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DEFINING THE FUTURE

# SEER-SEM + CMMI = High Maturity Software Cost Estimation

2008 SEER User Conference  
Redondo Beach, CA

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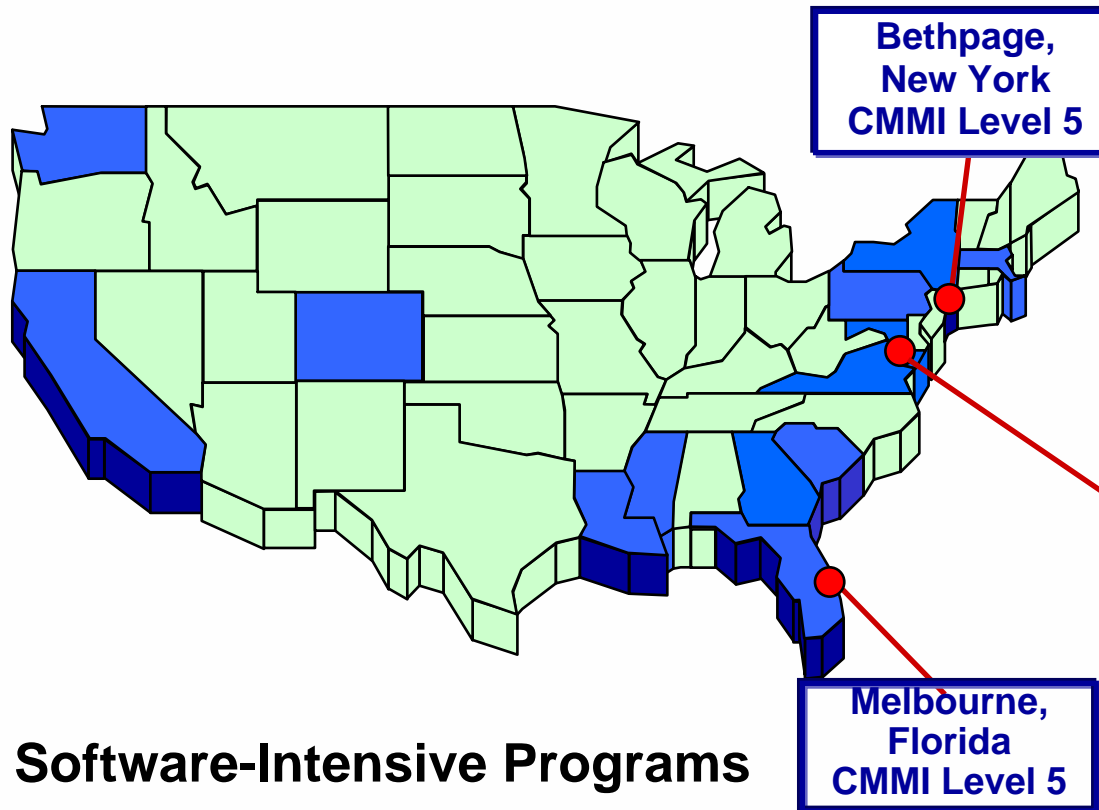
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Northrop Grumman Integrated Systems

# Topics

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- **Who we are**
- **State of the industry**
  - Our track record
- **Key relationships between CMMI goals and practices and high maturity cost estimating behaviors**
- **Practical advice on implementing high maturity behaviors**
- **Summary**

# ISER SW Engineering, Major Sites



Hollywood, Maryland



## Major Software-Intensive Programs

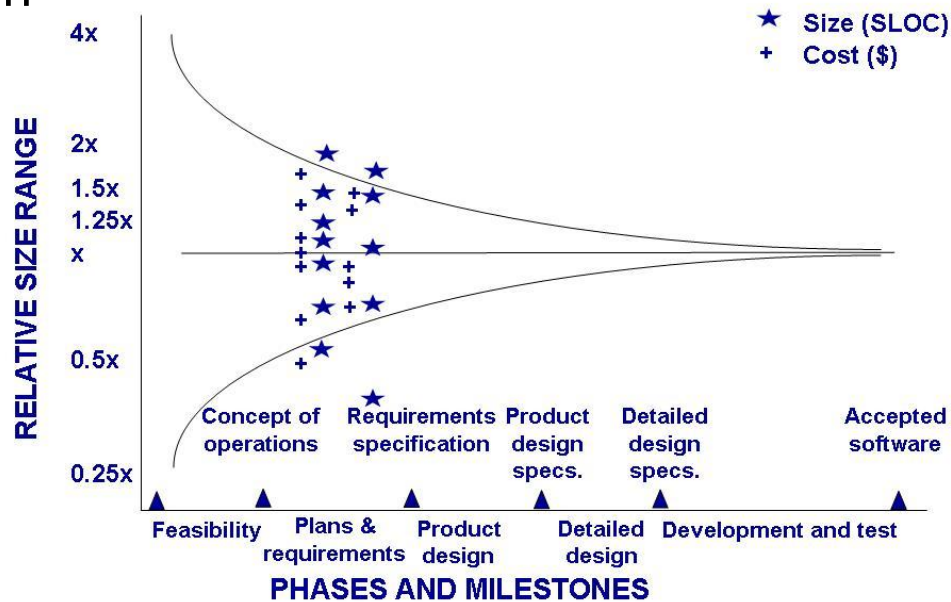
- E-8C Joint STARS
- E-4D Advanced Hawkeye
- E/A-18G Growler
- KC-45A Tanker

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# What Is Achievable?

- Industry record is dismal
  - 2006 Chaos Report
    - 46% of projects are “challenged” with cost or schedule overruns or requirements gaps
    - 19% of projects fail
  - Barry Boehm’s data indicate a  $\pm 50\%$  proposal accuracy is common



Sources: Chaos Report – Rubinstein, “Standish Group Report: There’s Less Development Chaos Today,” *SD Times*, March 2007. Boehm data – Pfleeger and Atlee, *Software Engineering: Theory and Practice*, 3<sup>rd</sup> edition, Prentice-Hall, 2006; also published in Boehm et al., *Software Cost Estimation with COCOMO II*, Prentice-Hall, 2000.

