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Estimation Methods for SE Reuse

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- Biography
 - Ph.D. candidate at USC, Industrial and Systems Engineering (w/ Dr. Boehm & Dr. Settles)
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Outline

- Overview of Reuse
- Systems Engineering Reuse
 - Estimating Systems Engineering Reuse
 - State of the Art
 - State of the Practice
- Towards COSYSMO 2.0
 - Constructive Systems Engineering Cost Model (COSYSMO)
 - Proposed COSYSMO 2.0 Concepts
- Conclusion
 - Call for Participation



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Overview of Reuse

- Don't reinvent the wheel [Tracz 1995]
 - Maximize benefits, minimize required resources
- Engineers are *trained* to build upon (or reuse) existing capabilities [Prieto-Diaz 1996]
 - Aerospace engineers reuse hardware designs (ex: landing gear)
 - Electrical engineers reuse architectures (ex: processor architecture)
 - Software engineers reuse code and objects (ex: print function)
- As good engineers, systems engineers reuse their products



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Systems Engineering Reuse

- Systems engineering activities are support-focused [Blanchard and Fabrycky 1998]
 - Do not produce physical products (HW, SW, etc.)
 - Produce architectures, requirements, test plans, and other technical documents
- Systems engineering products can be viewed as “artifacts”
 - Encapsulation of systems engineering knowledge in a document or process
 - Representative of systems engineering effort
- Reuse of an artifact *should* reduce the expected systems engineering effort for the development of a new system [Valerdi et al 2006]

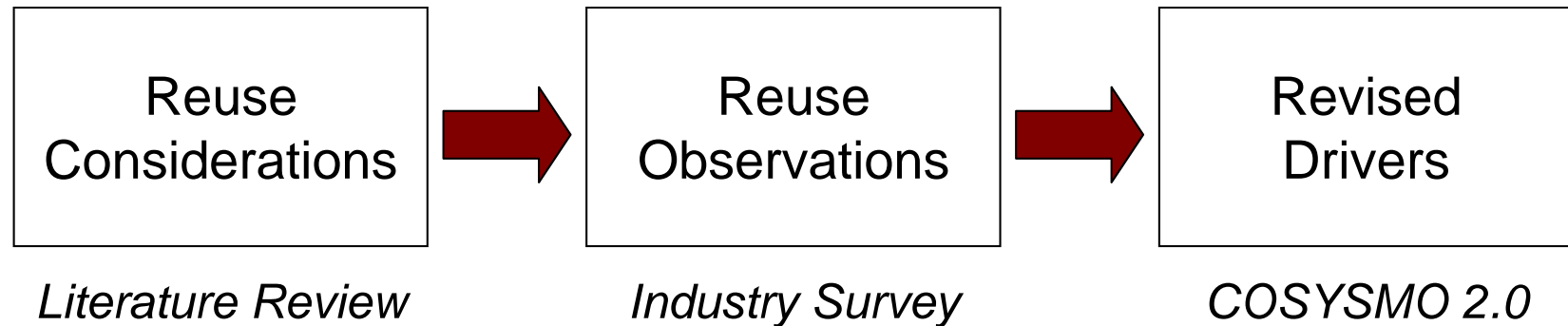


Estimating Systems Engineering Reuse

- Constructive Systems Engineering Cost Model (COSYSMO) [Valerdi 2005]
 - Successful, implemented by both academia and industry
- Not without its limitations
 - Relies on a “built from scratch” assumption
 - Lack of reuse estimation capability cited as a potential source of error
- Need to develop reuse estimation capability for COSYSMO 2.0
 - Use observations from literature and industry survey to guide



Guidance for Estimating Systems Engineering Reuse





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Systems Engineering Reuse *State of the Art*

How does the systems engineering literature handle reuse?

