Cost Estimating Value Enhancement Practice

March 2000

European Construction Institute

ECI Benchmarking Steering Committee

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Value Enhancement Practice

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Source Document

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Preface

Mike Mills, Brown & Root Energy Services, Chairman, ECI Benchmarking Steering Committee

Measurement is the precursor to enhancement. Thus, an important aspect of the work of both the ECI and its American counterpart, the Construction Industry Institute (CII), is the benchmarking of the effect on project performance of a number of Value Enhancing Practices (VEPs). The VEPs selected are those which offer the greatest opportunity for performance enhancement on construction projects. To date, the following VEPs are being measured:

- Team Building
- Strategic Alliances
- Pre-Project Planning
- Design / Information Technology
- Constructability
- Project Change Management
- Safety

As part of the process of continuous improvement, the ECI Benchmarking Steering Committee regularly review VEP development and identify additional practices which can have a significant impact on project outcome. Cost Estimating was identified as one such practice.

The VEP was developed by a Cost Estimating Working Group which drew together participants from the Engineering Construction Industry with specialist knowledge of Cost Estimating. The objectives, set by the Benchmarking Steering Committee, were to:

- distill the key practices used in Cost Estimating,
- determine areas which can be benchmarked,
- develop a source document providing guidance as to what is considered to be current best practice in Cost Estimating,
- distill this guidance into a VEP Summary document, providing the essential core elements of Cost Estimating in guideline form,
- weight the constituent elements relative to their impact on project performance and develop a questionnaire to objectively measure the VEP.

This document contains the VEP Source Document and the VEP Summary.

ECI are grateful to the Benchmarking Steering Committee and the Cost Estimating Working Group for their efforts in developing these documents. Members of the Working Group who compiled this document were:-

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John Harrop	-	Faithful & Gould
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Summary of Value Enhancement Practice

Cost Estimating

1 Definition

Cost Estimating is a planned and systematic process for identifying and predicting costs within the constraints of varying levels of uncertainty and for an identified scope. Good quality estimates are those which are neither conservatively high, due to excessive contingencies, nor optimistically low, due to lack of proper scope definition or unrealistic targets.

2 Characteristics of Effective Cost Estimating

2.1 Estimates predict the cost of work that it is proposed to carry out at some future date. An estimate must recognise the reality that all relevant details cannot be known exactly and consequently some uncertainty will exist about the total cost.

2.2 The items which make up a total estimate can be categorised as follows:-

- Known items, i.e. firm, identified scope with values based on measured or calculated quantities.
- Unknown items, i.e. scope which cannot be quantified but is firmly believed to exist
- Contingency, i.e. an unspecific provision for the whole estimate to cover minor errors or omissions, as well as the uncertainty associated with quantities unit rates and productivity.

Care and clarity is needed when incorporating allowances into estimates so as not to introduce bias or hidden reserves.

2.3 An estimate should be viewed as a set of values within a range of possible outcomes. Accuracy is best described by a probability statement / curve.

2.4 The purpose for which an estimate is required and time available for estimate preparation will determine the estimating methodology together with the quantity and quality of input data that can be brought to bear.

In addition to quantities and unit rates, other key factors which can influence an estimate include: -

- Project execution strategy
- Anticipated project schedule or, as a minimum, a project execution duration
- Phasing of expenditure and cash flow, and escalation assumptions
- Location parameters – (including local practices and productivity)
- Exchange rate
- Allowances for overheads and profit where required.
- The level of contingency necessary to take the total estimate to the required level of confidence

2.5 Estimates should follow a formal review and approval process with a record of the review being issued to all parties involved in the project.

2.6 Estimates should be structured in such a manner that they can satisfy all the uses to which they may subsequently be put. A consistent estimate framework should be adopted and maintained throughout.

2.7 Project execution should contain feedback loops aimed at improving the quality of future estimates. There should be provision for data collection for future estimates. This process may form part of routine cost control and is not, therefore, an additional cost to the project. Strict attention to change control is the key to both good cost control and effective estimate reconciliation.

2.8 Estimates should be subject to ongoing reconciliation throughout the project lifecycle.

3 Recommendations

3.1 There should be a clear understanding of the scope of work to be estimated along with boundaries and exclusions to the estimate.

3.2 For every estimate the methodology adopted should be fit for purpose.

3.3 All key assumptions should be documented and, for larger projects a methodology report produced which documents the project execution strategy. This would take account of commercial issues, contracting arrangements, local issues, sourcing of design / other services and construction philosophy / constraints. The strategy should be agreed with the major project stakeholders.

3.4 The total cost should be divided into a series of standard items.

3.5 An assessment should be made of the quality of information available on:-

- project scope
- project specification
- quantities
- cost data (rates)
- project schedule
- project location factors
- cost escalation

3.6 As part of the estimating process, cross checks should be made against published data, check lists, other current estimates and past project out-turn data to compare level of estimate.

3.7 A formal estimate review and approval process should also be undertaken involving, as appropriate, staff from commercial, project management, design, construction and quality disciplines, along with other stakeholders. To win acceptance from all contributors, it is good practice to hold interim reviews.

