniques include :

1. **Pricing strategies,**
2. **Sales and revenues,**
3. **Return on investment (ROI),**
4. **Gross profit**
5. **Break-even analysis.**

Pricing Strategy

- **Type I** acquisitions is to win the project and execute it *profitably* and satisfactorily according to contractual agreements.
- **Type II** refers to a new industry that a company is trying to get a foothold into.

Simple Return on Investment

$$Simple\ ROI = \frac{(Gains - Investment\ Costs)}{Investment\ Cost}$$

Simple Return on Investment

- What would be the ROI for a new marketing program that is expected to cost $500,000 and deliver $700,000 in profits during the same time?
- ROI = ($700,000 – 500,000) / $500,000 = 40%

Complex Return on Investment

$$ROI = \frac{(Average\ yearly\ profit\ during\ earning\ life)}{(original\ \ fixed\ investment + working\ capital)}$$

Complex Return on Investment

Time, end year	After Tax Profit, K$	Depreciation, K$	Cash Flow, K$
0	-1,000	0	-1,000
1	275	200	475
2	200	200	400
3	130	200	330
4	70	200	270
5	0	200	200

$$ROI = \frac{\frac{(275+200+130+70+0)}{5}}{(1{,}000+0)} = 13.5\%$$

Gross Profit

- Gross profit margin ratio

$$\text{Gross Profit Margin Ratio} = \frac{\text{Gross Profit}}{\text{Sales}}$$

Break-Even Analysis

- **Selling Price (SP)** – is the price that each unit will sell or retail for.
- **Variable Costs (VC)** – consist of costs that vary in proportion to sales levels.
- **Contribution Margin (CM)** – is equal to sales revenues less variable costs or (SP – VC).
- **Fixed Costs (FC)** – costs remain constant (or nearly so) within the projected range of sales levels.
- **Units (X)** – is another way to say number of items sold or produced.

Break-Even Analysis

$$SP \times X = VC \times X + FC$$

$$X = \frac{FC}{(SP - VC)}$$

$$X = \frac{FC}{CM}$$

Break-Even Analysis

Example:

- Each unit retails at $5.
- Costs $2 to make each one, and the fixed costs for the period are $750.
- What is the break-even point in units and in sales revenue?

Break-Even Analysis

Answer:

- Break-even units:
- X = FC / (SP - VC)
  = $750 / ($5 - $2)
  = $750 / $3
  = 250 units
- Break-even sales revenue = break-even units x SP
  = 250 x $5
  = $1,250

Sample Question #1

1. The difference between a cost element and a cost category is best explained by:

A. Cost elements are a grouping of detailed line items.
B. Cost categories are subdivided by assemblies.
C. Cost elements are a subdivision of a cost category.
D. Cost categories are a subdivision of an assembly.

Sample Question #2

2. Which of the following is *not* an element of the cost of a project?

A. Material
B. Freight
C. Material waste
D. Esteem value

Sample Question #3

3. Which of the following is an indirect cost of a concrete wall?

A. Material
B. Forming labor
C. Supervisory labor
D. Labor fringe benefits and taxes

Elements of Analysis

1. Statistics and probability
2. Economic and financial analysis
3. Optimization
4. Physical measurements

Statistics and Probability

- Samples & population
- Descriptive statistics
  - Basic statistics
  - Normal distribution
  - Non-normal distribution
  - Histograms
- Inferential statistics
  - Probability
  - Regression analysis
  - Statistical significance
  - Chi-squared & t-test

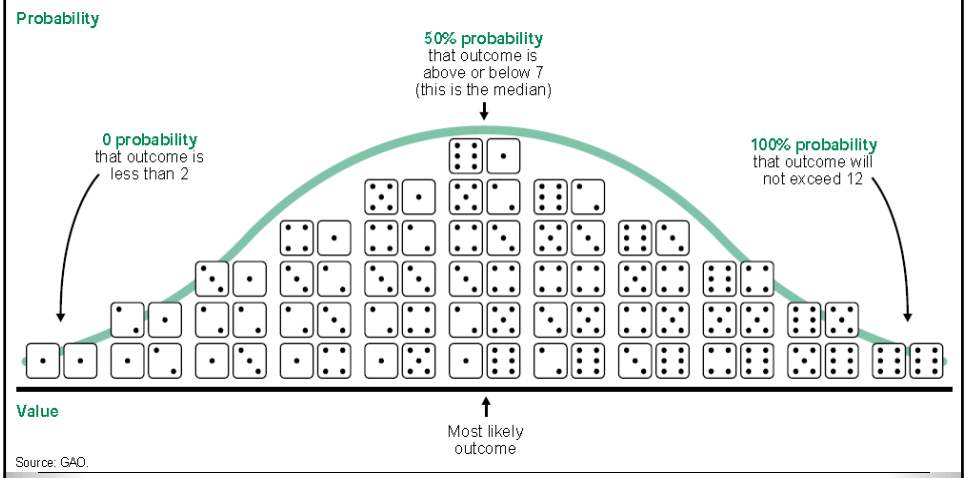
Main Elements

1. **Population** is the collection of all elements of interest to the decision-maker. The size of the population is usually denoted by N.
2. **Sample** is a subset of data randomly selected from a population. The size of a sample is usually denoted by n.
3. **Statistical inference** is an estimation, prediction or generalization about the population based on the information from the sample.
4. **Reliability** is the measurement of the "goodness" of the inference.

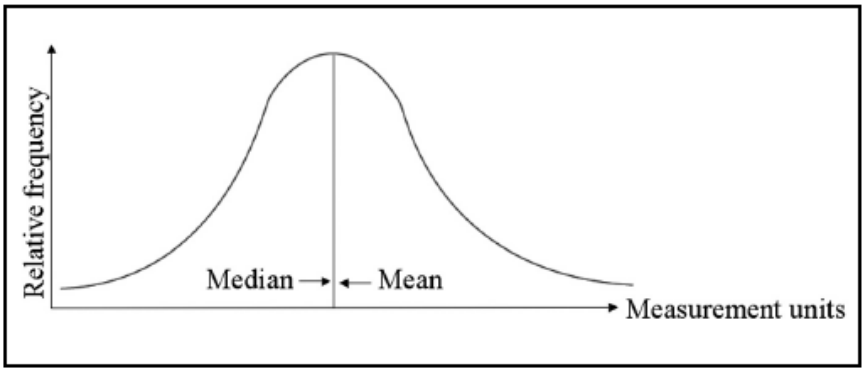
Describing Data

1. Qualitative description
   - Categorization
   - Summarizing
2. Quantitative description
   - Graphically
   - Numerically

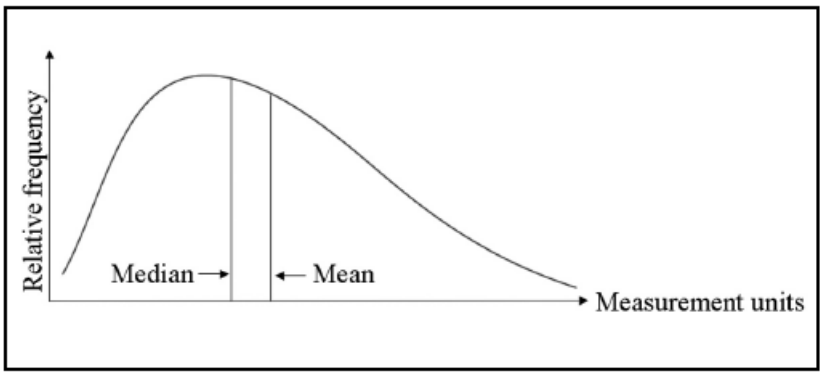
Distribution of Two Dice Experiment



Symmetric Distribution



Skewed Distribution



- Note that the median lies between the mode and mean in all skewed distributions.
- If negatively skewed, the median is higher than the mean.
- If positively skewed, the median is lower than the mean.

Qualitative Description

Measures of dispersion

- **Range**: is the difference between the largest and the smallest values of the data set.

  The alternative might be to calculate the average absolute deviation.
- **Variance**
- **Standard deviation**

Variance & Standard Deviation

- Variance of population $\sigma^2 = \frac{\sum(x - \mu)^2}{N} = \frac{\sum x^2 - N\mu^2}{N}$
- Variance of sample $s^2 = \frac{\sum (x - \bar{x})^2}{n - 1} = \frac{\sum x^2 - n\bar{x}^2}{n - 1}$

- The population standard deviation is denoted by **(σ).**
- The sample standard deviation is denoted by ***(s).***

Qualitative Description

Relative standing

- **Percentile**: the p^{th} percentile is the number with exactly p% of the measurements fall below it
- **Z-score**: is the number of standard deviations a point is above or below the mean of a set of data.
  - The population z-score for a measurement x is: $z = \frac{(x - \mu)}{\sigma}$
  - The sample z-score for a measurement x is: $z = \frac{(x - \bar{x})}{s}$

Random Variables& Probability Distributions

A random variable is a variable whose numerical value is determined by the outcome of a random experiment.

Discrete probability distribution

Example: Two coins are tossed. Let X be the number of heads appeared.

Probability distribution of X

x	0	1	2
p(x)	1/4	2/4	1/4

Expected Value & Variance

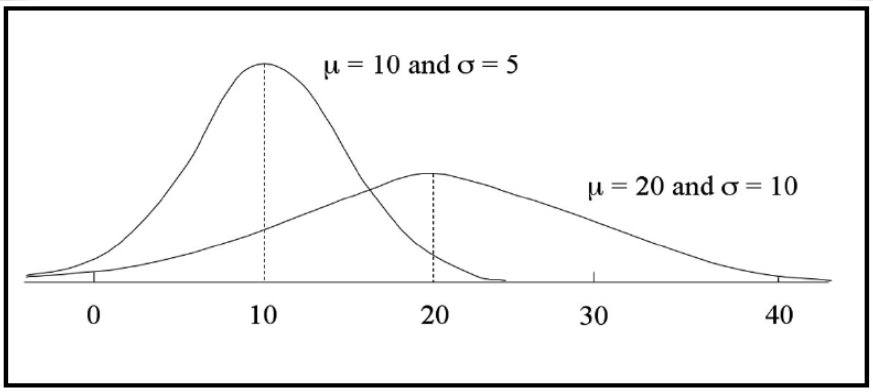
- The expected value μ is:

$$\mu = E(x) = \Sigma x.p(x)$$

- The population variance is defined as:

$$\sigma = E(x-\mu)^2 = \Sigma(x-\mu)^2.p(x)$$

Normal Distribution



Z-values

Z	*Pr (-z < Z < z)*	*Pr(Z<-z) or Pr(Z>z)*
1.00	.683	.158
1.282	.80	.10
1.645	.90	.05
1.96	.95	.025
2.00	.954	.023
2.326	.98	.01
2.576	.99	.005
3.00	.997	.0015

Frequency Distribution

JOB	HRS/SFCA	JOB	HRS/SFCA	JOB	HRS/SFCA	JOB	HRS/SFCA
1	.050	6	.050	11	.040	16	.050
2	.050	7	.065	12	.055	17	.060
3	.065	8	.060	13	.045	18	.055
4	.055	9	.050	14	.050	19	.070
5	.050	10	.045	15	.065	20	.045

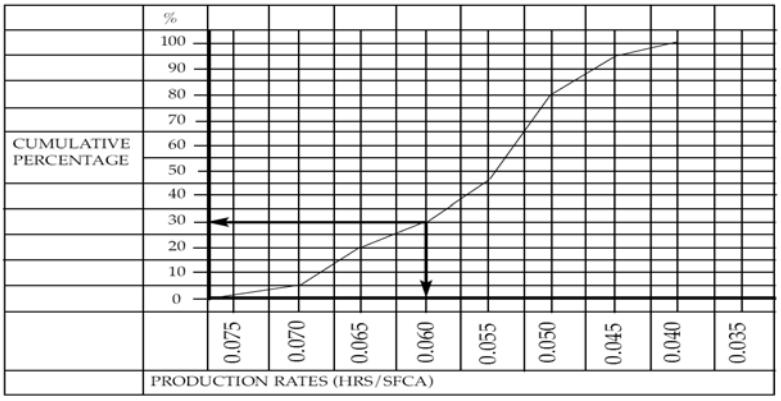
Percentage Distribution

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
rate (SFCA)	frequency (f)	cum. freq. (cf)	cum. percent (%)
.040	1	20	100
.045	3	19	95
.050	7	16	80
.055	3	9	45
.060	2	6	30
.065	3	4	20
.070	1	1	5
	$n = 20$		

Cumulative Probability

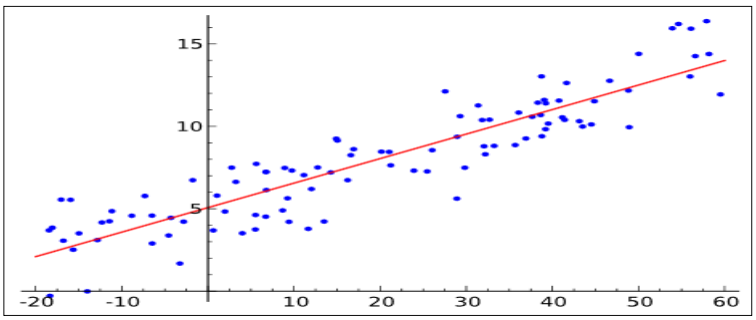
Rate (HRS/SFCA)	Frequency	Probability of Occurrence	Cumulative Probability
.070	1	5 percent	100 percent
.065	3	15 percent	95 percent
.060	2	10 percent	80 percent
.055	3	15 percent	70 percent
.050	7	35 percent	55 percent
.045	3	15 percent	20 percent
.040	1	5 percent	5 percent

Cumulative Probability Curve



Regression Analysis

- Finds some sort of relationship between one or more of the parameters and the outcome measure.



Root Mean Square Error

- The RMSE of predicted values for times x of a regression's dependent variable is computed for n different predictions as the square root of the mean of the squares of the deviations:

$$RMSE = \sqrt{\frac{\sum_{x=1}^{n} (x - \bar{x})^2}{n}}$$

R-Squared

The **coefficient of determination**, R^2 is used in the context of statistical models whose main purpose is the prediction of future outcomes on the basis of other related information.

R^2 is most often seen as a number between 0 and 1, used to describe how well a regression line fits a set of data.

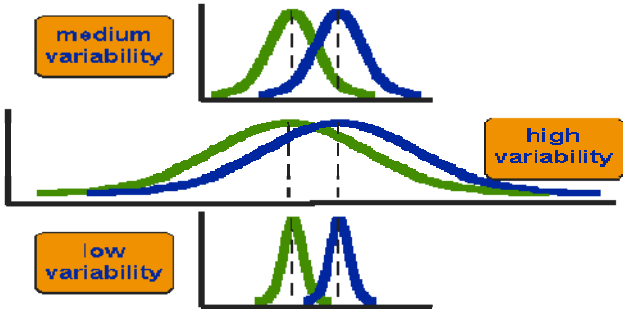
X-Squared Test

Chi-squared test is used to assess two types of comparison: tests of goodness of fit and tests of independence.

1. A test of **goodness of fit** establishes whether or not an observed frequency distribution differs from a theoretical distribution.
2. A **test of independence** assesses whether paired observations on two variables, expressed in a contingency table, are independent of each other.

T-test

The t-test assesses whether the means of two groups are *statistically* different from each other.



Economic & Financial Analysis

- Economic cost
- Cash flow analysis
  - Simple & compound interest
  - Uniform & gradient series payments
- Present/Future values
- IRR

Time Value of Money

- Common language terms and their symbols for time value of money problems are as follows:
  - P = present value or present worth
  - F = future value or future worth
  - A = annual amount or annuity
  - G = uniform gradient amount
  - n = number of compounding periods or asset life
  - I = interest rate
  - S = salvage value

Formulas for Economic Analysis

Formula Name	Operation	Symbol	Formula
Single-Payment Compound Amount	P to F	(F/P, I%, n)	$F=P\ (1+I)^n$
Present Worth	F to P	(P/F,I%, n)	$P=F(1+I)^{-n}$
Uniform Series Sinking Fund	F to A	(A/F,I%, n)	$A=F[I/((1+I)^n - 1)]$
Capital Recovery	P to A	(A/P,I%, n)	$A = P[(I(1 + I)^n))/(1 + I)^n - 1]$
Compound Amount	A to F	(F/A,I%, n)	$F = A[((1 + I)^n - 1)/ I]$
Equal Series Present Worth	A to P	(P/A,I%, n)	$P = A[((1 + I)^n - 1) / I(1 + I)^n]$
Arithmetic Uniform Gradient Present Worth	G to P	(P/G,I%, n)	$P = G[((1 + I)^n - In - 1)/ (I^2(1+I)^n]$

Capitalized Cost (CC)

- A bridge is built for $5,000,000 and will have maintenance costs of $100,000 per year.
- At 6 percent interest, what is the capitalized cost of perpetual service?

Capitalized Cost = $5,000,000 + ($100,000) / 0.06
= $5,000,000 + $1,666,667 = $6,666,667

Equivalent Uniform Annual Cost

- Unit A has an initial cost of $20,000 and $3,000 salvage value, a life of 10 years
- Unit B has an initial cost of $15,000 and $2,000 salvage value, a 5-year life.
- Cost of capital is 10 %.

