

Unit 9 – Estimating and whole life costs



Unit 9 - Learning Objectives

To gain an understanding of the following:

- Comparative estimating
- Bottom up estimating
- Parametric estimating
- PERT (3 point) estimating
- Estimating classifications
- Whole life costing

Estimating overview

The Importance and practical difficulties of estimating

Throughout the project life cycle the accuracy of an estimate will change. Estimates are, after all, only quantified approximations of project costs, durations and resources. Estimates however are vital to any project, without them you cannot put together a schedule, find out what your resource needs are or even draw up a budget.

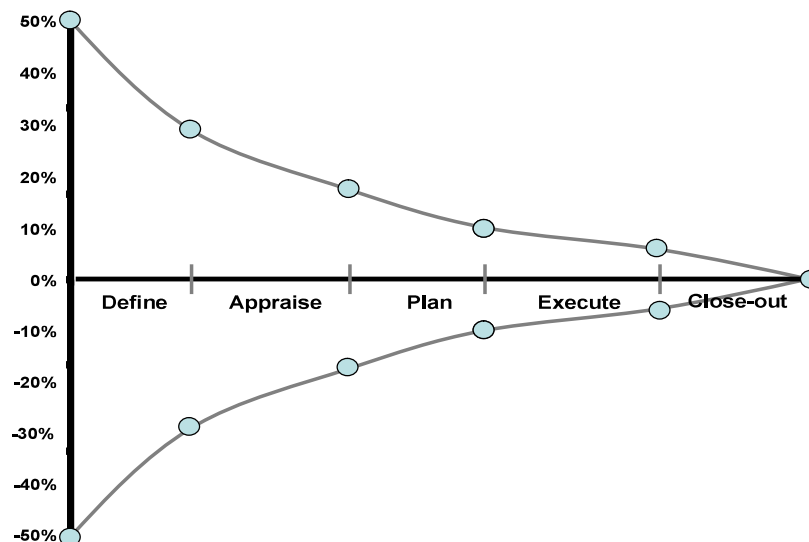
An important factor to keep in mind is that an estimate can never be 100% accurate (unless you are extremely lucky); therefore it is best not to mention accuracy and estimate in the same breath. When referring to estimating we will use the term range, this is breadth of tolerance around the expected result.

The start of a project is the hardest time to estimate, due to the level of uncertainty over key factors like, what is to be done, when, by whom etc. At this stage an estimate's range is likely to be wide, compared to the latter stages of a project when the detail is more clearly known.

It is quite common to update estimates throughout the projects life cycle. However, probably the most important estimate is the one that features in the project management plan (PMP). The reason for this is that it is the estimate upon which the project will be authorised.

The Estimating Funnel

The concept that estimates improve as the project life cycle progresses is commonly called the estimating funnel.



The above diagram illustrates how this process works as we progress through the project our estimate becomes more accurate.

Estimating techniques

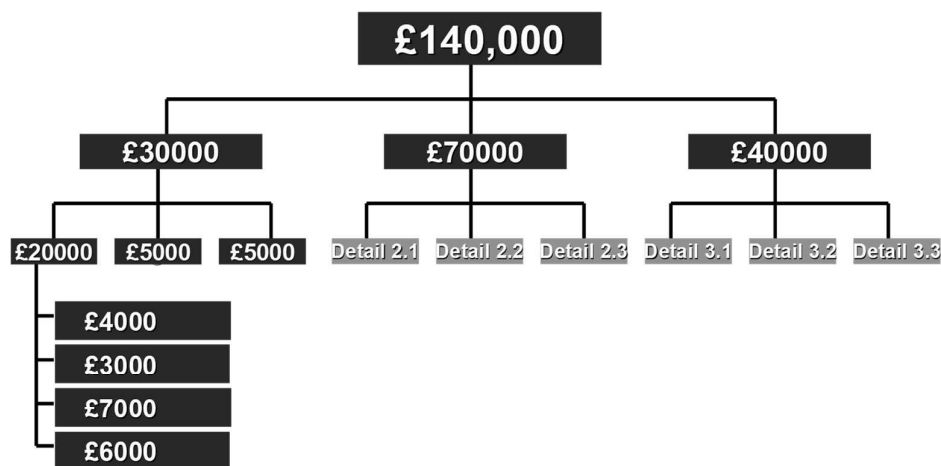
There are three main techniques for estimating (as stated by the APM), which are listed below. Each of these techniques is a useful tool when determining duration resources and costs.