3.8 Full account must be taken of commercial factors, e.g.:

- cash flow / expenditure phasing.
- project financing to compensate for differing profiles for cashflow and expenditure.
- exchange rates, where costs are to be incurred in more than one currency
- bonds, guarantees and insurance
- forward escalation of costs, identifying and isolating those items subject to inflation.

3.9 A risk review should be undertaken, identifying those items subject to uncertainty and the range of potential outcomes for the total estimate.
(A separate VEP for Risk Assessment is being prepared.)

ECI Benchmarking Steering Committee

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1 Introduction

The purpose of this document is provide guidance as to what is considered to be best practice in the compilation of cost estimates over the complete project lifecycle. It will give an insight into the estimating process, guidance as to what should be included in an estimate, point to some of the valuable estimating aids that exist, and show how estimates should be presented. This document also considers the importance of a retrospective review in improving the estimating process, as well as the skills and competencies required by the estimator.

Cost estimating can be defined as: -

A planned and systematic process for identifying and predicting costs within the constraints of varying levels of uncertainty and for an identified scope

Given that definition, the difference between a good estimate and a bad one can be considerable. An estimate, by definition, is never "correct." However, good quality estimates are those that are neither conservatively high (due to excessive contingencies, allowances, etc) nor optimistically too low (due to lack of proper scope definition or unrealistic targets).

Companies that consistently produce poor quality estimates will either win no new business or consistently overrun and erode profit margins.

A better way to gauge the quality of an estimate is by the magnitude of under-run or over-run, an approach that is only really valid if there are no scope variations or identified changes during project execution. That in itself is a rare event.

An estimate can only be considered to be good if: -

- each item is priced objectively.
- the project out-turn is within the calculated (estimated/assumed/implicit) spread.

On this basis, estimate quality can only be judged against some independent measure, the best being that of the completed project on which the estimate was based.

By following these guidelines, the chances of compiling what will be considered to be a good estimate will be significantly increased.

2 Estimating Approach

2.1 Scope Structure/Definitions

Key to the preparation of any estimate is a clear understanding of the work to be estimated. To obtain a comprehensive understanding of the work involved it is recommended that a standardised approach to scope definition be adopted. This may incorporate a generic work

package list or set of deliverables, referred to as a work breakdown structure, a cost classification listing, referred to as a cost breakdown structure, and organisational responsibility assignment, referred to as the organisational breakdown structure. Whilst the level of detail required for estimate production may vary, depending upon the type of estimate involved, the following principal points should be considered:

- Scope and its boundaries.
- Schedule.
- Exclusions.

2.2 Project Execution Strategy

Having defined the scope of the work, it is necessary to establish a cost-effective strategy for execution. This should take into account commercial and financial issues, partnering and contracting arrangements, local issues, considerations of sourcing of design, supply and other services, construction philosophy and constraints, and, where appropriate, the competition.

Alternative execution strategies should be assessed against the project objectives, constraints and risks, considering relative strengths, weaknesses, opportunities and threats (SWOT Analysis).

It is recommended that an initial (top down) order of cost and preliminary assessment of risk be allocated to each cost item/work package. This makes it possible to identify the significant cost drivers/risks within the project and enables the estimator to prioritise the work.

The project execution strategy should be documented, possibly in the form of a strategy matrix. This will list all items within the defined scope and assign a responsible party for each phase of execution, from initial basic/process design through to commissioning and start up.

2.3 Estimating Strategy

Whilst developing the project execution strategy consideration should be given to the information and time available for preparation of the estimate. This will help to determine the most appropriate techniques to be adopted and whether in-house estimating is sufficient. If not, external support will be required. The estimating strategy should also be detailed in a methodology document.

2.4 Information Requirements for Different Types of Estimate

The type of cost estimate produced is determined by the following factors: -

- Purpose / use (e.g. for feasibility, sanction, control, tender).
- Project stage / phase (e.g. pre-sanction, pre-construction, construction).
- Level and quality of project scope available (e.g. preliminary details, outline or detailed design).
- Level and quality of data available (e.g. historical, project specific, quotations).
- Time for preparation of the estimate (limiting the estimating methodology and the quality that can be brought to bear).
- Resource level and availability.
- Risk culture of the company.

Estimating techniques vary according to the nature of the estimate required, the level of engineering data and the time available in which to produce the estimate. However, in order to produce any estimate, a number of individual constituent parts need to be present:-

- Project scope
- Project specification
- Quantity
- Rates (cost data)
- Project schedule data
- Local factors / performance efficiency data
- Escalation norms

In all categories data might be actual - prepared specifically for the estimate, historical - in the form of data from a previous project of a similar nature, or judgmental - based upon knowledge and experience.

Cost estimating techniques generally fall into one of two categories:

Top Down / Parametric - used when project scope / design information is minimal.

This type of estimate is usually prepared using, for example, major plant items and factors, cost per unit of function / use, and cost per gross area or volume etc.

