COCOMO Productivity Improvement Model (COPROMO)

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Outline

• Objectives
• Approach
• Assessment results
• Conclusions
AFRL Contract Objectives

- Assess the near-term and longer-term impact
  - of Knowledge-Based Software Assistant (KB-SA) technology
  - on software cost and schedule
- Develop a general software technology impact assessment model
  - Including spreadsheet implementation
- Apply the model to other sources of technology
  - Commercial technology
  - DARPA/AFRL Evolutionary Design of Complex Software (EDCS) technology
  - Combinations of technologies

Approach: Models

- Use COCOMO II model and extensions as assessment framework
  - Well-calibrated to 161 projects for effort, schedule
  - Subset of 106 1990's projects for current-practice baseline
  - Extensions for Rapid Application Development formulated
- Determine likely near-term (2006) and longer-term (2013) impact of technologies on model parameter settings
- Use these in models to assess impact of technologies on cost and schedule
  - Effort used as a proxy for cost
COCOMO II.1998 Productivity Ranges and Current Practice

Average Multiplier for 1990's projects

COCOMO II.1998 Estimation Accuracy

<table>
<thead>
<tr>
<th>Prediction Accuracy</th>
<th>General</th>
<th>Calibrated to Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort PRED(.30)</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Schedule PRED(.30)</td>
<td>72%</td>
<td>81%</td>
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</tbody>
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Approach: Projects

- Assess technology impact on embedded, high-assurance, real-time (EHART) DoD applications
  - Critical DoD warfighting software
  - Commercial technology investment relatively low
- Use COCOMO II 1990’s-projects average ratings as 1998 baseline
  - Conservative since organizations with well-collected data are generally more advanced
  - Balanced by fact that COCOMO II projects’ average completion year was 1994

Approach: Technology

- Assess technology impact on EHART projects starting in 2006, 2013
  - Using best-available technology in 2006, 2013
- Assess impact of several technology combinations
  - CD: Commercial technology and DoD general practice
  - Commercial plus DoD-sponsored technology combinations
    - KG: KBSA-Applications Generations
    - KD: KBSA-Project Decision Support
    - K: both KG and KD
    - E: EDCS
    - EK: both EDCS and KBSA
Approach: KBSA Technology

- Assessed Andersen Consulting ADM package
  - Some good ideas
  - Partially implemented
- Focused assessment on potential impact of overall KBSA technology
  - Applications Generation, including KB domain engineering
  - KB Project Decision Support
    - Software Engineering Decision Assistant concept

SEDA: Software Engineering Decision Assistant

Example Model-Based Decision Aids

- Domain Model to Architectural Style
- Process Drivers to Life Cycle Model
  - Rqts. Understanding, Arch. Understanding, Size, Schedule, Robustness
    → [Waterfall/Evolutionary/Incremental/Spiral/...]
- Expert COCOMO (cost drivers to risk assessment)
- Quality Attribute Risk & Conflict Consultant (QARCC)
- Software Cost Option Strategy Tool (S-COST)
- UML-Based Architecture View Integration
- System Architecting Heuristics (Rechtin)
  - Rubber Schedule, KISS (> N COTS, > M interacting features, ...)
**RESL: Architecture/Risk Resolution**

- **CD:** Significant gains due to open systems technology, commercial-off-the-shelf architecture technology, SEI Architecture program, and DoD emphasis on risk management.
- **KG:** Significant additional gains over CD in domain architecture.
- **KD:** Significant additional gains over CD in architecture and risk analysis technology.
- **E:** Complementary gains from ED and KB.
- **EK:** Complementary gains from E and K.

**TOOL: Use of Software Tools**

- **CD:** Significant gains due to general tool technology capabilities.
- **KD:** Significant additional gains over CD in tool support, particularly in longer term.
- **E:** Significant gains due to enhanced EDCS tool capabilities, particularly in resolution and triaging tool.
- **EK:** Complementary combination.

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size (KSLOC) is the primary determinant of software effort in COCOMO II (and other cost models). For COCOMO II, effective size = f(KSLOC or FP, BRAK, ADSI, DM, CM, IM, SU, UNFM).

Baseline: is a 100 KSLOC embedded, high-assurance, real-time (EHART) software application.

CD: Commercial technology will provide better reuse infrastructure (e.g., ORB's) and some of the reusable componentry needed for EHART applications. Better requirements technology will reduce breakage somewhat. The overall effects for EHART applications will be less than the effects for mainstream commercial applications since much of the commercial technology will not satisfy EHART dependability, performance, or real time deadline requirements.

Existing DOD initiatives such as the SEI Product Line Practices and Survivable Systems Projects will create some size reductions in those areas.
SIZE: KSLOC (cont.)

KD: Same as CD

KG, K: Significant gains over CD due to EHART domain-specific architectures, reusable components, and application generators

E: Similar domain-specific gains, plus additional reduced breakage due to requirements and rationale capture technology, and reduced software understanding penalties due to software understanding technology

EK: Gains over E due to stronger KB application generator technology

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COCOMO-II. 1998 Scale Factors & Multipliers Projected Over Time for KBSA Evaluation

Results are conservative, particularly for EDCS, as maintenance savings would be greater than development savings, due to reductions in amount of software understanding, redesign, recode, and retest effort, particularly via incremental software analysis, generation, and verification technology.

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RVHL: Reuse and Very High Level Language

Baseline: Relatively low current capability and experience in EHART domain (standard 3GL module reuse)

CD: As indicated under SIZE in the Effort impact analysis, commercial technology and DoD EHART domain initiatives will provide some but not much improvement over standard 3GL module reuse

KD: Some gains over CD via domain oriented reuse asset identification and decision support

KG: Some gains over CD via domain oriented prototype applications generation

K: Complementary gains from KD and KG

E: Significant gains over CD via domain architecture technology and associated prototype applications generation

E K: Some complementary gains from E and K

NOTE: Construction stage RVHL multipliers are all 1.0.
Impact of Technologies on Software Effort or Cost

Impact of Technologies on Software Schedule
Effect of 50% Reduction in Effort Improvement Factors

Conclusions

- Both KBSA branches provide strong improvements over pace of commercial technology
  - Applications Generation and Decision Support
  - Particularly in Embedded, High-Assurance, Real-Time (EHART) domain
  - Payoffs greater in long term
- KBSA and EDCS technology thrusts synergetic
  - Particularly if driven by domain KB's and architectures, applications generation technology
  - KB Decision Support an attractive EDCS technology followon
- COPROMO model useful for corporate technology benchmarking and strategy evaluation