Equivalent Uniform Annual Cost

EUAC Unit A:

$$EUAC_A = (\$20{,}000\text{-}\$3{,}000)(A/P,10\%,10) + \$3{,}000(0.10)$$
$$= (\$17{,}000)(0.1627) + \$300$$
$$= \$2765.90 + \$300 \qquad = \$3065.90$$

EUAC Unit B:

$$EUAC_B = (\$15{,}000\text{-}\$2{,}000)(A/P,10\%,5) + \$2{,}000(.10)$$
$$= (\$13{,}000)(0.2638) + \$200$$
$$= \$3429.40 + \$200 \qquad = \$3629.40$$

Rate of Return (ROR)

- Unit A and Unit B each with a 1-year life
- Cost of $20,000 for Unit A versus a $10,000 cost for Unit B
- Incremental benefit of $15,000 for Unit A as compared to Unit B.
- If the organization has a hurdle rate of 20 % for capital projects, which alternative is a better choice?

Rate of Return (ROR)

NPW of cost = NPW of benefit

$10{,}000 = 15{,}000(P/F,I,1)$

$I = 50\%$

NPV

If an investment may be given by the sequence of cash flows and i=10%;

Year	Cash flow	PV
0	(1,000,000)	(1,000,000)
1	300,000	272,727
2	500,000	413,223
3	500,000	375,657
Sum	300,000	61,607

NPV = 61,607

IRR

If an investment may be given by the sequence of cash flows

Year	Cash flow
0	-1000000
1	300000
2	500000
3	500000

then the IRR is given by

$$\text{NPV} = -1000000 + \frac{300000}{(1+r)^1} + \frac{500000}{(1+r)^2} + \frac{500000}{(1+r)^3} = 0.$$

In this case, the answer is 13.19% (in the calculation, that is, r = .1319).

Benefit / Cost Analysis

- The simple comparison between benefits and costs of a proposed action.
- Project A with the NPW of Benefits of $1,500,000 and NPW Of Costs of $1,200,000
- Project B with NPW Benefits of $2,000,000 and NPW Costs Of $1,700,000.

Benefit / Cost Analysis

- **Project A:**
  B / C = $1,500,000 / $1,200,000 = 1.25
- **Project B:**
  B / C = $2,000,000 / $1,700,000 = 1.17

Payback Period

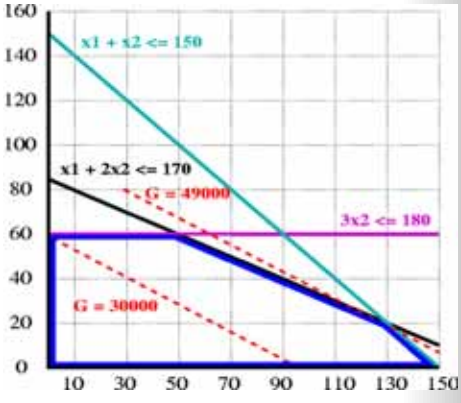
- Payback period is the period of time necessary for the benefits of the project to pay back the associated costs for the project.
- An investment of $4,000 with benefits of $800 per year would have a payback period of 5 years.

Optimization

- Model
- Linear programming
- Simulation
- Sensitivity analysis

Linear Programming

- **Linear programming** (**LP**, or **linear optimization**) is a mathematical method for determining a way to achieve the best outcome in a given mathematical model for some list of requirements represented as linear relationships.



LP - example

A calculator company produces a scientific calculator and a graphing calculator.

Long-term projections indicate an expected demand of at least 100 scientific and 80 graphing calculators each day.

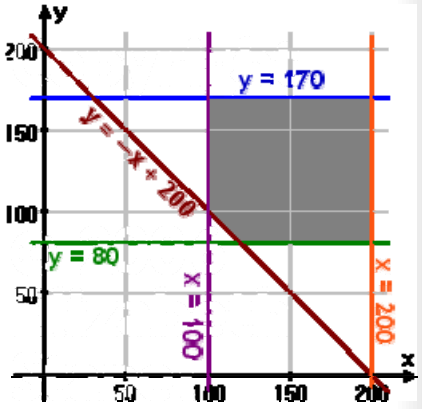
Because of limitations on production capacity, no more than 200 scientific and 170 graphing calculators can be made daily.

To satisfy a shipping contract, a total of at least 200 calculators must be shipped each day.

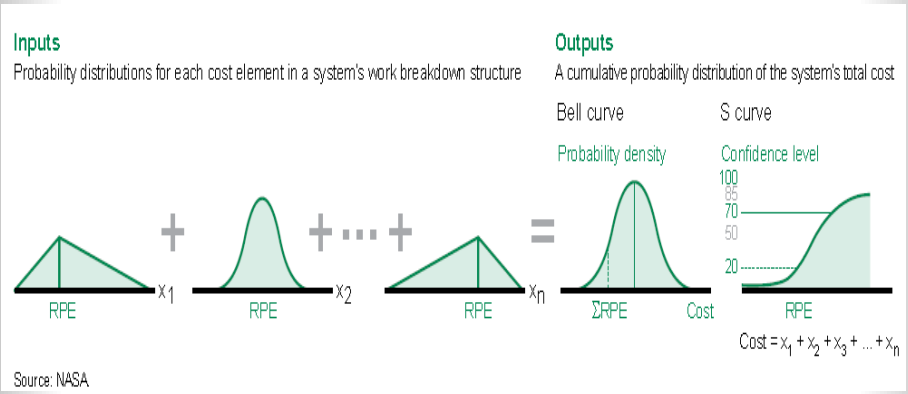
If each scientific calculator sold results in a $2 loss, but each graphing calculator produces a $5 profit, how many of each type should be made daily to maximize net profits?

LP - example

When testing the corner points at (100, 170), (200, 170), (200, 80), (120, 80), and (100, 100), it should result in the maximum value of R = 650 at (x, y) = (100, 170).



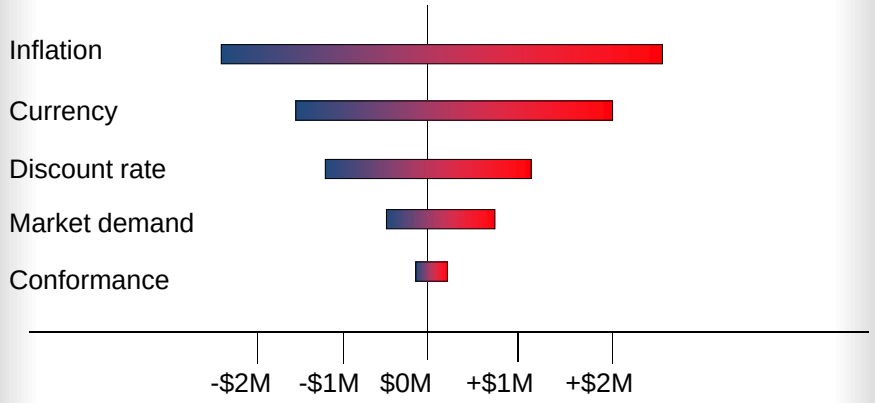
Simulation



Sensitivity Analysis

Base	1,000 units	$1 per unit	$1 per unit	Total $2,000
Sensitivity 1 Additional 200 units	1,200 units +20%	$1 per unit labor	$1 per unit material	Total $2,400 +20%
Sensitivity 2 Labor at $1.50	1,000 units	$1.50 per unit labor +50%	$1 per unit material	Total $2,500 +25%

Sensitivity Analysis



Physical Measurements

- Highway regulations in a certain jurisdiction state that a truck with two axles may have a maximum weight of 16,000 pounds on the front axle and 20,000 pounds on the rear axle.
- Convert these weights to their equivalents in kilograms, rounded to the nearest ten kilograms.

Physical Measurements

$$16{,}000lb = 16{,}000lb \times \left(\frac{453.6g}{1lb}\right) \times \left(\frac{1kg}{1{,}000g}\right) = 7{,}257.5kg = 7{,}260kg$$

$$20{,}000lb = 20{,}000lb \times \left(\frac{453.6g}{1lb}\right) \times \left(\frac{1kg}{1{,}000g}\right) = 9{,}071.9kg = 9{,}070kg$$

Sample Question #1

Production rates for placing concrete in wall forms are recorded on several projects and shown in the following table:

Project	Crew hours / cubic yard
1	0.375
2	0.680
3	0.420
4	0.481
5	0.555
6	0.621
7	0.587

Sample Question #1

Calculate the average production rate experienced on these projects.

A. 0.531 crew hours / cubic yard
B. 0.620 crew hours / cubic yard
C. 0.533 crew hours / cubic yard
D. 0.465 crew hours / cubic yard

Sample Question #2

If the total yards placed per project are as shown in the following table, calculate the weighted average production rate experienced on these projects.

Project	Cubic yards placed
1	1,200
2	426
3	391
4	288
5	61
6	55
7	126

Sample Question #2

A. 636.8 crew hours / cubic yard

B. 0.531 crew hours / cubic yard

C. 0.465 crew hours / cubic yard

D. 0.0015 crew hours / cubic yard

Enabling Knowledge

1. **Enterprise in society**
2. **People & organizations in enterprise**
3. **Information management**
4. **Quality management**
5. **Value management**
6. **Environment, health, safety**

Enterprise in Society

- Societal values
- Decision policy
- Ethics
- AACEI Canons of Ethics

Societal values

Societal values are the assumptions, beliefs or principles that guide people's decision-making and actions in society.

- **Freedom**
- **Democracy**
- **Equality**
- **Diversity**
- **Wellbeing**
- **Responsibility**
- **Respect**

Decision Policy

- Definitive position of an organization on how investment or project decisions will be made.
- Establishes the basis for decision models.
- Provides a basis for consistent and appropriate decision making and defines authority and accountability within the organization.

Ethics

AACEI Canon of Ethics:

- Relations With the Public
- Relations With Employers and Clients
- Relations With Other Professionals
- Standards of Professional Performance

People & Organizations in Enterprises

- **Leadership**
  - Leadership role
  - Motivation
  - Performance / productivity
- **Organizational structure**
  - Organizational design
  - Basic structures
  - Teams
  - Typical organizations

Leadership

- It is about positively influencing people's behavior toward self control and enhanced individual and group performance.
- To obtain commitment from people around objectives, a leader must first understand those enterprise objectives, develop a personal vision of their purpose, and communicate the vision and get other stakeholders to see that they have a shared purpose.

Motivation

- Intrinsic motivation rise from within people, such as a personal desire to learn or to help others.
- Extrinsic sources originate from outside the person, such as rewards or improved working conditions.

McGregor Theory

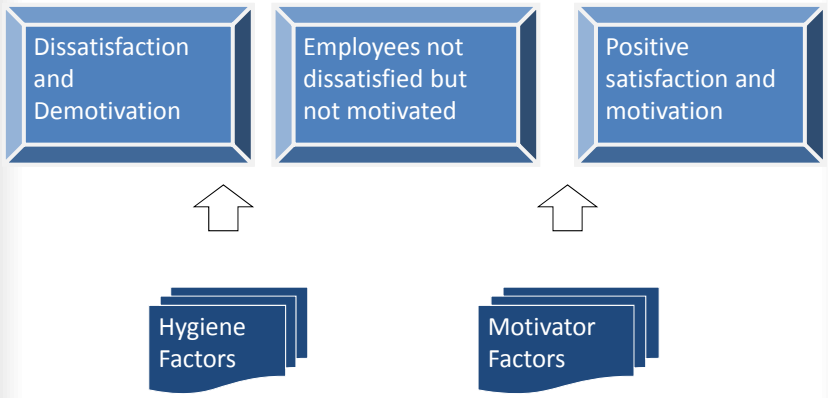
X-Theory

- Dislike work
- Need control and force to work
- Like t o be directed
- Lack ambition

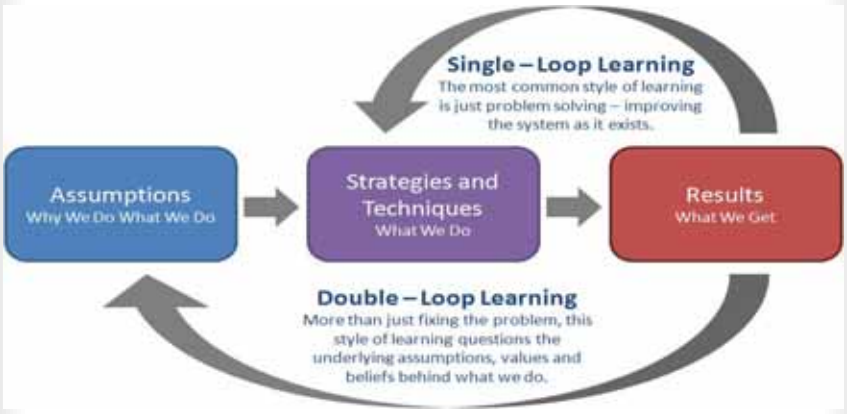
Y-Theory

- Like to work
- Can be self-disciplined for objectives they are committed to
- Accept responsibility

Hygiene (Herzberg) Theory



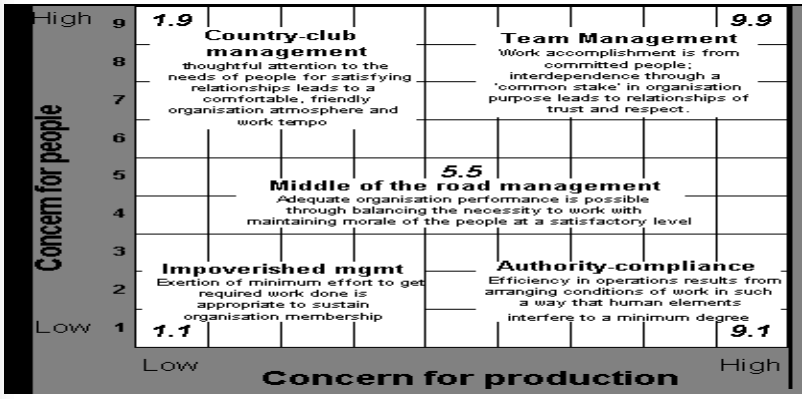
Argyris - Effect



Likert – Four Model

- Exploitative authoritative
- Benevolent authoritative
- Consultative System
- Participative System

Mouton Grid

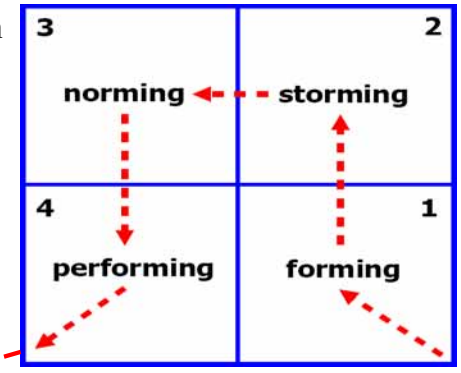


Maslow's Hierarchy of Needs

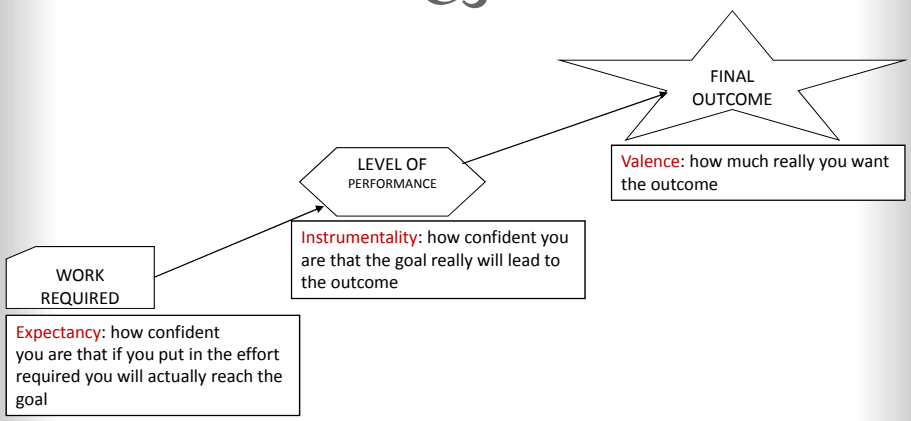
Team Development Model

Dr. Bruce Tuckman

1. Forming
2. Storming
3. Norming
4. Performing
5. Adjourning



Expectancy Theory



Performance Management

- Waste
- Inefficiency
- Improvement cost
- Individual skills
- Crew skills
- Supervision competencies
- Worker attitude
- Sociological, cultural, demographic characteristics

Performance Management

- Absenteeism & turnover
- Overtime
- Level of technology
- Learning curve
- Work area environment
- Weather
- Geographic location

Performance Management

- Proximity to other work
- Job layout
- Work rules
- Safety practices
- Quality control practices
- Materials & tools
- Wages, salaries, benefits

Organization Structure

- Organizational design
- Basic structures
- Teams
- Typical organizations in TCM

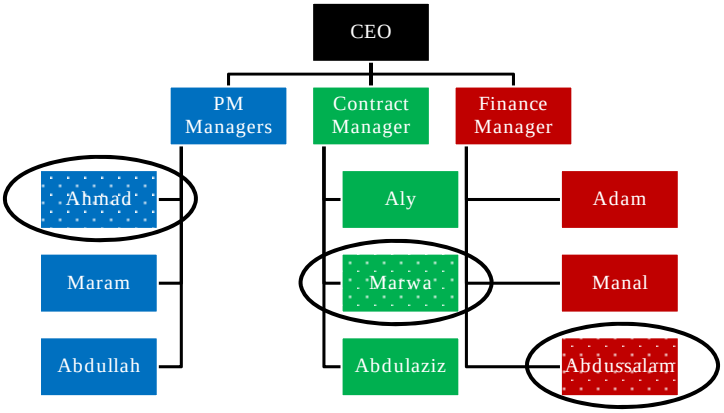
Organization Design

- *Division of labor*. Consider departmentalization or specialization.
- *Unity of command*. Consider lines or chains of command.
- *Unity of directions*. Consider authority and responsibility.
- *Span of control*. Consider levels of control and degree of centralization.

