Capability Acquisition Management in Support of SoS

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Systems of Systems Engineering Collaborators Information Exchange (SoSECCIE)
Agenda

▼ History of Milestones
  ▪ FY 2011
  ▪ FY 2012
  ▪ FY 2013

▼ Task Overviews

▼ Way forward
Timeline of the Capability Acquisition Management Team

- Created I&I entrance and exit criteria for SETRs
- Developed process for considering I&I as the threat changes
- Defined a process to assess how well I&I has been institutionalized
- Defined a process to assess system OE as a function of the cost to improve Mission OE---(CAIV)
- Developed process to assess risk of achieving Mission OE within budget

CNO tasked OPNAV and ASN-RDA to establish an Integration and Interoperability (I&I) chartered effort
DASN (RDT&E) established CAM team
Created I&I criteria for ITR, ASR, CDR, TRR, Gates 1, 2, 4, 5
Created I&I criteria for SRR, SFR, PDR, and Gates 3 & 6
FY 13 CAM Tasking Context

Materiel Solution Analysis

- I&I Integrated Capability Framework
- Naval SoS SE Guidebook

Develop Mission I&I Criteria

Technology Development, Engineering and Manufacturing Development

- FY11 and FY12 I&I SETR Criteria and Gate Review Templates
- FY13 CAM Task 1: Develop I&I SETR entrance and exit criteria
- FY13 CAM Task 4: I&I policy and standards derived from the CJCSI
- FY13 CAM Task 6: I&I Institutionalization Assessment

Operations and Support

- FY 13 CAM Task 2: Threat Assessment
- FY 13 CAM Task 3 (CAIV): Identify New or Updated Capability
- Recommended Alternative
- FY 13 CAM Task 5: Risk of achieving OE within budget
2011 and 2012 Mission I&I SETR Event Tier Development

▼ Incorporated I&I criteria within the SETR process.

- List of criteria statements for Initial Technical Review (ITR) SETR event
  - Tier 1: SETR Event
  - Tier 2: I&I SETR Category Title
  - Tier 3: I&I SETR Subcategory
  - Tier 4: I&I SETR Evaluation Criteria – I&I Principle Criteria
  - Tier 5: I&I SETR Detailed Criteria – Designed to help a less experienced SE to evaluate the Tier 4 criteria (starting at SRR)

▼ Within this structure, numbers are used to identify the categories and criteria. Tiers 1, 2, and 3 are categories and Tiers 4 and 5 are the actual I&I evaluation criteria.

▼ During the development of the criteria, the documents that require review were identified to support the questions within the SETR end-to-end process.
CAM TASK 1

DEVELOP I&I ENTRANCE AND EXIT CRITERIA FOR THE SETR PROCESS.
The scope of this task incorporates entry and exit criteria of the SETR process to tier two of the “I&I SETR Category Title” for SETR events.

Update sections of the Naval SETR Handbook to embed I&I entrance and exit criteria into the SETR process.

- Analyze and determine the Integration and Interoperability (I&I) SETR entry and exit criteria, leading to the traceability and evaluation of the Systems of Systems throughout the life cycle.
  - Developed entry/exit criteria that is associated to the I&I SETR questions
  - Incorporate the I&I entry/exit criteria into the SYSCOM instructions

Correlate the I&I exit criteria to the GATE REVIEW I&I criteria

- The results from the SETR Exit criteria will provide evidence to support the Gate review
CAM TASK 2

IDENTIFY APPROPRIATE POINT(S) IN THE ACQUISITION LIFE-CYCLE FOR THE ASSESSMENT OF I&I REQUIREMENTS AGAINST CHANGING THREATS
Assessing Impact on I&I When The Threat Changes Near TRR