# What Is Achievable?

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- **Root cause analysis is difficult to establish**
  - End-of-job actuals confound the accuracy of the proposal with management track record during project execution
  - Credit, or blame, must be shared
- **Our track record**
  - Seven major SW development projects completed 1998-2007
    - Median SW cost performance index (CPI) = 102%
    - All projects completed on schedule with schedule performance index (SPI) = 100%
  - As-delivered SW quality at six-sigma levels

# Key Relationships

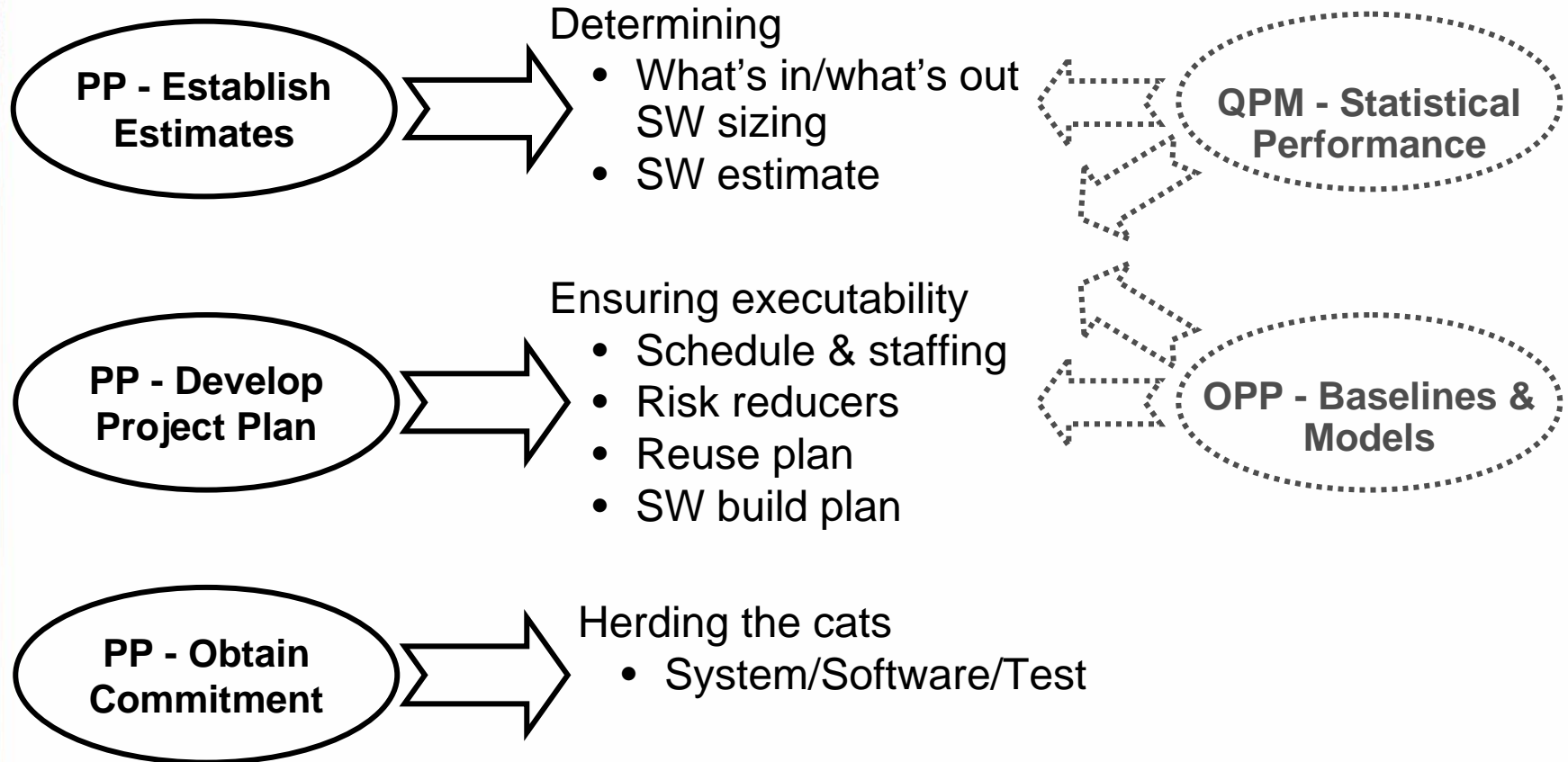
Mapping of CMMI Goals/Practices to Key Estimating Behaviors

# Getting Started

## Generic Practices in the CMMI

- **“Must-win” estimating efforts**
  - Are planned and managed like projects
  - Follow a defined process
  - Are executed by a team of product & estimating specialists
- **All relevant IPTs, engineering disciplines, and other stakeholders must commit to the estimate**
  - Identify & involve (with mutual agreement)
  - Monitor & control
  - Objectively evaluate
  - Review status with higher management

# Project Management Basics

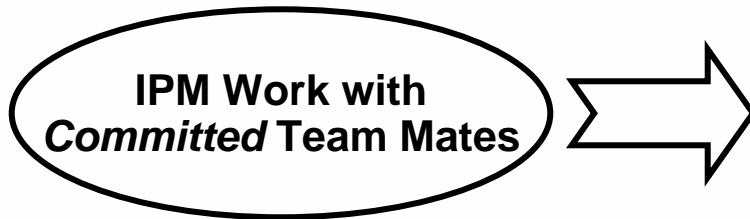


**PP** = Project Planning  
**QPM** = Quantitative Project Management  
**OPP** = Organizational Process Performance

# "Closed Loop" Estimating



- Estimating the process *defines* the process
- The estimate depends on the process baseline, closing the estimating loop



