

▶ **Determining the Cost of the Certification and Accreditation Process using Expert Opinion and Monte Carlo Simulation**

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SCEA Conference
June 2010

▶ Challenge

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

Works Cited

- ▶ The Customer is required to complete a rigorous process of reviews, known as **Certification and Accreditation (C&A)**, to ensure their networks and systems are secure
 - Mandated and regulated by DCID 6/3¹, DIACAP², and other federal guidance

- ▶ The customer had the sense that their C&A process took too long & cost too much
 - Customer had a published schedule, but felt it was unrealistic and/or inaccurate
 - Insufficient primary data sources to support the claim that the process took too long

1. Director Of Central Intelligence Directive 6/3, <http://www.fas.org/irp/offdocs/DCID_6-3_20Policy.htm> (1999). Online.
2. Department of Defense Information Assurance Certification and Accreditation Process. Wikipedia, 11 Mar. 2010. Web. 22 Mar. 2010. <<http://en.wikipedia.org/wiki/DIACAP>>.

▶ Solution

Challenge

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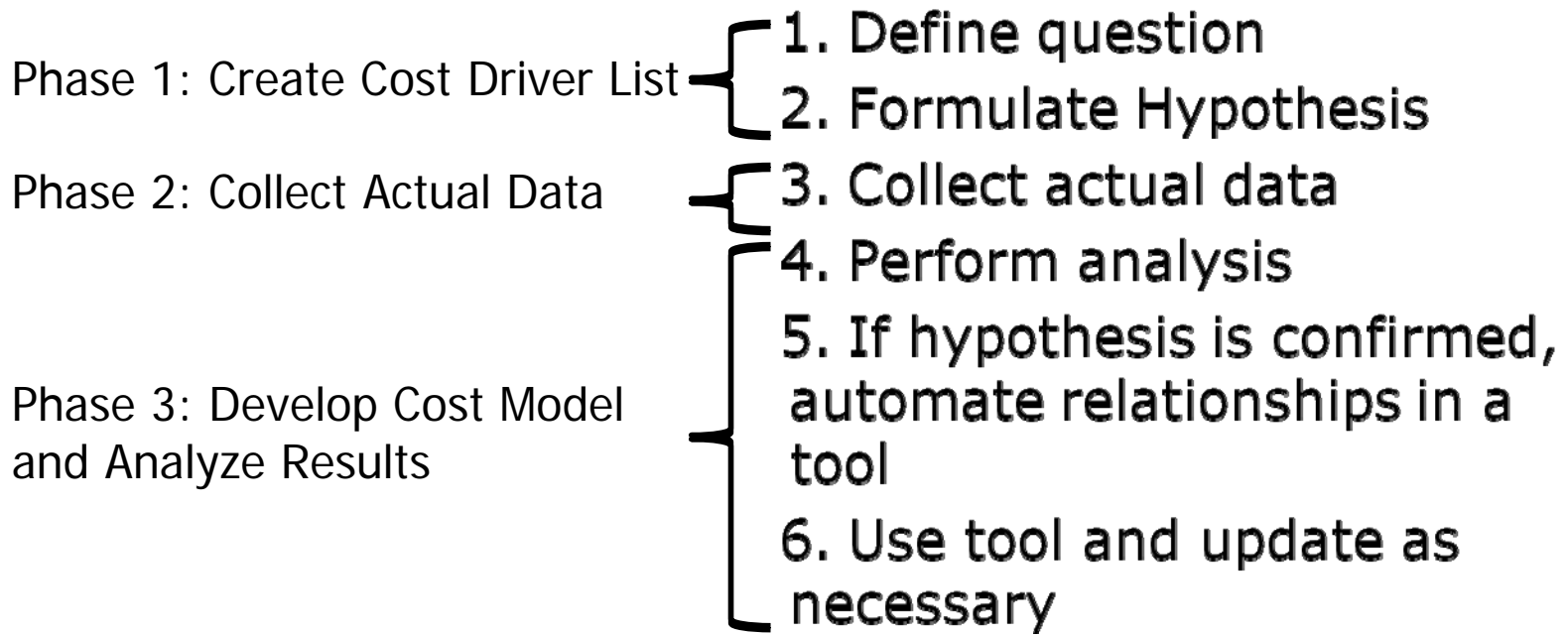
- ▶ Team was tasked by the customer to provide a model with the capability to:
 - Aid in planning and budgeting
 - Gain an understanding of the true cost and schedule for a system to complete the process
 - Provide support for a business process re-engineering effort, if deemed necessary

- ▶ The model is expected to estimate the **cost** and **schedule** for the customer's Certification and Accreditation (C&A) process
 - **Cost**
 - Measured in labor hours for each step of the process
 - Converted to dollars using labor rates
 - **Schedule**
 - Measured in days/weeks for each step of the process
 - Appropriate adjustments for work days vs. calendar days

▶ Solution

- Challenge
- Solution**
- Phase 1
- Phase 2
- Phase 3
- Findings
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▶ **Team developed six process steps to finding solution, broken down into three phases:**



▶ Solution: Phase 1

Challenge

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Phase 2

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PHASE 1: Create Cost Driver List

▶ Phase 1 Process Steps

Challenge

Solution

Phase 1

Phase 2

Phase 3

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▶ Process Steps:

- 1. Define question
 - “Develop a model to estimate the cost and schedule to complete C&A on a system”
- 2. Formulate Hypothesis
 - “Systems with higher Difficulty levels require more effort and time to certify and accredit than systems with lower Difficulty levels”
 - Difficulty level determined by a mix of cost and schedule drivers
 - Will be addressed on upcoming slides

▶ Definition of Cost Drivers

Challenge

Solution

Phase 1

Phase 2

Phase 3

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Conflation of cost drivers determines system difficulty

- ▶ Team conducted preliminary interviews with Subject Matter Experts (SMEs)
- ▶ Through those discussions, the following cost and schedule drivers were identified:
 - **Protection Level** (PL1-5): “an indication of the implicit level of trust that is placed in a system’s technical capabilities”¹
 - **Confidentiality** (Basic, Medium, High): “Assurance that information is not disclosed to unauthorized entities or processes”¹
 - **Integrity** (Basic, Medium, High): “protection against unauthorized modification or destruction of information”¹
 - **Availability** (Basic, Medium, High): “Timely, reliable access to data and information services for authorized users”¹
 - **Users** (Foreign vs. Domestic): “an individual who can receive information from, input information to, or modify information on, a system without a reliable human review”¹
 - **Complexity**- captures other factors, defined on next slide

1. Director Of Central Intelligence Directive 6/3,
<http://www.fas.org/irp/offdocs/DCID_6-3_20Policy.htm> (1999). Online.

▶ Definition of Complexity

Challenge

Solution

Phase 1

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- ▶ In preliminary discussions, SMEs felt that Complexity was a factor but were unable to provide a definition
 - Used a scale of 1-5
 - Each SME was asked for input during data collection interviews
 - The conflation of this SME input became the formal definition
- ▶ SMEs were able to identify both system and non-system elements of Complexity
 - System related elements of Complexity:
 - Many unique pieces of HW/SW
 - Multiple baselines
 - Multiple locations
 - New system or certification
 - Parent (not Child system)
 - Complex architecture
 - Nonstandard HW and/or SW
 - Non-system related elements of Complexity:
 - Inexperienced personnel
 - Scheduling conflicts
 - Poor Version Control
 - Dynamic requirements
- ▶ The more of these elements that pertain to a system, the more Complex it is
- ▶ Still somewhat subjective definition

▶ Solution: Phase 2

Challenge

Solution

Phase 1

Phase 2

Phase 3

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PHASE 2: Collect Actual Data

▶ Phase 2 Process Steps

Challenge

Solution

Phase 1

Phase 2

Phase 3

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▶ Process Steps

3. Collect actual data

- Team found there was insufficient primary data
- As an alternative, decided to conduct data collection interviews with SMEs
- **Program Manager (PM) Actual data** was discovered mid-way through SME data collection interviews
 - Incorporated into analysis
 - Cross check for **Simulated SME data**

▶ Background on SME Data Collection Interviews

Challenge

Solution

Phase 1

Phase 2

Phase 3

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- ▶ Benefit: Research suggests that groups are more accurate than individuals when making quantitative judgments³
 - Some research indicates that groups are only 1/8th of a standard deviation unit better
 - Other research “found that three-person groups are 23-32 percent more accurate than individuals” in making quantitative judgments³

- ▶ Limitation: Analysis of expert opinion data suggests that such interviews do not return the actual extreme points^{4,5}

3. Plous/Wesleyan University, Scott. The Psychology of Judgment and Decision Making. USA: McGraw Hill, 1993. Print.
4. Cuppan, Christopher D., Blackburn, Fred, Coleman, Richard L., St. Louis, Nancy. “Risk Analysis of a Major Government Information Production System”, SCEA, 1997.
5. Kahneman, Daniel, Paul Slovic, and Amos Tversky. Judgment under Uncertainty: Heuristics and Biases. Cambridge, London: Cambridge UP, 1982. Print.

▶ SME Data Collection Interviews

Challenge

Solution

Phase 1

Phase 2

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- ▶ To bound the dataset, SMEs were asked to estimate the cost and schedule for the notionally hardest and notionally easiest systems
 - **Difficulty 5/Notionally Hardest System:** PL5, Foreign Users, High Confidentiality, High Integrity, High Availability, etc
 - **Difficulty 1/Notionally Easiest System:** PL1-2, Domestic Users, Low Confidentiality, Low Integrity, Low Availability, etc

- ▶ SMEs were asked to estimate the minimum, mode, and maximum effort and schedule for each step of the process
 - Benefit: Ability to identify which steps in process consume the most time and effort
 - Limitation: “Build Up” approach to determine total cost and schedule of the process is subject to errors of omission⁶

6. SCEA. *Cost Estimating Body of Knowledge (CEBoK), Module 2 Costing Techniques: The Basic Types of Cost Estimates*. 2009. Print.

▶ Delphi Technique

Challenge

Solution

Phase 1

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Phase 3

Findings

Works Cited

- ▶ Elements from the Delphi technique⁷
 - Interviews were conducted one-on-one
 - Data collection results were compiled and sent back anonymously to SMEs for their review

- ▶ Traditional Delphi technique was not employed because SMEs were unable to conduct multiple reviews of the data collection results⁷

7. Dalkey/RAND, Norman. *The Delphi method: An experimental study of group opinion*. Publication no. RM-5888-PR. Tucks Professional Services. Web. 7 Dec. 2009.
<http://www.tucksprofessionalservices.com/resource_centre/allabout_codex/Articles/RandOfficialDelphiTechnique>.