- If the threat has evolved since the PDR & CDR:
  - Request new Capability Based Assessment and Mission Level Threat Analysis
  - Revisit the CDD and CPD and the Test and Evaluation Master Plan (TEMP) updated after the PDR
  - Verify whether any impact due to a threat change calls for mission level test changes prior to proceeding with the Production and Deployment Phase
  - If proceeding under risk, the Test phase provides the opportunity to assess the system against the new or evolved threat and will help to define new system requirements for future improvement
  - Ensure that any acquisition strategy changes are made before engineering and manufacturing development or production contracts are awarded (changing directions can be very costly)

![Flowchart Diagram]

- TRR
- MLTA still valid?
- Identify as risk. Make risk chart
- Risk Level?
- ML test reqmts consistent w/ MLTA?
- MLTA still valid?
- Make recommendations
- Proceed
- Rethink strategy. Proceed
- Rethink strategy. Stop
- Stop. Rethink strategy.
1. **Single System** - Calculating the measure of operational effectiveness (MOE’s) for a single weapon system can usually be accomplished as shown below, and provides a program manager with much needed information. The advantage of this approach is that the program manager can deliver a limited capability to the warfighter on schedule, and full capability to the warfighter at a later date.

<table>
<thead>
<tr>
<th>Original design vs original threat</th>
<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_k \text{(OD,OT)} \times R_w = P_{ssk} \text{(OD, OT)}$</td>
<td>$0M$</td>
<td>$0$ mos</td>
</tr>
<tr>
<td>ex: $0.90 \times 0.95 = 0.86$</td>
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</table>

<table>
<thead>
<tr>
<th>Original design vs evolved threat</th>
<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_k \text{(OD,ET)} \times R_w = P_{ssk} \text{(OD,ET)}$</td>
<td>$0M$</td>
<td>$0$ mos</td>
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<tr>
<td>ex: $0.60 \times 0.95 = 0.57$</td>
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<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
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</thead>
<tbody>
<tr>
<td>$P_k \text{(ID,ET)} \times R_w = P_{ssk} \text{(ID,ET)}$</td>
<td>$300K$ $2.5M$</td>
<td>$3$ mos (software) $20$ mos (redesign)</td>
</tr>
</tbody>
</table>
Assessing Impact of the Evolved Threat on MOE

2. System of Systems - When System of Systems (SoS) interoperability or system performance at the mission level information is required, the approach is the same; however, the calculation of kill probability ($P_k$) becomes more complicated because the effectiveness of the interactions between the systems must be considered. The example below assumes that the system under development is not the only one capable of killing the target; others may also contribute to the mission success.

<table>
<thead>
<tr>
<th>The SoS w/original design vs original threat</th>
<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_k (\text{SoSOD,OT}) \times R_w = P_{ssk} (\text{SoSOD, OT})$</td>
<td>$0M$</td>
<td>0 mos</td>
</tr>
<tr>
<td>ex: $0.92 \times 0.97 = 0.89$</td>
<td></td>
<td></td>
</tr>
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</table>

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<tr>
<th>The SoS w/original design vs evolved threat</th>
<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
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</thead>
<tbody>
<tr>
<td>$P_k (\text{SoSOD,ET}) \times R_w = P_{ssk} (\text{SoSOD,ET})$</td>
<td>$0M$</td>
<td>0 mos</td>
</tr>
<tr>
<td>ex: $0.90 \times 0.97 = 0.87$</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>An improved design vs the evolved threat</th>
<th>Est Cost Delta</th>
<th>Est Sched Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_k (\text{SoSID,ET}) \times R_w = P_{ssk} (\text{SoSID,ET})$</td>
<td>$10M$</td>
<td>20 mos</td>
</tr>
<tr>
<td>ex: $0.94 \times 0.97 = 0.91$</td>
<td></td>
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</table>
CAM TASK 3

DEFINE SYSTEM METRICS TO IMPROVE SYSTEM OPERATIONAL EFFECTIVENESS AS A FUNCTION OF THE COST OF THE IMPROVEMENT TO MISSION OPERATIONAL EFFECTIVENESS
Mission execution is based on increasingly complex Mission and Platform Systems of Systems (SoSs) and with capabilities distributed across and within platforms

