Engineered Resilient Systems

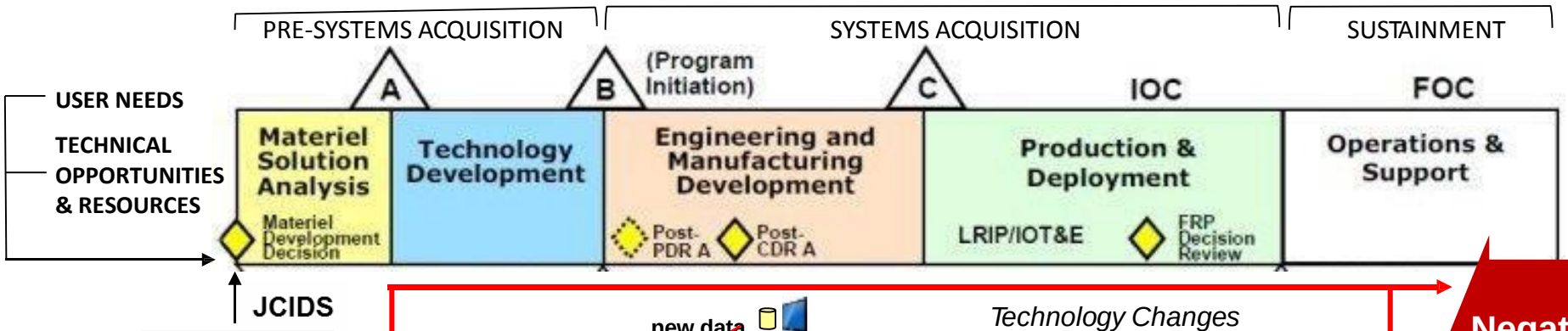
Advanced Analytics and Modeling in Support of Acquisition

David R. Richards
Lead Technical Director for ERS
US Army Engineer Research and Development Center (ERDC)
Research and Development, US Army Corps of Engineers

DISTRIBUTION A. Approved for public release per DoDD 5320.9: Case 17-S-1237

Historic Acquisition Process

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



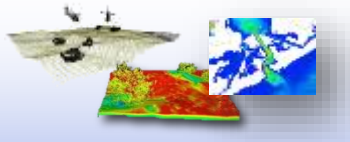
5000.1

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 Leverages Years of Major DoD S&T Investments

ADVANCED MODELING



CONTEXT SIMULATION

HIGH-PERFORMANCE COMPUTING

MATHEMATICAL OPTIMIZATION

OPEN & TRUSTED SYSTEMS

TRADES ANALYSIS

ANALYSIS OF ALTERNATIVES

ENGINEERING ANALYSIS

PROTOTYPING

DECISION SUPPORT & ANALYSES
TradeStudio
Analytic Tools

MODELS
CREATE
Envir Sims
Lifecycle Intel

OPERATIONS
UTL
Mission
Doctrine

CAPABILITIES ASSESSMENTS

DEVT TEST & EVALUATION

EMERGING RESEARCH
X-ARPAs
Research
Algorithms

KNOWLEDGE MGMT
Notebooks
Knowledge Hub
Wiki

HPC ***General Computing*** ***Amazon Web Cloud*** ***Enterprise Computing*** ***Embedded Computing***

Components of the ERS Design Environment

Tradespace Tools & Analytics

Policy / Regulation

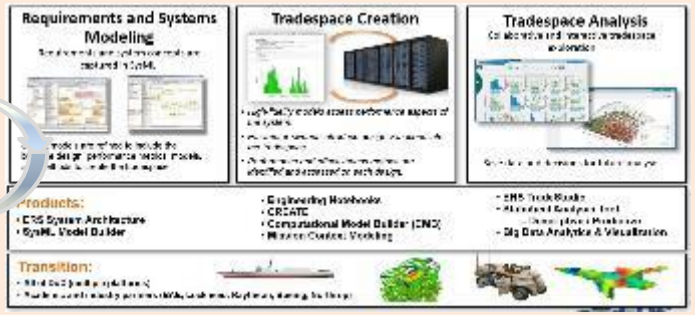
ARCHITECTURE
TRADE ANALYSIS
ADVANCED MODELING
ENV REPRESENTATION
MISSION CONTEXT
...ilities
other