- SW Cost Working Group
- SW Process Management Team

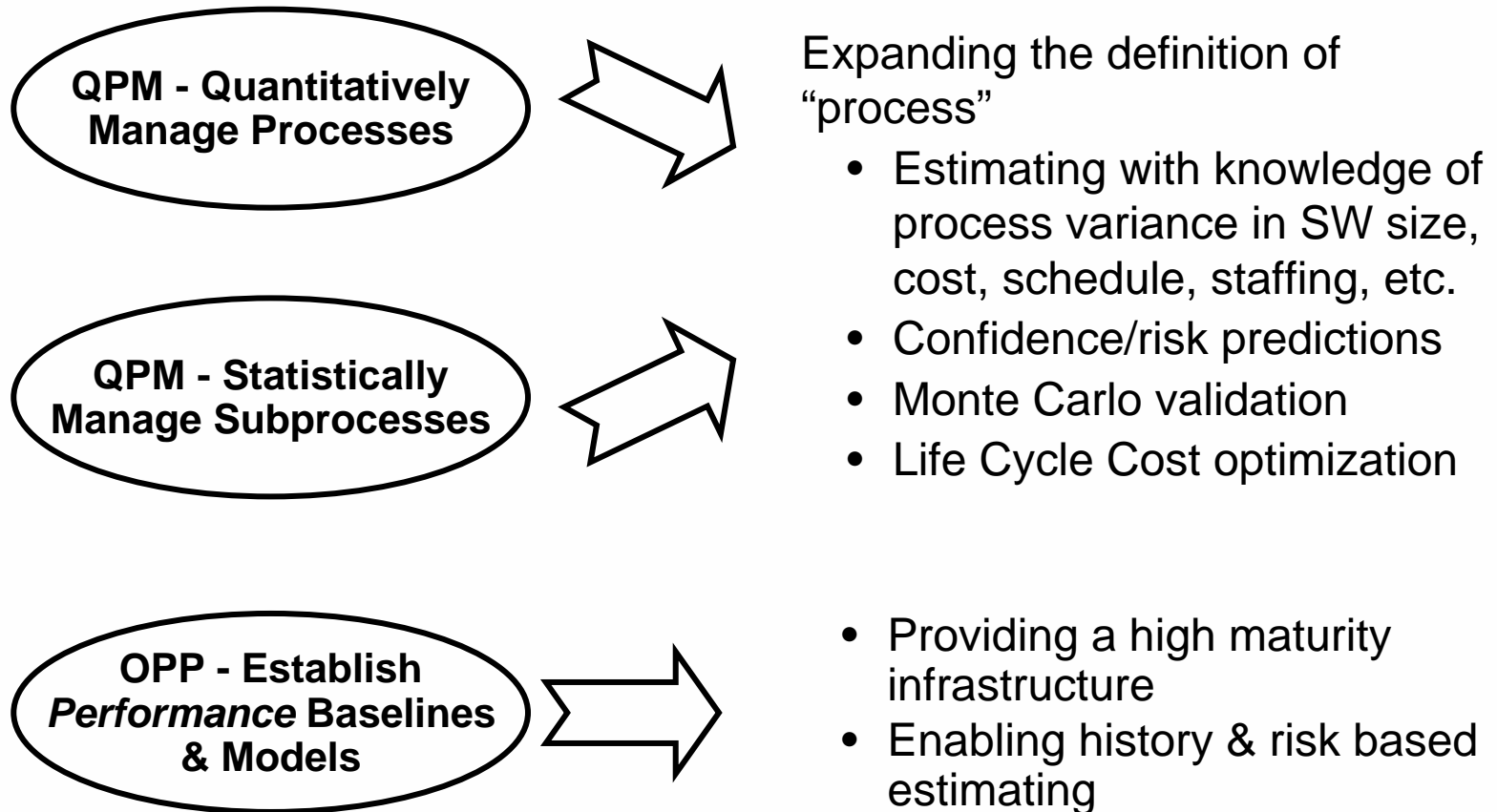


IPM = Integrated Project Management  
SAM = Supplier Agreement Management

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# Using Maturity to Your Advantage



QPM = Quantitative Project Management  
OPP = Organizational Process Performance

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# Practical Advice

How a High Maturity Organization Approaches System/Software Cost Estimation

# Principles

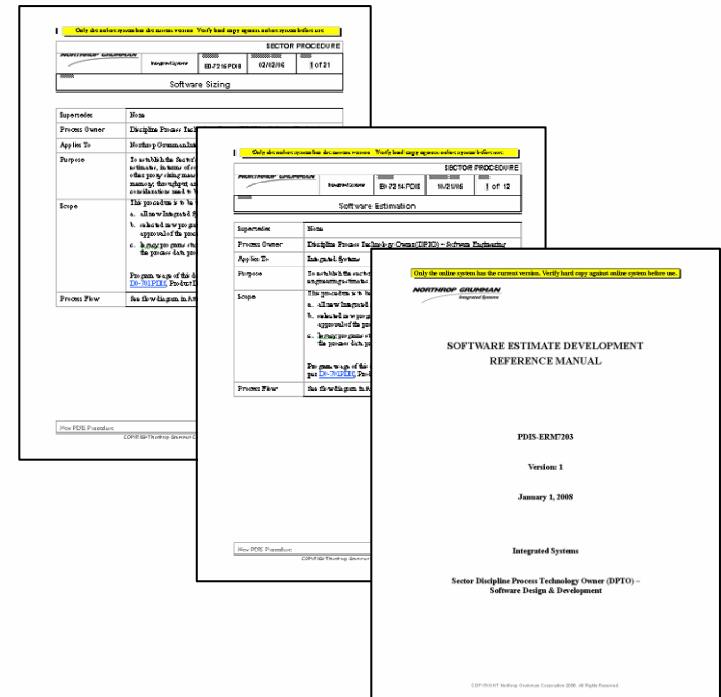
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- **No rogues**
  - “We don’t need no stinking process!”
- **Manage the estimate**
  - One is better than many
  - Who’s on first?
  - Two is better than one
- **Avoid the Lake Wobegon syndrome**
  - Using parametric tools credibly to ensure cost realism and reasonableness
- **Ensure executability**
  - Execution risk – do you think about it? Your management and your Customer do
  - Specific risk items will be in the Customer’s evaluation of Most Probable Cost. Addressing them is your choice
  - Ditto for your Customer’s other concerns
  - Know how your Customer scores an estimate
- **Justify, justify, justify reuse**
  - Establish the pedigree and substantiate the choice