Organization Design Framework

- *Functional: Focused on division of labor or specialization.*
- *Divisional: Focused on unity of command and direction concerning product lines and/or regions.*
- *Matrix: Focused on tasks. Typically, task managers draw resources from functional and divisional organizations as needed.*

Matrix Organization



Typical Organizations in TCM

- Matrix type is commonly used in TCM, particularly for *project management*.
- Asset and project management are task and product-focused efforts using teams with resource needs that vary over the life cycle of the effort.
- A matrix is a flexible and efficient design for drawing resources from functional and divisional organizations as needed.

Information Management

- **Data**
- **Database management**
  - History
  - Reference data
  - Lessons learned
  - Metrics
  - Validation
  - Basis
  - Normalization
- **Information technology**
  - Enterprise Resource Management (ERM)

Data

- Data are the raw material of information management.
- Data include text, numbers, images, and so on that are generally not organized in a way to make them useful.

Database Management

Knowledge Management:

1. **Data management** is concerned with the safe and effective storage of the enterprise's information assets, including raw data, processed information, and knowledge
2. **Information control or database management** is concerned with the way data are formed into information and made available to the enterprise.

Information Technology

- Information systems (Technology) are the mechanisms or tools by which knowledge is delivered to the enterprise and those it interacts with.
- They include hardware and software information technology (IT), which may include not only computers, but also telecommunication hardware, the Internet, or even a cork bulletin board.

Quality Management

- Quality
- Requirements
- Quality planning
- Quality management
- Quality assurance
- Quality control
- Continuous improvement
- PDCA
- Quality measurement
- Quality policy
- Quality standards
  - ISO 9000
  - ISO 10006
- Quality focused practices
  - Benchmarking
  - Cost of quality
  - Value analysis
  - Change management

Quality Management

1. *Customer focus. The entry process to TCM is requirements elicitation and analysis .*
2. *Leadership. TCM establishes a unity of purpose and direction for cost management throughout the asset and project life cycles in alignment with the enterprise's strategies.*
3. *Involvement of people. TCM recognizes the roles and responsibilities of everyone involved in asset and project management.*
4. *Process approach. TCM is by definition a process for applying the skills and knowledge of cost engineering.*

Quality Management

5. *System approach to management*. TCM is focused on identifying, understanding, and managing its component processes as a system in alignment with the enterprise's strategies.
6. *Continuous improvement*. TCM is about improving on it by performance-focused planning.
7. *Factual approach to decision making*. The TCM investment decision making process focuses on objective, economic analysis as the basis for decision making.
8. *Mutually beneficial supplier relationships*. TCM focuses on proactive team approaches, including the involvement of suppliers, contractors, and stakeholders other than owner.

Project Quality Management

Quality is

"the degree to which a set of inherent characteristics fulfill requirements"

Grade is

"a category assigned to products or services having the same functional use but different technical characteristics"

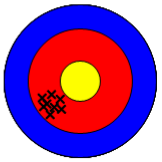
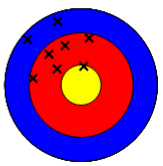
Project Quality Management

Precision is

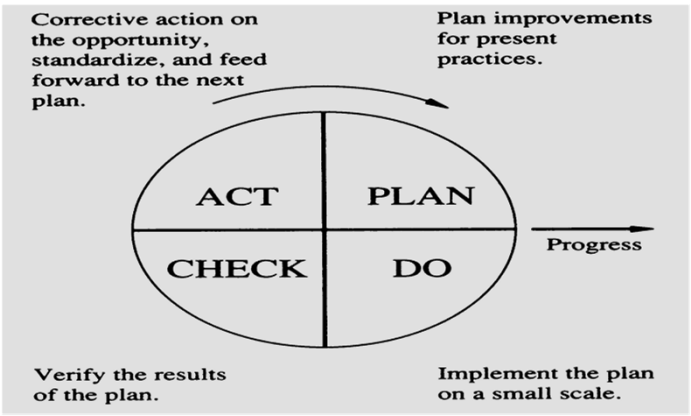
consistency that the value of repeated measurements are clustered and have little scatter

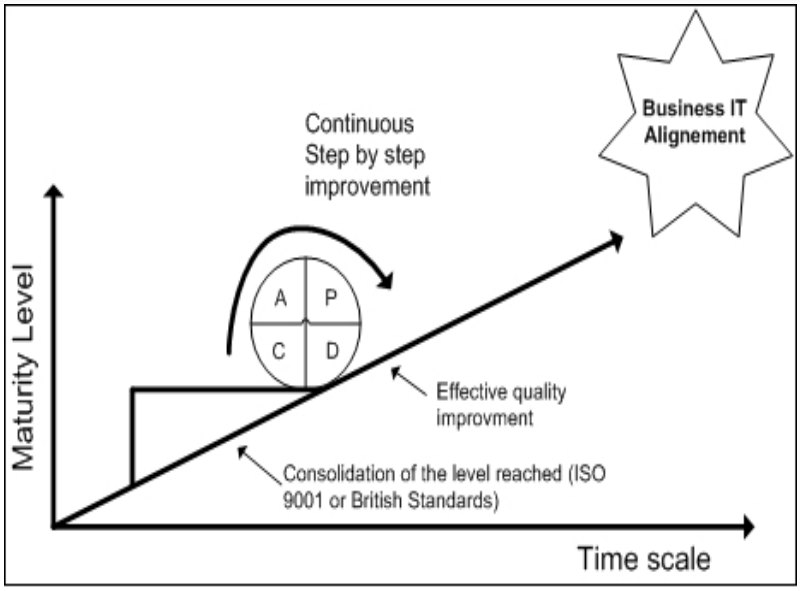
Accuracy is

correctness that the measured value is very close to the true value

	Accurate	Inaccurate (systematic error)
Precise		
Imprecise (reproducibility error)		

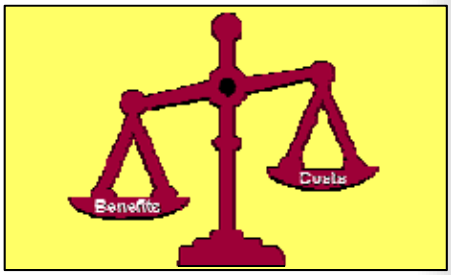
PDCA Cycle


Corrective action on the opportunity, standardize, and feed forward to the next plan.
Plan improvements for present practices.
ACT
PLAN
CHECK
DO
Progress
Verify the results of the plan.
Implement the plan on a small scale.


Continuous
Step by step
improvement
Business IT
Alignement
A
P
C
D
Maturity Level
Effective quality
improvment
Consolidation of the level reached (ISO 9001 or British Standards)
Time scale

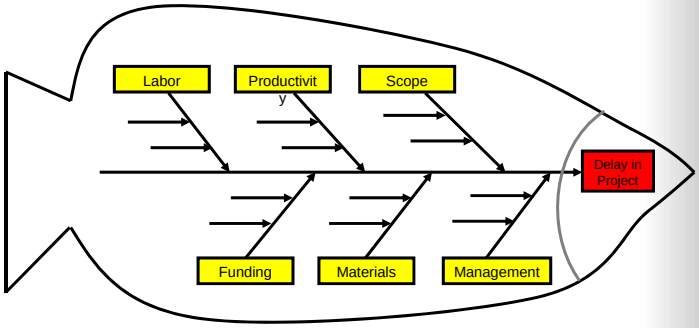
Cost-Benefit Analysis

- Less rework
- Higher productivity
- Lower costs
- Increased satisfaction



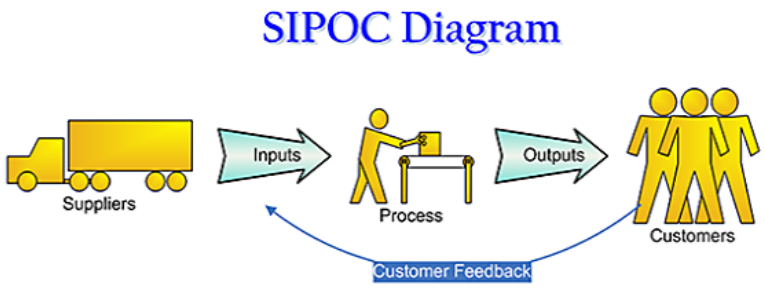
Seven Basic Quality Tools

1- Cause-and-effect diagram / Fishbone / Ishikawa



Seven Basic Quality Tools

2- Flowcharts



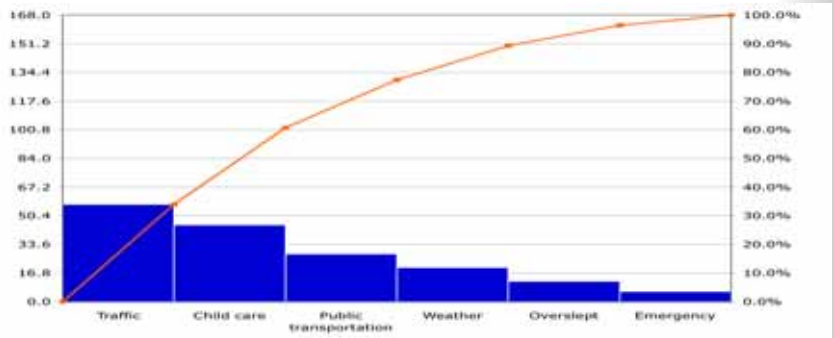
Seven Basic Quality Tools

3- Checksheets

	Site Meeting	
	Project background review	
	Design details – & unusual requirements	
	Schedule	
	Budget	
	Conflicts with University operations	
	Building inspection requirements	
	Site	
	Site office requirements	
	Storage areas	
	Access routes	
	Parking – workers	
	Parking – deliveries & service vehicles	
	Sanitary facilities	
	Eating areas	
	Site Security	
	Construction signs	
	University contacts	
	Emergency number	
	Paperwork	
	Forms and reporting requirements	
	Site meetings	
	Minutes of meetings	
	Daily Log	
	Shop Drawings	
	As-built drawings	
	Inspections	
	Progress billings – Stat. Dec., WCB clearances	

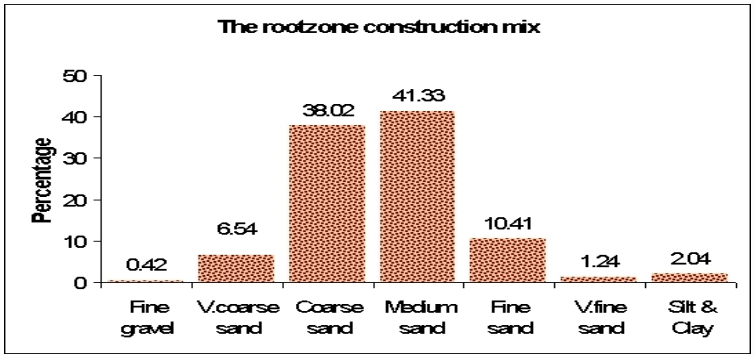
Seven Basic Quality Tools

4- Pareto diagram



Seven Basic Quality Tools

5- Histograms

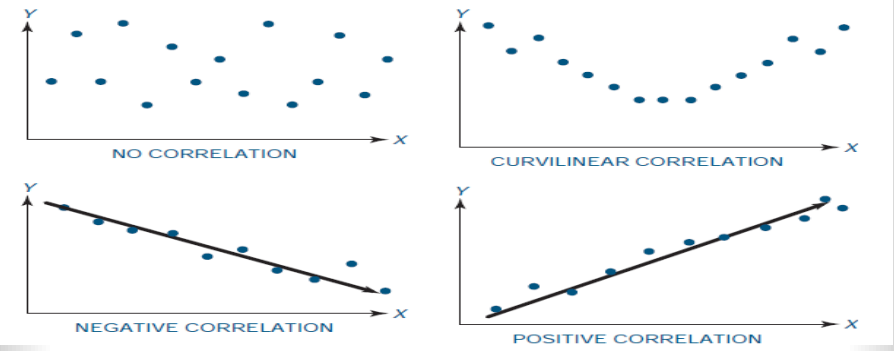


Seven Basic Quality Tools

6- Control charts

Seven Basic Quality Tools

7- Scatter diagram

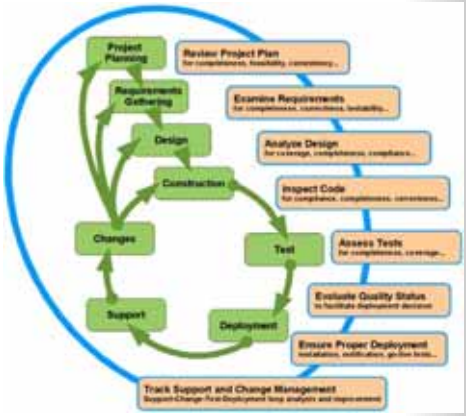


Quality Planning

- Quality Management Plan
- Quality Metrics
- Quality Checklists
- **Process Improvement Plan**
  - Process boundaries
  - Process configurations
  - Process metrics
  - Targets for improved performance
- Project document updates

Quality Assurance

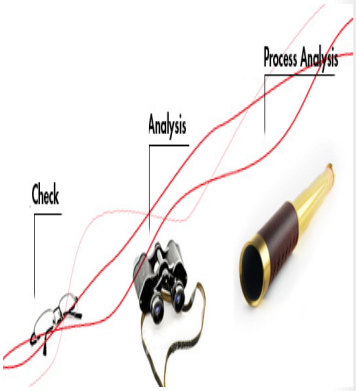
Is the process of auditing the quality requirements and the results from quality control measurements to ensure appropriate quality standards and operational definitions are used



Quality Assurance

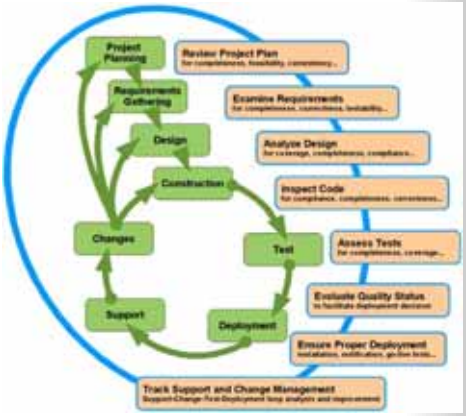
Quality audit

Is a structured, independent review to determine if project activities comply with organizational and project policies, processes, and procedures



Quality Control

The process of monitoring and recording results of executing the quality activities to assess performance and recommend necessary changes.



Quality Policy

- In TCM, quality policy is an imposed requirement, meaning the enterprise's quality management strategy and approach is already established; TCM is a process to deploy that policy.
- Another type of imposed requirement is accepted and agreed upon standards such as ISO 9000 & ISO 10006.

ISO 9000

- ISO 9000 (and its "family" of related standards) is focused on an enterprise having, maintaining, and following a documented quality process and procedures.
- Enterprises apply and seek certification in the standard to assure their customers that they have a quality management system in place.

ISO 10006

- ISO 10006 is similar to ISO 9000 but is focused specifically on project management.
- TCM can be the basis for creating a cost management process in an enterprise's quality management system in accordance with these standards.

