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DEFINING THE FUTURE

High Maturity System/Software Cost Estimation

November 14, 2007

Richard L. W. Welch, PhD
Northrop Grumman Integrated Systems

ISER-MLB-PR-07-143

- **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**

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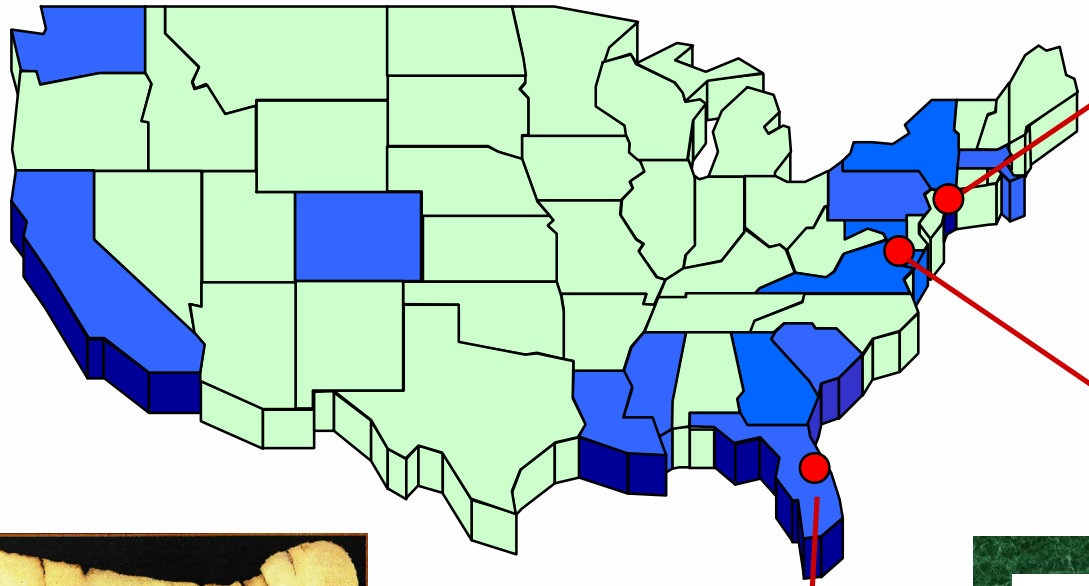

New York
Bethpage 235
CMMI Level 5

Maryland
Hollywood 98

Florida
Melbourne 164
CMMI Level 5

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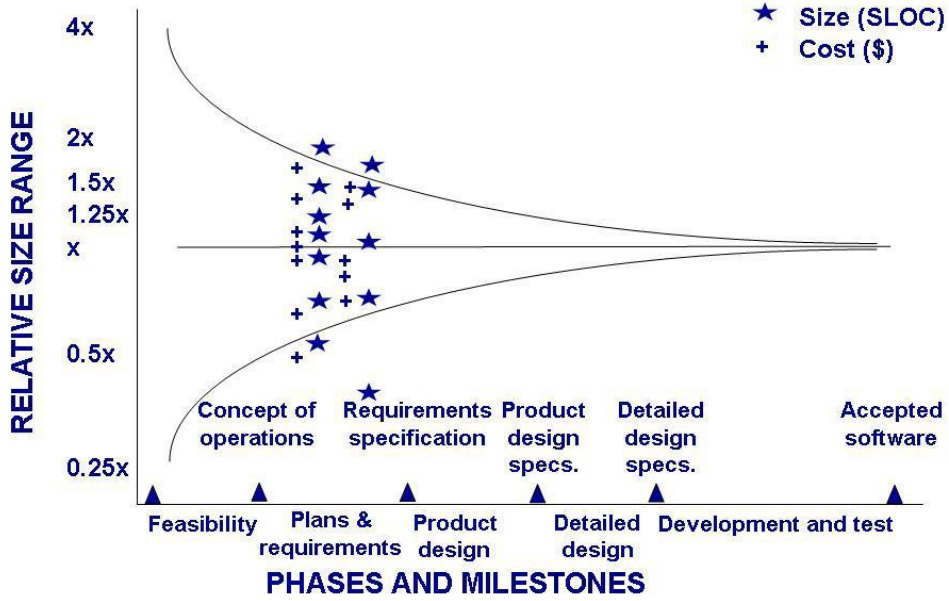
hievable?

- **Industry record is dismal**
  - 2006 Chaos Report
    - 46% of projects are ñchallengedò with cost or schedule overruns or requirements gaps
    - 19% of projects fail
  - Barry Boehmôs data indicate a ± 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, 3rd edition, Prentice-Hall, 2006; also published in Boehm et al., Software Cost Estimation with COCOMO II, Prentice-Hall, 2000.

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hievable?