Bottom-Up Estimating (Analytical)

Bottom-Up estimating requires the identification of each discrete activity required to complete the project. For each activity the resources (labour, materials, equipment or financial) and the elapsed time required to complete the activity are estimated. During this process it is important to allow for normal staffing overheads (leave, training, sickness).

Once you have identified any known constraints (limited skills, staffing, fixed dates before which certain activities cannot begin, equipment availability etc.), the Network Analysis process allows you to build up activity totals into a detailed estimate for the project.

The Bottom-Up approach is usually used when the fine detail of the programme and/or its component projects (Work Packages in the case of projects) are well defined. Because this approach is based on more information and is completed in more detail, the estimate can be more precise than a top-down.



The above diagram demonstrates how you can roll up the costs from the lowest level to gain your overall cost.

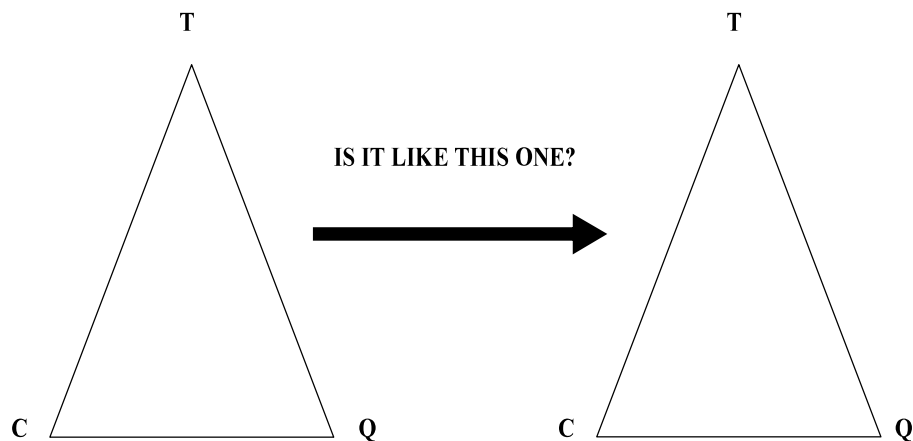
Comparative Estimating (Analogous)

Comparative estimating involves comparing current or completed tasks or projects for which you have some measures of the time and resources required. This method is based on actual past experience rather than opinion but will only be useful if the analogy is valid.

The previous task or project will be different in some respects - do these differences mean that the task or Project is not really comparable without having to make assumptions and thus reintroducing a large measure of opinion?

The Comparative method provides a firm basis for estimating if information is available, this information would then need to be scaled up or down to meet the needs of the project which is being estimated.

The following diagram highlights the fact that you are using comparisons with previous projects to base estimates upon.



Parametric Estimating (Statistical Modelling)

Parametric estimating uses defined parameters by which a project can be measured, such as the time or cost involved to build a specific project deliverable. This process can be repeated for a number of different deliverables, multiplied by the number of each of the parameters required to fulfil the project requirements.

The Parametric approach requires a reasonable amount of robust data in order to make this an easily accessible estimating technique.

An example for estimating the cost of a housing development is seen below. Type A house could be cost using the formula $A=4X+2Y+3S$, and Type B would be $B=2X+Y+S$

	Bed (X)	Bath (Y)	Reception (S)
Type A	4	2	3
Type B	2	1	1

The following technique uses one of the previous methods as its basis; it then provides outcomes based on their probability (high, medium and low)

Three Point Estimating

The previously mentioned forms of estimating do not necessarily account for things like human error, inconsistent data or straightforward errors in the estimating. However Three Point Estimating accepts a number of variations within the project values to produce a most likely outcome i.e. 90% probability, a mid-range value i.e. 50% probability and a least likely e.g. 10% probability.

Some organisations will ask their project teams or sub-contractors to provide a P10, P50, P90 estimate (where P stands for probability), although these numbers can vary dependant on the organisations requirements and level of risk they are prepared to accept.