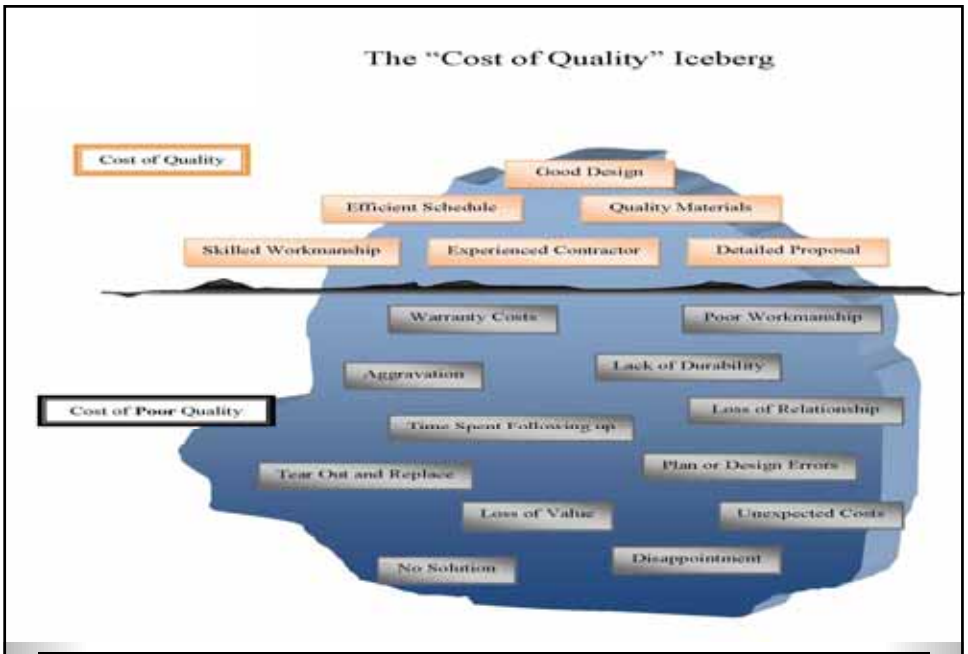
Benchmarking

- Identify best practice
- generate ideas for improvement
- provide a basis to measure performance

Cost of Quality (COQ)

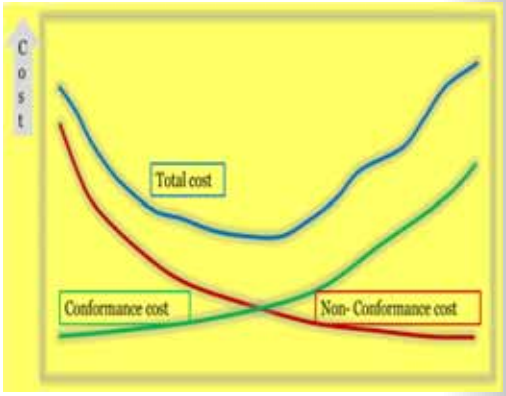
Quality costs are:

- Investment in preventing **nonconformance** to requirements
- **Appraising** the product or service for conformance to requirements
- **Failing** to meet requirements (rework)



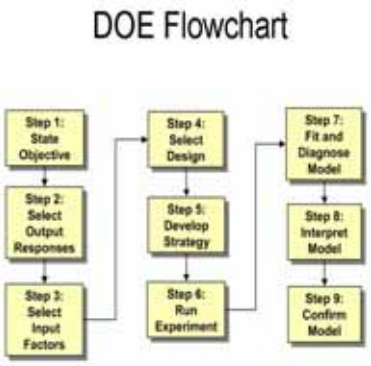
Cost of Quality (COQ)

- **Conformance** = prevention + appraisal
- **Non-conformance** = internal + external



Design of Experiments

DOE is a statistical method for identifying which factors may influence specific variables of a product or process under development

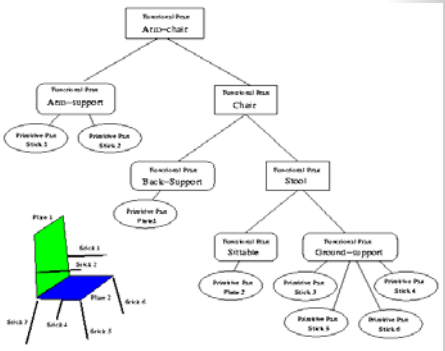


Value Management

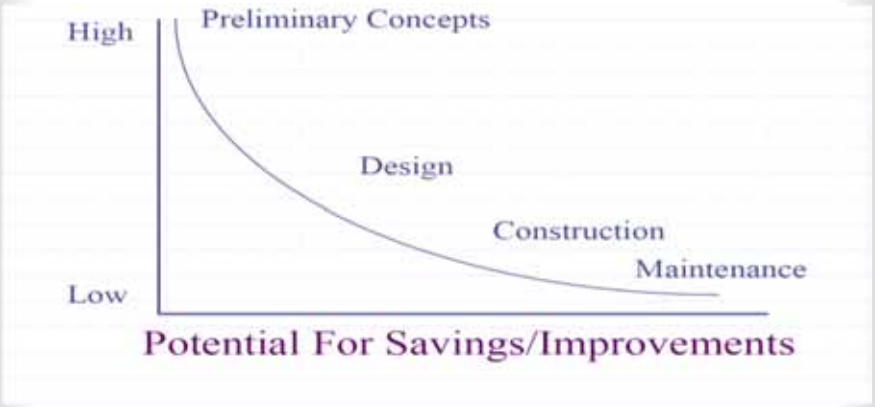
- Value
- Value management
- Value improving
- Manufacturability
- Constructability
- Reliability, Availability, Maintainability (RAM)

Value Engineering

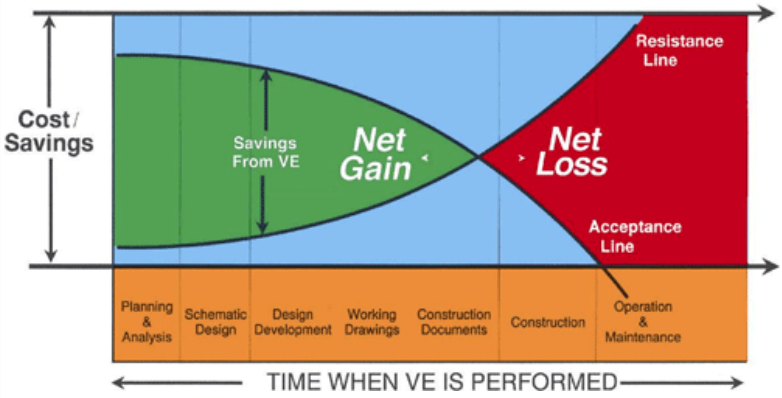
- Depends on breaking down the project into functions
- Experts define problems and propose alternatives
- 20% of the items cost 80% of the budget



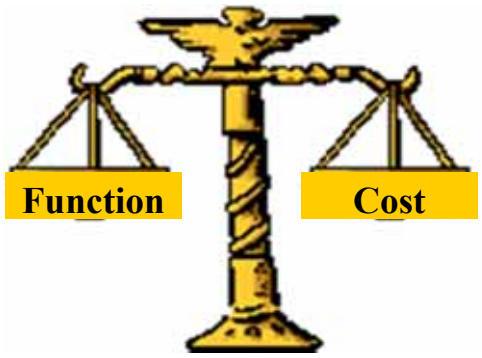
When …. ?



Potential Saving from VE



Value



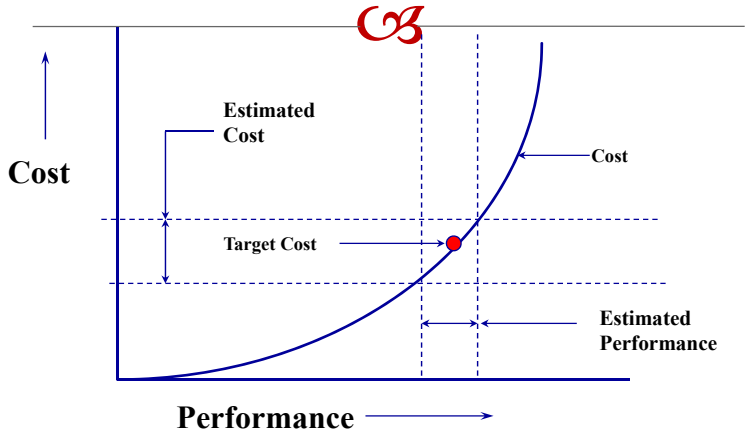
Value

$$Value = \frac{Function}{Cost}$$

Value

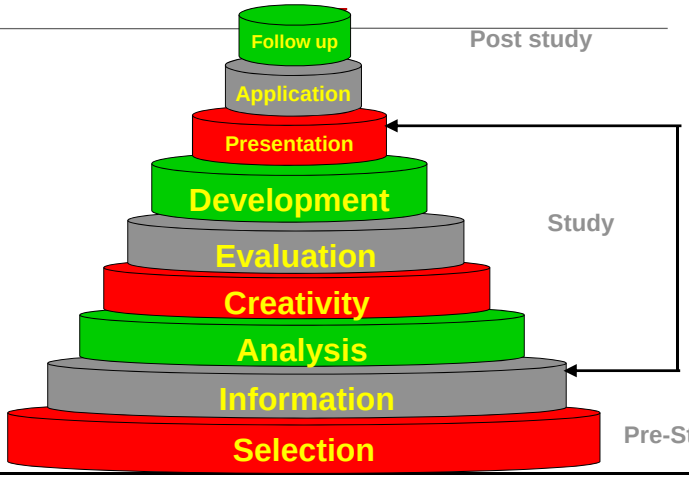
$$Value = \frac{Exchange + Use + Aesthetic}{Cost}$$

Performance - Cost

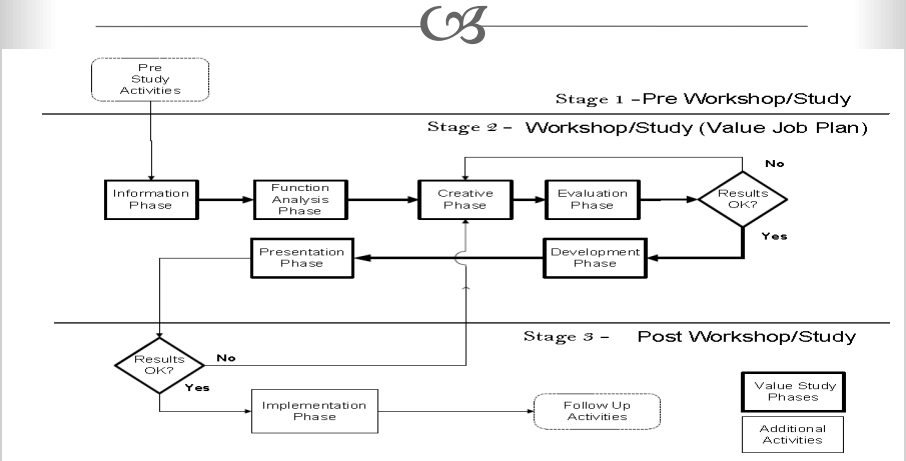


Performance = Requirements = Expectations

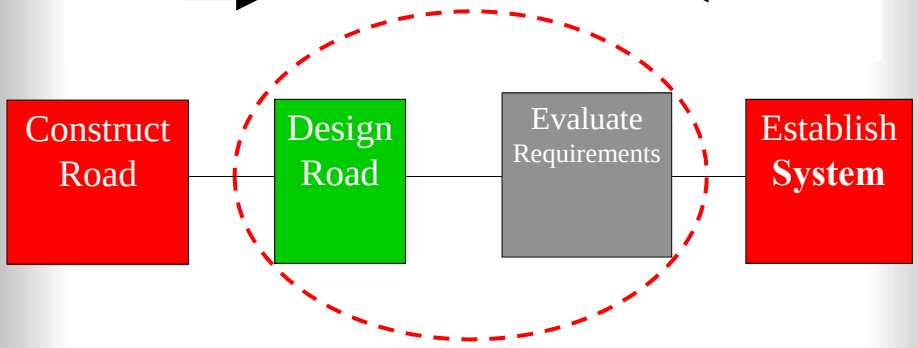
Value Study Phases



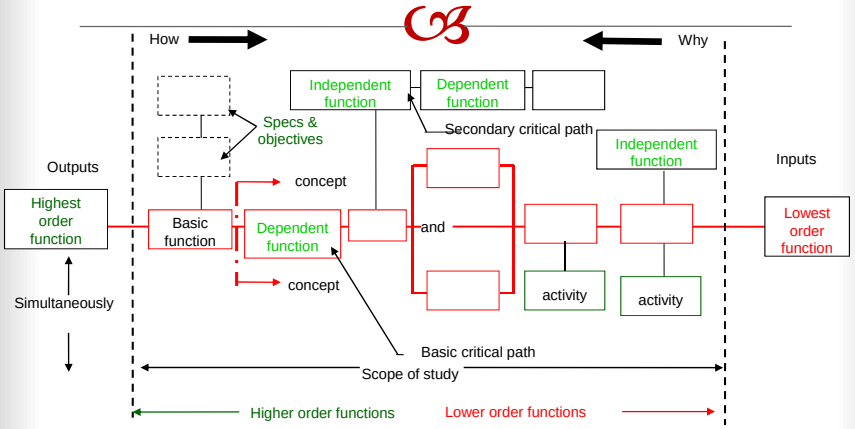
Value Study Flow Diagram



Function Analysis System Technique (FAST)



F.A.S.T.



Environment, Health, Safety

- Quality management
- Non-conformance
- EHS standards
- Sustainability development

Standards

- ISO 14000 series of standards pertain to the management systems that an organization employs to manage environmental matters, not to the environmental performance of the organization.
- Occupational Health and Safety Assessment Series (OHSAS) 18000 standards.
- OHSAS 18000 series is compatible with ISO 14000 series.

Sustainable Development

As a matter of strategy for an enterprise, planning must not only consider the life cycle of the asset, but the life cycle of the environment and its asset value as *natural capital*.

Sample Question #1

1. The primary benefit of having accurate historical data for estimating purposes is: _____.

A. Actual costs can be tracked accurately.

B. The estimate can be based on a work breakdown structure instead of the chart of accounts.

C. Estimates can be based on costs actually experienced in the past on similar projects.

D. The estimate can be tied to current labor rates.

Sample Question #2

2. A chart of accounts and a work breakdown structure are examples of _____.

A. Historical cost databases.
B. Cost element structures used in organizing data.
C. Historical cost data.
D. Cost trending tools.

Process and Functional Skills and Knowledge

2.0 -Cost Estimating Skills and Knowledge

- **2.1 General Estimating Concepts**
  - 2.1.1 Cost Estimating Terminology
  - 2.1.2 Cost Estimate Classifications
  - 2.1.3 Estimate Variability
  - 2.1.4 Estimating Algorithms
  - 2.1.5 Codes of Accounts
  - 2.1.6 Historical Cost Data
  - 2.1.7 Internationalization

COST ESTIMATING TERMINOLOGY

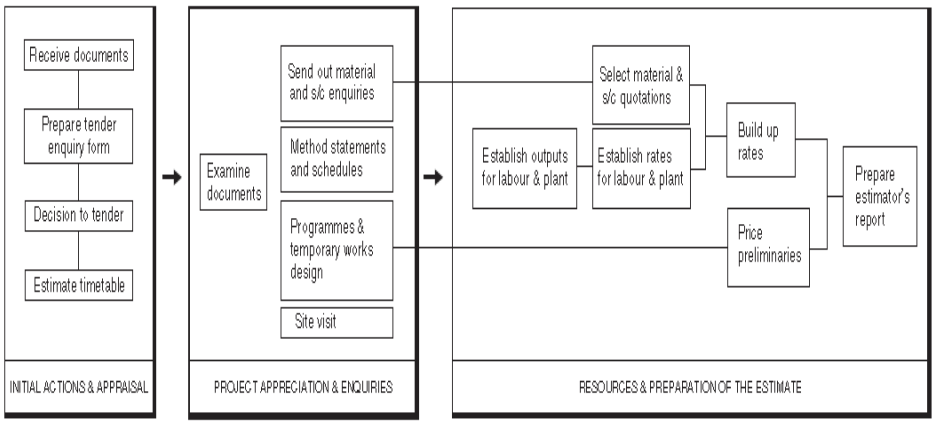
- AACE International, Inc. (AACE)
- AEC (Architecture, Engineering, Construction)
- American Society of Professional Estimators (ASPE)
- Codes of Accounts (COAs)
- Construction Specifications Institute (CSI)
- Cost Estimate Classification
- Design Build Institute of America (DBIA)
- Direct Cost
- Escalation
- Estimating
- Fees
- Glossary
- Indirect Cost
- Organization Breakdown Structure (OBS)
- Risk
- Specifications
- Standard
- Work Breakdown Structure (WBS)

Cost Estimate

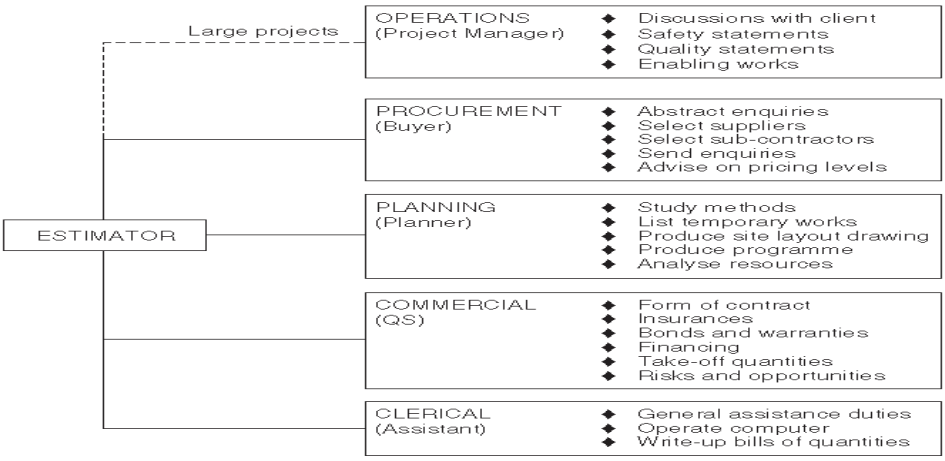
Cost estimate may be used for:

- determining the economic feasibility of a project,
- evaluating between project alternatives,
- establishing the project budget
- providing a basis for project cost and schedule control

Estimating Flowchart



Coordination of Estimating Team



Examinee Format of Definitions

AACE International
Examinee Format of Definitions
Certified Estimating Professional (CEP)

The basis behind the selection of terms and definitions is as follows:

Estimating Exam Scope

The exam will include the following estimating functions:

a. Scoping
b. Quantification
c. Costing
d. Pricing
e. Change Order Estimates
f. Estimating Database Development

Cost Estimating Terminology Sample Question

What are the challenges with terminology of emerging processes such as Building Information Modeling (BIM)?