- **Root cause analysis is difficult to establish**
  - End-of-job actuals are confounded with the project management track record
  - 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

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Key Relationships

Mapping of CMMI Goals/Practices to Key Estimating Behaviors

Getting Started
Generic Practices

- **"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

The Basics

PP SG 1 Establish Estimates

Determining
- Whatôs in/whatôs out
- SW sizing
- SW estimate

PP SG 2 Develop Project Plan

Ensuring executability
- Schedule & staffing
- Risk reducers
- Reuse plan
- SW build plan

PP SG 3 Obtain Commitment

Herding the cats
- System/Software/Test

QPM SG 2 Statistical Performance

OPP SG 1 Baselines & Models

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

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Closed Loop" Estimating

IPM SG 1 Getting to a Defined Process

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

IPM SG 2 & 3 Working with *Committed* Team Mates

- SW Cost Working Group
- SW Process Management Team

SAM SG 1 Supplier Agreements

IPM = Integrated Project Management
SAM = Supplier Agreement Management

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Using Maturity to Your Advantage

QPM SG 1 The Quantitatively Defined Process

Expanding the definition of ñprocessò

- Å Estimating with knowledge of process variance in SW size, cost, schedule, staffing, etc.
- Å Confidence/risk predictions
- Å Monte Carlo validation
- Å Life Cycle Cost optimization

QPM SG 2 Statistical Management

OPP SG 1 *Performance* Baselines & Models

- Å Providing a high maturity infrastructure
- Å Enabling history & risk based estimating

QPM = Quantitative Project Management
OPP = Organizational Process Performance

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Practical Advice

How a High Maturity Organization Approaches System/Software Cost Estimation

- **No rogues**
  - ñWe donôt need no stinking process!ò
- **Manage the estimate**
  - One is better than many
  - Whoôs on First?
  - Two is better than one
- **Parametric tools work**
  - How do you use them credibly?
- **Ensure executability**
  - Think about execution risk. Your management and your Customer do
  - Risk items will be in the Customerôs evaluation of Most Probable Cost. Addressing them in the bid is up to you
  - Know how your Customer scores an estimate
  - Avoid the Lake Wobegon syndrome. You *need* cost realism and reasonableness
- **Justify, justify, justify reuse**
  - Establish the pedigree and substantiate the choice

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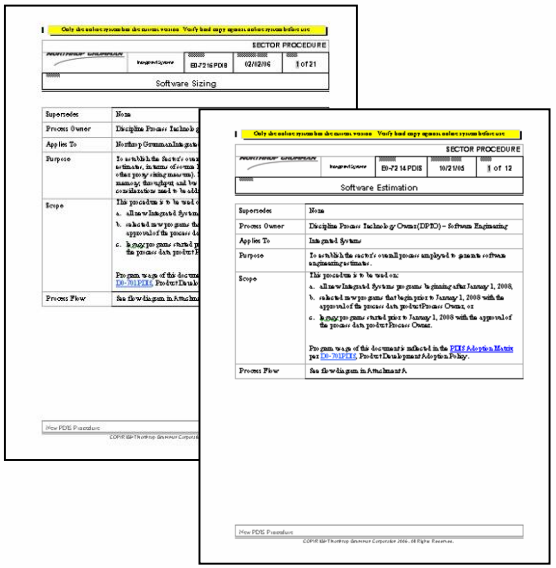
No Kegaes

Follow a Defined Estimating Process

- **SW Sizing procedure**
  - Allowable methods
  - Counting rules
  - Reuse sizing
  - Checklists
- **SW Estimation procedure**
  - SW Cost Working Group
  - Parametric Model for size-based components
  - Discrete methods for other costs
- **Discipline review & approval**