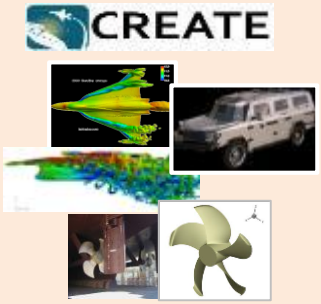
ERS Cloud

10,000X Productivity Improvement In AoA

HPCMP & S&T Resources

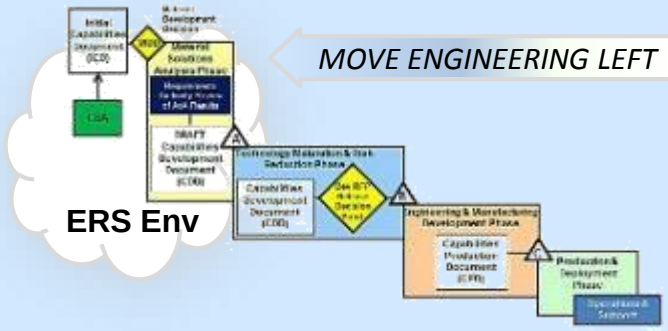
Integrated Capability and Workflow





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

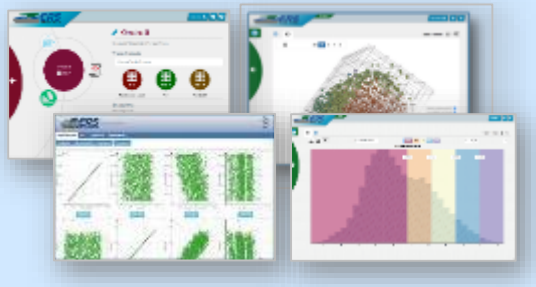
Requirements Generation



Fully Explore & Identify KPPs

Analysis of Alternatives

Reduces alternatives from thousands to tens or less



Rapidly Analyze Many More Alternatives

Virtual Prototyping & Evaluation

RAPID PROTOTYPING & RESPONSE

Virtual Warfighting, Reduce Prototyping Time & Costs

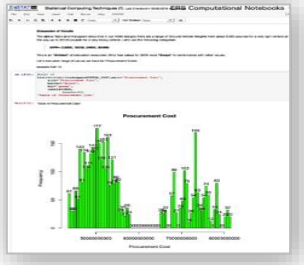
ERS Workflow

Requirements and Systems Modeling

Requirements and system concepts are captured in SysML.

SysML models are refined to include the baseline design, performance metrics, models, and methods to create the tradespace.

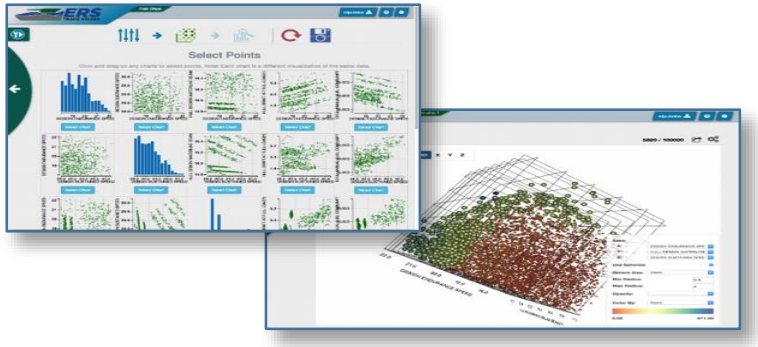
Tradespace Creation



- *High-fidelity models assess performance aspects of the system.*
- *Parameter sweeps introduce design variations into the tradespace.*
- *Performance and effectiveness metrics are identified and assessed on each design.*