# No Rogues

## Follow a Defined Estimating Process

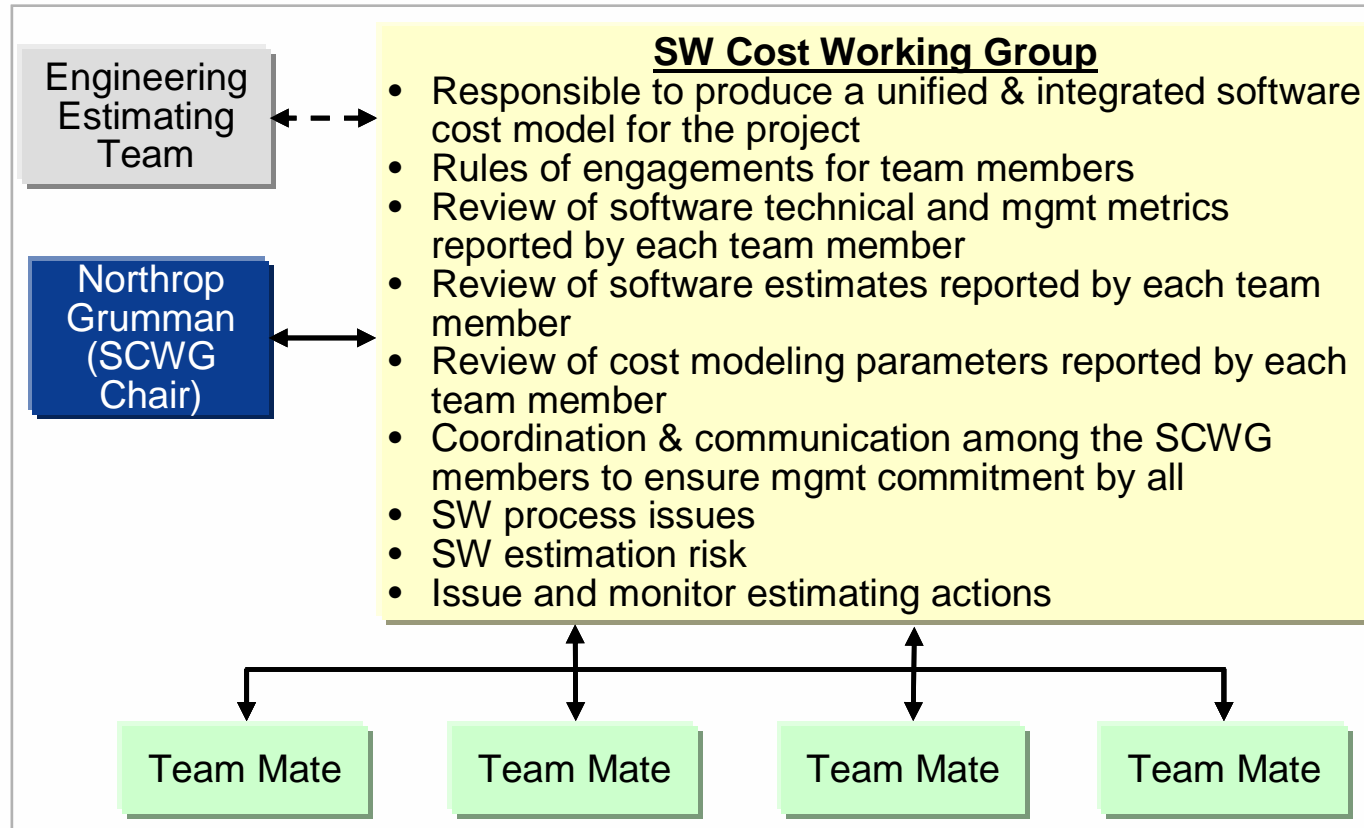
- **SW Sizing procedure**
  - Allowable methods
  - Counting rules
  - Reuse sizing
  - Checklists
- **SW Estimation procedure**
  - SW Cost Working Group
  - Parametric size-based estimate
    - SEER-SEM is our preferred tool
  - Discrete methods for other costs
- **SW Estimating reference manual**
- **Discipline review & approval**



