



Engineered Resilient Systems

Power of Advanced Modeling and Analytics in Support of Acquisition

NDIA 16th Science and Engineering Technology Conference

March 24-26, 2015

'Maps and Gaps in DoD COIs'

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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 Buys Down Acquisition Risk

Acquisition Challenges

Rapidly changing threats

Constant technology disruptors

Changing workforce

Better Buying Power 3.0
Achieving Dominant Capabilities Through Technical Excellence and Innovation

Achieve Affordable Programs

- Continue to set and enforce affordability caps

Achieve Dominant Capabilities While Controlling Lifecycle Costs

- Strengthen and expand "should cost" based cost management
- Build stronger partnerships between the acquisition, requirements, and intelligence communities
- Anticipate and plan for responsive and emerging threats
- Institutionalize stronger DoD level Long Range R&D Planning

Incentivize Productivity in Industry and Government

- Align profitability more tightly with Department goals
- Employ appropriate contract types, but increase the use of incentive type contracts
- Expand the superior supplier incentive program across DoD
- Increase effective use of Performance-Based Logistics
- Remove barriers to commercial technology utilization
- Improve the return on investment in DoD laboratories
- Increase the productivity of IR&D and CR&D

Incentivize Innovation in Industry and Government

- Increase the use of prototyping and experimentation
- Emphasize technology insertion and refresh in program planning
- Use Modular Open Systems Architecture (MOSA) to stimulate innovation
- Increase the return on Small Business Innovation Research (SBIR)
- Provide draft technical requirements to industry early and engage industry in funded concept definition to support requirements definition
- Provide clear "best value" definitions so industry can propose and DoD can choose wisely

Eliminate Unproductive Processes and Bureaucracy

- Emphasize Acquisition Executive, Program Executive Office and Program Manager responsibility, authority, and accountability
- Reduce cycle times while ensuring sound investments
- Streamline documentation requirements and staff reviews

Promote Effective Competition

- Create and maintain competitive environments
- Improve technology search and outreach in global markets

Improve Tradecraft in Acquisition of Services

- Increase small business participation, including more effective use of market research
- Strengthen contract management outside the normal acquisition chain
- Improve requirements definition
- Improve the effectiveness and productivity of contracted engineering and technical services

Improve the Professionalism of the Total Acquisition Workforce

- Establish higher standards for key leadership positions
- Establish stronger professional qualification requirements for all acquisition specialists
- Strengthen organic engineering capabilities
- Ensure the DoD leadership for development programs is technically qualified to manage R&D activities
- Improve our leaders' ability to understand and mitigate technical risk
- Increase DoD support for Science, Technology, Engineering and Mathematics (STEM) education

Continue Strengthening Our Culture of Cost Consciousness, Professionalism, and Technical Excellence

Distribution Statement A: Approved for Public Release

ERS Contributes to BBP 3.0

- Strengthen organic engineering capabilities
- Improve decision makers' ability to understand and mitigate technical risk
- Remove specific barriers to commercial technology utilization
- Improve the return on investment in DoD laboratories
- Increase the productivity of IR&D and CR&D
- Increase the use of prototyping and experimentation
- Use Modular Open Systems Architecture to stimulate innovation

ERS Investments

- Open Systems Architecture
- Advanced Modeling and Simulation
- Tradespace Tools & Analytics
- Virtual Prototyping
- Mission Context Tools
- Support T&E Community
- Knowledge Management
- Advanced Training Techniques

"We are also continuing to implement acquisition reform efforts, most notably through the Better Buying Power initiative that seeks to achieve affordable programs by controlling costs, incentivizing productivity and innovation in industry and government..."

Quadrennial Defense Review 2014





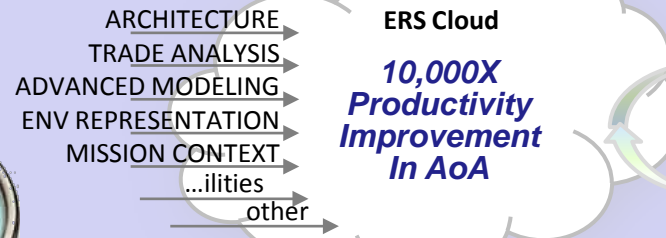
ERS Attributes

Tradespace Tools & Analytics

Integrated Capability and Workflow

Better Buying Power 3.0
Achieving Dismant Capabilities Through Technical Excellence and Innovation

- Enhance product and service affordability
- Reduce lifecycle costs
- Improve performance
- Reduce risk
- Improve quality
- Reduce waste
- Improve sustainability



HPCMP & S&T Resources

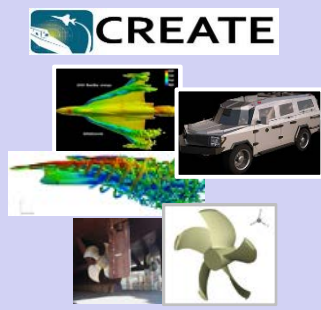
Workflow

Requirements & Systems Modeling Requirements and system concepts are captured in SysML.	Tradespace Creation High fidelity models assess performance aspects of the system. Parametric sweeps introduce design variations into the Tradespace. Performance metrics are identified and assessed on each design.	Tradespace Analysis Collaborative & interactive Tradespace exploration. Statistical analysis reduces visualization burden.	Alternative Analysis Tradespace is reduced to a small set of alternatives. Design alternatives are compared. Modeling & Simulation is used to assess designs and mission.
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Products:

- SysML Model Builder
- ERSTAT
- CREATE
- Conceptual Model Builder (CMB)
- Environmental Simulator (EnvSim)
- Machine Assisted Design
- Decision Dashboard
- FACTX
- Statistical Analysis Tool
- Descriptive
- Predictive
- Big Data Analysis & Visualization
- Analysis of Alternatives (AoA)
- Mission Context Analysis

Infrastructure:
Knowledge Management Environment (KME), Cloud Computing Environment (CCE), & Big Data Environment (BDE)



