The Role of Mission Analysis in Development Planning

John Lohse, Raytheon
Kirk Michealson, Lockheed Martin

19 June 2012
Agenda

• Background
• NDIA Development Planning Working Group
  ✓ Formation
  ✓ Report
  ✓ Findings
• NDIA Industry Team Formation
• Industry’s Pre-Milestone A Systems Engineering Process
  ✓ Consolidated Industry Analytics
• The Role of Architecture
• S&T/IR&D during Development Planning
• Next Steps
• Summary
Background

Since 2008, there has been an increased Focus on Pre-Milestone A Systems Engineering

• National Academy of Sciences Study (January 2008)
  - Pre-Milestone A and Early-Phase Systems Engineering
• DoDI 5000.02 Update (December 2008)
  - Increased focus on early systems engineering
• Weapons Systems Acquisition Reform Act (May 2009)
  - Direction to reinvigorate Development Planning – upfront technical analysis and planning for successful materiel solutions
The NDIA Systems Engineering Division agreed to form a Working Group (WG) to provide recommendations for how Industry can support government Development Planning activities

- WG formed with approx. 65 Government/Industry members
- WG Workshop held June 8 & 9, 2010
  - 55 senior level attendees

The objectives of the Working Group were to:

1. Identify specific areas, activities and knowledge in the pre-milestone “A“ timeframe where Industry engagement could inform early technical analysis and engineering for DoD Acquisition Programs;
2. Understand the available and potential mechanisms necessary to facilitate Industry involvement in that early technical analysis and engineering;
3. Recognize the issues, limitations, and questions, and formulate recommendations to foster Industry involvement in early technical analysis and engineering
Key Motivator

The Government decision-maker can make better and more informed decisions to achieve a balanced design of performance, schedule and cost including life cycle cost - i.e. what is practical and feasible - on a given program if they have more pertinent critical information of the type that Industry can provide.

Start Programs Right!
The NDIA Development Planning WG completed a formal report on the WG findings and recommendations

- Issued January 2011
- Issued to:
  - Mr. Lemnios, ASD R&E
  - Mr. Welby, DASD SE
- Forwarded to all WG members
The lack of technical engagement during early program formulation has potential significant implications:

• A lack of iterative technical engagement with the operational user at the start of an acquisition program
  - Limited awareness of potential solutions
  - Poor understanding of user capability needs
• A lack of awareness of how preferred solutions impact a broad set of systems that are expected to operate as a systems of systems (SoS)
• A lack of technical feasibility verification of proposed solutions prior to the MDD and AoA
  - Uninformed decisions by the MDA
• A lack of technical analysis conducted on the preferred system solution(s) that emerge from the AoA recommendations
  - Improperly planned risk reduction and technical maturation activities in the Technology Development phase
Industry intellectual capital supports the Government in multiple ways, including:

• Provides legacy knowledge that can determine if new materiel acquisitions are necessary
• Provides a more comprehensive definition of the potential conceptual solution space for new acquisitions
• Helps to determine the feasibility of candidate conceptual solutions
• Provides a more comprehensive assessment of technologies that can be employed
• Leverages Industry’s inherent cost, schedule, and technical trades, as well as the associated risks

It is strongly advised that the Government and Industry work together to define opportunities for Industry involvement in the Development Planning process

• Optimize the balance of Government/Industry collaboration and Industry competition in a continuous manner
NDIA Industry Team Formation

The NDIA SE Division Mission Analysis Committee formed an Industry Team to address Industry best practices during Pre-Milestone A Systems Engineering

• Objective – Identify Industry best practices and analytics in Pre-Milestone A Systems Engineering and areas for potential Industry and Government collaboration

• Representation from across Industry
  - John Lohse, Raytheon
  - Gene Rosenbluth, Northrop Grumman
  - Bill Jennings, Boeing
  - Kirk Michealson, Lockheed Martin
  - Frank Sweighosky, Lockheed Martin
  - Bob Scheurer, Boeing
  - Anne Johnson, Raytheon
  - Steve Elgin, General Dynamics
Industry’s Pre-Milestone A Systems Engineering Process

The answer to “What problem are we trying to solve?” enables the tailoring of this process!
## Pre-MDD Enablers and Analytics