Bottom Up / Detailed - used when project scope / design is sufficiently advanced.

Prepared using varying degrees of detailed measurement in conjunction with established rates, supplier quotations, labour-hour and other norms.

Initial estimates for preliminary assessment purposes will usually be prepared with little more data than knowledge of the size and capacity of the plant to be built, probable location and completion date. They will often be based upon ballpark estimating techniques such as cost per tonne of required product and rely heavily on historical data.

Slightly more detailed estimates generally have a better scope definition for major work packages, but may rely on the use of factors for peripheral items such as off-sites, utilities and the balance of plant.

As the need for more detailed estimates arises (e.g. for project sanction or budget estimating), the degree of engineering input will be increased. Preliminary design data and drawings will be produced improving scope and boundary definition and enabling initial parametric data to be replaced.

For fully detailed estimates (e.g. for control purposes or for fixed price tendering), the engineering input will increase again, enabling detailed specifications, drawings and bills of quantities to be produced and prices sought from potential suppliers and contractors.

A project programme should be produced to a level of detail dependent upon the level of estimate. As a minimum the programme should identify the high-level activities and allocate them to the project schedule, thereby introducing time factors and key dates into the estimating process.

In all cases the estimating process must ensure that the estimate covers the required scope of work and no more, and is good practice to ensure a clear audit trail is visible.

Cost and other data

Normally, this will be take the form of a database of cost information and statistics, including labour hour and other norms for particular processes, collected by the estimating department. Sources may be previous projects as well as published data, established estimating manuals and periodicals. In addition use may be made of computer aided design (CAD) packages which have automated facilities for generating quantitative data from drawings and computerised parametric data bases. Sources will have different base dates, and in some instances may have built in provisions for inflation. Some may contain differing provisions for price escalation due to variations and/or scope changes and whether they are based on bids, contract prices, work in progress or completed work. Constant monitoring and full understanding of the context of such data is essential to ensure accurate use and interpretation.

Information Quality

It is good practice to use a checklist to assess the quality of information used in compilation of the estimate.

In recent years a number of measures have been developed to assess the completeness of engineering data used in the compilation of estimates. One example is the Project Definition Rating Index (PDRI), developed by the CII, which allows the status of design information to be rated and a score obtained. It should however be noted that until the basic design concepts have been fixed, the rating would be subject to change.

2.5 Accuracy

The accuracy of the estimate should improve throughout the course of the project as scope and specification definition become firmer and as costs progress from estimated to actual.

Figure 1 shows a typical distribution:

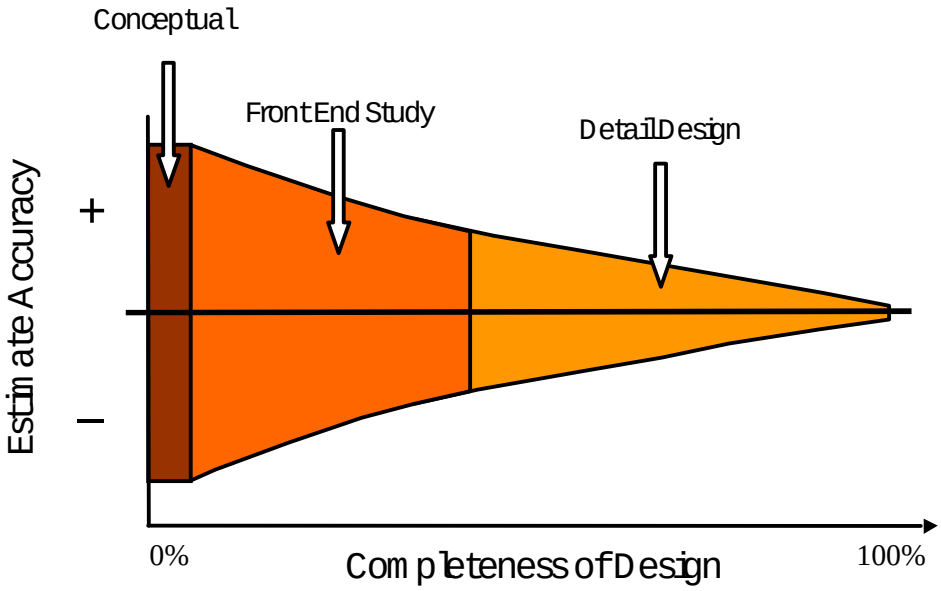


Figure 1: *Improvement in estimate accuracy with each project phase*

The accuracy of an estimate will generally improve with the time spent on its preparation. Figure 2 below indicates the broad relationship between estimate accuracy and time.