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

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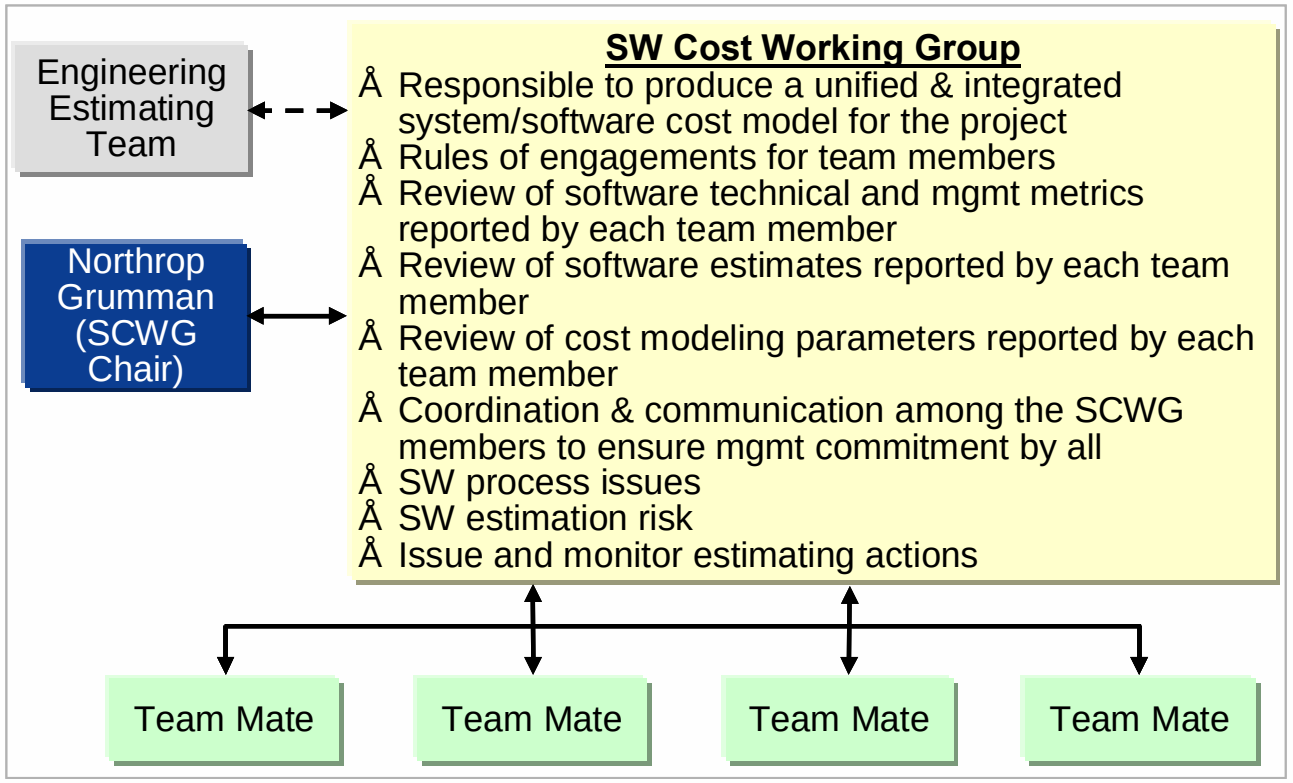
One Is Better Than Many

Software Cost Working Group (SCWG)



Our SCWG anticipates the SW Process Management Team that will oversee and manage the development after contract award.

