PSM 2008 Workshop: Toward Integrating Systems Engineering and Software Engineering Estimation: Harmonizing COSYSMO and COCOMO

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Workshop Premise

It is highly desirable to integrate systems engineering estimation and software engineering estimation

Background/Observations

- This is the latest of a series of workshops on systems and software engineering estimation (COSYSMO and COCOMO) that have occurred over a number of years at PSM and in other venues such as the University of Southern California COSYSMO/COCOMO Workshops
- The COSYSMO systems engineering estimation model/tool and its risk and reuse extensions, the COSYSMOR tool developed by Lockheed Martin and endorsed in several venues including PSM 2007, and the COCOMO software engineering estimation model/tool have evolved somewhat independently, resulting in:
  - A disjunction of the two sets of cost drivers, e.g., COCOMO can represent the affect on cost of schedule compression, but COSYSMO can not
  - The need to relate and harmonize the tasks and the phases/portions of the product or system life cycle covered by each tool

Workshop Goals/Intended Products

1. Obtain some degree of consensus about what changes (additions/deletions/definitions), if any, should be made to the COSYSMO and COCOMO cost drivers
2. Obtain some degree of consensus about what the tasks or activities and life cycle phases in COSYSMO and COCOMO should be
3. Identify other concerns and problems relating to harmonizing COSYSMO and COCOMO and identify the next steps to be taken

Review/Level Setting: COSYSMO and COCOMO Model Form

Both COSYSMO and COCOMO are parametric models of the form $K=A*S^E*(\Pi D_i)$ *****,

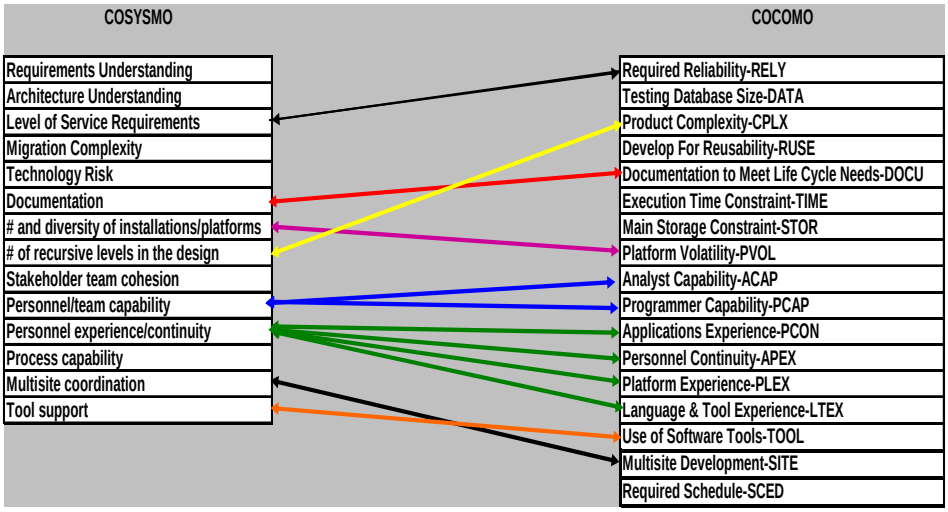
- Where: K is the cost/effort estimated for the project; S is size or scope and the cost drivers, D_i (i=1, 2, ...n) are selected for the project. The values for A, the productivity constant, and E are based on organizational experience
- The D_i are presumed to be mutually independent
- ΠD_i modifies the productivity (actually, unit effort) for the domain/organization, e.g., sonar software coded in C^{++}, for the particular situation,<product/project, process, personnel, tools>, being estimated

  * Note: *This form is basically the same as the activity-based model where typically only one or a small set of activities is included and cost driver values (e.g., D_i s) are not explicitly stated*

Review/Level Setting: Cost Drivers

- The cost drivers, the D_i, characterize attributes of: the product/project, the processes used to perform the task estimated, the personnel, the tools, and in the case of COCOMO at least one attribute of the processor, e.g., Main Storage Constraint
- Each driver value is selected with respect to the baseline's value, captured in the constant A (see previous page). "Nominal" for driver D_i is coded as D_i=1.0, i.e., the project being estimated does not differ (at least not appreciably) from the baseline with respect to the attribute characterized by D_i

COSYSMO and COCOMO Cost Driver Mapping



Arrows indicate corresponding COSYSMO and COCOMO cost drivers

Some Suggestions For Consideration

- COCOMO Drivers, Attribute Representations, that COSYSMO Needs
  - Does COSYSMO need a driver corresponding to Execution Time Constraint (TIME) ?
  - Does COSYSMO need a driver corresponding to Storage Constraint (STOR) ?
  - COSYSMO does need a a driver or some other way of representing schedule compression (SCHED)*
  - Does COCOMO need Migration Complexity ?
  - Does COCOMO need Technology Risk ?
- COSYSMO Drivers, Attribute Representations, that COCOMO Needs
  - Requirements Understanding
  - Architecture Understanding
  - Process Capability

*Note: The COCOMO SCHED driver values appear excessive, i.e., 1.14, 1.43; Another approach, e.g., estimate based on schedule vs. cost for a given size, may be better to represent the operative schedule/cost relationship