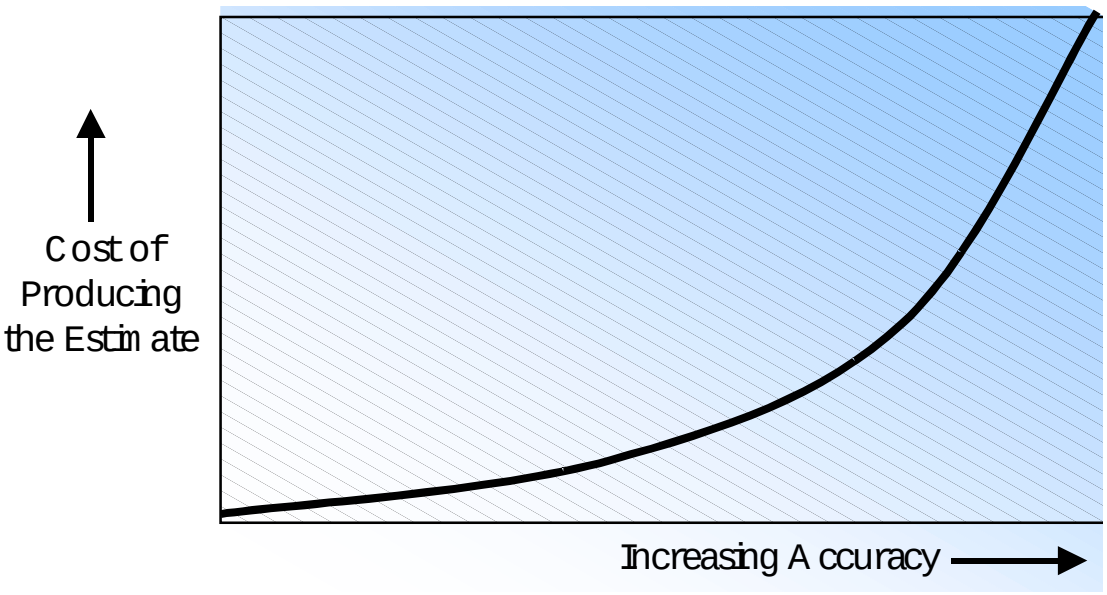


Figure 2: *Increase in estimate accuracy and cost of preparation (typical)*

Estimate accuracy can be best illustrated by a probability statement/curve, indicating that accuracy and risk are one and the same thing. This approach links into risk assessment methodologies.

2.6 Cost Structures

In a typical classification system, the total cost is divided into a series of cost accounts, referred to as the cost breakdown structure (cbs), each of which will represent a significant element of the total cost. Each cost account may be linked to a series of work packages (in the wbs) and organisational responsibility may be identified in an organisational breakdown structure (obs). The use of such structures may also serve as a checklist for defining the scope of work, and will help to ensure that estimates are consistent .The coding system may reflect standard methods of measurement or estimating checklists that are published for the particular disciplines involved

Cost estimates are prepared for a variety of reasons, and it is therefore important to organise them in such a way as to satisfy the various uses to which they will be put. Whilst they may not be prepared specifically for use in implementing a project they usually form an integral part of the project control process. It is therefore desirable that the estimate structure be developed as early as possible and be used consistently throughout the life of the project. Cost estimators should be aware that the commercial success of the project will be significantly influenced by the estimating process.

2.7 Review and Approval

The requirement to review and approve a cost estimate within an organisation should be determined by an internal company control procedure. The procedure will cover factors such as estimate type and level of company exposure. Other factors such as estimator experience and company familiarity with the type of work may also be addressed.

Before a review is started, and as part of the estimating process, cross checks should be made against benchmarks and other existing data to assess the level of the estimate. This will put the estimate into context and provide justification in the review and approval process.

The review should not look simply at the monetary values, but consider the process followed in the preparation of the estimate. For large projects the estimating process should be detailed in a methodology document forming part of the estimate back up.

The approval process needs to win acceptance from all contributors such as project, design and construction teams, and estimators as well as management. To achieve this buy-in it is good practice to hold interim reviews before final completion of the estimate. Decisions on assumptions can be shared, and the estimate can be allowed to evolve, producing fewer surprises and minimising errors.

3 Estimating Processes

3.1 Estimate Formats

The manner in which an estimate is presented can have a significant effect upon its perceived quality so a consistent and standardised approach should be adopted for the layout of both detail and summary estimate sheets. The advent of computerised packages has resulted in data manipulation becoming the key requirement. Layout and presentational aspects are now often seen as secondary requirements. The following guidelines aim to identify the key fields/formats that should be evident on each detail estimate sheet. Summary formats should be tailored to the particular requirements of the relevant organisation. Typical features that should be present on the estimate sheet are: -

Project Title/ Unique Reference/ Date of Compilation

Enables a particular project or enquiry to be readily identified, together with any individual estimates where multiple estimates are involved. An audit trail of changes to the estimate should also be kept, including identification of the person making a change.

Estimate Base Date

Identifies the point in time at which estimate rates were based (i.e. money values).

Estimate Framework

Estimates may be structured in a number of ways, but typically they will either reflect the wbs or the cbs.

Estimate Item Numbers

Each item within a given estimate structure grouping can be identified and tracked by a unique item number.

Estimate Item Description

An accurate definition of each item.

Quantity

The quantity of each item.

