Engineered Resilient Systems (ERS)

A DoD Science and Technology Priority Area

Overview Presentation
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ERS Goals

- **Expanding upon "fast, informed, adaptable" goals shown last year, ERS goals are to develop tools and procedures that enable DoD to:**
  - **Produce more complete and robust requirements pre-Milestone A**
    - **Generate requirements that consider many more alternative scenarios**
    - **Make much more informed decisions early in the acquisition process**
  - **Make the engineering design process much more efficient and effective**
    - **Consider many more design concepts in much less time**
    - **Increase productivity of work flow and collaboration**
  - **Consider the manufacturability of a proposed design explicitly**
    - **Ensure the design is producible from both engineering and cost perspectives**
    - **Affect feedback between manufacturability and capability**
  - **Establish baseline resiliency of current capabilities**
    - **Small perturbations of original requirements**
    - **Completely new missions and requirements**
    - **Support adaption to evolving Tactics, Techniques and Procedures (TTPs) of the threat**

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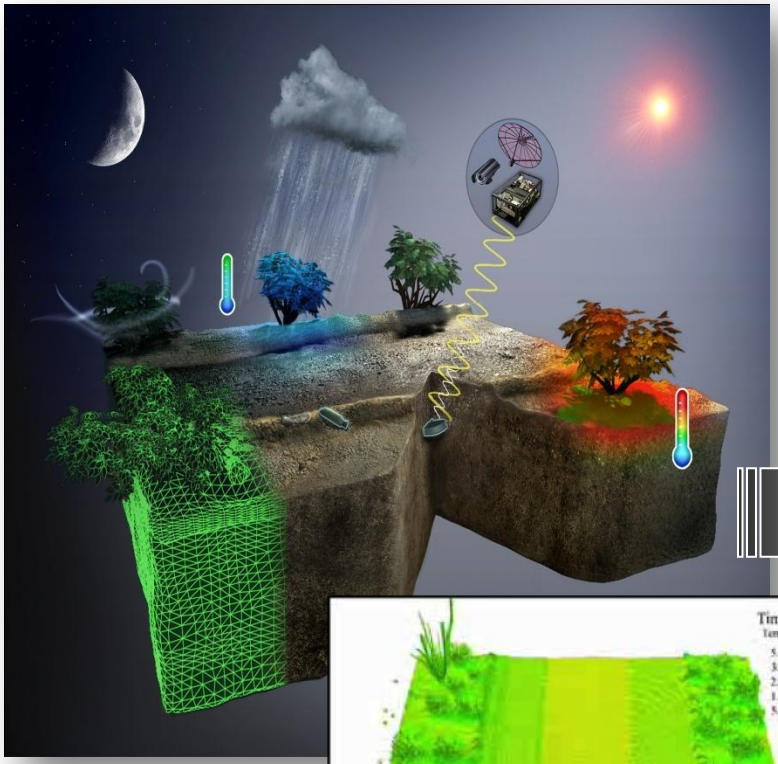
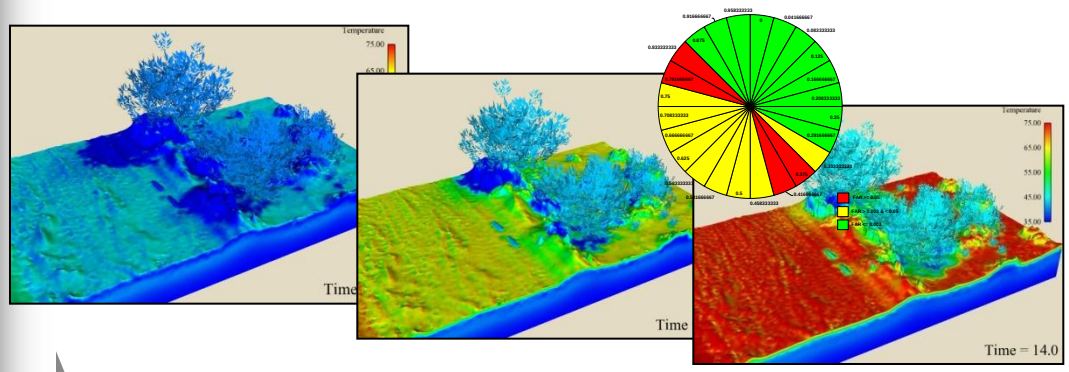
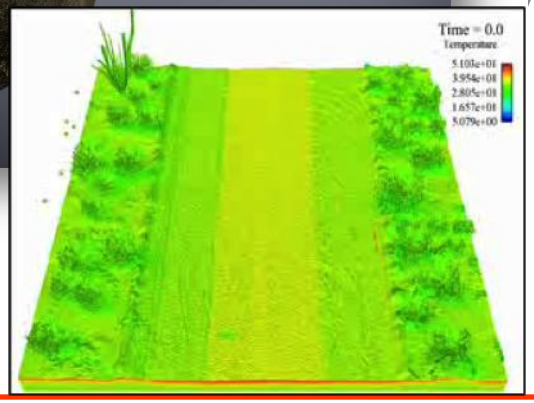
ERS – a Reachable Goal

