Capability Acquisition Management in Support of SoS

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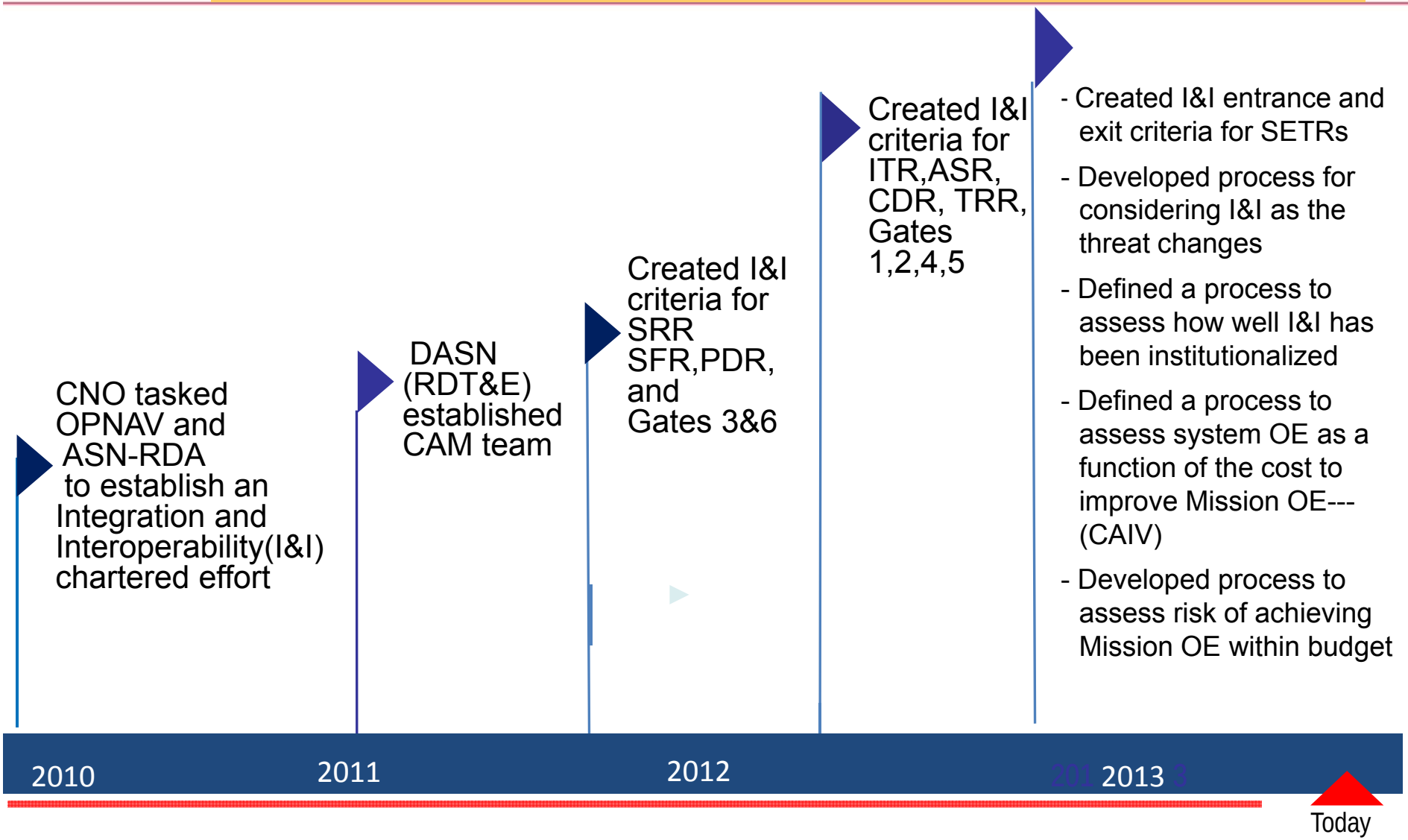
Systems of Systems Engineering Collaborators Information Exchange (SoSECIE)