Units of Measurement

The unit by which the item has been quantified, i.e. hours, linear metres, tonnes etc.

Unit Rate

This is the monetary cost for a unit of the estimate item. It should be at the same base date as the other rates included in the estimate and have a visible currency base.

Estimate Line Item value

At its simplest this is the product of the quantity and unit rates. However, the calculation may also contain elements to deal with exchange rates, location factors, escalation, discounts and premiums. The estimate structure should make all these adjustments transparent.

Basis of Estimate

Indication of the source of the rate utilised, location of any working papers/ material take-off, information on the quality of the estimate etc. (allowance, quotation etc. for the audit trail). In addition,

- Each estimate sheet should identify the estimator responsible.
- Arithmetic checks and approvals should be signed, initialled or stamped.

This provides the basic building blocks of any estimate. It is important, therefore, that any estimate sheet is logical in its structure and presentation and clear in its content to assist in the scope checking and verification process. It is essential that a clear audit route is visible for both the basis of scope, calculations and rates.

3.2 Checklists

The purpose of an estimating checklist is to ensure that no significant items have been omitted. Different organisations will require certain items to be included for each type of estimate. The degree of detail to which any checklist is developed should reflect the needs of the organisations involved.

Best estimating practice dictates that an organisation should have a generic estimating skeleton, which it can utilise as a checklist. This is likely to reflect the company code of accounts, ensuring that historical cost data is retained in a standard structure. A generic structure has the advantage of being more readily standardised than work breakdown structures, which are usually based upon programme activities. However, in both cases the use of checklists allows for the management of estimate preparation in a consistent manner across an organisation.

3.3 Location Factors/ Performance Efficiencies

It is important to recognise that an estimate can vary significantly depending upon the location and manner in which the work is undertaken. The effect of these variables should be adequately assessed in the estimating process.

Performance efficiencies for labour and location factors need to be applied to labour and material for specific locations on plant (e.g. working at height). In the case of international estimating, the labour rates and productivity must reflect the country in which the work is to be undertaken. Whilst there are a number of published lists of location factors for specific countries (e.g. Richardson International Construction Factors) it is important that location factors used be applicable to the industry in question. The estimator may have to gather information for the location in question.

3.4 Commercial Considerations

Exchange Rates

Where costs will be incurred in more than one currency, assumptions on exchange rates will be required unless the values are to be shown in the currency of expenditure. If a company is active in other countries then it may maintain a list of current exchange rates. The approach adopted should be consistent within a company, particularly when comparing estimates. Each estimate must specify the exchange rates used.

It is likely, as with other parts of the estimate, that assumption made on exchange rates will turn out to be wrong, for reasons that are beyond the control of the estimator. Uncertainties surrounding these assumptions are often better managed through contractual processes and should not adversely affect the perceived quality of the estimate.

It should be clearly understood who is to carry the exchange rate risk. Organisations may operate in different currencies and be better placed to undertake risk mitigation exercises such as currency hedging (taking out an option to buy currency at a later date at a fixed rate), forward buying and taking out currency insurance. Whatever strategy is adopted, the estimate should reflect it and the risk assessment should attempt to quantify the residual risk.

Insurance / Bonds / Guarantees

Before an estimate is completed, a check should be made to determine whether any provision should be made for Insurance, Bonds, Bank Guarantees, ECG (Export Credit Guarantee), ECA (Export Credit Agencies) and the like. In respect of Insurance, care should be taken to avoid any gaps or overlapping of coverage.

Cash Flow and Expenditure Phasing

It is important to produce a timetable indicating when the values within an estimate will be realised. This can show either the cash flow and/or the expenditure phasing.

A cash flow will illustrate the timing of payments both in and out of the company/project. One key purpose of this profile will be to reveal the extent of any financial exposure. This will help determine the level of financing required to execute the project.

The expenditure phasing, also known as 'Value of Work Done' (VOWD), shows the value of work achieved with time. At the start of the project it will reflect the planned physical progress of the work and should be consistent with the project schedule.

Cash flow and expenditure phasing will complement each other, with differences between the two indicating the accrued value of a project.

When calculating any escalation provision for an estimate the expenditure phasing profile should be used as this reflects the actual timing of the work being carried out.

Financing

Any provision required for project financing may be evident from a review of the two profiles of cashflow and expenditure.

Where payments to a Contractor are made according to actual progress, the Contractors financing costs will be small and particularly so where there is neutral funding. Neutral funding is where an Owner makes payments to the Contractor in line with expenditure. This makes the Owner totally responsible for the funding of a project.

If payments by an Owner are to be based upon milestones achieved, the Contractor may require project financing. As part of the cost risk analysis, if carried out, consideration should be given to the possibility of a milestone missing its schedule, thereby incurring additional finance charges.

3.5 Escalation Forecasting

In order to estimate the out-turn cost of a project it is necessary to take into account the potential impact of cost inflation over time. For example: -

- A significant time gap may exist between completion of an estimate and commencement of the project. During the intervening period there may be general or specific changes in cost due to market activity.
- A contract might include an escalation clause allowing the cost to change in line with general increases in labour costs.
- When evaluating the economic value of a project, the full revenue earned and cost incurred need to be incorporated.