			<i>Discuss Reuse?</i>	<i>Artifact Reuse?</i>	<i>Systems Engineering Reuse?</i>	
Systems Engineering	Texts	Maier and Rechtin	The Art of Systems Architecting (2002)	✓		
		Blanchard and Fabrycky	Systems Engineering and Analysis (1998)			
	Handbooks	INCOSE	Systems Engineering Handbook (2008)	✓	✓	✓ (1 instance)
		NASA	Systems Engineering Handbook (2004)	✓		
	Standards and Procedures	NASA 7123.1A	NASA Procedural Requirement--Systems Engineering Processes and Requirements (2007)	✓		
		IEEE 1220-2005	Systems Engineering--Application and Management of the Systems Engineering Process	✓		
ANSI/EIA 632		Processes for Engineering a System (2003)	✓			
Software Engineering		IEEE 1517-1999	Software Life Cycle Processes--Reuse Processes (1999)	✓	✓	



Systems Engineering Reuse *State of the Art*

*How does the **software** engineering literature handle reuse?*

Observations

1. Reuse is done for the purpose of economic benefit, intending to shorten schedule, reduce cost, and/or increase performance [Lam 1997, Stephens 2004]
2. Reuse is not free, upfront investment is required [Poulin 1997, Mili et al 2002]
3. Products, processes, and knowledge are all reusable artifacts [Basili and Rombach 1991, Prieto-Diaz 1993]
4. Reuse needs to be planned from the conceptualization phase of programs [Lynex and Layzell 1998]
5. Reuse is as much of an organizational issue as it is a technical one [Griss 1999, Poulin and Caruso 1993]
6. The benefits of reuse are limited to related domains and do not scale linearly [Bollinger and Pfleeger 1992, Selby 2005]

February 7, 2008

Estimation Methods for Systems Engineering Reuse [Fortune and Valerdi 2008] 8



Systems Engineering Reuse *State of the Art*

Reuse success factors

1. Platform

- Appropriate product or technology, primed for reuse

2. People

- Adequate knowledge and understanding of both the heritage and new products

3. Processes

- Sufficient documentation to acquire and capture knowledge applicable to reuse as well as the capability to actually deliver a system incorporating or enabling reuse

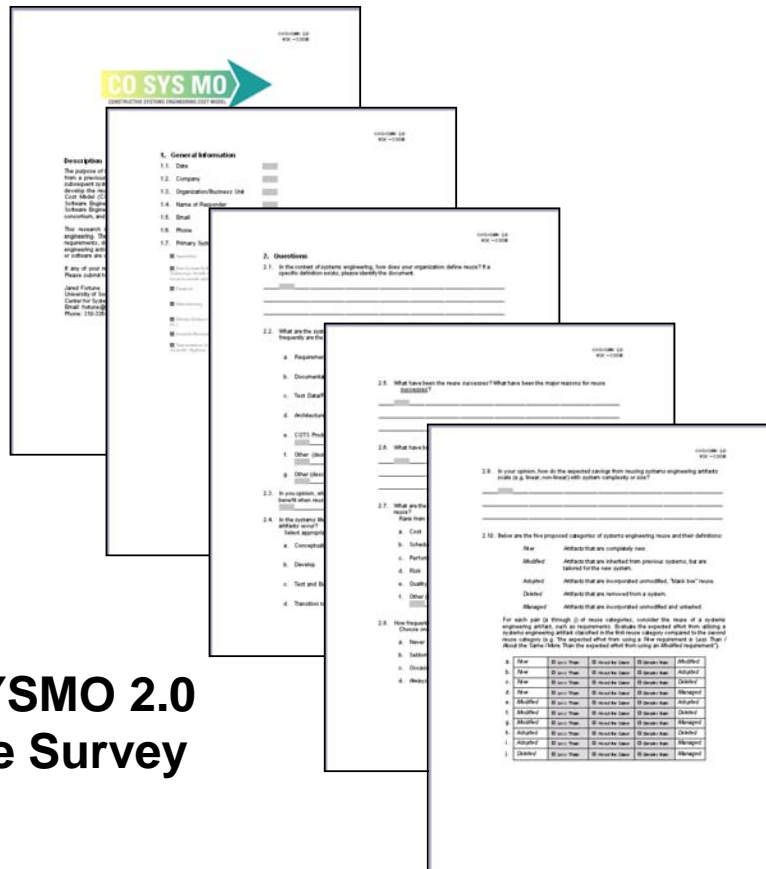
[Fortune and Valerdi 2008]



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Systems Engineering Reuse *State of the Practice*

How does industry handle reuse?



