REVIC II: Converting the REVIC model to COCOMO II

Dan Stickland
Software Systems Engineering
Dynetics, Inc.
daniel.stickland@dynetics.com

Nhachi Khong
Software Systems Engineering
THAAD Project Office
khongn@thaad.redstone.army.mil

Overview

- Reasons for research
- REVIC model background
- REVIC to COCOMO II
- REVIC II Single Model
- REVIC II Multiple Model
- Future Work
- Summary

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Cyclical Process of Estimation

What have my projects looked like in the past?
What kinds of projects are like mine?
How does software of this complexity behave?

COST
SCHEDULE
PHASES
PROJECT

What does my estimate tell me?
What else does this estimate have in error?
How do I report my findings?
How can I refine my model?

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Calibration

Inputs needed: actual effort, actual duration, actual size, historical environment, schedule, requirements volatility, COCOMO II Scale Factors

Project X

1439.3 person-hours
35 months

Preeminence
Development/Feasibility
Acting upon Risk Assessment
Team Cohesion
Process Maturity
Personnel Continuity

Scale Factor

SCE

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K VOL

Calibration Tool

Several project histories needed for accurate calibration
Reasons For Research

- Some projects don't have the luxury of past history for calibration
- Uncalibrated COCOMO cost/schedule results traditionally low for defense projects
- Uncalibrated REVIC cost/schedule results close to defense project actuals due to DoD database
- COCOMO II offers flexibility of modern software practices
- How do you get REVIC model results and COCOMO II flexibility in one model? How do you extrapolate the REVIC calibrations without the historical data?

**REVIC Model**

- Similar to the Intermediate COCOMO model
- Calibrated to completed DoD projects
- Includes Requirements and Development Test and Evaluation (system level integration & testing)

**REVvised Intermediate COCOMO - version 9.9 - 1994**

- (Organic) - small; no new algorithms
  - PM = 3.4644 \times (KDSI) \times 1.05 \times (EF.)
  - TDEV = 3.68 \times (PM) \times 0.38
- (Semidetached) - combination
  - PM = 3.97 \times (KDSI) \times 1.12 \times (EF.)
  - TDEV = 3.8 \times (PM) \times 0.35
- (Embedded) - large; new algorithms
  - PM = 3.312 \times (KDSI) \times 1.05 \times (EF.)
  - TDEV = 4.376 \times (PM) \times 0.37

**Phase Effort Schedule**

- EQ = 11% 30%
- FD = 21% 39%
- ID = 22% 27%
- CT = 22% 15%
- ET = 24% 21%
- ET = 22% 24%

- Requirements and DT&E effort and schedule percentages are "taxed" based on the development phases

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Easier to calculate the mechanics of changing to a similar model and apply those alterations to COCOMO II COCOMO model accounts for the Requirements Phase, but doesn’t use REVIC multipliers.

- Merge DT&E phase with IT phase; parse effort later based on published percentages
- Additional 22% effort and 28% in schedule

PM = (1.22 * A (KDSI) * B)
TDEV = (1.35 * C (PM) (1.22) * D)
Effort divided by the escalation factor (22%) so the schedule formula is not “double taxed.”

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- Change the COCOMO I multipliers to include additional DT&E phase

(Embodied)
PM = 3.312 * (KDSI) * 1.05 * (E.F.)
TDEV = 5.876 * (PM) * 0.38

(Stretched)
PM = 3.97 * (KDSI) * 1.12 * (E.F.)
TDEV = 3.8 * (PM) * 0.35

- Add the environmental factors RVOL (Requirements Volatility) and RISK (Platform Risk); replace VMVH (Virtual Machine Volatility: Host) and VMVT (Virtual Machine Volatility: Target) with similar VIRT (Virtual Machine Volatility)

<table>
<thead>
<tr>
<th>XL</th>
<th>LO</th>
<th>NM</th>
<th>HI</th>
<th>VH</th>
<th>XII</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVOL</td>
<td>0.00</td>
<td>0.00</td>
<td>0.93</td>
<td>1.00</td>
<td>1.19</td>
</tr>
<tr>
<td>RISK</td>
<td>1.00</td>
<td>1.30</td>
<td>1.40</td>
<td>1.60</td>
<td>1.80</td>
</tr>
<tr>
<td>VIRT</td>
<td>0.00</td>
<td>0.00</td>
<td>0.87</td>
<td>1.00</td>
<td>1.15</td>
</tr>
</tbody>
</table>
REVIC to COCOMO 87 (con'd)

- Effort and schedule phase distribution changed to account for additional DT&E phase. Requirements absorbed as a Developmental Phase. Effort increased by 22% and schedule increased by 28%.

\[ \text{New REVIC Effort} = \text{COCOMO Effort} \times (100 + \text{increase}) \]

<table>
<thead>
<tr>
<th>Phase</th>
<th>Effort</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ</td>
<td>10%</td>
<td>23%</td>
</tr>
<tr>
<td>PI</td>
<td>15%</td>
<td>30%</td>
</tr>
<tr>
<td>DD</td>
<td>24%</td>
<td>20%</td>
</tr>
<tr>
<td>CT</td>
<td>18%</td>
<td>12%</td>
</tr>
<tr>
<td>DT+DT&amp;I</td>
<td>39%</td>
<td>38%</td>
</tr>
</tbody>
</table>

Incorporating REVIC in a COCOMO 87 model requires changes to the formulas, Environmental Factors, and phase distribution.