It is therefore important that each estimate clearly identifies the period of time for which the estimate is valid. Normally qualifying the estimate as 4Q99, mid 2000, current or real (now) satisfies this requirement. When the estimate has taken escalation into account it will be reflected by the timetable for which it is valid. Terms used to reflect this can be 'escalated', 'inflated', 'MOD' (money of the day), 'outturn' or 'nominal'. Whatever terms are used, they should be consistent across the company.

When calculating escalation it is important to: -

- Identify and isolate those items within the estimate that will be subject to inflation. Establish whether vendor and/or subcontractor quotes are fixed. If not, establish which elements are to be escalated, and when from.
- Escalation is rarely applied to the whole estimate. Where it is the estimate might be raised to a value higher than necessary.
- Utilise published indices, industry or trade specific. Within larger companies there may also be internal inflation factors applicable.
- Where standard factors are not applicable, be clear about assumptions made.

3.6 Allowances

When preparing an estimate, items may be classified into one of the two categories, namely:-

1. **Known Items –** These estimates are for firm, identified scope, and the values may be based upon measured or calculated quantities.
2. **Unknown Items** – These estimates are a provision or allowance for scope which cannot be quantified but which is firmly believed to exist. The values may be based upon historical precedent, ratios, factors or even personal judgement. The estimate methodology should clearly state the reasons for and the basis of the assumptions made. Sometimes this category is called 'Known Unknowns'.

In addition to the specific items above, there is also a need to consider and if necessary provide for the uncertainty inherent with all estimates. This final allowance is usually called Contingency or Unallocated Provision; this, by definition, is an unspecific provision for the whole estimate and generally covers for minor errors or omissions, as well as the uncertainty associated with quantities, unit rates and productivity. It is customary to show this as a percentage, and the actual amount will reflect the uncertainty and confidence in the estimate. The level of contingency can be determined objectively by the estimator or can be calculated using probabilistic methods which are described in more detail in the following section.

Whichever method is used, the level of contingency should take into account the degree to which the estimate is based upon known and unknown items. Contingency is not meant to provide for the 'unknown scope', neither should allowances be introduced to cover for uncertainty. Care must therefore be taken by the estimator to avoid any overlap of provision, and a blurring of distinction between the different categories of allowance.

3.7 Uncertainty/Risk Assessment

It should be noted that this subject is treated in much greater detail in a separate Value Enhancement Practice (VEP) document; what follows is an outline of the main principles involved.

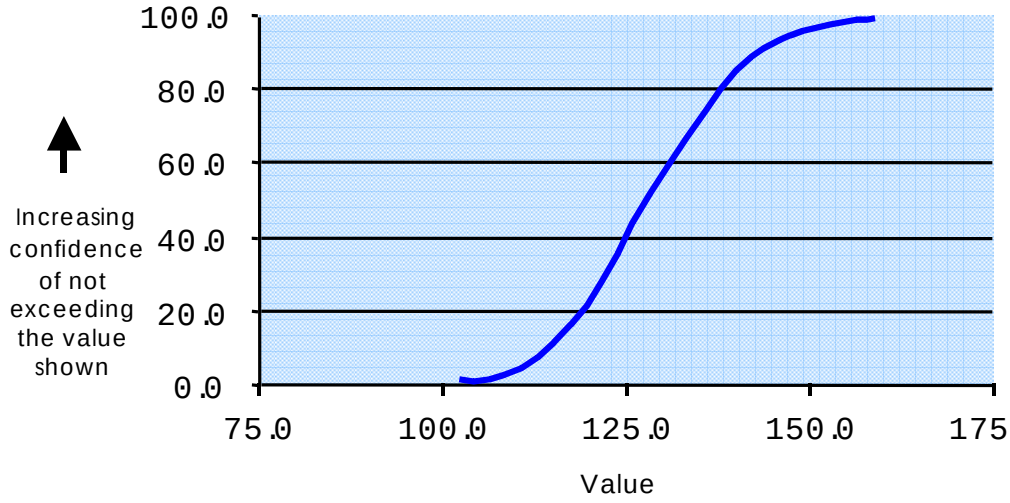
An estimate should not be treated by its customers as an exact value, but rather a set of values within a range of possible outcomes. One of the last and most important roles of the estimator is to ensure that the customer appreciates the range of potential outcomes.

One method by which a range of potential outcomes is calculated is the probabilistic risk analysis. This requires the estimator to address the uncertainty for items within the estimate such as quantities, unit rates, productivity ratios, levels of allowance, etc, by producing a range of potential outcomes for each item. These are called distributions and can be both above and below the initial values used in the estimate. Depending upon the level of sophistication of the risk model, and the application used, it is possible to include correlations between separate estimate items. This allows trends between similar or related estimate items to be taken into account by the risk analysis.

