



The COSYSMO 3.0 Final Model

**Dr. Jim Alstad USC Center for Systems
and Software Engineering**

**PSM Users' Group 2018 – Workshop #9
Lockheed Martin Global Vision Center
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Jim Alstad 310/344-0894 jalstad@usc.edu

Acknowledgements

- This presentation was adapted from one with these authors:

Dr Jim Alstad	
Dr Barry W Boehm	USC Center for Systems and Software Engineering
Dr Jo Ann Lane	
Mr Garry Roedler	Lockheed Martin
Dr Gan Wang	BAE Systems
Ms Marilee Wheaton	The Aerospace Corporation

COSYSMO 3.0 Objectives

- **Context:**
 - **Current and future trends create challenges for full-system cost estimation**
 - **Emergent requirements, rapid change, net-centric systems of systems, COTS, clouds, apps, widgets, high assurance with agility, multi-mission systems**
 - **Current development practices can minimize cost of one phase, such as development, while raising full-system cost**
- **COSYSMO 3.0 is being developed to mitigate this situation by supporting accurate estimates of systems engineering costs, with benefits including:**
 - **Allowing thoughtful system-level systems engineering during development, which can result in, for example, choosing new technologies that reduce total system cost**
 - **Allowing thoughtful engineering of systems to support life-cycle flexibility**

Workshop Preview

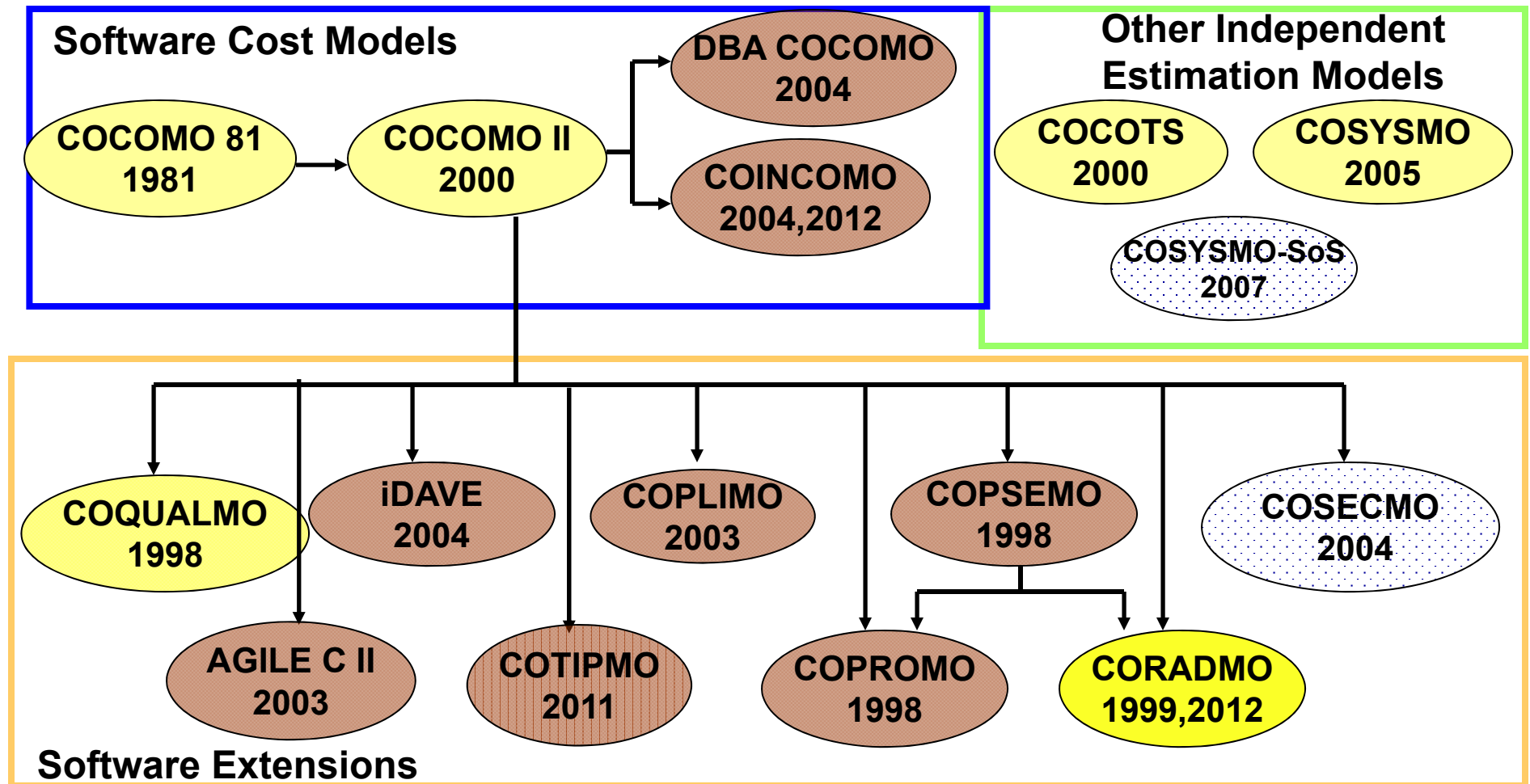
- **Agenda:**
 - Go over this presentation, capturing feedback
 - The COSYSMO 3.0 Final Model
 - Suggestions for further COSYSMO development
- **Intended output:**
 - This presentation
 - With feedback captured

