A Better Way to Assess Benefits, Costs, and Risks in a Product Support Business Case Analysis

Frank Camm, John Matsumura, Lauren A. Mayer, and Kyle Siler-Evans

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Traditional DoD Approach to BCA

• With stakeholders, down-select courses of action (COAs).
• Assess net present value (NPV) of each COA if successful.
• Assess benefits of each COA if successful.
• Assess likelihood and magnitude of various problems associated with risk for each COA.
• Use a common scale to assess NPV, benefits, risk; weight each factor; calculate the utility of each COA.
• Recommend the COA with the highest utility score.

RAND’s Proposed Approach

• With stakeholders, down-select to 4 F-22 air vehicle COAs, 4 engine COAs: Baseline, Air Force, contractor, RAND

• Assess NPV of successful COAs relative to baseline.

• Assess benefits of successful COAs relative to baseline.

• Assess sources of risk; translate into probability of success over time for each COA.

• Use Monte Carlo model to generate probability density for
  – NPV of each COA relative to baseline, adjusted for risk
  – Difference in NPVs, adjusted for risk, for each pair of COAs

• Present these findings to senior leaders; leave the final choice of COA to them.
Cost Analysis Mainly Adjusts Standard Methods

• Treats each COA as a standard project with cash flows for 2018-33.

• Assesses the costs of efforts to mitigate risks to ensure success against primary goal: health of the fleet

• Costs changes in government and contractor labor, relative to baseline, without overhead rates
Formal Mental Models Approach Frames Risk Assessment

• Used broadly structured surveys, interviews with stakeholders to identify most important sources of risk

• Identified eight sources of risk to assess in depth
  – Hiring, training, retaining new government personnel.
  – Accessing technical data.
  – Accessing information technology, proprietary tools.
  – Accessing information software systems.
  – Designing, executing a new performance-based logistics (PBL) agreement.
  – Acquiring relevant knowledge about sustainment of 5th generation fighter.
  – Acquiring knowledge about and relationships with lower-tier vendors relevant to F-22.
  – Ensuring the adequacy of a general sustainment process comparable to that currently provided by contractors.

• Identified factors relevant to their relative importance.
Aggregation Function Quantifies Relationships Identified in Mental Models

• Function combines effects of
  – Importance of mitigating each risk to total COA success (parameter value for $r_i$)
  – How long it would take to mitigate each risk for each COA (probability distribution $p_i$)
  – Degree to which resolving one risk could mitigate other risks relevant to COA (parameter value for $s$)

• Generates probability of success by year $t$ for each run of a Monte Carlo model

• This function yields the behavior we sought: $p_T = \left[ \sum_{i=1}^{n} r_i p_i \right]^{(1 + \frac{1}{s})}$
  
  $r_i =$ relative importance of $i$th source of risk
  $p_i =$ probability of successful mitigation of $i$th risk
  $s =$ ability to substitute one mitigation for another
  $p_T =$ probability of total COA success
**Elicitation of Expert Judgment Uses Formal Methods to Limit Bias, Build Consensus**

- Three groups of experts—government, contractor, independent.
- Sent them in advance descriptions of COAs.
- Sent them in advance questionnaires to collect values we needed in aggregation function: $r_i, p_i, s$.
- Met each group as a panel and walked through the questionnaire together, probing for the basis for their answers.
- Finalized each panel’s input values with each panel.
Monte Carlo Analysis Applies Expert Judgment in Thousands of Potential Futures

• For each group and COA
  – Use aggregation function to generate 1000 dates of successful implementation
  – For each date, calculate annual cash flows
  – For each date, apply OMB discount rate to determine NPV

• Result for each group and COA: A distribution function for NPV like that at the right.
Sample Output: Risk-Adjusted Cost Savings for Air Vehicle COAs

COA 1

COA 2

COA 3

Lifetime NPV (Million 2015$)

Air Force | LM/Boeing | Independent

COA 1

COA 2

COA 3

50% confidence interval from 25th to 75th percentile

× Mean NPV

Median NPV

Better approach to product support BCAs - 9 - Mar 2018
Reactions to RAND Approach

• Senior F-22 leadership
  – Prefers it to the traditional approach.
  – Monetization of risk clarifies importance of high uncertainty.
  – Results strongly shaped Air Force choice among COAs.

• Cost analytic community
  – Cautious about a new risk analytic paradigm.
  – Not what they understand how to do today.
  – Appears to rely too much on subjective judgment.