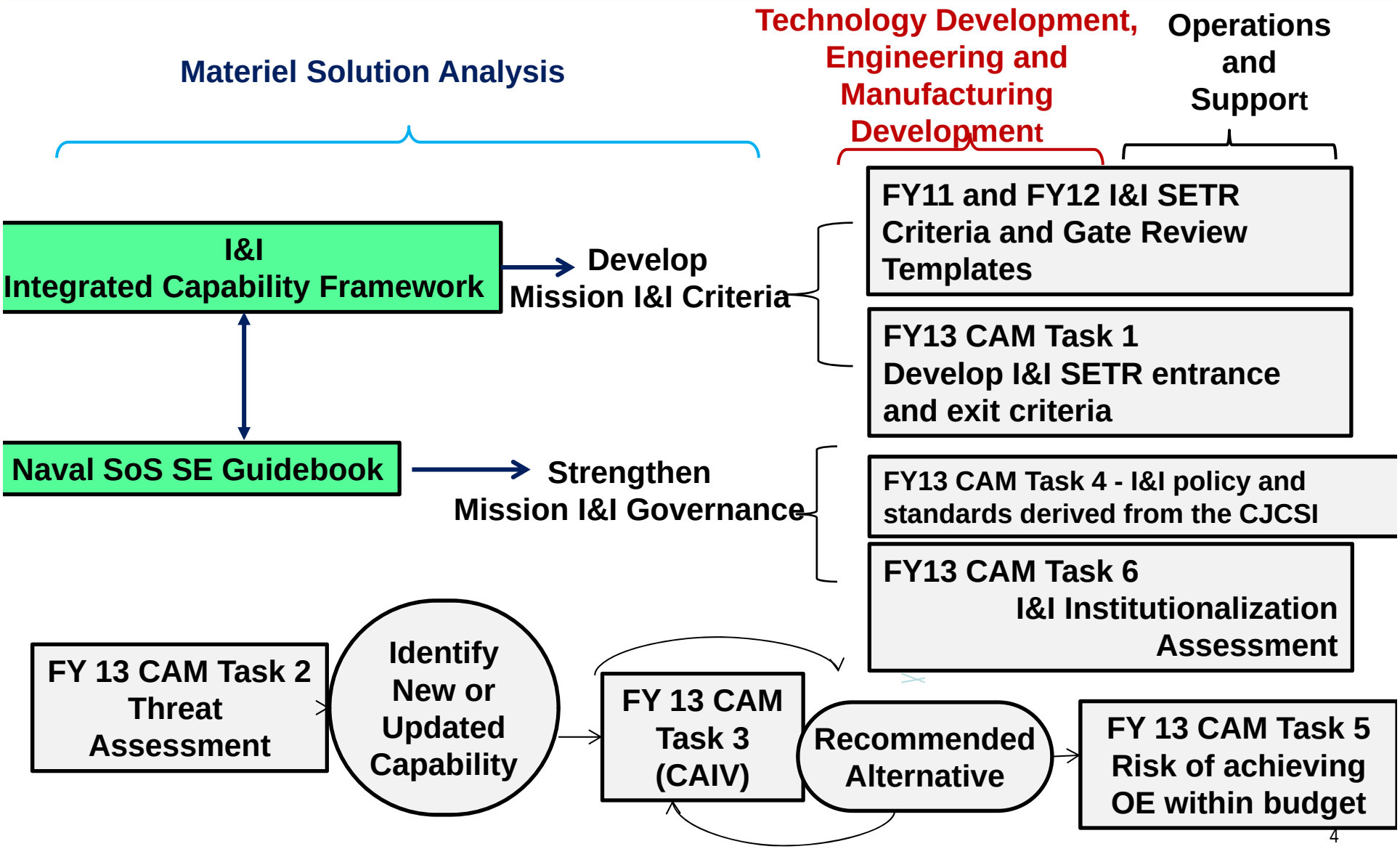
Agenda

- **History of Milestones**
  - FY 2011
  - FY 2012
  - FY 2013
- **Task Overviews**
- **Way forward**

Timeline of the Capability Acquisition Management Team



FY 13 CAM Tasking Context



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.

3.0 System Requirements Review (SRR)	
I&I Criteria Tier	Artifacts
3.1 Mission Engineering (ME)	
3.1.1 Capability Gap Analysis	
3.1.1.3 Have all mission level stakeholders been identified?	CONOPS, STAR, CDD, TDS, CARD
3.1.1.3.1 Have all mission areas, mission threads, and kill chains been identified?	
3.1.1.3.2 Have all the ROC/POE mission areas been identified?	
3.1.1.3.3 Have all the joint mission areas been identified?	
3.1.1.3.4 Have all the coalition mission areas been identified?	
3.1.1.4 Does the derived system requirement(s) fulfill the mission level capability gap(s)?	
3.1.1.4.1 Has a derived requirement(s) been identified for each gap assigned to the system?	

CAM TASK 1

DEVELOP I&I ENTRANCE AND EXIT CRITERIA FOR THE SETR PROCESS.

FY 13 I&I Entry and Exit Criteria/SETR/Gate Alignment

- **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**

ITR	Entry Criteria	Exit Criteria
Mission Engineering (ME)	Is the program capable of producing a STAR report.	The program has demonstrated that all mission capability gaps have been identified and addressed.
	Provide evidence that a mission level capability gap analysis has been performed.	Provide evidence that the funding has been initiated to support the mission level development, testing, validation and certifications of the SOS.
	Provide evidence that an assessment of the technical and cost risks of the proposed program has been conducted.	Does the program (S) have a clear perspective of all system Stakeholder roles at the mission level.
	Explain how impacts created by external systems have been documented in the ITR artifacts, including the AoA guidance, ICD, CONOPS, and DoDAF products.	Provide evidence that all of the systems needed to fulfill the mission gaps have been identified in the ITR artifacts, including AoA guidance, ICD, and draft DoDAF
Systems engineering (SE)	Has a draft copy of these artifacts been made available to commence the review; AoA, CONEMP, CARD, DODAF Views (at a minimum OV-1, OV-2, OV-3, OV-4, OV-5 & OV-6c), HSIP, IMP, IMS, MRD, TDS and final	What is the plan to develop and/or update the data input, output and interface functionality for the COTs/GOTs GFE mission level reference model to account for the selected system.
	Provide evidence the underlying Mission Area assumptions used in developing the CARD technically and programmatically sound, executable, and complete.	Provide evidence that the CARD captures the key program cost drivers, development costs (all aspects of hardware, human integration, and software), production costs, operation, mission, integration/interoperability and support costs. Demonstrate that the CARD identifies funding requirements to support
	Demonstrate that the AoA Study Plan includes key operational considerations that impact the proposed Program Interoperability Requirements. The analysis should include not only the system under consideration, but its impact on the broader SOS with which it will eventually operate. If new communication networks are proposed, demonstrate that the analysis precludes potential Strike Force Interoperability ambiguities, conflicts and race conditions	Describe how interoperability certification requirements have been accounted for in the program's POM input.
Test and Evaluation (TE)	Provide a list of the required systems that align to the NTA to meet the mission requirement.	
	Requirement Managers (OPNAV/MCPC) of all the systems in the mission architectures have been formally advised of the need to coordinate to support system development and test.	