Decision Support

Big Data Analytics and Visualization

Open Architecture

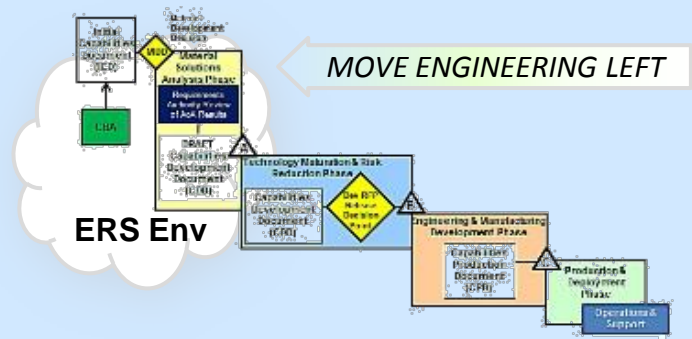
Knowledge Management

Data Retention

Requirements Generation

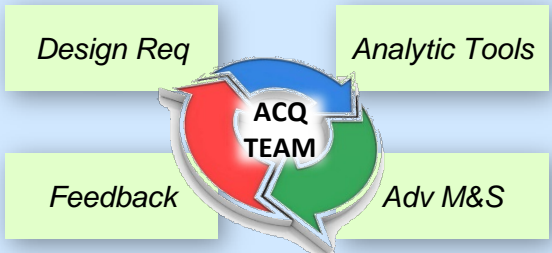
Analysis of Alternatives

Virtual Prototyping & Evaluation



Fully Explore & Identify KPPs

Reduces alternatives from thousands to tens or less



Rapidly Distill Alternatives

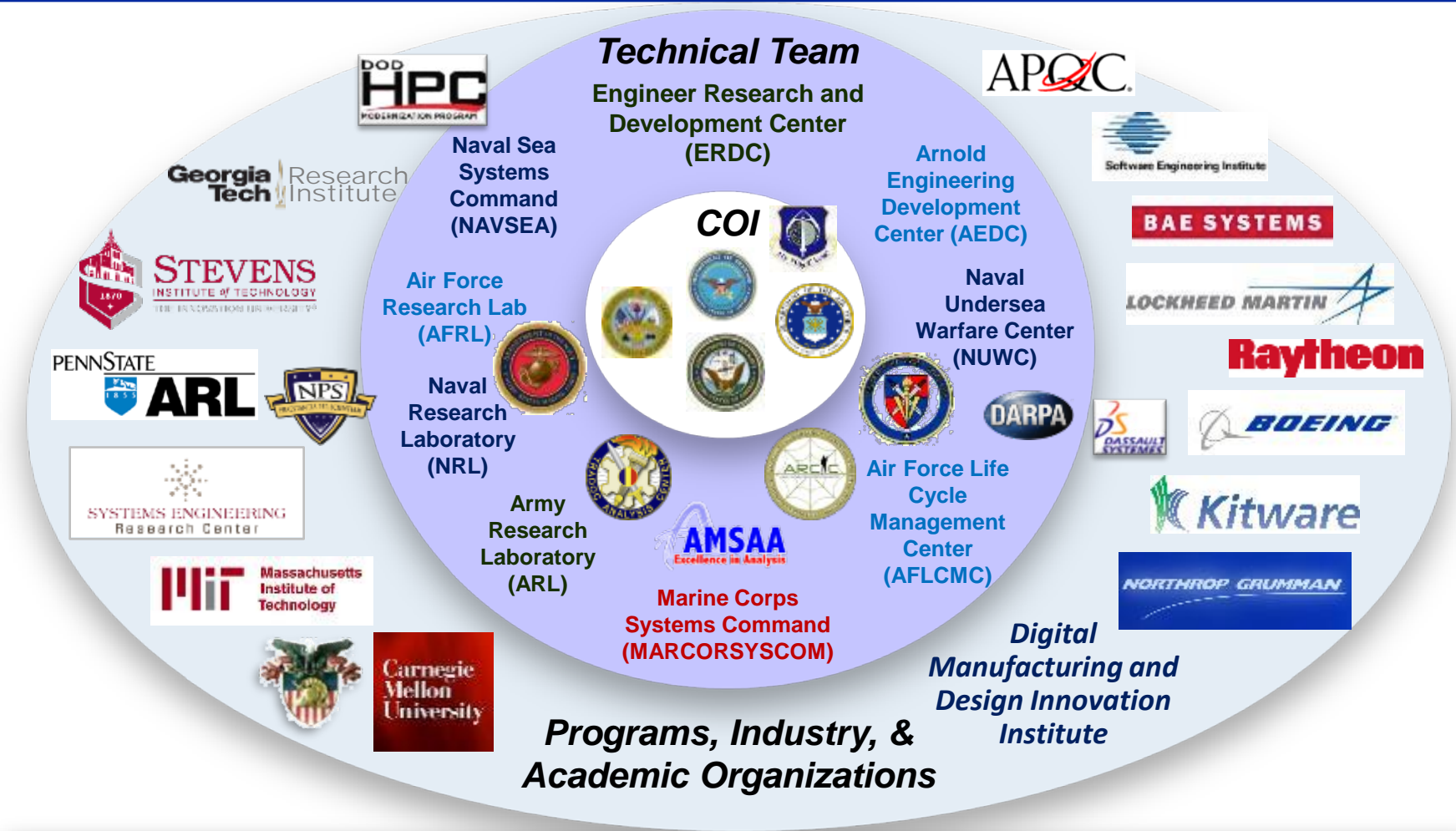


RAPID PROTOTYPING & RESPONSE

Virtually Warfight



ERS Consortium



Government, Industry, and Academic Partners

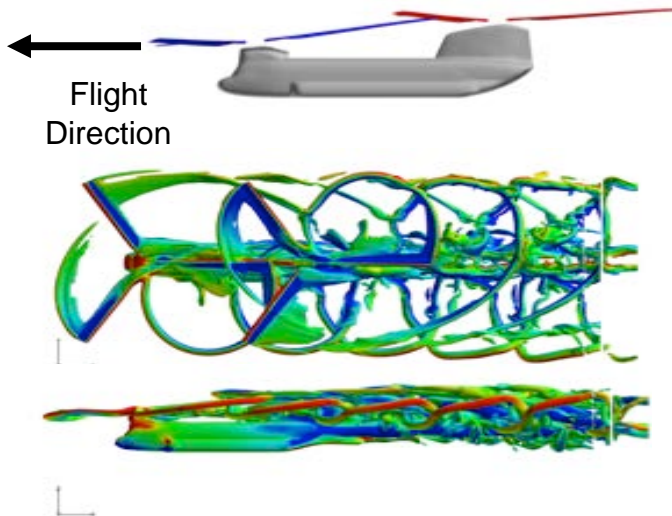




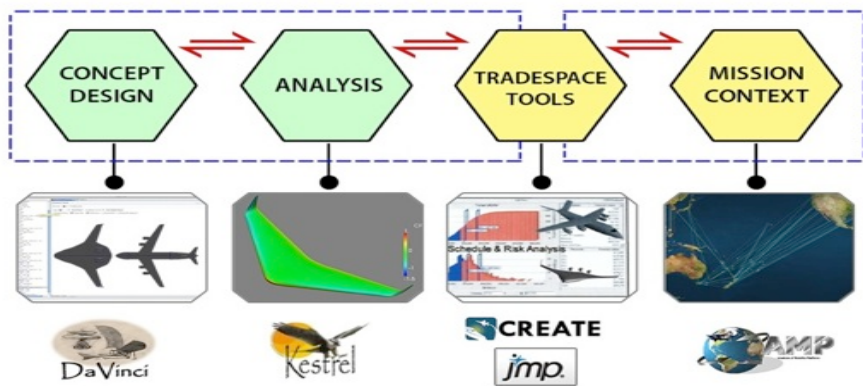
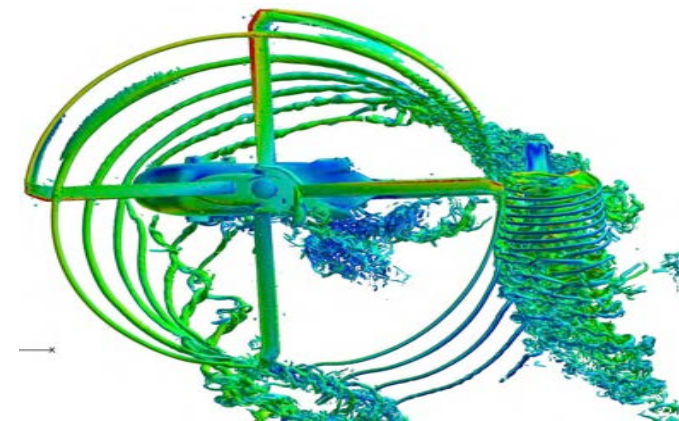
ERS: Demonstrated Capability

Set-Based Design

- Concept
- LX(R)
- SSCTF



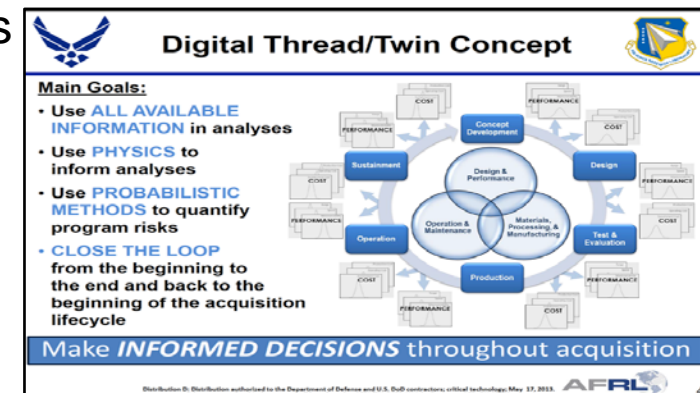
- Industry-Government Collaboration
- New Analysis Tools



- Joint Platforms, Partners, and Tools
- Learn from related efforts in other Services

Conceptual Design

Mission Performance





ERS Tools Used in DoD Acquisition

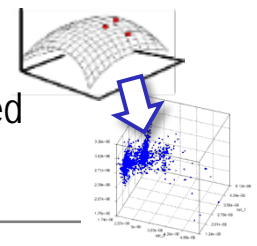


US Navy NSWCCD

ERS Ships Demonstrations

LX(R) AoA

22,000 alternatives analyzed in 6 weeks



Small Surface Combatant

19M designs analyzed in 3 months resulting in 270K feasible alternatives

The ERS Cloud Computing Environment (CCE) will improve these speeds by 100X.

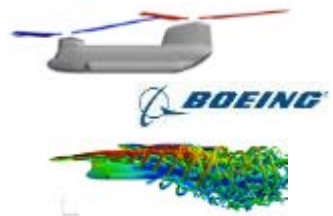
"The methods used for this [LX(R)] study were so comprehensive that the results of the study were 'irrefutable.'"
Ray Mabus, Sec of the Navy



US Army AMRDEC

ERS Rotorcraft Demonstration

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



Full, accurate assessments achieved in **hours/days rather than weeks/months** with ERS tools & CREATE Helios models.