A. Translating the new terminology into other languages.
B. Consistent and accurate communication as the standard vocabulary associated with the process evolves.
C. Gaining acceptance of the new terms.
D. Incorporation of the new terminology into glossaries and other sources.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical +/- range relative to index of 1 (i.e. Class 1 estimate) [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Screening or feasibility	Stochastic (factors and/or models) or judgment	4 to 20	1
Class 4	1% to 15%	Concept study or feasibility	Primarily stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget authorization or control	Mixed but primarily stochastic	2 to 6	3 to 10
Class 2	30% to 75%	Control or bid/tender	Primarily deterministic	1 to 3	5 to 20
Class 1	65% to 100%	Check estimate or bid/tender	Deterministic	1	10 to 100

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Functional area, or concept screening	SF or m^2 factoring, parametric models, judgment, or analogy	L: -20% to -30% H: +30% to +50%
Class 4	1% to 15%	or Schematic design or concept study	Parametric models, assembly driven models	L: -10% to -20% H: +20% to +30%
Class 3	10% to 40%	Design development, budget authorization, feasibility	Semi-detailed unit costs with assembly level line items	L: -5% to -15% H: +10% to +20%
Class 2	30% to 75%	Control or bid/tender, semi-detailed	Detailed unit cost with forced detailed take-off	L: -5% to -10% H: +5% to +15%
Class 1	65% to 100%	Check estimate or pre bid/tender, change order	Detailed unit cost with detailed take-off	L: -3% to -5% H: +3% to +10%

Note: [a] The state of construction complexity and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual cost from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Cost Estimate Classification Matrix for Building and General Construction Industries

Cost Estimate Classification Sample Question

A good Class 4 estimate can be prepared with the information available at the completion of Phase I design. An example of information at the end of preliminary design is:

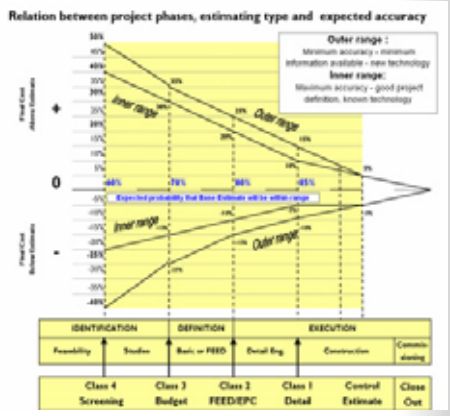
A. Equipment list and specifications.
B. Piping spool drawings.
C. Drawings released for construction.
D. Material invoiced costs.

Estimate Variability

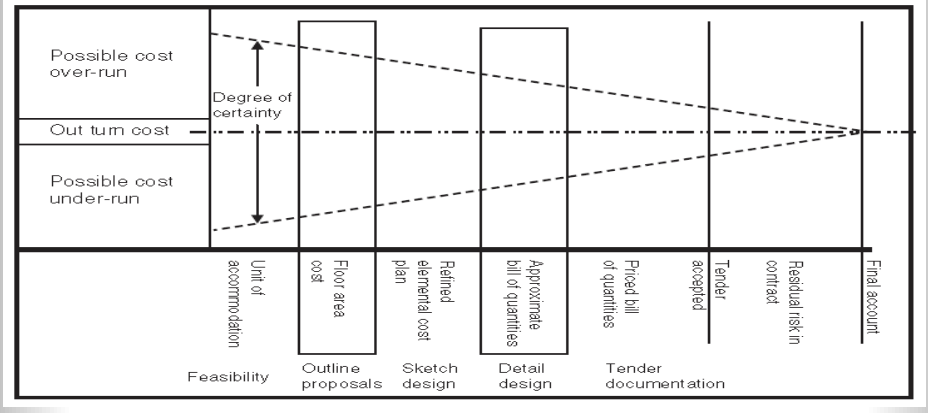
- Level of definition
- Experience
- Available data
- Location
- Time
- Size
- Implementation
- Management

Estimate Cost

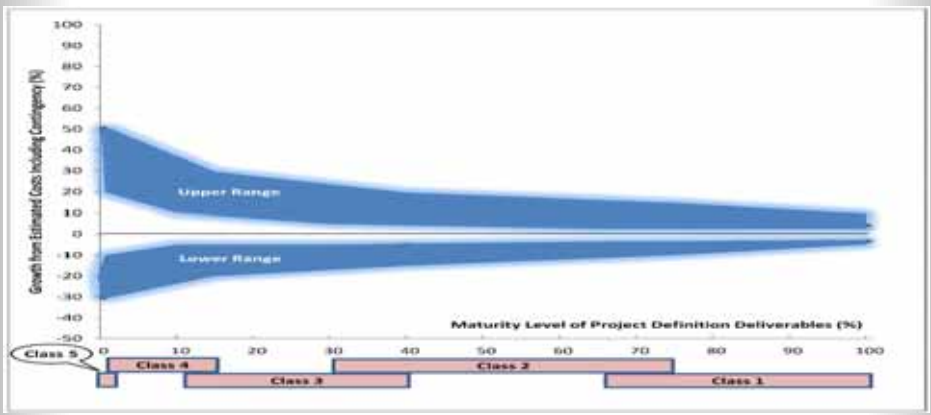
- Activity Cost Estimates
- **Bases of estimates**
  - how it was developed
  - assumptions
  - constraints
  - range of possible estimates (±15%, 8-10)
  - Confidence level
- Project document updates



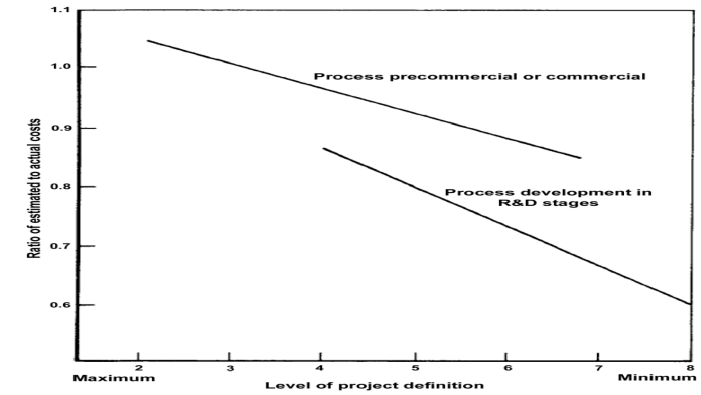
Estimate Degree of Certainty



Variability in Accuracy Range



Accuracy vs. Definition

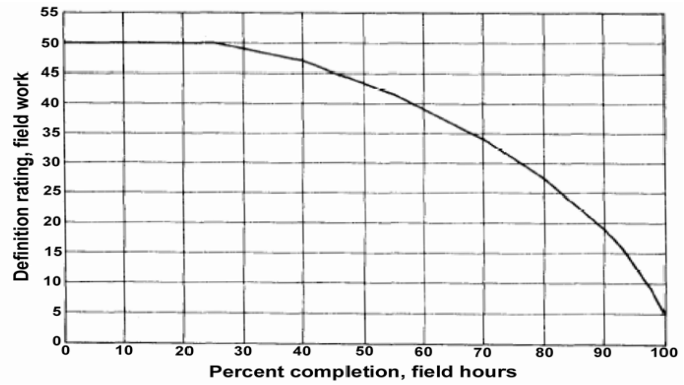


RAND Model of Cost Growth vs. Project Definition

Estimate Maturity Matrix

	ESTIMATE CLASSIFICATION				
	Class 5	Class 4	Class 3	Class 2	Class 1
MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	0% to 2%	1% to 15%	10% to 40%	30% to 75%	65% to 100%
Existing Site Plan	P	P	C	C	C
Demolition Plan and/or Drawings	S	P	P	C	C
Utility Plan and/or Drawings	S	P	P	C	C
Site Electrical Plan and/or Drawings	S	P	P	C	C
Site Lighting Plan and/or Drawings	S	S/P	P	C	C
Site Communications Plan and/or Drawings	S	S/P	P	C	C
Erosion Control Plan and/or Drawings	S	S/P	P	C	C
Stormwater Plan and/or Drawings	S	S/P	P	C	C

Field Performance



Drawdown of the Field Performance Rating (Hackney)

Estimate Variability Sample Question

As an estimator responsible for the quantity takeoff for sitework clearing and grubbing, you figure the quantity as 17,500 square yards at a scale of 1" = 100'. You then discover that the scale of the drawing has been erroneously noted by the designer and is actually 1" = 200'.

What is the correct quantity for sitework clearing and grubbing?

A. 70,000 square yards
B. 4,375 square yards
C. 8,750 square yards
D. 35,000 square yards

Estimating Algorithms

- Order of Magnitude
- Parametric
- Factor
- Capacity

Estimating Algorithms Sample Question

Given the following information on actual solid process plant costs, what would the Lang factor be?

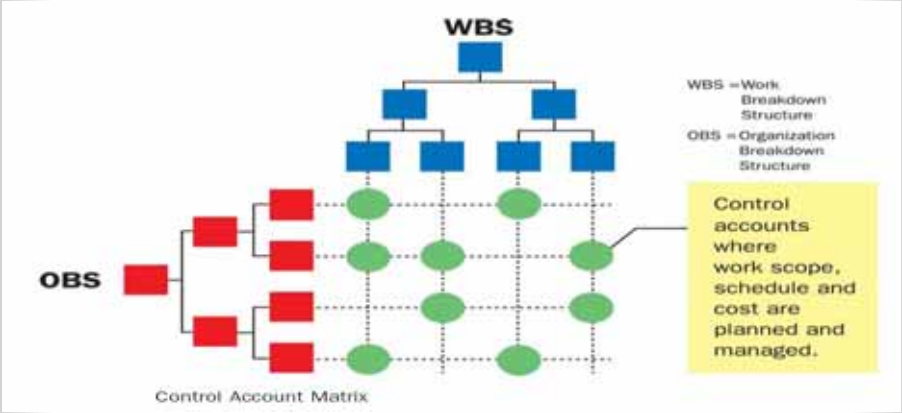
Total Installed Cost	$2,000,000
Direct Cost	$1,300,000
Equipment Cost	$560,000

A. 3.57
B. 2.32
C. 0.28
D. 1.54

Code of Accounts

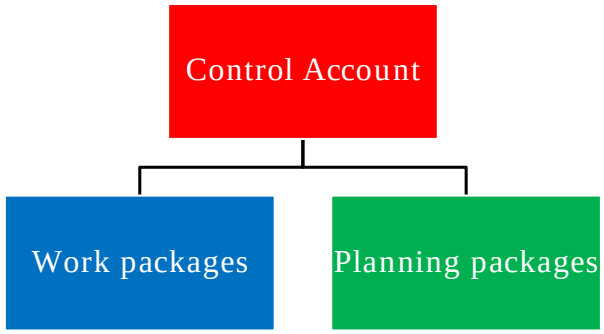
- A systematic coding structure for organizing and managing scope, asset, cost, resource, work, and schedule activity information.
- A COA is essentially an index to facilitate finding, sorting, compiling, summarizing, or otherwise managing information that the code is tied to.
- A complete code of accounts includes definitions of the content of each account.

Code of Accounts



Planning Package

Planning package is a WBS component with known work content but without detailed schedule activities



Code of Accounts Sample Question

A project code of accounts is _____.

A. A means of organizing project costs, resources, and activity categories.

B. A substitute for a work breakdown structure (WBS).

C. For use in lieu of a work breakdown structure (WBS).

D. The same as a work breakdown structure (WBS).

Historical Cost Data

- Identify potential sources
- Accurate historical cost data
- Historical cost data, how to be used and filtered.
- City Cost Index (CCI)
- Time index
- Location index
- Size index

Historical Cost Data Sample Question

A common method of preparing a preliminary estimate for a building is to apply a historical unit cost to the gross area of the building. A potentially more accurate estimate can be derived by _____.

A. Using the Chilton factor method.
B. Preparing a definitive estimate.
C. Applying historical unit costs to the various building subsystems.
D. Using the Lang factor method.

Internationalization

- Internationalization is about being able to translate quantities and / or costs for any location in the world.
- It is the need and corresponding ability for a project to be administered and communicated in any location in the world.

Internationalization

Length Conversion

Imperial/USA unit	Metric (SI) unit	Metric (SI) unit	Imperial/USA unit
Inch	2.54 centimeters	Centimeter	0.39 inches
Foot	30.48 centimeters	Meter	3.28 feet
Yard	0.91 meters	Meter	1.09 yards
Mile	1.61 kilometers	Kilometer	0.62 miles

Weight (or mass) conversion

Imperial/USA unit	Metric (SI) unit	Metric (SI) unit	Imperial/USA unit
Ounce (weight)	28.35 grams	Gram	0.035 ounces
Pound	0.45 kilograms	Kilogram	2.21 pounds
UK ton (2240 pounds)	1.02 metric tons	Metric ton (1000 kg.)	0.98 UK tons
US ton (2000 pounds)	0.91 metric tons	Metric ton (1000 kg.)	1.10 US tons

Internationalization Sample Question

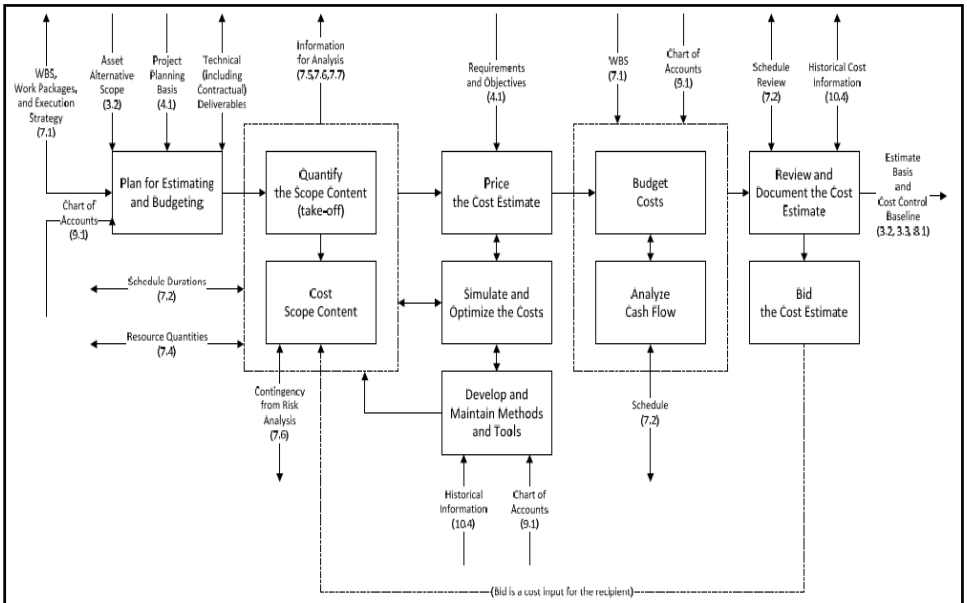
If a pump will pump 12 gallons/minute (gpm), what volume in metric units will it pump in the same amount of time?

A. 45.4 liters / minute
B. 45.4 cubic centimeters / minute
C. 454 cubic centimeters / minute
D. 4,542 cubic centimeters / minute

Process and Functional Skills and Knowledge

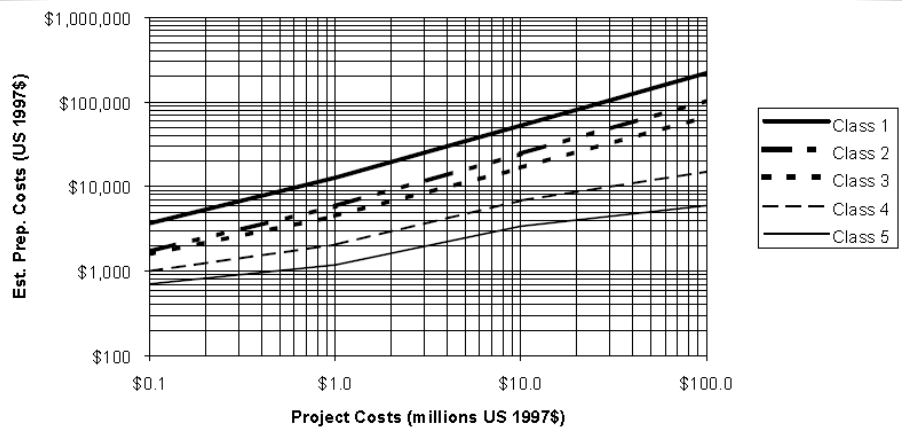
2.2 Estimating Processes and Practices

- 2.2.1 Planning the Estimate
- 2.2.2 Estimating Methodologies
- 2.2.3 Quantification
- 2.2.4 Costing
- 2.2.5 Pricing
- 2.2.6 Conditioning
- 2.2.7 Risk Evaluation and Contingency Determination
- 2.2.8 Estimate Documentation
- 2.2.9 Estimate Reconciliation
- 2.2.10 Estimate Review and Validation
- 2.2.11 Estimate Reporting
- 2.2.12 Estimate Closeout
- 2.2.13 Building Information Modeling (BIM)



Process Map for Cost Estimating and Budgeting

Estimate Cost



Estimate Responsibility Matrix

Document	Rev.	Level of Completion	Estimating Responsibility	Source Information	Date
Project Scope Description		Defined	PM	Owner PM	
Production Capacity		Defined	Process	Process Engineer	
Plant Location		Specific	PM	Owner PM	
Soils & Hydrology		Defined	Civil Engineer	Owner Civil Engineer	
Project Execution Plan		Defined			
Project Master Schedule		Defined			
Start-Up Sequence		Preliminary			
Escalation Strategy		Defined			
Work Breakdown Structure		Defined			
Project Code of Accounts		Defined			
Contracting Strategy		Defined			
Subcontracting Plan		Defined			
Constr. Work Packages		Complete or Near			
Constr. Mgmt Manpower		Defined			
Construction Indirects		Defined			
Scaffolding		Factored			
Construction Productivity (expand by commodity if applicable)		Defined			

Estimate Resources

- Conceptual estimating factors
- Material cost and pricing information
- Labor work-hour charts and information
- Labor productivity information
- Labor wage rates, composite crew mixes
- Others

Planning the Estimate Sample Question

What is the first process in estimate preparation?

