Engineered Resilient Systems
Power of Advanced Modeling and Analytics in Support of Acquisition

18th Annual NDIA Systems Engineering Conference
October 28, 2015

Jeffery P. Holland, PhD, PE (SES)
ERS Community of Interest (COI) Lead
Director, US Army Engineer Research and Development Center (ERDC)
Director, Research and Development, US Army Corps of Engineers
SecDef S&T Priorities: Communities of Interest

17 cross-cutting, S&T areas staffed with Senior Leaders and Subject Matter Experts from the Services and Defense Agencies

- Each COI led by a Steering Group (SES) Lead from across the Services and OSD
- Specific cross-cutting S&T areas where there is substantial investment across multiple Components.

ERS COI Steering Group

Dr. Jeffery P. Holland  
(Steering Group & Army Lead)  
Col(S) K. Colin. Tucker  
(Air Force Lead)  
Mr. Robert A. Gold  
(OSD Lead)  
Dr. Thomas H. Killion  
(Navy Lead)
### Problem: Acquisition Driven by a Linear, Process-heavy Engineering Environment

#### Linear Acquisition Process
- Lacks adaptability to changes
- Stove-piped workforce and data sources
- Information shared via static documents
- Limited Reuse

#### Negatively impacts:
- Response time
- Time & delivery
- Budget
- …etc.

<table>
<thead>
<tr>
<th>Operational</th>
<th>FIXED 75% Lifecycle Costs Material Solution</th>
<th>TECHNOLOGY DISRUPTION</th>
<th>UNSTABLE PERFORMANCE</th>
<th>COST &amp; SCHEDULE OVERRUN</th>
<th>LIMITED EFFECTIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering &amp; Cost</td>
<td>Pre-System Acquisition</td>
<td>Systems Acquisition</td>
<td>IOC</td>
<td>Sustainment</td>
<td></td>
</tr>
<tr>
<td>USER NEEDS</td>
<td>Material Solution Analysis</td>
<td>Technology Development</td>
<td>Engineering &amp; Manufacturing Development</td>
<td>Production &amp; Deployment</td>
<td>Operations &amp; Support</td>
</tr>
<tr>
<td>TECHNICAL OPPORTUNITIES &amp; RESOURCES</td>
<td>Materiel Development Decision</td>
<td></td>
<td>Post-PDR A</td>
<td>Post-CDR A</td>
<td>LRIP/OT&amp;E</td>
</tr>
<tr>
<td>JCIDS</td>
<td></td>
<td></td>
<td>Materiel Changes</td>
<td>Design Changes</td>
<td>Requirements Changes</td>
</tr>
</tbody>
</table>

**Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.**
ERS Goal: Quantify and Buy Down Acquisition Risk

Problems

- Increasing Costs
- Rate of change and uncertainty

- Rapid, emergent threat
- Requirements creep
- Adaptability deficiency
- Life extension demand
- Technology disruptors
- Workforce decline/expertise

New Technology Approach

Empower rigorous risk analysis

- Requirements Generation
- Analysis of Alternatives
- Lifecycle Intelligence
- Virtual Prototyping

Mitigate Issue:
28% Life Cycle Cost vs. 72% Life Cycle Cost

National Academies Press (NAP) 2008
Significant Leverage of DoD S&T Investments to Radically Improve Acquisition

ERS LEVERAGES YEARS OF MAJOR DOD S&T INVESTMENTS

Advanced Modeling
Simulation
High Performance Computing
Mathematical Optimization
Open & Trusted Systems

2012

ERS INTEGRATED CAPABILITY

Open Architecture Implementation
Lifecycle Intelligence & Modeling
Data Access & Retention
Knowledge Management
Security

Linked to Acquisition Processes
Big Data Analytics & Visualization

Technologies Proved to Impact Decision-Making Within Current Acquisition Processes

ERS is the first integration of modern computational engineering tools and technologies that directly impact DoD Acquisition environments.
ERS Attributes

**Tradespace Tools & Analytics**
- ARCHITECTURE TRADE ANALYSIS
- ADVANCED MODELING
- ENV REPRESENTATION
- MISSION CONTEXT
- Analytics
- other

**Integrated Capability and Workflow**
- ERS Cloud
  - 10,000X Productivity Improvement In AoA
- HPCMP & S&T Resources

**Requirements Generation**
- Fully Explore & Identify KPPs

**Analysis of Alternatives**
- Reduces alternatives from thousands to tens or less
- Rapidly Distill Many More Alternatives

**Virtual Prototyping & Evaluation**
- RAPID PROTOTYPING & RESPONSE
  - Virtual Warfighting, Reduce Prototyping Time & Costs

