Engineered Resilient Systems

Power of Advanced Modeling and Analytics in Support of Acquisition

18th Annual NDIA Systems Engineering Conference
October 28, 2015

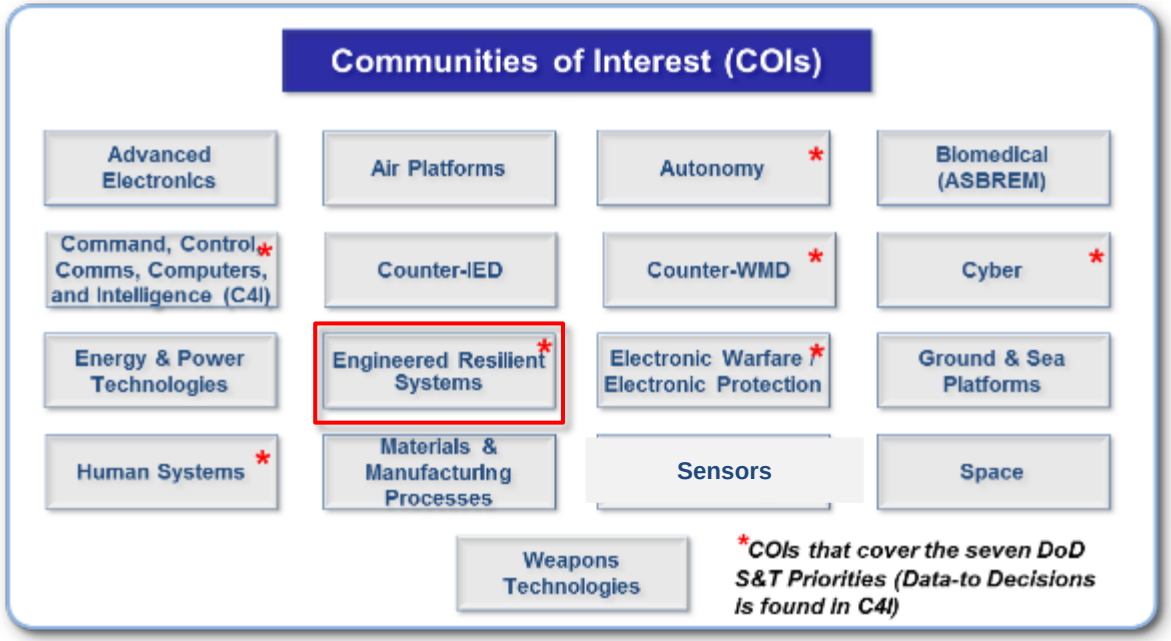
Jeffery P. Holland, PhD, PE (SES)
ERS Community of Interest (COI) Lead
Director, US Army Engineer Research and Development Center (ERDC)
Director, Research and Development, US Army Corps of Engineers

ERS VIDEO

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

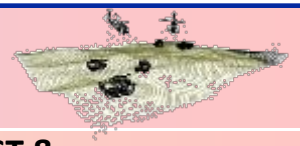
- **Each COI led by a Steering Group (SES) Lead from across the Services and OSD**
- **Specific cross-cutting S&T areas where there is substantial investment across multiple Components.**