*Ill-defined processes introduce risk and justify estimate plus-ups.*

# One Is Better Than Many

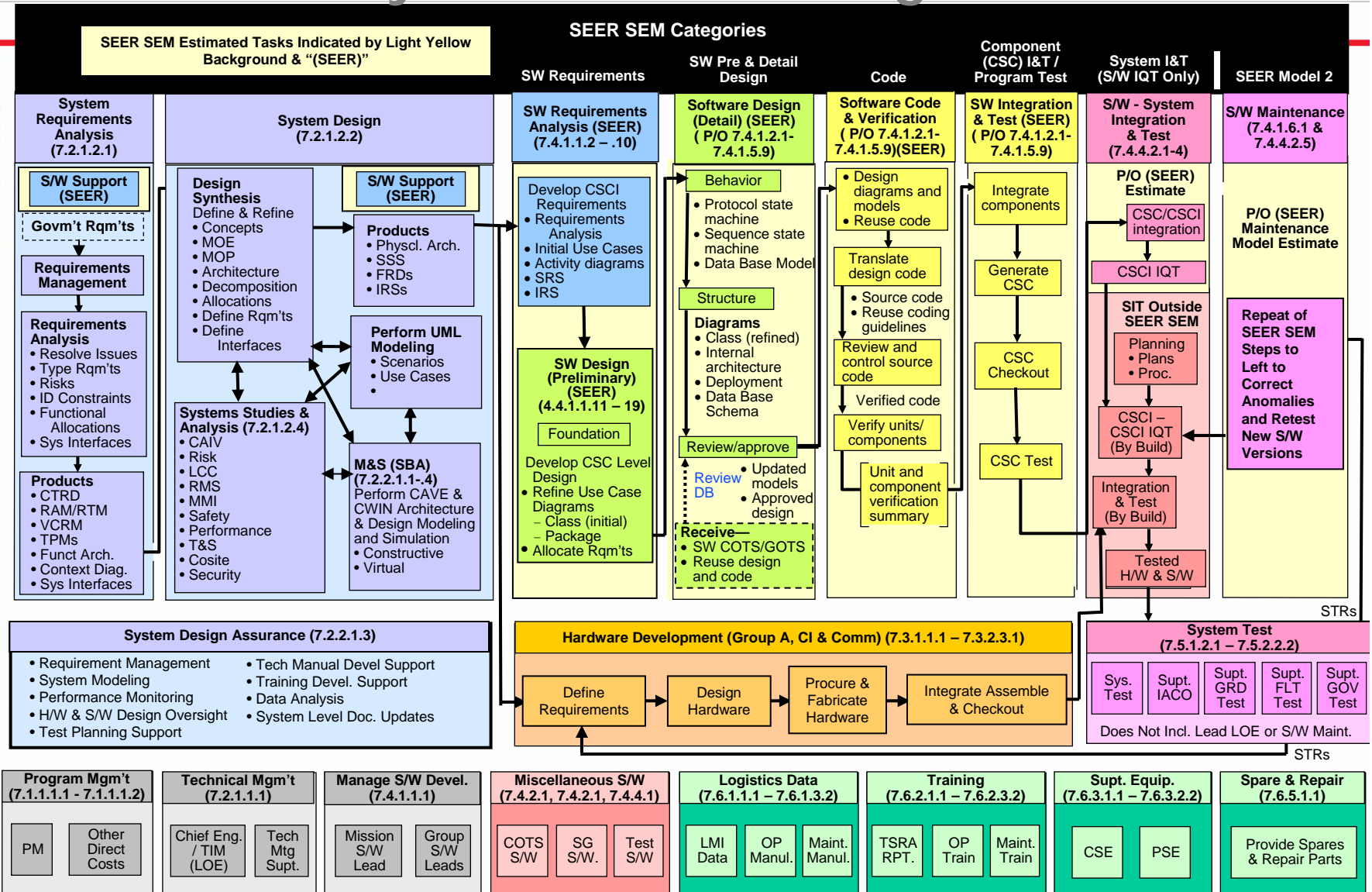
## Software Cost Working Group (SCWG)