Agenda

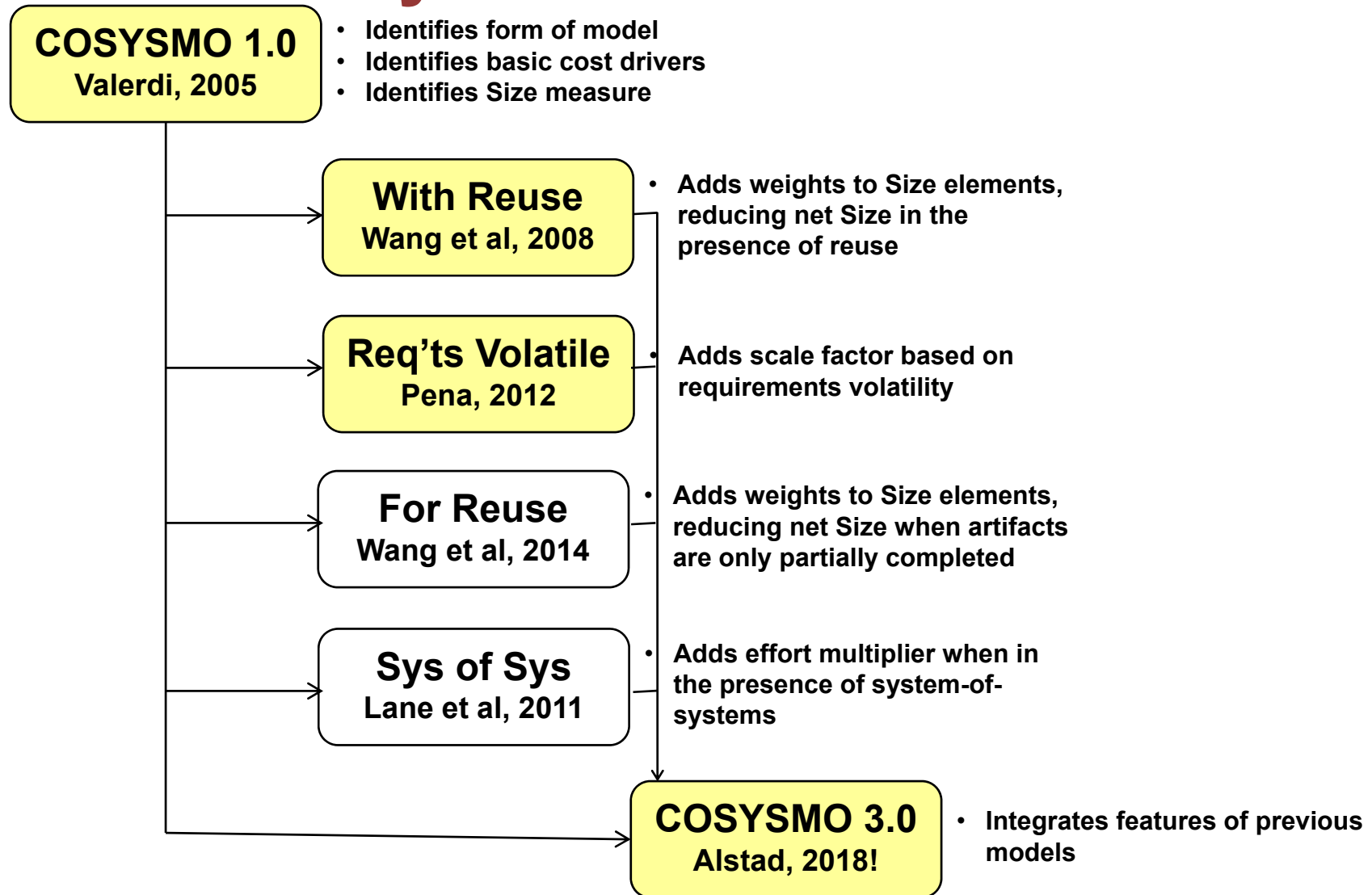
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- The motivation for COSYSMO 3.0
- History of COSYSMO 3.0
- Overview of the content of the COSYSMO 3.0 estimating model
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History of COSYSMO Models



COSYSMO 3.0 Directions

Incorporate and harmonize existing COSYSMO model research and experience for estimating systems engineering effort:

- **Several factors affecting the COSYSMO cost model have been shown to be valuable in increasing estimation accuracy (terminology from [24]):**
 - **Reuse (partial model—Development With Reuse) [3, 24]**
 - **Reuse (with Development For Reuse) [24]**
 - **Requirements volatility (RV) [4]**

The rating scales for these could be integrated into a comprehensive COSYSMO model.

Enhancement included:

- **System-of-system considerations are hypothesized to affect system engineering costs:**

9/12 — Interoperability considerations [6]



COSYSMO 3.0 Directions

Part 2

Enhancements under discussion:

- **Explore a model for total development cost based primarily on the COSYSMO parameters (following work led by Reggie Cole of Lockheed Martin [17, 7])**

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COSYSMO 3.0

Top-Level Model

$$PH = A \cdot (\text{AdjSize})^E \cdot \prod_{j=1}^{15} EM_j$$

Elements of the COSYSMO 3.0 model:

- Calibration parameter A
- Adjusted Size model
 - eReq submodel, where 4 products contribute to size
 - Reuse submodel
- Exponent (E) model
 - Accounts for diseconomy of scale
 - Constant and 3 scale factors
- Effort multipliers EM
 - 15 cost drivers

Expert-Based COSYSMO 3.0 Size Model

$$AdjSize_{C3} = \sum_{SizeDrivers} eReq(Type(SD), Difficulty(SD)) \times \\ PartialDevFactor(AL_{Start}(SD), AL_{End}(SD), RType(SD))$$

- ***SizeDriver* is one of the system engineering products that determines size in the COSYSMO family (per [2]). Any product of these types is included:**
 - System requirement
 - System interface
 - System algorithm
 - Operational scenario
- **There are two submodels:**
 - Equivalent nominal requirements (“eReq”)
 - Raw size
 - Partial development
 - Adjusts size for reuse

Size Model – eReq Submodel

- The eReq submodel is unchanged from [2].
- The submodel computes the size of a *SizeDriver*, in units of eReq (“equivalent nominal requirements”)
- Each *SizeDriver* is evaluated as being easy, nominal, or difficult.
- The following table contains conversion factors for the conversion of a *SizeDriver* to a number of eReq:

Size Driver Type	Easy	Nominal	Difficult
System Requirement	0.5	1.0	5.0
System Interface	1.1	2.8	6.3
System Algorithm	2.2	4.1	11.5
Operational Scenario	6.2	14.4	30.0

How Reuse Is Addressed

Reuse operates in two directions [1]:

- **Development with reuse (DWR):** previously developed artifacts are reused on the current project
 - Addressed completely by the DWR partial development model
- **Development for reuse (DFR):** the current project is creating artifacts to be reused on other projects
 - One aspect of DFR development is that DFR costs more than ordinary development
 - Addressed by the DFR cost driver (covered there)
 - Another aspect of DFR is that the artifacts may be only partially completed, as during an IR&D project
 - Addressed by the DFR partial development model

Size Model – Partial Development Submodel

- (Concepts here are simplified a little)
- The basic DWR concept:
 - If a reused *SizeDriver* is being brought in, that saves effort, and so we adjust the size by multiplying the raw size by a *PartialDevFactor* less than 1.
 - The value of *PartialDevFactor* is based on the maturity of the reused *SizeDriver*, and is looked up in a table [24].
 - How fully developed was the *SizeDriver*?
 - If there is no reuse for this *SizeDriver*, then *PartialDevFactor* = 1 (no adjustment).

DWR Activity Level:	New	Design Modified	Design Implemented	Adapted for Integration	Adopted for Integration	Managed
DWR % for this AL through end	100.00%	83.00%	70.13%	56.88%	37.82%	17.50%

- The basic development-for-reuse (DFR) concept is analogous:
 - A product to be reused may be not be taken through the full development cycle (e.g., an IR&D project)

DFR Activity Level:	Conceptualized for Reuse	N/A	Designed for Reuse	Constructed for Reuse	N/A	Validated for Reuse
DFR % from start through this AL	31.96%		54.60%	78.06%		90.69%

COSYSMO 3.0

Exponent Model

- Exponent model is expanded from Peña [4, 9]

$$E = E_{Base} + SF_{ROR} + SF_{PC} + SF_{RV}$$

Where:

- E_{Base} = A minimum exponent for diseconomy of scale
- SF = scale factor
- ROR = Risk/Opportunity Resolution
- PC = Process Capability
- RV = Requirements Volatility

The effect of a large exponent is more pronounced on bigger projects

COSYSMO 3.0


Cost Driver Model

- Here are the 13 cost drivers:

	Driver Name	Data Item
UNDR	CONOPS & requirements understanding	Subjective assessment of the CONOPS & the system requirements
	Architecture understanding	Subjective assessment of the system architecture
	Stakeholder team cohesion	Subjective assessment of all stakeholders
CMPX	Level of service requirements	Subjective difficulty of satisfying the key performance parameters
	Technology risk	Maturity, readiness, and obsolescence of technology
	# of Recursive levels in the design	Number of applicable levels of the Work Breakdown Structure
OPRN	Development for reuse	Is this project developing artifacts for later reuse?
	# and Diversity of installations/platforms	Sites, installations, operating environment, and diverse platforms
	Migration complexity	Influence of legacy system (if applicable)
PERS	Personnel/team capability	Subjective assessment of the team's intellectual capability
	Personnel experience/continuity	Subjective assessment of staff consistency
ENVR	Multisite coordination	Location of stakeholders and coordination barriers
	Tool support	Subjective assessment of SE tools

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System-of-Systems: Multiple Subprojects

- Lane [10] developed a model for allocating systems engineering effort across a system-of-systems and its constituent systems.
 - This applied the COCOMO II multiple-subproject model to this systems engineering situation.
 - Her model is part of the COSYSMO 3.0 Final Model

$$PM_{C3M} = A_{C3} \cdot (TotalSize_{C3})^{E_{C3}} \cdot \sum_{s \in Subprojects} \left(\frac{Subproject_s Size_{C3}}{TotalSize_{C3}} \cdot \prod_{j=1}^{15} EM_{C3:s,j} \right)$$



COSYSMO 3.0

Interoperability Model

- **After groundwork for including interoperability had been laid, no interoperability data could be found**
- **So interoperability was dropped from the Final Model**

