



**7th Annual Practical Software and Systems Measurement Users' Group Conference**  
**Keystone, CO**  
**July 16, 2003**

**Dr. Barry W. Boehm – *USC Center for Software Engineering***

# Workshop Agenda

## Day 1 (1:30 AM – 5:00 PM 7/16)

- Next-level tutorial
- Review of drivers
- SE Sizing discussion
- Tool demo

## Day 2 (8:30 AM – 4:30 PM 7/17)

- Action item review from February meeting
- Discussion of key driver issues
- Data collection form
- Data collection lessons learned
- Possible data sources
- COSYSMO Trade Study
- Delphi exercise

# USC-CSE Affiliates (34)

- **Commercial Industry (15)**
  - Daimler Chrysler, Freshwater Partners, **Galorath**, Group Systems.Com, Hughes, IBM, Cost Xpert Group, Microsoft, Motorola, Price Systems, Rational, Reuters Consulting, Sun, Telcordia, Xerox
- **Aerospace Industry (6)**
  - **BAE**, Boeing, **Lockheed Martin**, **Northrop Grumman**, **Raytheon**, **SAIC**
- **Government (8)**
  - DARPA, DISA, FAA, NASA-Ames, NSF, OSD/ARA/SIS, **US Army Research Labs**, US Army TACOM
- **FFRDC's and Consortia (4)**
  - **Aerospace**, JPL, SEI, **SPC**
- **International (1)**
  - Chung-Ang U. (Korea)

**\*COSYSMO Contributors**

# **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**

# Model Differences

## COCOMO II

- **Software**
- **Development phases**
- **20+ years old**
- **200+ calibration points**
- **23 Drivers**
- **Variable granularity**
- **3 anchor points**
- **Size is driven by SLOC**

## COSYSMO

- **Systems Engineering**
- **Entire Life Cycle**
- **2 years old**
- **~3 calibration points**
- **18 drivers**
- **Fixed granularity**
- **No anchor points**
- **Size is driven by requirements, I/F, etc**

# **CMMI and SE Effort Estimation**

**From CMMI-SE/SW/IPPD/SS, v1.1**

**Level 2: Project Planning**

**SP 1.4 Determine Estimates of Effort and Cost**

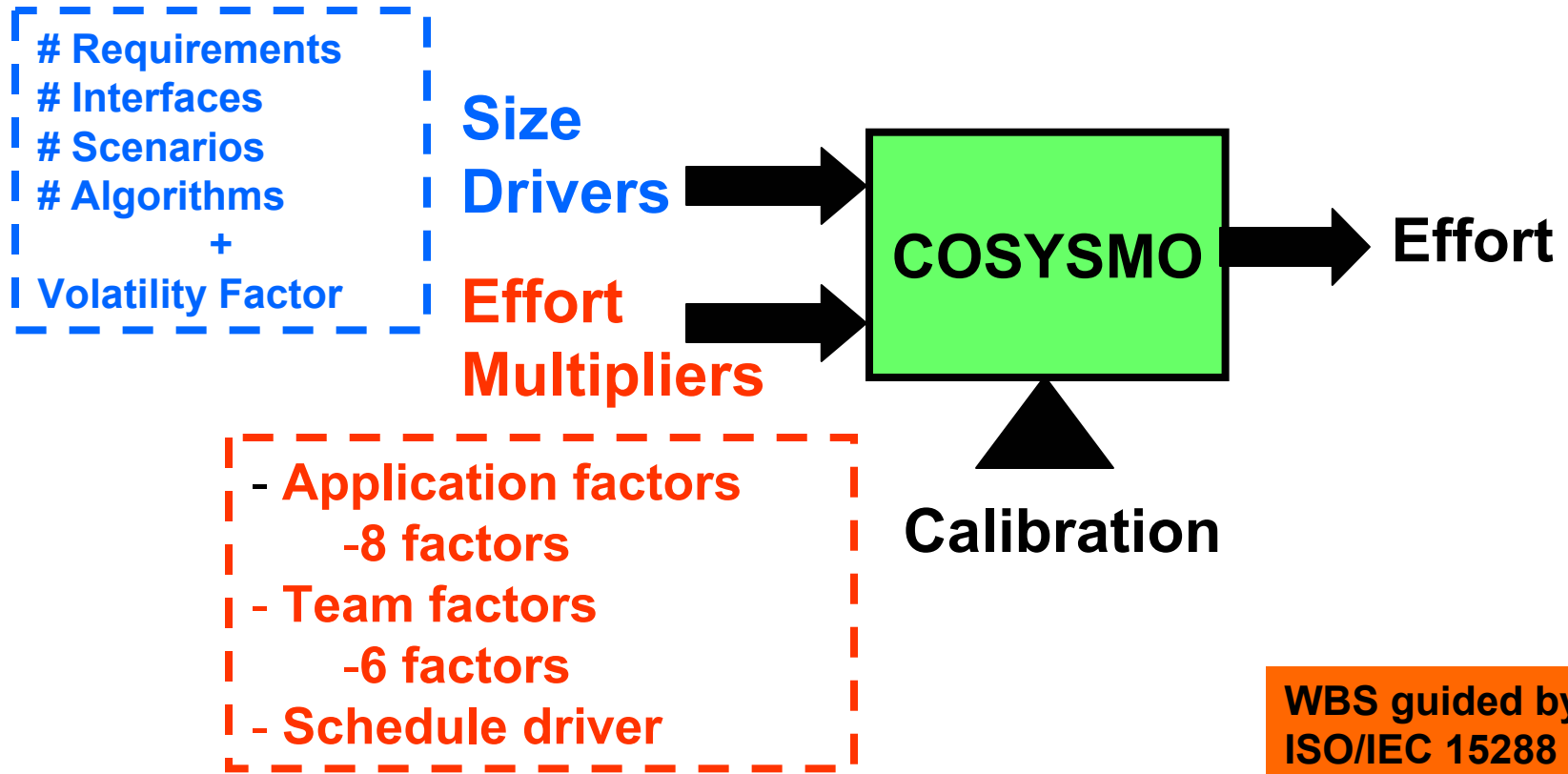
- Estimate effort and cost using models and/or historical data**

