Constructive Cost Model
COCOMO

Adapted from Allan Caine
Outline

- COCOMO in a Coconut-shell
- Complete Examples
- Intermediate COCOMO: Cost Drivers
- Advantages and Limitations of COCOMO
COCOMO in a Coconut-shell

\[ E = a (KLOC)^b \]

- Where
  - E is the Effort in staff months
  - a and b are coefficients to be determined
  - KLOC is thousands of lines of code
## The Constants

<table>
<thead>
<tr>
<th>Mode</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>2.4</td>
<td>1.05</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>3.0</td>
<td>1.12</td>
</tr>
<tr>
<td>Embedded</td>
<td>3.6</td>
<td>1.20</td>
</tr>
</tbody>
</table>
The Modes

- **Organic**
  - 2-50 KLOC, small, stable, little innovation

- **Semi-detached**
  - 50-300 KLOC, medium-sized, average abilities, medium time-constraints

- **Embedded**
  - > 300 KLOC, large project team, complex, innovative, severe constraints
Examples

- Suppose size is 200 KLOC,
  - Organic
    - $2.4(200)^{1.05} = 626$ staff-months
  - Semi-Detached
    - $3.0(200)^{1.12} = 1,133$ staff-months
  - Embedded
    - $3.6(200)^{1.20} = 2,077$ staff-months
Project Duration

\[ TDEV = c \left( E \right)^d \]

- Where
  - TDEV is time for development
  - $c$ and $d$ are constants to be determined
  - E is the effort
## Constants for TDEV

<table>
<thead>
<tr>
<th>Mode</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>2.5</td>
<td>0.38</td>
</tr>
<tr>
<td>Semi-detached</td>
<td>2.5</td>
<td>0.35</td>
</tr>
<tr>
<td>Embedded</td>
<td>2.5</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Example

- Picking up from the last example,
  - Organic
    - $E = 626$ staff months
    - $TDEV = 2.5(626)^{0.38} = 29$ months
  - Semi-detached
    - $E = 1,133$
    - $TDEV = 2.5(1133)^{0.35} = 29$ months
  - Embedded
    - $E = 2077$
    - $TDEV = 2.5(2077)^{0.32} = 29$ months
Average Staff Size

\[
SS = \frac{E}{TDEV} = \frac{[\text{staff} - \text{months}]}{[\text{months}]} = [\text{staff}]
\]
Productivity

\[ P = \frac{\text{Size}}{E} = \frac{\text{[KLOC]}}{\text{[staff - months]}} = \frac{\text{KLOC}}{\text{staff - month}} \]
Complete Example, Organic

- Suppose an organic project has 7.5 KLOC,
  - Effort $2.4(7.5)^{1.05} = 20$ staff–months
  - Development time $2.5(20)^{0.38} = 8$ months
  - Average staff $20 / 8 = 2.5$ staff
  - Productivity $7,500$ LOC / $20$ staff-months $= 375$ LOC / staff-month
Complete Example, Embedded

Suppose an embedded project has 50 KLOC,

- Effort $3.6(50)^{1.20} = 394$ staff–months
- Development time $2.5(394)^{0.32} = 17$ months
- Average staff $394 / 17 = 23$ staff
- Productivity $50,000$ LOC / $394$ staff-months = $127$ LOC / staff-month
## Comparison

<table>
<thead>
<tr>
<th>Item</th>
<th>Organic</th>
<th>Embedded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort (staff-months)</td>
<td>20</td>
<td>394</td>
</tr>
<tr>
<td>Development Time</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Average Staff</td>
<td>2.5</td>
<td>23</td>
</tr>
<tr>
<td>Productivity</td>
<td>375</td>
<td>127</td>
</tr>
</tbody>
</table>
Intermediate COCOMO

\[ E = a \left( KLOC \right)^b \times C \]

- Where
  - E is the effort
  - a and b are constants (as before)
  - KLOC is thousands of lines of code
  - C is the effort adjustment factor