• RAND analysts
  – Collection, application of subjective judgment more transparent.
  – Instability in definition of COAs made approach challenging.
  – The approach opens useful doors: We have more to learn.
A copy of the full report is available on-line. Contact me at camm@rand.org for the URL.
Back-Up Charts
Policy Context: RAND Supported the 2015 F-22/F119 Sustainment BCA

• First F-22/F119 Sustainment BCA occurred in 2010.
• It recommended transition of several air vehicle sustainment management functions to organic responsibility.
• SECAF later deferred transition of supply chain management and directed re-examination in 3-5 years.
• 2015 BCA focused on potential changes in supply chain management.
• RAND provided analysis support to the Air Force, which actually conducted the BCA
• This briefing describes the methodology RAND developed for its support of the 2015 BCA
Ground Rules and Assumptions for the 2015 F-22/F119 Sustainment BCA*

- Include stakeholders in entire assessment process.
- Work with stakeholders to select COAs for air vehicle, engine
- Focus analysis on fiscal years 2018 through 2033.
- Compare COAs on following terms
  - Life-cycle costs of operational readiness
  - Risks to the fleet from transition to and on-going operation of each COA
  - Mitigation of risks to ensure no harm to the fleet relative to aircraft availability and total not mission capable–supply (TNMCS) in CY13
- Anticipate another BCA in 2020.

*As Agreed to at 24 Jul 14 RSSG
SMEs Associated These Risk Drivers with Transferring ASIP Responsibilities to the USAF

Ability to transfer function

- Ability to acquire tech data packages
- Ability to generate future tech data
- Institutional knowledge for 5th gen
- Need to hire and train skilled staff

- Access to current tech data
- Access to appropriate tools (IP)
- Ability to sustain personnel dev. process
- Changes caused by LO

- Ability to “surge” to unexpected problems

• Air Force F-22 personnel identified risk drivers in solid ovals.
• Lockheed personnel added drivers in dashed ovals.
• We will elicit detail on risks primarily associated with ovals in center column
Aggregation Function Assesses Probability of COA Implementation by Year

We adapted an aggregation function from economic production theory with the attributes we sought:

\[ p_T = \left( \sum_{i=1}^{n} r_i p_i \right)^{(1 + \frac{1}{s})} \]

- \( p_T \) = Probability of implementing COA-function pair
- \( p_i \) = Probability of mitigating ith risk driver
- \( r_i \) = Importance of ith risk driver
- \( s \) = Degree of substitutability

Economic production analysis suggests \( s = 0.5 \) to 0.7 for risk tradeoffs within a bureaucracy
We Combine Data to Construct Many Potential Alternative Futures for Each COA

- Monte Carlo uses risk assessment to generate many alternative futures for each COA-function pair.
- These provide the basis for a subjective probability distribution for each COA-function pair.
<table>
<thead>
<tr>
<th>Risk Driver</th>
<th>Relevant?</th>
<th>If relevant, is it partially substitutable?</th>
<th>If partially substitutable, Rank</th>
<th>Likelihood of Never Reaching Sufficiency</th>
<th>Likelihood of Reaching Sufficiency in...</th>
<th>SUM of likelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attract and retain personnel</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td>2</td>
<td>50%</td>
<td>Less than 2 years: 50%, 2-5 years: 0%, Greater than 5 years: 0%</td>
<td>100%</td>
</tr>
<tr>
<td>Access technical data</td>
<td>☐ Yes, ☑ No</td>
<td>☑ Yes, ☐ No</td>
<td></td>
<td>10%</td>
<td>30%, 30%, 30%</td>
<td>100%</td>
</tr>
<tr>
<td>Access to IT and proprietary tools</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td></td>
<td>0%</td>
<td>50%, 50%, 0%</td>
<td>100%</td>
</tr>
<tr>
<td>Access to IS systems</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td>2</td>
<td>10%</td>
<td>10%, 50%, 30%</td>
<td>100%</td>
</tr>
<tr>
<td>Develop/ Institute new contracting vehicle</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td>3</td>
<td>25%</td>
<td>50%, 25%, 0%</td>
<td>100%</td>
</tr>
<tr>
<td>Management of institutional knowledge</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td>1</td>
<td>10%</td>
<td>10%, 50%, 30%</td>
<td>100%</td>
</tr>
<tr>
<td>Knowledge of/ relationship with the vendor base</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td></td>
<td>10%</td>
<td>10%, 50%, 30%</td>
<td>100%</td>
</tr>
<tr>
<td>Adequacy of comparable sustainment processes</td>
<td>☑ Yes</td>
<td>☑ Yes, ☐ No</td>
<td></td>
<td>10%</td>
<td>10%, 50%, 30%</td>
<td>100%</td>
</tr>
</tbody>
</table>
This figure shows the effect of removing each risk driver identified by subject matter experts on the estimated cost savings.

- Removing “contracting” as a risk driver increases the expected cost savings of COA 2.
- Results were the same for industry and government experts.