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



US Air Force AFLCMC

Lifecycle Cost Models

USAF Cost Capabilities Analytics (CCA) insert lifecycle intelligence into decisions

Proposed ERS Support to AoA processes



T-X Training Platform

JSTARS Recap



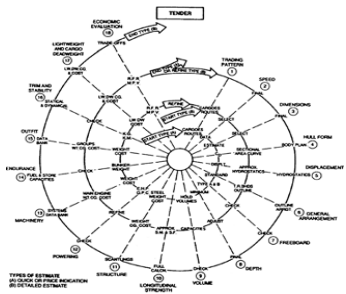


ERS Applications to Ships

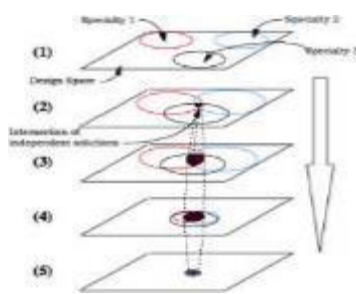
Design Experiment

FY14 Joint ERS/NSWCCD Effort:
Demonstrated advantage of tradespace-informed, set-based design techniques.

Point Design Process (spiral design)



Set-Based Design Process



Set-Based Design



Point Design



Workforce benefit articulated by Navy:

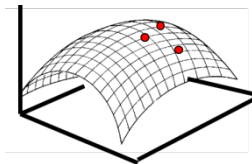
- Point Design team weighted with more experienced engineers;
- Set-based teams overcame experience gap with ERS approach.

LX(R) Amphibious Assault Ship

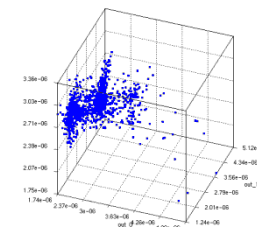
\$16B+ Buy, 11 Ship Total

- FY14/15 – Joint ERS/NSWCCD Effort
- Traditional AoA Process
 - Few ship design points developed
 - Difficulty answering complex cost vs. capability questions
- New AoA Process: Exploration of more robust design space
 - 22,000 alternative designs generated in 2 months.
 - Performed cost vs. capability analysis
 - Informed Navy's decision on the next amphibious assault ship

Traditional AoA



New AoA



Small Surface Combatant

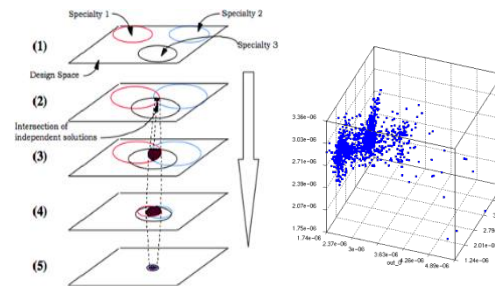
\$10B+ Buy, 20 Ship Total

Over 2 billion designs reviewed using ERS Cloud Computing Environment

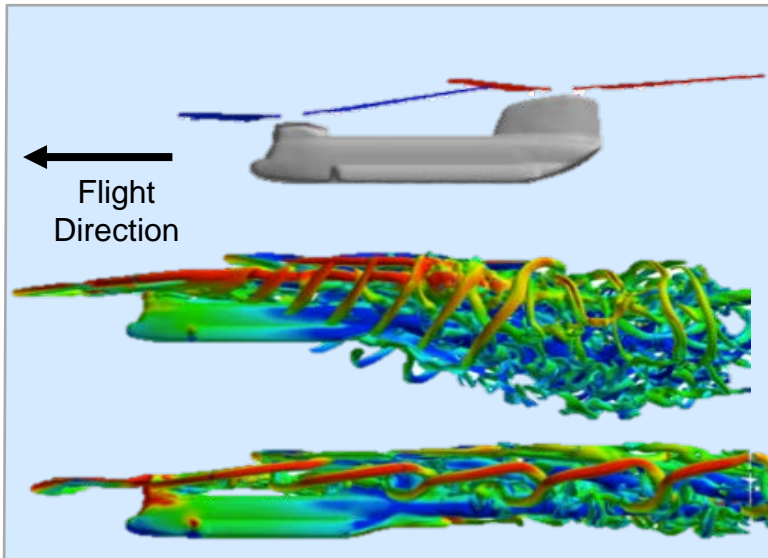
- Identified 280,000 resilient designs
- Decision time reduced by 1000X
- Cost versus capability data will inform RFI/RFP process
- Designs briefed to CNO, ASN(RDA), DEPSECDEF

Set-based design approach for mission systems

Design space exploration approach for ship designs



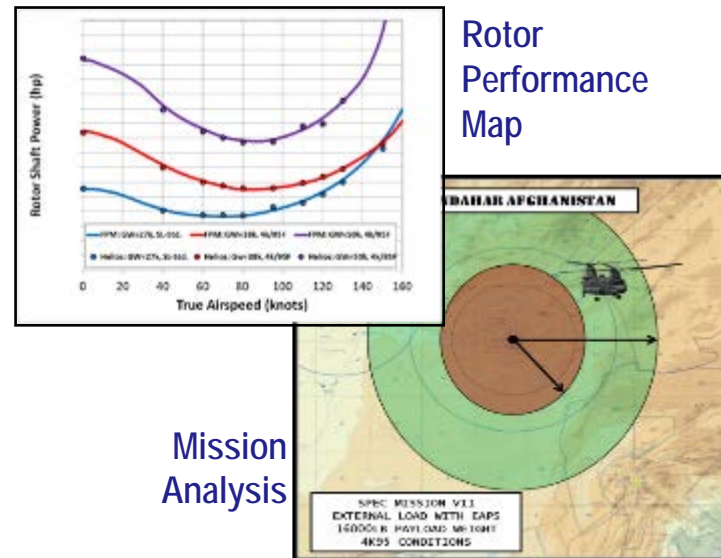
ERS Application to Rotorcraft



Initial experiment demonstrating value of virtual prototyping using validated, high-fidelity models