New
Cost Drivers

- Intermediate COCOMO introduces Cost Drivers
- They are used because
  - they are statistically significant to the cost of the project; and
  - they are *not* correlated to the project size (KLOC).
Categories

- I. Product Attributes
- II. Computer Attributes
- III. Personnel Attributes
- IV. Project Attributes
I. Product Attributes

- RELY Required Software Reliability
- DATA Data Base Size
- CPLX Product Complexity
II. Computer Attributes

- **TIME** Execution Time Constraint
- **STOR** Main Storage Constraint
- **VIRT** Virtual Machine Volatility\(^1\)
- **TURN** Computer Turnaround Time

\(^1\)The hardware and software in combination.
III. Personnel Attributes

- ACAP Analyst Capability
- AEXP Application Experience
- PCAP Programming Capability
- VEXP Virtual Machine Experience\(^1\)
- LEXP Programming Language Experience

\(^1\)The hardware and software in combination.
IV. Project Attributes

- **MODP**  Modern Programming Practices
- **TOOL**  Use of Software Tools
- **SCED**  Required Development Schedule
Example

- Suppose the following assumptions are made:

**TABLE 8-6 Cost Driver Ratings: Microprocessor Communications Software**

<table>
<thead>
<tr>
<th>Cost Driver</th>
<th>Situation</th>
<th>Rating</th>
<th>Effort Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELY</td>
<td>Local use of system, No serious</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>recovery problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA</td>
<td>20,000 bytes</td>
<td>Low</td>
<td>0.94</td>
</tr>
<tr>
<td>CPLX</td>
<td>Communications processing</td>
<td>Very high</td>
<td>1.30</td>
</tr>
<tr>
<td>TIME</td>
<td>Will use 70% of available time</td>
<td>High</td>
<td>1.11</td>
</tr>
<tr>
<td>STOR</td>
<td>45K of 64K store (70%)</td>
<td>High</td>
<td>1.06</td>
</tr>
<tr>
<td>VIRT</td>
<td>Based on commercial microprocessor hardware</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td>TURN</td>
<td>Two-hour average turnaround time</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td>ACAP</td>
<td>Good senior analysts</td>
<td>High</td>
<td>0.86</td>
</tr>
<tr>
<td>AEXP*</td>
<td>Three years</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td>PCAP</td>
<td>Good senior programmers</td>
<td>High</td>
<td>0.86</td>
</tr>
<tr>
<td>VEXP</td>
<td>Six months</td>
<td>Low</td>
<td>1.10</td>
</tr>
<tr>
<td>LEXP</td>
<td>Twelve months</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td>MODP</td>
<td>Most techniques in use over one</td>
<td>High</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOOL</td>
<td>At basic minicomputer tool level</td>
<td>Low</td>
<td>1.10</td>
</tr>
<tr>
<td>SCED</td>
<td>Nine months</td>
<td>Nominal</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Effort adjustment factor (product of effort multipliers)</td>
<td>1.17</td>
<td></td>
</tr>
</tbody>
</table>
Example ..2

- So, the nominal amount of staff-months will be increased by 17% for organic, semi-detached, or embedded projects.
- Suppose it is estimated that a project will take 51 nominal staff-months at $5,000 / staff-month.
- The cost:
  - Nominally, $255,000 (51 X $5,000)
  - Adjusted, $298,350 (51 X $5,000 X 1.17)
The "Proof"
Advantages

- Based on history
- Repeatable
- Unique adjustment factors
- Has different modes
- Works well on similar projects
- Highly calibrated
- Well-documented
- Easy to use
Limitations

- Ignores requirements volatility
- Ignores documentation
- Ignores customer’s “skill”
- Oversimplifies security
- Ignores software safety
- Ignores personnel turnover
- Ignores many hardware issues
- Personnel experience may be obsolete
- Must know the cost drivers
- Must be able to predict project size
Final Word

“The models are just there to help, not to make the management decisions for you.”

-- Barry Boehm