HOW COST ESTIMATION CAN DRIVE SMARTER PROJECT MANAGEMENT IN TECHNICAL INDUSTRIES

By Ko des Bouvrie

Cost Engineering Consultancy
Experience:
- Co-founder of Cost Engineering Consultancy and Cleopatra Enterprise
- Senior Consultant with more than 40 years of experience
- Consulting industries such as oil & gas, petrochemical, power, mining & minerals, chemicals, construction and pharmaceutical

Field associations:
- Member of NAP/DACE, AACE International, ICEC and AcostE
- Teacher of cost engineering courses
Introduction
What is estimating?
Estimating techniques
Accuracy of the estimate
Benchmarking and continuous improvement
A Brief Introduction

- 24+ years experience
- Software and consultancy solution
- Operating worldwide
- Knowledge Provider
- Empowering organizations to improve their project performance
Clients and Industries

- Bulk storage
- Construction industry
- EPC(M)
- Food and Nutrition
- Infrastructure
- Offshore
- Oil & Gas industry
- Heavy industry
- Pharmaceutical industry
- Petro-/chemical industry
- Power industry
- Mining & Minerals
Our vision:

- Benchmarking
- Cost Management
- Cleopatra Enterprise Estimating
- Consultancy
- Academy
- Scheduling CESK

CONTINUOUS IMPROVEMENT
What is estimating?
To start: **what is cost engineering?**

- *That area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problems of cost estimating, cost control and profitability.*
The **Profession of Cost Engineering**: Applying methods and techniques for:

- Cost estimating,
- Cost control,
- Scheduling,
- Value engineering,
- Contracting & Tendering,
- Quantity surveying,
- Risk management,
- Profitability analysis,
- Business planning & management science

to support asset and project management.
"It costs time"
"It costs resources"
"It costs money"

Everything invested in assets and projects is a Cost
What is estimating?
What is estimating?

- Predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project.
- Involves assumptions and unknowns
- Goal is to minimize the uncertainty of the estimate given the level of scope definition.
A heated exchange took place between the King and the project manager.

What was **objective**?
- “dig a ditch next to the castle wall”
- or
- “defend the castle from attack”
Estimating techniques
Estimate types through the project lifecycle

**Identification phase**
- Project Initiation Note
- Feasibility Study
  - ± 40% Screening Estimate
  - ± 25% Study Estimate
  - Approval

**Definition phase**
- Development plan
  - ± 25% Budget Estimate
  - Initial Commitment plan
  - Initial Execution Plan
- Basis for design
- Project specification
  - ± 10% Control Estimate
  - Commit. Plan
  - Project Execution plan
  - Operations Reference plan
  - Review
  - Approval

**Execution phase**
- Detailed design
- Materials procurement
- Construction
- Commit. & Cost control
  - ± 5% Counter Estimate
  - Purchase Order control
  - Reporting

**Operational phase**
- Commission, Start-up handover
- Close out
- Operations Reference plan
- Project debrief

**Abandon phase**
- Identical to Execution phase
### AACE Cost Estimate Classification System

<table>
<thead>
<tr>
<th>Estimate Level</th>
<th>Level of Project definition</th>
<th>End Usage</th>
<th>Methodology</th>
<th>Expected Accuracy Range</th>
<th>Preparation Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0% to 2%</td>
<td>Concept Screening</td>
<td>Capacity factored Parametric Models, Judgment or analogy</td>
<td>L: -20% to -50% H: +30% to +100%</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1% to 15%</td>
<td>Study or Feasibility</td>
<td>Equipment factored or Parametric Models</td>
<td>L: -15% to -30% H: +20% to +50%</td>
<td>2 to 4</td>
</tr>
<tr>
<td>3</td>
<td>10% to 40%</td>
<td>Budget, Authorization or Control</td>
<td>Semi-detailed unit cost with assembly level items</td>
<td>L: -10% to -20% H: +10% to +30%</td>
<td>3 to 10</td>
</tr>
<tr>
<td>2</td>
<td>30% to 70%</td>
<td>Control or Bid / Tender</td>
<td>Detailed Unit Cost with Forced Detailed take-off</td>
<td>L: -5% to -15% H: +5% to +20%</td>
<td>4 to 20</td>
</tr>
<tr>
<td>1</td>
<td>50% to 100%</td>
<td>Check Estimate or Bid / Tender</td>
<td>Detailed Unit Cost with Detailed take-off</td>
<td>L: -3% to -10% H: +3% to +15%</td>
<td>5 to 100</td>
</tr>
</tbody>
</table>
Class 5 estimate