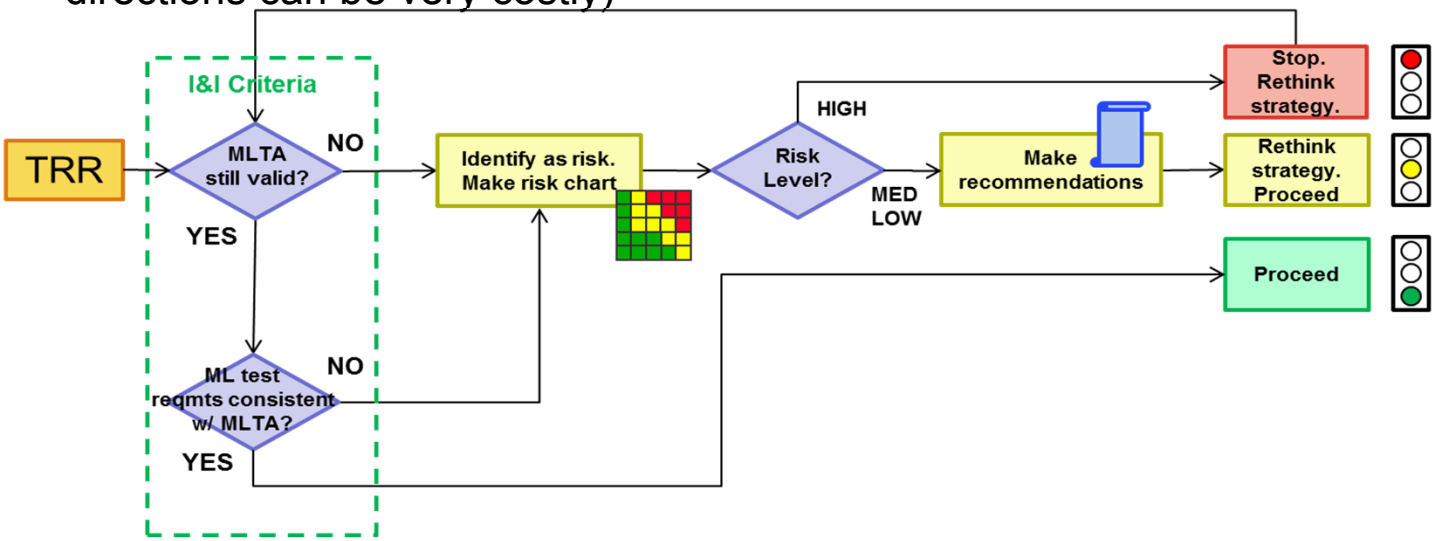
The results from the SETR Exit criteria will provide evidence to support the Gate review

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)



Assessing Impact of the Evolved Threat on MOE

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.

	Est Cost Delta	Est Sched Delta
original design vs **original** threat $P_{k\,(OD,OT)} \times R_w = P_{ssk\,(OD,\,OT)}$ ex: 0.90 x 0.95 = 0.86	$0M	0 mos
original design vs **evolved** threat $P_{k\,(OD,ET)} \times R_w = P_{ssk\,(OD,ET)}$ ex: 0.60 x 0.95 = 0.57	$0M	0 mos
An **improved** design vs the **evolved** threat $P_{k\,(ID,ET)} \times R_w = P_{ssk\,(ID,ET)}$ ex: 0.88 x 0.95 = 0.84	$300K $2.5M	3 mos (software) 20 mos (redesign)

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.

The SoS w/original design vs **original** threat	Est Cost Delta	Est Sched Delta
$P_{k\ (SoSOD,OT)} \times R_w = P_{ssk\ (SoSOD,\ OT)}$ ex: 0.92 x 0.97 = 0.89	$0M	0 mos
The SoS w/original design vs **evolved** threat		
$P_{k\ (SoSOD,ET)} \times R_w = P_{ssk\ (SoSOD,ET)}$ ex: 0.90 x 0.97 = 0.87	$0M	0 mos
An **improved** design vs the **evolved** threat		
$P_{k\ (SoSID,ET)} \times R_w = P_{ssk\ (SoSID,ET)}$ ex: 0.94 x 0.97 = 0.91	$10M	20 mos

CAM TASK 3

DEFINE SYSTEM METRICS TO IMPROVE SYSTEM OPERATIONAL EFFECTIVENESS AS A FUNCTION OF THE COST OF THE IMPROVEMENT TO MISSION OPERATIONAL EFFECTIVENESS

Background on CAM Task 3

- **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
  - Cost estimated using Total Ownership Costs per NAVSEA 2005 Cost Estimating Handbook
- **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

State the problem in terms of mission impact

Identify quantified hierarchical criteria to support mission

Establish Performance & OE Weights

Develop Alternatives to implement criteria

Estimate and score Alternative Performance

Estimate Alternative Costs

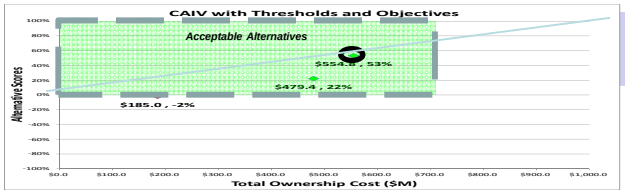
Perform CAIV analysis

Solution found?

N

Y

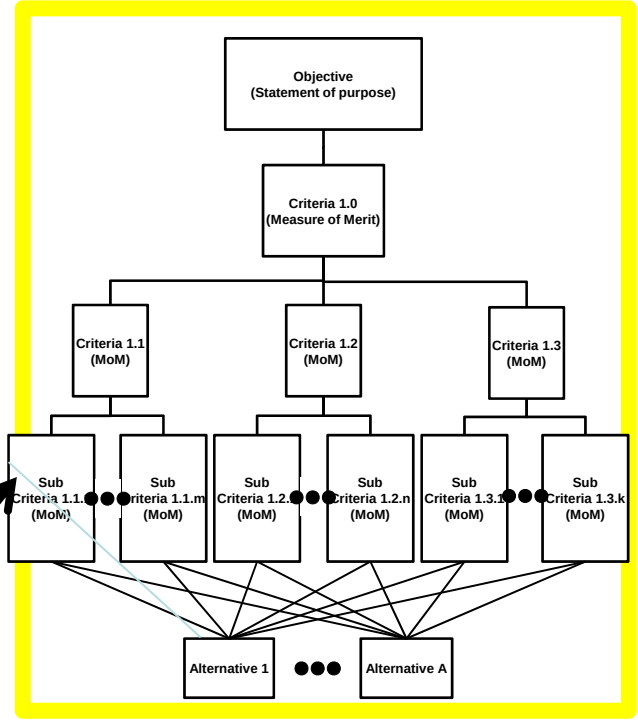
Provide recommended solution based on best "Bang for the buck"



Supporting Processes

Integrated Capability Framework (ICF): provides design trade space and performance analysis framework