▶ Solution: Phase 3

Challenge

Solution

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Phase 2

Phase 3

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PHASE 3: Develop Cost Model And Analyze Results

▶ Phase 3 Process Steps

Challenge

Solution

Phase 1

Phase 2

Phase 3

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▶ Process Steps

4. Perform analysis to test hypothesis
5. If hypothesis is confirmed, automate relationships in a tool
 - Ex: C&A cost model built in Excel utilizing VBA
6. Use tool and update as necessary
 - Ex: Feedback from customer, new data becomes available, etc.

Primary Data (PM Data)

Challenge

Solution

Phase 1

Phase 2

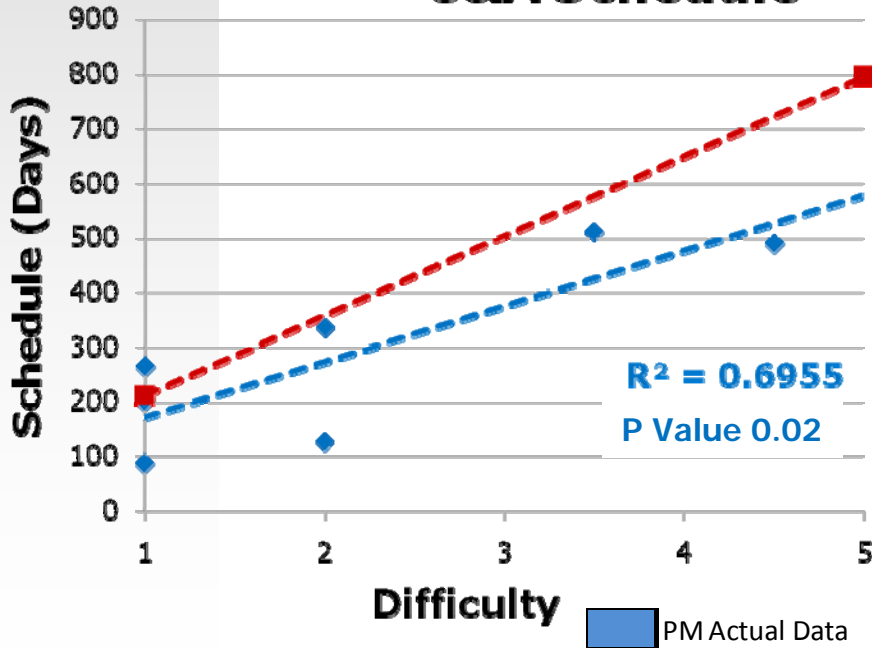
Phase 3

Findings

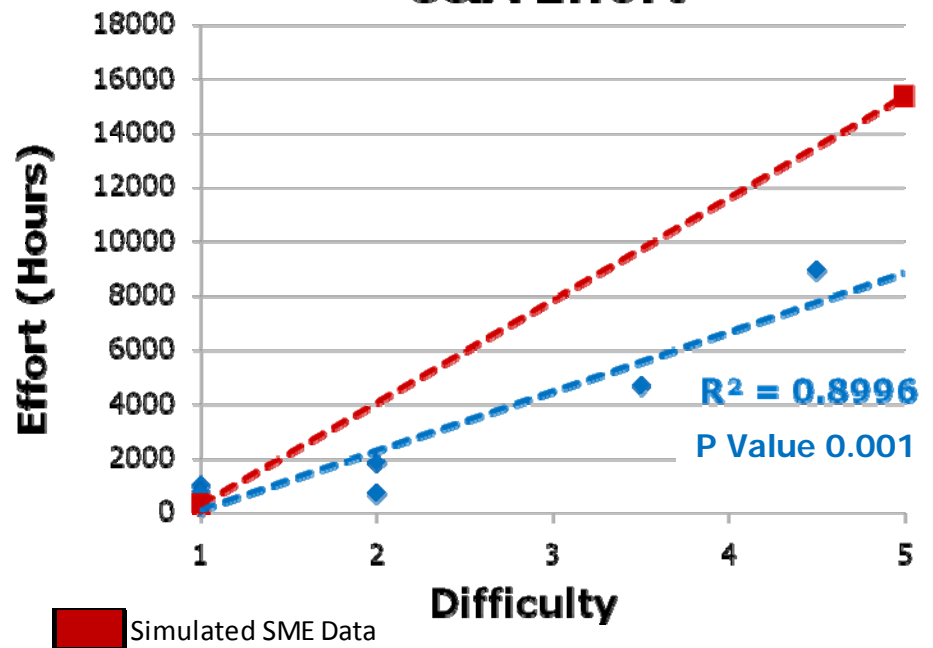
Works Cited

- ▶ Mid-way through the SME interview process, primary data from a PM was found
- ▶ PM Actual Data was normalized to cross check the Simulated SME data

C&A Schedule



C&A Effort



Schedule & Effort CERs from PM Actual Data are Statistically Significant

► Analysis: Types of Data

Challenge

Solution

Phase 1

Phase 2

Phase 3

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Characteristics	Simulated SME Data	PM Actual Data
Sample Size	N= 5	N= 7
Level of Detail	Each process step of C&A	Start/Finish of C&A process
Effort	SMEs estimate Min, Mode and Max	Derived from Actual Schedule and % FTEs
Schedule	SMEs estimated Min, Mode and Max	Actuals
Difficulty Level	SMEs provided data for Notionally Easiest (Diff 1) and Notionally Hardest (Diff 5) Systems	Difficulty of Systems in sample ranged from 1 to 4.5
How was data used?	Run through Monte Carlo Simulation	Normalized