Increasing emphasis on cost control
- The Navy needs to be smart buyer in selection of capabilities

Current practice is limited to system functional and performance based trade-space analysis
- Does not address Platform or Mission System of Systems (SoSs) impacts on mission effectiveness
- Does not address cross-platform impacts of changes, including Configuration Control across ship class

Mission Capabilities are defined in accordance with the Integrated Capability Framework (ICF), Navy Task List and the Mission Level Assessment and Evaluation data base for mission and high level activity task metrics
- System function metrics are derived by system development PMOs
FY 13 CAM TASK 3 Overview

▼ Scope:
  ▪ The process transits from Mission capabilities to Mission and Platform SoS allocations to System functional allocations
  ▪ Limited to KPPs and KSAs and supporting MOEs and MOPs

▼ Metrics
  ▪ Mission and high level activity tasks sourced from Mission Level Assessment and Evaluation (MLA&E) data base
  ▪ Supporting functional metrics are derived by system development PMOs

▼ Timing: A mission solution AoA is required when a new or evolved threat is identified; as documented in CAM FY13 Task 2
  ▪ Trade-space objectives:
    − Does a specific system update improve mission success sufficiently to warrant acquisition and life cycle cost?
    − Does adding a platform SoS capability improve mission success sufficiently to warrant acquisition and life cycle cost?
    − Which ship class improvements or new ship class should the Navy invest in to address a new threat?

▼ CAIV used to explore alternative trade space and identify required metrics
  ▪ Appropriate architectures for CAIV are aligned with the Integrated Capability Framework (ICF)
  ▪ Alternative performance and cost estimates made as a bottoms up from the MOE hierarchy
  ▪ Best “bang for the buck” recommended.
Mission Focused AoA Process

**Process**

1. State the problem in terms of mission impact
2. Identify quantified hierarchical criteria to support mission
3. Establish Performance & OE Weights
4. Develop Alternatives to implement criteria
5. Estimate and score Alternative Performance
6. Perform CAIV analysis
7. Solution found?
   - Yes (Y)
   - No (N)

**Supporting Processes**

1. **Integrated Capability Framework (ICF):** provides design trade space and performance analysis framework
2. **Analytical Hierarchy Process (AHP):** framework to decompose Mission needs to system functional alternative implementations, and determine performance weights
3. **Kepner-Tregoe Analysis (KTA):** evaluates OE and costs of alternative(s)
4. **NAVSEAs 2005 Cost Estimating Handbook:** Cost as an Independent Variable (CAIV): Evaluates alternative(s) Performance vs life cycle Cost

**Integrated Capability Framework (ICF):**
- Provides design trade space and performance analysis framework

**Analytical Hierarchy Process (AHP):**
- Decomposes Mission needs to system functional alternative implementations
- Determines performance weights

**Kepner-Tregoe Analysis (KTA):**
- Evaluates OE and costs of alternative(s)

**NAVSEAs 2005 Cost Estimating Handbook:**
- CAIV: Evaluates alternative(s) Performance vs life cycle Cost

**Modified Kepner Tregoe (KTA) Analysis**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Weight</th>
<th>Performance Score</th>
<th>Performance Score</th>
<th>Total Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X.1 MOE or MOP</td>
<td>Raw Perf</td>
<td>X.1, At least</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X.n MOE or MOP</td>
<td>Raw Perf</td>
<td>X.n, At least</td>
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<tr>
<td>X, X +1 MOE or MOP</td>
<td>Raw Perf</td>
<td>X, X +1, At least</td>
<td></td>
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<td></td>
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**CAIV with Thresholds and Objectives**
- Acceptable Alternatives
- Total Ownership Cost (M)
- Cost to achieve implement Sub Criterian

**Supporting Processes**

- Objective (Statement of purpose)
- Criteria 1.0 (MoM)
- Criteria 1.1 (MoM)
- Criteria 1.2 (MoM)
- Criteria 1.3 (MoM)

**Selected Alternatives**
- Alternative 1
- Alternative A
- Alternative B

**Performance vs life cycle Cost**
- Cost alternative(s) Evaluation
- Alternative 1 Description
- Alternative A Description
- Alternative B Description
1. State the problem and broaden the objectives of the problem or consider all factors, objectives and its outcomes

2. Identify the criteria that influence the behavior. Then, structure the problem in a hierarchy of different levels of influence constituting goal, criteria, sub-criteria, etc.