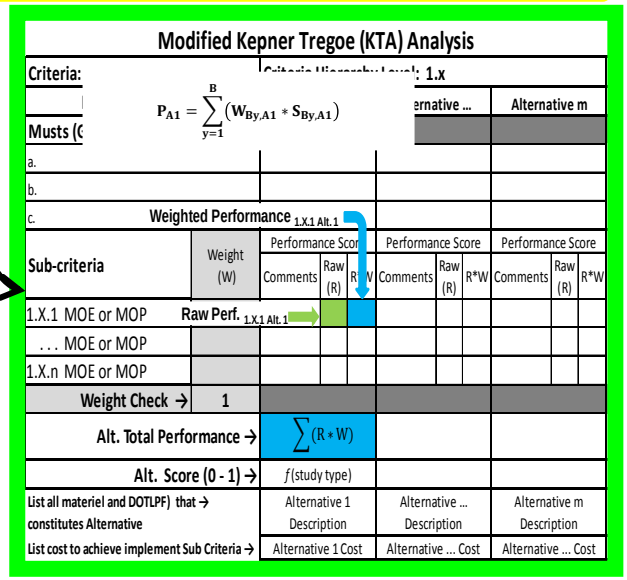
Analytical Hierarchy Process (AHP): framework to decompose Mission needs to system functional alternative implementations, and determine performance weights



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

NAVSEAs 2005 Cost Estimating Handbook:

Cost as an Independent Variable (CAIV): Evaluates alternative(s) Performance vs life cycle Cost



Modified Kepner Tregoe (KTA) Analysis

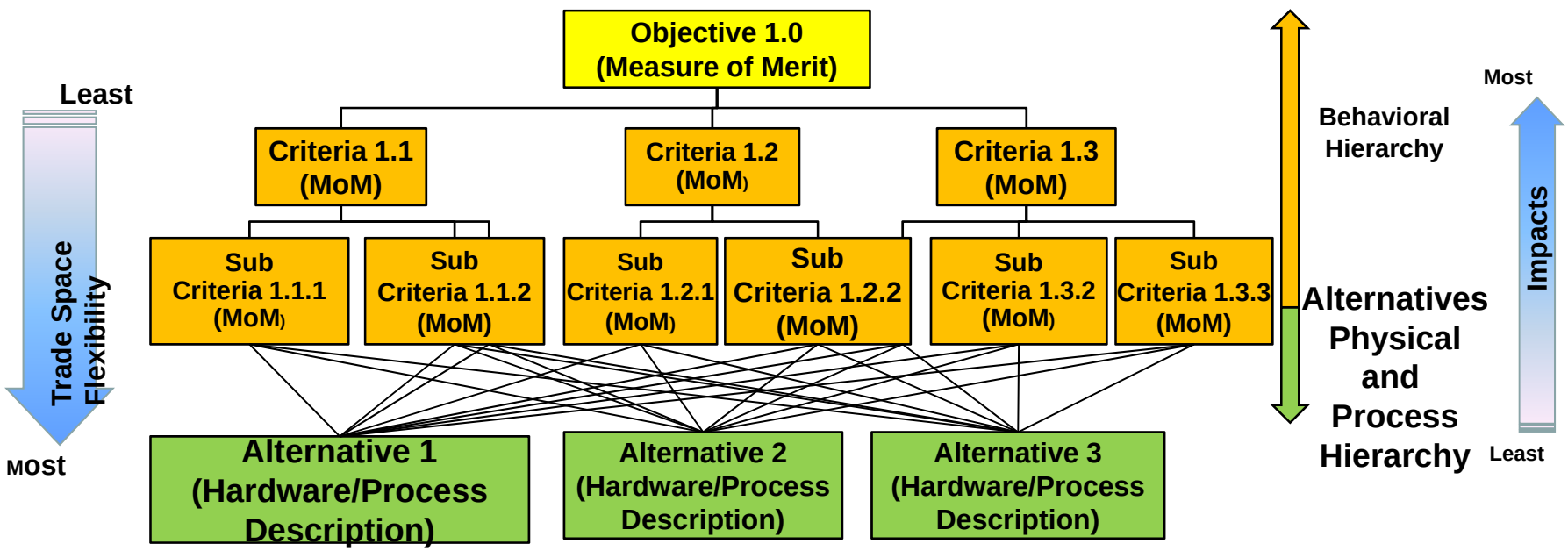
Criteria: | Criteria Hierarchy Level: 1.x

$$P_{A1} = \sum_{y=1}^{B} (W_{By,A1} * S_{By,A1})$$

Musts (C					ernative ...			Alternative m		
a.										
b.										
c. Weighted Performance 1.X.1 Alt.1										
Sub-criteria	Weight (W)	Performance Scor			Performance Score			Performance Score		
		Comments	Raw (R)	R*W	Comments	Raw (R)	R*W	Comments	Raw (R)	R*W
1.X.1 MOE or MOP	Raw Perf. 1.X.1 Alt.1									
. . . MOE or MOP										
1.X.n MOE or MOP										
Weight Check →	1									
Alt. Total Performance →		$\sum(R*W)$								
Alt. Score (0 - 1) →		f(study type)								
List all materiel and DOTLPF) that → constitutes Alternative		Alternative 1 Description			Alternative ... Description			Alternative m Description		
List cost to achieve implement Sub Criteria →		Alternative 1 Cost			Alternative ... Cost			Alternative ... Cost		