▶ Analysis

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

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- ▶ Simulation output from SMEs was higher than PM actuals for Notionally Hardest System
 - Possible explanation: Reliance of heuristics⁵
 - SMEs have not encountered a system equivalent to the Notionally Hardest System
 - When making “judgments under uncertainty,” people tend to use heuristics, which can result in bias responses⁵
 - **Anchoring and Adjusting-** could have used their own responses for the Notionally Easiest System as an anchor⁵
 - “Discussion of best-or worst-case scenarios can lead to unintended anchoring effects”³
 - Heuristics, such as anchoring and adjusting, can sometimes cause estimation errors⁵

3. Plous/Wesleyan University, Scott. The Psychology of Judgment and Decision Making. USA: McGraw Hill, 1993. Print.

5. Kahneman, Daniel, Paul Slovic, and Amos Tversky. Judgment under Uncertainty: Heuristics and Biases. Cambridge, London: Cambridge UP, 1982. Print.

Primary Data (PM Data)

Challenge

Solution

Phase 1

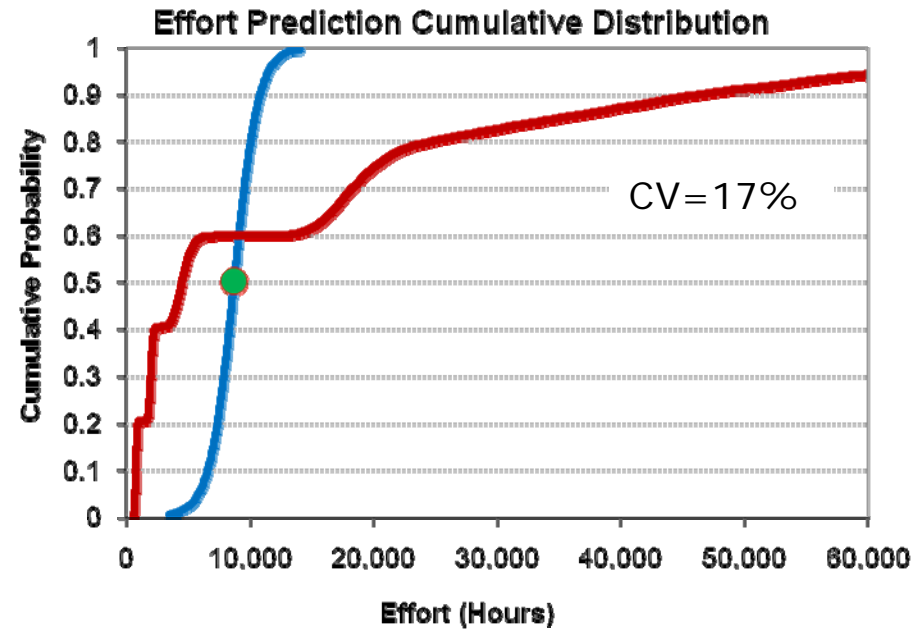
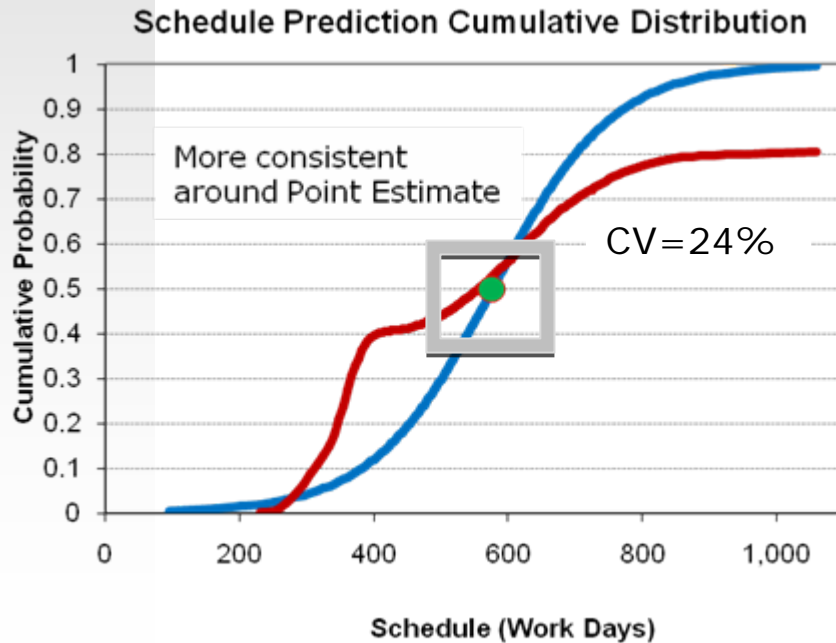
Phase 2

Phase 3

Findings

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- ▶ Next, generated hybrid distributions for the SME data based off of the CERs
- ▶ From there, found the Prediction Interval of the PM data at a system difficulty of 5
- ▶ All 5 SMES are sampled in each simulation run (and that point is the average of all the simulation runs)