*One team → one model*

# Who's on First?

## Process/Lifecycle/Estimate Integration

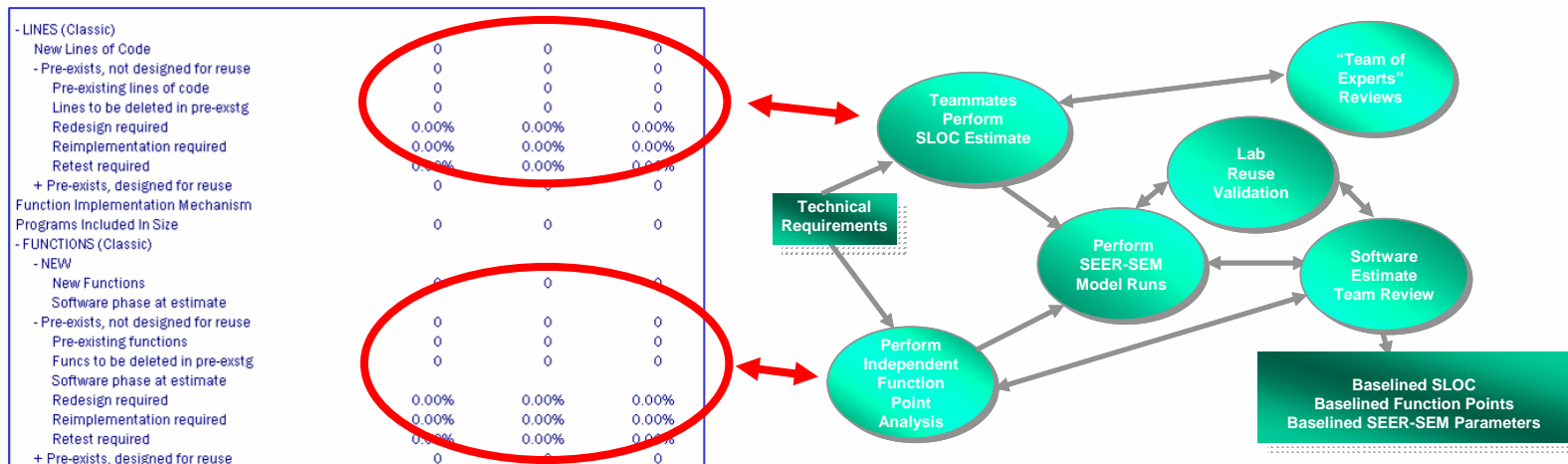


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# Two Is Better Than One

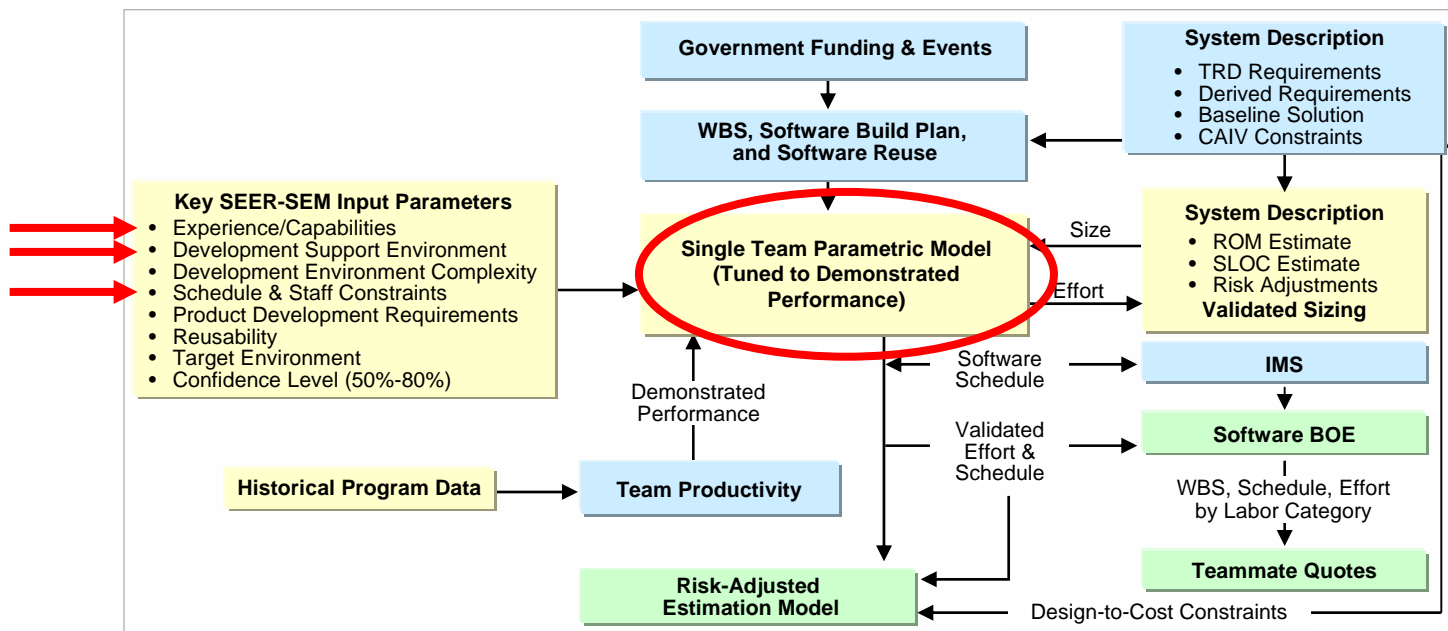
## Independent Estimates of SW Sizing

- **Good:** multiple, independent reviews of all size estimates by the SCWG and third party “team of experts”
- **Better:** independent estimates with the same technique (with reviews)
- **Best:** independent estimates with different techniques (with reviews)



# Avoid the Lake Wobegon Syndrome

- History matters – Customers will not accept forecasting an unrealized productivity improvement

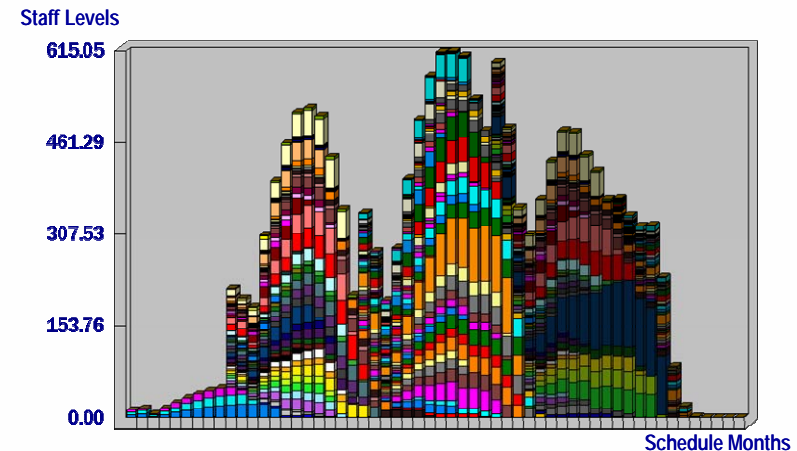


*"All the women are strong,  
all the men are good-looking,  
and all the children are above average"*  
Garrison Keillor

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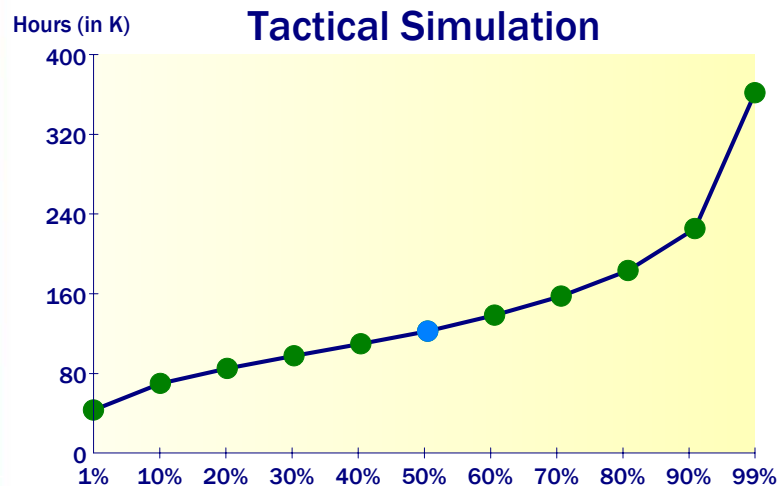
# Ensure Executability

- **Functional discipline reviews**
  - Estimation methodology
  - Process, metrics & performance baselines
  - Indirect & other non-project commitments
- **Non-Advocate Review (NAR)**
  - Ensure program is executable within cost and schedule proposed and do not expose the company to unacceptable risk
  - Is the program executable?
- **Independent Cost Evaluation (ICE)**
  - Independent, objective evaluation of proposed costs, designed to assess the reasonableness of the bases of estimates (BOEs) cost risks associated with program execution, and the resultant financial impacts
  - Is the cost realistic?



