Chapter 8
Cost Estimating and Budgeting

Project Management for Business, Engineering, and Technology

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Cost Overruns on Projects

Sources of Cost Escalation and Overruns

- Uncertainty and Lack of Accurate Information
- Changes in Requirements or Design
- Economic and Social Factors
- Inefficiency, Poor Communication, and Lack of Control
- Ego Involvement of the Estimator
- Project Contract
- Bias and Ambition
Cost Estimating and the Systems Development Life Cycle

Cost estimate

Contingency fund

Cumulative cost

Cost estimate

Regions of time-cost uncertainty

At project initiation

At project definition

At project execution

Time
System Life Cycle Costs

**Life cycle costs (LCC)**

- All costs of a system throughout its full cradle-to-grave life cycle, i.e.:
  - all costs incurred during the *project* life cycle phases of Definition and Execution
  - PLUS all costs associated with the Operations phase of the system and the eventual disposal of the system
Purpose of life cycle cost analysis

- To anticipate the realities of *operating*, *maintaining*, and (ultimately) *disposing of* the end-item system.
- To *establish target costs* for operating, maintaining, and disposing of the end-item system.
- To *design* the system so it will meet those target costs.
Estimating Process

Estimate versus Target or Goal

- **Estimate**: a *realistic assessment* based upon known facts about the work, required resources, constraints, and the environment, derived from estimating methods.

- **Target or goal**: a desired outcome, commitment, or promise.

Don’t confuse estimates with goals. The estimating process is directed at producing good estimates, not restating targets or goals.
Estimating Process

Accuracy versus Precision

- **Accuracy**: the closeness of the estimated value to the actual value
- **Precision**: the number of decimal places in the estimate.
- Accuracy of estimates is more important than precision
Estimating Process

**Estimating Methods**

1. Expert opinion
2. Analogy + compensation for differences
3. Parametric: Formula or Cost Function, e.g.,

\[
\text{Cost, engine A} = (\text{Cost, engine B}) \left( \frac{\text{Thrust, engine A}}{\text{Thrust, engine B}} \right)^{0.7}
\]

\[
\text{Cost, cabling} = 150 \left( \text{total area} + 10\% \right) + 300\sqrt{\text{number of rooms}} + 125 \left( \text{number of floors} \right)
\]
4. Cost engineering
   Detailed cost breakdown of labor, materials, etc. at the work package or task level.
   Example below
Schedule showing hours allocated to work packages by labor grade.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>H</td>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Total, 1 = 60
Total, 2 = 30
### Labor Hours and Nonlabor Costs

<table>
<thead>
<tr>
<th>Work Package</th>
<th>Hours by Labor Grade</th>
<th>Nonlabor Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Material</td>
</tr>
<tr>
<td>A</td>
<td>60</td>
<td>500</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>40</td>
<td>8,000</td>
</tr>
<tr>
<td>G</td>
<td>100</td>
<td>1,500</td>
</tr>
<tr>
<td>H</td>
<td>70</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>$10,000</td>
</tr>
</tbody>
</table>

**Labor Grade**

\[
\text{Hours} \times \text{Labor Rate} \times (100\% + \text{Overhead Rate}) = \text{Labor Cost}
\]

- 1: \(305 \times $20 \times (100\% + 90\%) = $11,590\)
- 2: \(350 \times $25 \times (100\% + 100\%) = $17,500\)
- 3: \(100 \times $40 \times (100\% + 120\%) = $8,800\)

**Preliminary Estimate**

\[
\text{Preliminary Estimate} = \text{Labor Cost} + \text{Nonlabor Costs}
\]

\[= $37,890 + $26,500 = $64,390\]

**Final Estimate**

\[
\text{Final Estimate} = \text{Preliminary Estimate} + \text{G/A Rate}
\]

\[= $64,390 \times (100\% + 10\%) = $70,829\]

**Budget**

\[
\text{Budget} = \text{Final Estimate} + \text{Contingency (Reserve)}
\]

\[= $70,829 + $7,100 = $77,929\]
Estimating Process

- Any of these methods can be used in any area of project

- Parametric and cost engineering methods are the best
Estimating Process

- Rule of Thumb:
  The smaller the work packages or portion of the end-item estimated, the better the estimate
Estimation Process