REVIC II Single Model

- COCOMO II 1995.0 model base
- Development modes (Organic, Semideveloped, Embedded) are duplicated through the manipulation of Scale Factors (Rosetta Stone)
- No change to Environmental Factors (COCOMO II has up-to-date factors for software development)
- Target: single COCOMO II model that replicates the REVIC cost/schedule exponential and multiplicative constants and phase distribution.
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**REVIC II Single Model: Rosetta Stone**

\[ PM = 2.94 \times EAF \times \text{SIZE} \times (0.91 + 0.01 \times Z) \]

\[ TDEV = 3.67 \times (PM) \times 0.289 \]

### Development

<table>
<thead>
<tr>
<th>Mode</th>
<th>Team</th>
<th>Team Mod</th>
<th>Embedded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>25</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Embedded</td>
<td>25</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

### Sum of Scale Factors

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**REVIC II Single Model: Sum of Scale Factors**

- In COCOMO II, effort and schedule exponential values driven by the sum of the Scale Factors (directly proportional relationship).
- In REVIC, Organic mode has the smallest cost exponent and the largest schedule exponent, Semidetached mode has the largest cost exponent and the smallest schedule exponent (inversely proportional relationship).
- To get a single model that represents the three models using Scale Factors, the default COCOMO II formula must be altered to allow for REVIC's inverse relationship.

\[ X + Y \times (Z \text{Scale Factors}) = \text{effort exponent} \]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Target Exponent Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded</td>
<td>1.12</td>
</tr>
<tr>
<td>Semidetached</td>
<td>1.05</td>
</tr>
<tr>
<td>Organic</td>
<td>0.95</td>
</tr>
</tbody>
</table>

- Isolate the target effort exponent; use the default X and Y values of COCOMO II to get matching target Sum of Scale Factors.
Solve for three unknowns using matrix division; answers used in new exponent formulas

\[ \begin{align*}
X &= 0.91 \\
Y &= 0.01 \\
A &= 0.435 \\
B &= 0.004
\end{align*} \]

\[ \begin{align*}
PM &= 2.94 \times EAF \times (SIZE)^{0.91 + 0.01} \\
TDEV &= 3.67 \times (PM) \times 0.435 \times 0.004 \times Scale Factors
\end{align*} \]

Match Set A Factors to target sum of scale factors

**REVIC II Final Formula**

\[ \begin{align*}
PM &= 3.59 \times EAF \times (SIZE)^{0.91 + 0.01} \\
TDEV &= 3.85 \times (PM) \times 0.435 \times 0.004 \times Scale Factors
\end{align*} \]

Add the DT&E phase (22% effort; 28% schedule)

**REVIC II is exponentially equal but geometrically lower than REVIC**

Geometric Multiplier Solutions:
- KDSI to KLOC conversion; reduce KLOC (REVIC to COCOMO II)
- Conversion factor depending on Development Mode
- Can not use REVIC multipliers (3 vs. 1)

Single model evolution leaves work in the hands of the user
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### REVIC II Single Model: Performance Deltas

<table>
<thead>
<tr>
<th>Size</th>
<th>REVIC</th>
<th>REVIC 1</th>
<th>Data</th>
<th>REVIC</th>
<th>REVIC 1</th>
<th>Data</th>
<th>REVIC</th>
<th>REVIC 1</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GB</td>
<td>74.0</td>
<td>74.0</td>
<td>0.000</td>
<td>45.6</td>
<td>45.6</td>
<td>0.000</td>
<td>50.4</td>
<td>50.4</td>
<td>0.000</td>
</tr>
<tr>
<td>2GB</td>
<td>114.0</td>
<td>114.0</td>
<td>0.000</td>
<td>59.0</td>
<td>59.0</td>
<td>0.000</td>
<td>50.4</td>
<td>50.4</td>
<td>0.000</td>
</tr>
<tr>
<td>3GB</td>
<td>188.0</td>
<td>188.0</td>
<td>0.000</td>
<td>68.6</td>
<td>68.6</td>
<td>0.000</td>
<td>50.4</td>
<td>50.4</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**REVIC II Multiple Model**

- **COCOMO II.1999.0 model base**
- **Development modes (Organic, Semidetached, Embedded) are separate models**
- **No change to Environmental Factors (COCOMO II has up-to-date factors for software development)**
- **Target: three COCOMO II models that replicate the REVIC cost估ervex exponential and multiplicative constants and phase distribution**

**REVIC II**

- OR
- SD
- ED

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**REVIC II Multiple Model: Exponents**

