COCOTS
(CONstructive COTS)
Software Integration
Cost Model: Overview & Status

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Outline

- Model Development History and Support
- Problem Context
- COTS Software Integration Cost Sources
- Early Design/Post-architecture Model Versions
- Data Collection Status
- Prospective Follow-ons

Model Development History and Support

USA/ESC Effort
- March 1994 through June 1997
  - Initial Code Model Definition, Experimental Calibration

FAA Effort
- Phase 1 (July to October, 1997)
  - Code Code Model Refinement, Experimental Calibration
- Phase 2 (October 1997 to July 1998)
  - Code Code Model Refinement
  - Assessment, Tuning, and Validity Models Defined
- Phase 3 (July 1998 to December 1998)
  - Further Data Collection & Model Refinement Calibration
  - Code calibration model available by end 1998

ONR Effort
- January 1998 through 1999
  - Further Refinement of Models, including activity analysis & effort distribution
  - Data Collection & Calibration
  - Determination of How Sway to Associate COCOTS with COCOMO II
  - Coordination of FAA and ONR Data Collection Being Pursued with Help of DoD
Problem Context: Modeling

COTS and Custom Applications Components

New COCOTS Modeling Problem

COTS Infrastructure
COCOMO II: PVOL, PEXP

COTS Tools
LTEX, TOOL

Cost Modeling Currently Addressed

Center for Software Engineering

COCOMO vs. COCOTS Cost Sources (COTS in System)

1) COTS Assessment
2) COTS Tailoring

Application Code Development
Integration and Test Separate from COTS Effects

3) COTS/Application Code Cost Development and (29/48%) Test

1) Decreased Application Effect due to COTS Volatility

COCOMO Effort Estimation
COCOTS Effort Estimation Component

TIME

STAFFING

LCO - Life Cycle Objective
LCA - Life Cycle Allocation
IOC - Initial Operational Capability
**COTS Integration Cost Sources:**

1) **Assessment**

**Initial Filtering Effort**

Total Effort = \( \left( \frac{\text{# COTS Candidates}}{\text{Average Filtering Effort}} \right) \)

**Final Selection Effort**

Total Effort = \( \sum \left( \frac{\text{# COTS Candidates}}{\text{Average Assessment Effort for Attribute in Given Domain}} \right) \)

- *List of attributes refined in collaboration with Dr. Elizabeth Bailey*
- *Effort/candidate is project dependent, within domain guidelines*

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**COTS Integration Cost Sources:**

1) **Assessment - Assessment Attributes**

| Attribute | Communication | Technical/Arch | Performance | Price:
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*Cause for Software Engineering*
COTS Integration Cost Sources:

2) Tailoring

Total Effort = \[ \sum \left( \frac{\# \text{ COTS Candidates Tailored at Complexity Level } i}{\text{Complexity Level in Domain}} \right) \text{Average Effort at Tailoring } i \]

- Five tailoring effort complexity levels:
  - Very Low, Low, Nominal, High, Very High
- Differentiated based on number tailored parameters, difficulty of needed scripts, API iterations, etc.
COTS Integration Cost Sources: 
3) Glue Code Development and Test

\[ \text{Total Effort} = \text{A} \times [\text{size}(1+\text{breakage})]^{\text{B}} \times \prod \text{(effort multipliers)} \]

- **A** - a linear scaling constant
- **Size** - of the glue code in SLOC or FP
- **Breakage** - of the glue code due to change in requirements and/or COTS volatility
- **Effort Multipliers** - 13 parameters, each with settings ranging VL to VH
- **B** - an architectural scale factor with settings VL to VH

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COTS Integration Cost Sources: 
3) Glue Code Development and Test - Glue Code Cost Drivers

**Personnel Drivers**

1. ACSP - COTS Integrator Experience with Product
2. ACSPC - COTS Integrator Personnel Capability
3. ASCIP - Integrated Experience with COTS Integrator Process
4. APCC - Integrator Personnel Continuity

**COTS Component Drivers**

5. ACPS - COTS Product Maturity
6. ACPSW - COTS Supplier Product Extension Willingness
7. APCX - COTS Product Interface Complexity
8. ACPSS - COTS Supplier Product Support
9. ACSSD - COTS Supplier Provided Testing and Documentation

**Application/System Drivers**

10. ACRSL - Constraints on Application System/Subsystem Reliability
11. AACP - Application Interface Complexity
12. ACSTP - Constraints on COTS Technical Performance
13. ASR - Application System Reliability

**Nonlinear Scale Factor**

1. AARST - Application/Architectural Engineering
**COTS Integration Cost Sources:**

4) *Increased Application Effort Due to COTS Volatility*

**Approximate Model:**

Total Effort = (Application Effort) \* \left( \frac{\text{BRAK COTS}}{100} \right) \* (EAF)_{COTS}

**Detailed Model with COCOMO II Parameters:**

Total Effort = (Application Effort) \* \left( \left(1 + \frac{\text{BRAK COTS}}{1 + \text{BRAK}}\right)^{1.01 + \Sigma} - 1 \right) \* (EAF)_{COTS}

- **BRAK COTS:** % application code breakage due to COTS volatility
- **BRAK:** % application code breakage otherwise
- **Σ:** COCOMO II scale factor
- **EAF:** Effort Adjustment Factor (product of effort multipliers)

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**Total COTS Integration Cost Estimate**

Total Integration Effort (in Person-Months) =

Assessment Effort + Tailoring Effort + Glue Code Effort + Volatility Effort

where

Assessment Effort = Filtering Effort + Final Selection Effort

Total integration Cost =

(Total Integration Effort) \* ($$/Person-Month$$)
Recent Development: two models, differing fidelity
(Parallels COCOMO II modeling)

Early Design COCOTS model

- roll up of parameters in Assessment, glue code submodels into fewer, more aggregated factors; inclusion of only the approximate Volatility model.
- less fidelity but requires fewer data points to calibrate.
- intended for more "what if" kind of estimating, earlier in the development process.

Post-architecture COCOTS model

- the full model as presented in preceding charts

Data Collection Status

- 6 Student Digital Library Projects
- 4 FAA Projects
  - 4 to 8 additional projects upcoming
- PSM Coordinating DoD Data Sources
- Other Sources Being Explored
  - NASA
  - USC-CSE Affiliates
Prospective COCOTS Follow-ons

- Extensive data collection and conditioning
- Recalibration and iteration of the model within current structure
- Experimental usage and refinement, including exploration of other cost drivers and model forms
- Modeling of schedule estimation and activity distribution
- Integration with COCOMO II estimation model
- More extensive model implementation
- Modeling other COTS related costs
  - Licenses, training, maintenance, hardware

Conclusions

- COCOTS provides solid framework for estimating software COTS integration cost
  - needs further data, calibration, iteration
  - current spreadsheet model could be used experimentally
- COCOTS can be extended to cover other COTS related costs
  - biggest challenge will be complex, dynamic COTS price structures