Tradespace Analysis

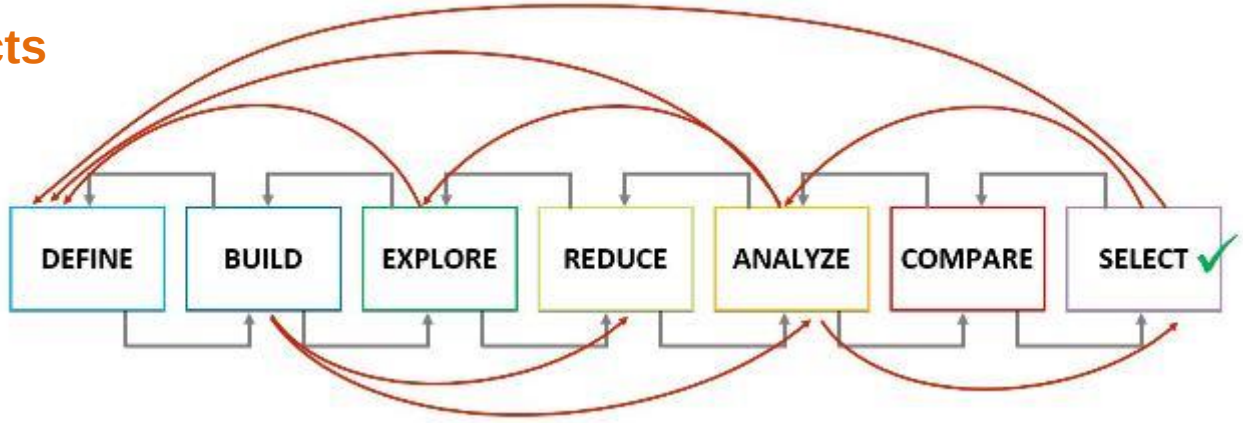
Collaborative and interactive tradespace exploration



Save data and decisions for future analyses

Major ERS System Engineering Products

- **ERS System Architecture**
- **Conceptual Model Builder**
- **Engineering Notebooks**
- **ERS TradeStudio**
- **Big Data Analytics & Visualization**
- **Environmental Simulation**

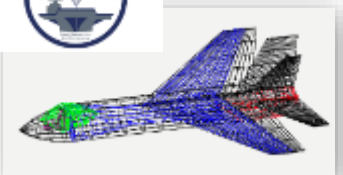


ERS Transition to Acquisition Community

US Navy
NAVAIR / NAVSEA

NGAD AoA Tool Enhancements

- AoA support
- HPC CREATE tools
- Tradespace tool enhancements



Submarine Virginia-class replacement

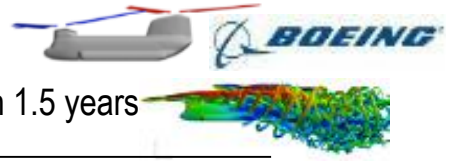
- Early-stage submarine design
- ERS trades analysis

Currently Developing ERS-supported *Advanced Design Space Exploration (DSE)*

US Army
AMRDEC/TARDEC

ERS Rotorcraft Design Adaptation

CH-47 rotor blade improvement;
Concept to LRIP in 1.5 years



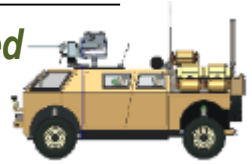
Gray Eagle flight performance predictions

- Full-scale aircraft with articulating control surfaces
- Trade & evaluate aircraft modification impact