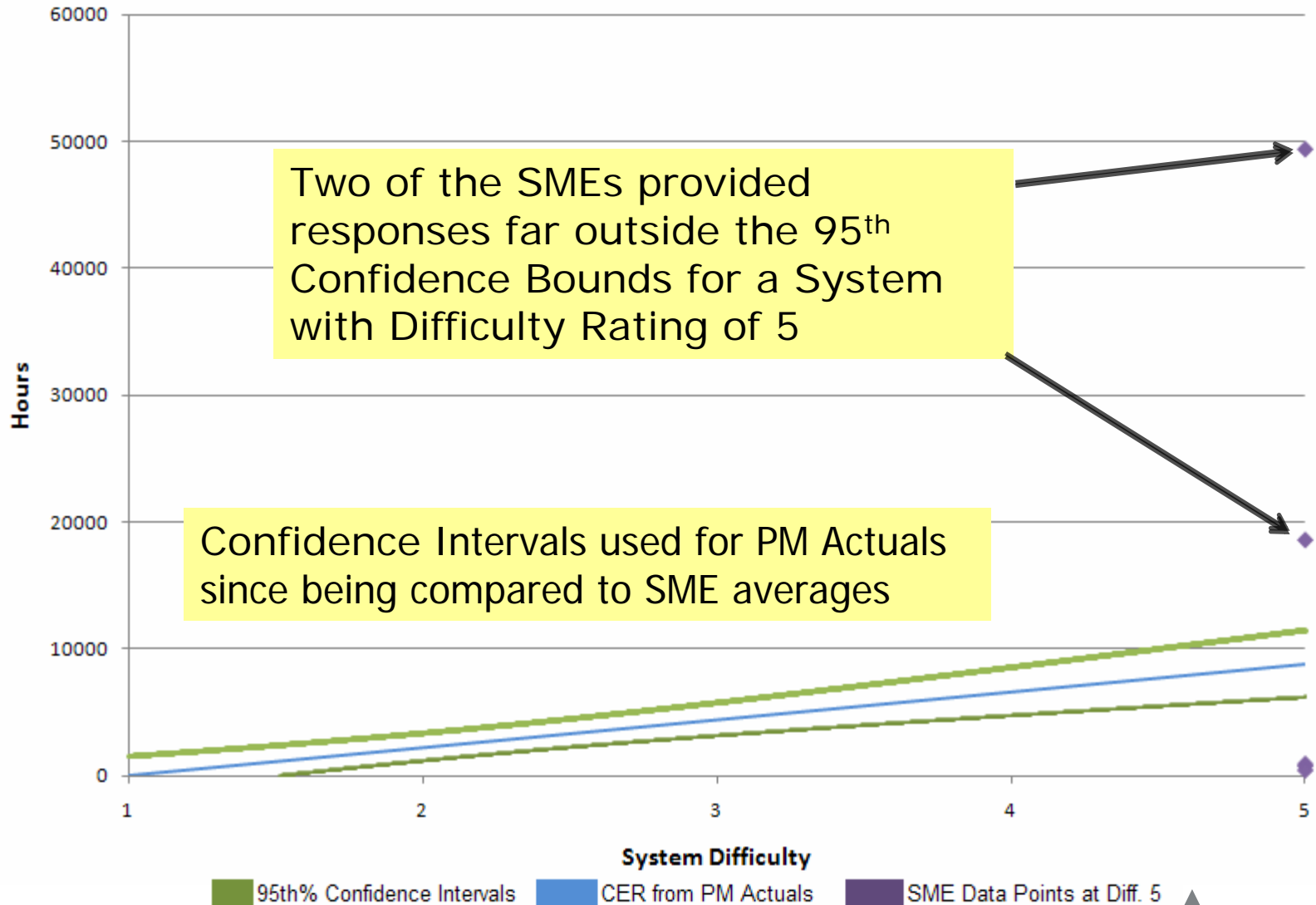


■ PM Prediction Interval for Notionally Hardest Sys (Diff 5)
 ■ Simulated SME Data from Schedule at Notionally Hardest Sys (Diff 5)
 ● Point Estimate