- Prepared based on very limited information, and subsequently have wide accuracy ranges.
- Prepared for strategic business planning purposes:
  - Market studies, assessment of initial viability, evaluation of alternate solutions, location studies, etc.
- **Methods** include capacity scaling:
Example: wind turbine, scaled per MW:

\[
\text{Cost new wind turbine} = \text{Cost reference} \left( \frac{\text{Capacity new}}{\text{Capacity reference}} \right)^x
\]

\[
\text{Cost new wind turbine} = € 654,000 \left( \frac{1.24 \text{ MW}}{1.05 \text{ MW}} \right)^{0.6} = € 723,000
\]
Class 4 estimate

- Prepared based on limited information and subsequently have fairly wide accuracy ranges.
- Typically used for project screening, determination of feasibility, concept evaluation, and preliminary (but generally not final) budget approval.
- **Methods:** factor and parametric estimating.
Class 4 estimate

- **Factor estimating example: Lang factor method**
  - More detailed than the six-tenth method
  - Needs sufficient specification of equipment
  - Basis: equipment prices free at site (including transportation cost to site)

Total Installed Cost = Process equipment cost \times \text{Lang factor}
## Lang Factors

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor</th>
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<tr>
<td>Process equipment</td>
<td>1.00</td>
</tr>
<tr>
<td>Free at site</td>
<td></td>
</tr>
<tr>
<td>Foundation</td>
<td>1.43</td>
</tr>
<tr>
<td>Supporting</td>
<td>1.57(A)</td>
</tr>
<tr>
<td>Platforms</td>
<td>1.79(B)</td>
</tr>
<tr>
<td>Insulation</td>
<td>2.79(C)</td>
</tr>
<tr>
<td>Assembly</td>
<td></td>
</tr>
<tr>
<td>Piping, including Insulation</td>
<td>2.36 (A)</td>
</tr>
<tr>
<td>Preparing the terrain for building</td>
<td>2.68 (B)</td>
</tr>
<tr>
<td>Buildings</td>
<td>3.43 (C)</td>
</tr>
<tr>
<td>Electrical installations</td>
<td></td>
</tr>
<tr>
<td>Instrumentation</td>
<td></td>
</tr>
<tr>
<td>Insurance, taxes</td>
<td></td>
</tr>
<tr>
<td>Contingency</td>
<td></td>
</tr>
<tr>
<td>Engineering including temporary facilities and construction supervision</td>
<td></td>
</tr>
</tbody>
</table>

(A) = Solids  
(B) = Solids/Liquids  
(C) = Liquids
Class 4 estimate

- **Parametric estimating example**
  - Parametric relation between cost and weight of a pressure vessel:
Class 3 estimate

- Prepared to form the basis for budget authorization, appropriation, and/or funding.
- In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control.
- **Methods**: hybrids between factor/parametric and deterministic methods.
Composites can also be made for:

- Instrumentation hook-ups
- Electrical lighting
- Structures / pipe racks

Build up of a piping composite:

- 14 m of pipe
- 5 fittings
- 6 flanges
- 4 valves
- Fitting Factor per meter pipe = 0.79
- Valve Factor per meter pipe = 0.29

Composites for generating more detailed estimates, based on limited information:

Class 3 estimate
Objects combine composites:
- 4.5” pipe
- 150 m pipe per equipment
- 0.9 – 1.2 Control valve per equipment
- 5.5 Field instruments per equipment
- 3 lighting fixtures per equipment
Deterministic (detailed) estimate.

Forms a detailed control baseline against which all project work is monitored in terms of cost and progress control.

For contractors, this class of estimate is often used as the “bid” estimate to establish contract value.

Method: prepared from material lists and detailed design drawings. At this stage, not all quantities are known yet, so some still need to be based on typical quantities.
Example unit rate for painting a 2” steel pipe.