**Decision Support**
- Big Data Analytics & Visualization

**Open Architecture**
- Knowledge Management
- Data Retention

- MOVE ENGINEERING LEFT
- TRADE ANALYSIS
- ENV REPRESENTATION
- MISSION CONTEXT
- Analytics
- other

**ERS Env**

**Analytic Tools**
- Design Req
- Feedback
- Adv M&S

**ACQ TEAM**

**RAPID PROTOTYPING & RESPONSE**

**ERS Overview - NDIA SE Conference - October 2015**

Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.
ERS Powerful Tradespace Toolset

ERS Tradespace Concept

- Architecture
- Tradespace Analytics
- Advanced Modeling
- Environmental Rep.
- Mission Context

ERS CLOUD COMPUTING ENVIRONMENT (CCE)

10,000X Improvement in productivity in Analysis of Alternatives

Efficiently discover key performance parameters (KPPs)

HPCMP and S&T Resources

Cost models -ilities
...other

Currently Applied ERS Advanced Tradespace Analytics: Two Levels

Trade lite
- Early concept tool
- Functional / component breakdown
- Explore tradespace edges

Expand Tradespace Fully
- Performance Assessments
- Performance Metrics
- High-fidelity Models
- Parameter Sweeps: Design Variations

TRADEstudio
- Highly computational
- Sifts through millions of designs
- Refined set of specifications for viable design solutions
Technology Transition to DoD

**PRODUCT DISTRIBUTION PROCESS**

1. **DIRECT PRODUCT DELIVERY**

2. **HOSTED SERVICES**
   (to DoD, Industry, Academia)
   Access to ERS tools via configured environment on ERS Cloud

3. **FEDERATED SERVICES**
   ERS Cloud interacts with Industry and Academic Clouds to accommodate models with IP or licensing restrictions.

**THREE CURRENT SERVICES**

- **Tools and Models**
- **Data and Information**
- **Virtualized Environments**

**ERS CLOUD**

Cloud Computing Environment (CCE)

**ERS USER COMMUNITY**

DoD, Industry, Academia

**DEVELOPMENT TEAM**

DoD, Industry, Academia

Distributed product development teams

**ERS OVERVIEW**

- Engineering Design Teams
- PEOs/PMs/Industry Cloud Services

**ERS OVERVIEW**

- Secure DoD Environment
- ers.hpc.mil

**ERS OVERVIEW**

- DEVELOPMENT TEAM
- PRODUCT DISTRIBUTION PROCESS
- ERS USER COMMUNITY

**ERS OVERVIEW**

- Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.
DoD Acquisition Impact

**US Navy NSWCCD**

**ERS Ships Demonstrations**

- **LX(R) AoA**
  - 22,000 alternatives analyzed in 6 weeks

- **Small Surface Combatant (SSC)**
  - 19M designs analyzed in 3 months
  - resulting in 270K feasible alternatives

- **Submarine Class**
  - Virginia-class replacement - Currently preparing analysis tools

**US Army AMRDEC**

**ERS Rotorcraft Demonstration**

- Evaluated Boeing’s IRAD-produced, CH-47 rotor blades

- **Full, accurate assessments achieved with ERS tools & CREATE Helios models.**

**US Air Force AFLCMC/AFRL/ACC**

**Performance and Mission Demonstrations**

- **TX-Trainer:** High fidelity simulations for performance testing

- **ISR Futures:**
  - Powerful ISR Mission Assurance Analytics
  - Across DoD sensor suite and platforms

- **USAF Cost Capabilities Analytics:** Cost-modeling capability in ERS tradespace.
Building Major Industry Partnerships

Industry Partners are formally engaged in ERS development.

Architecture Working Group Participants
Access to HPC Resources for design projects
ERS tradespace analysis in exploratory platform designs
Analysis of very big data
Test upgraded capabilities on existing platforms

BAE Systems
Lockheed Martin
Raytheon
Phoenix Integration
Kitware
NDIA
Boeing
ERS FY16-17 – Mapping to Acquisition Processes

DEFENSE ACQUISITION SYSTEM (DAS)
- 5 DAS Phases of Trades Analysis support – Full DAS Coverage
- Environment modeling supporting vehicle / ship / aircraft analysis
- HPC support to Trades and AoA analyses
- HPC-based Analytical modeling supporting stealth, structures, survivability, manufacturability, performance, security (confidentiality, integrity, availability) and resilience (detect, defend, respond, recover)

JCIDS
- Scalable Capability Set Generation
- HPC Support for Capability Based Analysis

INDUSTRY
- Meeting requirements
- Innovation
- Efficient, effective design
- Integrity of IP

OPEN ARCHITECTURE IMPLEMENTATION
- MODELS
- MULTI-DIMENSIONAL TRADESPACE ANALYTICS
- HIGH PERFORMANCE COMPUTING
- BIG DATA ANALYTICS & VISUALIZATION
- IP PROTECTION
- KNOWLEDGE MANAGEMENT
- SECURITY