FY14 and Prior

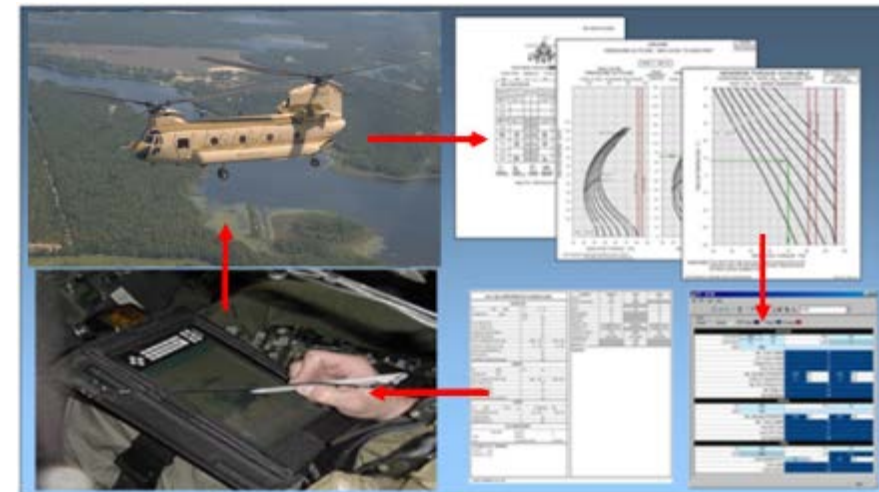
- Boeing proposed new CH-47 rotor blade
- CREATE-AV Helios validated on old blade design
- CREATE-AV Helios confirmed added lift of new blade design
- Paved way for larger projects in virtual prototyping (potential: Future Vertical Lift)



ERStat team wrote a wrapper around Helop mission tool to now perform 1000's "missions".

FY15: CREATE-AV Helios

- Analyzed payload allowance and maximum forward velocity characteristics
- Pre-flight test validation
- ERSTAT (ERS-built tradespace) generated and analyzed 1000's of missions in a matter of minutes



Future: Integrate mission planning data/tools into ERSTAT. Empowers mission data with more robust datasets.

FY16 and Beyond:

- Live flight tests with new rotor blade will be informed by early computational analyses
- Integrate Rotor Performance Maps into real-time mission planning tools from ERS work



Details of Current Capabilities





Architecture and Workflow Products

Workflow

Requirements & 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

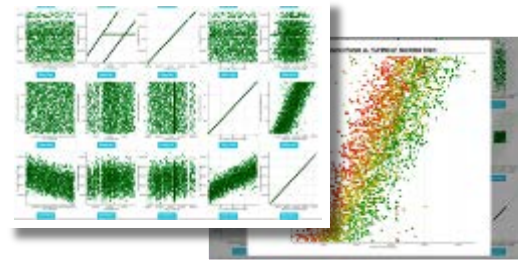
Tradespace Creation



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

Tradespace Analysis

Collaborative and interactive Tradespace exploration



Statistical analysis reduces visualization burden

Alternative Analysis

- Tradespace is reduced to a small set of alternatives
- Design alternatives are compared



Modeling and Simulation is used to assess designs and mission

Products:

- SysML Model Builder
- ERSTAT
- CREATE
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- FACT-X
- Statistical Analysis Tool
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Infrastructure:

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DoD Enclave and Community Interfaces

DEVELOPMENT TEAM

DoD, Industry, Academia



Distributed product development teams



PRODUCT DISTRIBUTION PROCESS

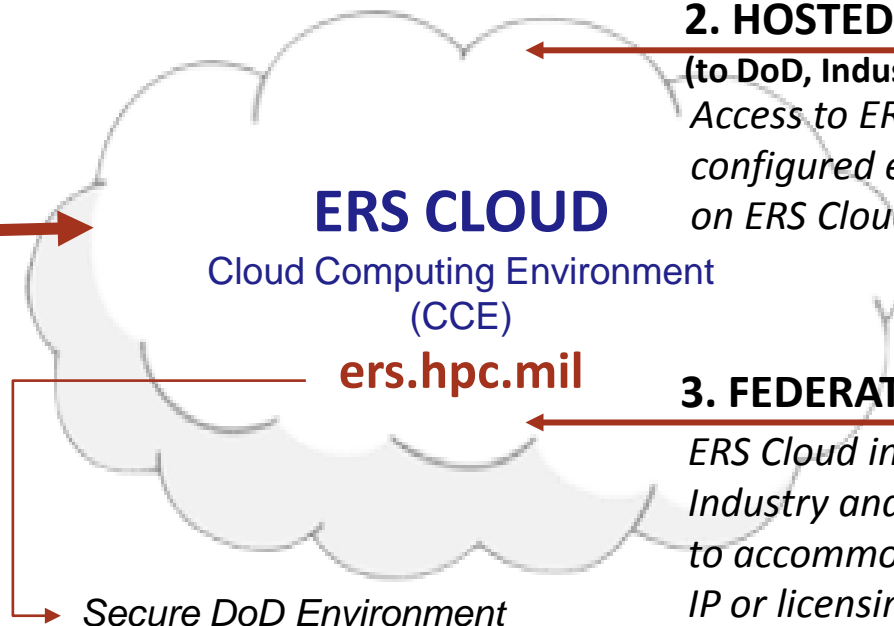
THREE CURRENT SERVICES

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

1. 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



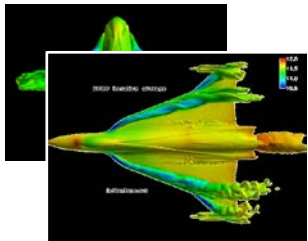
Engineering Design Teams



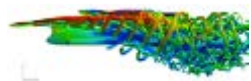


ERS Leverages Computational Research & Engineering Acquisition Tools and Environments (CREATE) Program

Aircraft (AV) Tools:



Fixed-wing aircraft, rotorcraft, conceptual design, and operational testing and transition



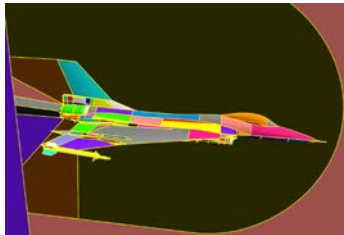
Ground Vehicle (GV)



Autonomous navigation and operational testing

Meshing and Geometry (MG) Support:

CREATE MG improves the ease, speed, flexibility, and quality of geometry and mesh generation



Fully Validated on Real Problems

CREATE-AV

Aircraft (AV) Design Tools

CREATE-SHIPS

Ship Design Tools

CREATE-RF

Radio Frequency (RF) Antenna Design and Integration Tools

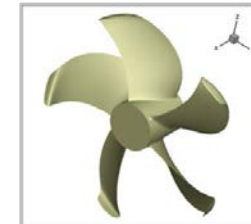
CREATE-MG

Meshing and Geometry (MG) Support

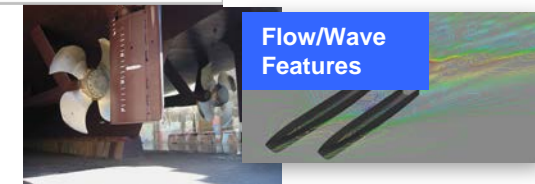
CREATE-GV

Ground Vehicle (GV) Design Tools

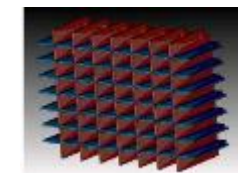
Ship Design Tools:



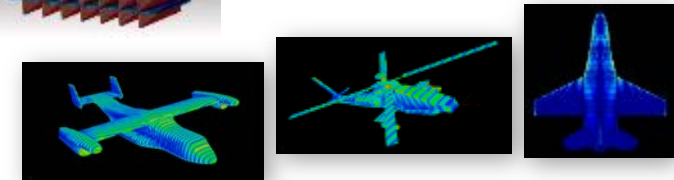
Shock/damage, hydrodynamics and early-stage design, and operational testing and transition



Radio Frequency (RF) Antenna:



Conceptual design and detailed analysis tools for myriad DoD platforms





FY15-16 ERS Planned Developments

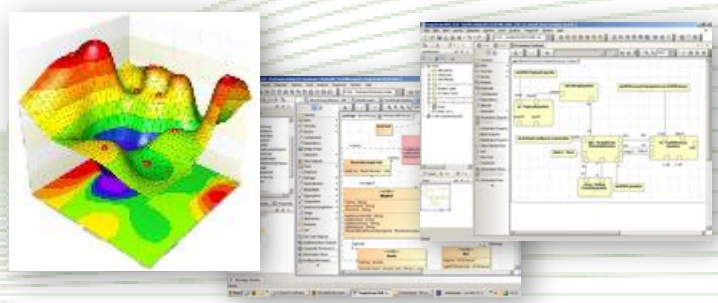




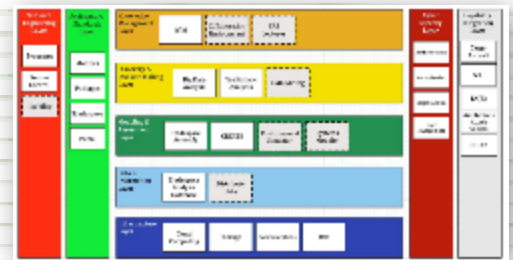
Major S&T Building Blocks

Science & Technology Components Impact Engineering Approach

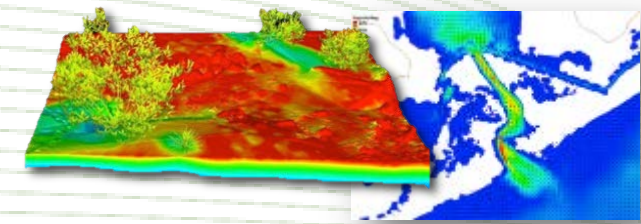
Tradespace Analytics
Big data analyses and visualization



Open Architecture
Integrating capabilities



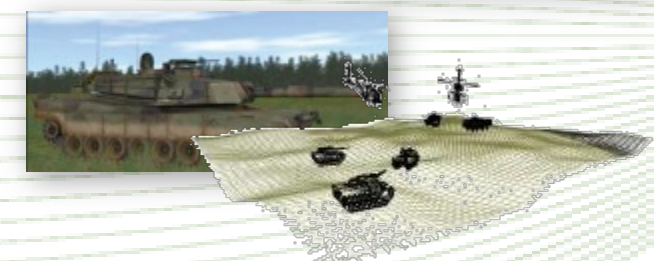
Environmental Representation
Physical understanding of the world



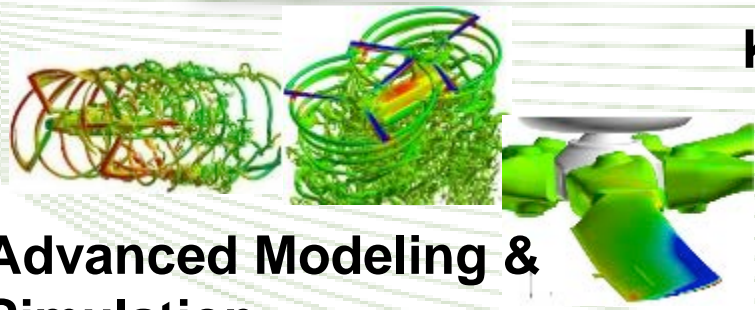
Knowledge Management



Mission Simulation
Evaluate ability to warfight



Advanced Modeling & Simulation
Multi-effects, virtual behavior



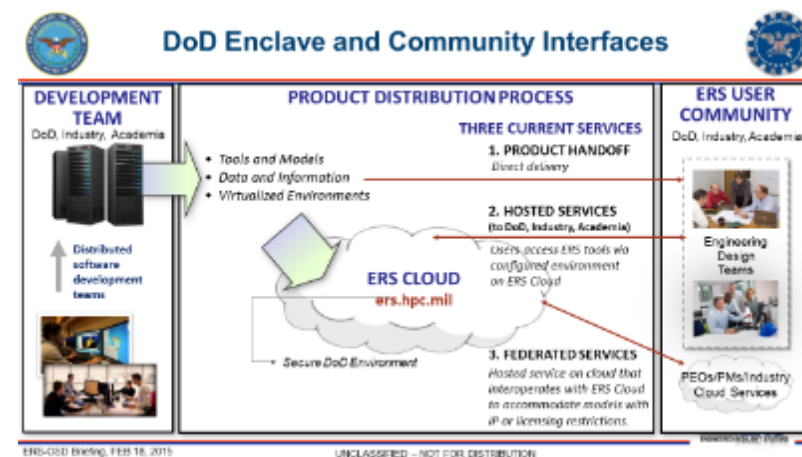


FY15-16: Open Architecture



- **Continued focus on Integrating New and Existing Tools & Capabilities**
 - **Support Transition**