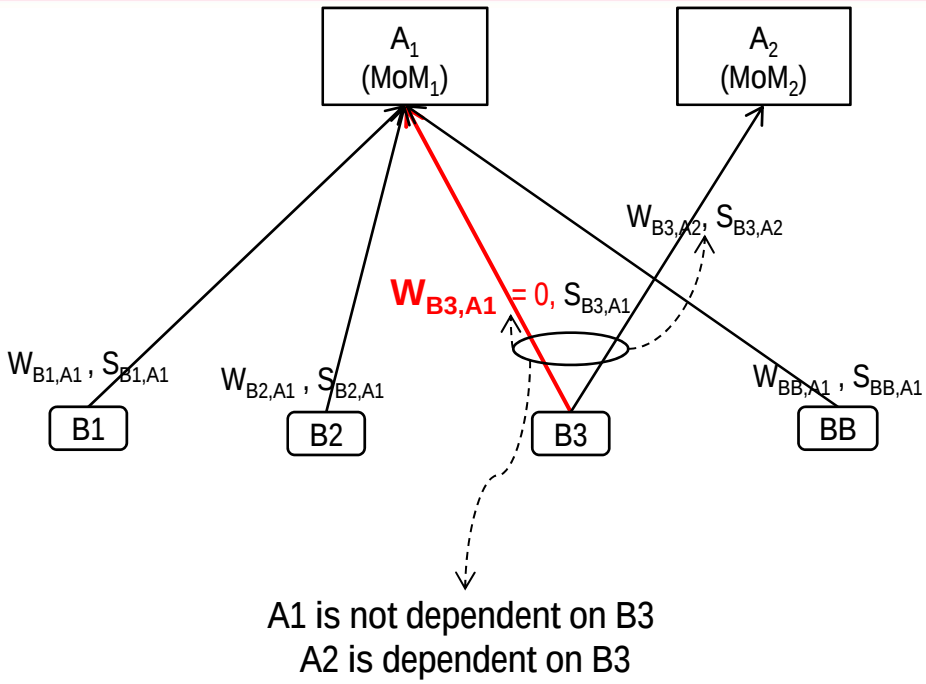
General AHP Hierarchal Model and Method

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.



Based on Wanki Kim, *Reverse analytic hierarchy process (AHP) to prioritize emerging IT technologies: A case study in Korea IT industry*, African Journal of Business Management Vol.6 (24), pp. 7214-7229, 20 June, 2012

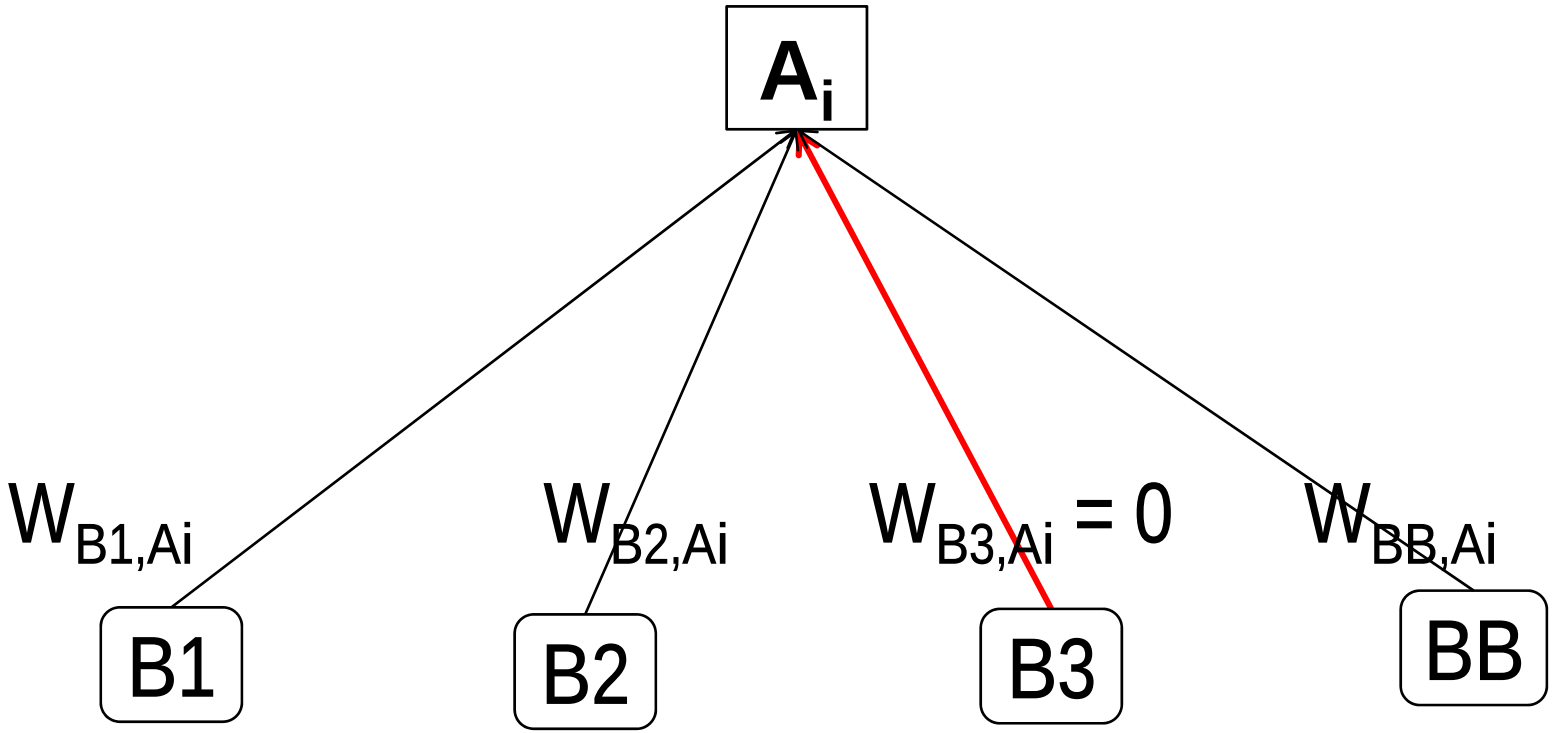
Hierarchical Evaluation Network Rules



$$P_{A1} = \sum_{y=1}^{B} \left(W_{By,A1} * S_{By,A1} \right)$$

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) $W_{B,A}$ = performance weight for element B 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) $S_{B,A}$ = Score of element B 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