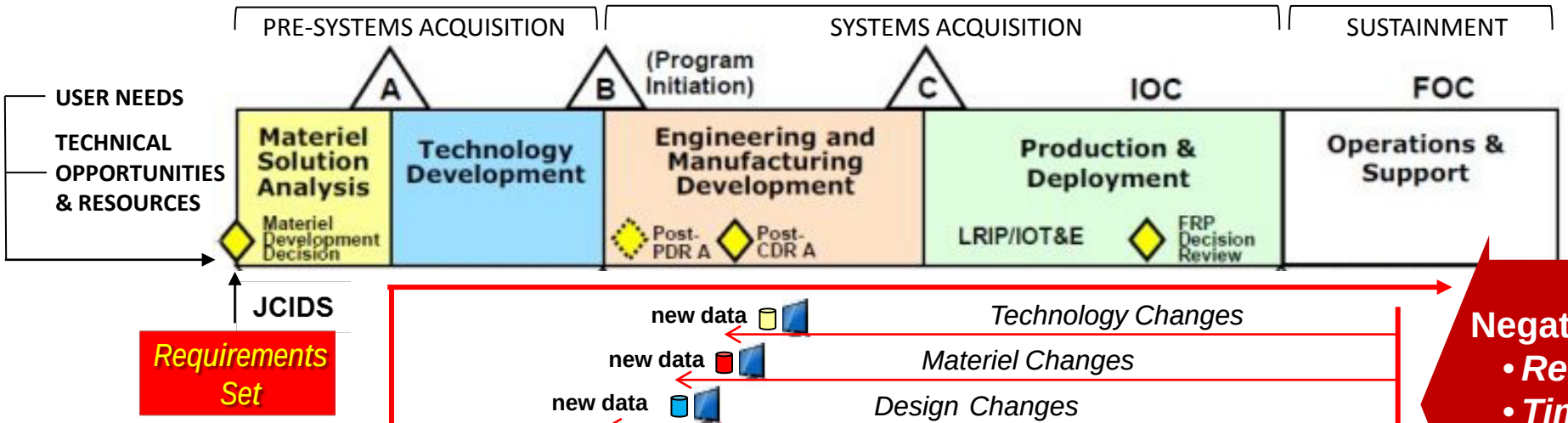


ERS COI Steering Group

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*

Operational		**EVOLVING THREAT**	**MISSION CHANGE**		
Engineering & Cost	**FIXED** 75% Lifecycle Costs Material Solution	**TECHNOLOGY DISRUPTION**	**UNSTABLE PERFORMANCE**	**COST & SCHEDULE OVERRUN**	**LIMITED EFFECTIVENESS**



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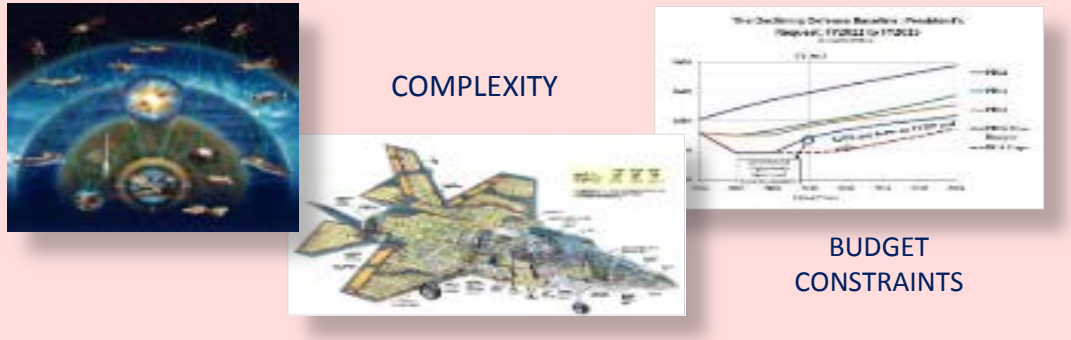
Negatively impacts:
- ***Response time***
- ***Time & delivery***
- ***Budget***
- ***…etc.***

- ***Linear acquisition process***
- ***Lacks adaptability to changes***
- ***Stove-piped workforce and data sources***
- ***Information shared via static documents***
- ***Limited Reuse***

ERS Goal: Quantify and Buy Down Acquisition Risk

Problems

- *Increasing Costs*
- *Rate of change and uncertainty*

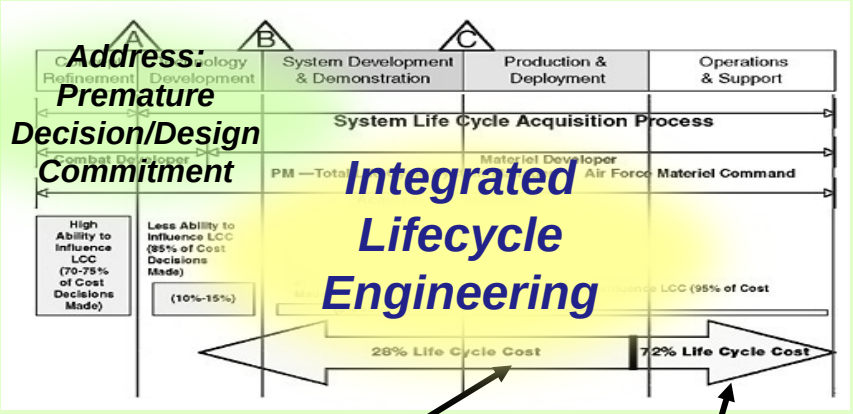


- *Rapid, emergent threat*
- *Requirements creep*
- *Adaptability deficiency*
- *Life extension demand*
- *Technology disruptors*
- *Workforce decline/expertise*