<table>
<thead>
<tr>
<th>Phase</th>
<th>Enablers</th>
<th>Analytics</th>
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</table>
| **Mission Capability Needs Analysis** | Threat Intelligence  
Scenario Databases and Development  
(e.g. Integrated Security Constructs)  
Mission Task Breakdown  
Service Task Lists  
Joint Capability Areas  
Mission Architecture  
Concept of Employment (existing)  
Wargaming Activities  
Government Documentation  
(e.g. QDR, NSS, NDS, NMS, Joint and Service UONs, Risk Assessments, etc)  
Military Exercises and Experimentation  
Warfighting Lessons Learned | Identify the Problem  
Threat Set Definition  
Political Impact  
(e.g. DIME - Diplomatic, Information, Military, Economic)  
Mission Capability Needs  
Measures of Effectiveness  
Performance Standards and Conditions  
Current State and Programmed State of Capability  
Mission Capability Gaps  
Red Team Assessments  
Stakeholder Analysis |
| **Capability Solution Analysis** | Mission Capability Needs  
Mission Capability Gaps  
Measures of Effectiveness  
Current State of Technology  
Technology Roadmaps  
SoS Architecture  
Rules of Engagement  
Concept of Operations  
Planning and Budgeting | Identify/Reduce Potential Candidate Solutions  
DOTMLPF Assessment  
Concept Feasibility Assessment  
Solution Space Constraints  
Technology Needs Assessment  
Technology Gaps Assessment  
Technology Realism Assessment  
Solution Boundaries  
Key/Critical Measures (i.e. MoPs, COIs, KPPs, KSAs)  
Concept of Employment (per candidate)  
Affordability Analysis  
Service Budget Portfolio Analysis  
Cost, Schedule, Risk Assessment  
Tradespace Analysis  
Solution Capability Assessment (per candidate)  
Red Team Assessments  
Stakeholder Analysis |
## Pre-MDD Activities

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<tr>
<th>Phase</th>
<th>Activities</th>
<th>Techniques, Methodologies, and Tools</th>
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<tbody>
<tr>
<td><strong>Pre-MDD</strong></td>
<td><strong>Mission Capability Needs Analysis</strong></td>
<td><strong>Analysis of Future Threats, Strategy, &amp; Needs</strong></td>
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<td></td>
<td>Identify threats</td>
<td>BOGSAT, Back of the Envelope</td>
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<td>Identify range of missions/mission areas/use cases</td>
<td>Spreadsheet analysis</td>
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<td>Identify strategic/political interests</td>
<td>Math Models</td>
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<td>Identify mission areas of interest</td>
<td>First Principal Analysis</td>
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<td><strong>Advanced Concept Engineering</strong></td>
<td><strong>Monte Carlo Analysis</strong></td>
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<td></td>
<td>Define representative scenarios (including operating environments and conditions)</td>
<td>Analytic Hierarchy Process (AHP)</td>
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<td></td>
<td>Understand current Mission Architecture</td>
<td>Discrete Event Simulation</td>
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<td></td>
<td>Identify Mission Measures of Effectiveness (MOEs)</td>
<td>(DoDAF, Zachman, etc.)</td>
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<td>Solicit advanced concepts from S&amp;T Base</td>
<td>Concept of Employment (ConEmp)</td>
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<td>Solicit advanced concepts from Industry</td>
<td>M&amp;S: EADSIM, ESAMS, STORM, SUPPRESSOR,</td>
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<td><strong>Capability Analysis &amp; Gap Identification</strong></td>
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<td>Identify current capabilities of mission area(s) of interest</td>
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<td>Identify current Concepts of Employment (ConEMPs)</td>
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<td>Evaluate current capabilities based on MOEs</td>
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<td>Rank gaps relative to the importance to the mission and the severity of the gap</td>
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<td><strong>Bound the Solution Space</strong></td>
<td><strong>Solution Identification</strong></td>
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<td></td>
<td>Perform or incorporate JCSDS DOTMLPF Study (Verify need for a materiel solution)</td>
<td>BOGSAT, Back of the Envelope</td>
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<td>Understand current SoS Architecture</td>
<td>Spreadsheet analysis</td>
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<td>Identify conceptual solution space constraints (physical, doctrinal, technology, schedule, and budget)</td>
<td>Math Models</td>
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<td>Provide a timeline projection for the availability of critical needs</td>
<td>First Principal Analysis</td>
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<td>Define/bound the conceptual solution space</td>
<td>Analytic Hierarchy Process (AHP)</td>
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<td>Identify Mission Measures of Performance (MOPs) and Critical Operating Issues (COIs)</td>
<td>Discrete Event Simulation</td>
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<td><strong>Capability Solution Analysis</strong></td>
<td><strong>Concept of Employment (ConEmp)</strong></td>
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<td><strong>Solution Identification</strong></td>
<td><strong>Concept of Employment (ConEmp)</strong></td>
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<td>Explore potential technologies from S&amp;T and Industry Base (e.g. JCTDs, CRADAs, CRAD, RAD, etc.)</td>
<td>Constrained Optimization Framework</td>
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<td>Identify &quot;potential&quot; conceptual solution candidates (including disruptive and late blooming technologies)</td>
<td>3DoF to 6DoF Simulations</td>
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<td>Provide technology assessment of conceptual solution space (current vs future, practical vs plausible, TRL, MRL, etc.)</td>
<td>M&amp;S: EADSIM, ESAMS, STORM, SUPPRESSOR,</td>
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<td></td>
<td>Understand technology, cost, and schedule realism</td>
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<td></td>
<td>Generate ConEmps for each candidate</td>
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<td>Integrate ConEmps into SoS Architecture for each candidate (i.e. system integration assessment)</td>
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<td>Evaluate conceptual solution candidates against &quot;programmatics&quot; (e.g. cost, schedule, risk, etc.)</td>
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<td>Evaluate conceptual solution candidates against capability gaps using MOEs (i.e. how well does the solution concept fill the gap?)</td>
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<td>Evaluate conceptual solution candidates for compliance to the &quot;ilities&quot;</td>
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<td></td>
<td>Write a &quot;draft&quot; Initial Capabilities Document</td>
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<td>Influence the writing of the AoA Study Guidance</td>
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# MDD - Milestone A
## Enablers and Analytics