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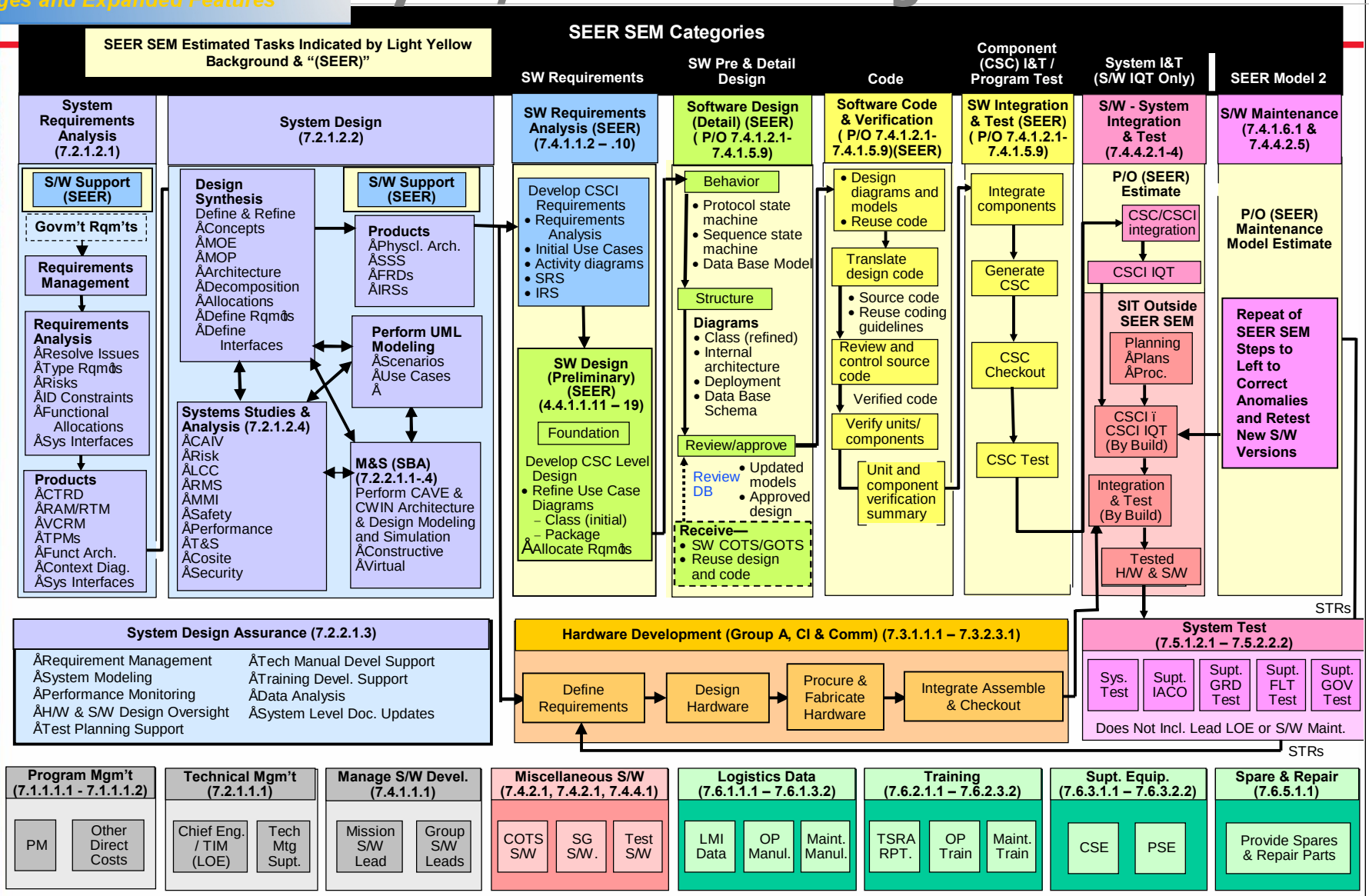
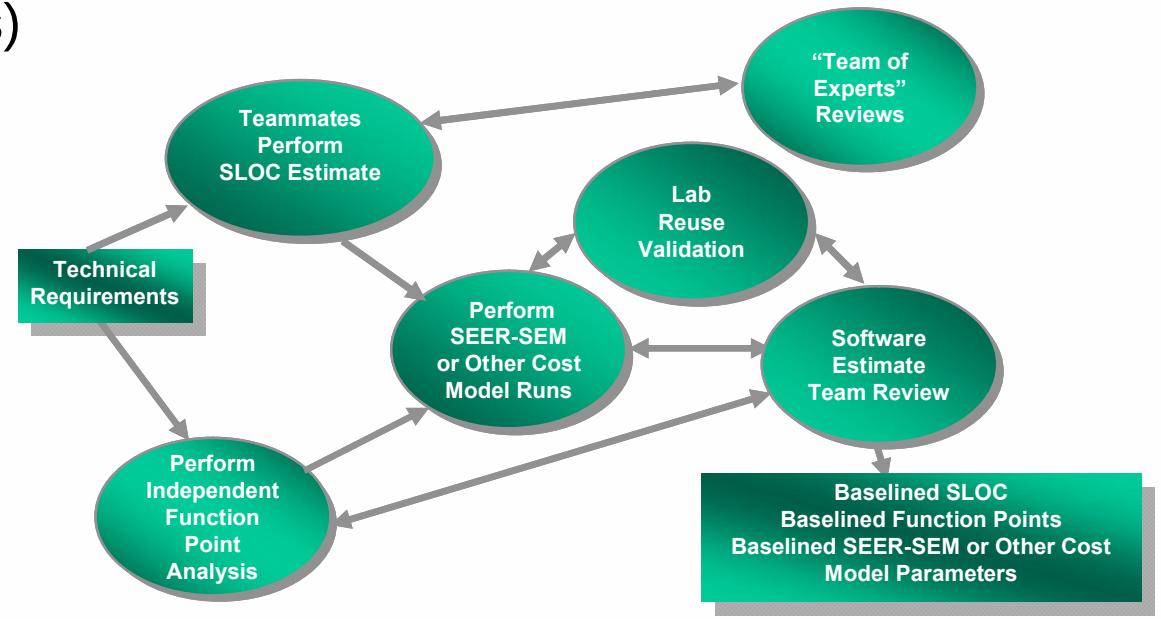
First?
ecycle/Estimate Integration



Two Is Better Than One

Independent Estimates

- **SW Sizing**
  - Good: multiple, independent reviews of all size estimates by the SCWG and third party ñteam of expertsò
  - Better: independent estimates with the same technique (with reviews)
  - Best: independent estimates with different techniques (with reviews)