A. Pricing.
B. Scoping.
C. Quantification.
D. Costing.

Conceptual Estimating

1. Order of Magnitude (OOM)
   - Class 5 & Class 4 (Class 3)
   - Screening
   - Feasibility
   - Alternatives
   - Preliminary Budget

Conceptual Estimating

2. End-Product Units Method
   - Electrical plant capacity in kilowatts
   - Hotel capacity in rooms
   - Hospital capacity in beds
   - Parking garage capacity in car spaces

Conceptual Estimating

3. Physical Dimensions Method
   - similar to the end-products units method
   - building estimate may be based on square meters
   - pipelines, roadways, or railroads may be based on a linear basis.

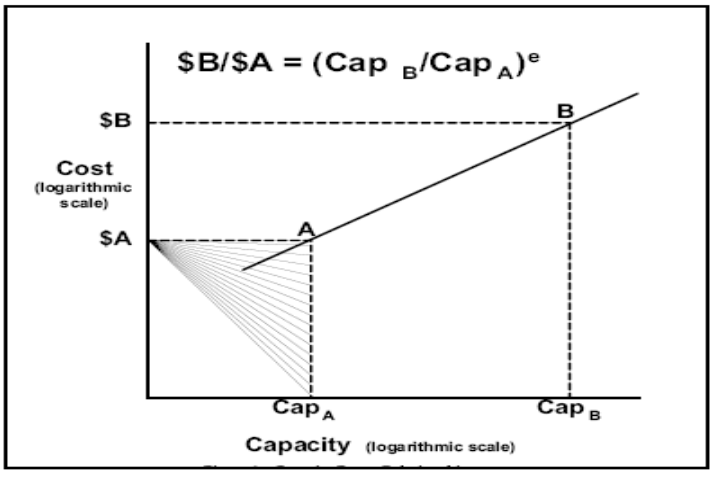
Conceptual Estimating

4. Capacity Factor Method
   - Scale of operations
   - Six tenth's factor

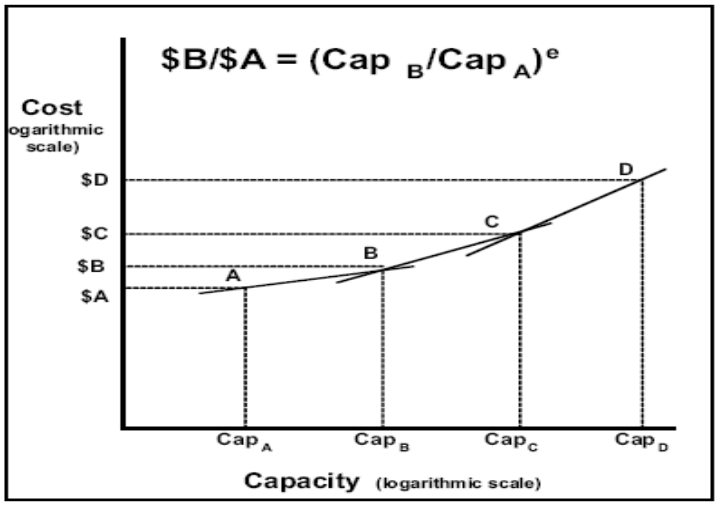
$$\frac{\$B}{\$A} = \left(\frac{Cap_B}{Cap_A}\right)^e$$

   - $A & $B are the costs of the two facilities
   - Cap_A & Cap_B are the capacities of the two facilities
   - (e) is proration factor (0.50 – 0.85)

Capacity Factor Relationship



Capacity Factor Relationship



Capacity Factor (Lang)

PROCESS Direct Costs	ALL SOLID Process				FLUID & SOLID Process (*)				ALL FLUID Process			
	Mat'l	Labor	Total	TC%	Mat'l	Labor	Total	TC%	Mat'l	Labor	Total	TC%
Purchased Equipment	1.000	N/A	1.00	26%	1.000	N/A	1.00	24%	1.000	N/A	1.00	20%
Equipment Setting	0.014	0.024	0.04	1%	0.014	0.024	0.04	1%	0.014	0.024	0.04	1%
Site Development	0.016	0.029	0.05	1%	0.016	0.029	0.05	1%	0.016	0.029	0.05	1%
Concrete	0.038	0.054	0.09	2%	0.031	0.059	0.09	2%	0.028	0.052	0.08	2%
Structural Steel	0.106	0.050	0.16	4%	0.103	0.040	0.14	3%	0.100	0.030	0.13	3%
Buildings	0.016	0.006	0.02	1%	0.016	0.006	0.02	1%	0.016	0.006	0.02	0%
Piping	0.200	0.160	0.36	9%	0.307	0.242	0.55	13%	0.520	0.450	0.97	19%
Instrumentation & Controls	0.100	0.200	0.30	8%	0.100	0.215	0.32	7%	0.140	0.280	0.42	8%
Electrical	0.109	0.086	0.20	5%	0.109	0.086	0.20	5%	0.088	0.072	0.16	3%
Insulation	0.020	0.004	0.02	1%	0.030	0.004	0.03	1%	0.060	0.012	0.07	1%
Painting	0.009	0.060	0.07	2%	0.009	0.060	0.07	2%	0.008	0.050	0.06	1%
Direct Costs =	1.63	0.67	2.30	59%	1.74	0.77	2.50	59%	1.99	1.01	3.00	59%
PROCESS Indirect Costs												
Labor Indirects & Field Costs	0.160	0.392	0.55	14%	0.176	0.424	0.60	14%	0.220	0.500	0.72	14%
Contractor Engineering & Fee	0.015	0.703	0.72	18%	0.016	0.759	0.78	18%	0.020	0.890	0.91	18%
Owner Engineering & Oversight	0.080	0.242	0.32	8%	0.082	0.267	0.35	8%	0.085	0.330	0.42	8%
Total PROCESS Direct and Indirect =	1.88	2.01	3.89	100%	2.01	2.22	4.22	100%	2.32	2.73	5.04	100%

Capacity Factor Relationship (example 1)

- Estimate costs of a 100,000 BBL / day hydrogen peroxide unit to be built in Philadelphia and completed in 2010.
- We have recently completed a 150,000 BBL / day plant in Malaysia with a final cost of $50 million in 2008.
- Our recent history shows a capacity factor of **0.75** is appropriate.

$$\$B = \$50M \times (100/150)^{0.75} = \$36.9M$$

Capacity Factor Relationship (example 2)

- The plant in Malaysia included items ($10M) that will not be included in the proposed plant for Philadelphia.
- Construction in Philadelphia is expected to cost 1.25 times the construction costs in Malaysia
- Escalation will be included as a 1.06 multiplier from 2008 to 2010
- There are costs ($5M) for pollution requirements in Philadelphia that were not included in the cost of the Malaysian plant.

Capacity Factor Relationship (example 2)

150,000 BBL / day plant in Malaysia	$50M
deduct items costs	-$10M
adjusted cost for scope =	$40M
place adjustment (x 1.25) =	$50M
escalate to 2010 (x 1.06) =	$53M
factor = $53M x $(100/150)^{.75}$ =	$39M
add pollution requirements (+$5M) =	$44M

Conceptual Estimating

5. Ratio (Factor) Method

- Used in estimating the cost of process and chemical plants, where the cost of the specialized process ***equipment*** makes up a significant portion of the total project cost.
- An equipment factored estimate can typically be generated when project definition is approximately 1% to 15% complete (Class 4).

Conceptual Estimating

5. Ratio (Factor) Method

- Depending on the particular factoring techniques and data used, the factors may estimate Total Installed Costs (TIC) or Direct Field Cost (DFC) for the facility.

Conceptual Estimating

Type of Plant	Factor
Solid Process Plant	3.10
Solid-Fluid Process Plant	3.63
Fluid Process Plant	4.74

The following is an example of a Lang Factor estimate for a fluid process plant:

Total estimated equipment cost = $1.5M
Total plant cost = $1.5M X 4.74
Total plant cost = $7.11M

Acct No	Item Description	Adj Factor	Costs				Eqmt Mult	% Total
			Labor $	Eqmt $	Eqmt Factor	Total		
51	Columns			650,000				
52	Vertical Vessels			540,000	3.2	1,728,000		
53	Horizontal Vessels			110,000				
54	Shell & Tube Heat Exchangers			630,000	2.5	1,575,000		
55	Plate Heat Exchangers			110,000	2.0	220,000		
56	Pumps, Motor Driven			765,000	3.4	2,601,000		
				2,805,000				
	DIRECT FIELD COSTS	25% Of DFC	1,038,000			7,753,000	2.8	53.8%
10	Temporary Construction Facilities							
11	Construction Services/Supplies/Consumables							
12	Field Staff/Subsistence/Expense							
13	Payroll Burdens/Benefits/Insurance							
14	Construction Equipment/Tools							
15	International Expense							
	INDIRECT FIELD COSTS	115% Of DFL				2,229,000		15.5%
	TOTAL FIELD COSTS					9,982,000	3.6	69.2%
20	Project Management							
21	Project Controls/Estimating							
22	Project Procurement							
23	Project Construction Management							
24	Engineering/Design							
25	Home Office Expenses							
	HOME OFFICE COSTS	30% Of DFC				2,326,000		16.1%
	TOTAL FIELD and HOME OFFICE COSTS					12,308,000	4.4	85.3%
30	Owner's Costs							
31	Project Commissioning Costs	3%	Of DFC			233,000		
32	Escalation							
33	Other Non-Assignable Costs							
34	Contingency	15%	Of Above			1,881,000		
35	Fee							
	OTHER PROJECT COSTS					2,114,000		14.7%
	TOTAL PROJECT COSTS					$14,422,000	5.1	100.0%

Projacs

Conceptual Estimating

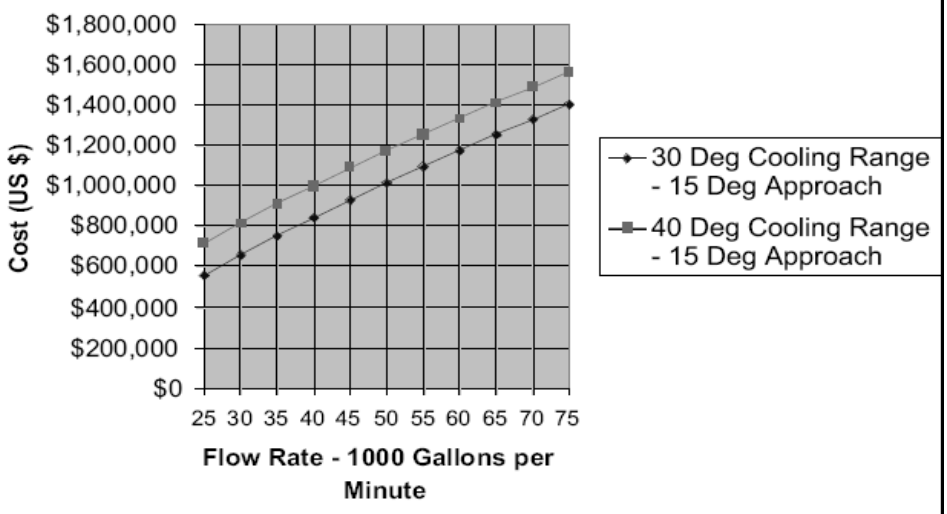
6. Parametric Method

- When there is little technical data or engineering deliverables to provide a basis for using more detailed estimating methods
- Comprises cost estimating functions that provide logical and repeatable relationships between independent variables, such as design parameters or physical characteristics and cost.

Conceptual Estimating

6. Parametric Method

- Capacity factor and equipment factor estimates are simple examples of parametric estimates
- It is reliant on the collection and analysis of previous project cost data in order to develop the Cost Estimating Relationships (CER)



Parametric Estimate of Indirect Cost

	Proposed Ranges
Field Supervision & Field Office Expenses	25.0% to 41.0%
Temporary Facilities & Structures (Includes Temporary Support Systems & Utilities)	9.0% to 18.0%
Construction Equipment & Tools	20.0% to 35.0%
Construction Consumables & Small Tools	9.0% to 15.0%
Statutory Burdens & Benefits	40.0% to 50.0%
Misc. Overhead & Indirects	2.5% to 6.0%
Profit/Fees for Construction Management	1.5% to 2.5%
Mobilization/Demobilization	4.0% to 6.5%
Scaffolding	4.0% to 6.0%
Total	**115% to 180%**

Parametric Estimate of Equipment

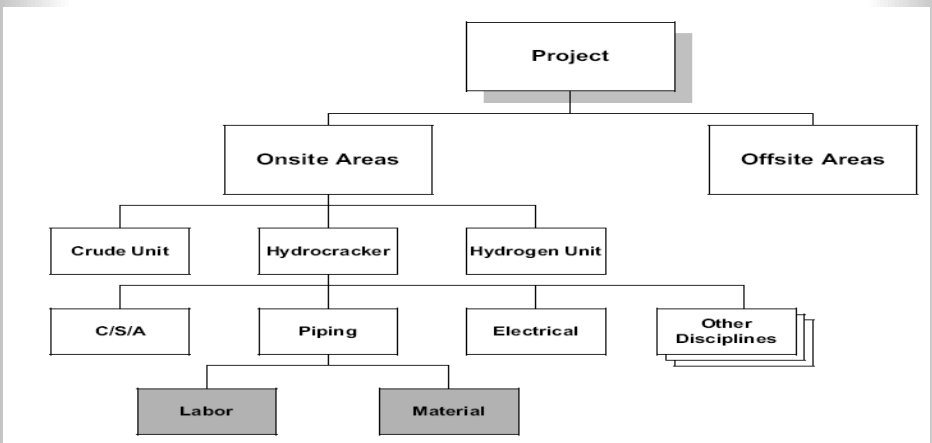
Equipment	Proposed Models	Parameter Ranges	%AAD	Coefficients
Pressure Vessels (Carbon Steel)	$C_E = \exp[A_1 + B_1\ln(W) + C_1\ln(W)^2]$	$180 < W < 621{,}000$ $2 < P < 20$	21%	$A_1 = -1.731737$ $B_1 = 0.5598$ $C_1 = 0.024773$
Pressure Vessels (Stainless Steel)	$C_E = \exp[A_2 + B_2\ln(W)]$	$168 < W < 108{,}849$ $2 < P < 5$	27.6%	$A_2 = -2.788577$ $B_2 = 0.94935$
Atmospheric Storage Tanks (Carbon Steel)	$C_E = \exp[A_3 + B_3\ln(W)]$	$2{,}800 < W < 1{,}540{,}000$	4.2%	$A_3 = -4.619487$ $B_3 = 0.9892$
Separation Tower (Carbon Steel)	$C_E = \exp[A_4 + B_4\ln(W) + C_4\ln(W)^2]$	$5{,}360 < W < 178{,}000$ $3.5 < P < 30$	12.8%	$A_4 = 13.271536$ $B_4 = -2.253712$ $C_4 = 0.154118$
Separation Tower (Stainless Steel)	$C_E = \exp[A_5 + B_5\ln(W) + C_5(L/D)]$	$6{,}400 < W < 39{,}000$ $1.4 < (L/D) < 21.3$ $3.5 < P < 37$	37%	$A_5 = -2.484312$ $B_5 = 0.964302$ $C_5 = 0.04109$
Shell and Tube Heat Exchangers – BEU Type (Carbon Steel)	$C_E = \exp[A_6 + B_6\ln(W)]$	$4{,}400 < W < 77{,}400$ $7 < P < 85$	3.2%	$A_6 = -2.910474$ $B_6 = 1.016550$
Oil Injected Screw Compressor	$C_E = \exp[A_7 + B_7W_P + C_7W_P^{0.5}]$	$7 < W_P < 315$ $7 < P < 85$	9.2%	$A_7 = 2.193159320$ $B_7 = -0.01059287$ $C_7 = 0.450875824$

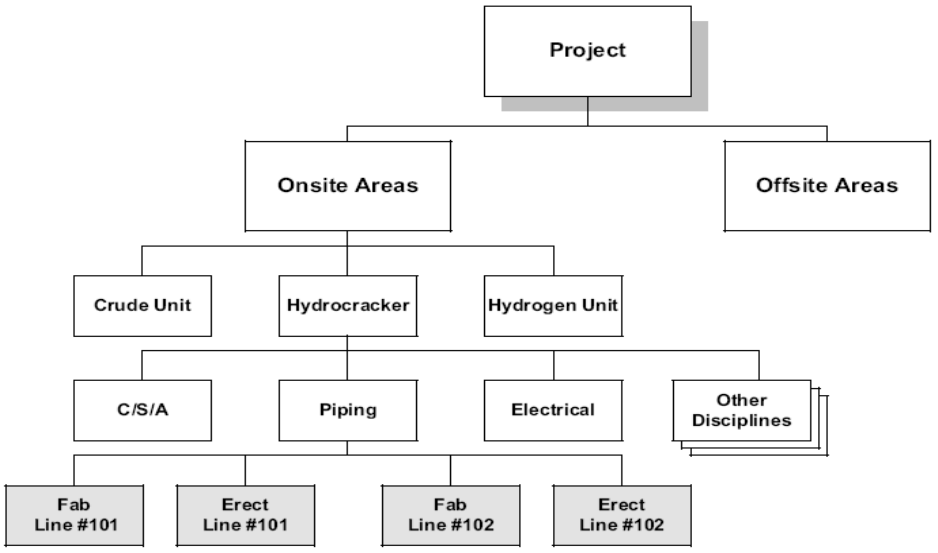
Deterministic Estimating

7. Deterministic Method

- Are prepared to support final budget authorization, contractor bid tenders, cost control during project execution, and change orders
- Class 3 through Class 1 estimates

Cost / Estimate WBS





Schedule WBS

Estimating Methodologies Sample Question

Manufacturing indirect costs are those which are independent of the production rate and must be paid regardless of plant output. Which of the following qualify as manufacturing indirect costs?