Procedure for larger projects

1. Project Management (PM)

2. Functional Management (FM)

3. Work Team Leads

WBS Information
Estimation Process

Procedure for larger projects, steps 1-3

1. PM: Uses WBS to identify work packages
2. FM: Subdivide work packages into identifiable tasks; determine labor, material, facilities, and resources requirements for each
3. Supervisors/team leads: Estimate number of labor hours and quantities of materials needed
Estimation Process

Project Management

Functional Management

Work team

6. Labor and cost estimates

4., 5.
Estimation Process

Procedure for larger projects, steps 4-6

4. FM: check and aggregate time and material estimates
5. FM: convert time estimates into costs
6. PM: checks over and approves all estimates aggregates costs; added in overhead costs:

Project cost = \( \sum \text{direct costs} + \sum \text{overhead costs} \)
Estimation Process

Project Management  7., 8.

Functional Management

Work team
Estimating Process (cont’d)

Procedure for larger projects, steps 7-8

7. PM: Adds in contingency amounts.

Two possible contingencies

1. Base estimate = \( \Sigma \) (WP estimates + WP contingency) (to handle “known-unknowns”)

2. Final estimate = Base estimate + overheads + project contingency (to handle “unknown unknowns”; PM controls this)

8. PM: Compares bottom-up estimates to top-down targets or goals. Attempt to reconcile differences.
Estimating Process

Estimates can be made at any level

- project
- work package
- task
Project Budget

- Specific for each project
  - Not a fiscal budget.
- Subdivided into Control Accounts, one for each work package
- Each cost account is a portion of the project total budget
- Rosebud Example
## Elements of Typical Budget

### I. Direct Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Labor (DL)</strong></td>
<td>50,000.00</td>
</tr>
<tr>
<td>Charges for labor working directly on project</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Overhead on Labor (% of DL)</strong></td>
<td>20,000.00</td>
</tr>
<tr>
<td>Labor support: benefits, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Nonlabor and Materials (M)</strong></td>
<td>10,000.00</td>
</tr>
<tr>
<td>Subcontractors, consultants, travel, telephone, materials, purchased parts</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Overhead on Nonlabor and Materials (% of M)</strong></td>
<td>3,333.33</td>
</tr>
<tr>
<td>Shipping, insurance, security, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Total</strong></td>
<td>83,333.33</td>
</tr>
</tbody>
</table>

### II. General & Administrative (% of Direct Total)

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(Indirect overhead)</strong></td>
<td></td>
</tr>
<tr>
<td>Corporate overhead: proposals, publicity, president, etc.</td>
<td>16,667.00</td>
</tr>
<tr>
<td><strong>Budget Amount</strong></td>
<td>100,000.00</td>
</tr>
</tbody>
</table>
Project budget subdivided into control accounts

ROSEBUD

Project Budget $356,755

Cost Accounts

Project management

- Basic design: $31,362
  - Materials: $138,571
  - Assembly: $20,945

- Hardware: $179,868
  - Installation: $20,352

- Software: $122,228
  - Procedures: $100,846
  - Specifications: $21,272

- Final Tests: $10,857
  - User Test: $6,622
  - System Test: $4,235
Project Budget

- The best project budgets are time-phased to allow cost tracking vs. time
- Example
### Project: ROSEBUD
#### Department: Programming

**Work Package L: S/W Specifications**

<table>
<thead>
<tr>
<th>Charge</th>
<th>Rate</th>
<th>Months</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct labor</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional</td>
<td>$35/hr.</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Associate</td>
<td>$30/hr</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td>Assistant</td>
<td>$20/hr</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Direct labor cost</strong></td>
<td></td>
<td>6,050</td>
<td>11,050</td>
</tr>
<tr>
<td>Labor overhead</td>
<td>75%</td>
<td>4,538</td>
<td>5,000</td>
</tr>
<tr>
<td>Other direct cost</td>
<td></td>
<td>3,750</td>
<td>11,050</td>
</tr>
<tr>
<td><strong>Total direct cost</strong></td>
<td></td>
<td>10,588</td>
<td>19,338</td>
</tr>
<tr>
<td>General/administrative</td>
<td>10%</td>
<td>1,059</td>
<td>1,059</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td></td>
<td>11,647</td>
<td>21,272</td>
</tr>
</tbody>
</table>

