# The IC CAIG Risk Methodology

Shishu Gupta

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***Selected slides taken from:***

R. L. Coleman, J. R. Summerville (TASC), S. S. Gupta (IC CAIG)

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# Risk

*As we know*
*There are known knowns.*
*There are things we know we know.*
*We also know*
*There are known unknowns.*
*That is to say*
*We know there are some things*
*We do not know.*
*But, there are also unknown unknowns,*
*The ones we don't know we don't know.*

-- *Donald Rumsfeld, 2002*
*Secretary of Defense*
(excerpted from *Pieces of Intelligence: The existential poetry of Donald H. Rumsfeld)*

# The Tenets of IC CAIG Risk

- **Cost Primacy**: Risk must never be used to correct cost estimation shortcomings or used to bypass or short-circuit cost estimate reconciliation
  - Errors or shortcomings uncovered in cost estimation are fed back to the cost estimator, not repaired in the risk estimate
  - Exception: the *usual* failure to foresee growth is the province of the risk estimate
- **Cost-Risk Consistency**: Risk methods must be in best possible agreement with cost methods
- **Risk Consistency**: Risk methods must be in closest possible internal agreement
  - Consistency is not better than being right, but we place great value on internal consistency
  - If inconsistency suggests prior error, we endeavor to correct it
- **Mathematical & Statistical Principles**: We strive to follow them
- **Historical Checks**: History is the only sure test of methodologies
  - This does not mean slavishly repeating history, but rather testing ourselves against history
- **Primacy of Lower Moments**: Correct lower order moments more important than higher order
  - Get the right mean/median first, then work on the standard deviation / CV
  - Extension: We believe that lower order moments are more easily estimated and more stable
- **Improvement**: Improvement is the standard, not perfection
  - Corollary: if a change introduces improvement in any aspect, and no degradation, the change should be accepted

# General Model Architecture

## Inputs

**Scoring**

- Interval with objective criteria
- Interval
- Ordinal
- None

**Dollar Basis**

- Historical
- Domain Experts
- Conceptual

## Structure

**Organization**

- Coverage & Partition
  - Cost Estimating
  - Schedule / Technical
  - Requirements
  - Threat
- Assigning Cost to Risk
  - CERs
  - Direct Assessment of Distribution Parameters
  - Factors
  - Rates
- Below-the-Line
  - Yes
  - No

**Probability Model**

- Distribution
  - Normal
  - Log Normal
  - Triangular
  - Beta
  - Other (e.g., Bernoulli)
- Correlation
  - Functional
  - Injected historical
  - Relational
  - Injected nominal
  - None

## Execution

**Compu-tation**

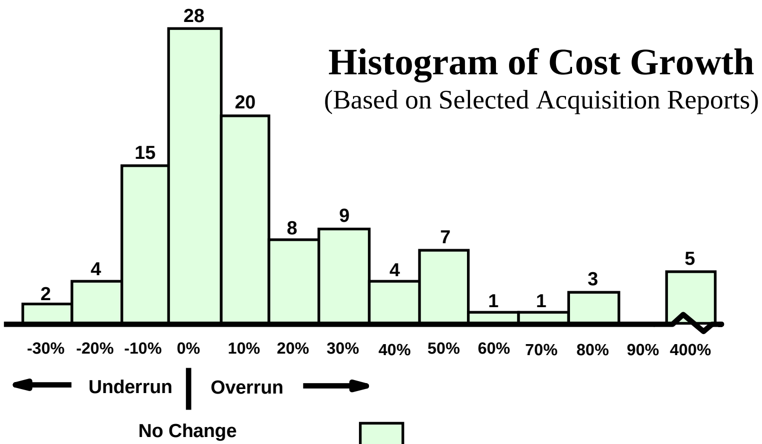
- Monte Carlo
- Method of Moments
- Deterministic