**COSYSMO 2.0
Reuse Survey**

Reuse Survey Responders
BAE Systems
General Dynamics
Lockheed Martin
Orbital Sciences
Raytheon
Reynolds, Smith, and Hills

*11 responses
(32% return)*

[Fortune et al 2008]

February 7, 2008

Estimation Methods for Systems
Engineering Reuse

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Systems Engineering Reuse *State of the Practice*

- Survey Results
 1. Requirements reuse is only performed occasionally, but has the largest “benefit” associated with it
 2. Reuse occurs more frequently in the early life cycle than later
 3. Cost savings is the most promoted benefit for reuse
 4. Reuse successes are most often attributable to utilization of personnel with previous experience
 5. Reuse failures are most often attributable to utilization of personnel with a lack of knowledge/understanding

[Fortune et al 2008]

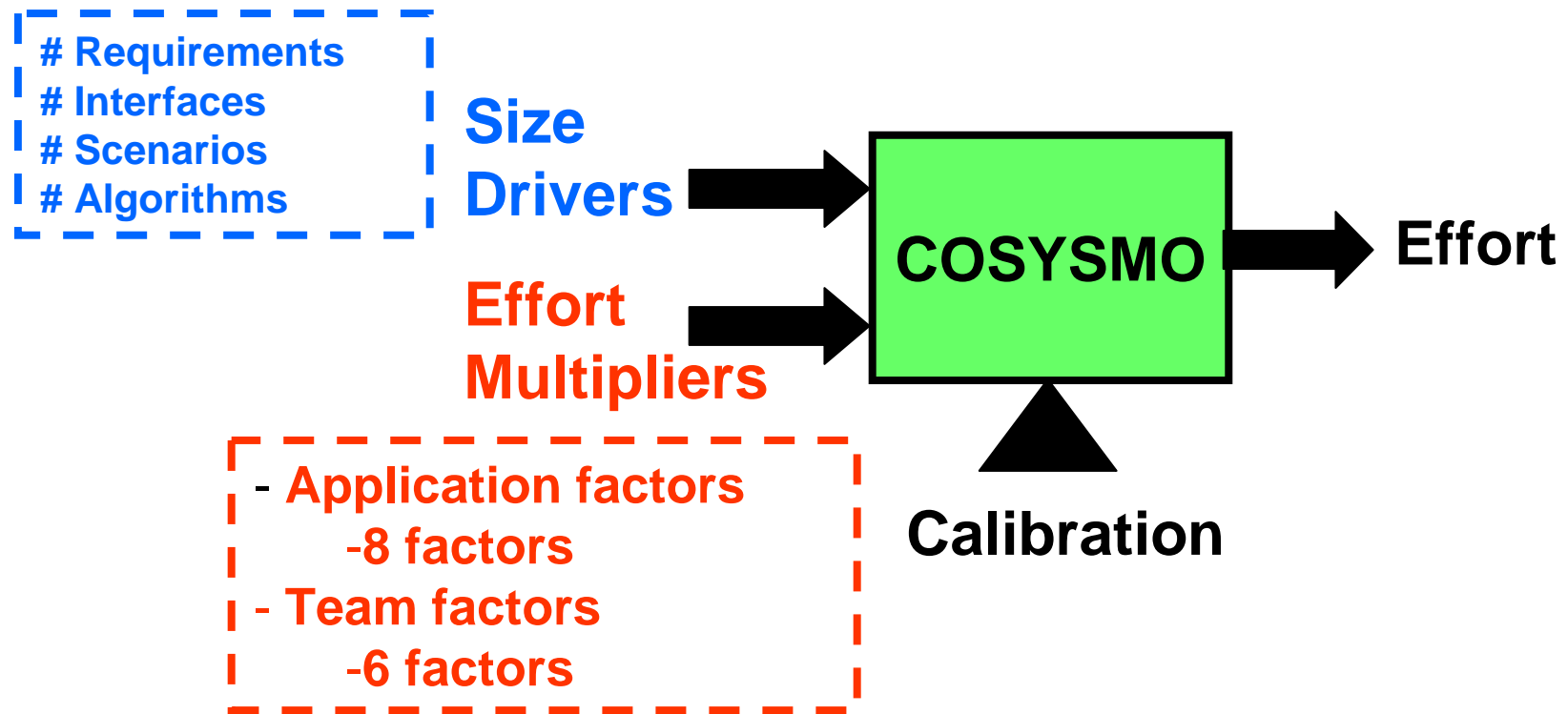


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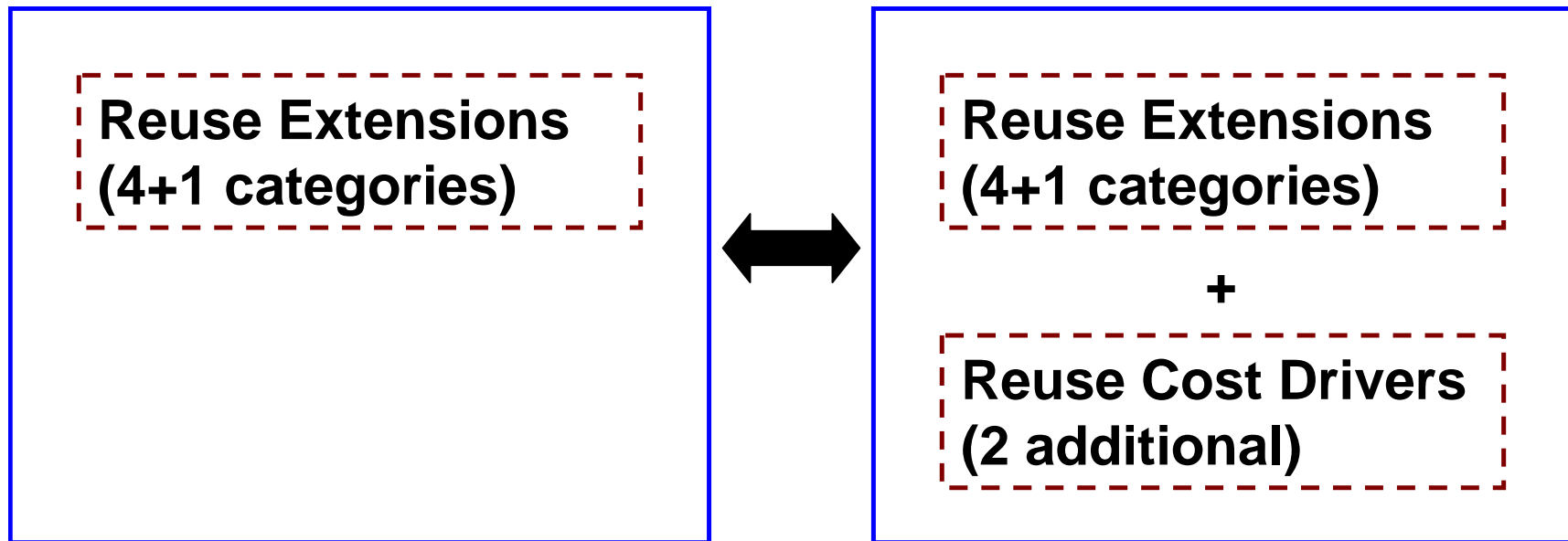
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Towards COSYSMO 2.0



[Valerdi 2008]

