Suggestion for an Affiliate Breakout Group Topic
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Problem Statement

As the government contracting community moves from traditional, sole source/cost plus contract vehicles to competitive, fixed price ones there is an ever increasing need for a credible, supportable, fact-based **System Engineering (SE) estimation model.**

An Approach

I submit that USC/CSE has the research knowledge and tools based upon the COCOMO II development effort to lead such a task, with the USC Industrial Affiliates help (including data, peer review, and WB Delphi team membership). The resultant model could eventually be a candidate as an emerging extension to COCOMO II. Another valued resource to consider would be INCOSE for insight and data.

SE Estimation Model Building Blocks

SE Cost Drivers

- Conceptually, the current COCOMO II cost drivers apply to SE as well, but not necessarily the current productivity range/values:
  - Current Scale Factors have a strong SE focus
    - FLEX - Development Flexibility
    - TEAM - Team Cohesion
    - PREC - Precedentedness
    - RESL - Architecture and Risk Resolution
    - PMAT - Process Maturity (EIA, CMMI, etc.)
  - Most Effort Multipliers (EMs) apply well to SE (DATA, RUSE, and LTEX are perhaps exceptions), the Early Design composite multipliers would be most appropriate intially, however for the Post-Architecture EM set...
    - ACAP/PCAP - Personnel/Team Capability (some ACAPs are actually SE types)
    - CPLX - Product Complexity (design)
    - TIME - Time Constraints (performance requirements issues)
    - RELY - Required Reliability (testing rigor)
    - STOR - Storage Constraints (performance requirements issues)
    - APEX - Application Experience
    - TOOL - Use of SW Tools (instead, SE tools like DOORS, etc.)
    - SITE - Multi-Site Development
    - DOCU - Documentation to Match Life-Cycle Needs

- PVOL - Platform Volatility
- PLEX - Platform Experience
- SCED - Required Development Schedule
- PCON - Personnel Continuity

- REVL - Requirements Volatility and Evolution applies (except you are not adjusting SW SLOC but some other measure of SE size)

- Other Cost Drivers?

SE Sizing

- We need an Early Design Model measure of SE size derivable from RFP and preliminary Interface docs / System Specs for the proposal, plus more definitive data process and artifact data from system architectural and design work later in development (Post Architectural Model)

An Early Design SE Sizing Candidate: Requirements

- Some requirement attributes that may drive SE cost
  - Clarity
  - Completeness
  - Stability
  - Maturity (TBDs,TBRs)
  - Complexity
  - Other Attributes?

- Requirements-based sizing has the advantage of applying to both COTS/Component based and custom developed systems

Other SE Sizing Candidates: Either Early Design or Post-Architectural

- Number/Complexity/Maturity/Stability of External Interfaces
- Number/Complexity/Maturity/Stability of Internal Interfaces
- Function Points/Feature Points
- Use Cases (or elements of)
- OO Design Artifacts and Complexity
- Number/Complexity/Page Counts/Planned Releases of SE-Generated Documents
- Other Candidates?

SE Effort Scope and Distribution

- We need a high-level SE Task list (analogous to the COCOMO II SW activities performed) for better definition of what constitutes SE effort (may need to combine or descope for simplicity):
  - System Requirements Management
  - Project Office Support (including customer change requests *)
  - Detailed Project Planning
  - Simulation and Modeling
  - Concept of Operations Development
  - System Arch. and Design
  - Technical Performance Monitoring
  - Verification and Validation Activities
  - Project Office Support (both contractor and customer)
  - Specialty Engineering (e.g., "ilities")
  - Other Tasks?

  * One issue with SE estimation that may not apply to all shops, but is quite significant for us (Raytheon Garland) is the SE effort needed for anticipated changes to a program. SE is responsible for reviewing and responding to Request For Changes (RFCs). Some customers may actually direct the SE group to write the draft RFC. They (SE) are responsible for writing/coordinating the response to the RFC via the Engineering Change Proposal (ECP) mechanism. Possible bottoms-up drivers for estimating this task are:
    - Proposal requirement maturity TBDs/TBRs provides some indication
    - Customer change request history is an indicator (number of RFCs per month) along with…
    - Anticipated length of the program

- Conceptually, MBASE distribution of the SE effort would seem start in the Inception (PS to LCO) phase, peak during the Elaboration (LCO to LCA) phase, would require sustaining ("minding the store" effort) during Construction (LCA to IOC), and then pick back up in the latter part of Construction and continue through much of the Transition phase (IOC to PR)

Miscellaneous Comments

- If building a useful SE estimation model was a simple task it would have been done long ago.
  - In fact, there have been many barriers:
    - Lack of reliable SE "sizing" data,
    - Ill-defined SE tasks and roles, and thus fuzzy SE effort data,
    - Complexities related to estimating IPT efforts (also a SW estimation issue)
    - Others?

- Choice of development method (Waterfall, Spiral, Incremental, etc.) would seem to be a driver. Is the SE effort for the first few spirals relatively more than later spirals? Typical SE staffing profiles per method as development proceeds would be useful. MBASE anchor points would seem to provide a good starting point.

- Need to define relationship to USC COCOTS and other such COTS based estimation models

- For simplicity, may need to initially limit an SE estimation model to software intensive systems

- Recent movement of DoD standards towards best commercial practices, including less formal documentation might make historical SE effort expenditures for 2167A-like projects suspect for use in future systems.