- **SW Estimation** ï addressed on next slide

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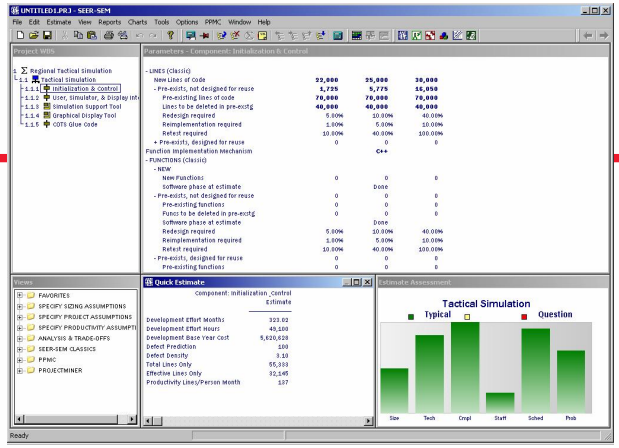
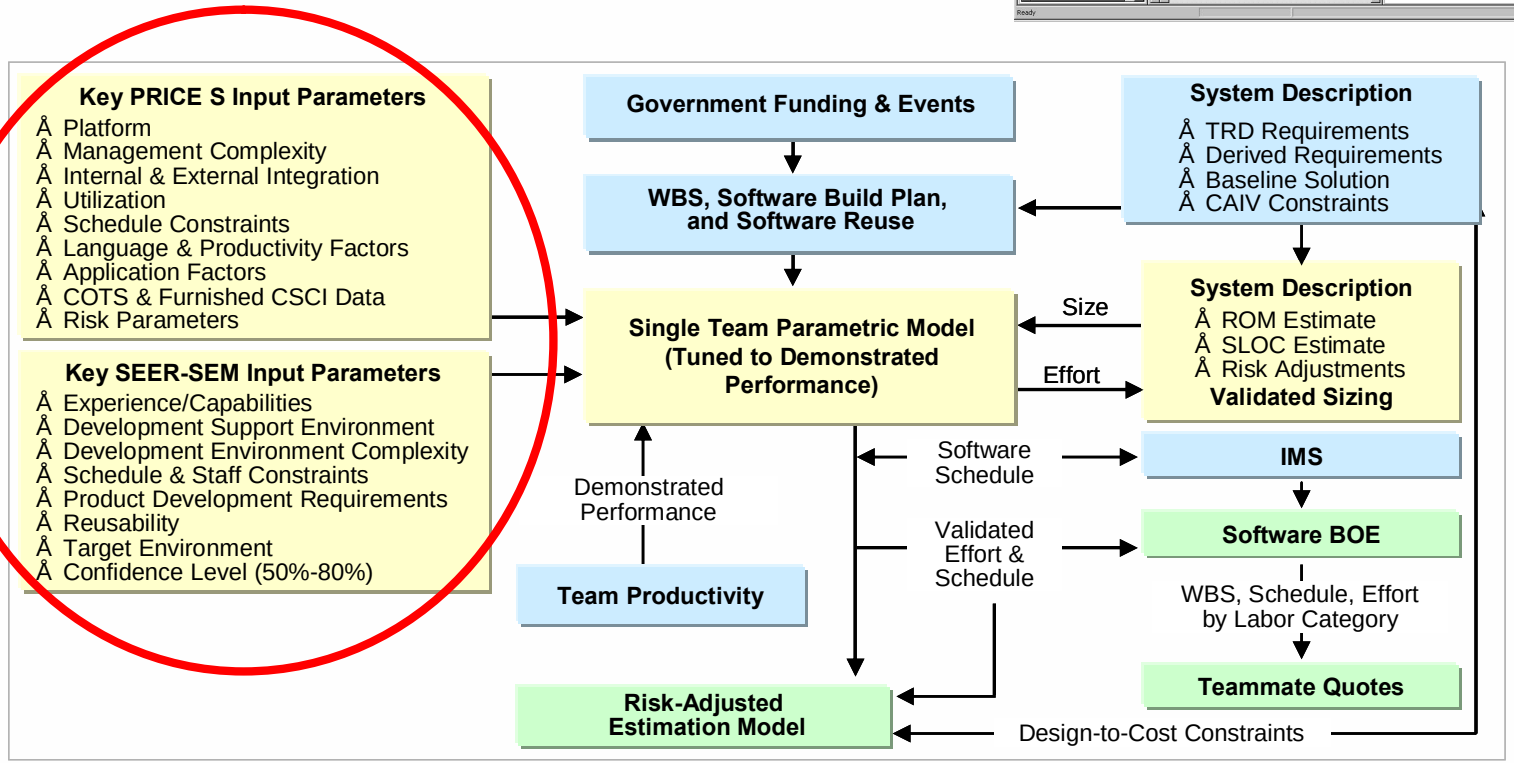
Tools Work



- **Very accurate – when properly calibrated & used**
- **Know your Customer preference**



Recognize that your bid defines the project's process.

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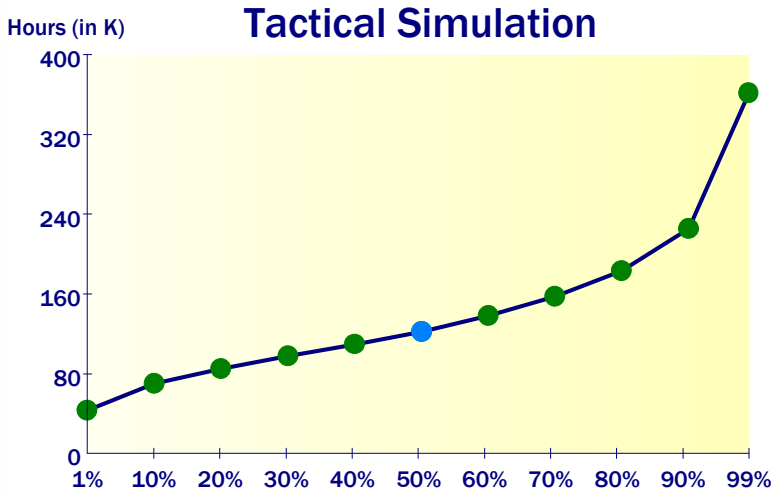
Risk

- **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.