# Execution Risk

- **50/50 bids do not always make the most sense**
  - If you are bidding mean performance, you are *almost certainly* not at 50/50 anyway
  - Management or Customer direction
- **80/20, 90/10, or other bid strategies require process performance baselines that capture statistical variation in the process**
- **Commercial parametric tools do offer these capabilities**
  - Variable Risk/Confidence settings for parameters & estimates
  - Monte Carlo risk analyses



Air Force policy is to estimate and fund programs to a high (80-90%) confidence. That is to say, programs are to be estimated and funded so that the total program costs for any given program would be less than the budget 80-90% of the time. Also, program milestones and program completion should meet the planned schedule 80-90% of the time.

Sources: US Air Force Software Management Guidebook, V0.9, December 2004. SEER-SEM screenshot on this page is from Galorath's "Regional Tactical Simulation" example.

# Customer Risk Items

- **Specific allowances in the estimate**
  - SW growth
    - Holchin, Popp studies
    - Planned vs. unplanned growth
  - Build currency with incremental development
  - Maintenance of the SW baseline *before* final system delivery
  - Multi-site development
  - Security

<b>- DEVELOPMENT SUPPORT ENVIRONMENT</b>			
Modern Development Practices Use	Hi	VHi	VHi
Automated Tools Use	Nom+	Hi	Hi+
Turnaround Time	VLo	VLo	Low
Response Time	Low	Low	Low
Multiple Site Development	Hi-	Hi	Hi
Resource Dedication	Nom	Nom	Nom
Resource and Support Location	Nom+	Hi-	Hi
Development System Volatility	Nom	Nom	Nom
Process Volatility	Nom	Nom	Nom
<b>+ PRODUCT DEVELOPMENT REQUIREMENTS</b>			
<b>+ PRODUCT REUSABILITY REQUIREMENTS</b>			
<b>+ DEVELOPMENT ENVIRONMENT COMPLEXITY</b>			
<b>- TARGET ENVIRONMENT</b>			
Special Display Requirements	Hi	Hi	Hi+
Memory Constraints	Nom	Nom	Nom
Time Constraints	Nom	Nom+	Hi-
Real Time Code	Nom	Nom	Nom+
Target System Complexity	Nom+	Hi	Hi
Target System Volatility	Nom	Nom	Nom+
Security Requirements	Nom	Nom	Nom

SW Growth Data Sources: Holchin, "Code Growth Study", March 1996 and Popp, "Calibrating Software Code Growth," NAVAIR, February 2006, but see also the US Comptroller-General data in Stewart, *Cost Estimating*, 2<sup>nd</sup> edition, Wiley, 1991. Mike Ross' Galorath white paper "Software Size Growth and Uncertainty: Both Affect Estimate Quality and Project Risk," November 3, 2005 is also a valuable resource.

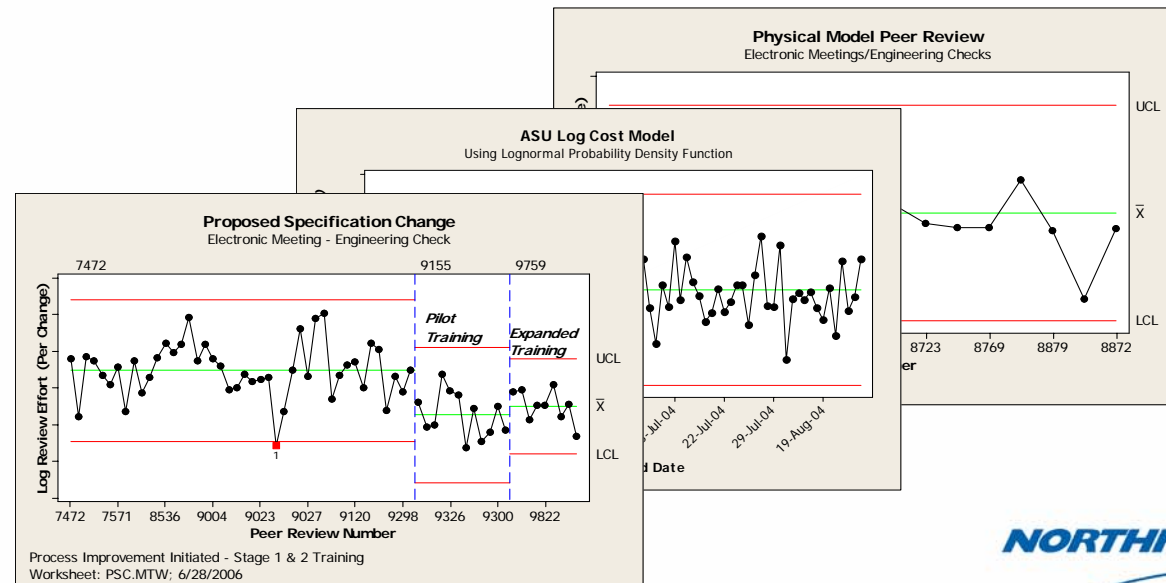
# Other Customer Concerns

- Customer funding profile
- Compatibility of detailed SW Build Plan with availability of all hardware, software, and lab components
  - Traceability to the IMS
- CMMI maturity of all sites that are part of the software development team
- Managing the software team to have one unified development process