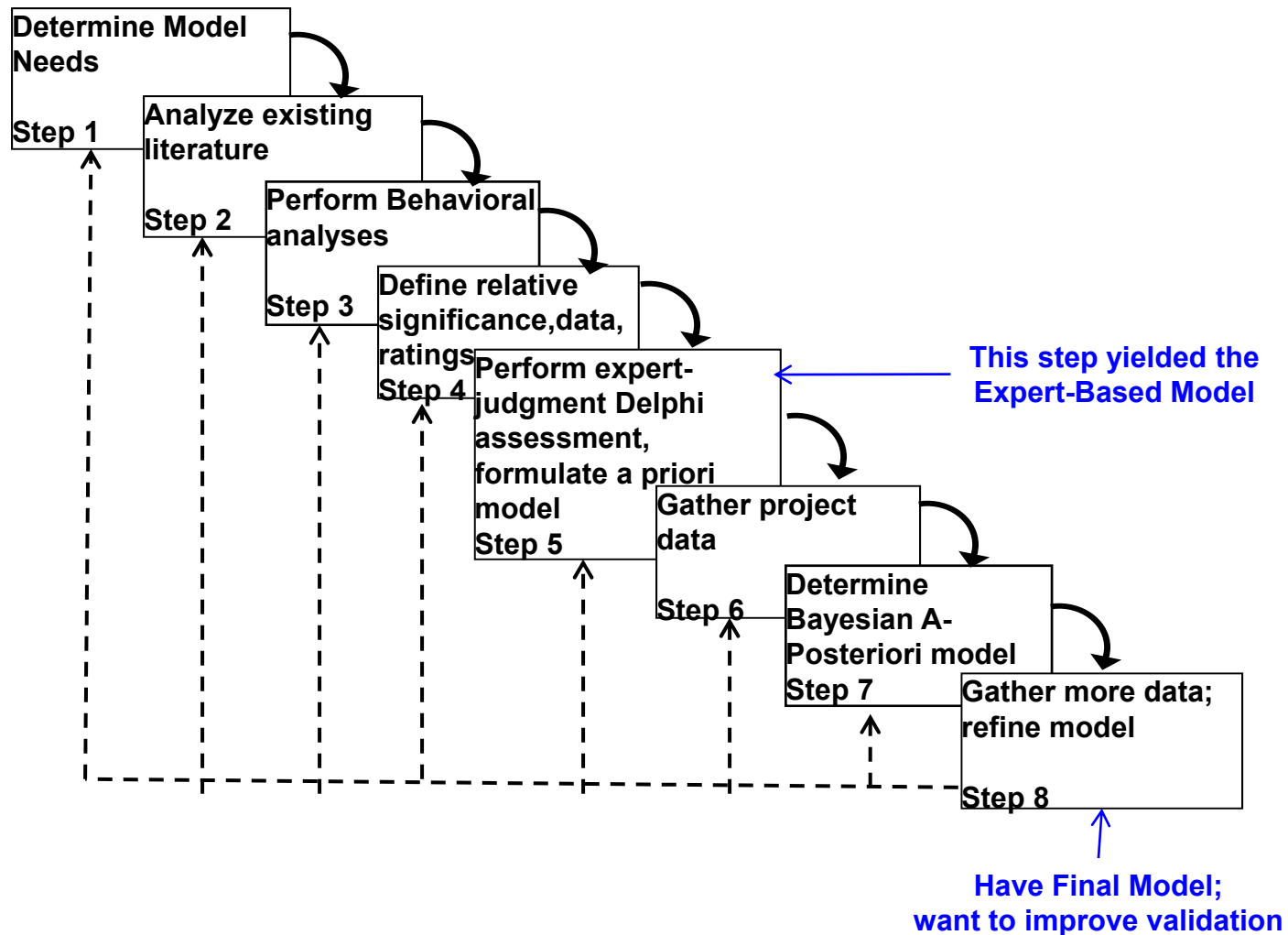
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USC-CSSE Modeling Methodology

Figure 4.1 from [22]



Model Status & Plans

- **The expert-based version of the COSYSMO 3.0 model was under development for over a year, with critical input from:**
 - The COSYSMO 3.0 Working Group
 - Attendees at conferences like this one
- **The Expert-Based Model was completed last year**
 - Along with a “Rosetta Stone”, for rerating old projects under COSYSMO 3.0
- **I obtained a suitable (though imperfect) data set**
 - By calibrating to that data set, I generated the COSYSMO 3.0 Final Model, which is what is presented here.

Core Members of the Working Group

Member	Present Affiliation
Barry Boehm	USC
Brad Clark	Software Metrics
Bob Epps	Retired
Bill Golaz	Lockheed Martin
Gary Hafen	Retired
Jo Ann Lane	San Diego State University
Dan Ligett	Softstar Systems
Garry Roedler	Lockheed Martin
John Sautter	Northrup-Grumman
Gan Wang	BAE Systems
Marilee Wheaton	The Aerospace Corporation

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- Attributes of the Final Model
 - Numeric values of parameters
 - Reuse and size parameters shown above
 - Other properties of the Final Model
- A solicitation
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Cost Driver & Scale Factor Values

Text Rating:		Very Low	Low	Nominal	High	Very High	Extra High
Numeric Rating:		-2	-1	0	1	2	3
Cost Driver	Step Size	Effort Multipliers					
CONOPS & Requirements Understanding	0.765	1.71	1.31	1.00	0.76	0.59	(Invalid)
Architecture Understanding	0.805	1.54	1.24	1.00	0.81	0.65	(Invalid)
Stakeholder Team Cohesion	0.802	1.55	1.25	1.00	0.8	0.64	(Invalid)
Level of Service Requirements	1.277	0.61	0.78	1.00	1.28	1.63	(Invalid)
Technology Risk	1.262	0.63	0.79	1.00	1.26	1.59	(Invalid)
# of Recursive Levels in the Design	1.179	0.72	0.85	1.00	1.18	1.39	(Invalid)
# and Diversity of Installations/ Platforms	1.238	(Invalid)	(Invalid)	1.00	1.24	1.53	1.90
Migration Complexity	1.252	(Invalid)	(Invalid)	1.00	1.25	1.57	1.96
Personnel/Team Capability	0.831	1.45	1.2	1.00	0.83	0.69	(Invalid)
Personnel Experience/ Continuity	0.858	1.36	1.17	1.00	0.86	0.74	(Invalid)
Multisite Coordination	0.812	1.52	1.23	1.00	0.81	0.66	0.54
Tool Support	0.892	1.26	1.12	1.00	0.89	0.8	(Invalid)
Scale Factor	Step Size	Scale Factor Values					
Risk & Opportunity Management	-0.012	0.0602	0.0482	0.0361	0.0241	0.012	0.0000
Process Capability	-0.0107	0.0536	0.0429	0.0322	0.0214	0.0107	0.0000
Requirements Volatility	0.0095	0.0000	0.0095	0.0189	0.0284	0.0379	(Invalid)



Model Constants

A	Productivity Factor	26.33
EBase	Exponent Base	1.0332

Summary of Sources of the Model

Element of the Model	Source(s)
Basic structure (size, exponent, cost drivers, equation)	C1, RV thesis
Reuse submodel	PE, Delphi
New drivers (requirements volatility, risk/opportunity management, development for reuse)	PE, WG
Parameters values for size multipliers, reuse level factors, requirements volatility, development for reuse	Delphi
Interoperability	(Dropped)
Other parameter values	Fits
Placement of process capability	Calibration

Key:

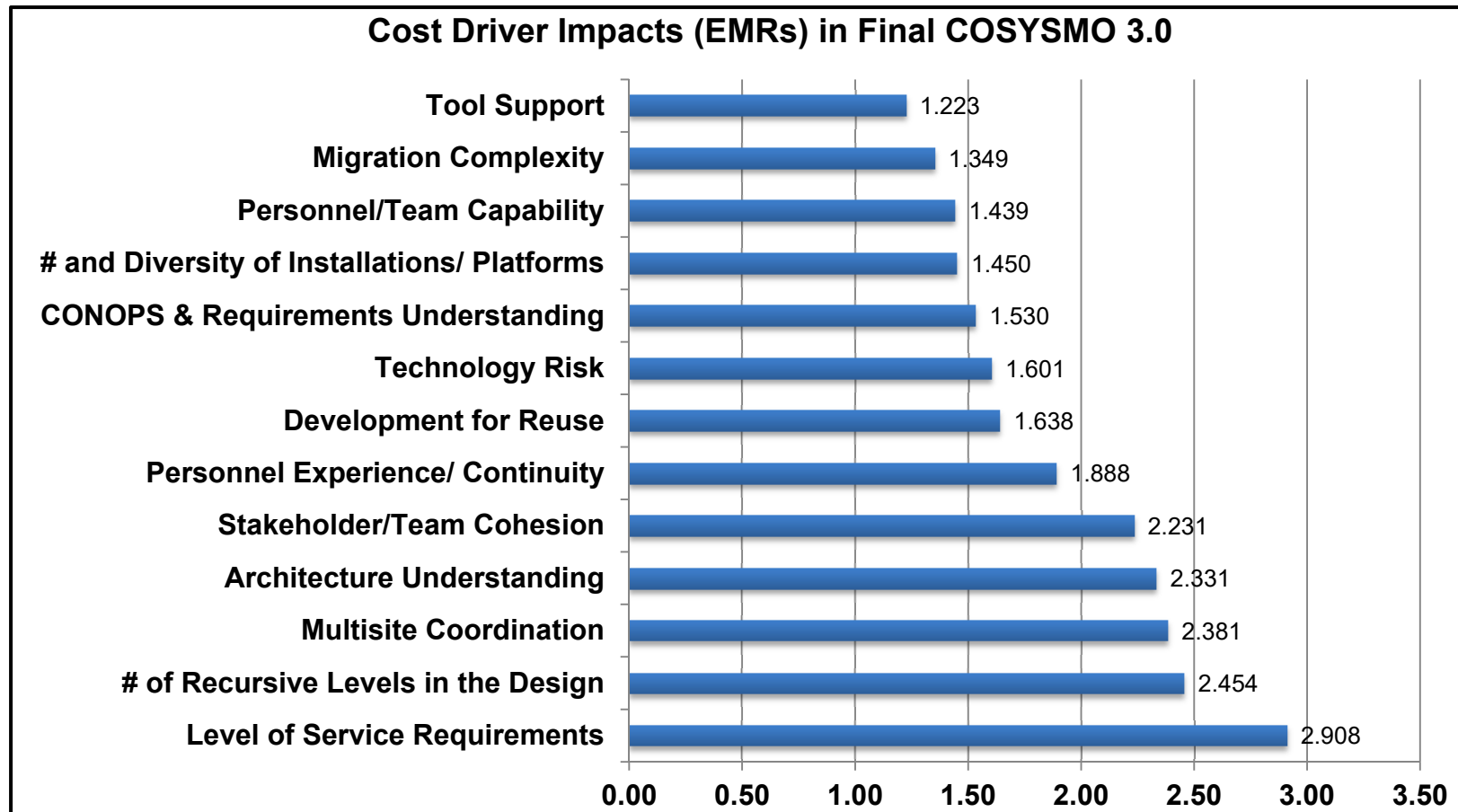
C1 = COSYSMO 1.0

RV = Requirements Volatility

PE = Published enhancements to C1

WG = COSYSMO 3.0 Working Group

Cost Driver Impacts



The EMR (Effort Multiplier Ratio) of a cost driver is its maximum possible value divided by its minimum possible value; this is the impact of the cost driver.

COSYSMO 3.0 Features versus Previous Models

Feature	COSYSM O 1.0	COSYSMO 2.0	COSYSMO RV	GRF	Sys-of-Sys	COSYSM O 3.0
Use of a specific size measure	X	X	X	X	X	X
Cost drivers	X	X	X	X	X	X
Use of exponent on size	X	X	X	X	X	X
Addresses reuse		X		X		X
Tailoring via calibration parameter	X	X	X	X	X	X
Sophisticated reuse model				X		X
Use of rated exponents			X			X
Account for increased cost when developing for reuse						X
Subproject model					X	X
Size includes multiple artifacts	X	X	X	X	X	X
Address interoperability					X	

Numerical Properties of COSYSMO 3.0 versus Previous Models

Parameter	COSYSMO 1.0	Previous Proposals (Together)	Expert- Based C3	Final (v4) COSYSMO 3.0	PL4O.nlm
# Cost Drivers	14	-	14	13	13
# Scale Factors	0	2	3	3	3
Total EMR	44,095	-	145,745	23,001	2,198
A (Productivity factor)	38.55	-	38.55	26.33	29.09
Nominal Exponent	1.060	1.060	1.116	1.120	1.162
Multiplier, on 25,000 eReq project	1.84	1.84	3.24	3.39	5.14
Max - Min Exponent	0.000	0.038	0.153	0.151	0.152
Multiplier, on 25,000 eReq project	1.00	1.47	4.73	4.63	4.66

Coordination with COCOMO III (1/2)

The Final Model has been coordinated with Brad Clark's in-progress COCOMO III definition effort, with these results:

- **Essentially identical definitions of Risk/Opportunity Management scale factor.**
- **Essentially identical definitions of Multi-Site Development cost driver.**
- **COSYSMO 3.0 Development for Reuse cost driver taken from COCOMO II.**
- **COSYSMO 3.0 Personnel/Team Capability cost driver definition modified to agree with COCOMO II's.**

Coordination with COCOMO III (2/2)

- A 2012 paper* was published distinguishing the scopes of COCOMO and COSYSMO in a project; Brad and the COSYSMO 3.0 Working Group coordinated on an (unpublished) update ("COCOMO – COSYSMO Estimation Boundaries")

*Wang, G., Valerdi, R., Roedler, G., Ankrum, A., Gaffney, J. E., "Harmonizing Systems and Software Cost Estimation," International Journal of Computer Integrated Manufacturing, Volume 25, 2012 - Issue 4-5: Special Issue: Through Life Cost Estimating.