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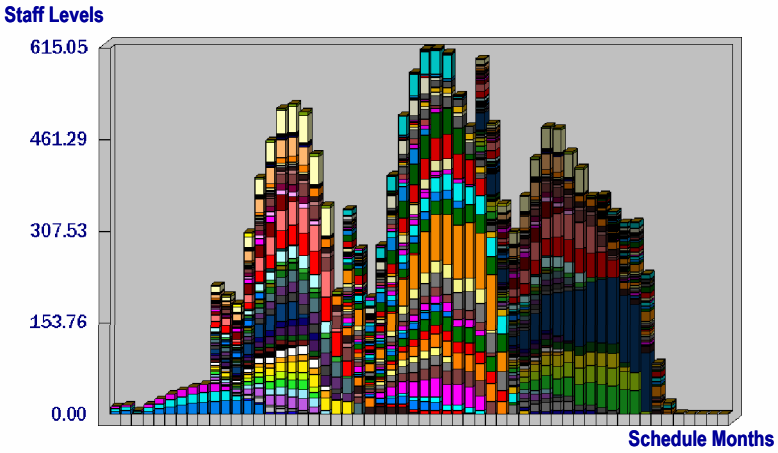
ecutability



- **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?

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Risk Items

- **Specific allowances in estimate**
  - SW growth
    - Holchin, Popp studies
    - Planned vs. unplanned growth
  - Build currency with incremental development
  - Maintenance of the SW baseline between completion of software integration & test and final system delivery to the Customer
  - Multi-site development
    - Multiple Site Development in SEER-SEM
    - Management Complexity (CPLXM) in Price
  - Security requirements

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, 2nd edition, Wiley, 1991.

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omer Concerns

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

# of Processes with Subs

CMMI Process Areas	Prime	Subs
Level 2		
Requirements Management	✓	✓
Project Planning	✓	✓
Project Monitoring & Control	✓	✓
Supplier Agreement Management	✓	✓
Measurement & Analysis	✓	✓
Product & Process Quality Assurance	✓	✓
Configuration Management	✓	(1)
Level 3		
Requirements Development	✓	(2)
Technical Solution	✓	✓
Product Integration	✓	(3)
Verification	✓	(3)
Validation	✓	(3)
Organizational Process Focus	✓	(4)
Organizational Process Definition	✓	(4)
Organizational Training	✓	(4)
Integrated Project Management for IPPD	✓	(1)
Risk Management	✓	(1)
Integrated Teaming	✓	(1)
Integrated Supplier Management	✓	(4)
Decision Analysis & Resolution	✓	(1)
Organizational Environment for Integration	✓	(4)
Level 4		
Organizational Process Performance	✓	(5)
Quantitative Project Management	✓	(5)
Level 5		
Organizational Innovation & Deployment	✓	(5)
Causal Analysis & Resolution	✓	(5)

Notes:

(1) Subcontractor internal processes and IPT operations integrate with primeôs 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 teamôs process control and optimization.

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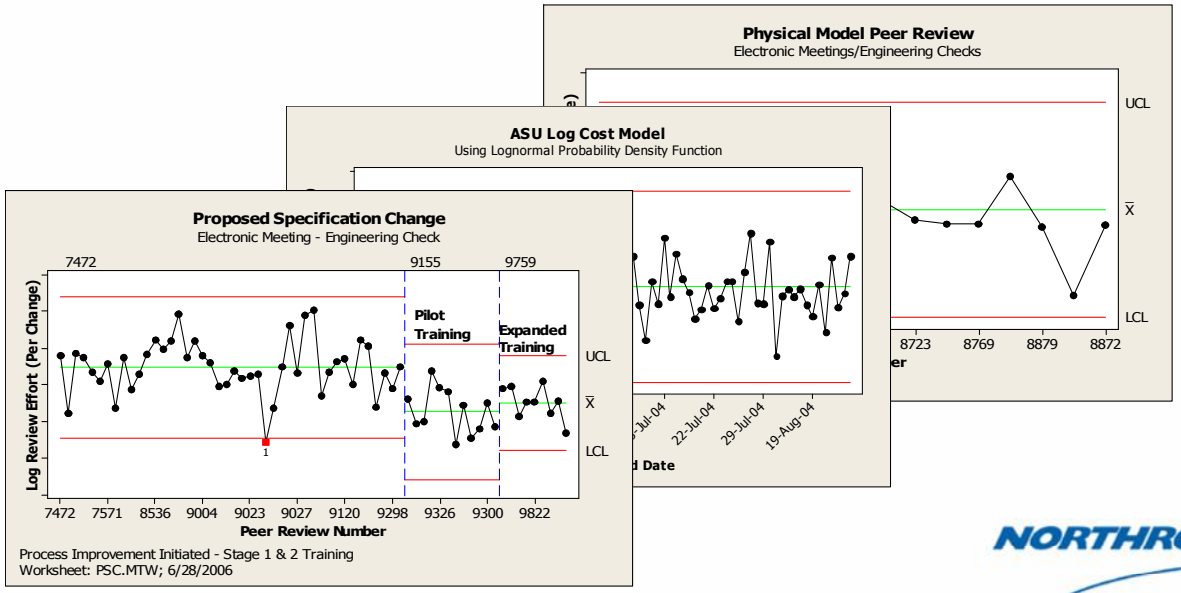
Your Advantage