Kestrel CFD Model Built [CREATE-AV] from scanned model

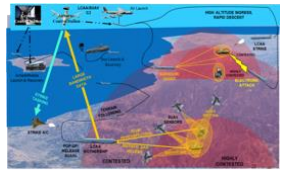
LRV Tradespace Expanded Design

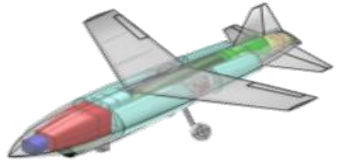
Expanded tradespace resulted in new design concept

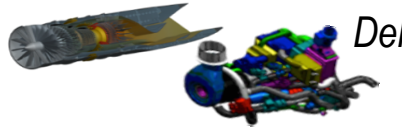


US Air Force
AFLCMC/AFRL

Low Cost Attritable Aircraft Technology



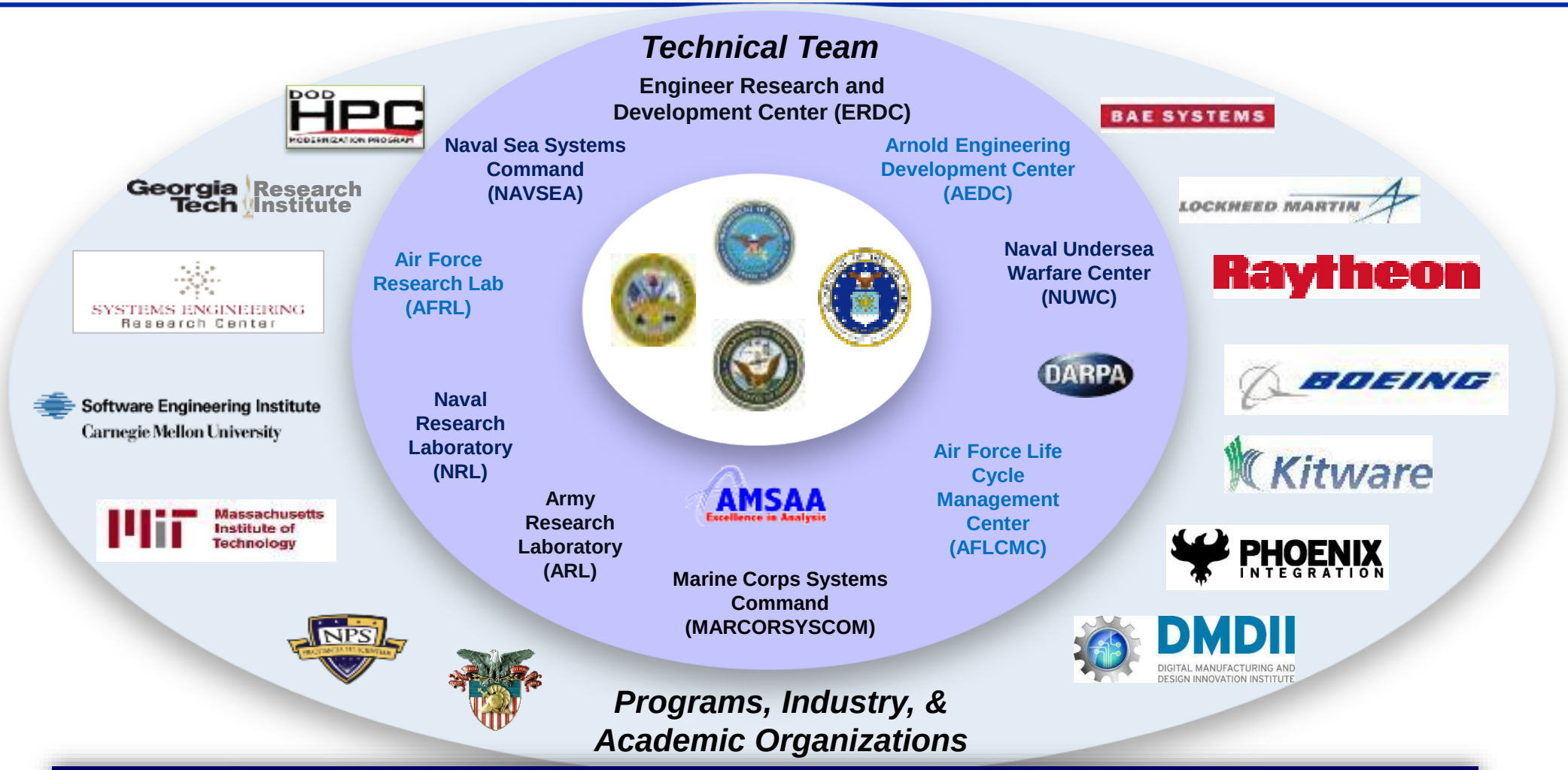




Delivering LCAAT Prototype

- Developing integrated toolset for rapid design creation
- Ability to trade many new designs rapidly
- Understanding conceptual design via advanced tradespace analytics and physics-based computations.