These numbers are simply a probability of the outcome of a budget or schedule as an example.

The following equation is related to three-point estimating which is linked to PERT (Project Evaluation and Review Technique).

$$\frac{(\text{Optimistic Estimate} + (4 \text{ times Most Likely Estimate}) + \text{Pessimistic Estimate})}{6}$$

You should be aware that as a general principal, the accuracy of a cost estimate should be consistent within a range appropriate to the progress stage of the project.

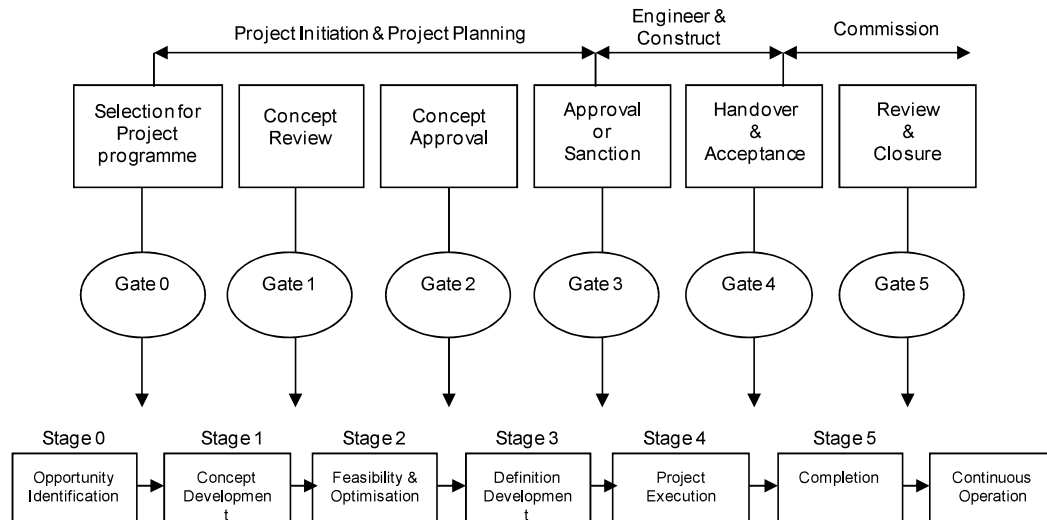
The Verification of the estimate accuracy is documented as part of the Risk Assessment process which is incorporated within the Project Risk Analysis and Management Strategy.

General Approach to Estimate Accuracy

In order of accuracy, the Unclassified (or Analogous) estimate, which is often referred to as a Rough Order of Magnitude (ROM) estimate, generally forms the first stage where no specific quantification is undertaken.

These estimates are a form of expert judgement which are based upon a minimum amount of information and can be the basis on which key strategic and entrepreneurial decisions and Asset Reference (Life) Plans are made.

At the other end of the estimating accuracy scale there is the fully Detailed Estimate, sometimes called the Definitive or Contractor's Estimate, which would be prepared during the Execution Phase of a project.



The classification of estimate accuracy types is appropriate to the progress stage of the project. Using the model shown below, at the Gate1/Gate2 (Conceptual Stages) the accuracy level is typically within the $\pm 30\%$ range. However at the Gate3 (Sanction Stage) the target accuracy range will have been refined to $\pm 15\%$.

Thereafter, Post Sanction, further refinement takes place with the aim of establishing an estimate with an accuracy range of $\pm 10\%$ as quickly as possible.

The need to produce a more accurate estimate at this stage is threefold.

- It gives the Client/Project Sponsor a more accurate tool to re- appraise the Capital Costs and thereby to re-evaluate the project
- It provides a Baseline Cost (Control Estimate) against which cost performance can be measured
- It enables more reliable Planning and Scheduling to be performed

Within some organisations there is a requirement to produce a further refinement in the estimate, bringing the result to a $\pm 5\%$ accuracy. This is known either as an Execution Stage or Definitive/Contractor's Estimate and can be very time consuming to prepare.

These estimates are produced concurrently with the design aspects and come to fruition at about 70% completion of detailed design drawings and specifications, when substantive information is also available on vendor supply. The overall objective is to establish a definitive estimate.