TOD
Target of Design

PPBES
- Budget Alternative Assessments
- Budget / Schedule Trades

USERS
- Engineering community
- Analysts
- Warfighters
- Researchers

ERS Overview - NDIA SE Conference - October 2015
Distribution Statement A – Approved for public release by DOPSR. Distribution is unlimited.
ERS Adoption Strategy

2012 – 2014
TECHNOLOGY DEVELOPMENT & EXPERIMENTATION
- Initial Tradespace Tools
- Prototype Knowledge Management Environment
- Initial Integrating Architecture
- Linked Physics-based Models

2015 – 2016
IMPLEMENTATION WITHIN DOD PROJECTS
- LX(R) • Small Service Combatant • CH-47 Rotors • Aero Fixed-Wing • Ground Vehicles • Naval Weapons Sys Modeling
- Cloud Computing Environment (CCE) • Support New Platforms

2017 – 2019
CAPABILITY INTEGRATION TESTING AND FIELDING
- User-configured Analytics
- Risk Representation and Mitigation
- Environmental Simulation Anywhere on Earth
- Manufacturability, Producibility & Life Cost Tools
- Mission Context Tools

2020 – 2024
FULL TRANSITION TO ACQUISITION PROCESSES
- Modeling of entire acquisition cycle
- Validated cost representation
- Virtual prototyping of all materiel alternatives
- Cognitive computing

Trade Analysis at Increasing Echelons

- Completed
- Current Work & Partner Development
- Initiated & Continuing
- Near Future and Outyears

ERS V1.X ERS V1.0 ERS V2.0 ERS V3.0 ERS V.4.0
- Modeling of entire acquisition cycle
- Validated cost representation
- Virtual prototyping of all materiel alternatives
- Cognitive computing

Full Cloud Capability • Secure Access • System Trust • Documentation • User Training & Help
## Future Work Investments

### Significant Challenges

<table>
<thead>
<tr>
<th>Technical Area</th>
<th>Challenges 2016 - 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Virtual Prototyping</strong></td>
<td>Physics-based modeling, environmental influences and variations, Universal Task List (UTL) unit and system behaviors, mission immersion</td>
</tr>
<tr>
<td><strong>Modeling Sub-systems</strong></td>
<td>Dependencies, category theory, composition, reconfigurable and dynamic design</td>
</tr>
<tr>
<td><strong>Material Life and Failure</strong></td>
<td>Material models, material strength, thermal models, etc.</td>
</tr>
<tr>
<td><strong>Lifecycle Cost Modeling</strong></td>
<td>True cost analysis over sustainment</td>
</tr>
<tr>
<td><strong>System-of-system Analysis</strong></td>
<td>Identify and describe system of systems behaviors, components, structures, and contribution to joint and universal tasks</td>
</tr>
<tr>
<td><strong>Modeling Manufacturing</strong></td>
<td>Identify and generate manufacturing processes and assembly operations capable of predicting time and cost of manufacturing</td>
</tr>
</tbody>
</table>
ERS Track Presentations
Leadership - Government - Industry

**Wednesday, October 28**

**Engineered Resilient Systems (ERS) Overview - 2015**

Dr. Jeffery P. Holland (SES) - ERS Steering Group Lead

**Complexity: Driver of Systems Engineering**

Ms. Kristen J. Baldwin (SES) – Principal Deputy, ODASD (SE)

**US Air Force Acquisition Challenges and Directions**

Mr. Jeff H. Stanley (SES) – Assoc Dep Secy, Air Force ST&E, SAF-AQ

**ERS Demonstration: LX(R) Analysis of Alternatives**

Mr. Adrian J. Mackenna – NSWC Carderock

**Application of ERS to Submarine Design**

Dr. Joseph T. (Tim) Arcano, Jr. (SES) – Technical Director, NSWC Carderock

**Impact of Modeling and Simulation on Rotorcraft Acquisition**

Dr. Marty A. Moulton - Branch Chief; DIR, USA RDECOM

**Engineered Resilient Systems Architecture**

Dr. David C. Stuart (for Dr. Cary Butler) - ERS Architecture Lead

**Simulation Support for Early Design, DDG 1000 Adv Gun Sys**

Mr. Brent Baker - Senior Simulations Engineer; BAE Systems

**Support of ERS by the DoD HPCMP CREATE Program**

Dr. Douglass Post - CREATE Assoc Director, HPCMP

**Large-scale Tradespace Capabilities**

Dr. Tommer R. Ender – Sr. Research Engineer, GTRI

**Engineering Data Visualization Efforts for ERS**

Dr. Patrick O’Leary – Asst Dir Scientific Computing, Kitware

**Environmental Simulation in Support of ERS**

Mr. David R. Richards - ERS Technical Director

**Next Generation 463L Cargo Pallet Panel**

Moderator: Mr. Clay Mims, AFLCMC/WNZ

**Thursday, October 29 (morning session only)**

**Engineered Resilient Systems Government & Industry Panel**

Moderator: Dr. Owen J. Eslinger - ERS Program Manager
Questions & Answers