ERS Technical Team & Partners



Partnering with and Leveraging Key Program Executive Offices (PEOs), Program Managers (PMs), Industry and Academia

DISTRIBUTION A. Approved for public release per DoDD 5320.9: Case 17-S-1237

Connecting with Industry Partners

INDUSTRY IS KEY TO ERS

Industry connection to ERS tools and technologies is critical to success and acquisition reform

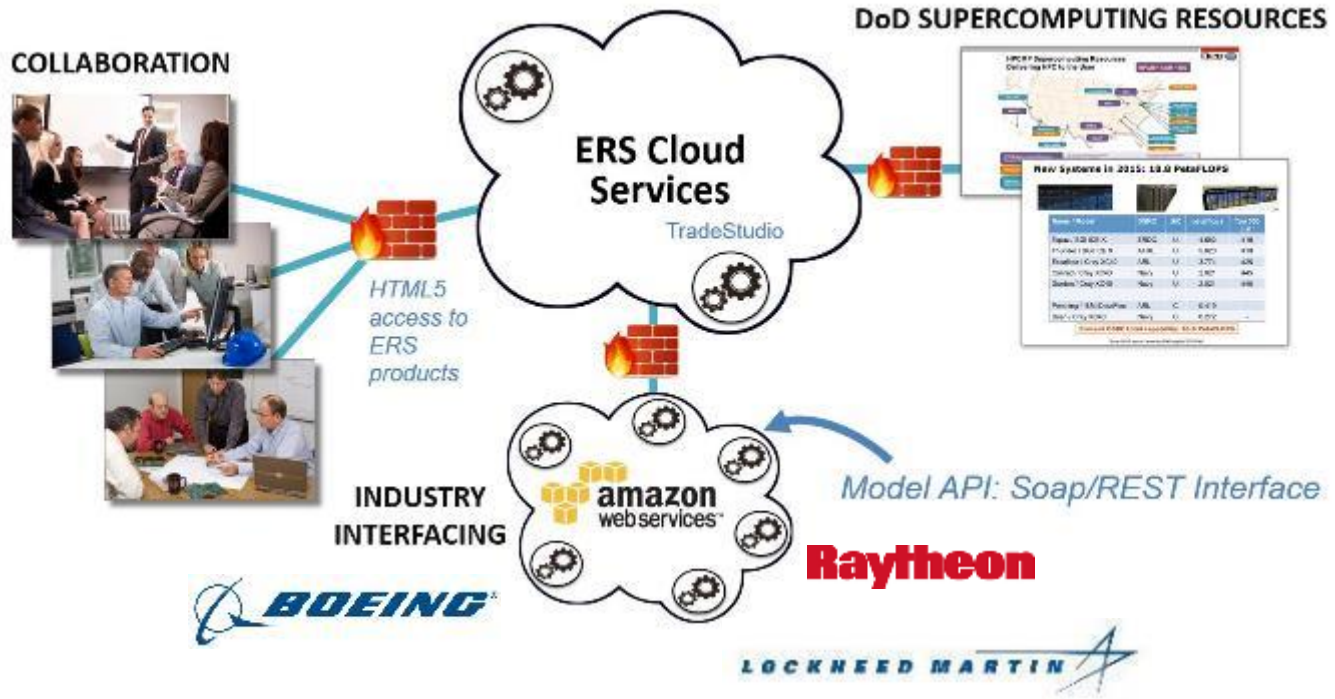
IP PROTECTION IS CRITICAL

Protection of Intellectual Property is provided via privately controlled Amazon Web Services