New Technology Approach

Empower rigorous risk analysis

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



Address:
Premature Decision/Design Commitment

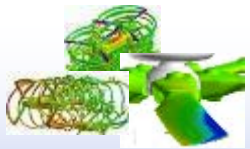
Integrated Lifecycle Engineering

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

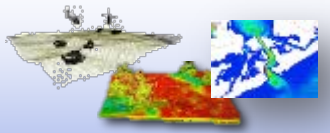
National Academies Press (NAP) 2008

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

MODELS

MULTI-DIMENSIONAL TRADESPACE ANALYTICS

LIFECYCLE INTELLIGENCE & MODELING

HIGH PERFORMANCE COMPUTING

DATA ACCESS & RETENTION

BIG DATA ANALYTICS & VISUALIZATION

KNOWLEDGE MANAGEMENT

IP PROTECTION

SECURITY

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
…ilities
other

ERS Cloud

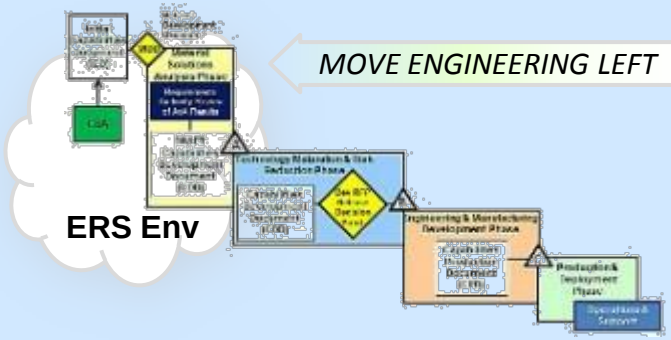
10,000X Productivity Improvement In AoA

HPCMP & S&T Resources

Integrated Capability and Workflow

Decision Support | *Big Data Analytics & Visualization* | *Open Architecture* | *Knowledge Management* | *Data Retention*

Requirements Generation



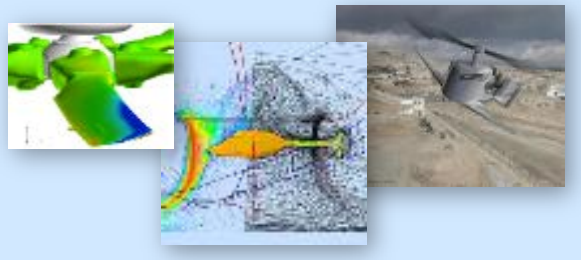
Fully Explore & Identify KPPs

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

ERS Powerful Tradespace Toolset

ERS Tradespace Concept

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

Cost models
-ilities
….other

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

Currently Applied ERS Advanced Tradespace Analytics: Two Levels

TRADElite

- **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

DEVELOPMENT TEAM

DoD, Industry, Academia

Distributed product development teams

PRODUCT DISTRIBUTION PROCESS

THREE CURRENT SERVICES

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

ERS CLOUD

Cloud Computing Environment (CCE)

ers.hpc.mil

Secure DoD Environment

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.

ERS USER COMMUNITY

DoD, Industry, Academia

Engineering Design Teams

PEOs/PMs/Industry Cloud Services

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

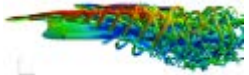
Submarine Class
Virginia-class replacement - Currently preparing analysis tools

US Army AMRDEC

ERS Rotorcraft Demonstration

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

BOEING



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

ERS and CREATE tools ready for transition to Future Vertical Lift program

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.

LOCKHEED MARTIN

BAE SYSTEMS

Raytheon Missile Systems

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

Lean Design®

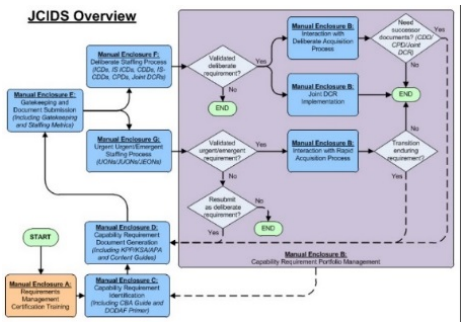
PHOENIX INTEGRATION

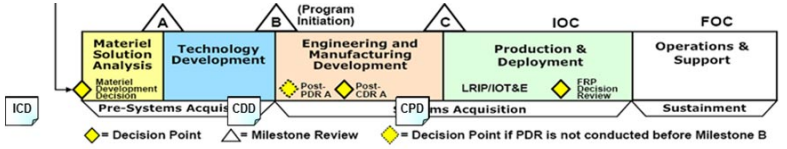
Kitware

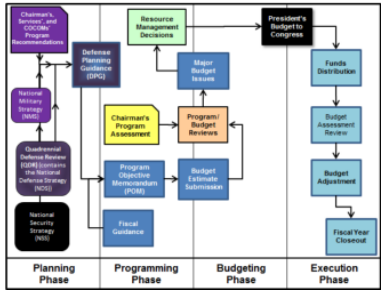
NDIA
National Defense Industrial Association