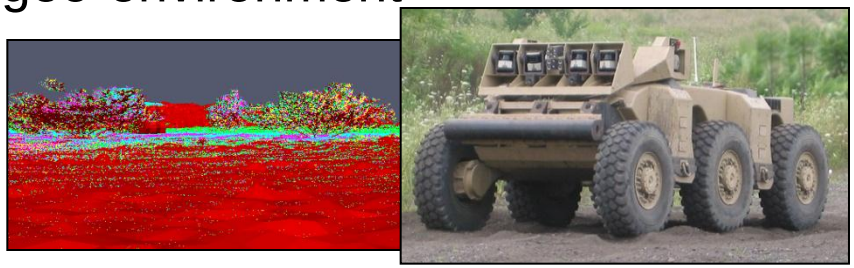
Example: High-fidelity models to predict and improve performance of Current and Future Force sensor systems for surface and near-surface target detection within complex geo-environments





Geometric representations of vegetation indigenous to a specific geo-environment





Simulated LADAR Sensors

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Engineered Resilient Systems S&T Priority Steering Council POCs

AF – Bill Nolte

Supporting: G. Richard Freeman, Ed Kraft, Sean Coghlan, Kenny Littlejohn, Bob Bonneau, Ernie Haendschke, Mark Longbrake, Dale Burnham, Al Thomas, Ken Barker, Thing Adams

Army - Jeffery Holland (PSC Lead), Kevin Flamm

Supporting: David Richards, David Horner, Owen Eslinger, Niki Goerger, Simon Goerger, Elias Rigas, Robert King, Chris Gaughan, Lester Strauch

Navy - Rich Carlin

Supporting: John Pazik, Terry Ericsen, Ralph Wachter (now detailed to NSF), Connie Heitmeyer, Lynn Ewart-Paine, Bill Nickerson, Bob Pohanka, Adrian Mackenna

DARPA - Chris Earl

Supporting: LTC Nathan Wiedenman

OSD - Scott Lucero, Phil Zimmerman

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The ERS Team

- **Comprised of Members from:**
  - **OSD and organizations within the Services (e.g. AFLCMC, AFRL, AEDC, ARL, NAVSEA, NRL, NUWC, ONR, MARCORSYSCOM)**
  - **Academic and Industrial**
- **Leveraging DARPA programs**
- **Seeking partnerships with key Program Executive Offices (PEOs), Program Managers (PMs), and Industry**

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Capabilities Delivered by the ERS

Acquisition Challenges

- Increase speed and agility of system development
- Improve effectiveness and quality of fielded systems
- Minimize lifecycle costs, including cost of redesign

Secretary of Defense, Dr. Robert Gates:
"… we need to have in mind the greatest possible flexibility and versatility for the broadest range of conflict …"

FAR TERM (FY 18+)

- Explicitly consider evolving TTPs in design
- Living, adaptive repository of 100,000's of alternative designs, operational/mission contexts, value
- Semantic search and large-scale data mining
- Direct assessment of the producibility (manufacturability) of proposed alternatives
- Estimate lifecycle costs of design alternatives
- Fully incorporate training modules into collaborative tools

MID TERM (FY 16 - 18)