SECURITY ASSURANCE

Data in motion and at rest is protected via the ERS security architecture.

CURRENT EXPERIMENTATION



- Use 3rd party web service (such as AWS, Microsoft Azure, Google, etc.)
- Contractor info hosted / secured on 3rd Party system
- Government pulls from web service as needed

ERS Architecture Working Group
Government, Industry & Academia – Active Engagement

Industry Partners are formally engaged in ERS development.

Government-Industry-Academia Architecture Working Group

Nov. 18-19, 2015
Software Engineering Institute

August 24-25, 2016
ERDC ITL

Amazon Web Services Workshop

August 5-6, 2016
ERDC ITL

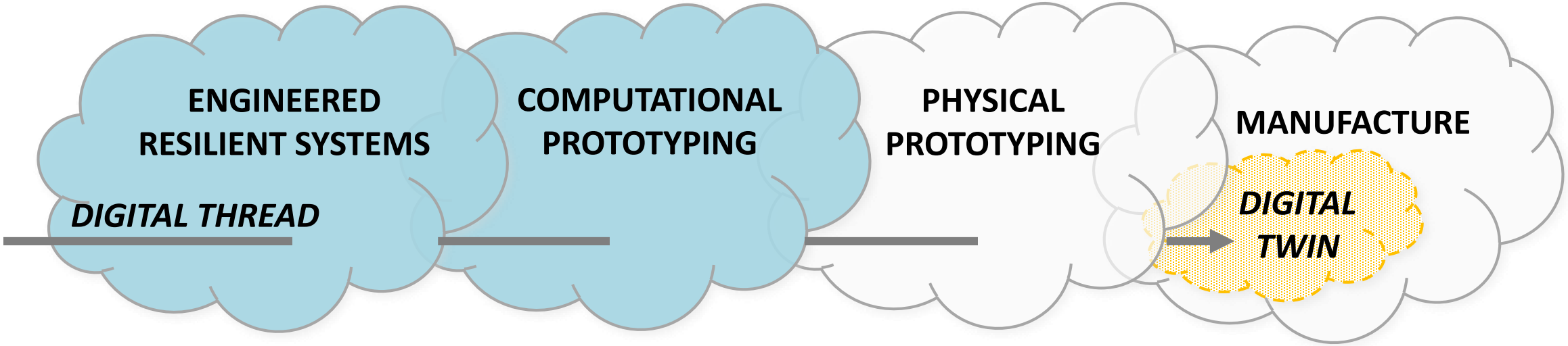
2017 Industry Workshop planned:
Business Processes, Technology Challenges

Digital Engineering Concept

ERS ENGINEERED RESILIENT SYSTEMS DEPARTMENT OF DEFENSE

COMPUTATIONAL PROTOTYPING ENVIRONMENT

CONCEPTUAL ANALYTICS → **REFINED ANALYTICS** → **BUILD & TEST** → **PRODUCE**



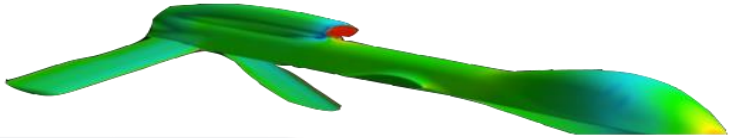
Data Storage *Search* *Rapid Retrieval* *Lessons Learned*