BOEING

ERS FY16-17 – Mapping to Acquisition Processes







JCIDS

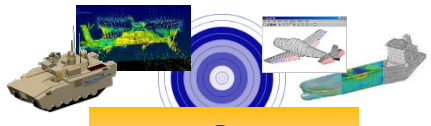
- Scalable Capability Set Generation
- HPC Support for Capability Based Analysis

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)

PPBES

- Budget Alternative Assessments
- Budget / Schedule Trades



TOD

Target of Design

INDUSTRY

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

OPEN ARCHITECTURE IMPLEMENTATION

MODELS

MULTI-DIMENSIONAL TRADESPACE ANALYTICS

LIFECYCLE INTELLIGENCE & MODELING

ERS

HIGH PERFORMANCE COMPUTING

DATA ACCESS & RETENTION

BIG DATA ANALYTICS & VISUALIZATION

IP PROTECTION

KNOWLEDGE MANAGEMENT

SECURITY

USERS

- Engineering community
- Analysts
- Warfighters
- Researchers

ENGINEERED RESILIENT SYSTEMS

ERS Adoption Strategy

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

2012 – 2014
TECHNOLOGY DEVELOPMENT & EXPERIMENTATION

- Initial Tradespace Tools
- Prototype Knowledge Management Environment
- Initial Integrating Architecture
- Linked Physics-based Models

Continuous Technology Advances, Insertions and Improvements

COMMUNITY EXPANSION

2015 – 2016
IMPLEMENTATION WITHIN DOD PROJECTS

- 2nd Gen Tradespace Tools - Ships, GV, AV
- Industry Linked to Architecture
- Initial Cost Modeling
- Initial Mission Tools

SHIPS ENGINEERS

LX(R) ● Small Service Combatant ● CH-47 Rotors ● Aero Fixed-Wing ● Ground Vehicles ● Naval Weapons Sys Modeling
Cloud Computing Environment (CCE) Support New Platforms →

Trade Analysis at Increasing Echelons →

ROTORCRAFT ENGINEERS

FIXED-WING VIRTUAL PROTOTYPING & PERFORMANCE

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

MISSION ANALYSIS MISSION ASSURANCE

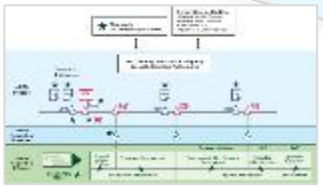
ERS V1.X *ERS V1.0* *ERS V2.0* *ERS V3.0* *ERS V.4.0*

CLOUD COMPUTING ENVIRONMENT

ERS ENGINEERED RESILIENT SYSTEMS

FULL DOD INTEGRATED CAPABILITY

DOD DECISION-MAKERS JCIDS, DAS, PPBE



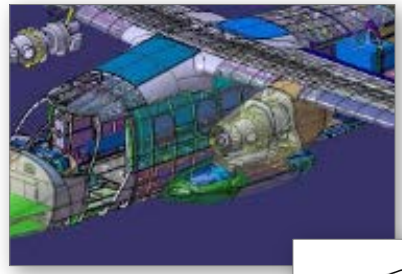
2020 – 2024
FULL TRANSITION TO ACQUISITION PROCESSES

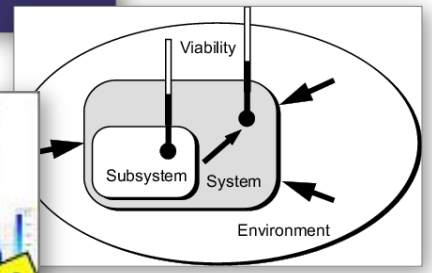
- Modeling of entire acquisition cycle
- Validated cost representation
- Virtual prototyping of all materiel alternatives
- Cognitive computing

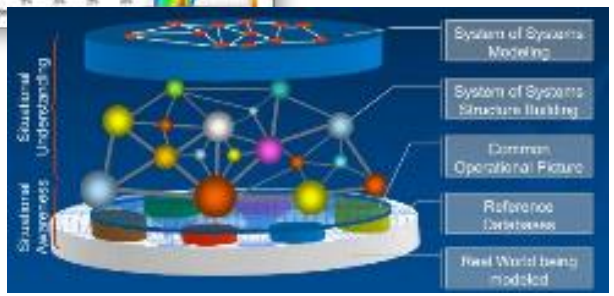
Full Cloud Capability ● Secure Access ● System Trust ● Documentation ● User Training & Help →

Future Work Investments
Significant Challenges

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







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