A. Distribution costs.
B. Royalties.
C. Operating supplies.
D. Depreciation.

Quantification

"Quantification is an activity to translate project scope information into resource quantities suitable for costing"

Summary Take-Off

Commodity/Activity	Take-Off Method	Pricing Method
Earthwork		Quoted subcontract rates.
Site Work		Quoted unit rates.
Hydrovac		Quoted day rate.
Piling		Quoted unit rates.
Concrete	Civil design drawings, vendors shop drawings and soil tests.	Quoted rates for materials and/or subcontracts.
Steel		
Architectural/Buildings		Quoted subcontract rates.
Equipment	Equipment list.	80% budget quotes.
Piping	Supplied by piping engineering.	
Heat Tracing	Heat tracing and insulation specifications, piping take-offs and vendor quotations. Steam supply and condensate return headers are to be estimated based on heat load requirements and in	

Quantification Sample Question

The gross area of a building construction project entails:

A. The total floor area plus any covered exterior areas.

B. The sum of all the floor or slab areas of a project that are enclosed by the exterior skin of the building.

C. The area of the site less areas of all paved areas (vehicular and pedestrian) and landscaped areas.

D. The ground floor area multiplied by the number of floors above grade.

Costing

"Costing is the process of applying unit costs to the individual quantities of items associated with the estimate."

Costing
Sample Question

A derrick barge will be used to install an offshore platform and the daily rate is $320,000 per day and a mobilization/demobilization cost of $200,000. The installation time is expected to be five days. How much will it cost to install the offshore platform?

A. $1,600,000
B. $1,160,000
C. $1,800,000
D. $1,700,000

Pricing

Pricing is defined as the process of determining the cost of a product or project to the ultimate user or owner of the item.

Pricing
Sample Question

Your direct cost estimate is $2,000,000. Your organization applies the following markups general and administrative expense (G&A) 5%, contingency 10%, profit 7%. The markups are compounded. What is your total project cost?

A. $2,440,000
B. $2,630,490
C. $3,907,136
D. $2,471,700

Conditioning

Conditioning is a global term for preparing an estimate for a given purpose or set of "conditions".

Conditioning Sample Question

Which of the following is the most commonly used to forecast escalation?

A. Price indices.
B. Monte Carlo risk analysis.
C. Time value of money.
D. Present and future risk analysis.

Estimate Allowances

- Allowances are often included in an estimate to account for the predictable but indefinable costs associated with project scope.
- Allowances are most often used when preparing deterministic or detailed estimates.
- Included in the estimate as a percentage of some detailed cost component.

Estimate Allowances

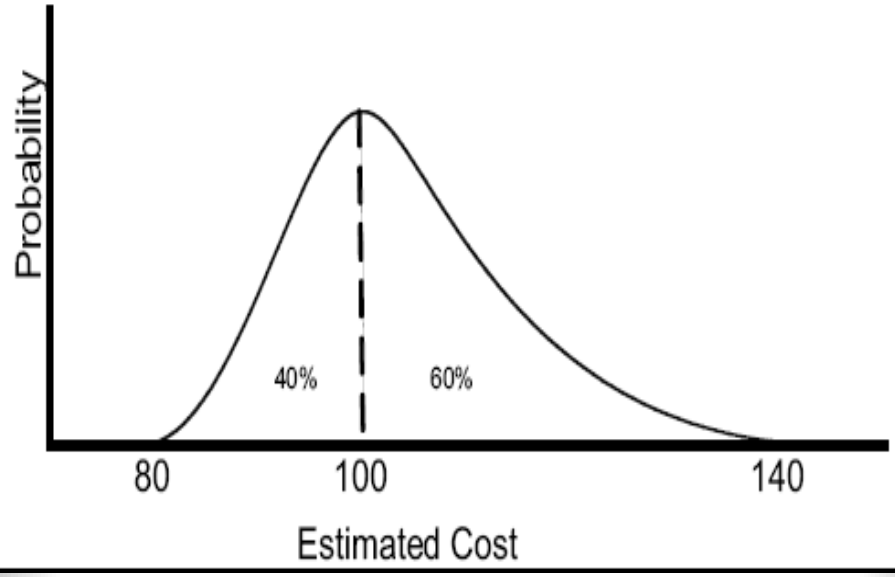
- Design allowance for engineered equipment (2-5%)
- Material take-off (2-15%)
- Overbuy allowance (2-10)
- Unrecoverable shipping damage
- Allowance for undefined major items.

Estimate Allowances

Commodity	Design/Material Take-Off (MTO) Allowance	Construction Waste Allowance
Earthwork	10%	12%
Site Work	12%	10%
Piling – Drilled Caisson	5%	7%
Piling – Sheet	3%	1%
Concrete	7%	10%
Steel – Fabrication	8%	10%
Steel – Module	8%-10%	15%
Steel – Stick-Build	5%-10%	12%
Architectural/Buildings	6%-10%	8%
Equipment	5%	0%
Piping – Fabrication	5%-10%	10%
Piping – Module	5%-10%	10%
Piping – Stick-Build	5%-10%	10%
Steam Tracing	15%	8%
Electrical Equipment	5%	0%

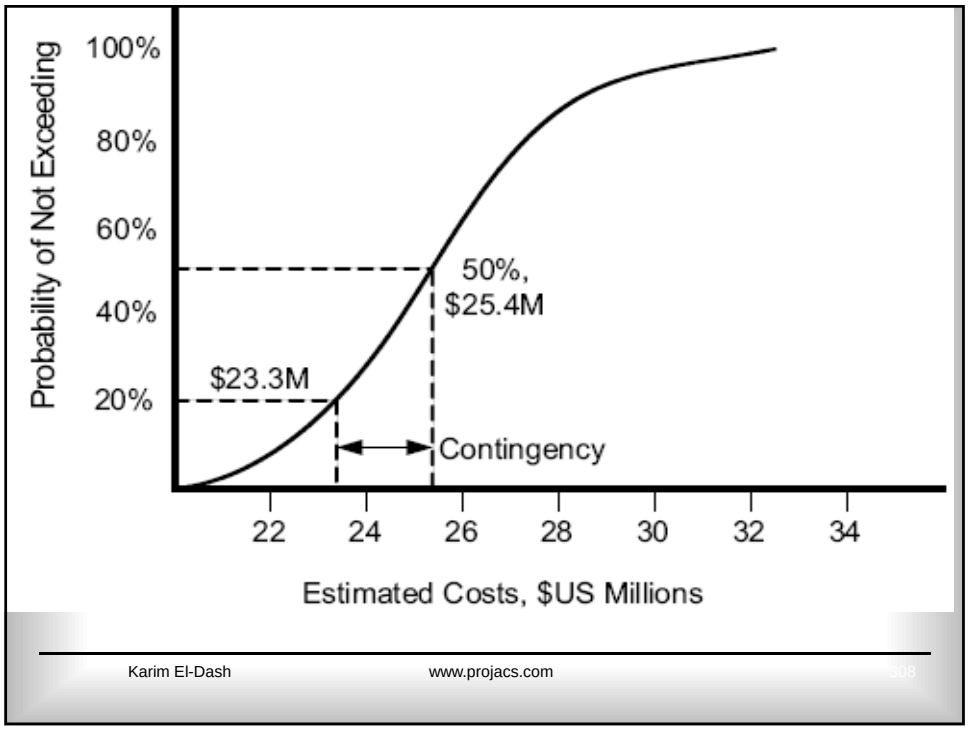
Contingency & Risk Management

- Contingency is an amount used in the estimate to deal with the uncertainties inherent in the estimating process
- The funds added to the originally derived point estimate to achieve a given probability of not overrunning the estimate



Project Estimate

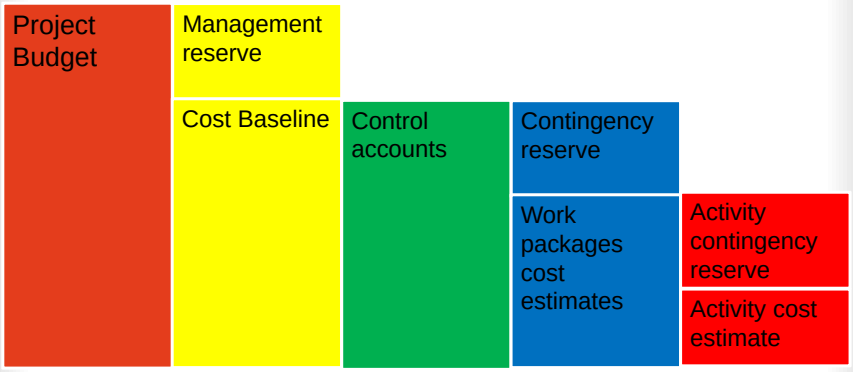
Cumulative Probability of Underrun	Indicated Funding Amount (Million $)	Estimated Contingency (Million $)	(%)
10%	$22.3		
20%	$23.3		
30%	$24.2		
40%	$24.8		
50%	$25.4	$2.1	9.0%
60%	$26.0		
70%	$26.6	$3.3	14.2%
80%	$27.4		
90%	$28.6		



Determine Budget

- Cost Aggregation
- Reserve Analysis (Management contingency reserve for unknown unknowns)
- Expert judgment
- Historical relationships
- Funding limit reconciliation

Project Budget Components



Risk Evaluation and Contingency Determination Sample Question

As a predictive process, estimating must address risks and uncertainties. One of the ways an estimator addresses risks and uncertainties in her estimate is to _____.

A. Perform a thorough risk assessment.

B. Include contingency in the estimate using Monte Carlo simulation.

C. Evaluate the risk and include potential costs in unit costs.

D. Model potential costs of omission.

Documentation

- Is the estimate documented clearly?
- Are the estimate summary and details well organized?
- Are these presented at an appropriate level of detail?
- Is every cost appearing on the estimate summary traceable to the estimate detail and estimate backup?

Basis of Estimate

- Overall project scope.
- Demonstrating an understanding of scope and schedule.
- Potential cost risks and opportunities.
- Key communications made during estimate preparation.
- All documents used to prepare the estimate.
- Support during dispute resolutions.
- Initial baseline for scope, quantities and cost.
- Historical relationships between estimates.
- Facilitate the review and validation of the cost estimate.

Recommended Practices

- Be factually complete, but be concise.
- Be able to support your facts and findings.
- Identify estimating team members and their roles.
- Describe the tools, techniques, and estimating methodology.
- Identify other projects that were referenced or benchmarked.
- Develop the cost estimate and the BOE concurrently.
- Establish context of estimate, review and validation.
- Qualify any rates or factors that are referenced.

Estimate Documentation Sample Question

A Basis of Estimate (BOE) _____.

A. Should not describe the accuracy of the estimate, leaving that up to the independent judgment of the stakeholders.

B. Should not discuss drawbacks or shortcomings of the scoping documents in order not to antagonize their developer.

C. Will describe the primary estimating methodology used in preparation of the estimate.

D. Will not address any anomalies, variances, or other shortcomings of the estimate or scoping documents.

Reconciliation

- Provide an overview of the major differences between the current estimate and the last published estimate.
- Identify the cost impacts due to scope changes, pricing updates, labor productivity adjustments, etc.

Reconciliation

	Previous Estimate	Current Estimate	Variance $	Variance %
Sitework	$250,000	$275,000	+$25,000	+9.1%
Concrete	$525,000	$475,000	-$50,000	-10.5%

Estimate Reconciliation Sample Question

The main benefit of reconciling an estimate on a project with an accounting of the final costs incurred on the project is:

A. It provides a basis for reward or penalty for the estimator.

B. It provides a basis for reward or penalty for the project manager.

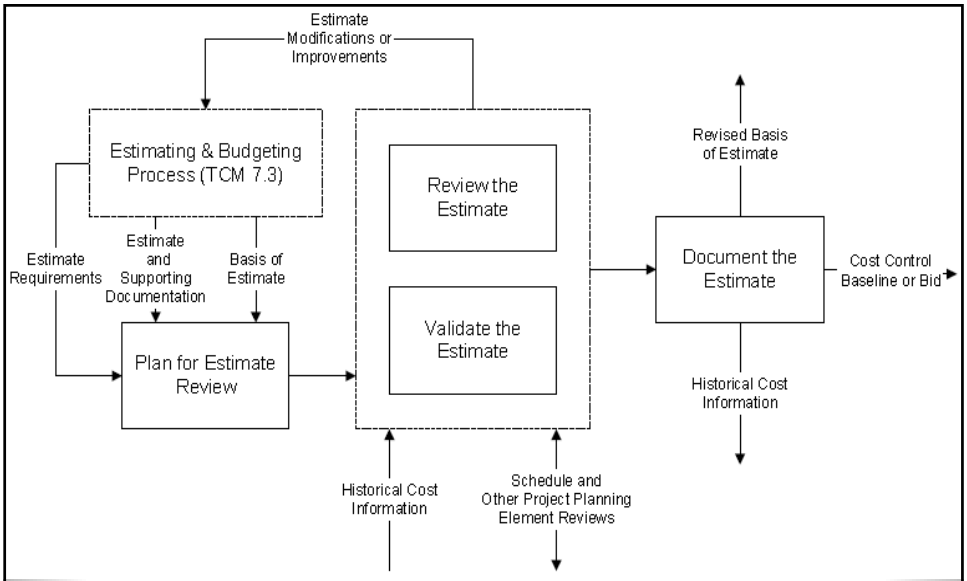
C. The lessons that can be learned from the comparison of actual costs with those estimated that can then be applied to future estimates.

D. All of the above.

What is Estimate Review?

Review determines if the estimate was:

- Developed using contractually or procedurally required practices, tools and data
- Whether it covers the entire project scope
- Whether it is free from errors and omissions
- Whether it is structured and presented in the expected format



Estimate review, validation & documentation process

Review & Validation

- Plan for the Estimate Reviews
- Technical (Engineering/Design) / Scope Reviews
- Estimating Team Reviews
- Project Manager/Project Team Reviews
- Management Reviews
- Reviewing Estimates Prepared By Others
- Documenting the Estimate
- Feedback Loop

What to Review?

- Basis of Estimate
- Estimating Personnel and Discipline
- Estimating Methodology and Procedures
- Estimate Documentation
- Estimate Validation
- Estimate Detail

Validation

- The goal of validation is to ensure that key metrics from the estimate are in line with the same metrics from similar projects.
- It can be considered a top-down view of the estimate that provides a unique, objective perspective.
- It is the responsibility of the manager.

Review & Validation Sample Question

A common approach to an estimate is to leave review of the frontends of contracts until after the direct costs have been estimated. One result is that _____.

A. It is immaterial as direct costs are independent of terms and conditions.

B. Estimated costs do not reflect the terms and conditions of the contract.

C. Indirect costs are overestimated.

D. Terms and conditions are ignored by the contractor.

Risk Basis of Estimate

- Cost estimates are probabilistic in nature.
- Cost of project depends on how risks influence its execution.
- Direct correlation between estimated cost and risk analysis.
- PM and team should review the risk basis of the estimate.