- **Architecture Documentation – V.1 (Sep 2015)**
- **ERS CONOPS Documentation – V.1 draft (Apr 2015)**
- **System Design**
 - Government, Industry, and Academia in Architecture Working Group
 - Identify use cases, quality attributes, requirements, and interfaces
- **Initial Lifecycle Cost Modeling to be inserted (Oct)**
- **Industry Pilots**
 - Joint projects with multiple industry partners
- **Intellectual Property Management**
- **ERS Demonstration: November 2016 (Washington, DC)**



**ERS Architecture Working Group
Cross-service, Acquisition
Representatives**

- *Define Quality Attributes*
- *Develop Use-cases*
- *Address Test/Eval Metrics*





FY15-16: Big Data Environment (BDE)

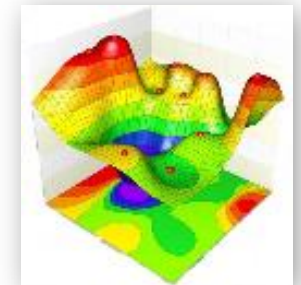
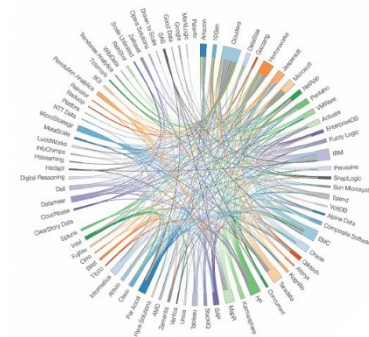


Solutions for Big Data Challenges and Enhancements to Analytics

- Ongoing investigation of innovative techniques to support growing dataset size and complexity
- Integrating open source capabilities to scale to petabyte-sized data sets
 - Employ Hadoop Ecosystem (open source algorithms for distributed storage and processing of very large data sets on computer clusters)
 - Insert big data capabilities in ERS Cloud to do more sophisticated analyses – scalability of data requests, more precise and sensitive analytics
 - Integrate big data processing with Kitware Visualization Tool



Hadoop Ecosystem



Big Data Visualization





FY15-16: Tradespace Analytics



Two-fold Effort: ERS Tradespace Toolset and Tradespace Analytics

Tradespace Toolset



Tradespace toolset framework for the DoD community

Enables:

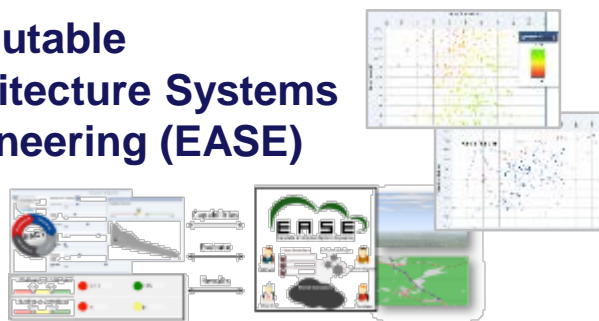
- True characterization of “resilience”
- Scenario-specific needs context
- Risk mitigation through option buy-in and forecasting

FY15-16:

- Integrated with EASE
- Transitioned initial capability to users
- Link SysML behavior to Modeling and Simulation
- Deliver & test on new platforms (GV, Fixed Wing, LEO satellite)
- Integration of CREATE/HPC assets

Tradespace Analyses

Executable Architecture Systems Engineering (EASE)



Links analytical, experimental, and training objectives with modeling and simulation tools

FY15-16:

- Enhancements of FACT and EASE
- Use-case Development
- Alignment of use case to Maneuver Support Center of Excellence (MSCoE) for Phase II demonstration

Target Users

Visualization for multiple user types

Primary Users

- SMEs – engineering analysts
- Operations Research Systems Analysts

Secondary Users

- General engineering analysts
- Stakeholder PMs (CONOPS, TTPs)

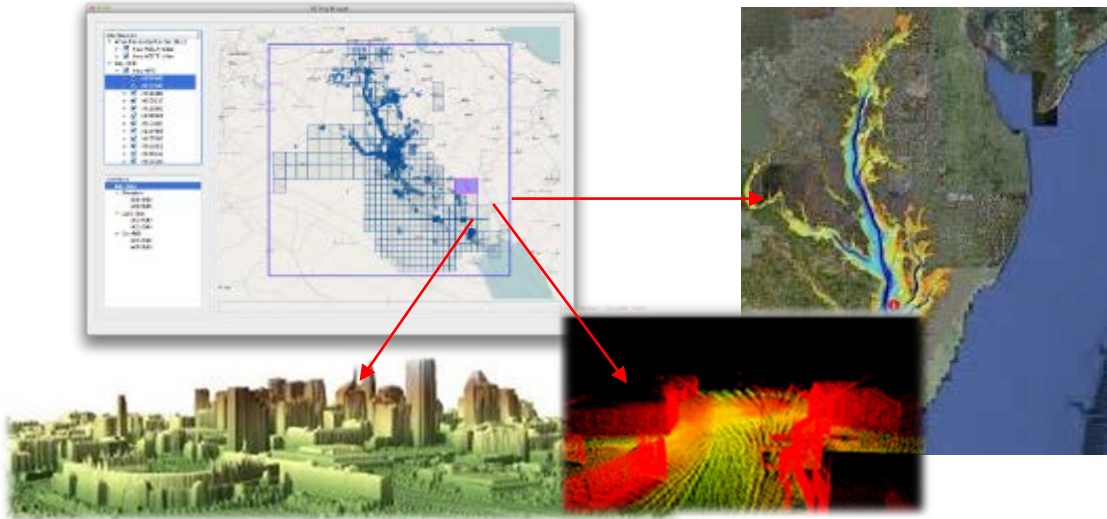
Tertiary Users

AoA PMs and high-level Decision-makers – budget, warfighting, requirements, “what if” drills





