The IC CAIG Risk Methodology

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Selected slides taken from:
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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

### Scoring
- Interval with objective criteria
- Interval
- Ordinal
- None

### 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

### Inputs
- Dollar Basis
  - Historical
  - Domain Experts
  - Conceptual

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

### Computation
- Monte Carlo
- Method of Moments
- Deterministic

### Execution
- 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

<table>
<thead>
<tr>
<th>Risk Categories</th>
<th>Risk Scores (0=Low, 5=Medium, 10=High)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Technology Advancement</td>
<td>0</td>
</tr>
<tr>
<td>2 Engineering Development</td>
<td>Completed (State of the Art)</td>
</tr>
<tr>
<td>3 Reliability</td>
<td>Historically High for Same Item</td>
</tr>
<tr>
<td>4 Productivity</td>
<td>Production &amp; Yield Shown on Same Item</td>
</tr>
<tr>
<td>5 Alternate Item</td>
<td>Exists or Availability on Other Items Not Important</td>
</tr>
<tr>
<td>6 Schedule</td>
<td>Easily Achievable</td>
</tr>
</tbody>
</table>

Histogram of Cost Growth
(Based on Selected Acquisition Reports)

Typical Risk Assessment Score Mapped to Factor--
RDT&E

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


Note shift of mean, and increased variability
<ul>
  <li>Extreme Value fit to data without 1.0s:</li>
  <li>K-S stat is less than the critical value.</li>
  <li>Extreme Value is a good representation of this data.</li>
</ul>

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

K-S stat = 0.087
95% Critical Value (n=47) = 0.126

Extreme Value:
\[ \mu = 1.16 \]
\[ \beta = 0.32 \]

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

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1 Lilliefors methodology applied to Extreme Value distribution to generate critical value with Monte Carlo simulation
Scope of the Estimate

**Goal**

Minimize Budget Perturbations (CARD + History)

Minimize reprogramming requests

Sell the Program (CARD)

Win the Proposal (A-spec, SOO / SOR)

**Scope of Risk**

- Programmatic
- Requirements
- Schedule
- Technical
- Cost Est
- Contracts

**Independence**

- Congress / Executive Branch
- DoD / IC (CAIG)
- Service / Agency
- PEO / Directorate
- Program Office
- Contractor

Line of Budgetary Control
Backup
NAVAIR Cost Growth

Average program cost growth
R&D 21%, Prod 19%

Fraction of programs ending on-cost or under-cost target
7-16% (i.e., about 1/8)


1 Uncohorted, dollar weighted
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.

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