- Extend ERS to ground vehicles, weapons and software systems
- Embed ERS developers on Ships, Air Vehicle, and Sensor Acquisition Teams
- Integrate experimental and M&S data into design tools
- Quantify uncertainty of M&S and experimental outputs
- Field capability to evaluate and buy-down risk through acquisition process

NEAR TERM (FY 13 - 15)

- Capture and simulate essential components of the DoD acquisition and operational analysis processes
- Integrate M&S, collaborative tools, tradespace analysis, engineering design processes into single architecture
- Express lessons learned and create communities of interest through DoD social media exploitation
- Demonstrate ERS for Ships, Air Vehicles, and Sensors
- Provide technical basis for improvements to DoD policy

Revolutionary Capabilities That Result In

- 75% time savings via reduction of rework
- 100-fold increase in number of operational scenarios considered pre-Milestone A
- Quantification of risk for proposed systems
- Integration of Producibility and Lifecycle concepts formally across acquisition process
- Transformation of the acquisition process through risk mitigation, productivity enhancement, and knowledge management

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ERS Technical Thrust Areas and Gaps

- Integrating Architecture
- Data/knowledge Management and Training
- Virtual Collaborative Environment
- Interoperable Modeling, Simulation, and Experimental Data
- Mission Context
- Risk, Reliability, and Trustworthiness
- Decision Support
- Tradespace Analytics
- Manufacturability

Validation, verification, and demonstration for components and systems

ERS Thrusts / *Technology Gaps*	Models Aiding Design and Analysis	Support for Collaborative Analyses	Tools Incorporating Risk and Cost	User-Friendly Control of Distributed Systems
Integrating Architecture	X	X	X	X
Data/Knowledge Management and Training		X	X	X
Virtual Collaborative Environment		X		X
Interoperable Modeling, Simulation, and Experimental Data	X	X		X
Mission Context	X		X	
Risk, Reliability, and Trustworthiness	X		X	X
Decision Support	X	X	X	X
Tradespace Analytics		X	X	X
Manufacturability	X		X	

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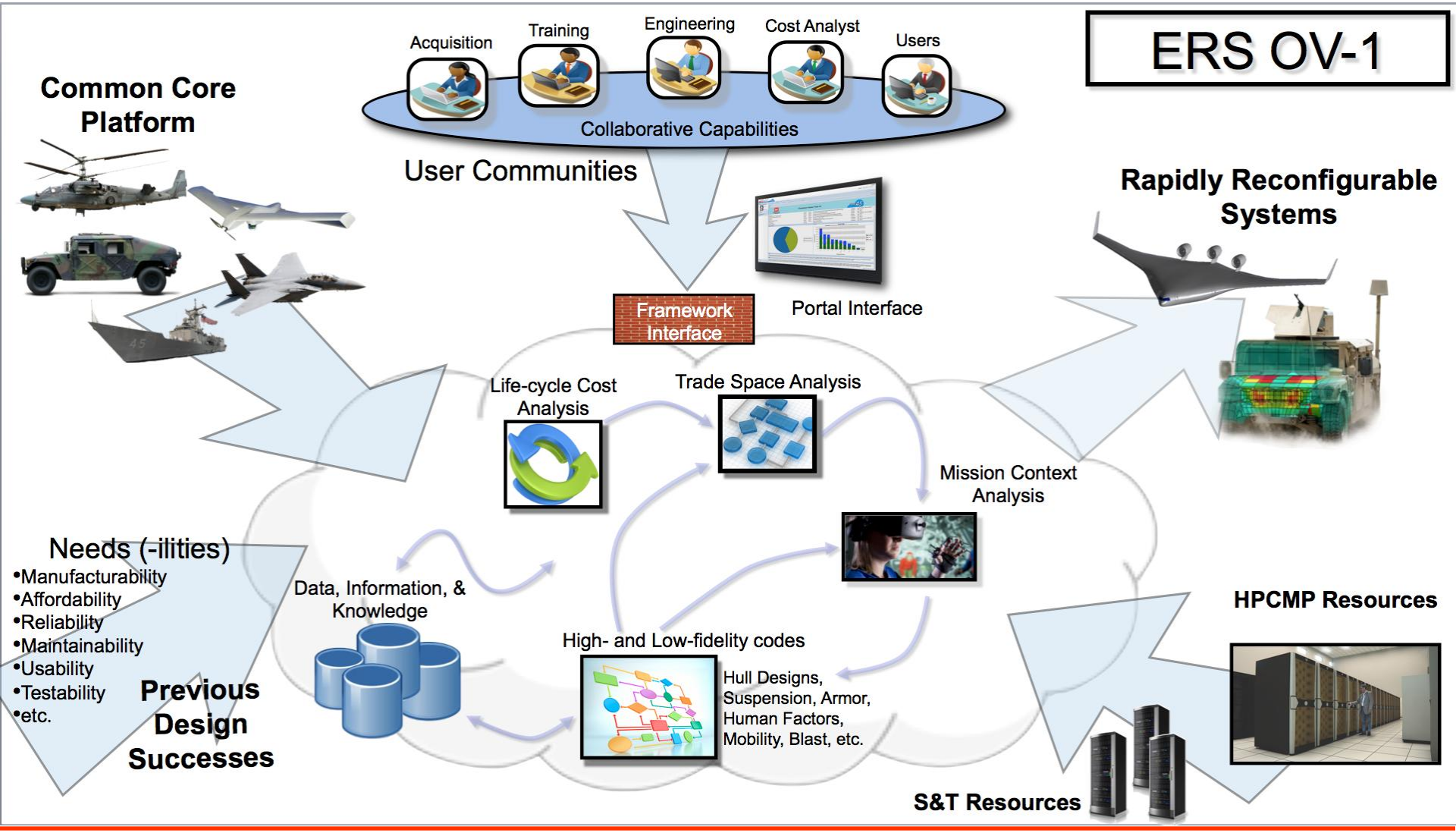
ERS Architecture