Knowledge Management *Security Classification Capability*

Basis of Computational Prototyping Environment

Engineered Resilient Systems

- Architectural Integration
- Tradespace Analysis
- Environmental Simulation
- Big Data Analytics
- Knowledge Management



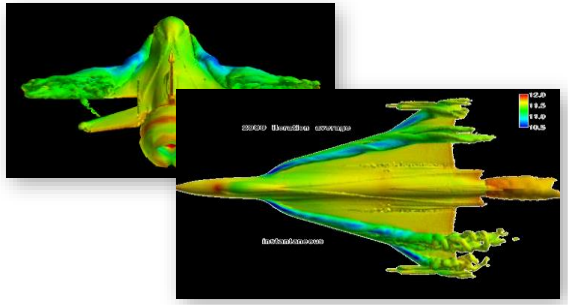
CREATE

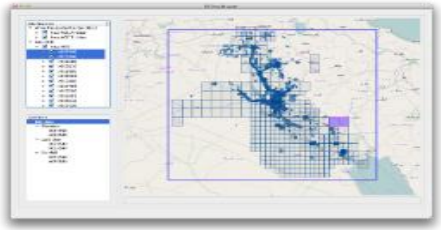
- High-Performance Computing
- High-Fidelity Computational Physics
- AV, Ships, GV, RF, MG
- Future Possibilities in Space and Electronic Warfare

AFSIM, SIMAF, EAAGLES, JSE, Digital Thread, Digital Twin

Computational Prototyping Environment

- Virtual Proving Ground for T&E
- Generic Workflow Automation for Army Platforms
- High-Fidelity Physics Supporting Tradespace Analysis
- 3D Physics-Informed, Gaming-Based Visualization



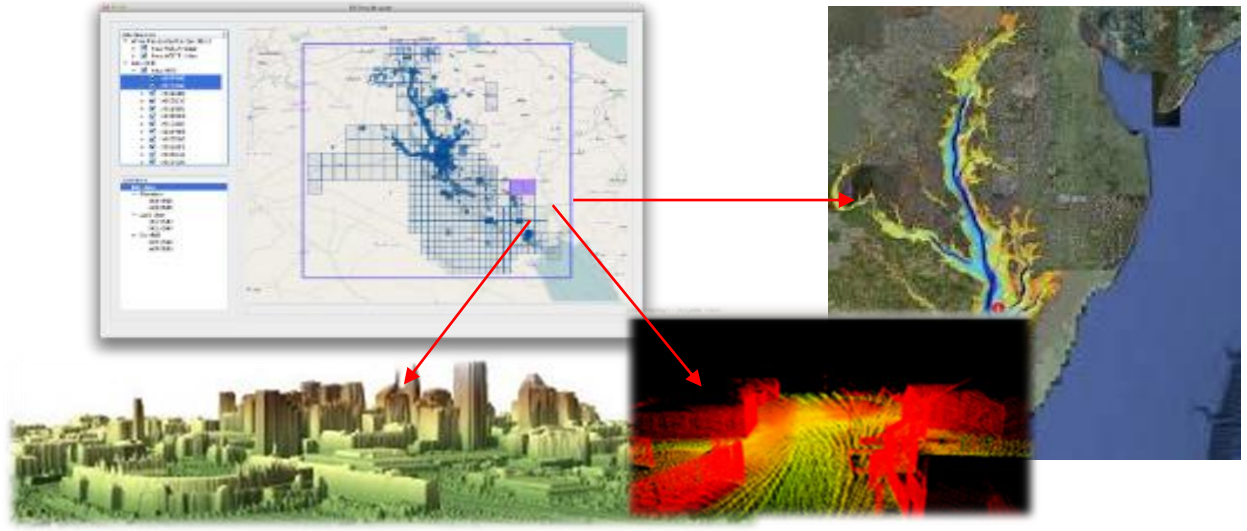


DoD Computational Prototyping

Key Features of the CPE

- Complement and reduce reliance on physical experimentation
- Fast, accurate – compute before bending metal
- Consider vast array of factors
- Understand and mitigate systems risk
- Inverse modeling to understand how to defeat concepts