**Level 2: Measurement and Analysis**

**SP 1.2 Specify Measures**

- Estimates of actual measures of effort and cost (e.g., number of person hours)**

# COSYSMO Operational Concept



# COCOMO-based Parametric Cost Estimating Relationship

$$PM_{NS} = A \cdot (Size)^E \cdot \prod_{i=1}^n EM_i$$

Where:

**PM<sub>NS</sub>** = effort in Person Months (Nominal Schedule)

**A** = constant derived from historical project data

**Size** = determined by computing the weighted average of the (4) size drivers

**E** = could represent economy/diseconomy of scale, currently equals 1

**n** = number of cost drivers (14)

**EM** = effort multiplier for the  $i_{th}$  cost driver. The geometric product results in an overall effort adjustment factor to the nominal effort.



# 4 Size Drivers

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

- Each weighted by complexity, volatility, and degree of reuse

## 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.

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
- Simple to understand	- Takes some effort to understand	- Hard to understand
- Little requirements overlap	- Some overlap	- High degree of requirements overlap
- Familiar	- Generally familiar	- Unfamiliar
- Good understanding of what’s needed to satisfy and verify requirements	- General understanding of what’s needed to satisfy and verify requirements	- Poor understanding of what’s needed to satisfy and verify requirements

# 14 Cost Drivers

## *Application Factors (8)*

1. Requirements understanding
2. Architecture complexity
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

# Raytheon Data Collection Lessons Learned

- **SE Labor Accounting Collection and “Binning” are significant efforts**
  - **Need to separate organizational reporting structure from EIA 632 / ISO/IEC 15288 SE tasks performed**
    - **Using all “SE Hours” from your SE organization may not be appropriate**
    - **There may be “SE Hours” from an outside group**
  - **May need to map from a local, historical SE Labor “Binning” to COSYSMO**
    - **COSYSMO Prototype has a “Collection Mode” mapping example/vehicle**
- **SE Sizing (in progress) – 5 Garland projects**
  - **Requirements and Major Interface counts relatively easy**
  - **Critical Algorithm and Operational Scenario counts seem more elusive**

# USC/Raytheon myCOSYSMO\* Demo

Welcome to the USC-CSE COSYSMO prototype, version 1.11

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 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 \(Example Only\)](#)

# COSYSMO Table of Contents (TOC)

The TOC is “Home Base”

**Conventions:**

- Click on the grey buttons to get to the relevant worksheet(s)
- Return back to TOC from the grey button labeled “TOC” in ULH corner of each destination worksheet
- Grey fields mean user can input or potentially change the default values
- Formula worksheets are protected, but no password
- Extensive embedded notes mirroring current COSYSMO descriptions, driver selection criteria, etc.