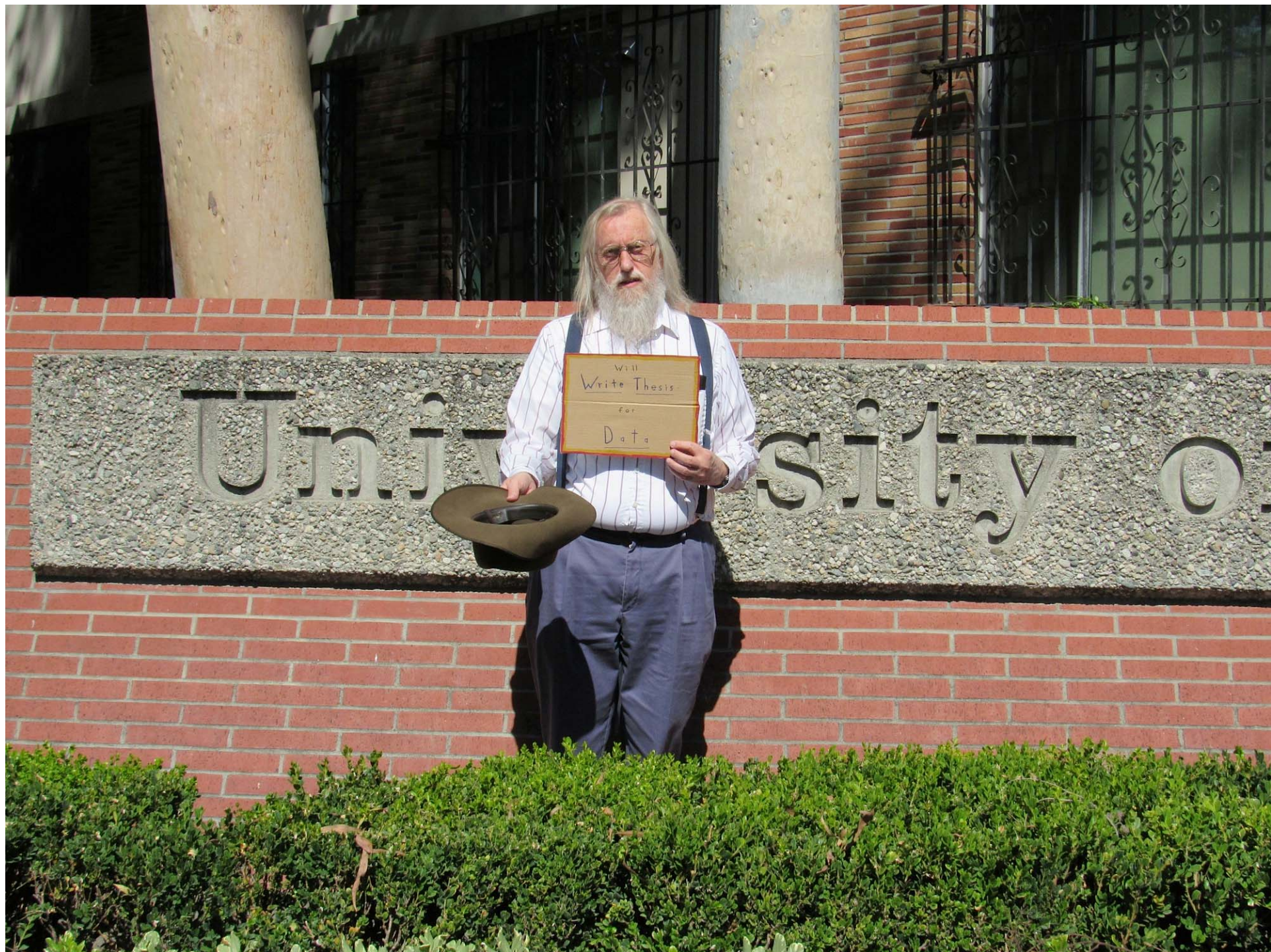
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Will improve
model
for data




Data Gathering

- **Please contact Jim if your organization may be able to provide data**

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 - Fitting without using linear regression
 - Enhancing Bayesian analysis
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Fitting a Model Can Be a Difficult Problem – Part 1

- Part of my thesis work was demonstrating that the Final Model could be calibrated to a particular dataset, PL4O, with $\text{PRED}(.30) \leq 50\%$.
- Model PL4O was the result of a linear regression fit to the PL4O data set. The result:
 - F statistic (CD) = 1668; $\text{PRED}(.30) = 66.7\%$; few coefficients fit significantly; some coefficients have non-credible values.
- Then, model PL4O.Bayes was the result of a Bayes computation, using:
 - PL4O data
 - The Delphi result and CEM CD values as priors

The result:

- F statistic (CD) = 103.1; $\text{PRED}(.30) = 28.2\%$; all but three coefficients fit at $p < .05$ or better; all coefficient values are credible.