**Cross Checks**

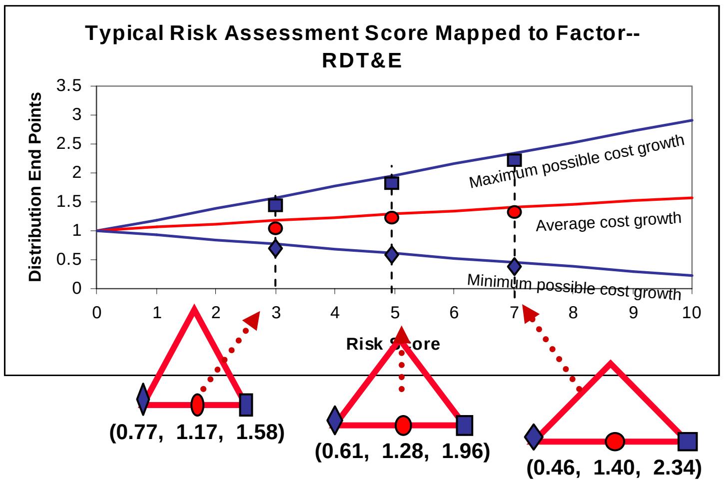
- Means
- CVs
- Inputs

# Assigning Cost to Risk

- **Risk CERs**: Equations are developed that reflect the relationship between an interval risk score and the cost impact of the risk (this might also be termed a Risk Estimating Relationship (RER))
  - These equations are equivalent to CERs in a cost estimate
  - Allows technical experts to provide technical risk scores
  - e.g., Risk Amount = 0.06 * Risk Score