**Project X SE cost and schedule estimate example using COSYSMO vers. 1.11**

Model Assumptions & Notes	Getting Started	Local SE Data Repository	COSYSMO Table of Contents (TOC)			Model Drivers and Activities <b>New!</b>	Acronyms	Version Release History
SE Costing Inputs and Outputs			Navigation	Errors?	SE Sizing Artifacts Input		Navigation	
1. Executive Cost Summary			<a href="#">Go To</a>		12a. REQ (No. of System Requirements)		<a href="#">Go To</a>	
2. WBS and Size Definitions			<a href="#">Go To</a>		12b. IF (No. of Major Interfaces)		<a href="#">Go To</a>	
3. Estimation Assumptions			<a href="#">Go To</a>		12c. ALG (No. of Critical Algorithms)		<a href="#">Go To</a>	
4. Parameters I			<a href="#">Go To</a>		12d. SCN (No. of Operational Scenarios)		<a href="#">Go To</a>	
5. Parameters II			<a href="#">Go To</a>		12e. SP1 (Spare 1)		<a href="#">Go To</a>	
6. Staffing Table and Charts			<a href="#">Go To</a>		12f. SP2 (Spare 2)		<a href="#">Go To</a>	
7. Labor Distribution			<a href="#">Go To</a>		12g. SP3 (Spare 3)		<a href="#">Go To</a>	
8a. Application Factors			<a href="#">Go To</a>					
8b. Team Factors			<a href="#">Go To</a>					
9. COSYSMO Model Computations			<a href="#">Go To</a>					
10. Model Hours and Staffing per Phase			<a href="#">Go To</a>					
11. Other Hours (Non-Model Sources of Effort)			<a href="#">Go To</a>					

[Greetings](#) > [Table of Contents](#) > [1. Executive Cost Summary](#) > [2. WBS and Model Definition](#) > [3. Project Assumptions](#) > [4. Parameters I](#) > [5. Par](#)

# 4. Rate Cost Drivers - Application

TOC	COSYSMO Application Factor Selection											See Embedded Comments for Descriptions and Selection Criteria
COSYSMO Application Factor Description	Identifier	Current Prod. Range	Suggested Prod. Range	VLOW (VL)	LOW (L)	NOM (N)	HIGH (H)	VHIGH (VH)	XHIGH (XH)	Rating Selected	Resulting Multiplier	Application Factor Rating Selection Comments
Requirements Understanding	RQMT	1.73	1.73	1.40	1.20	1.00	0.90	0.81	----	N	1.00	
Architecture Complexity	ARCH	1.66	1.66	1.28	1.14	1.00	0.88	0.77	----	N	1.00	
Level of Service (KPP) Requirements	LSVC	2.50	2.50	0.66	0.83	1.00	1.33	1.65	----	N	1.00	
Migration Complexity	MIGR	1.50	1.50	----	----	1.00	1.25	1.50	----	N	1.00	
No. and Diversity of Installations/Platforms	INST	1.50	1.50	----	----	1.00	1.25	1.50	----	N	1.00	
No. of Recursive Levels in the Design	RECU	1.50	1.50	0.82	0.91	1.00	1.12	1.23	----	N	1.00	
Documentation to Match Lifecycle Needs	DOCU	0.67	0.67	0.82	0.91	1.00	1.12	1.23	----	N	1.00	
Technology Maturity	TMAT	2.50	2.50	1.75	1.37	1.00	0.85	0.70	----	N	1.00	

Select the Rating from the pull that best represents the Rating program being estimated in the Mode or in the SE Data Collect Rating that best characterizes t program for which you are prov

Productivity Range (PR) is the Highest Number / Lowest Number and is an indication of the "Relative Degree of Influence" of this parameter on SE effort as currently

The "Suggested" column has no immediate impact in the COSYSMO SE Costing Mode. However, for the COSYSMO SE Data Collection Mode, it serves as a means of collecting your inputs as to what you think the "Relative Degree of Influence" of this parameter should be based upon your overall experience (not specific to the past program being characterized). If you agree with the "Current" number, do nothing. If you disagree, simply overwrite the current number with a new number n (n>1.0) in the appropriate cell.



# 5. Estimate Size - Requirements


<b>TOC</b>		<b>Total New Equivalent REQ</b>			<b>1,000</b>			<p>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.</p>					
<b>New No. of System Requirements</b>					<b>Adapted No. of System Requirements</b>								
New REQ Complexity Scale	REQ Scaling Factor	Enter Most Probable New REQ	Sizing Confidence level (H,M,L)	Expected New REQ	Adapted REQ Complexity Scale	REQ Scaling Factor	Enter Most Probable Adapted REQ	Sizing Confidence level (H,M,L)	Expected Adapted REQ	REQ Adaptation Level	Total New Equivalent REQ	Comments	
Easy	0.50	0		0							0		
Nominal	1.00	1,000		1,000							0		
Difficult	4.00	0		0							0		
	Easy	Nominal	Difficult										
No. of System Requirements	- Well specified	- Loosely specified	- Poorly specified		Easy	0.50	0		0		0		
	- Traceable to source	- Can be traced to source with some effort	- Hard to trace to source		Nominal	1.00	0		0		0		
	- Simple to understand	- Takes some effort to understand	- Hard to understand										
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# Parametric Cost Model Critical Path