3. At the bottom of this behavior hierarchy, the alternatives under consideration are listed, with each alternative feeding the behavior hierarchy.

4. Establish importance weights between objective and criteria, criteria and sub-criteria, etc.

**Hierarchical Evaluation Network Rules**

1) Evaluation flow is bottoms up. Elements in each level in the hierarchy feeds elements the next level above.

2) Each element in the network is connected to at least one element in the level above.

3) $W_B,A = \text{performance weight for element } B \text{ in support of element } A$
   - If there is no dependence of an upper level element on a next lower element, this is shown by weight = zero.
   - non-zero weights should sum to 1: \[ \sum_{y=1}^{B} (W_{By} \neq 0) = 1 \]

4) $S_B,A = \text{Score of element } B \text{ in support of element } A$
   - % of ability, based on performance thresholds and objective
   - Relative % of ability, normalized range to highest to lowest scoring element in hierarchical layer

\[ P_{A1} = \sum_{y=1}^{B} (W_{By,A1} \ast S_{By,A1}) \]

To avoid bias in process, care must be given to determine importance weights, thresholds, and objectives as objectively as possible, prior to scoring.
IMPLEMENTING CAIV: ESTABLISH RELATIVE IMPORTANCE
WEIGHTS
Establishing weights is a top-down process

- Start with the trade off objective and evaluate the relative contribution of each of the element’s criteria from the next level down.
  - Identify stakeholders for each hierarchical level interface
  - Survey technical stakeholders (SMEs) to establish relative mission importance of for each element of a layer to each element of the next higher level
    - Technical Performance
    - Supportability Reliability, Program Protection, Safety, etc.
  - Solicit input for relative importance of how the objective is supported by the underlying criteria.
- Repeat for each criteria level, working down fundamental key measures

Best to establish weights prior to scoring system

- Avoids “gaming the system”
- Provides results that are less influenced by unintentional bias
Process: Establish initial relative weights (Quick Comparison)

1. Provide an evaluation form to each stake holder selected to weigh N criteria
   a. Put each criteria \( C_{i,B_{y,A}} \) into an evaluation matrix with a criterion chosen (base-line criteria) to compare other criteria to
   b. Have the evaluator identify the relative importance of each criteria to the base-line criteria
      - Make sure provide meaning for scale
      - To the left of “1”: base-line is \( M \) times more important than comparison (comparison is \( 1/M \) times the importance of base-line)
      - “1” is equal importance between the two
      - To the right of “1”: comparison is \( M \) times more important than base-line (base-line is \( 1/M \) times the importance of comparison)

2. Average the column responses for each respondent

3. For each row, average the importance results for each comparison pair to provide the first pass weights \( W_{fi,B_{y,A}} \)

4. These are used to establish the final relative weights
CAIV With Set Thresholds, Objectives, and Cost Limit

Alternative Bang for the Buck (Scoring Re: Threshold & Objectives)

- **Acceptable Alternatives**
- **Recommended Alternative**
- **Over Cost Alternatives**
- **Under Performing Alternatives**

Performance Threshold

Alternative Score

Alternative Cost ($M)
CA IV Cost and Performance Hierarchical Flows

- **Requirements Cognizance**
- **Requirements Flexibility**

**Criteria 1.0**
- Platform Operational Effectiveness
  - Platforms, DOTLPF

**Criteria 1.1.X**
- System Capability Effectiveness
  - Platforms, DOTLPF

**Criteria 1.1.1.X**
- Task Effectiveness
  - Platforms

**Cost to Execute Mission portfolio**
- Cost to Execute Single mission
  - Cost of Platform(s) to provide capabilities through task execution
    - Cost of System(s) to execute functions
      - Cost to implement DOTLPF