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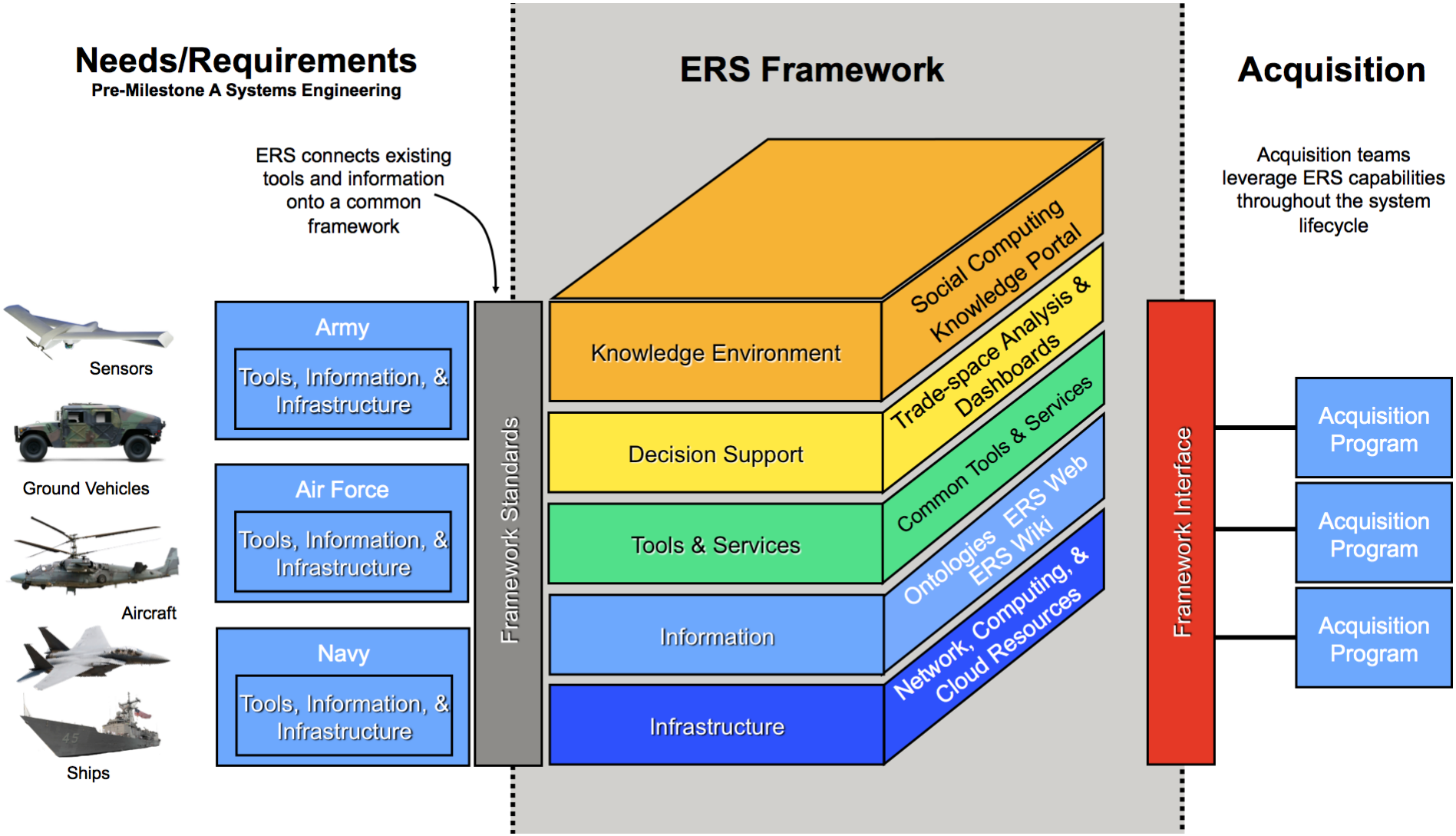
ERS Architecture



