CO SYS MO

CONSTRUCTIVE SYSTEMS ENGINEERING COST MODEL

18th International Forum on COCOMO and Software Cost Modeling
Los Angeles, CA
October 22, 2003

Status and Plans

Ricardo Valerdi – ***USC Center for Software Engineering***

Outline

- Details on Tomorrow’s Workshop
- COSYSMO Drivers & Sizing approaches
- Raytheon/USC myCOSYSMO Prototype
- Delphi Round 2

COSYSMO Workshop Agenda

Morning (8:30 AM – noon)

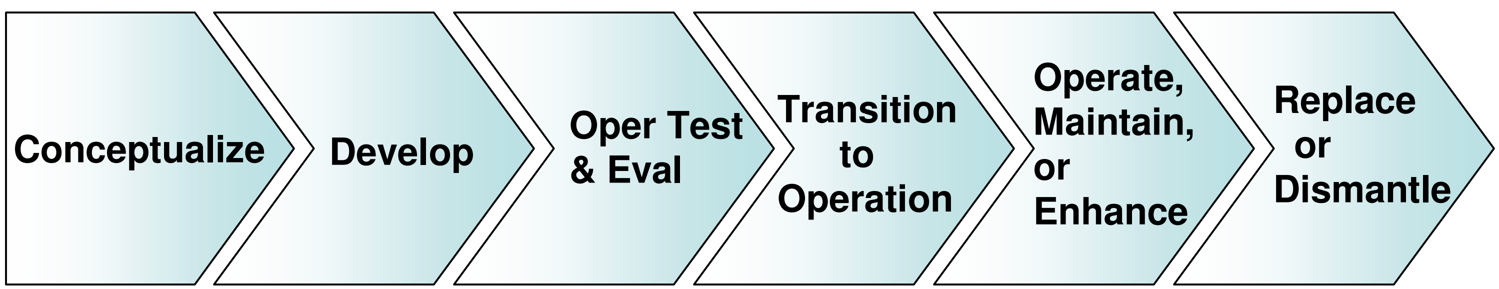
- Brief Introduction on COSYSMO
- Updates on action items
- Updates on related work
- Results from Delphi Round 2

Afternoon (1:00 PM – 5:00 PM)

- SE Sizing discussion
- Data collection form & NDAs
- Synchronization with INCOSE activities
- Open issues
- Action items

COSYSMO Introduction

- Parametric model to estimate system engineering costs
- Includes 4 size & 14 cost drivers
- Covers full system engineering lifecycle
- Developed with USC-CSE Corporate Affiliate and INCOSE participation



Size Drivers vs. Effort Multipliers

- Size Drivers: Additive, Incremental
  - Impact of adding a new item inversely proportional to current size

    10 → 11 rqts = 10% increase

    100 → 101 rqts = 1% increase
- Effort Multipliers: Multiplicative, system-wide
  - Impact of adding a new item independent of current size

    10 rqts + high security = 40% increase

    100 rqts + high security = 40% increase

4 Size Drivers

1. Number of System Requirements*
2. Number of Major Interfaces
3. Number of Operational Scenarios
4. Number of Critical Algorithms

*Weighted by complexity, volatility, and degree of reuse

Systems Engineering Sizing

Requirements

System Level (too high): The system shall provide notification of out-of-tolerance inputs and outputs to authorized parties.

File Level (about right): Each system component has one or more files of parameters to monitor, report exceptions, and adjust tolerances in a familiar way.

Parameter Level (too low): The system shall determine that the temperature T at point P, is between T11 and T12, and report exceptions to the safety monitor.

Interfaces

For hardware interfaces, use Number and Complexity of External Interface files.

For user interfaces, use Number and Complexity of Input Files, Output Files, External Queries.

Number of System Requirements

This driver represents the number of requirements for the system-of-interest at a specific level of design. Requirements may be functional, performance, feature, or service-oriented in nature depending on the methodology used for specification. They may also be defined by the customer or contractor. System requirements can typically be quantified by counting the number of applicable "shall's" or "will's" in the system or marketing specification. Do not include a requirements expansion ratio – only provide a count for the requirements of the system-of-interest as defined by the system or marketing specification.

0.5	1.0	3.0
Easy	**Nominal**	**Difficult**
- Well specified	- Loosely specified	- Poorly specified
- Traceable to source	- Can be traced to source with some effort	- Hard to trace to source
- Little requirements overlap	- Some overlap	- High degree of requirements overlap

Number of Major Interfaces

This driver represents the number of shared major physical and logical boundaries between system components or functions (internal interfaces) and those external to the system (external interfaces). These interfaces typically can be quantified by counting the number of external and internal system interfaces among ISO/ISE 15288-defined system elements.