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<thead>
<tr>
<th>Phase</th>
<th>Enablers</th>
<th>Analytics</th>
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</table>
Candidate Trade Analyses  
Capability vs Cost  
Capability vs Risk  
Life Cycle Assessment  
Technology Realism Assessment  
Concept of Employment (per candidate)  
Affordability Analysis  
Cost, Schedule, Risk Assessment  
Solution Capability Assessment (per candidate)  
Red Team Assessments  
Stakeholder Analysis |
| AoA            | Engineering Analysis                                                     | Refine Selected Solution  
Measures of Performance  
System Architecture  
SoS Interface Definition  
Technology Readiness Levels  
Manufacturing Readiness Levels |  
Critical Technology Element Definition  
Affordability Analysis  
Cost, Schedule, Risk Assessment  
Performance Requirements Decomposition  
Design Requirements Definition  
System Concept  
Red Team Assessments  
Stakeholder Analysis |
<table>
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<tr>
<th>Phase</th>
<th>Activities</th>
<th>Techniques, Methodologies, and Tools</th>
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<tbody>
<tr>
<td>AoA Planning</td>
<td>Identify the conceptual solution candidates to be evaluated (from the AoA Study Guidance)</td>
<td>Analytic Hierarch Process (AHP)</td>
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<td>Identify technical, schedule, and budget constraints</td>
<td>M&amp;E - Cost/Benefit Analysis</td>
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<td>Identify relevant trade studies</td>
<td>Monte Carlo Analysis</td>
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<td>Identify the AoA evaluation criteria/critical success factors</td>
<td>Discrete Event Simulation</td>
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<td>Refine representative scenarios (including operating environments and conditions)</td>
<td>Architecture (DoDAF, Zachman, etc.)</td>
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<td>Write the AoA Plan</td>
<td>Constrained Optimization Framework</td>
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<td>Refine the SoS Architecture around each candidate</td>
<td>3DoF to 6DoF Simulations</td>
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<td>Identify SoS interfaces and enabling systems/technologies</td>
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<td>Understand legacy system knowledge for SoS interfaces or system upgrades</td>
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<td>Define life cycle parameters, attributes, suitability, etc.</td>
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<td>Provide technology assessment of candidates (current vs future, practical vs plausible, TRL, MRL, etc.)</td>
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<td>Provide 'ilities' assessment of candidates (sustainability, reliability, maintainability, survivability, etc.)</td>
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<td>Provide integration readiness assessment of candidates for SoS interfaces</td>
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<td>Provide initial list of Critical Technology Elements (CTEs)</td>
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<td>Provide initial cost estimate of candidates</td>
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<td>Provide initial schedule estimate of candidates</td>
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<td>Create initial risk assessment of candidates based on technology, cost, and schedule</td>
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<td>AoA Conduct</td>
<td>M&amp;E: EADSM, ESAMS, STORM, SUPPRESSOR,</td>
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<td>Identify common models, data, and tools</td>
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<td>MDD to</td>
<td>Gather relevant models, data, and tools</td>
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<td>Milestone A</td>
<td>Validate models, data, and tools</td>
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<td>Determine procedure for model/data/tool configuration management and knowledge repository</td>
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<td>Identify analysis techniques</td>
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<td>Perform capability vs cost trades (i.e. affordability analysis)</td>
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<td>Perform capability vs risk trades (i.e. performance, schedule, cost)</td>
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<td>Perform AoA</td>
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<td>Identify the Preferred System Concept</td>
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<td>Write a CONOPS for the Preferred System Concept</td>
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<td>Write AoA report</td>
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<tr>
<td>Engineering Analysis</td>
<td>Identify Preferred System Concept technical, schedule, and budget constraints</td>
<td>Monte Carlo Analysis</td>
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<td>Refine SoS Architecture</td>
<td>Analytic Hierarch Process (AHP)</td>
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<td>Identify level of expectations for Preferred System Concept</td>
<td>M&amp;E - Cost/Benefit Analysis</td>
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<td>Identify Preferred System Concept SoS interfaces and enabling systems/technologies</td>
<td>Discrete Event Simulation</td>
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<td>Understand legacy system knowledge for SoS interfaces or system upgrades</td>
<td>Architecture (DoDAF, Zachman, etc.)</td>
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<td>Refine Preferred System Concept life cycle parameters, attributes, suitability, etc.</td>
<td>Constrained Optimization Framework</td>
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<td>Refine Preferred System Concept MOPs</td>
<td>3DoF to 6DoF Simulations</td>
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<td>Refine technology assessment of the Preferred System Concept (TRL, MRL, etc.)</td>
<td>Man-in-the-Loop Simulations</td>
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<td>Refine integration readiness assessment of the Preferred System Concept for SoS interfaces</td>
<td>Software/Hardware-in-the-Loop Simulations</td>
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<td>Refine Preferred System Concept CTEs</td>
<td>Test Shots</td>
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<td>Provide cost estimate of the Preferred System Concept</td>
<td>M&amp;E: EADSM, ESAMS, STORM, SUPPRESSOR,</td>
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<td>Provide schedule estimate of the Preferred System Concept</td>
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<td>Identify risk assessment of the Preferred System Concept based on technology, cost, and schedule</td>
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The Role of Architecture