The result of the risk analysis is a range of potential outcomes for the total estimate and is best represented in graphical format either as a histogram or cumulative probability S curve (as shown below). The S curve shows both the range of outcomes and their relative probabilities of occurance. From the example shown, there is a 40% chance that the outcome will be 125 or less; likewise, there is nearly 100% chance that the outcome will be 150 or less.

For the purposes of presenting an estimate to a customer, it is common practice to submit the estimate at standard levels of probability such as P50, P10 or P90. A P50 value has a 50 % chance of being either overrun or underrun, whereas a P90 has a 90% chance of coming in at that level or under.

Probabilistic Risk Analysis is a powerful tool when used correctly but it is not suitable for all estimates, particularly where there is little detail available, such as in early conceptual estimate. The VEP on Risk Management should be consulted for a fuller description of the processes involved.



4 Retrospective Review

To reduce uncertainty cost estimators must focus on providing the most cost-effective level of service in support of the project decision making process.

A key aspect of reducing uncertainty is to look back at what has been previously been achieved, both internally within one's own organisation and externally via benchmarking and continuous improvement processes. However, it is important to recognise that this process necessarily focuses on what could have been achieved whilst possibly ignoring what should have been achieved – narrowing perspective and restricting extraordinary performance.

Effective retrospective reviewing requires: -

- An open and honest culture where participants are prepared and willing to discuss both successes and failures.
- A system for collating out-turn costs.
- An organised estimate structure and project reporting facilitating comparison between estimated and out-turn costs.

- A change control procedure for identification, categorisation and evaluation of changes to the original project scope on which the estimate was based.
- A record of significant events that impacted on out-turn cost.
- Access to those involved on the project to capture circumstances that may be difficult to document.

4.1 Company Culture

Company culture must encourage a wide perspective view of individual functions, if they are to add the greatest possible value to the customer. It is generally understood that in seeking to challenge complacency and improve results, projects and people have to take risks and that occasionally unfavourable outcomes will occur. If the company culture encourages the attribution of blame for all unfavourable outcomes there will be an inevitable drive towards risk-averse cost estimates and in-built or hidden contingencies. In the long term routine overestimation is inefficient and the business may become unprofitable.

Having captured issues at the project level a summary review of the whole portfolio of projects is needed to determine significant trends. This then needs to be disseminated to all concerned in order that systems and processes can be updated.

This process should be repeated frequently in order to determine whether improvements are being achieved.

4.2 Cost Estimate Structure

One of the benefits of adopting a comprehensive work, cost and organisational breakdown structure is that they provide the cross-referencing by which estimated costs can be compared to the out-turn costs.

Views on successes and failures are collected through a series of interviews, sometimes undertaken by an external independent facilitator. Care should also be taken when stripping out exceptional costs from final cost analyses and derived cost ratios. Every project has these costs to a greater or lesser degree and it would be unrealistic to exclude them from the basis for judging accuracy and developing future estimates. Information on the degree of variance, where it occurred and the reasons for it, provide valuable input for future risk analysis studies.

When the work is completed and the final accounts settled they are recorded against the relevant cost headings in order that final costs can be compared against the estimated costs and a table of variances produced. This table should include the real reasons for differences, developed by polling all involved in the project.

4.3 Cost Reporting

As each phase of the project progresses the actual costs involved are documented through a translation process from estimated costs, through commitments in the form of purchase orders, contracts or internal work instructions and eventually into invoices and receipts.

Projects progress by phases, typically inception, feasibility, definition, bidding and construction operations and maintenance, each characterised by increasing levels of scope definition. Often a project is frozen pending a decision to proceed. These “snapshots” provide the opportunity to carry out retrospective reviews as each phase is completed and the reconciliation can be made between each phase of the estimating process.

4.4 Change Control

It is important to have an effective change control process throughout the lifecycle of the project. As a project progresses through its phases it is usual to establish a series of milestones or stage gates for authorisation to proceed. This requires a statement of the scope of the project and a definition of its content. The definition can then be used to evaluate any changes (additions, deletions or revisions) and to perform any economic justifications required.

Records of each change are collated in a change register. This should include evaluation of acceptable options, justification of the selected changes, cost and schedule impacts and authorisation records.

This provides the basis for adjustments to the estimated final project cost as well as an audit trail for retrospective review in line with the wbs/cbs.

4.5 Post Project Review

There may be two opportunities for post project review. The first is conducted when the project has been handed over and reviews estimates for engineering, procurement, construction and commissioning. The second is conducted after an extended period of operation – maybe two or three years – and addresses operations and plant maintenance.

The first opportunity arises on completion of the project and should concentrate on feedback on the quality of cost estimating – how accurate was the forecast project out-turn cost. Other cost indicators (actual cost per key cost driver, level of errors and omissions, contingency use etc.) should also be developed at this stage. There is also an opportunity to review the project delivery strategy to determine whether best value for money was achieved from the chosen procurement route.

The second arises when there is a full picture with respect to plant reliability, maintenance and operations costs. At this time there will also be feedback on the accuracy of the indices used to forecast escalation, currency exchange rates, tender price index, product prices, etc.