PM Actuals and SME data

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 - Phase 2
 - Phase 3**
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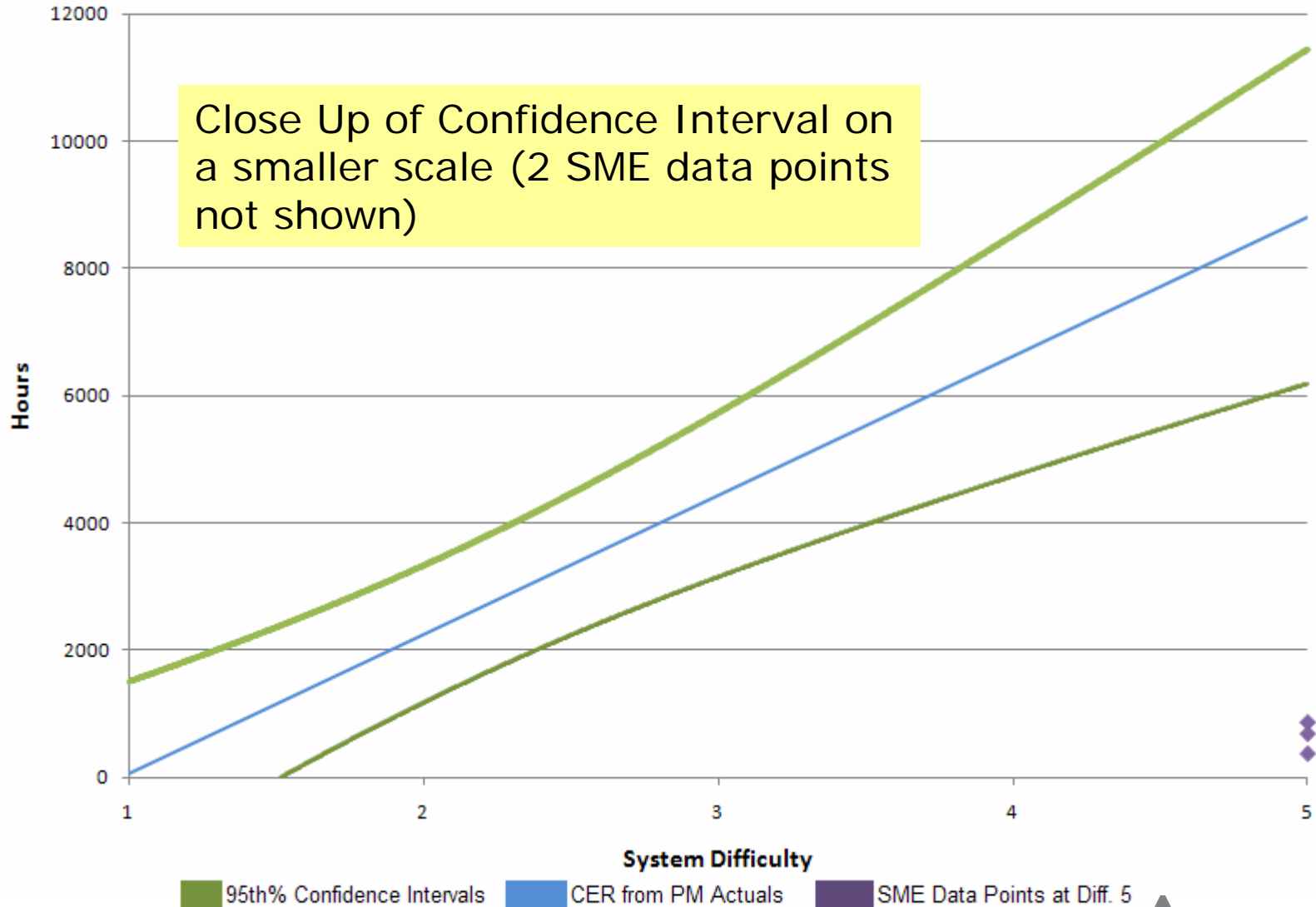
PM Effort Confidence Intervals and SME Data



PM Actuals and SME data

- Challenge
- Solution
- Phase 1
- Phase 2
- Phase 3**
- Findings
- Works Cited

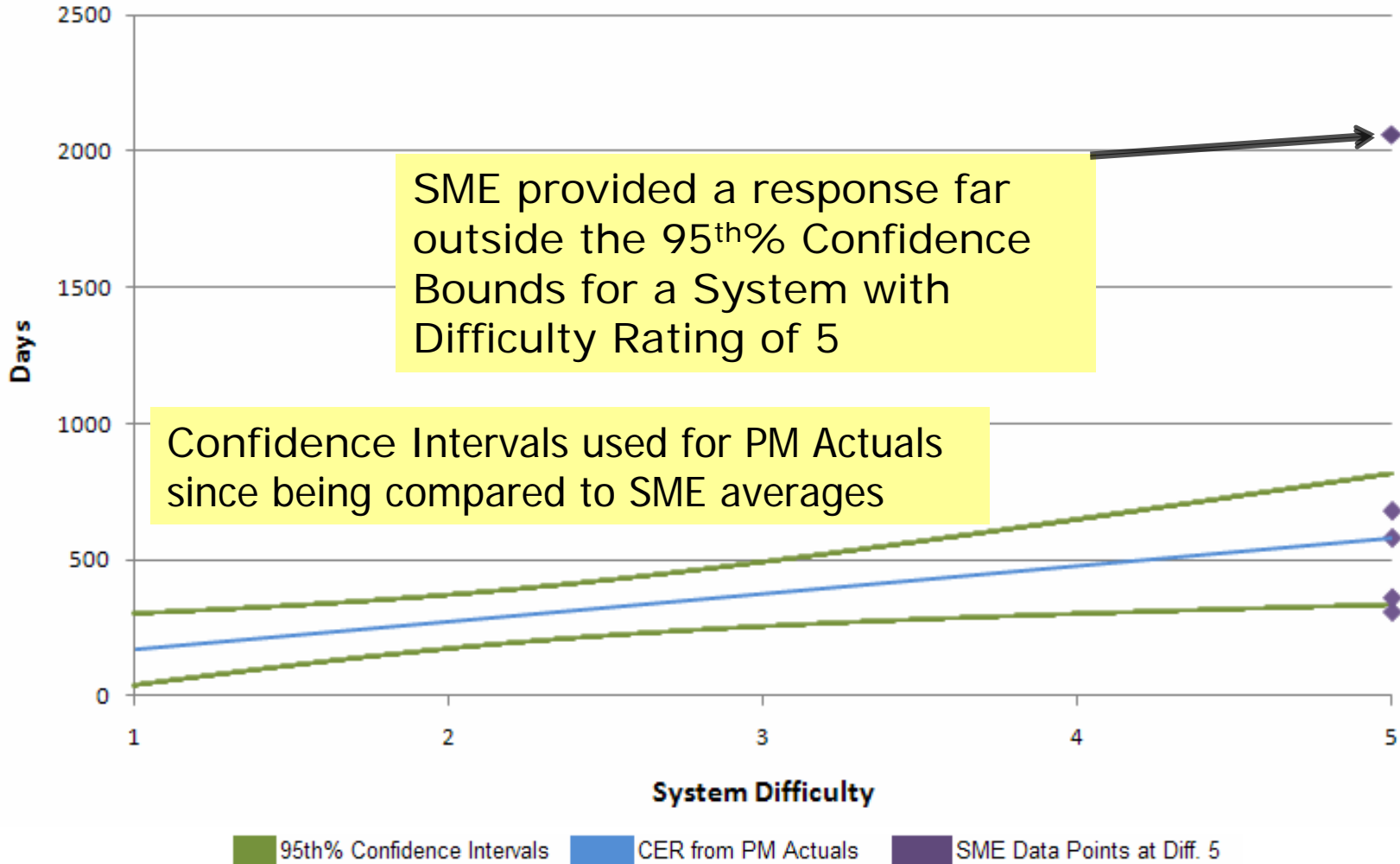
PM Effort Confidence Intervals and SME Data