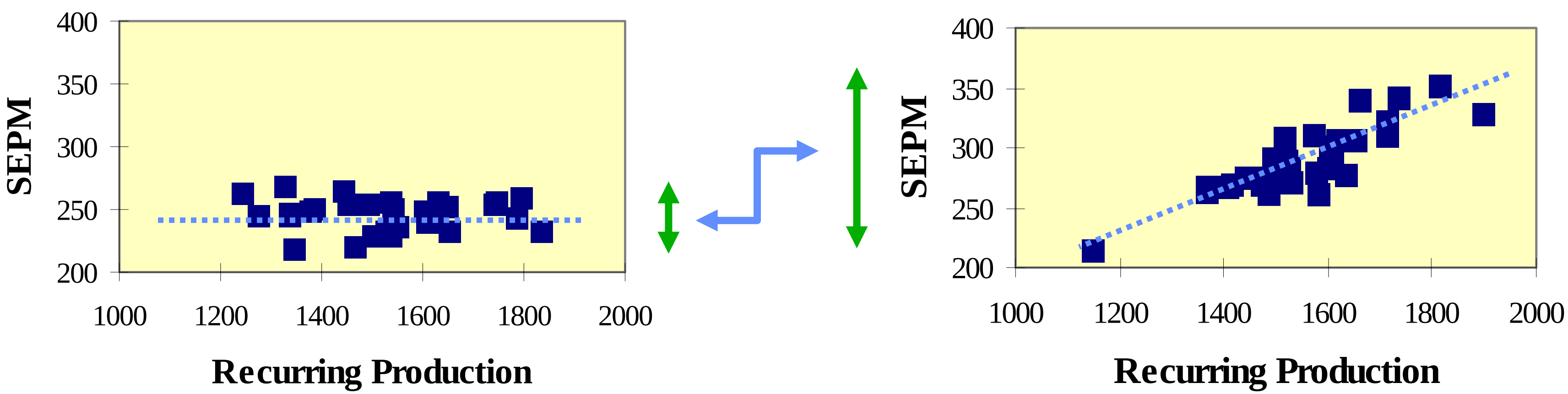

| Risk Categories | Risk Scores (0=Low, 5=Medium, 10=High) | | | | |
|---|---|---|---|---|---|
| | 0 | 1-2 | 3-5 | 6-8 | 9-10 |
| 1 Technology Advancement | Completed (State of the Art) | Minimum Advancement Required | Modest Advancement Required | Significant Advancement Required | New Technology |
| 2 Engineering Development | Completed (Fully Tested) | Prototype | HW/SW Development | Detailed Design | Concept Defined |
| 3 Reliability | Historically High for Same Item | Historically High on Similar Items | Known Modest Problems | Known Serious Problems | Unknown |
| 4 Producibility | Production & Yield Shown on Same Item | Production & Yield Shown on Similar Items | Production & Yield Feasible | Production Feasible & Yield Problems | No Known Production Experience |
| 5 Alternate Item | Exists or Availability on Other Items Not Important | Exists or Availability of Other Items Somewhat Important | Potential Alternative Under Development | Potential Alternative in Design | Alternative Does Not Exist & is Required |
| 6 Schedule | Easily Achievable | Achievable | Somewhat Challenging | Challenging | Very Challenging |




"Nominal, ordinal, interval, and ratio typologies are misleading," P.F. Velleman and L. Wilkinson, The American Statistician, 1993, 47(1), 65-72

# Functional Correlation

- Old: No Functional Correlation; Simulation run with WBS items entered as values
- New: Simulation run with functional dependencies entered as in the cost model




Not Correlated

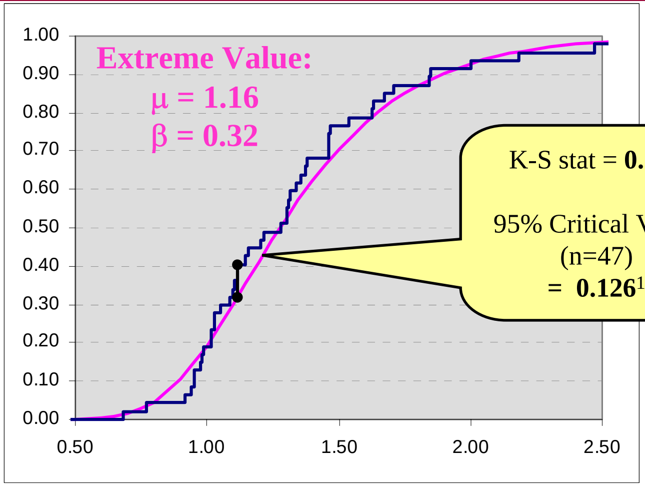
Correlated

"An Overview of Correlation and Functional Dependencies in Cost Risk and Uncertainty Analysis", R. L. Coleman and S. S. Gupta, DoDCAS, 1994

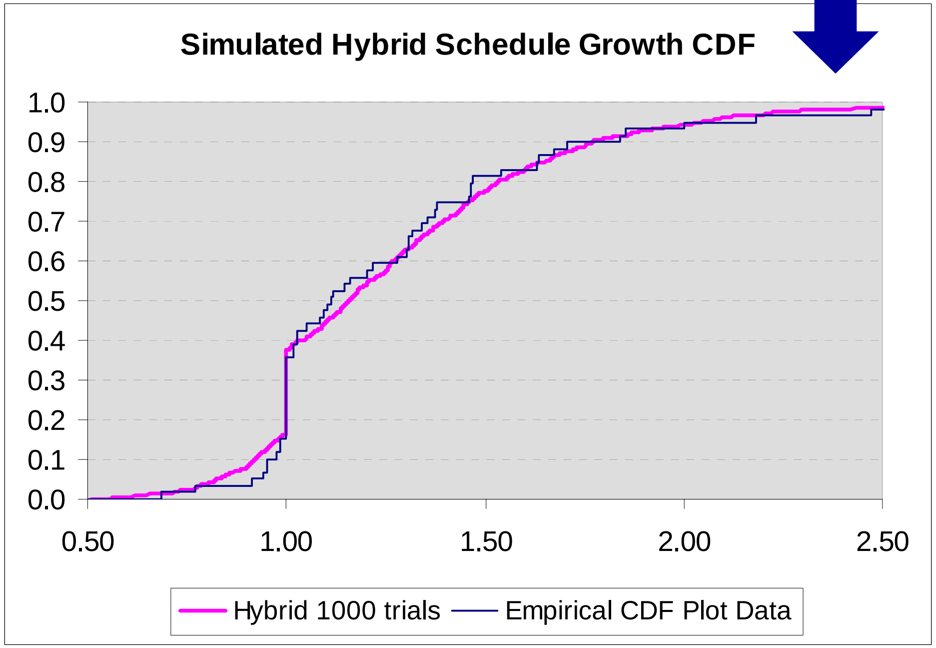
***Note shift of mean, and increased variability***