- Solve for the form of Scale Factor values using the Target Exponent Values and default COCOMO II effort exponent equation:

\[
X + Y (\text{Scale Factors}) = \text{effort exponent} \\
A + B (\text{Scale Factors}) = \text{schedule exponent}
\]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Effort</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded</td>
<td>1.2</td>
<td>0.33</td>
</tr>
<tr>
<td>Semidetached</td>
<td>1.12</td>
<td>0.35</td>
</tr>
<tr>
<td>Organic</td>
<td>1.05</td>
<td>0.34</td>
</tr>
</tbody>
</table>

- Use COCOMO II default values for effort and org. COCOMO II default value for schedule to develop REVIC II schedule exponents:

\[
A + B (29) = 0.32 \text{ (Embedded)} \\
A + B (21) = 0.35 \text{ (Semidetached)} \\
A + B (14) = 0.38 \text{ (Organic)}
\]

\[
0.28 + 0.00333 (29) = 0.32 \text{ (Embedded)} \\
0.28 + 0.00333 (21) = 0.35 \text{ (Semidetached)} \\
0.28 + 0.00714 (14) = 0.38 \text{ (Organic)}
\]

**REVIC II Multiple Model: Formulas**

- Replace COCOMO 3 multipliers with REVIC multipliers:

\[
\text{PM} = 3.312 \times \text{EAF} \times (\text{SIZE}) \times (0.91 + 0.01 \times \text{Scale Factors})
\]

\[
\text{TDEV} = 4.376 \times \text{PM} \times (0.28 + 0.00138 \times \text{Scale Factors})
\]

- COCOMO II multipliers with PM

\[
\text{PM} = 3.97 \times \text{EAF} \times (\text{SIZE}) \times (0.91 + 0.01 \times \text{Scale Factors})
\]

\[
\text{TDEV} = 3.8 \times \text{PM} \times (0.28 + 0.00333 \times \text{Scale Factors})
\]

- Organic

\[
\text{PM} = 3.4644 \times \text{EAF} \times (\text{SIZE}) \times (0.91 + 0.01 \times \text{Scale Factors})
\]

\[
\text{TDEV} = 3.665 \times \text{PM} \times (0.28 + 0.00714 \times \text{Scale Factors})
\]
**REVIC II Multiple Models: Final Formulas**

| REVIC II (Multiple Model)  | Embedded  | PM = 4.041 * EAF * (SIZE)^1.2  
| TDEV = 5.264 * (PM) * 0.32  |
| Semidetached  | PM = 4.443 * EAF * (SIZE)^1.12  
| TDEV = 4.862 * (PM) * 0.35  |
| Organic  | PM = 4.227 * EAF * (SIZE)^1.12  
| TDEV = 4.382 * (PM) * 0.38  |

**Additional 22% in effort and 28% in schedule for DT&E phase**

**REVIC Example**

**KDSI: Embedded Mode; Noncritical Environmental Factors**

**REVIC II Multiple Models: Final Formulas**

- PM = (1.22) * GE (SIZE) * EE
- TDEV = (1.28) * GS (PM) * GE

**REVIC values matched geometrically and exponentially**
<table>
<thead>
<tr>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total for Entire Project</td>
<td>Development: 14.0% Duration: 4.0% Cost (B): 10.0% Total: 24.0%</td>
</tr>
<tr>
<td>Calculations</td>
<td>Rounding Error: 0.5%</td>
</tr>
</tbody>
</table>

**REVIC II Single Model Example**

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<tr>
<th>Label/Column</th>
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<tbody>
<tr>
<td>Total for Entire Project</td>
<td>Development: 30.0% Duration: 4.0% Cost (B): 10.0% Total: 40.0%</td>
</tr>
<tr>
<td>Calculations</td>
<td>Effort is 12.5% low in hours to 47% low</td>
</tr>
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**REVIC Duplication Using COCOMO 87**

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**Future Work**

- REVIC, COCOMO II express size in KDSI (Delivered Source Instructions) where COCOMO II expresses size in KSLOC (Source Lines of Code).
- Rosetta Stone: KSLOC = KDSI reduced by (25-40%).
- Difference between large DoD programs KDSI and KSLOC counts?
- Some indication that in REVIC there is no difference (SoftEst tool).

**Maintenance**

- REVIC includes Annual Change Traffic percentage in Maintenance.
- COCOMO II uses PM calculations with Software Understanding, Unfamiliarity, and Annual Maintenance Change Factor.
- Maintenance must reflect the cost per year of maintenance in REVIC in the REVIC II models.
- Ongoing research into maintenance.
Summary

- REVIC II is used when COCOMO II default calibrations are not as accurate (IND programs) and no historical information is available.
- REVIC II uses the calibration and phasing of REVIC with the flexibility and modern programming practices of COCOMO II.
- The REVIC II Single Model uses a single formula and adjusted Scale Factors to duplicate the effort and schedule of the three developmental phases of REVIC in a COCOMO II base model. It is correct exponentially, but not geometrically.
- The REVIC II Multiple Model uses three separate formulas and adjusted Scale Factors to duplicate the effort and schedule of the three developmental phases of REVIC in a COCOMO II base model. It duplicates the REVIC outputs.
- More research needed in the areas of KSLOC/KDSI conversion and Maintenance in REVIC II.