Fitting a Model Can Be a Difficult Problem – Part 2

- Per previous slide, there are tensions between data-only fits and Bayesian fits:

Tensions between Types of Fits	
Data-Only Fits	Bayesian Fits
Data tends to be close to fit	Data may be dispersed from fit
May have non-credible coefficient values	Coefficients tend to have credible values

- Also between another dimension of fits:

Another Tension between Types of Fits	
Least-squares Fits	Absolute-Deviation Fits
Example fitting techniques: linear regression, F statistic	Example fitting techniques: MMRE, PRED
Data far from the middle have more influence on the fit	All data have equal influence on the fit
Must work on log(data)	Can work directly on the data

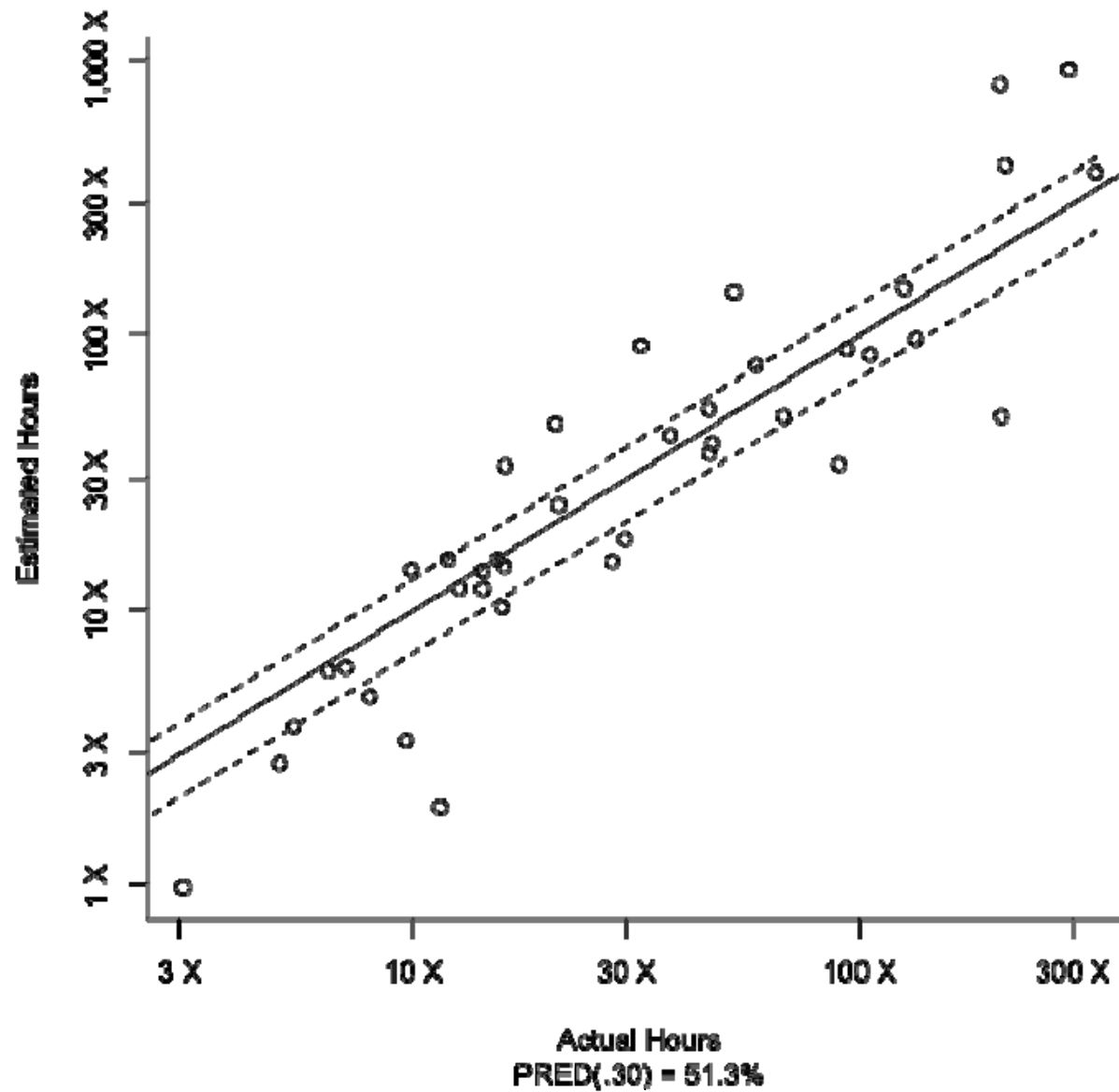
Fitting a Model to this Dataset with $\text{PRED}(.30) \geq 50\%$

- We want a model fit to the PL4O data set that results in $\text{PRED}(.30) \geq 50\%$.
 - Need the Bayes to achieve credible coefficients
 - Want a technique that achieves the $\text{PRED}(.30)$ on the actual data; don't care about sum of squares measures
- An approach: hill-climbing
 - Take an error function on the current model's parameters
 - Trying small variations in parameter values, see if any variation leads to an improvement
 - And, if so, which variation leads to the biggest improvement
 - If no improvement, stop with this local maximum
 - Modify the parameter values by taking a step in the direction of biggest improvement, and repeat
- The free statistics software package R includes a hill-climbing function called “nlm”.

Results of Using nlm

- **Used nlm with these arguments:**
 - The PL4O.Bayes parameter values to start; and
 - An error function of PRED(.30) computed on the PL4O dataset (“Actuals”) versus “Estimates”, values computed using the current parameter values and PL4O ratings.
 - Note: some details of the error function are given in the Backup
- **nlm found a model PL4O.nlm with these properties:**
 - All parameter values are credible; and
 - PRED(.30) on the PL4O dataset = 51.3%.

Estimated vs Actual Effort for PL4O.nlm Model



New Practices in Model Calibration (Summary)

- **Current two-step practice for Bayesian fit:**
 - Use linear regression on data to find a fit (coefficients)
 - Then apply prior information to update coefficients and their variances
 - Uses a single-variable model to compute new coefficients and variances
 - **Expansion of Bayesian model generation:**
 - Use of full covariance matrix, not just variances
 - More appropriate to the task at hand
 - Fine-grained control over application of priors
 - Can choose coefficients on which to apply prior information
 - Use of priors from multiple sources
 - Recasting Bayes data set to allow use of ordinary linear regression packages
 - Eliminates the need for two separate steps
 - Allows mixing of variance-only and covariance priors
- 9/12 — (R software to support this)

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Ideas for Further Development of COSYSMO (1/2)

Jim's suggestions:

- **Create a validated model for interoperability**
 - Existing COSYSMO 3.0 work provides an excellent foundation
- **Create tailored models for different types of project**
 - “Tailored” = some driver values are pre-filled in
 - Defense, software-intensive, ...
- **Estimating model for total development cost, based primarily on COSYSMO 3.0 drivers**
 - Some work already done at Lockheed-Martin
- **Better integrate activity levels between DWR and DFR**



Ideas for Further Development of COSYSMO (2/2)

Other suggestions:

Bibliography (1/5)

1. **“A Generalized Systems Engineering Reuse Framework and its Cost Estimating Relationship”, Gan Wang, Garry J Roedler, Mauricio Pena, and Ricardo Valerdi, INCOSE 2014.**
2. **“The Constructive Systems Engineering Cost Model (COSYSMO)”, Ricardo Valerdi (PhD Dissertation), 2005.**
3. **“Estimating Systems Engineering Reuse with the Constructive Systems Engineering Cost Model (COSYSMO 2.0)”, Jared Fortune (PhD Dissertation), 2009.**
4. **“Quantifying the Impact of Requirements Volatility on Systems Engineering Effort”, Mauricio Pena (PhD Dissertation), 2012.**
5. **“Life Cycle Cost Modeling and Risk Assessment for 21st Century Enterprises”, Barry Boehm, Jo Ann Lane, Supannika Koolmanojwong, Richard Turner (presentation), April 29, 2014.**
6. **"System Interoperability Influence on System of Systems Engineering Effort", Jo Ann Lane, Ricardo Valerdi, CSER 2011.**
7. **“COSYSMO Extension as a Proxy Systems Cost Estimation” (presentation), Reggie Cole, Garry Roedler, October 23, 2013.**

Bibliography (2/5)

8. **“COSATMO: Developing Next-Generation Full-Coverage Cost Models” (presentation), Jim Alstad, USC CSSE Annual Research Review, April 29, 2014.**
9. **“Quantifying the Impact of Requirements Volatility on Systems Engineering Effort” (presentation), Mauricio Peña, Ricardo Valerdi, October 18, 2012 (COCOMO Forum).**
10. **“Cost Model Extensions to Support Systems Engineering Cost Estimation for Complex Systems and Systems of Systems”, Jo Ann Lane, CSER 2009.**
11. **“Proposed Modification to COSYSMO Estimating Relationship”, Gan Wang, Ricardo Valerdi, Barry Boehm, Alex Shernoff, INCOSE 2008.**
12. **“Towards COSYSMO 3.0”, revised PowerPoint presentation by Gan Wang (filename is “COSYSMO 3.0 Definition Outline.Rev.pptx”), May 2015.**
13. **“COSATMO: Presenting the Harmonized COSYSMO 3.0 Model” (presentation), Jim Alstad, October 22, 2014 (COCOMO Forum).**

Bibliography (3/5)

14. **“Towards COSYSMO 3.0”, 3rd revision of PowerPoint presentation by Gan Wang (revises [12]) (filename is “COSYSMO 3.0 Definition Outline.Rev3.pptx”), June 2015.**
15. **“C4ISR Architecture Working Group Final Report - Levels of Information System Interoperability (LISI)”, Department of Defense, Washington DC: OSD(ASD(C3I)) C4ISR AWG, 1998.**
16. **“The Levels of Conceptual Interoperability Model”, Tolk, A., and Muguira, J., Proceedings of the 2003 Fall Simulation Interoperability Workshop. Orlando FL, September 2003.**
17. **“Towards a Holistic, Total Engineering Cost Model”, Wang, G., Shernoff, A., Turnidge, J., and Valerdi, R., INCOSE Singapore, July 2009.**
18. **“COSYSMO Reuse Extension”, Wang, G., Valerdi, R., Ankrum, A., Millar, C., and Roedler, G., INCOSE Utrecht, June 2008.**
19. **“COSATMO: Presenting the Harmonized COSYSMO 3.0 Model” (presentation), Jim Alstad, October 22, 2014 (COCOMO Forum)**

Bibliography (4/5)

20. **“A Survey on Interoperability Measurement.”** Ford, T., Colombi, J., Graham, S., and Jacques, D., Twelfth International Command and Control Research and Technology Symposium (12th ICCRTS), Newport, RI, June 19-21 2007.
21. **“A Framework For Intelligent Assessment and Resolution of Commercial-Off-The-Shelf Product Incompatibilities”,** Bhuta, Jesal (PhD Dissertation), 2007.
22. **“Software Engineering Economics”** Boehm, Barry W., Prentice-Hall, Upper Saddle River NJ, 1981.
23. **“The Incremental Commitment Spiral Model”,** Boehm, B., Lane, J., Koolmanojwong, S., Turner, R., Addison-Wesley, Upper Saddle River, NJ, 2014.
24. **“The Generalized Reuse Framework—Strategies and the Decision Process for Planned Reuse”,** Wang, G., INCOSE SEDC16.
25. **“Systems and Software Engineering—Life Cycle Management—Part 1: Guide for Life Cycle Management”,** ISO/IEC TR 24748-1:2010(E).

Bibliography (5/5)

26. “Guide to the Systems Engineering Body of Knowledge (SEBoK)” version 1.5.1, SEBoK Authors, The Trustees of the Stevens Institute of Technology, Hoboken NJ, 18 December 2015, <http://sebokwiki.org/wiki/>.
27. “System Verification” page in [26]
<http://sebokwiki.org/w/index.php?title=System_Verification&oldid=50858>, 16 June 2015 13:52.
28. “Assessing Systems Engineering Effectiveness in Major Defense Acquisition Programs (MDAPs) (Final Technical Report (A013), SERC Technical Task Order TO001)”, Boehm, B., Ingold, D., et al, Systems Engineering Research Center, September 30, 2009.
29. “Proposed Modification to COSYSMO Estimating Relationship”, Wang, Gan, Boehm, Barry, Valerdi, Ricardo, Shernoff, Alex, INCOSE International Symposium, June 2008, Vol.18(1), pp.249-262.