NASA - Software Estimating Tool (N-SET)

A NASA Research Project

NASA Cost Analysis Symposium

20-22 June 2006

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Briefing Structure

Background

User Interface Features – Input Data

Data Analysis Process LOCOMO

User Interface Features – Output Results

Summary
Topics

- Background
  - Project Overview
  - Project Description
  - Approach
- User Interface Features – Input Data
- Data Analysis Process (*Dr. Tim Menzies*)
- User Interface Features – Output Results
- Summary
  - Benefits and Beneficiaries
  - Deliverables and Schedule
  - Next Steps
Project Overview

• **NASA Research Project funded by HQ IPAO**
  – FY05 and FY06

• **The Problem**: NASA is unable to estimate software size/cost early in a project because the software requirements/architecture are not complete and cost model inputs, primarily size, are not available

• **The Purpose** is to develop an early life cycle software estimation tool so that it can be used by the entire NASA community, including NASA contractors without restriction
Project Overview (cont)

• The objective is to leverage existing assets that will allow us to establish a capability to help cost analysts create software estimates early in a program development

• Team has over 100 years of cross organizational cost data collection and cost model development experience

• Integrated development team includes:
  – Task Sponsor: Tom Coonce (NASA HQ IPAO)
  – Task Manager: Sherry Stukes (JPL)
  – Technical Lead: Jairus Hihn (JPL)
  – Task Engineer: Michael Luna (JPL)
  – University Collaboration: Tim Menzies (West Virginia University)
Project Description

- Develop an early lifecycle software cost estimation tool leveraging existing data and capabilities
- Collect additional software data from:
  - Jet Propulsion Laboratory
  - Goddard Space Flight Center
  - Marshall Space Flight Center
- Analyze, normalize, evaluate, stratify, and validate data
- Create a calibrated, validated, and documented tool initially using available data and subsequently using newly collected data
Approach

Data Analysis
- Normalize
- Stratify
- Evaluate
- Validate

Develop Tool
- User Friendly
- Documented

Validated Tool

Proof of Concept

GSFC

JPL

MSFC

Collect Data

Modify collection forms

Determine integrated mission parameter set

Collect Data

= current activities
User Interface Features

Input Data

• Required Input
  – User information
  – Project descriptive information
  – Technical parameters

• Technical Parameters based on:
  – Generally available information
  – Information available in CADRe

• Features
  – Pull-down menus
  – Context sensitive definitions
Sample User Interface Screen

Mike’s Splash Screen
Sample User Interface Screen

Mike’s Splash Screen
Sample User Interface Screen

Mike’s Splash Screen
LOCOMO: building “local” cost models for N-SET

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Motivation

- Should you let an electrician fix your pipes?
  - No- the skill of electricians and plumbers comes from different training.

- Should you build one cost model to cover all your projects?
  - Not sure… lets check
An experiment

- Take a “partial description” of a project
  - E.g. we use “standard analysts” (in COCOMO speak; “acap=1”)

- Go to a log of old projects
  - E.g. the nasa93 COCOMO-I data sets.

- Find some projects “near” the partial descriptions
  - E.g. find the 20 “nearest neighbors” in nasa93 to acap=1

- Build some cost models from those 20

- Compare those cost models to other “partial descriptions”
### Median performance statistics

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<td>3.9, 1.1, 25.6, 72.0</td>
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### Goal:
- Keep it simple for the users
- Details hidden from users.
- All automatic (“under the hood”)

### “A” values different to standard COCOMO Values (≤ 3.2)

### PRED(30) = % of tests whose predicted is within 30% of actual

### MMRE = mean magnitude relative error

\[ \text{MMRE} = \frac{\text{abs}(\text{actual} - \text{predicted})}{\text{actual}} \]
e.g. COCOMO models learned from 20 nearest neighbors to acap=1

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<th>mmre,</th>
<th>pred(30)</th>
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<td>5.06</td>
<td>1.04</td>
<td>60.9</td>
<td>68.6</td>
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</table>

Median performance statistics

“A” values very different to those seen before

PRED(30) = % of tests whose predicted is within 30% of actual

MMRE = mean magnitude relative error = abs(actual - predicted) / actual

• High-reliability systems,
• Some time pressure on development

time = 1.1, rely=1.2
Urgent need to collect more localized data from local sites

- Current NASA initiative:
  - Tune cost models to specific NASA Center products

- LOCOMO:
  - Proof positive that such tunings are essential
Why use LOCOMO?

- **LOCOMO.cost = $0**
  - http://unbox.org/wisp/trunk/locomo

- **LOCOMO based on COCOMO**
  - COCOMO: white box
  - Other commercial tools: black box

- **LOCOMO: uses NASA-specific data**
  - Other commercial tools: mostly DOD
    - Often over-estimate NASA projects since they assume MIL standards
    - MIL assumes more documentation/ testing/ security requirements than NASA

- **Estimation with smallest number of variables**
  - In our example, only 1 or 2
    - Other tools: dozens to hundreds of variables

  - So, given minimal project information
    - Can still get project estimates

  - And, with more data,
    - Can select more relevant data and get better estimates
LOCOMO: next steps

• Apply this to different NASA sites

• Assess manual vs automatic stratifications
  – Manual: “earth orbit”, “deep space”, “mars projects”
  – Automatic: LOCOMO
  – Which is better?

• Many studies inside “the guts” of LOCOMO
  – Effects on variance of automatic stratification
  – Why pick “20” nearest
    • Why not 5? Or 50?
  – What does “nearest” mean?
    • ? Log transform on the numerics
User Interface Features

Output Results

• Estimate reflecting the responses to the input screen
  – Effort months
  – Schedule duration

• Assumes size and attribute factor is “learned” from the data

• Uses COCOMO I as the basis of estimate, but is hidden from the user
• Statistical characteristics of the model
  – Y-intercept
  – Exponent
  – Range
  – Standard deviation
  – $R^2$
  – Mean, Median, and Mode
## Benefits and Beneficiaries

<table>
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<tr>
<th>Beneficiary</th>
<th>Benefit</th>
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<tbody>
<tr>
<td>IPAO</td>
<td>Data and metrics for use in Independent Cost Estimates (ICEs) and Source Selection evaluations. Tool consistent with CADRe data.</td>
</tr>
<tr>
<td>NASA HQ</td>
<td>Can be used to develop “Should Cost” estimates.</td>
</tr>
<tr>
<td>NASA Centers</td>
<td>Will help with analogy for proposals and other types of estimate preparation.</td>
</tr>
<tr>
<td>NASA Support Contractors</td>
<td>Will provide general information about historical programs so that they can do a better job of preparing their products and estimates for NASA.</td>
</tr>
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Deliverables and Schedule

• Deliverable Items
  – Estimating Tool (Excel based, open source)
  – Calibrated and validated tool
  – Tool documentation
  – User Guide
  – List of technical parameters to be included in CADRe

• Schedule
  – User Focus Group meeting – Jul 06
  – Data Collection – On-going
  – Update User Interface (Focus Group feedback) – Aug 06
  – Update LOCOMO learning based on new data – Sept 06
Next Steps

• Collect additional software data
  – Jet Propulsion Laboratory
  – Goddard Space Flight Center
  – Marshall Space Flight Center
  – Kennedy Space Center
  – Glenn Research Center

• Analyze, normalize, evaluate, stratify, and validate data
• Run LOCOMO learning tool on additional stratified data sets
• Dynamically link the learning tool into the N-SET input data and produce formatted output report
• Perform validation exercise on randomly selected data
• Document the process and tool (N-SET)