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

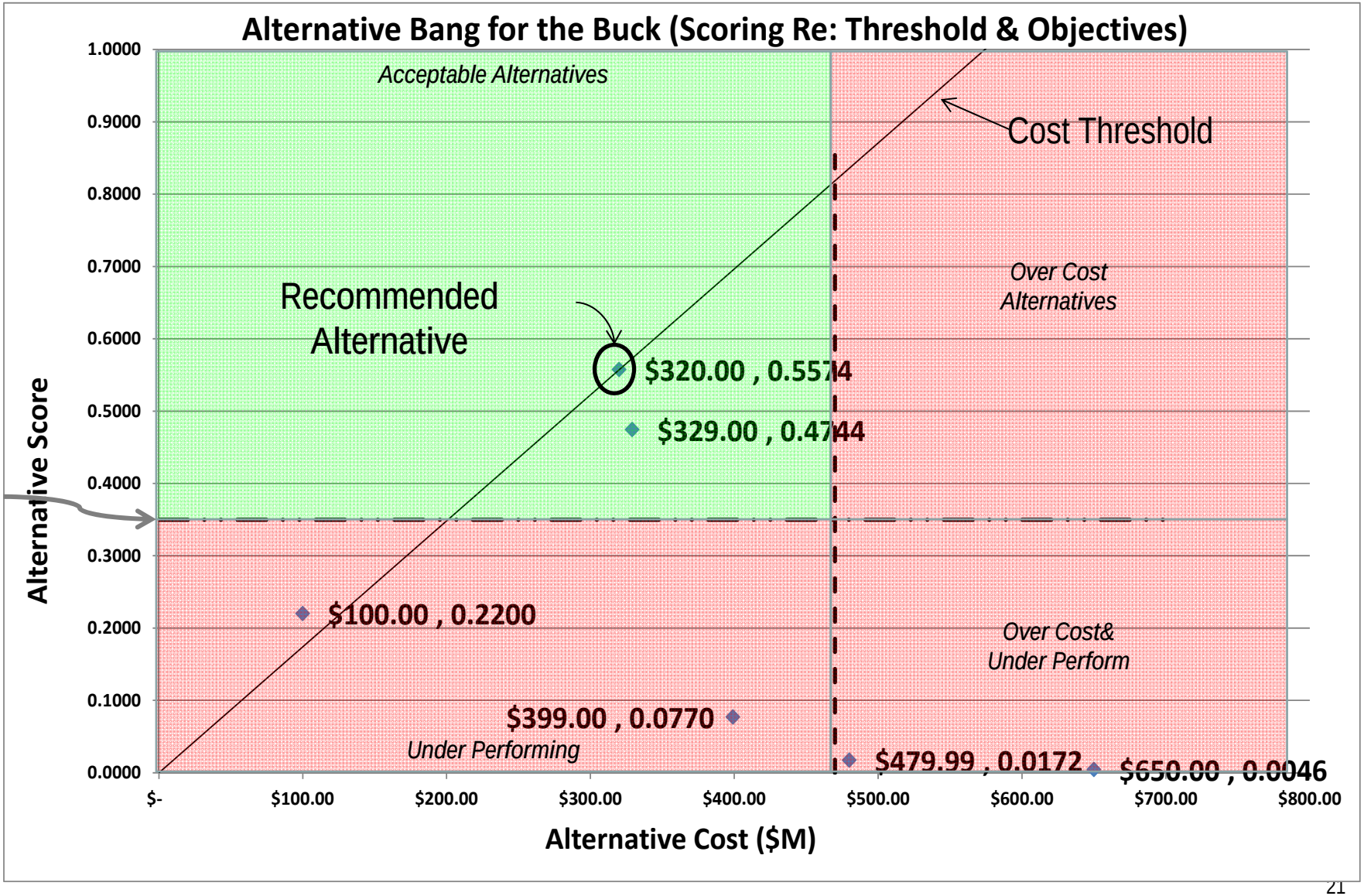
Establish Relative Importance Weights with Quick Comparison AHP

- **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

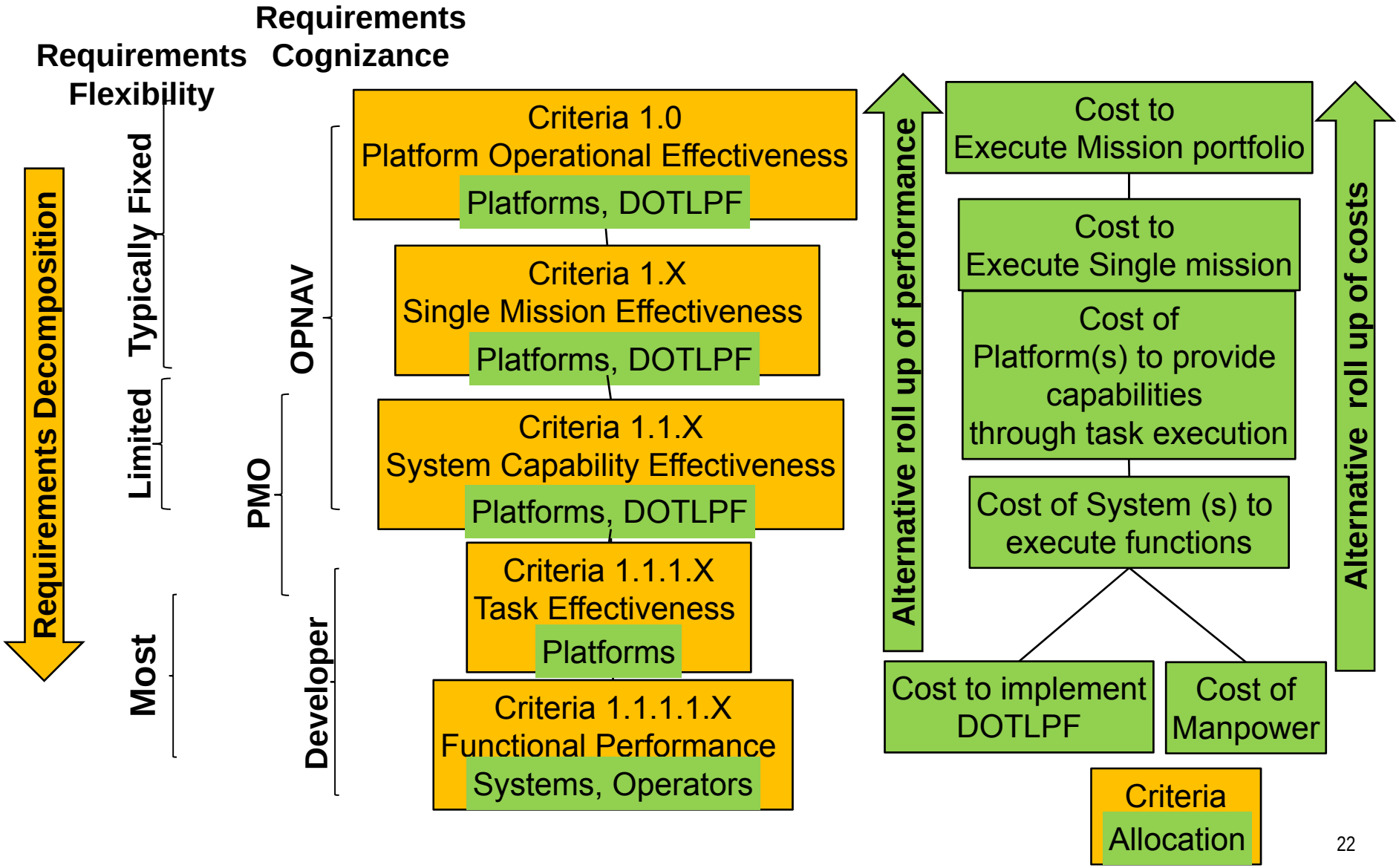
Process: Establish initial relative weights (Quick Comparison)

