Benchmark Benefits to System Designers Considering Complex Trade Spaces

NDIA 15th Annual Systems Engineering Conference

Mr. Garth Jensen
ONR Science Advisor to OPNAV N9

Dr. John Tangney
ONR; Lead, Human Systems Priority Steering Council
• **Need Effectiveness Estimates**
  – Realistic Mission Training Simulations – **Lightweight**
  – **Mission** Success Metrics – performance metrics support
  – **Calibrated** Using Experts in the Loop
  – **Integrated**, Joint, Coalition

• **Enable Exploration of Large Design Space**
  – Hardware, Software, Human Elements – baseline and notional
  – Broadly Available to Industry – e.g. Networked PCs
  – Flexible – i.e. Modest Fidelity

• **Gain Confidence in Capability Based Assessments**
  – Operator CONOPS and TTPs
  – Trade Space Analyses within **Mission**
Initial Push

“Priority S&T Investments … FY13”

“Human Systems … effectiveness across a broad range of missions”

OSD – Priority Steering Councils
Continued Push -- Strategic Guidance
January 2012

• **President**
  – … focus on … Asia Pacific …. **deepening partnerships**
  – … military is agile, flexible, and **ready for the full range of contingencies**

• **DepSecDef**
  – … Joint Force of the future that will be smaller and leaner, but will be **agile, flexible, ready**, and technologically advanced.
  – … led by the highest quality, **battle-tested professionals**

• **Primary Missions**
  – Counter Terrorism and Irregular Warfare
  – Deter and Defeat Aggression
  – Provide a Stabilizing Presence
  – Conduct Stability and Counterinsurgency Operations
  – Conduct Humanitarian, Disaster Relief, and Other Operations

• **Joint Force**
  – … resist the temptation to sacrifice **readiness**
  – … **limited resources may better tuned** to their requirements
  – … encourage **innovation in concepts of operation**
Synthetic Environments for Assessment

Bottom Line: SE’s Implement Top-Down Approach to Science
Synthetic Environment for Assessment (SEA)

Working Definition of SEA:
Modeling and simulation experiments with human operators to estimate mission effectiveness in realistic mission scenarios under “interesting” perturbations.
The Problem Space

For many domains of interest, requirements shift too fast for the conventional “research, design, build, test” cycle of acquisition

– What is the impact of new capability “x” on training, team performance, retention, etc?
– Given new mission profile “y,” what new capabilities are required for team T to meet performance standards?

This is what Simulation Based Acquisition hasn’t solved… until now

– SEA is an architecture that allows interoperable models to be reconfigured in infinitely many ways to test many different hypotheses
– SEA is not a “system” that you plug models into (like SAF)
– SEA facilitates validated collections of models that provide calibrated simulations for testing new ideas and concepts.
## SEA Impacts Multiple Levels of the Acquisition Process

Provide objective assessment and trade-offs of alternative real options in terms of total ownership cost in the context of usability and effectiveness
- To manage independent and dependent variables in simulation
- Include acquisition, training, logistics, maintenance, replacement, retirement

<table>
<thead>
<tr>
<th>Operations</th>
<th>- CONOP (re)formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Estimates of readiness and robustness</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>- Build confidence in revolutionary designs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Modular approach to scale</td>
</tr>
<tr>
<td></td>
<td>- Quantify cost/benefit of candidate designs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training</th>
<th>- Valid benchmarks with metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Blur the distinction between training and operations</td>
</tr>
<tr>
<td></td>
<td>- Operationalize the phrase “train as you fight”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science &amp; Technology</th>
<th>- Common tool for cross/multi-disciplinary work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Complex scenarios for model building, theory testing</td>
</tr>
</tbody>
</table>
Use Cases for SEA in Support of Acquisition

<table>
<thead>
<tr>
<th>User Groups</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Technology</td>
<td>Hypothesis testing, theory development</td>
</tr>
<tr>
<td></td>
<td>Concept exploration, trust building</td>
</tr>
<tr>
<td>Acquisition Professionals</td>
<td>New technology testing</td>
</tr>
<tr>
<td></td>
<td>Risk identification</td>
</tr>
<tr>
<td></td>
<td>Design space exploration</td>
</tr>
<tr>
<td>Analysts</td>
<td>Doctrine analysis</td>
</tr>
<tr>
<td></td>
<td>Testing new organizational structures</td>
</tr>
</tbody>
</table>
Priority Steering Council
Human Systems