Understand The Problem

Mission Architecting
- Understand Customer’s Desired Capabilities
- Analyze Requirements & Needs
- Analyze Operations
- Analyze Quality Attributes
- Identify Reuse Assets
- Identify Key Performance Goals And Measures
- Initiate Technical Standards List
- Understand Customer’s Architecture

Develop An Operational Concept

SOS Architecting
- Define Mission Nodes & Their Relationships
- Define Information Exchanges
- Define Operational Activities
- Develop Operational States
- Develop Operational Event Sequence Diagrams
- Initiate Simulation Activities

Develop A System Concept

System Architecting
- Define System Functions From Operational Activities
- Define System Data Exchange
- Define Systems, Subsystems, & Functions
- Develop State Event Sequence Diagrams
- Perform Capacity Planning
- Perform Performance Predictions

Mission Architecting Is The First Step In The Architecting Process
S&T/IR&D during Development Planning

Notional Timeline

Source: Lt. General Richard Scofield, USAF (ret.)
Early Mission Analysis in the S&T/IR&D Process

A mission perspective of “why” we do things will lead to a better transition of technology to programs.

What/Who drives S&T/IR&D?
- OCOM Science Advisor
- Warfighter Needs
- Threat Assessments
- Vulnerability Assessments
- Services
- MOUTs
- DIPS
- Political Will

Long-Term Technology Needs: Understand the Needs to Drive Technology

Transformational technology jumps!

S&T Labs  →  Transition to programs

Industry Process

MA = Mission Analysis
Next Steps

NDIA Systems Engineering Division
In conjunction with the Military Operations Research Society
Development Planning Working Group
Collaborative Engagement Workshop on
Development Planning, S&T, Pre-milestone A SE, and IR&D Interactions

Lockheed Martin Global Vision Center
2121 Crystal Drive, Arlington (Crystal City), VA

June 21 – 22 (half day on June 22)
Workshop Objectives

• Understand how to better align Service and Industry technology investments;
  – Provide recommendations to improve the transition rate of technology from development to fielded capability;
• Identify available and potential mechanisms where Industry Pre-milestone A SE and IR&D can provide information needs to better inform Government Decision Makers;
  – Define the "context" that is needed for contractors to better respond to DP and S&T RFIs;
  – Include both Intellectual Property (IP) and non-IP environments
• Understand the differences in Development Planning and S&T focus relative to near term threat response and long term mission needs
  – Supports ASD R&E Rapid Fielding Initiative
• Define effective analytical techniques and methodologies used in the Development Planning timeframe
  – Identify supporting tools as appropriate

Improving the Integration of Government and Industry S&T/IR&D to support Development Planning Decisions
Summary

• The NDIA Development Planning Working Group established a solid foundation on which to foster Industry and Government collaboration

• Industry is highly proficient in performing most of the Government Development Planning Activities

• Numerous areas exist where Government and Industry would mutually benefit from collaboration during Development Planning and help….

