An Adaptable Architecture for the Airborne Electronic Attack (AEA) System of Systems (SoS)

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This briefing is unclassified in its entirety
Purpose Statement

- Discuss the methodology to build an *adaptable System of Systems* architecture that can be used to compare performance of alternative solutions.

- Definitions
  - Adaptable – capable of becoming suitable to a particular situation or use
  - System of Systems – a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities
Outline

- AEA SoS Description
- Focus of Effort
- Methodology
- Architecture Challenges
- Solutions
- System Analyses
Airborne Electronic Attack System of Systems (AEA SoS) Description

- Limited number of AEA assets support multiple air and ground elements against multiple threats
- Requires informed AEA decisions across the theater in real-time
- Requires coordination between a variety of assets (SoS) to improve:
  - AEA tasking awareness
  - Flexibility and confidence to make changes
  - Overall AEA Efficiency
- Goal – to improve AEA support through interoperability & coordination
  - Information sharing
  - Management of assets
Focus of Effort

- Develop a means to verify that the SoS provides significant improvements to combat effectiveness
- Develop a means to quantify those improvements
- Determine which ‘attributes’ make a statistically significant difference
Methodology

- Build an adaptable architecture to model the AEA SoS

- Using the architecture as a baseline, perform Systems Analyses to determine and measure the improvements to combat effectiveness
  - Screening model – to identify the key ‘attributes’
  - High Fidelity model – to determine effectiveness
Architecture Challenges

- Need an *adaptable* architecture that represents various:
  - Configurations
  - Situations
  - Attributes
Architecture Challenge – Various Configurations

- AEA SoS Architecture must be adaptable to many different configurations

- AEA SoS consists of many different players/roles
  - AEA Platforms (*Jammers*)
  - Intelligence, Surveillance, and Reconnaissance (ISR) Platforms
  - Protected Element (*Bombers, Ground troops, etc*)
  - Command Element (*Air Operations Center, Air Control aircraft, etc*)
  - AEA Battle Management (*Operational-level, Tactical-level*)

- Each role can be thought of as its own *Family of Systems*

- Definition
  - Family of Systems – a set of systems that provide similar capabilities through different approaches
Solution – Generic Activity Modeling

- Activity diagrams - used to model activities and exchanges within the AEA SoS
  - Abstract Operational Node classes – defined to account for variable configurations
  - Abstract High Level Activities – defined for each operational node
  - Abstract Information Element classes – defined to represent the information exchanges between operational node activities

- Result – an all-encompassing “one size fits all” operational model

- Definitions
  - Generic – very comprehensive, relating to or descriptive of an entire group or class
  - Abstract – thought of or stated without reference to a specific instance; generalized
Notional Activity Model – Execute AEA Mission
Architecture Challenge – Various Situations

- AEA SoS Architecture must be adaptable to the many different ‘situations’ that may occur during a mission
  - New Jamming Request from the Protected Element
  - AEA Platform Malfunction
  - Change in Mission Priorities
  - Command Element Cancels Mission
  - React to a Pop-up SAM
Solution – Notional Modeling of Specific Situations

- Activity diagrams – used to model specific ‘situations’

- Derived from notional Execute AEA Mission Activity Diagram

- Each Situation represents a single thread through the architecture
Solution – Notional Modeling of Specific Situations
The AEA SoS Architecture must be adaptable to take into account a number of various ‘attributes’ that can change from one mission to the next.

Some examples out over 40 identified attributes:

- AEA – PE Support Relationship
- Communications Quality
- Jammer Effectiveness
Using the adaptable architecture

Method:
1. For each swimlane, show settings for appropriate attributes
2. Inside each swimlane, show standardized operations functions
3. Build multiple configurations (attributes & functions)
4. Model attribute and function interactions using the architecture foundation
5. Simulate to compare performance from different configurations
# AEA Objects

<table>
<thead>
<tr>
<th>Cognitive attributes</th>
<th>Information attributes</th>
<th>Physical attributes</th>
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<tbody>
<tr>
<td><strong>Support Relations</strong></td>
<td><strong>Comms quality</strong></td>
<td><strong>AEA Jammer</strong></td>
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<td>AEA 1</td>
<td>AEA 2</td>
<td>AEA 3</td>
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<td><strong>Function</strong></td>
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<td><strong>Stand Off Jammer</strong></td>
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- **Functions**: Maneuver, Sense, Communicate, Process, Engage
2. Single Configuration (example)

Swim lanes (Roles)

Protected Entity | Adversary | ISR | AEA BM | AEA Operator | Command Element
---|---|---|---|---|---
Objects
Bomber | Radar | Air Recon | Oper | Tac | AEA 1 | AEA 2 | AEA 3
Attributes

Functions

M, S, C, P

SOJ

SIJ

Escort

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3. Multiple configurations

- Each configuration accounts for all swim lanes & functions

- Each configuration has different:
  - Attributes
    - Cognitive / authorities
    - Information / communications
    - Physical / platform types
  - Functions
    - Attribute impacts on performance
4. Attributes impact on functions

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Spatial relationships</th>
<th>Sensor interpretation</th>
<th>Message interpretation</th>
<th>Speed</th>
<th>Weapon control</th>
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<td>Physical</td>
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<td>Sensor characteristics</td>
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<td>Effectiveness</td>
<td>Radio/Data Link</td>
<td>Computer characteristics</td>
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<td>Physical Effectiveness</td>
<td>characteristics</td>
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- **Nominal values shown. Simulations calculations generated from Triangle distributions (Lowest, Nominal, Highest)**

- **Functions from the architecture’s System Views (SV)**
- **NOTIONAL Data**

- Attributes from configuration factors

- **Notional Data**

- **APL**

- **NDIA**

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Simulation Courses of Action (COA)
5. Simulate to compare performance from different configurations

- Course Of Action (COA) Scorer model
  - Jammer location
  - Expected Jammer Effectiveness
  - Time to implement

- Monte Carlo Simulation
  - Attributes’ effect on Battle Manager’s Decision Window

Do longer decision windows make a difference in AEA combat?

For these configurations, faster decisions increased jammer effectiveness by 45% and 53%

Less is better
5. Simulate to compare performance from different configurations

Sample data plots using JMP ANOVA

Oneway Analysis of Mission_Value By AEA-PE Relationship

Statistical different performance between these configuration factors

Can’t see any performance differences between these factors

NOTIONAL Data
Adaptable Architecture Summary

- Adaptable Architecture provides a neutral arena to compare performance from multiple alternatives

- AA employs a capability-based approach vs platform-based approach to SoS solutions

- AA enables a comprehensive analysis across different force configurations and dynamic situations
Questions?