Proposed COSYSMO 2.0 Research

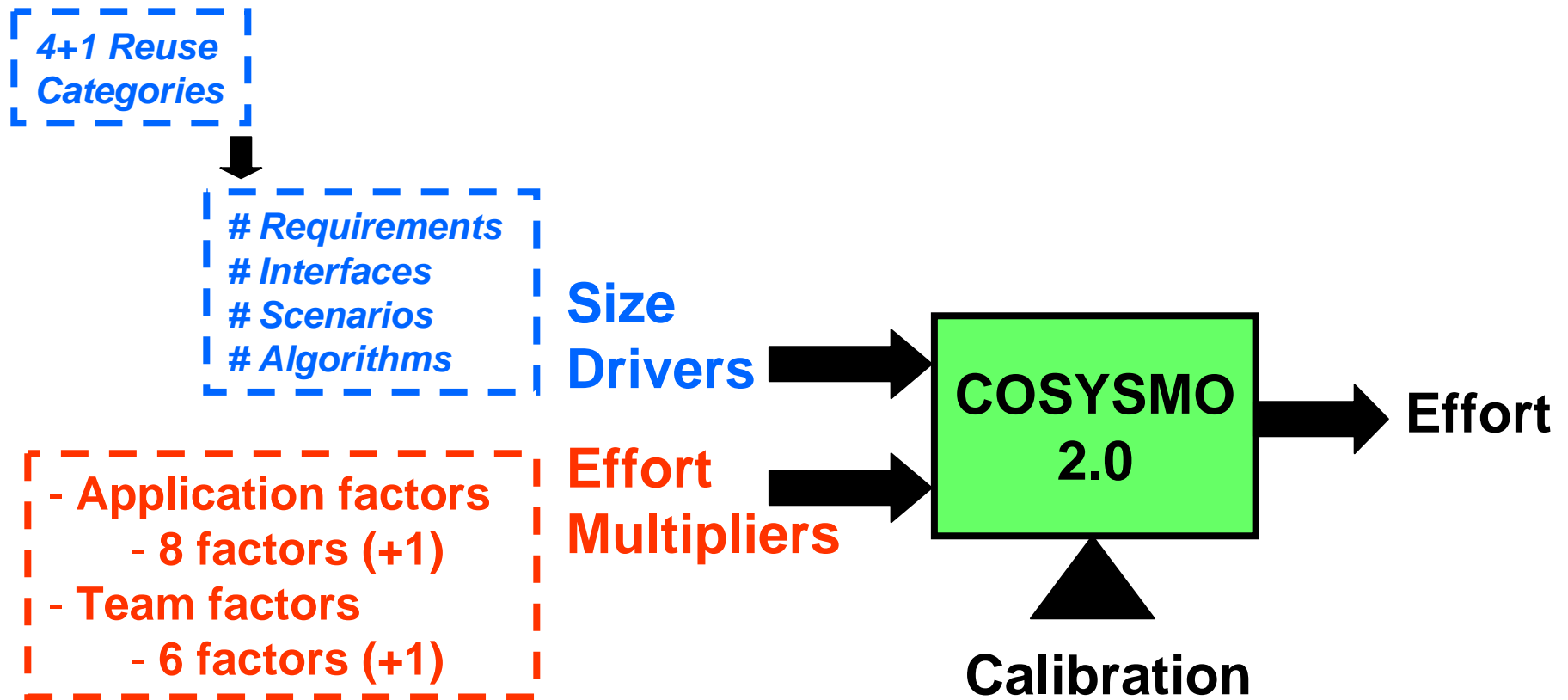


- Need to assess the explanatory power of each approach



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Proposed COSYSMO 2.0 Concept





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New: Artifacts that are completely new