1.0	3.0	7.0
Easy	**Nominal**	**Difficult**
- Well defined	- Loosely defined	- Ill defined
- Uncoupled	- Loosely coupled	- Highly coupled
- Strong consensus	- Moderate consensus	- Low consensus
- Well behaved	- Predictable behavior	- Poorly behaved

Number of Operational Scenarios

This driver represents the number of operational scenarios that a system must satisfy. Such threads typically result in end-to-end test scenarios that are developed to validate the system and satisfy all of its requirements. The number of scenarios can typically be quantified by counting the number of unique end-to-end tests used to validate the system functionality and performance or by counting the number of use case sequence diagrams developed as part of the operational architecture.

14.0	29.0	58.0
Easy	**Nominal**	**Difficult**
- Well defined	- Loosely defined	- Ill defined
- Loosely coupled	- Moderately coupled	- Tightly coupled or many dependencies/conflicting requirements
- Timelines not an issue	- Timelines a constraint	- Tight timelines through scenario network

Number of Critical Algorithms

This driver represents the number of newly defined or significantly altered functions that require unique mathematical algorithms to be derived in order to achieve the system performance requirements. As an example, this could include a complex aircraft tracking algorithm like a Kalman Filter being derived using existing experience as the basis for the all aspect search function. Another example could be a brand new discrimination algorithm being derived to identify friend or foe function in space-based applications. The number can be quantified by counting the number of unique algorithms needed to support each of the mathematical functions specified in the system specification or mode description document.

3.0	6.0	15.0
Easy	**Nominal**	**Difficult**
- Existing algorithms	- Some new algorithms	- Many new algorithms
- Basic math	- Algebraic by nature	- Difficult math (calculus)
- Straightforward structure	- Nested structure with decision logic	- Recursive in structure with distributed control
- Simple data	- Relational data	- Persistent data
- Timing not an issue	- Timing a constraint	- Dynamic, with timing issues
- Library-based solution	- Some modeling involved	- Simulation and modeling involved

14 Cost Drivers

Application Factors (8)

1. Requirements understanding
2. Architecture understanding
3. Level of service requirements
4. Migration complexity
5. Technology Maturity
6. Documentation Match to Life Cycle Needs
7. # and Diversity of Installations/Platforms
8. # of Recursive Levels in the Design

14 Cost Drivers (cont.)

Team Factors (6)

1. Stakeholder team cohesion
2. Personnel/team capability
3. Personnel experience/continuity
4. Process maturity
5. Multisite coordination
6. Tool support

USC/Raytheon myCOSYSMO* Demo in SAL 3rd floor

Welcome to the USC-CSE COSYSMO prototype, version 1.15

We appreciate the sponsorship and continued support of INCOSE and the USC-CSE Industrial Affiliates

COSYSMO Model hours generated by the "SE Costing Mode" are not yet based upon validated data and are provided only for demonstration/visualization purposes.

The "SE Costing Mode" and "SE Data Collection Mode" examples provided are just that --- only examples that are not generally related to one another.

Worksheets that appear in the SE Costing Mode only have white banners, Worksheets that appear in the SE Data Collection Mode only have green banners, and...
Worksheets common to both Modes have blue banners.

Click for SE Costing Mode (Example Only)

Click for SE Data Collection Mode (Example Only)

***Developed by Gary Thomas at Raytheon Garland**

Delphi Survey

- 32 Surveys returned
- Distributed to CSE Affiliates and INCOSE members via MWG, SECOE, CAB
- 2 rounds were done at Keystone in July ‘03
- Combined experience
  - 600 Years of SW/SE
  - 200 Years of cost modeling
- Most respondents were from Military/Defense domain
- Special thanks to Arnie Goodman and Dick Stutzke

Participants (32)

Paul Mohlman	Aerospace	Bill Slobodian	Northrop Grumman
Abe Santiago	Aerospace	Lori Vaughan	Northrop Grumman
Anh Tu	Aerospace	Gary Thomas	Raytheon
Maurie Hartman	Boeing	Randy Case	Raytheon
Rob Flowe	DAU	Bob Vojtech	Raytheon
Denton Tarbet	Galorath	John Rieff	Raytheon
Gary Hafen	LMCO	Greg Cahill	Raytheon
Rick Edison	LMCO	Larry S Kleckner	Raytheon
Garry Roedler	LMCO	Tony Jordano	SAIC
Carl Newman	LMCO	Charley Zumba	SAIC
Bob Beckley	LMCO	Jim Armstrong	SPC
Trish Persson	LMCO	Sarah Sheard	SPC
Steven Wong	Northrop Grumman	Chris Miller	SPC
Steve Copoloff	Northrop Grumman	Barry Boehm	USC
Joe Kiernicki	Northrop Grumman	Don Reifer	USC
Ed Tse	Northrop Grumman	George Friedman	USC

Questions or Comments?

Dr. Barry Boehm

boehm@sunset.usc.edu

Ricardo Valerdi

rvalerdi@sunset.usc.edu

Website

http://www.valerdi.com/cosysmo