- **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 ñcommon causeòvariation from the process



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nt BOE Scoring Criteria

	Red	Estimate **un-substantiated** 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).
	Yellow	Estimate **not well correlated to, or substantiated** by supporting data. In general, engineering estimates were based on the estimatorôs 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.
	Green	Estimate supported by **relevant** comparable data from ñsimilar programsò and/or **validated parametric** estimating systems.
	Blue\ Green	Estimate supported by **relevant** comparable data from **“multiple similar** programs.ò
	Blue	Estimate supported by **production experience** and/or **cost trend data for “multiple programs.”**

Source: ESC Training material

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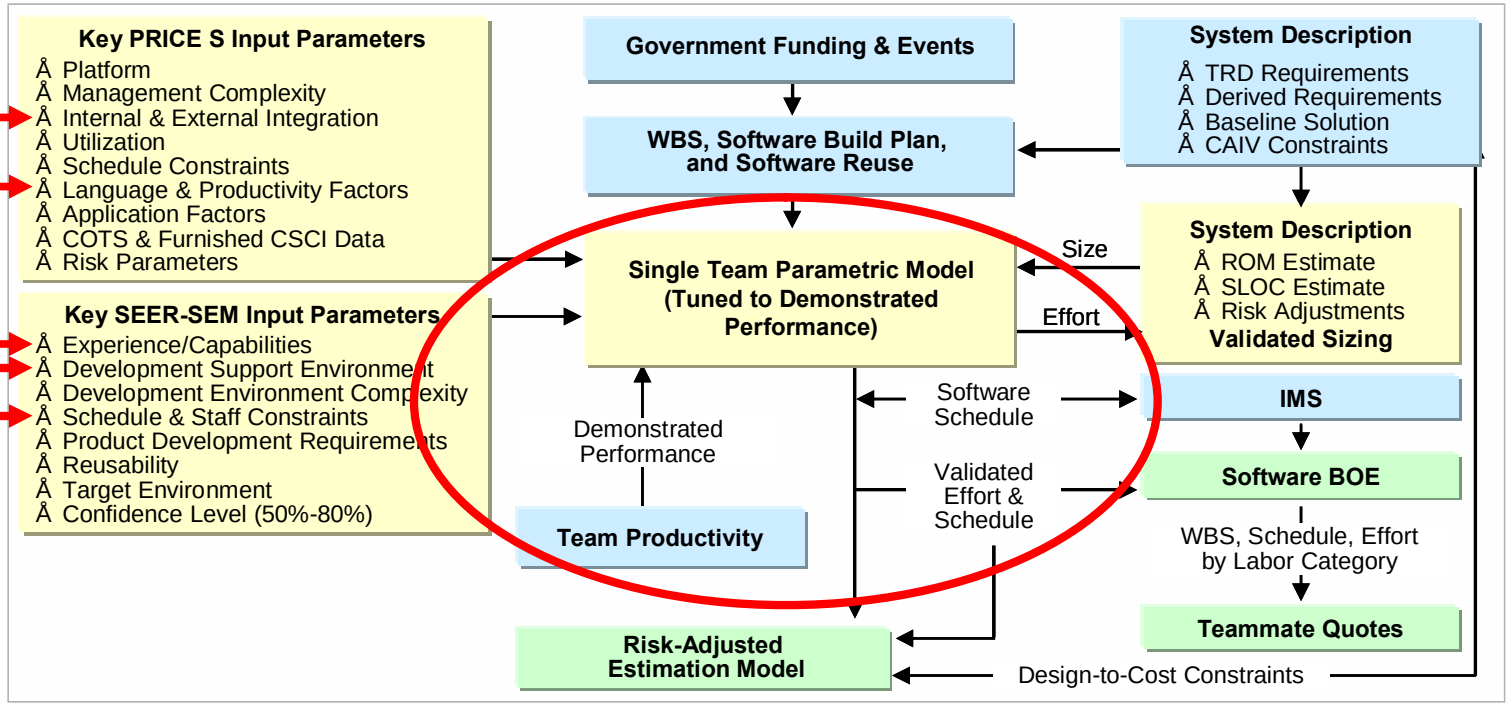
Lake Wobegon Syndrome