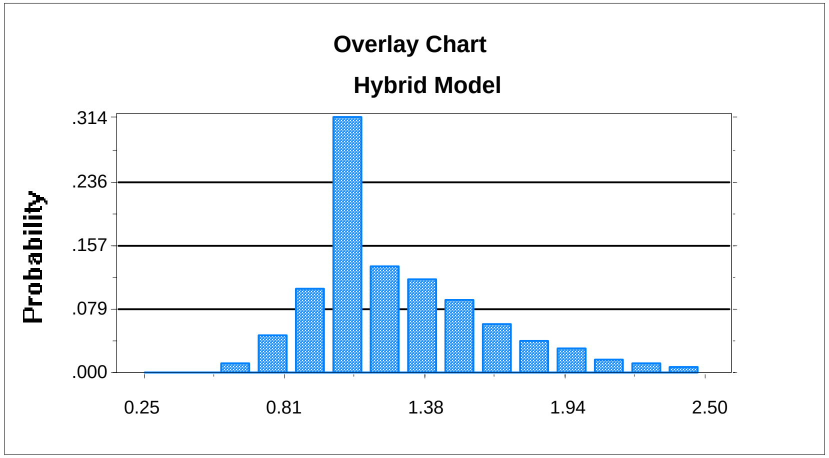
# Schedule Growth Distribution

- Extreme Value fit to data without 1.0s:
- K-S stat is less than the critical value.
- Extreme Value is a good representation of this data.




Results of simulation combining this distribution with a discrete 20.3% probability of a 1.0




[1] Lilliefors methodology applied to Extreme Value distribution to generate critical value with Monte Carlo simulation