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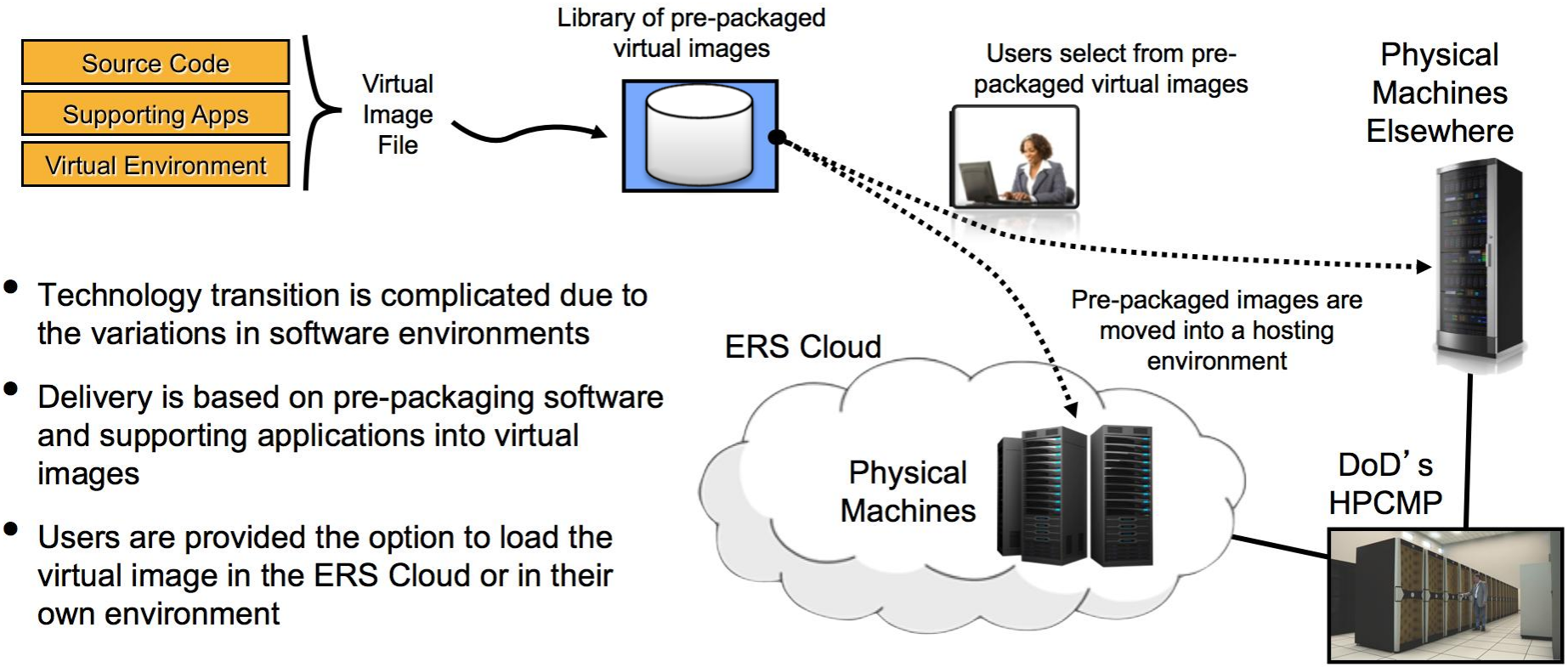
ERS Architecture