- **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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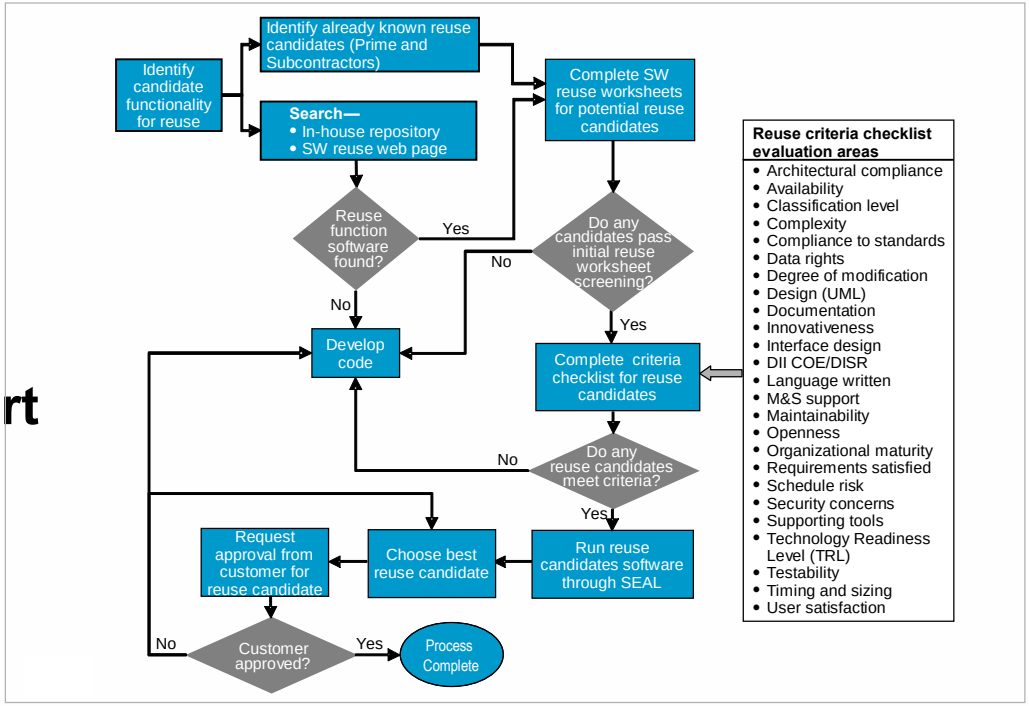
Justify, Justify Reuse

Establish the Pedigree

- Source
- Functionality provided
- Maturity & certifications
- In-house expertise
- Previous use
- Existing runtime & support environments
- Existing test procedures
- Portability
- Maintainability, reliability, quality



Don't neglect COTS software & hardware.

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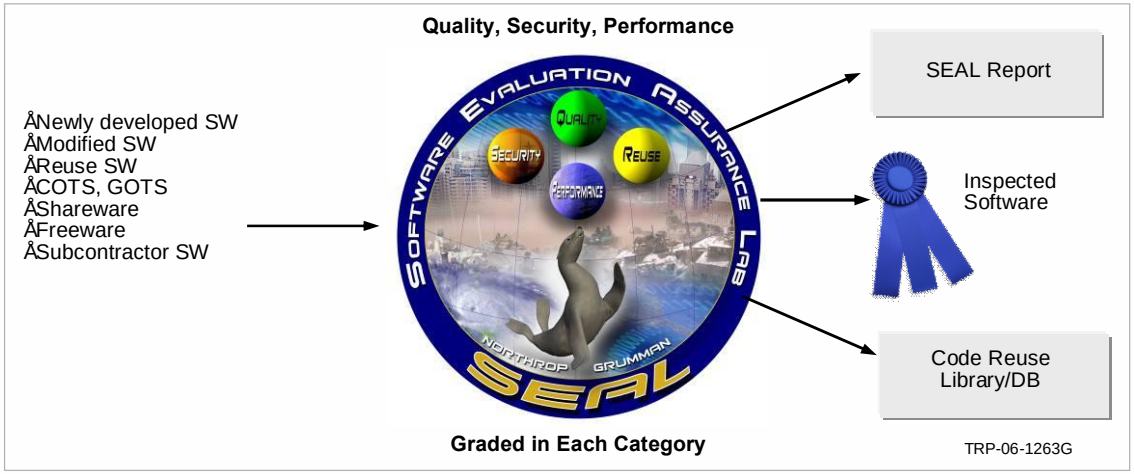
Justify, Justify Reuse

Substantiate the Choice

- SW reuse checklists
- SW reuse worksheets
- Software Evaluation Assurance Lab (SEAL) reports
- Integration with other software in the project's System Integration Lab



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- **CMMI goals and practices should be used to shape your engineering estimating process**
- **Estimates should be planned and managed like projects**
- **Parametric tools work**
  - Tune them to your process performance models and baselines
- **Estimate must be executable**
  - Use your process performance models and baselines to achieve the desired confidence level
- **SW reuse must be justified**

s

Richard L. W. Welch, PhD
Northrop Grumman Corporation
(321) 951-5072
Rick.Welch@ngc.com

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