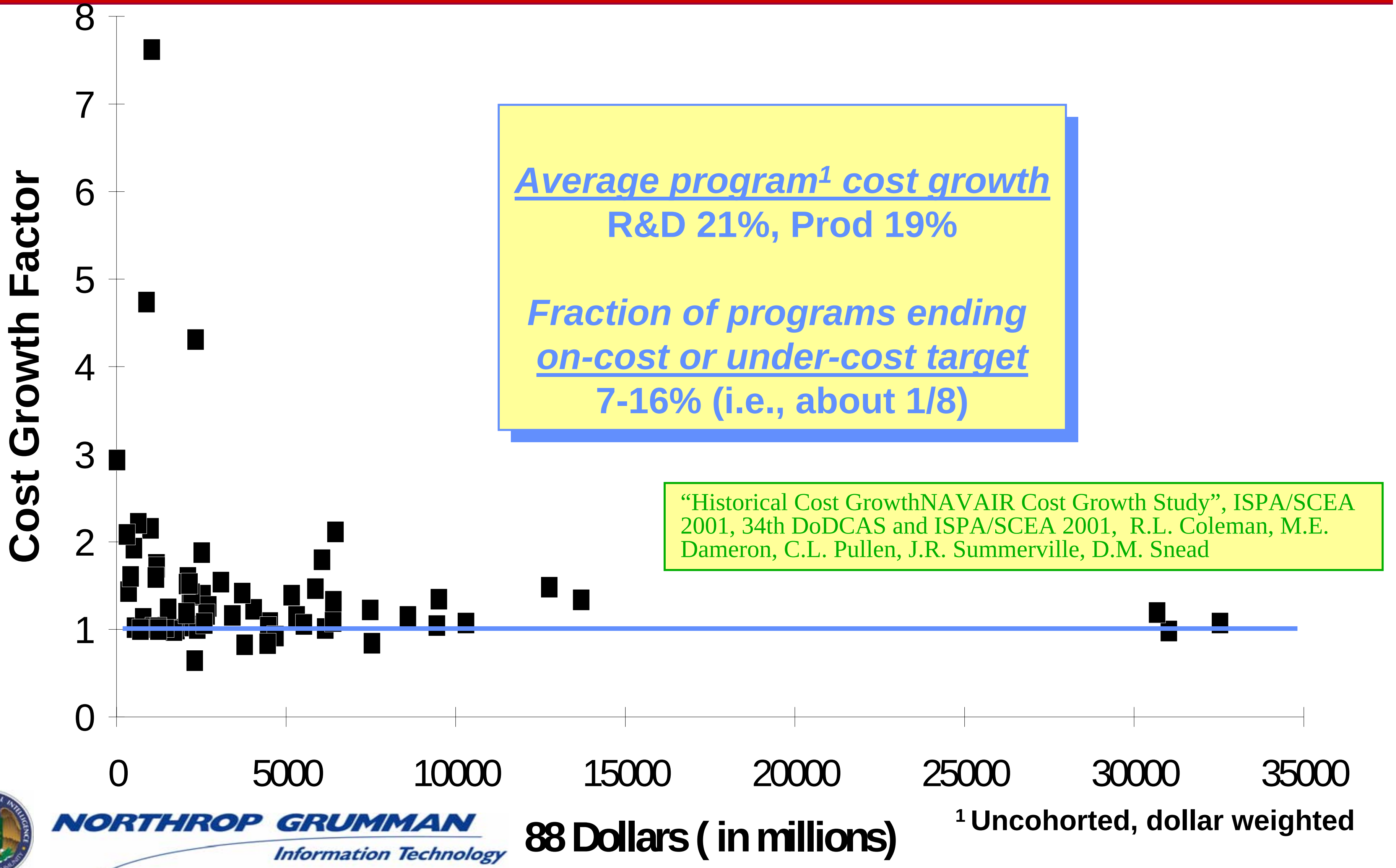
# Scope of the Estimate

Independence (increasing upward)

| Level | Goal | Scope of Risk |
|---|---|---|
| Congress / Executive Branch | Minimize Budget Perturbations (CARD + History) | - Programmatic<br>- Requirements<br>- Schedule |
| DoD / IC (CAIG) | | |
| ······ Line of Budgetary Control ······ | | |
| Service / Agency | Minimize reprogramming requests | - Technical<br>- Cost Est |
| PEO / Directorate | | |
| Program Office | Sell the Program (CARD) | - Contracts |
| Contractor | Win the Proposal (A-spec, SOO / SOR) | |