*Should extend for as many months as required by the project.*

*Should be itemized to include costs for materials, freight, subcontracts, travel, and all other nonlabor direct costs.*

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**Budget for programming department for Work Package L:**
Project Cost Accounting System

- Enables budget information be aggregated or disaggregated according to work packages or functional areas
- Example
Aggregation of cost account information by project and organization.

ROSEBUD
$356,755

- Project management
  - $12,550
- Basic design
  - $31,362
- Hardware
  - $179,868
- Software
  - $122,228
- Final tests
  - $10,857

KANE, Assoc.
$356,755

- Engineering
  - $70,209
  - $31,362
- Programming
  - $25,507
- Purchasing
  - $239,417
- Technical support
  - $9,072

Materials
- $138,571
Assembly
- $20,945
- $17,902
Installation
- $20,352
Specifications
- $21,272
- $21,272
System test
- $4,235
- $4,235
User test
- $6,622
- $6,622
Project Cost Accounting System; Cost Monitoring

Weekly Expense and Cumulative Expense Profiles.

- Created from work package budgets and the project schedule
- Assume expenses occur uniformly throughout work package duration
- Example
Project Cost Accounting System; Cost Monitoring

- Weekly expense profile
  - Analogous to resource loading profile
- Example
Compute uniform per-week cost (analogous to weekly resource requirement)

For each work package, total budget, time, and average per-week expense (assume uniform expenditure through time period)

<table>
<thead>
<tr>
<th>Work Package</th>
<th>Budget ($)</th>
<th>Time (wks)</th>
<th>Per-week ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project mgt</td>
<td>$12,550</td>
<td>24</td>
<td>$523</td>
</tr>
<tr>
<td>J</td>
<td>$31,362</td>
<td>6</td>
<td>$5,227</td>
</tr>
<tr>
<td>M</td>
<td>$138,571</td>
<td>4</td>
<td>$34,643</td>
</tr>
<tr>
<td>V</td>
<td>$20,945</td>
<td>6</td>
<td>$3,491</td>
</tr>
<tr>
<td>Y</td>
<td>$20,352</td>
<td>5</td>
<td>$4,070</td>
</tr>
<tr>
<td>L</td>
<td>$21,272</td>
<td>2</td>
<td>$10,636</td>
</tr>
<tr>
<td>Q</td>
<td>$100,846</td>
<td>8</td>
<td>$12,606</td>
</tr>
<tr>
<td>W</td>
<td>$4,235</td>
<td>1</td>
<td>$4,235</td>
</tr>
<tr>
<td>X</td>
<td>$6,622</td>
<td>1</td>
<td>$6,622</td>
</tr>
<tr>
<td></td>
<td>$356,755</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Sum per-week costs across all tasks according to schedule.

Plot showing expected per work expenses based on scheduled activities and per-week costs of each.
Cumulative expense profile shows the Budgeted Cost of the Work Scheduled (BCWS), which is the expected expenditure growth throughout the project.

Example
Rosebud Project

Early start times

Cumulative expense profile

Weekly expense ($1000)

Cumulative expense ($10000)

BCWS

1 Jan 2 Feb 3 Mar 4 Apr 5 May 6 June 7 July

S356,755
Project Cost Accounting System; Cost Monitoring

- Planning and Control
  - The weekly and cumulative expense profiles are used to adjust schedules to accommodate cash-flow and working capital constraints
  - Example
Late start times
Cumulative expense profile, early start
Cumulative expense profile, late start of L and Q

Weekly expense profile, late start

Weekly expense profile, late start of L and Q

Maximum required Working capital

Cumulative expense profile, early start

1 Jan 2 Feb 3 Mar 4 Apr 5 May 6 June 7 July
Project Cost Accounting System; Cost Monitoring

- Planning and Control
  - During project execution actual expenses are tracked against BCWS
  - Example