• **Big Ideas**
  
  – **Training:** Enable Engineering & Assessment for Joint Mission Effectiveness
    – Baseline Effectiveness Using Realistic Mission Training Scenarios
    – Extend Mission Training Scenarios to Joint Missions
    – Provide Synthetic Environments for Collaboration with Industry, Others
  
  – **Interface:** Natural interfaces to manage multiple scale, multiple role systems
    – Develop common representation schemes for system/data interaction
    – Develop natural language and gestural system interaction
    – Develop operator state monitoring technology
Training for Readiness; Interface for Effectiveness

**Training for Readiness**

**Problem: Complex Evolving Threats Outpace Readiness Training**

- Warriors train for tomorrow’s fight using yesterday’s technology, methods, and strategies
- Current training scenarios not matched to evolving mission complexity and dynamics
- Warfighters are trained to doctrine -- fight strategically and dynamically to meet new threats
- Training is costly
  - Live systems deplete inventory, consume fuel, require maintenance & wear out
  - Ranges & role players are expensive – lack fast responsiveness to changing scenarios
  - Training ranges not designed for flexible scenarios and throughput is inadequate

**Interface for Effectiveness**

**Problem: Current system operation is rigidly data-centric vice flexibly information-centric**

- Modern technologies exacerbate critical manning and talent pool deficiencies by ignoring role of Mission, Task & Context – Moving & presenting data vice information
- Current adaptive planning tools do not allow rapid “course of action” analysis and generation
- Information displays typically non-interactive, adapting little to changing needs
- Data quantity will continue to increase nonlinearly
Training Technology End States

- Seamless Virtual/Constructive training
- C2 with tactical players
- Quantified human system performance with mission effectiveness metrics
- Safe, live virtual constructive training
- Individual adaptive team training
- Increased Complexity
- Increased players
- Timely and effective training reflecting dynamic operational insights/challenges
- Personalized, adaptable, point of need training
- Integrated regional ally mission preparation
- Credible synthetic players: persistent, generative, robust
- Continuous, real time, high fidelity training with LVC multinational partnering – when and where needed
Interaction Quality

Mission Effectiveness (Re: Current)

- Task-centric interfaces for increased speed and accuracy of decisions
- Model context and decision space
- Situation sensitive adaptive interface

- Mission-centric automated information analyses (e.g. prioritized COA recommendations)
- Operator state driven tailored information

- Context sensitivity to Commander’s intent
- Common control station for UxS
- Tactically believable agents

- Natural language dialogue
- Influence operator state

- Social Cognitive Architectures for synthetic teammate development
- Hybrid force demonstration for multiple UxVs via natural man-machine interactions
Proposed Criteria for SEA

- Simulation in Form, but Fidelity Traded for Flexible Experimental Use
- Support Multiple Task Scenarios within the Environment, functionally equivalent to Operational Tasks
- Scenarios linked to Naval Mission Effectiveness Metrics
- Calibrated Metrics Using Naval Operators
- Distributed to Broad Science and Technology Community

Enable an Engineering Approach to Unified System Design, Training, and Operation.
NDIA Human Systems Mission Statement:

To promote the exchange of technical information and discussions between government, industry, and academia, and the expansion of research and development in areas related to the human as a system whose performance must be integrated into any system of systems.

Visit!

www.defenseinnovationmarketplace.mil

The Defense Innovation Marketplace is a centralized online resource to better connect industry with government customers and enhance innovation.
BACKUP
SEA Example
Complex Command and Control

Multi-unit coordination
- Warfare Cmdr (AS)
- SAG Cmdr
- TAO
- AIC
- VASTAC
- ASTAC
- NCTE
- JSAF
- DMI Maritime Console
- Scenario generation / threat representation

Unit control
- GDO/OOD
- COVE
- NSST
- SCAT 1 ..n
- CIWS Op
- Gun team
- SWC
- ASTAC
- SCARC
- ATO
- MRT3
- BRASS
- RATT
- TOFT
- Pilot

Weapons
- 25mm / 50 cal / M240
- CIWS
- NAWC TSD
- VAST
- CIWS Op
- 5 inch / 76MM / 57 MM
- VAST
- Gun team
- SO
- Hellfire
- M240 / Gau-21
- NPS / COTS
- Bombs / MSL / Guns

Gray – Distributed Training
Green – FAC/FIAC CoC
Yellow – Existing ONR Technologies
Red – Potential Technologies
Blue – Existing Trainers
Design “Search Space” of Alternatives
Live and Synthetic Training

“This is how we fight”
Summary

• Engineering and Assessment for Joint Mission Effectiveness
• Natural interfaces to manage multiple scale multiple role systems