1. **Provide an evaluation form to each stake holder selected to weigh N criteria**
   a. Put each criteria ($C_{i\ By,A}$) 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(Wfpi By, A)**
4. **These are used to establish the final relative weights**

CAIV With Set Thresholds, Objectives, and Cost Limit



CAIV Cost and Performance Hierarchical Flows



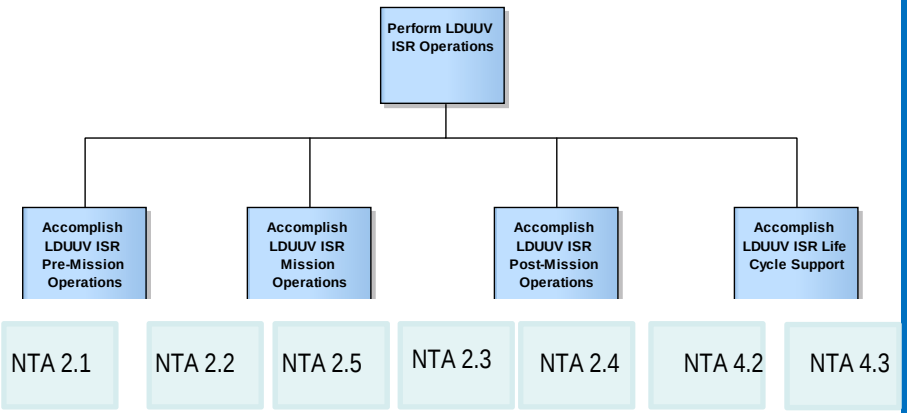
CAM TASK 5

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

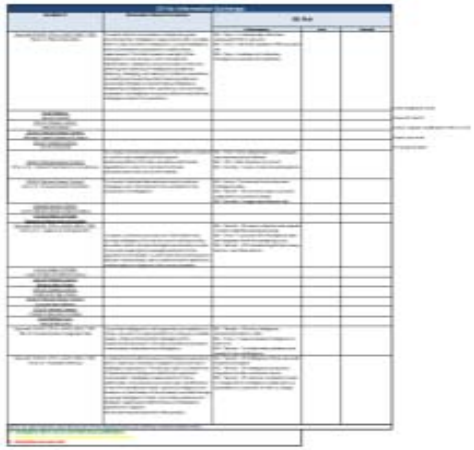
Step 1

OV - 5a from ICF