Once established, these estimates can be used for the purpose of being the key cost control document against which all subsequent expenditure is monitored.

On the basis that they are also very expensive to produce, they tend to be called for only if project costs are forecast to significantly deviate from their budgets. This is generally too late to alter the course of events and simply demonstrates the nature and degree of error in the original estimates and brings in the bad news earlier.

Classification and Accuracy of Estimates

The accuracy of a cost estimate should be within the appropriate range consistent with the progress stage of the project. The accuracy should be verified by a documented Risk Assessment process.

The recommended nomenclature for estimate classification used by the Institute of Chemical Engineers and the Association of Cost Engineers is referenced in the following information by ** and utilises the Project Process Model (Gate Procedure)

Gate 0

Unclassified typically based on Asset Life Plan, no specific quantification undertaken.

ROM (Rough Order of Magnitude) based on past experience, no specific quantification undertaken. Order of Magnitude Estimate - also known as 'ballpark' or 'blue sky'.

An Order of Magnitude Estimate would be conducted with a minimum amount of information being available as a basis for key strategic and entrepreneurial decisions on site selection and even commercial feasibility of a project.

Empirical (Experiential) and Structural (Exponential) methods would compensate for information not available.

For Example:

An approximate estimate of a fixed investment cost can be made for an identical process to a previous plant, but at a different scale, on the basis that the total plant cost is related to capacity raised to a power, (to account for differences in scale of production) to which appropriate escalation factors to update from previous installations considered to be broadly similar in nature to the scheme under consideration would be added.

If there is not an adequate precedent then an outline flow sheet or schematic drawing is necessary to identify the main process steps and flow quantities. Step counting methods can then be used to estimate capital costs.

Step counting is based on a model which relates basic process parameters to total erected cost taking into account the number of main plant items or the number of functional units involved.

The probable accuracy of estimates of these types is typically in the range of 30% - 50%. The cost to produce an estimate of this accuracy is in the order of +/- 0.1% of the total project expenditure.

Note: Estimates which are prepared after Gate 0 are often classified as 'D' through 'A', where Class 'A' is the highest in the accuracy range and Class 'D' the lowest.

Gate 1

Class D- +/- 20% to +/-30% but is typically +/- 25% at the Conceptual Stage Gate 1.

Also known as a **Study Estimate

A Class 'D' Estimate is the preferred minimum order of accuracy when compiling estimates for use in the preparation of annual budgets for a capital programme. However, at this stage in the budget process, the project design may not be sufficiently developed,

and therefore a ROM or Unclassified Estimate may result. The cost to produce an estimate of this accuracy is in the order of 0.1% to 0.2% of the total project expenditure.

Gate 2

Class C- +/-10% to +/-25% but is typically +/-20% at the Pre-Sanction Stage Gate 2.

Also known as a **Preliminary Estimate

A Class 'C' Estimate is the preferred minimum order of accuracy when compiling individual project estimates for Pre Sanction approval. At this stage approximately 10% of the anticipated Project funding within the based annual budget would be applied for. This funding would then be used to develop the design and work scope sufficiently to allow a Class 'B' Estimate to be prepared. The cost to produce an estimate of this accuracy is in the order of 0.4% to 0.8% of total project expenditure.

Gate 3

Class B - +/-5% to +/-15% but is typically +/-10% at Sanction Gate 3.

Also known as a **Definitive Estimate

A Class 'B' Estimate is the minimum order of accuracy for individual projects requiring full Sanction approval. The cost of producing an estimate of this accuracy is in the order of 1.0% to 3.0% of the total project expenditure.

Post Gate 3

Class A - +/-2% to +/-5% but is typically +/-5% and is prepared during the Execution Stage.

Also known as a **Detailed or Contractor's estimate

The cost of producing an estimate of this accuracy is in the order of 5.0% to 10.0% of the total project expenditure.

Information Required for Preparing Estimates - Class 'D' to Class 'A'

Whole-life costs

The whole-life costs of a facility (often referred to as through-life costs) are the costs of acquiring it (including consultancy, design and construction costs, and equipment), the costs of operating it and the costs of maintaining it over its whole life through to its disposal – that is, the total ownership costs.