FY15-16: Environmental Representation and Mission Context Immersion



Purpose

Environmental Simulator provides:

- Ability to represent any area of interest above, on, or under the earth
- Supports virtual prototyping and simulation under a variety of environmental conditions early in the acquisition process
- Predicts system performance in a variety of geographic settings under a variety of environmental conditions

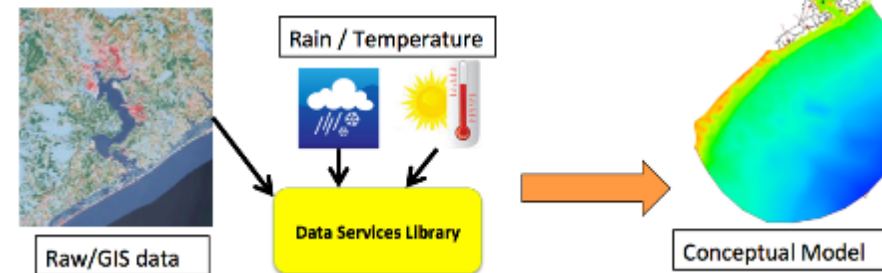
Description

The Environmental Simulator:

- An integrated computational modeling suite; provides robust high-fidelity, physics-based engineering analyses
- Assesses the impact of numerous environmental factors on military operations to support the DoD acquisition process

Modules to be demonstrated in FY15-16:

- Data Services Library
- Model Development Environment
- Model Coupling Interface
- Simulation Workflow Manager





FY15-16: Knowledge Management

- **Launch DoD Techspace and Expand ERS Knowledge Hub Information**
- **Address Information Assurance Challenges between ERS Hub and Federated Clouds**

STAKEHOLDER & COMMUNITY DEVELOPMENT



DoD Stakeholders

- Army
- Navy
- Air Force
- OSD



External Stakeholders

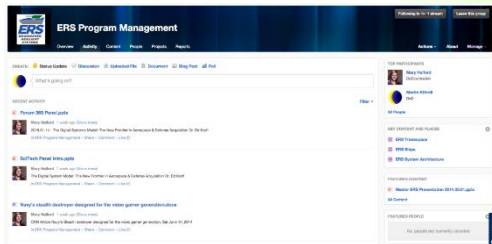
- Industry
- Academia
- Fed Agencies

CAC — Authentication —
 Username — Password —

DoD Techpedia COI



DoD TechSpace



KNOWLEDGE HUB

- Management
- Knowledge Base
- Standards
- Policies
- Tutorials
- Engineering Tools
- Analytical Tools
- Models
- Insights
- Wiki
- Chat
- Research

Input & Knowledge

ersWiki



DEMONSTRATION ENVIRONMENT

Acquisition & Engineering Communities

Formats, standards, solicitations, engineering data

ERS CLOUD Projects
ers.hpc.mil

Government

Industry

Research

Challenges to Address FY15/16:

- Information Assurance between DoD Acq environments
- Non-DoD access/use of HPC CREATE Models





Future Capabilities and Challenges

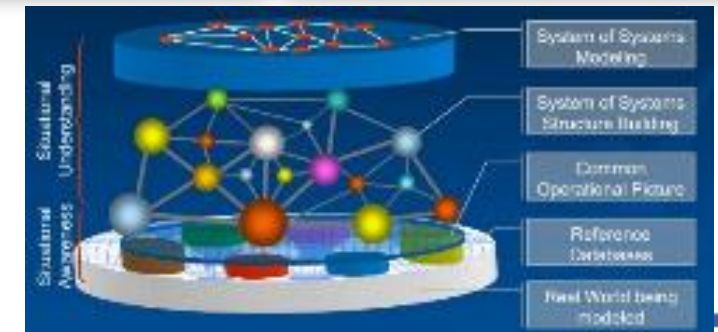
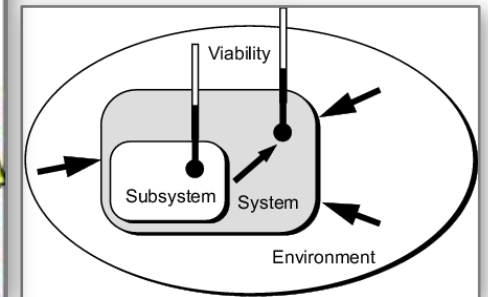
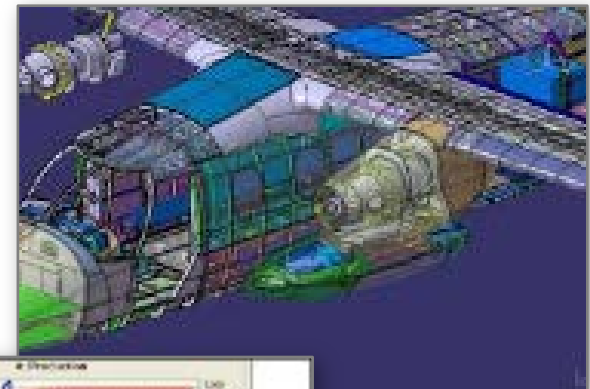




Future Work – Technical Challenges



- Virtual Prototyping
- Modeling Sub-Systems
- Material Life and Failure
- Lifecycle Cost Modeling
- System-of-Systems Analysis
- Modeling Manufacturing





10-Year Plan