PM Actuals and SME data

- Challenge
- Solution
- Phase 1
- Phase 2
- Phase 3**
- Findings
- Works Cited

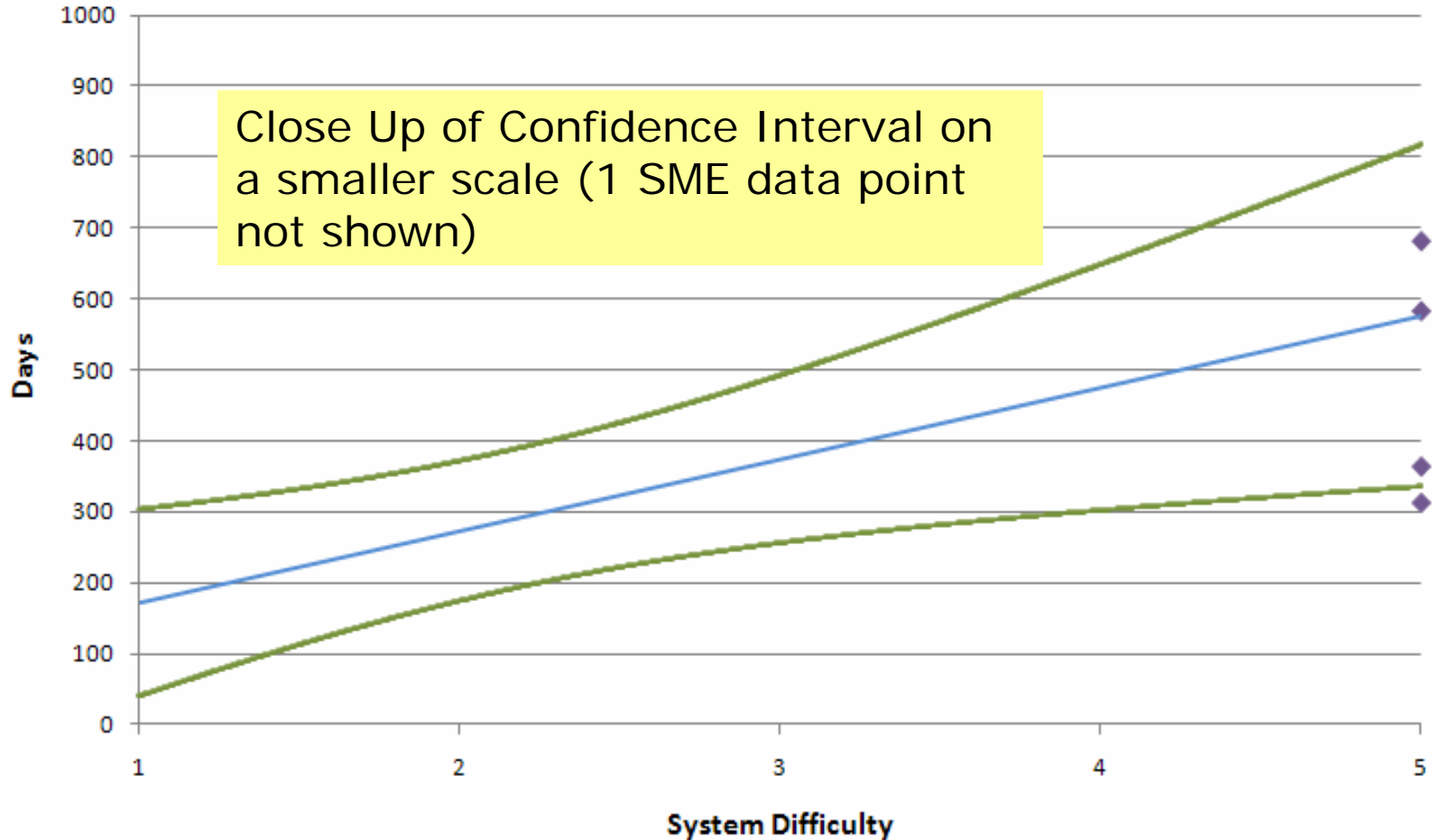
PM Schedule Confidence Intervals and SME Data