Cost contains:
- Labour hours and rate
- Rental tools and materials

<table>
<thead>
<tr>
<th>Level ID</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Total cost</th>
<th>Cost category</th>
<th>Non labour cost</th>
<th>Labour hours</th>
<th>Rental hours</th>
<th>Non labour cost</th>
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<tbody>
<tr>
<td></td>
<td><strong>Details</strong> Surface preparation, <strong>Power tool cleaning STA, Re7- 40/50%</strong></td>
<td>0.01 m²</td>
<td></td>
<td>0.08 Instal</td>
<td>Material</td>
<td>0.00</td>
<td>0.19</td>
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<td>Material</td>
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<td>0.40</td>
<td>0.40</td>
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<td></td>
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<td>0.01 t</td>
<td></td>
<td>0.96 Material</td>
<td></td>
<td>111.59</td>
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<tr>
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<td>0.03 h</td>
<td></td>
<td>1.88 Construction tools &amp; equipment</td>
<td>0.00</td>
<td>0.00</td>
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<td></td>
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<td></td>
<td>0.02 Construction tools &amp; equipment</td>
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<td>0.00</td>
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<td></td>
<td><strong>Details</strong> Surface preparation, <strong>Chipping hammer, Rent</strong></td>
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<td></td>
<td>0.00 Construction tools &amp; equipment</td>
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<td>0.00</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Details</strong> Surface preparation, <strong>Blasting grit, Disposal</strong></td>
<td>0.01 t</td>
<td></td>
<td>1.14 Miscellaneous</td>
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<td><strong>Details</strong> Painting, &gt;+120 up to +200 °C, CS, (m2), Field</td>
<td>0.25 m²</td>
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<td>0.84 Instal</td>
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<td>0.00</td>
<td>0.08</td>
<td>0.06</td>
<td>44.10</td>
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<td><strong>Details</strong> Painting, &gt;+120 up to +200 °C, CS, (m2), Prefab</td>
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<td>0.88 Prefabrication</td>
<td></td>
<td>0.00</td>
<td>0.06</td>
<td>0.06</td>
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<td><strong>Details</strong> Painting, &gt;+120 up to +200 °C, CS, (m2), Material</td>
<td>0.25 m²</td>
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<td>2.87 Material</td>
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<td>11.32</td>
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</table>
Accuracy of the estimate
An estimate should not be regarded as a single point number (or cost)

An estimate is a range of potential cost outcomes, and associated probabilities of occurrence

Thus – the accuracy range of an estimate is a probabilistic assessment of how far a project’s final actual cost can be expected to vary from the estimate

- The range is driven by risks
Estimate Accuracy Range

Probability

Higher probability of overrun than underrun

P10
€ 0.8
€ 1 Million
Base estimate

P90
€ 1.4
Cost

(-20%)  (+40%)
Accuracy Range (80% confidence)
Estimate Accuracy Range

- **P50**: equal probability of over- and underrun

- **Probability**

- **Cost**
  - € 0.8
  - € 1.1 Million
  - € 1.4

- **Estimate with contingency**

- **Accuracy Range (80% confidence)**
  - (-25%) to (+30%)
• Contingency does not increase the accuracy of the estimate
• Contingency reduces the probability of overrunning the budget
• Management decides
Estimate Accuracy and Project Definition

- **Class 5**
  - Order of magnitude
  - P50
  - P10
  - Base
  - P90
  - +50%
  - -30%

- **Class 3/2**
  - Study Type
  - Class 4
  - P90
  - P50
  - Control Estimate
  - Class 1
  - P90
  - +12%
  - -10%

- **Class 1**
  - Budget Type
  - Class 3/2
  - P90
  - P50

80% confidence interval
Scope creep raises P50

80\% confidence interval

Order of magnitude Class 5

Base

P10

P50

P90

Study Type Class 4

Budget Type Class 3/2

Control Estimate Class 1

Zero baseline

80\% confidence interval

Scope creep raises P50
Influences on the estimate

- Scope definition
- Software Tools
- Database
- Risk
  - Systemic risk (driven by organisation)
  - Project-specific risk
- Market influences
- Knowledge of the cost engineer
Benchmarking and continuous improvement
Benchmarking for continuous improvement

Early estimates using factors and parametric models

TIC factor

Detailed Estimate
Based on detailed Material Take-Off

Gather key quantities

Benchmarking:
Develop metrics and characteristic values

Project planning

Project execution

Project closing

Project initiation
Examples

- **Cost & schedule competitiveness**
  - How did the project perform compared to similar projects (internal and/or external)?

- **Cost & schedule factor**
  - How does productivity compare?

- **Cost & schedule growth**
  - How good were the estimate and schedule at predicting final outcomes?
Software systems support an integrated approach. As a result, maximum performance can be achieved.

Examples:
- Setting up a transparent budget meeting stakeholder requirements.
- Monitoring of project costs and planning during execution
- Visualize performance indicators / KPIs
- Provide improved forecasting information
- Perform Big Data analysis to retrieve meaningful ratios and metrics from projects to Benchmark and calibrate estimating data.
Integrated software for continuous improvement