# Backup

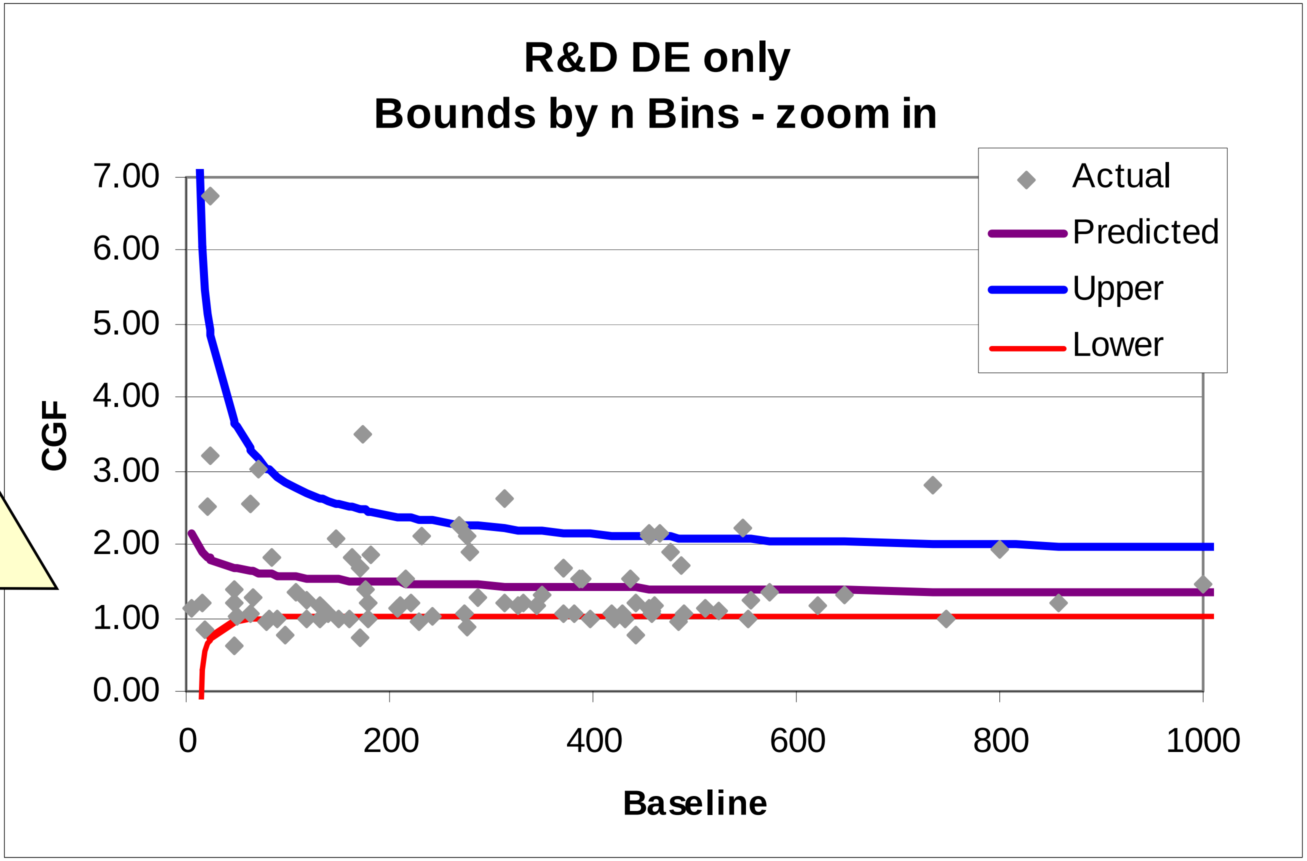
# NAVAIR Cost Growth




[1] Uncohorted, dollar weighted

# Dispersion – Bounds

Note that the upper and lower bounds are not symmetric. Also, dispersion is higher for smaller projects … an effect that is captured by the bounds.




"Modeling the Effect of Program Size on Cost Growth", Megan E. Dameron, Richard L. Coleman, Jessica R. Summerville, Cari L. Pullen, TASC, Inc., Donna M. Snead, NAVAIR 4.2, SCEA 2002

# Assessment Approach

**Schedule / Technical Risk**

- Develop a cost estimating risk distribution for each CWBS element
- Develop a schedule/technical risk distribution for each WBS entry for:
  - Hardware
  - Software
  - Note that "below-the-line" WBS elements get risk from "above-the-line" WBS elements via Functional Correlation
- Combine these risk distributions and the point estimate using a Monte Carlo simulation

**Cost Estimating Risk**

- Consists of a standard deviation and a bias associated with the costing methodologies
  - Standard deviation comes from the CERs and factors
  - Bias is a correction for underestimating