Step 2

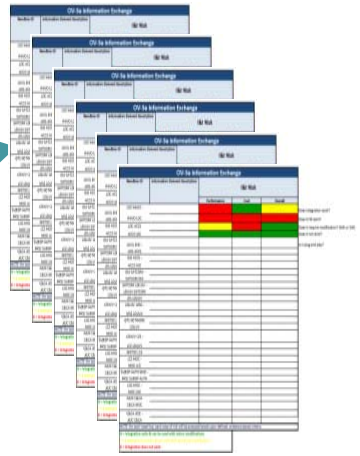
NTA Metrics from MLA&E process



Step 3

SME assessment of Risk to achieve NTA metrics

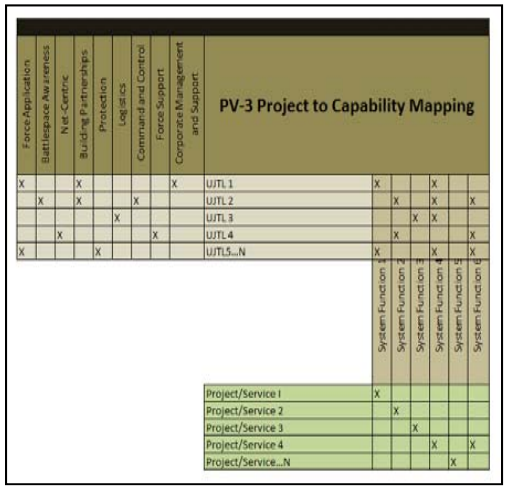
Risk Summary matrices for the Viewpoint



Step 4

Financial Mapping to NTA Metrics to Capability

Program Cost Estimation WBS



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

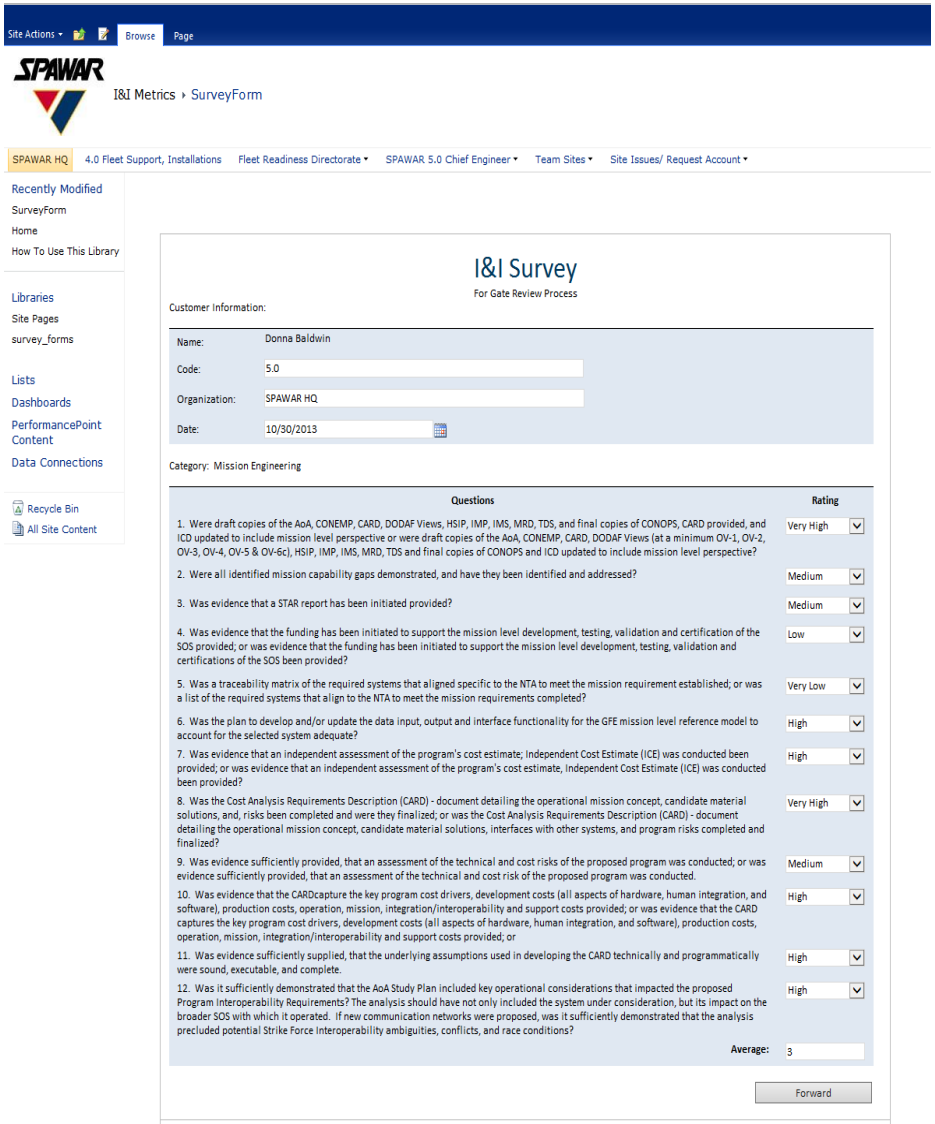
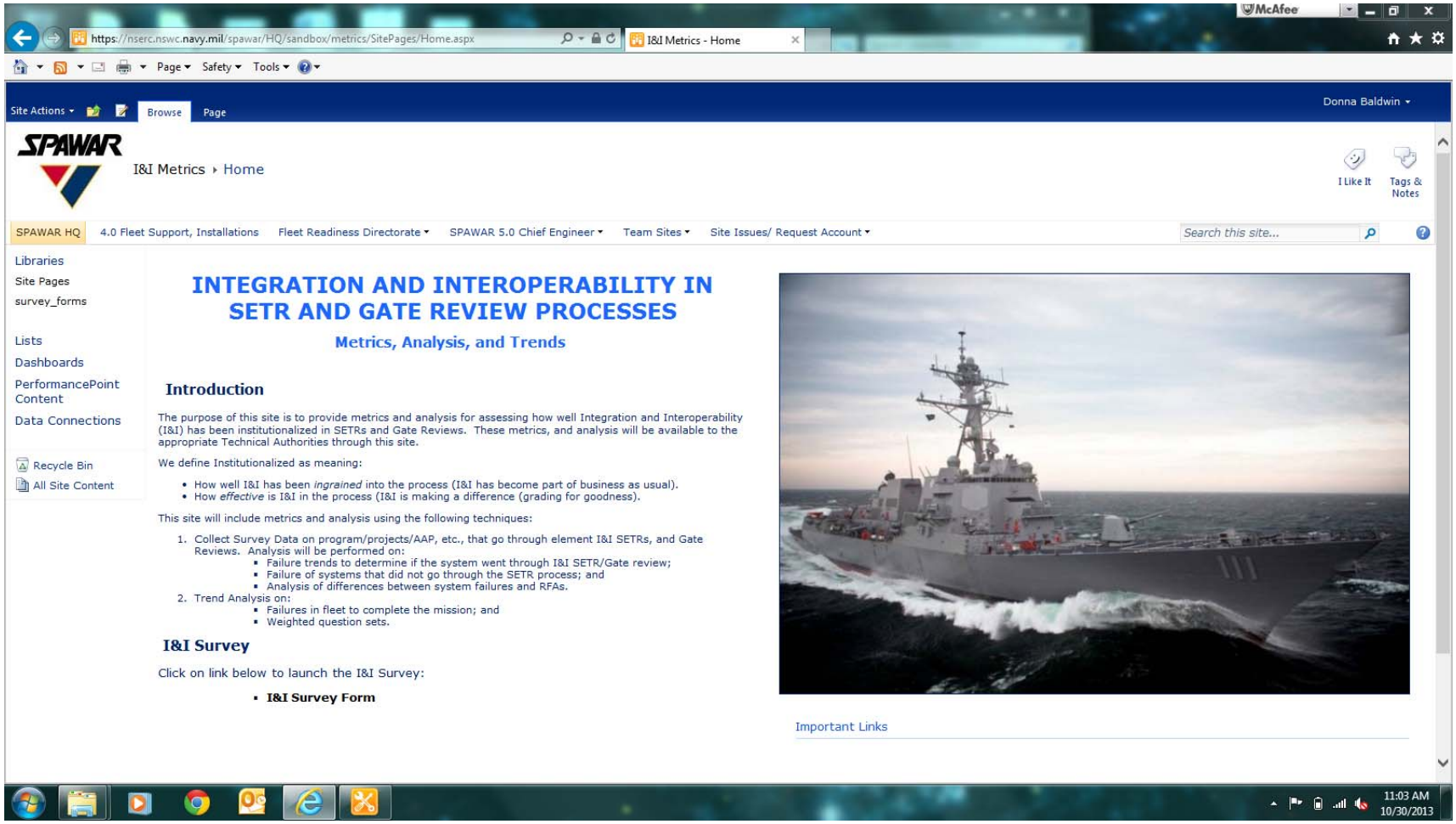
I&I Metrics Analysis Dashboards

- **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