<i>CMMI Process Areas</i>	<i>Prime</i>	<i>Subs</i>	<i>CMMI Process Areas</i>	<i>Prime</i>	<i>Subs</i>
<b>Level 2</b>			<b>Level 3 (continued)</b>		
Requirements Management	✓	✓	Organizational Process Definition	✓	(4)
Project Planning	✓	✓	Organizational Training	✓	(4)
Project Monitoring & Control	✓	✓	Integrated Project Management for IPPD	✓	(1)
Supplier Agreement Management	✓	✓	Risk Management	✓	(1)
Measurement & Analysis	✓	✓	Integrated Teaming	✓	(1)
Product & Process Quality Assurance	✓	✓	Integrated Supplier Management	✓	(4)
Configuration Management	✓	(1)	Decision Analysis & Resolution	✓	(1)
			Organizational Environment for Integration	✓	(4)
<b>Level 3</b>			<b>Level 4</b>		
Requirements Development	✓	(2)	Organizational Process Performance	✓	(5)
Technical Solution	✓	✓	Quantitative Project Management	✓	(5)
Product Integration	✓	(3)	<b>Level 5</b>		
Verification	✓	(3)	Organizational Innovation & Deployment	✓	(5)
Validation	✓	(3)	Causal Analysis & Resolution	✓	(5)
Organizational Process Focus	✓	(4)			
<b>Notes:</b>					
(1) Subcontractor internal processes and IPT operations integrate with prime's processes.					
(2) System requirements are allocated by prime; subcontractors develop requirements at the configuration item (CI) level.					
(3) All subcontractors integrate, verify and validate their products to the CI or subsystem level; this includes integration of software CIs into hardware CIs or line replaceable units (LRUs). Prime integrates, verifies and validates at the system level					
(4) Subcontractors follow their own CMMI-compliant business processes.					
(5) Prime is responsible team's process control and optimization.					

# Use SPC to Your Advantage

- **Statistical process control (SPC) reduces programmatic risk**
  - Gives superior insight into average performance and variability of the controlled processes
    - Higher confidence estimates
  - Enhances predictability and stability in executing the job
  - Enables proactive process improvement to meet management or Customer performance targets
    - Removal of “common cause” variation from the process



# Know How Your Customer Scores an Estimate

- They reward reality-based estimating
  - Model tuning with historical data
  - Reuse justification

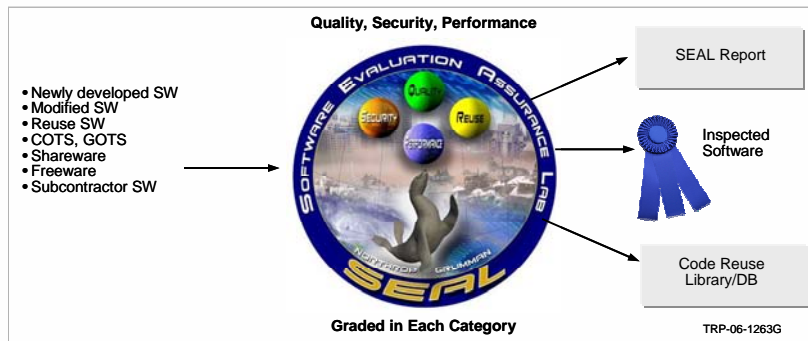
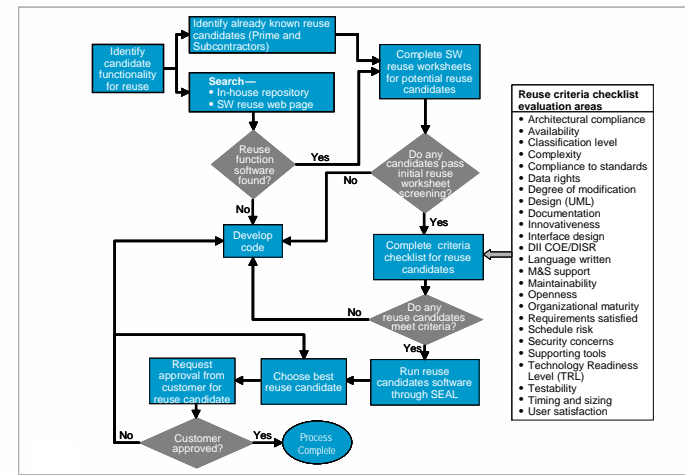
	<b>Red</b>	Estimate <b>un-substantiated</b> by supporting data. This definition includes un-supported engineering estimates and declarative statements (i.e., the xyz task will require three engineers for five months).
	<b>Yellow</b>	Estimate <b>not well correlated to, or substantiated</b> by supporting data. In general, engineering estimates were based on the estimator's experience and expertise is substantiated, the use of non-substantiated scaling factors, use of comparatives where relevance of comparative is not substantiated.  Note: Past experience shows that engineering estimates receive no higher than yellow.
	<b>Green</b>	Estimate supported by <b>relevant</b> comparable data from "similar programs" and/or <b>validated parametric</b> estimating systems.
	<b>Blue\ Green</b>	Estimate supported by <b>relevant</b> comparable data from " <b>multiple similar</b> programs."
	<b>Blue</b>	Estimate supported by <b>production experience</b> and/or <b>cost trend data for "multiple programs."</b>

Source: ESC Training material

*"In God we trust, all others bring data"*  
*W. Edwards Deming*

# Justify, Justify, Justify Reuse

- Establish the pedigree
  - Source
  - Reuse checklists & evaluation criteria ratings



- Substantiate the choice
  - SW reuse worksheets
    - Reuse %ages
  - SW assurance reports
  - Pre-award integration in the project's System Integration Lab

*Don't neglect COTS software & hardware.*

# Summary

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- **CMMI goals and practices should shape your engineering estimating process**
- **Estimates should be planned and managed like projects**
- **SEER-SEM is key to cost realism and reasonableness**
  - Tune the model to your process performance models and baselines
- **Ensure your estimate is executable**
  - Use SEER-SEM's capabilities and your process performance models and baselines to achieve the desired confidence level
- **SW reuse must be justified**

# QUESTIONS



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