Reporting

- Basis of estimate (BOE)
- Estimate summaries
- Estimate detail
- Estimate benchmarking report
- Estimate reconciliation report
- Estimate backup

Element Cost Plan

CB Construction Limited, Northbridge
Factory for Hitech Cables Limited

COST FEEDBACK

GIFA (m^2)	3 120

	Element	Element cost	Rate £/m^2
1	**Substructure**	186 450	60
2	**Superstructure**		
	Frame	207 410	66
	Roof coverings	120 360	39
	Roof drainage	11 520	4
	External walls	96 580	31
	Windows	23 950	8
	External doors	16 580	5
	Internal walls	8 780	3
	Internal doors	15 340	5
3	**Internal finishes**		
	Wall finishes	17 860	6
	Floor finishes	10 050	3
	Ceiling finishes	5 960	2
4	**Fittings and furniture**	7 250	2
5	**Services**		
	Sanitary appliances	7 410	2
	Internal drainage	inc	—
	Hot and cold water	inc	—
	Heating	25 550	8
	Electrical installation	36 870	12
	BWIC	3 630	1
6	**External works**		
	Site works	126 550	41
	Drainage	33 210	11
	External services	5 120	2
7	**Preliminaries**	144 550	46
8	**Contingencies**	56 280	18
9	**Budget total**	£ 1 167 260	£ 374

Element Cost Plan

CB Construction Limited, Northbridge

COST FEEDBACK *NEW PROJECT*

	Hitech Cables		Pluto Blinds
	GIFA	3 120	2 860

	Element	Element cost	Cost £/m^2	New budget
1	**Substructure**	186 450	60	170 913
2	**Superstructure**			
	Frame	207 410	66	190 126
	Roof coverings	120 360	39	110 330
	Roof drainage	11 520	4	10 560
	External walls	96 580	31	88 532
	Windows	23 950	8	21 954
	External doors	16 580	5	15 198
	Internal walls	8 780	3	8 048
	Internal doors	15 340	5	14 062
3	**Internal finishes**			
	Wall finishes	17 860	6	16 372
	Floor finishes	10 050	3	9 213
	Ceiling finishes	5 960	2	5 463
4	**Fittings and furniture**	7 250	2	6 646
5	**Services**			
	Sanitary appliances	7 410	2	6 793
	Internal drainage	inc	inc	inc
	Hot and cold water	inc	inc	inc
	Heating	25 550	8	23 421
	Electrical installation	36 870	12	33 798
	BWIC	3 630	1	3 328
6	**External works**			
	Site works	126 550	41	116 004
	Drainage	33 210	11	30 443
	External services	5 120	2	4 693
7	**Preliminaries**	144 550	46	132 504
8	**Contingencies**	56 280	18	51 590
9	**Budget total**	£ 1 167 260	£ 374	£ 1 069 988

Element Cost Plan

	Surface weighbridge (15 m long)	quant	unit	rate	total	lab	plt	mat	s/c	LAB	PLT	MAT	S/C
A	Excavate to reduce lev ne 1.0 m dp	23	m^3	8.94	205.62	3.97	4.97			91	114		
B	Excavate for thickening & downstand	9	m^3	24.85	223.65	19.88	4.97			179	45		
C	Load and remove to tip on site	17	m^3	7.96	135.32		7.96				135		
D	Backfill with selected material	15	m^3	5.64	84.60	2.32	3.32			35	50		
E	Level and compact	79	m^2	0.74	58.46	0.58	0.16			46	13		
F	Earthwork support	6	m^2	3.23	19.38	1.07	2.16			6	13		
G	Hardcore (Free Issue)	18	m^3	5.64	101.52	2.32	3.32			42	60		
H	Blind with dust (Free Issue)	62	m^2	0.66	40.92	0.33	0.33			20	20		
J	Soil stabilization mat	79	m^2	1.33	105.07	0.42		0.91		33		72	
K	Concrete grade 40 N in foundation	17	m^3	96.12	1 634.04	23.20		72.92		394		1 240	
L	Concrete grade 40 N in ramps	15	m^3	99.44	1 491.60	26.52		72.92		398		1 094	
M	Concrete grade 40 N in upstands	6	m^3	129.27	775.62	49.72		79.55		298		477	
N	Concrete grade 40 N in plinths	1	m^3	120.98	120.98	41.43		79.55		41		80	
P	Rebar 12 mm (upstand & downstand)	0.6	t	1 068.89	641.33	356.29		712.60		214		428	
Q	Rebar 16 mm	0.12	t	994.32	119.32	331.44		662.88		40		80	
R	Fabric A393	280	m^2	6.79	1 901.20	1.41		5.38		395		1 506	
S	Dowel bars 25 mm	30	nr	3.30	99.00	1.65		1.65		50		50	
T	Form plinths 900×900×250 mm high	4	nr	32.32	129.28	21.55		10.77		86		43	
U	Sawn formwork to sides of founds	47	m^2	34.80	1 635.60	23.20		11.60		1 090		545	
V	Sawn formwork to sides of upstands	17	m^2	38.10	647.70	24.85		13.25		422		225	
W	Cast in service duct	1	nr	16.58	16.58	9.95		6.63		10		7	
X	Grouting baseplates on return visit	1	item	256.87	256.87	207.15		49.72		207		50	
Y	Steel bumper stops	284	kg	3.15	894.60	0.67		2.48		190		704	
				TOTALS	11 338			check	11 338	4 287	450	6 601	–

Provisional Sums

CB CONSTRUCTION LIMITED	PC & Provisional sums	Project	Lifeboat Station		
		Ref. No:	T384	Date:	14.6.04

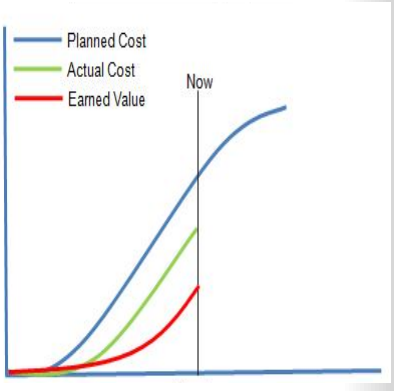
Bill ref:	Description	Prov sums	Prime cost sums			Notes for pricing preliminaries
			Gross	Discount	Nett	
	PC SUMS					Special attendances
6/1 a	Structural steelwork (Steelbuild Limited)		23 000	575	22 425	Good access roads and hardstanding
6/1 e	Electrical installation (name not given)		15 600	390	15 210	Scaffolding Covered storage
6/2a	Fire doors (nominated supplier)		3 840	192	3 648	
	PROVISIONAL SUMS					Prelims for defined prov sums:
6/2m	Contingencies	5 000				
6/2n	Drainage to sump	1 000				
6/2p	Glazed roof over entrance	3 500				Scaffolding Protection and cleaning
6/3	Daywork – labour add 110%	1 000 1 100				
	Daywork – materials add 15%	500 75				
	Daywork – plant add 60%	500 300				
	Totals:	12 975	42 440	1 157	41 283	

Trade Abstract

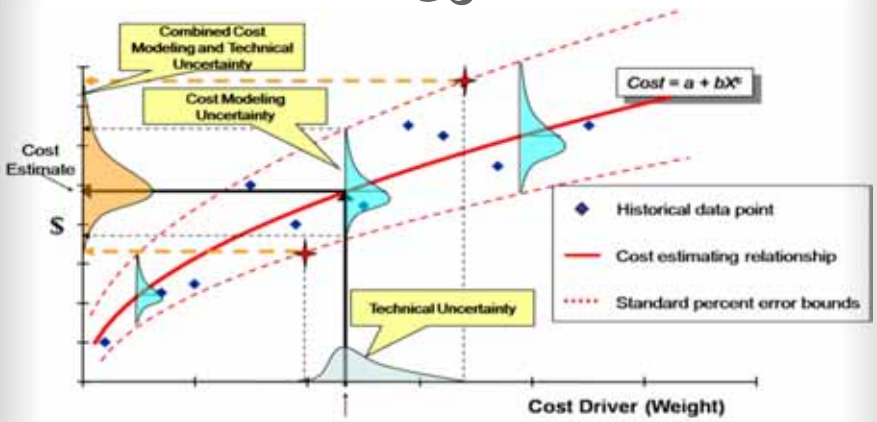
Trade		Bill pages	Spec pages	Estr	Quant	Unit	Lab	Plt	Mat	Total
D20	Earthworks	3/1–5, 4/35–37	2/1–12	JM	1075	m³	7 800	7 980	5 700	21 480
R12	Drainage	5/1–34	2/56–65	JM	823	m	8 650	6 520	9 520	24 690
E10	Concrete work	3/5–7, 4/38–40	2/13–15	JM	956	m³	12 520	3 750	51 840	68 110
E30	Reinforcement	3/11, 4/43	2/15–16	JM	76	t	13 680		24 700	38 380
E20	Formwork	3/7–10, 4/40–42	2/17–22	JM	2 150	m²	30 950		16 530	47 480
E40	Concrete sundries	3/7,11–13, 4/44,45	2/14	JM			2 150		3 180	5 330
F31	Precast concrete	4/46	2/35	PC			1 850		8 250	10 100
F10	Brickwork	3/19–22	2/24–28	PC	76	th	18 460		19 520	37 980
F11	Blockwork	3/20	2/27–32	PC	3 100	m²	18 880		17 450	36 330
F30	Brick sundries	3/22,23	2/24	PC			4 520		5 250	9 770
G20	Timber	3/28–31	2/39–44	PC	4 210	m	5 150		6 210	11 360
P20	Joinery	3/31–38	2/39–46	PC			2 380		5 310	7 690
G12	Metalwork	3/29,39	2/47–48	PC			2 680		8 450	11 130
P31	BWIC	3/55		JM			2 110		2 030	4 140
	Attendances	6/1		JM			410		385	795
					Totals		132 190	18 250	184 325	334 765

Cost Performance Baseline

- It is an authorized time-phased budget at completion (BAC) that is used as a basis against which to measure, monitor, and control overall cost performance on the project.



Cost Baseline



Estimate Reporting Sample Question

If a previous estimate totaled $55,000,000 and a current estimate, $52,500,000, it can be said that the $2,500,000 is _____.

A. Evidence that a mistake was made on one or the other of the estimates.

B. To be disregarded an inconsequential.

C. Not to be discussed to avoid embarrassment of the estimators.

D. To be evaluated and explained in a reconciliation section of the estimate report.

Closeout

"Estimate closeout" refers to the process of arranging final costs and adding them to the cost basis of a fixed asset in the organization's balance sheet to allow them to be included in the basis for depreciation.

Closeout

- Conversion of scope of work into measurable elements (quantity takeoff).
- Development of resource requirements.
- Refinement of the estimate and adding supporting documentation.
- Finalization of estimate and application to the purpose.
- Account for changes in scope, timing, or use.
- Transformation of estimated values and format into other formats to facilitate secondary purposes of the estimate.

Estimate Closeout Sample Question

The process of posting costs from an estimate to the cost basis of a fixed asset in the organization's balance sheet is known as _____.

A. Cost control.
B. Cost capture.
C. Capitalization.
D. Amortization.

Building Information Modeling

- (BIM) refers to a digital representation of the physical and functional characteristics of a facility.
- Shared knowledge resource for information about a facility forming a reliable basis for decisions.
- Shared resource for stakeholders to insert, extract, update or modify information in the BIM to support or reflect the roles of that stakeholder.

BIM

- Dimensions for modeling the information and geometry about a facility are:
  - 3D graphical modeling,
  - 4D time modeling, and
  - 5D cost modeling.
- Graphical representations with associated object information are combined for 3D.
- 4D view = 3D + time.
- 5D = 4D + cost.

BIM

- Cost estimating a project in BIM begins with classifying the cost estimate to be completed.
- This activity relies on the level of project definition (LOD).
- LOD 100 is the lowest and is authorized for 4D total project construction duration and 5D conceptual cost allowance.
- LOD 500 is the as-built BIM and is authorized for 5D record costs.

BIM
Sample Question

The Model Progression Specification includes _____ Levels of Detail.

A. Ten.
B. Seven.
C. Three.
D. Five.

Workshop: Cost Estimating

1. An estimate prepared using cost/capacity factors would typically be classified as which type of estimate.

A. Class 5 – Concept Screening Estimate
B. Class 4 – Study Estimate
C. Class 3 – Budget Estimate
D. Class 2 – Control Estimate

Workshop: Cost Estimating

2. Assuming the cost for a 150 Ton/Day Waste to Energy Plant has been normalized for location and escalation. The adjusted cost for the 150 TPD Plant is $80M. After analysis, the cost/capacity factor is assumed to be .65. What is the cost for a 90 TPD Plant?

A. $48.0M
B. $57.4M
C. $59.8M
D. $111.5M

Workshop: Cost Estimating

3. Which of the following is not true regarding a "detailed" estimate?

A. Each component of the project scope definition is quantitatively surveyed and priced using the most realistic unit prices available.
B. Requires a substantial amount of time and money to prepare.
C. Uses a conceptual estimating methodology.
D. Is typically the most accurate of the various estimating methodologies.

Workshop: Cost Estimating

4. Which of the following is true regarding "allowances?"

A. Allowances are never required in an estimate.

B. Allowances are most often used when preparing detailed or deterministic estimates.

C. Allowances are always calculated based as a percentage of some other detailed cost components of the estimate.

D. Allowances are the amounts added to an originally defined point estimate to achieve a given probability of not overrunning the estimate.

Workshop: Cost Estimating

5. What is the primary goal of an estimate review?

A. To predict the probable cost of a project.

B. To verify the estimating software used in preparing the estimate.

C. To ensure that the actual costs will not overrun the estimate.

D. To determine that a high quality and sufficiently accurate estimate has been prepared.

Workshop: Cost Estimating

6. The primary characteristic that determines the class of estimate being prepared is?

A. The end usage of the estimate.
B. The degree of project definition.
C. The effort required to prepare the estimate.
D. The estimating methodology.

Workshop: Cost Estimating

7. Estimating the cost of construction of a proposed hotel based on the average cost per hotel room of a recently completed hotel involves which estimating methodology?

A. Capacity factor method.
B. Physical dimensions method.
C. End-product units method.
D. Parametric method.

Workshop: Cost Estimating

8. The basic steps of preparing a cost estimating include all of the following except?

A. Understand the scope of the activity to quantify the resources required.
B. Evaluate project alternatives.
C. Apply costs to the resources.
D. Apply pricing adjustments.

Workshop: Cost Estimating

9. Estimate accuracy tends to improves as?

A. The amount of contingency included in the estimate increases.
B. The amount of contingency included in the estimate decreases.
C. The level of detail in the estimate increases.
D. The level of project definition used to prepare the estimate improves.

Workshop: Cost Estimating

10. A key element of estimate-schedule integration is?

A. Schedule impacts may directly affect labor productivity adjustments in the estimate, as well as labor and material pricing.

B. There should be a one-to-one relationship between estimate cost items and schedule activities.

C. Changes in the project schedule only affect the amount of escalation to be included in the estimate.

D. The estimate is usually not prepared in correlation with a specific schedule.

Process and Functional Skills and Knowledge

2.3 Other Estimating Issues

- 2.3.1 Bidding
- 2.3.2 Budgeting
- 2.3.3 Project and Lifecycle Costing
- 2.3.4 Project and Product Costs
- 2.3.5 Integrated Project Delivery

Bidding

- Bidding is the process of submitting a formal proposal to enter into an agreement to provide a service, product, or project in return for an identified price.
- The term “bid” is known as a “tender” in some countries.
- The estimate plays a prime role in the process of bidding.
- Factors include strategies to be the successful bidder.

Bidding

- Change Order
- Liquidated Damages (LDs)
- Quotes
- Request for Quotation (RFQ)
- Subcontractor
- Supplier
- Unbalanced bid

Bidding
Sample Question

An unbalanced bid is _____.

A. A bid submitted without adequate preparation.

B. A bid in which costs are front-end loaded.

C. A bid in which costs are allocated disproportionately to various accounts to achieve an unfair advantage over the other party.

D. A bid much different in total from the other bids submitted.

Budgeting

- "Budgeting is a process to develop a cost plan by allocating estimated costs or prices to controllable cost accounts or activities and time phasing the cost in accordance with the schedule."

Budgeting
Sample Question

Escalate $10,000,000 at an annual rate of 5% for a period of four years and eight months.

A. $12,335,000
B. $12,558,970
C. $12,657,394
D. $12,608,086

Life Cycle Cost

Total Cost Management (TCM) is defined as:

"a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product, or service."

Life Cycle Cost

- Discount rate
- MARR
- Constant dollar
- Operation cost
- Depreciation

Project & Life-Cycle Costing Sample Question

Which of the following is not a capital cost in so far as life cycle costing is concerned?

A. Salvage value of an asset during the retirement and disposal phase.

B. Architectural and engineering design costs for the original asset.

C. Construction costs, including costs of materials, equipment, labor, and miscellaneous.

D. Labor and material costs for maintenance and repairs.

Project & Product Cost

- A project is “a temporary endeavor with a specific objective to be met within the prescribed time and monetary limitations and which has been assigned for definition or execution.”
- A product is one of many outputs from the execution of a project.
- Those outputs can be in tangible or intangible form, a product being one of the possible tangible forms.

Project & Product Cost

- Fixed vs. variable cost
- Direct vs. indirect cost
- Project vs. construction cost
- Activity based costing
- Cost to serve
- Cost of quality

Cost to Serve

- **Cost to Serve** is a process-driven accountancy tool to calculate the profitability of a customer account, based on the actual business activities and overhead costs incurred to service that customer.
- The product and customer profiles are often illustrated using a Pareto analysis curve which highlights those that contribute most to the company's profit and those that erode it.
- Unlike Activity Based Costing (ABC), Cost to Serve is not resource-intensive and focuses on aggregate analyses around a blend of cost drivers.

Project & Product Cost Sample Question

What is the relationship between project cost and construction cost?

A. There is no relationship between project cost and construction cost.

B. Construction cost only includes direct costs.

C. Construction cost is a subset of project cost; i.e., project cost includes construction cost.

D. Construction cost is equal to project cost less indirect costs.

Integrated Project Delivery

- Integrated Project Delivery (IPD) is an approach to executing a project in which increased cooperation and communication between all parties leads to timely involvement of those parties in project activities and can lead to efficiencies in production, cost, and schedule in project execution.

Integrated Project Delivery Sample Question

Which of the following is not usually a feature of Integrated Project Delivery (IPD)?

A. Traditional design, bid, build.
B. Design / build.
C. Construction manager at risk (CMAR).
D. Open book pricing.

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Your Company has the contract for constructing a large major tilt-up box warehouse 400 feet by 300 feet. The major element of the project is the fabrication and installation of 10 foot wide by 24 foot long tilt-up panels consisting of #5 rebar on 12 inch centers and using 3,000 psi concrete.

The project has progressed to the point where the 2,500 psi concrete floor slab has been poured and cured. Due to the size of the tilt-up panels (10'x24'), they cannot be lifted by a crane operating on the concrete flooring; therefore, requiring all the lifts to be made outside of the building, often referred to suicide lifts.

The current month has just ended and the owner has issued a change order for a revised time frame of 30 days to complete the fabrication and installation of the exterior walls. Your project manager has received the change order and brings it to your attention with the following information for completing the installation of the tilt-up -panels.

- 140 tilt-up panels to complete
- Each panel requires forming consisting of 60 feet of 2 feet by 4 feet sheathing
- Each panel requires placing #5 rebar on 12 inch centers, tied
- Each panel requires placing 2 each lifting hooks
- Each panel requires placing 8 cubic yards of 3,000 psi concrete
- Each panel requires cure time before moving

With the change order and information in hand, the project manager asks you to prepare a business plan to accomplish the change, and give it to him within 30 minutes so he can reply to the owner.

In office memo format, what is your approach to providing the reply to the owner for the project manager to use?