PM Actuals and SME data

- Challenge
- Solution
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- Phase 2
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PM Schedule Confidence Intervals and SME Data



95th% Confidence Intervals CER from PM Actuals SME Data Points at Diff. 5

▶ Primary Data (PM Data)

Challenge

Solution

Phase 1

Phase 2

Phase 3

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- ▶ Computed test statistic for Kolmogorov-Smirnov Two-Sided test⁹
 - Null Hypothesis: The PM data and SME data have the same distribution
 - Resulting K-S Test returned the following at the $\alpha = .05$ significance level:
 - Schedule: 0.2759
 - Effort: 0.5463
- } KS Formula¹⁰ when n is greater than 35:

$$= 1.36/\sqrt{n}$$

$$= 0.2483$$
- ▶ **Reject** null hypothesis
 - Suggests that the SME and PM data are distributed differently
 - Possible explanations explored on following slide

9. Conover, W. J. Practical Non Parametric Statistics 3rd Edition with Minitab Student Edition 12 Set. 3rd ed. John Wiley & Sons, 2003. Print.

10. University of Hawaii: School of Ocean and Earth Science and Technology. "[Http://www.soest.hawaii.edu/wessel/courses/gg313/Critical_KS.pdf](http://www.soest.hawaii.edu/wessel/courses/gg313/Critical_KS.pdf)." *Critical Values for the Two-sample Kolmogorov-Smirnov Test (2-sided)*. University of Hawaii. Web.

▶ Primary Data (PM Data)

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

Works Cited

▶ Possible explanations for different distributions:

▶ **Simulated SME Data**

- Divergent opinions amongst SMEs
- Different experiences with the C&A process
- AKA “Six Blind Indians”

▶ **PM Actual Data**

- Effort calculation may need to be further examined
 - PM data was provided in calendar days
 - Converted to work days
 - Multiplied by the dedicated effort (% FTE)
 - Multiplier added to account for management effort

Findings

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

Works Cited

FINDINGS

Findings

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

Works Cited

- ▶ Provided support for original hypothesis:
“Systems with higher Difficulty levels require more effort and time to certify and accredit than systems with lower Difficulty levels”
- ▶ Built and delivered two models for the customer using Excel VBA (one from SME data, one from PM Actuals)
- ▶ In the absence of primary data, SME data collection effort was conducted
 - Primary Actual data found mid-way through the process
 - Simulation output from SMEs was higher than PM Actuals for systems with difficulty level 5
- ▶ Reiterates that primary data is preferential to SME data collection/expert opinion
- ▶ For a more complete discussion of SME-based estimates, see “The Correct Use of Subject Matter Experts in Cost Risk Analysis”⁸

8. Coleman, Richard L., Braxton, Peter. “The Correct Use of Subject Matter Experts in Cost Risk Analysis”, Naval Postgraduate School Acquisition Research Symposium, Monterey, CA, 2010.

▶ Future Research Topics

Challenge

Solution

Phase 1

Phase 2

Phase 3

Findings

Works Cited

- ▶ Explore why SMEs have such divergent opinions of the C&A process
- ▶ Develop a less subjective definition of “complexity”
 - Similar to Hardware and Software scoring matrices¹¹
- ▶ Best practices for conducting SME data collection interviews
- ▶ Best methods to overcome SME estimating biases
 - How to calibrate correctly?
 - How to use SMEs when estimating extreme values?

11. SCEA. *Cost Estimating Body of Knowledge (CEBoK), Module 9 Cost and Schedule Risk Analysis: How to adjust your estimate for uncertainty and historical cost and schedule growth.* 2009. Print.

Works Cited

Challenge

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Phase 1

Phase 2

Phase 3

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- ▶ Coleman, Richard L., Braxton, Peter. "The Correct Use of Subject Matter Experts in Cost Risk Analysis", Naval Postgraduate School Acquisition Research Symposium, Monterey, CA, 2010.
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- ▶ Cuppan, Christopher D., Blackburn, Fred, Coleman, Richard L., St. Louis, Nancy. "Risk Analysis of a Major Government Information Production System", SCEA, 1997.
- ▶ Dalkey/RAND, Norman. *The Delphi method: An experimental study of group opinion*. Publication no. RM-5888-PR. Tucks Professional Services. Web. 7 Dec. 2009.
<http://www.tucksprofessionalservices.com/resource_centre/allabout_codex/Articles/RandOfficialDelphiTechnique>.
- ▶ *Department of Defense Information Assurance Certification and Accreditation Process*. Wikipedia, 11 Mar. 2010. Web. 22 Mar. 2010.
<<http://en.wikipedia.org/wiki/DIACAP>>.

▶ Works Cited Continued

Challenge

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Phase 2

Phase 3

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- ▶ University of Hawaii: School of Ocean and Earth Science and Technology. "[Http://www.soest.hawaii.edu/wessel/courses/gg313/Critical_KS.pdf](http://www.soest.hawaii.edu/wessel/courses/gg313/Critical_KS.pdf)." Critical Values for the Two-sample Kolmogorov-Smirnov Test (2-sided). University of Hawaii. Web.

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