COTS-Based Systems (CBS)

Total Lifecycle Effort Modeling with COCOMO II & COCOTS

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The Aerospace Corporation, El Segundo, CA

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Briefing Outline

- COCOMO II Modeling
- COCOTS: Development Model
- COTS Integration Effort Distributions
- COCOTS: Latest Glue Code Submodel Calibration
- COCOMO II/COCOTS Integrated Tool
- CBS Post-deployment Modeling Horizon
- Current Insights into Maintenance Phase Issues
- COCOTS: Maintenance Phase Straw Model
- COTS-LIMO: A CBS Economic Lifespan Model
- COCOTS Benefits
COCOMO II MBASE Effort & Schedule Distribution Percentages

<table>
<thead>
<tr>
<th>Effort -</th>
<th>Schedule -</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td>IRR</td>
</tr>
<tr>
<td>24%</td>
<td>LCO</td>
</tr>
<tr>
<td>100%</td>
<td>LCA</td>
</tr>
<tr>
<td>76%</td>
<td>IOC</td>
</tr>
<tr>
<td>12%</td>
<td>RRR</td>
</tr>
</tbody>
</table>

Staffing: 12.5% 37.5% 100% 62.5% 12.5%

Time: COCOMO II MBASE Effort & Schedule
COCOTS: Development Model

1. COTS Assessment
2. COTS Tailoring
3. Glue Code Development
4. System Effort due to COTS Volatility

New System Development
Not Involving COTS Components

LCO – Lifecycle Objectives
LCA – Lifecycle Architecture
IOC – Initial Operational Capability

COCOMO II Effort Estimate
COCOTS Effort Estimate
Total COTS Development Effort Distribution

COTS Development Activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>% of Total COTS Development Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>assessment</td>
<td>7.8%</td>
</tr>
<tr>
<td>tailoring</td>
<td>27.7%</td>
</tr>
<tr>
<td>glue code</td>
<td>45.5%</td>
</tr>
<tr>
<td>volatility</td>
<td>19.0%</td>
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</tbody>
</table>
Average COTS Development Effort Distribution

Mean % of Total COTS Effort by Activity (+/- 1 SD)

- assessment: 49.07% ± 7.57%
- tailoring: 50.99% ± 7.48%
- glue code: 61.25% ± 0.88%
- system volatility: 20.27% ± 2.35%

% Person-months

0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00%

-20.00% -10.00% 0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00%
New Glue Code Submodel Results

• Current calibration looking reasonably good
  – Excluding projects with very large, very small amounts of glue code (Effort Pred):
    • [0.5 - 100 KLOC]: Pred (.30) = 9/17 = 53%
    • [2 - 100 KLOC]: Pred (.30) = 8/13 = 62%

  – For comparison, calibration results as of February 2000:
    • [0.1 - 390 KLOC]: Pred (.30) = 4/13 = 31%

• Propose to revisit large, small, anomalous projects
  – A few follow-up questions on categories of code & effort
    • Glue code vs. application code
    • Glue code effort vs. other sources
### New Glue Code Submodel Results (Detailed)

Overly large and small glue code projects set aside.  

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>eff size (ksloc)</th>
<th>B</th>
<th>xEAF (est)</th>
<th>(rpt'd)</th>
<th>%Rerr</th>
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<tbody>
<tr>
<td>B</td>
<td>468</td>
<td>1.04</td>
<td>0.510453806</td>
<td>650.7163767</td>
<td>984.53%</td>
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<tr>
<td>C</td>
<td>25</td>
<td>1.04</td>
<td>1.852572737</td>
<td>112.20507</td>
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<tr>
<td>N3</td>
<td>20</td>
<td>1.04</td>
<td>0.322405591</td>
<td>15.48293759</td>
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<tr>
<td>S</td>
<td>4.2</td>
<td>1.04</td>
<td>2.390191594</td>
<td>22.64600403</td>
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<tr>
<td>P2</td>
<td>3</td>
<td>1.04</td>
<td>0.963253616</td>
<td>6.431708548</td>
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<tr>
<td>Q</td>
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<td>1</td>
<td>0.673812512</td>
<td>71.76103253</td>
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<tr>
<td>P5</td>
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<td>J</td>
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<td>P1</td>
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<tr>
<td>E6</td>
<td>66</td>
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<td>179.5720163</td>
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<tr>
<td>P3</td>
<td>30</td>
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<tr>
<td>M1</td>
<td>5</td>
<td>1.05</td>
<td>3.069851933</td>
<td>35.4336211</td>
<td>-56.25%</td>
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<tr>
<td>OO4</td>
<td>156.25</td>
<td>1</td>
<td>1.634415034</td>
<td>543.9537534</td>
<td>-61.45%</td>
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<tr>
<td>K</td>
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<td>1.04</td>
<td>0.444883317</td>
<td>1.444643319</td>
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<tr>
<td>A</td>
<td>8.05</td>
<td>1.06</td>
<td>0.204635155</td>
<td>3.976522848</td>
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<tr>
<td>L</td>
<td>1.3</td>
<td>1</td>
<td>0.586150455</td>
<td>1.62305061</td>
<td>-76.81%</td>
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<tr>
<td>HH1</td>
<td>1</td>
<td>1.07</td>
<td>0.337287985</td>
<td>0.718423407</td>
<td>-88.03%</td>
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<tr>
<td>D</td>
<td>6.2115</td>
<td>1</td>
<td>0.341574591</td>
<td>4.519200912</td>
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<tr>
<td>P4</td>
<td>0.2</td>
<td>1.04</td>
<td>0.455368578</td>
<td>0.181892109</td>
<td>-96.97%</td>
</tr>
</tbody>
</table>