Physics-based Models & Simulations



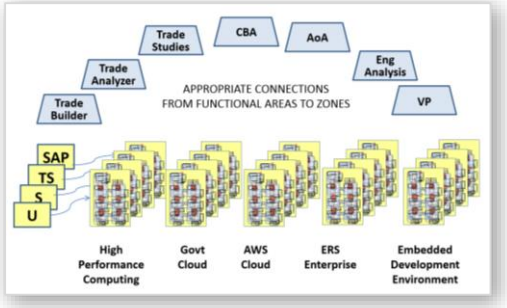
Mission Location

Physical Environment

S&T Work Remains

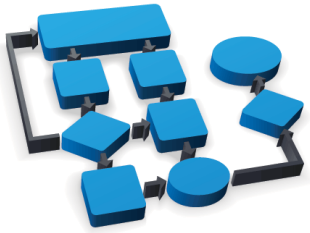
Critical S&T Focus Areas

Advanced Infrastructure



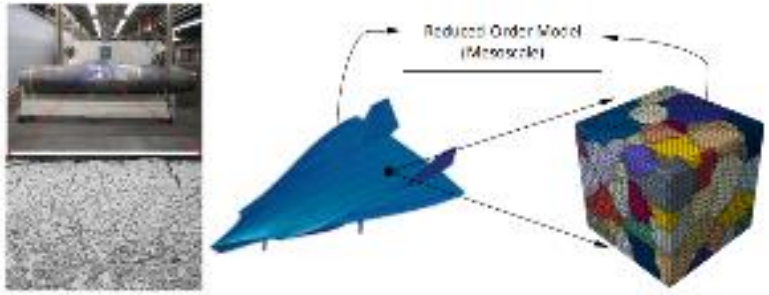
Computing infrastructure tailored to ERS-based decision making *for all data classification levels*

Workflow Automation



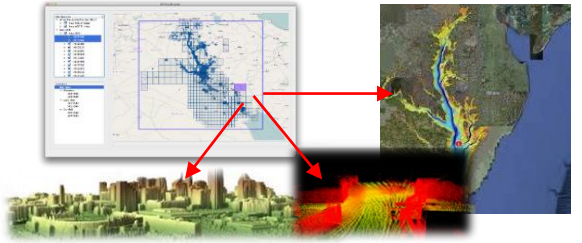
Automated workflows *over multiple critical domains*, in multiple security levels

Reduced Order Modeling



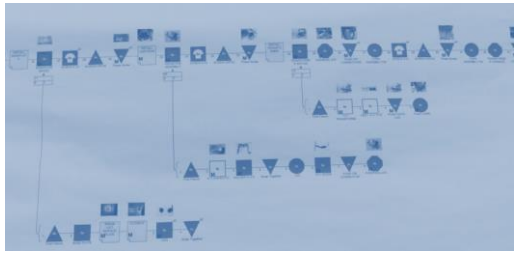
Need to incorporate techniques to reduce the computational complexity of high-physics models to reduce training time for all classes of users.

Environmental Simulation



Rigorous capability to *provide computational environmental conditions* to the warfighter anywhere in the world

Cost Modeling



ERS does not have a formal approach to cost modeling

Closing Comments

- **ERS Technologies are undergoing rapid development and are currently being used to support real acquisition decisions.**
- **Government, Industry and Academic partners are developing and using these tools.**
- **Computational prototyping is necessary to achieve acquisition reform**
- **S&T challenges remain**

***NDIA Conferences** (Engineering Systems and Science)*
2012, 2014, 2015, 2016, 2017

Industry has contributed greatly to the development of ERS.
Future partnerships on real, acquisition tasks are critical.

Questions