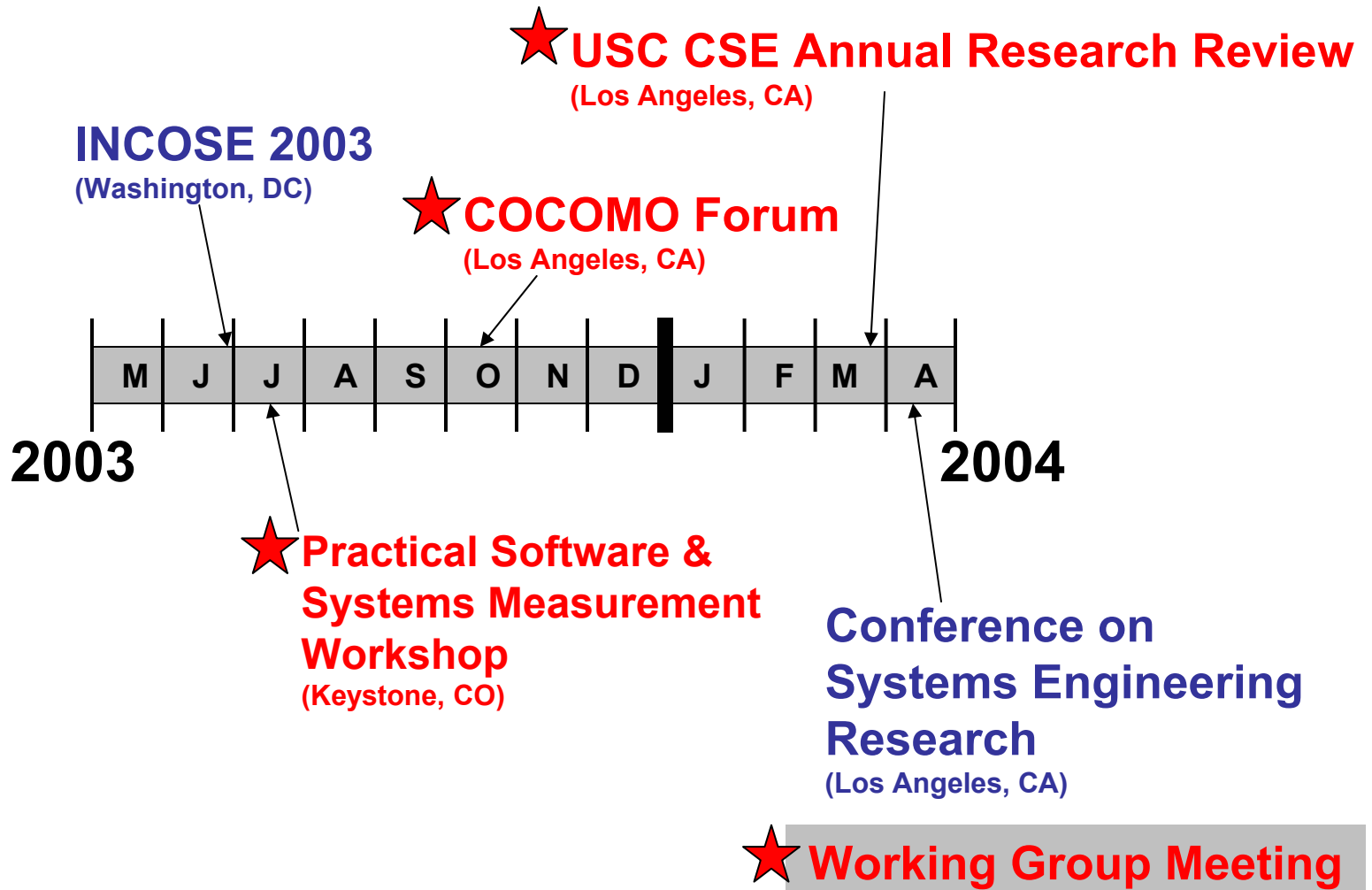
**Usual #  
Months\***

**Critical Path Task**

- |   |   |
|---|---|
| 6   | Converge on cost drivers, WBS                               |
| 6   | Converge on detailed definitions and rating scales          |
|  12 | Obtain initial exploratory dataset (5-10 projects)          |
| 6   | Refine model based on data collection & analysis experience |
| 12+   | Obtain IOC calibration dataset (30 projects)                |
| 9   | Refine IOC model and tool                                   |

**\*Can be shortened and selectively overlapped**

# Calendar of Activities: 2003/04



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# Questions or Comments?

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**Websites**

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