Rethinking Product Delivery

Transition from delivering codes to delivering environments



- Technology transition is complicated due to the variations in software environments
- Delivery is based on pre-packaging software and supporting applications into virtual images
- Users are provided the option to load the virtual image in the ERS Cloud or in their own environment

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ERS Roadmap

	FY14	FY15	FY16	FY17	FY18	FY18+
Architecture	Prototype architecture demonstrated for ships, air vehicles, sensors	ERS Architecture Ver 1 with formal connections to services, OSD, academic, and industry technologies				ERS Architecture Ver 3 as required
				ERS Architecture Ver 2 with plug-ins for risk, reliability, producibility, decision support components		
Data/Knowledge Management and Training	Initial database and knowledge management environments	On-line training on use and productivity of ERS deliverables				
			ERS Data and Knowledge Management Environment Release 1			ERS Data and Knowledge Management Environment Release 2
Virtual Collaborative Environment (VCE)	Prototype ERS VCE		Release 2 ERS VCE			
		Release 1 ERS VCE				
Interoperable Modeling, Simulation, and Experimental Data	Prototype ERS M&S Capability	Release 1 ERS M&S Capability	Establish service-level agreements with key M&S products	Develop neural network/statistical models	Quantify uncertainty of field and M&S outputs	Release 2 ERS M&S capabilities
			Establish initial methods to feed experimental data directly to ERS	Investigate and develop model for manufacturing-induced error within the lifecycle of a given alternative		Release Final ERS M&S capabilities
Mission Context	Prototype ERS Mission Context capability	Capability to evaluate multiple material solutions for missions and environmental conditions				Update mission and operational scenarios
		CENTCOM and PACOM	NORTHCOM and AFRICOM	SOUTHCOM and EUCOM	SOCOM and STRATCOM	
Risk, Reliability, and Trustworthiness			Establishment of initial ERS risk and reliability quantification methods			Techniques to assess manufacturing-induced error within the lifecycle of a given alternative
				Capabilities to assess reliability and trustworthiness for scales		Integrated risk/reliability/trustworthiness analytical capabilities
Decision Support	Prototype DS Capabilities		Release 1 of ERS tradespace analytical capabilities	Incorporate statistical analyses in support of reliability and risk	Release 2 of ERS tradespace analytical capabilities 10-fold increase in "effective coverage" of trades considered	Presentation of data (through the ERS VCE) on demand
						100-fold increase in "effective coverage" of trades considered

R2 – Funding Request

Deliverables

Future Activities

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PBR14 Program Starts

- **Tradespace Analysis for Decision Support**
  - **Develop prototype decision support tools for one or more use cases**
  - **FY14: Design guidelines and recommend tools and techniques paired with mission contexts and phases of acquisition**
  - **FY15: Develop prototype decision support tools for one or more use cases; conduct experiments and assessments**
- **Mission Context Development**
  - **FY14: Define a focused set of missions and requirements related to ground vehicles; identify and engage mission planners and operators in designing a means to efficiently incorporate mission context into the ERS framework and tool suite.**
  - **FY15: Expand the set of missions and associated requirements for ground vehicles in conjunction with CENTCOM and PACOM stakeholders; design and develop tools for automated parameter space population.**