**Cost of Manpower**

**Criteria Allocation**
CAM TASK 5

DEVELOP A PROCESS TO ALLOW THE NAVAL ENVIRONMENT TO ASSESS THE RISK OF ACHIEVING A BUDGETED OPERATIONAL CAPABILITY USING DATA THAT IS ALREADY BEING COLLECTED
Assess Risk of Achieving a Budgeted Operational Capability

Step 1

Perform LDUUV ISR Operations

Accomplish LDUUV ISR Pre-Mission Operations
Accomplish LDUUV ISR Mission Operations
Accomplish LDUUV ISR Post-Mission Operations
Accomplish LDUUV ISR Life Cycle Support

NTA 2.1  NTA 2.2  NTA 2.5  NTA 2.3  NTA 2.4  NTA 4.2  NTA 4.3

Step 2

NTA Metrics from MLA&E process

Step 3

Risk Summary matrices for the Viewpoint

SME assessment of Risk to achieve NTA metrics

Step 4

Program Cost Estimation

Financial Mapping to NTA Metrics to Capability
CAM TASK 6

DEVELOP METRICS AND PROCESSES FOR ASSESSING HOW WELL I&I HAS BEEN INSTITUTIONALIZED IN SETRS AND GATE REVIEWS, WITH THE DELIVERY OF THIS ASSESSMENT TO THE TECHNICAL AUTHORITY
Process Measures

I&I Metrics
Analysis Dashboards

- Using gate review process for data “Gathering”
  - Measure # of POR/Systems go through Gate Review total
  - Measure # of POR/Systems go through System SETR
  - Measure # of POR/Systems go through I&I evaluation at SETR
    - Assume if going through I&I SETR then went through System SETR
  - Measure Gate Review/DAB Decisions
    - Broken into 2 categories
      - Category A Decision = Approval to move forward with no actions required
      - Category B Decision = Anything that is NOT a Category A Decision

I&I Analysis Results will be displayed on the site with the use of built in site features such as SharePoint Dashboards, using Performance Point.
Developed a Survey Form

- By default, the survey is set-up to ask a number of key performance questions based on Entry/Exit criteria of events passing through Gate Review.

- Collect Survey Results: After the user completes the survey. The Surveys can then be accessed for historical archiving, and reporting.

- Analysis of Surveys Received: Once surveys have been received, the site provides several methods which can be used to analyze results.

- Business Performance Reporting: Survey results can be saved back to the Business Performance Reporting site to enable team members to view and collaborate on the analysis. (example of output on the right)
I&I Survey Site – Home Page

INTEGRATION AND INTEROPERABILITY IN SETR AND GATE REVIEW PROCESSES
Metrics, Analysis, and Trends

Introduction
The purpose of this site is to provide metrics and analysis for assessing how well Integration and Interoperability (I&I) has been institutionalized in SETRs and Gate Reviews. These metrics and analysis will be available to the appropriate Technical Authorities through this site.

We define institutionalized as meaning:
- How well I&I has been ingrained into the process (I&I has become part of business as usual).
- How effective is I&I in the process (I&I is making a difference [grading for goodness]).

This site will include metrics and analysis using the following techniques:
1. Collect Survey Data on program/projects/AAP, etc., that go through element I&I SETRs, and Gate Reviews. Analysis will be performed on:
   - Failure trends to determine if the system went through I&I SETR/Gate review;
   - Failure of systems that did not go through the SETR process; and
   - Analysis of differences between system failures and I&I.
2. Trend Analysis
   - Trends in fleet to complete the mission; and
   - Weighted question sets.

I&I Survey
Click on link below to launch the I&I Survey:

- I&I Survey Form

Important Links