These costs include internal resources and departmental overheads, where relevant; they also include risk allowances as required; flexibility (predicted alterations for known change in business requirements, for example), refurbishment costs and the costs relating to sustainability and health and safety aspects.

Cost management

Cost management is the process of planning, estimating, coordination, control and reporting of all cost-related aspects from project initiation to operation and maintenance and ultimately disposal. It involves identifying all the costs associated with the investment, making informed choices about the options that will deliver best value for money and managing those costs throughout the life of the project, including disposal.

Techniques such as value management help to improve value and reduce costs. Open book accounting, when shared across the whole project team, helps everyone to see the actual costs of the project.

Future costs include all operating costs, such as rent, rates, cleaning, inspection, maintenance, repair, replacements / renewals, energy and utilities use, dismantling, disposal, security and management over the life of the built asset. Loss of revenue may also need to be taken into account - for example to reflect the non-availability of the revenue-generating building during maintenance work for example.

The real costs of an asset

Long-term costs over the life of the asset are more reliable indicators of value for money than the initial construction costs. This is because:

- money spent on a good design can be saved many times over in the construction and maintenance costs. An integrated approach to design, construction, operation and maintenance with input from constructors and their suppliers can improve health and safety, sustainability, design quality; increase buildability; drive out waste; reduce maintenance requirements and subsequently reduce whole-life costs.
- investment in a well-built project can, in turn, achieve significant savings in running costs.

This means that the client should be prepared to consider higher costs at the design and construction stages in the interests of achieving significant savings over the life of the facility. It is essential to consider long-term maintenance very early in the design stage; most of the cost of running, maintaining and repairing a facility is fixed through design decisions made

Design	Build	Operate	Dispose	Total
£ 3%	£ 17%	Run/Maintain £ - 40%	£ 7%	100% Cost of Ownership
		Repair £ - 30%		
		Periodic Replacement/Refurbish £ - 10%		
1 Year	2 Year	25 Years	1 Year	Total

Capturing whole life cost

It is estimated that up to 80% of a building's whole-life cost can be attributed to running, maintenance and refurbishment costs. Consequently, there are spikes in expenditure at 10 years and every five years after that.

The initial choice of materials and the way that they are protected obviously plays an important role within the maintenance and refurbishment costs of a building over its lifetime. They therefore have a very large influence on the whole-life cost profile of the project.

The basic steps in Whole Life Costing

1. Identify capital and operational costs and incomes
2. Identify when they are likely to occur
3. Use “discounted cash flow” analysis to bring the costs back to a common basis – items should normally be entered into the analysis at the current cost and a “real” (excluding inflation) discount rate applied. Normally this will be done on a commercial spreadsheet package, which includes equations for discounted cash flow.
4. Undertake sensitivity analysis of the variables such as the discount rate, the study period, the predicted design lives of components, assumptions about running costs, etc.

Values for the costs should be as accurate as possible. Greater effort may be required for the most significant cost variables. Values can be derived from:

- a direct estimation from known costs and components
- historical data from typical applications
- models based on expected performance, averages etc.
- best guesses of future trends in technology, market and application.

For each cost, there should be an associated time profile of when the cost occurs (or recurs) for Whole Life Costing to be carried out. Time profiles of the costs may only consist of one occurrence but any cost spread over time or one which is repeated will generate a series of cost and time pairs. Costs may be fixed or variable over time. These values are most readily converted into calculations using a computer spreadsheet or purpose-built software.

The costs should be expressed in current terms as many financial or tax transactions are based on actual values at the time rather than the value in future (e.g. the current cost of a boiler should be used, not a projected future cost).

What other variables are important?

Aside from setting the performance criteria, it is essential to determine the following inputs to the calculation:

- the discount rate (if set too high it will make future costs appear insignificant)
- the period of study (often this is the contract period for PFI contracts or the period of foreseeable ownership)
- the format(s) in which whole life costs will be recorded and compared

(HM Treasury requirement for public sector organisations is 3.5% real discount rate, but different rates will be appropriate for different organisations.)

Learning Objectives

You should now have an understanding of the following:

- Comparative estimating
- Bottom up estimating
- Parametric estimating
- PERT (3 point) estimating
- Estimating classifications
- Whole life costing