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ERS Engineering Productivity Demonstrations FY13

- **Demonstration concept: show payoffs of early design collaborations of engineers working closely with warfighters**
  - Scenarios: demonstration of ERS concepts with clear benefits in applications to Army, Navy / USMC, Air Force weapons systems
  - Measurable illustrations of benefit, e.g.:
    - Demonstrate creation/evaluation of *two orders of magnitude more alternatives*
    - Show feasibility of significant *time and cost savings* from ensuring system concepts are *technically viable*, *risk-managed*, and *suitable for many missions*
- **Goals**
  - **Technical**: show power of core ERS concepts for *saving time and money* through *affordable upfront engineering* that drives *effective requirements*
  - **Organizational**: forcing function for building ERS common picture, getting the architecture started, conveying joint message to outside world
  - **Management**: create compelling cases for program offices to endorse and encourage investment in ERS S&T
- **Quick execution plan**
  - Funds key PSC participants for implementation
  - Team driven by plan with *quarterly demo deliverables, objectively measurable*
    - Each demo adds functionality: system models, operational context, trade analysis
    - End target: A set of demonstrations with compelling vision and potential customers, related by a common architecture

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ERS Development: Cornerstone Characteristics

- Enter data and models once
- Re-use as much as possible
- Robust knowledge management environment
- Distributed databases that are searched jointly
- Interoperable Modeling and Simulation
- Virtual collaborative environment
- Open architecture that encourages partnering
- Multiple information formats to support numerous stakeholders

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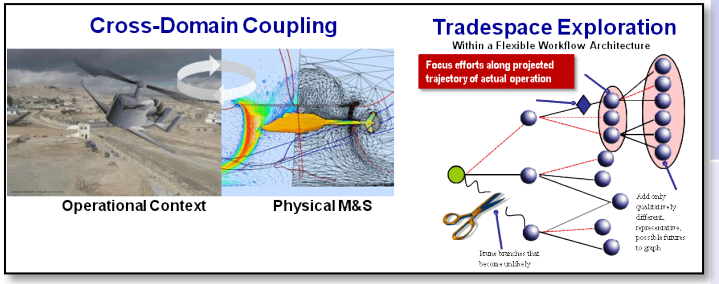
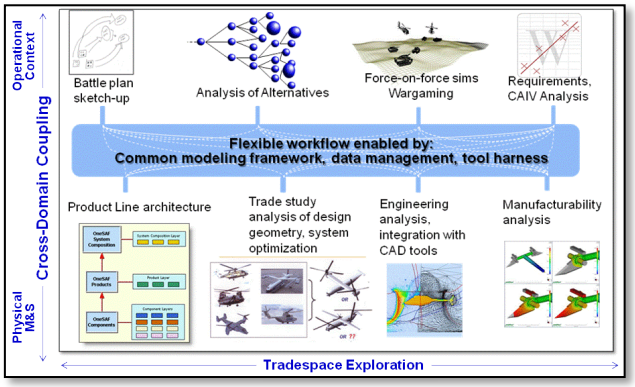
FY13 Execution Plan

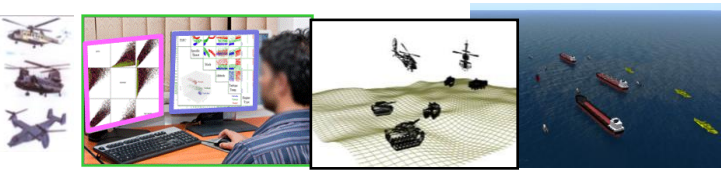
- **Oversight via ERDC, ERS PSC**
- **Tasks:**
  - **Technology**