Unfortunately, a common feature of many organisations is the tendency to finish one project and move on to the next opportunity. Investing time and effort on closing out should not be seen as delaying the onset of the next opportunity, rather as an opportunity to enhance the project estimating process. Lessons learned, what went well and what did not, increase the opportunity for continuous improvement.

5 Estimating Staff Competencies and Training

When considering the competencies required to work in cost estimating it must be recognised that individuals may work as part of a team or alone. In the former it is likely that personnel will carry out specific functions and specialise in certain aspects of the cost estimating discipline.

Cost estimators should have a sound engineering background with relevant experience of the industry they are working in.

5.1 Knowledge Required

Cost Estimating and Control (Primary Skills)

1. Elements of Cost
2. Code of Accounts (cbs) /Work Breakdown Structure (wbs)
3. Costing and Pricing
4. Estimating Methods
5. Types and Purpose of Estimates
6. Operating/Manufacturing Costs
7. Cost Indices and Escalation Factors
8. Risk Analysis/Contingency
9. Budgeting and Cash Flow.

Additionally, estimators require the following generic skills:

1. Organisation (time and data management)
2. Communication (written and spoken)
3. Interpersonal
4. Learning (holistic).

Estimators must have an appreciation of the following subject areas:

Supporting Skills and Knowledge

1. Computer Operations
2. Measurements/Conversions/Statistics & Probability
3. Cost/Schedule Terminology/Basic Applications
4. Basic Business and Finance
5. Inflation and Discounting.

Project Management

1. Management Theory/Organisational Structures
2. Behavioural Science/Motivational Management
3. Integrated Project Control
4. Planning and Scheduling
5. Quality/Materials Management
6. Resource/Productivity Management
7. Contracts and Contract Administration
8. Social and Legal Issues in Management
9. Health, Safety and Environmental issues (HSE).

Economic Analysis

1. Value Analysis/Value Engineering
2. Depreciation
3. Comparative Economic Studies
4. Profitability
5. Life Cycle Costs
6. Time Value of Money/Engineering Economics
7. Forecasting

5.2 Training Needs

Training may be vocational or through specialist courses. Regardless of the form of the training it must focus on improvements in areas where cost estimators may be expected to be competent. This should be considered as an on-going commitment to continuous improvement and training needs should be identified through regular discussions, at least on an annual basis, with cost estimating staff.

Increasingly estimators are earning due recognition and respect for the valuable contribution that they make to project management. With this recognition however comes responsibility and the need to ensure that estimators by their education, training and experience deliver the highest standard of service possible. This is not just a one-off requirement but should involve a long-term commitment to improvement and development.

5.3 Experience Requirements

Organisations aiming to achieve best practice in this area need to recognise the benefits of encouraging the sharing of experience across all working areas. This involves the facilitation of good communication and the provision of opportunities for job breaks or short-term secondments. It is not appropriate here to be prescriptive regarding the duration or nature of the experience required, but the general principle of learning by experience is commended.

Organisations in different countries have differing qualifications/accreditation. For example in the United Kingdom, National / Scottish Vocational Qualifications (NVQ/SVQ) are nationally recognised qualifications which can contribute to both organisational and individual development. The competencies of cost estimators can be assessed against the NVQ/SVQ in 'Project Control'. Level 3 is intended to have a wide application to all those who have responsibility for controlling at operational levels; the level 4 award is for those individuals who have a more strategic role in project control.

Other routes to professional accreditation include Certified Cost Engineer (CCE) which is accredited by the International Cost Engineering Council or through registration as Incorporated, Chartered or European Engineer through bodies such as the Association of Cost Engineers which are affiliated to the Engineering Council or the Federation of National Engineering Associations.

Although a number of professional opportunities exist to the Cost Estimator, they are no substitute for on the job training which will ensure that hands on experience is gained in the field.

6.0 GLOSSARY OF TERMS

Value Enhancing Practices: - Those elements of project execution which offer the greatest opportunity for performance enhancement on construction projects;

Probability Statement/Curve: - This is the output from the probabilistic Risk Modelling process and represent the percentage confidence of achieving a range of monetary outcomes, for instance 90% confidence in achieving an out turn value of £x or less.

Location parameters: - These are the factors that influence the estimated cost based upon the location and manner in which the work is to be undertaken, they include working in different countries together with performance efficiencies for (say) working at height.

Methodology Document: - This is a formal document which determines exactly how the estimating process is to be undertaken, and defines the responsibilities for information supply and estimate compilation.

Cost Breakdown Structure: - This is a cost classification system, which allows the total cost to be divided into a series of cost accounts.

Work Breakdown Structure: - This is a cost classification that allows the collection of costs against a generic work package list or set of deliverables.

Organisational Structure: - This is a cost classification structure that allows the collection of costs against organisational responsibility assignment.

Derived Cost ratios: - These are metrics resulting from project analysis that can be utilised to carry out sanity checks on estimates i.e. design to capital ratios.

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