**Pred (.30) = 8/13 = 62%**  
**Pred (.30) = 9/17 = 53%**
**Project Information**

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Project ID No.</th>
<th>Date Prepared</th>
<th>Rev No.</th>
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<tbody>
<tr>
<td>Test</td>
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<td>20-Nov-00</td>
<td>0</td>
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<table>
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<tr>
<th>Originators</th>
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<tr>
<td>Tester Name</td>
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</table>

**Please Select**

**Overall Project**
- [DISPLAY OVERALL PROJECT SHEETS](#)
- [HIDE OVERALL PROJECT SHEETS](#)

**COCOMO II Effort Modeling**
- [DISPLAY COCOMO II SHEETS](#)
- [HIDE COCOMO II SHEETS](#)

**COCOTS Effort Modeling**
- [DISPLAY COCOTS SHEETS](#)
- [HIDE COCOTS SHEETS](#)

**Combined Schedule**
- [DISPLAY SCHEDULE SHEET](#)
- [HIDE SCHEDULE SHEET](#)

**Master Parameters**

*** FOR ADVANCED USERS ONLY ***
To change driver values for various sub-models.

- [DISPLAY MASTER PARAMETER TABLES](#)
- [HIDE MASTER PARAMETER TABLES](#)
CBS Post-deployment Modeling Horizon

LCO  IOC  RRR

COCOMO II  Maintenance  Model

V  Transition  Operations

Retirement of System

start cycle?  repeating refresh cycles?  end cycle?

development  transition  maintenance
Current Insights into Maintenance Phase Issues

Priority of Activities by Effort Involved and/or Criticality

- **Higher**
  - training
  - configuration management
  - operations support
  - integration analysis
  - requirements management

- **Medium**
  - certification
  - market watch
  - distribution
  - vendor management
  - business case evaluation

- **Lower**
  - administering COTS licenses

**Notes:**
- S - spikes around refresh cycle anchor points
- C - continuous
COCOTOTS: Maintenance Phase Straw Model

CBS Maintenance Effort (for a Given Cycle Time $T_M$)

\[
= COCOMO \text{ Application Maintenance} + COTS \text{ Reassessment} + COTS \text{ Retailoring} + COTS \text{ Glue Code Evolution} + COTS \text{ Volatility Effect on Application Effort} + COTS \text{ Replacement}
\]

\[
CBS \ PM_{\text{Maint Total}} = \sum (PM_{\text{Maint-APP}} + PM_{\text{Re-ASST}} + PM_{\text{Re-TAIL}} + PM_{\text{GLUE-Evol}} + PM_{\text{VolEff-APP}} + PM_{\text{COTS-R}})
\]
COCOTS: Maintenance Phase Straw Model

Determining Optimal Refresh Cycle Time $T_M$

- Allow estimation parameters to change between each cycle $T_M$
- Test several $T_M$ cycle lengths over your total planning horizon
  - i.e., 9 months, 12 months, 18 months, 24 months, 36 months, etc.
- Select cycle length of least overall cost to schedule refresh efforts
A CBS Economic Lifespan Model: The COTS-LIMO Model

- Cost of maintenance
- \( F_n \) (synchronization, complexity of system, no. planned upgrades, etc.)
- Volatility effects dominate increased integration experience
- Increased integration experience dominates volatility effects
- Volatility effects just cancel increased integration experience

Graph:
- Time
- Maintain
- Retire
- \( n \), \( n+1 \), \( n+2 \), \( n+3 \), \( n+x \)
- Number of COTS in system
- \$
COCOTS Benefits

• Existing
  – Independent source of estimates
  – Checklist for effort sources
  – (Fairly) easy-to-use development phase tool

• On the Horizon
  – Empirically supported, tightly calibrated, total lifecycle COTS estimation tool