    …Start Programs Right!
Questions
Back-up
Capability Mission Analysis

Mission Capability Needs Analysis
- Analysis of Future Threats, Strategy & Needs
  - Identify Threats
  - Identify Range of Missions / Mission Areas
  - Identify Strategy / Political Interests
  - Identify Mission Areas of Interest

Identification of the Military Area Of Interest

Advanced Concept Engineering
- Define Representative Scenarios
- Understand Current Mission Architecture
- Identify Mission Measures of Effectiveness (MOEs)

Identification of the Existing Environment and What Constitutes Effectiveness

Capability Analysis
- Identify Current Capabilities
- Identify Current Concepts of Employment
- Evaluate Current Capabilities Based on MOEs

Evaluation of the Effectiveness of the Current Operational Capability

Gap Identification
- Identify Capability Gaps
- Rank gaps relative to the importance to the mission and severity of the gap

Evaluation of the Capability Gaps and the Importance of Each Gap
Capability Solution Analysis

1. **Bound the Solution Space**
   - Perform or incorporate JCIDS DOTMLPF Study
   - Understand current SoS Architecture
   - Identify conceptual solution space constraints & timeline for availability of critical needs
   - Define / Bound the conceptual solution space
   - Identify Mission Measures of Performance and Critical Operating Issues

2. **Solution Identification**
   - Explore potential technologies
   - Identify "potential" conceptual solution candidates
   - Provide technology assessment of conceptual solution space
   - Understand technology, cost and schedule realism
   - Downselect conceptual solution candidates

3. **Solution Integration**
   - Generate ConEmps for each candidate
   - Integrate ConEmps into SoS Architecture for each candidate

4. **Evaluate Solution Candidates**
   - Evaluate conceptual solution candidates against "programmatics"
   - Evaluate conceptual solution candidates against the MOPs
   - Evaluate conceptual solution candidates against capability gaps using MOEs
   - Rank the conceptual solution candidates

5. **Generate Documents**
   - Write a draft CONOPS
   - Write a draft Initial Capabilities Document
   - Influence the writing of the AoA Study Guidance

**Identify the Physical and Architectural Environment the Solution Must Reside In**

**Identify and Define the Solutions to be Evaluated**

**Define How Solutions Will Integrate Into the Existing Architecture and Employment**

**Rank Each Solution Option Based on the Defined Selection Criteria**

**Development of a ‘Draft’ CONOPS and ICD is Essential for Concept Communication**
Analysis of Alternatives

**AoA**

**Plan**
- Identify conceptual solution candidates to evaluate
- Identify technical, schedule and budget constraints
- Identify relevant trade studies
- Identify the AoA evaluation criteria / critical success factors
- Write AoA Plan

**SoS Assessment**
- Refine SoS architecture around each candidate
- Identify SoS interfaces and enabling system / technologies
- Understand legacy system knowledge for SoS interfaces or system upgrades
- Define life cycle parameters, attributes, suitability, etc
- Provide technology assessment of candidates
- Provide integration readiness assess. of candidates for SoS interfaces

**Candidate Assessment**
- Provide initial list of Critical Technology Elements (CTE)
- Provide initial cost estimate of candidates
- Provide initial schedule estimate of candidates
- Create initial risk assessment of candidates based on technology, cost and schedule

**Prepare Analysis**
- Identify common models, data and tools
- Gather relevant models, data and tools
- Validate models, data and tools
- Determine procedure for model / data / tool configuration management and knowledge repository
- Identify analysis techniques

**Conduct Analysis**
- Perform capability vs cost trades
- Perform capability vs risk trades
- Perform AoA
- Identify the preferred system concept

**Generate Reports**
- Write a “draft” CONOPs
- Write AoA report

**Internal AoA Provides Preparation for Solution Engineering Analysis**
Engineering Analysis of the Preferred System Concept
Shapes the Pre-Proposal Design

(This is Essential in Preparation for a Procurement Activity)
Program and Technical Planning

Planning Prepares the Way for Procurement Activities and Provides Information for Proposal Decision Making