Harmonizing COSYSMO and COCOMO Results Briefing

Participants

- **Lockheed Martin**
  - **Garry Roedler**
  - **John Gaffney**
  - **Elliott Reitz**
  - **Greg Mazourek**
  - **Howard Schimmoller**
  - **Lloyd Carruso**
  - **Liz Kung**
- **SAIC**
  - **Chris Miller**
  - **Shally Malhotra**
- **RCI**
  - **Don Reifer**
- **General Dynamics**
  - **Fran Marzotto**
- **Softstar**
  - **Dan Ligett**
- **Raytheon**
  - **Chris Leighton**
- **Air Force**
  - **Lindsay Magala**
- **BAE**
  - **Gan Wang**
  - **Alex Shernoff**
  - **Lori Saleski**

Areas Considered in Analysis of Harmonization

- Overlap/Gaps of tasks
  - Per WBS, work products, and combined activities
- Analysis of Cost Drivers
- Commonality of Terminology, Constructs, Life Cycle Phases, Units, …
- Compatibility issues from any findings or recommendations
- Consideration of common size drivers
- Base assumptions of the models

Approach to Analyze Overlaps and Gaps

- Reviewed example WBS for Electronic Systems from MIL-HDBK-881A
  - Determined ownership by discipline and coverage by COSYSMO or COCOMO
  - Identified potential areas of concern
  - Analyzed whether potential overlap or gap
  - Spreadsheet available
- Conducted additional brainstorming session
  - Confirmed using:
    - Documented guidance for the models
    - Referenced the models were based on (e.g., EIA 632 and ISO/IEC 15288 for COSYSMO)

Analysis of Overlaps and Gaps

- Potential Overlaps
  1. **PM, SE, SW, CM, QA outputs**
     - **Labor distribution by phase in COCOMO**
     - **Need to understand where these come from**
  2. **Algorithm Development**
     - **E.g., coded algorithms**

Analysis of Overlaps and Gaps

- Potential Gaps
  1. **SRS Development**
  2. **System I&T**
     - **Accounting for SW support as needed**
  3. **Accounting for subcontract or supplier mgt.**
     - **Gap for SW in COCOMO**
     - **This is accounted for in COSYSMO**
  4. **Additional costs for types of life cycle models**
     - **Expect differences in cost based on type of LC model used**
  5. **Technical Process Strategy/Definition/Mgt**
     - **Gap for SW in COCOMO**
     - **This is accounted for in COSYSMO**

Analysis of Overlaps and Gaps

- Potential Gaps (Cont'd)
  6. **Quality Management**
     - **Does not appear to be accounted for in COCOMO or COSYSMO**
  7. **Testing Database Size**
     - **COSYSMO does not account for variable costs for test data**
  8. **Development for Reusability**
     - **COSYSMO does not account for additional costs to develop for reusability**
  9. **Schedule vs Cost**
     - **COSYSMO does not address duration or schedule**

Results of Other Analysis

- Analysis of Cost Drivers
  - Most of the drivers have mappings between the models, albeit different in granularity or handling
  - Potential concerns covered in Gaps or Recommendations
- Commonality of Terminology, Constructs, Life Cycle Phases, Units, …
  - Additional commonality could improve concurrent usage, but is not essential
- Compatibility issues from any findings or recommendations
  - No apparent compatibility issues (backward compatibility or with other models in COCOMO Suite) from recommendations
- Consideration of common size drivers
  - No essential to harmonization, but may add utility to COCOMO
- Base assumptions of the models
  - Need to document assumption for COSYSMO

Additional Recommendations

- **Standard phase alignment for both models**
  - **Per definitions used in ISO/IEC 15288 and 12207**
- **Establish means to adequately account for recursion (at level of hands-off to SW)**
  - **Needed to resolve gaps**
- **Add Guidance to COSYSMO Drivers TO:**
  - **Account for constraints (e.g. Time & storage) as requirements in the size.**
  - **Describe volatility covered in Requirements/Architecture understanding**
- **Look into ability to use COSYSMO size drivers in COCOMO for early estimates**
- **Add documented list of assumptions to COSYSMO**

Next Steps

- Provide results and recommendations to USC team for these models
- Conduct 2-day workshop at USC in conjunction with COCOMO Forum
  - 29-30 OCT 2008
  - Workshop to be led by Ricardo Valerdi, Garry Roedler, and Jared Fortune
  - All PSM Workshop participants are invited

Backup

Parametric Cost Estimation

"Parametric techniques focus on the cost drivers, not the miscellaneous details. The drivers are the controllable system design or planning characteristics and have a predominant effect on system cost. Parametrics uses the few important parameters that have the most significant cost impact on the product(s), hardware or software, being estimated."

Source: Parametric Cost Estimating Handbook, sponsored by a joint Government/Industry Committee formed in 1994 to study ways to enhance the use of parametric cost estimating techniques

Activity-Based Cost Models

- Activity Based Cost (ABC) Models:
  - Estimate the costs for each activity or group of activities that compose project
    - Ideally, derived from the work break-down structure (WBS)
  - Enable the estimator to separately consider each activity in the process (e.g., software development process)
    - Provides an intellectual framework for considering the effect of changes (relative to past experience) such as: a new tool, a process change, different skill mix, etc.
    - Users need to identify all of the activities that compose the specific process whose cost is to be estimated
    - Relate to WBS and potentially more specific staffing
- Cost elements may be driven by:
  - Size of the product
  - Proportions (percents) of the cost (effort)
    - Examples: quality assurance, builds and controls, program office