Modified: Artifacts that are inherited, but are tailored

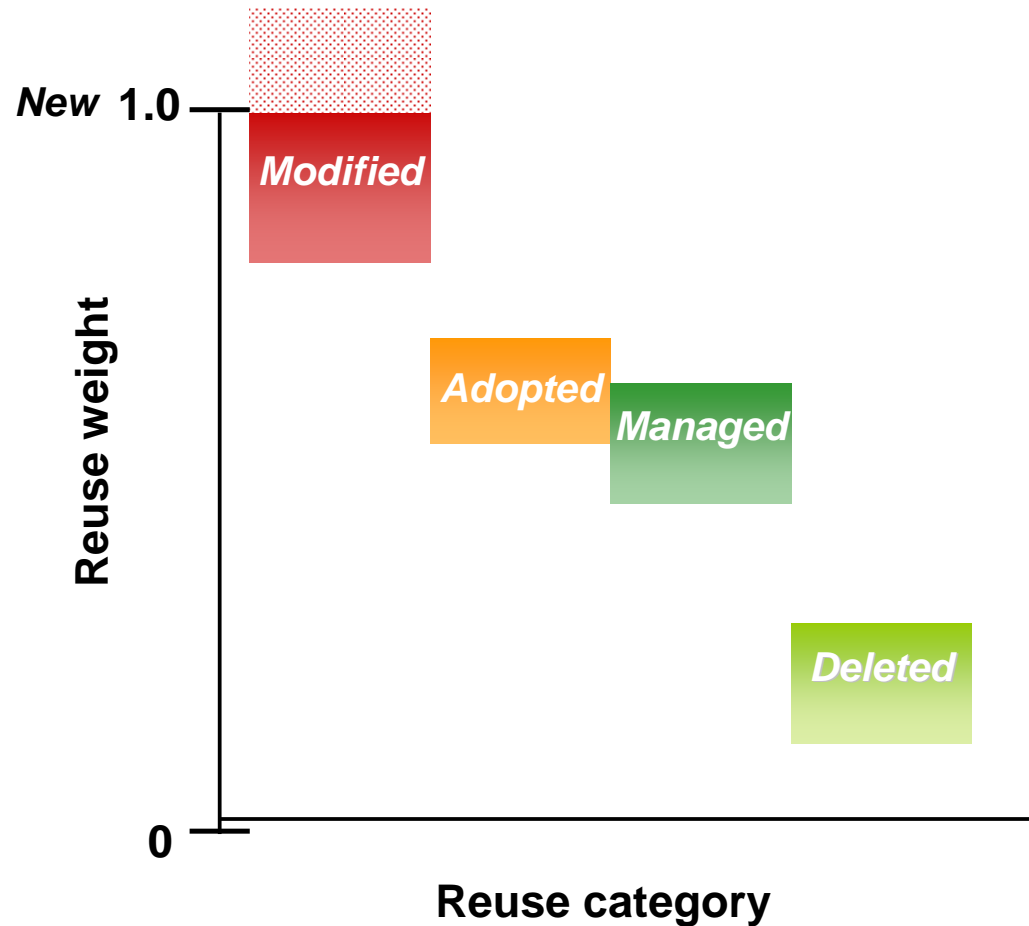
Adopted: Artifacts that are incorporated unmodified, also known as “black box” reuse

Managed: Artifacts that are incorporated unmodified and untested

Deleted: Artifacts that are removed from a system

4 or 5 categories

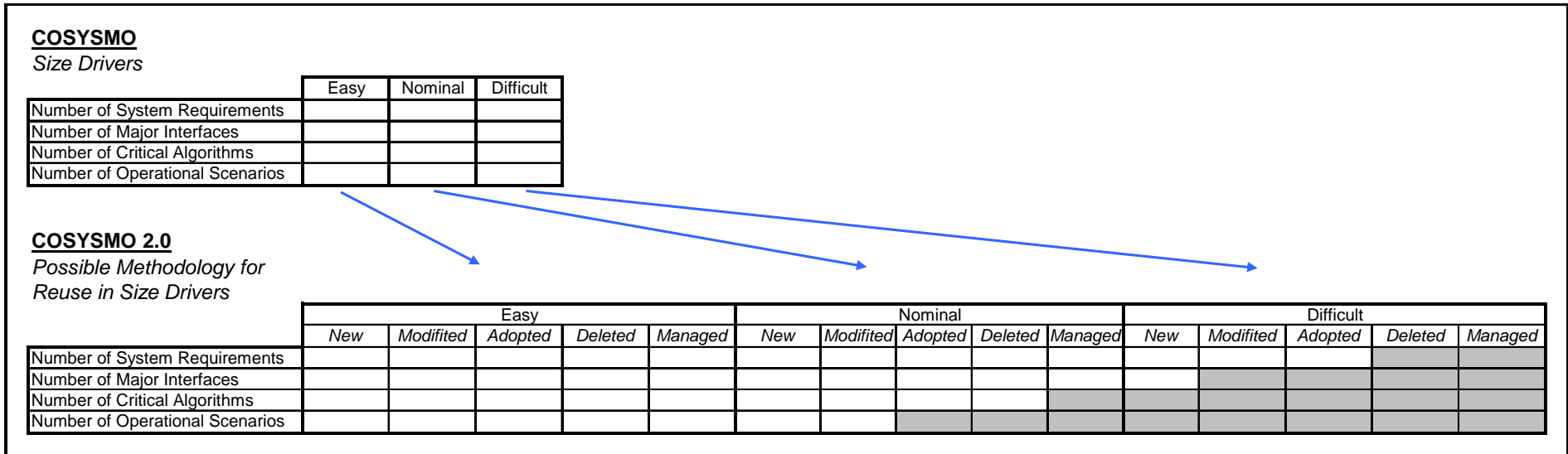
Proposed Size Driver Extensions





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Effect of Proposed Size Driver Extensions



- Identified need to test assumptions and find “most likely” combinations
- Weights for categories will be derived from a Delphi survey
 - Size drivers account for significant amount of estimation power of the model



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Conclusions

- COSYSMO 2.0 under development
 - Motivated by success of COSYSMO, identified need to account for systems engineering reuse
 - Guided by academic and industry handling of reuse
- Research will evaluate effect of accounting for reuse
 - First, examine explanatory power using size driver extensions
 - Second, develop additional/revised set of cost drivers (if necessary)
- Expect better estimation power in COSYSMO 2.0
 - Initiating data collection effort



Call for Participation

Background

The USC Center for Systems and Software Engineering (CSSE) and Lean Advancement Initiative (LAI) at MIT in collaboration with the INCOSE Measurement Working Group have initiated the next phase of development of a Systems Engineering Cost Model called COSYSMO. Since the first version of the model was completed in 2005, COSYSMO has been widely accepted and adopted by over a dozen industrial and government organizations. To continually address the needs of the user community, an incremental update to the model is currently underway. This update, called COSYSMO 2.0, will improve the estimation power of the model by accounting for systems engineering reuse. To perform an industry calibration, we are seeking industry data in the form of labor actuals on various types of systems engineering projects that involved a significant amount of reuse.

Benefits

By providing data for this model your organization will:

- ensure that your particular application domain is addressed by COSYSMO 2.0
- learn to tailor and calibrate the **updated model** for their specific application domain
- enable the **quantification of varying degrees of systems engineering reuse** on project estimates
- be able to claim in **CMMI reviews** that your systems engineering cost estimates are based on calibrated industry models

Proven Methodology

COSYSMO (Constructive Systems Engineering Cost Model) employs a proven methodology developed for the COCOMO (Constructive Cost Model), the most widely used software cost model in the world.

Proven Process

USC-CSSE and LAI at MIT have proven processes in place to ensure the confidentiality of the data with its Corporate Affiliates and Consortium Members. Successful data protection has enabled it to attract the participation of several organizations in this effort including Boeing, Raytheon, Northrop Grumman, Lockheed Martin, General Dynamics, SAIC, L-3 Communications, BAE Systems, and the US Air Force Space & Missile Systems Center.

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