  - **Architecture**



  - **Demo prep. and eval.**



Lab	Tech. Role	Tasks / Deliverables
ERDC (Richards)	Physical Modeling, Cross-Domain Coupling Architecture	(1) Select and integrate systems models into demonstration framework; (2) Implement scripting and surrogate tools to perform coupling within and across system and operational models; (3) Interface operational models from demos; (4) Produce joint architecture spec collaboratively with demos
ERDC/ARL	Tradespace, Exploration Tools	(1) Extend and apply tradespace evaluation tools for demonstration use; (2) Work with ERDC and ARL to integrate into demo framework
NUWC (Aguiar)	Collaborative Environments, Operational Context	(1) Select and integrate operational context models into demonstration framework; (2) Adapt and implement Virtual World Engineering Environment to provide collaborative framework; (3) Produce framework spec jointly w/ ERDC.
NAVSEA Carderock (Mackenna)	Tradespace Exploration Tools	(1) Implement capability for exploration of alternatives robust to requirement shifts; (2) Demonstrate advantages of set-based design
ERDC/ SERC/GTRI	Tradespace, Community Building	Integrate cross-service knowledge management capabilities. Build a community of ERS participants and stakeholders.
AEDC, AFRL (Kraft)	Tradespace Analysis	(1) Demonstrate capabilities for handling a broader range of solutions; (2) Show accelerated requirements analysis via surrogate response surfaces; (3) Demonstrate cost, schedule, and performance risk analysis

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FY 13 ERS Execution Timeline

1. Initial Efforts:

- Initiate demo by AF, Cargo Xplane
- Initiate demo NSWC, Ship Design
- Initiate demo ERDC, Sensors
- Crosscutting demo NUWC, VCE

2. Jan '13:

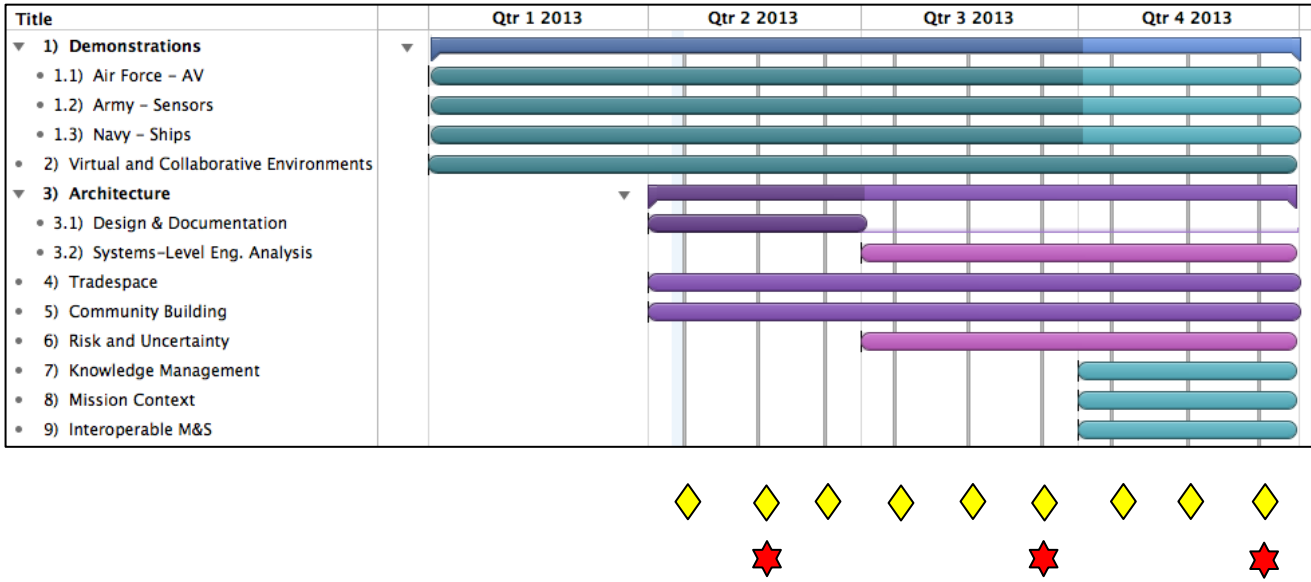
- Initiate tradespace analysis
- Develop Integrating Architecture
- Support ERS community building
- Completion and evaluation of demonstrations

3. Mar '13:

- Funding for further development of demonstrations
- Design, documentation and implementation of data model and architecture
- Commercial baselining activities

4. Apr '13:

- Additional demonstrations
- Final ERS data model and architecture
- Scenarios and use cases demonstrating integrated systems-level engineering analyses



In-Progress Review

Major Review

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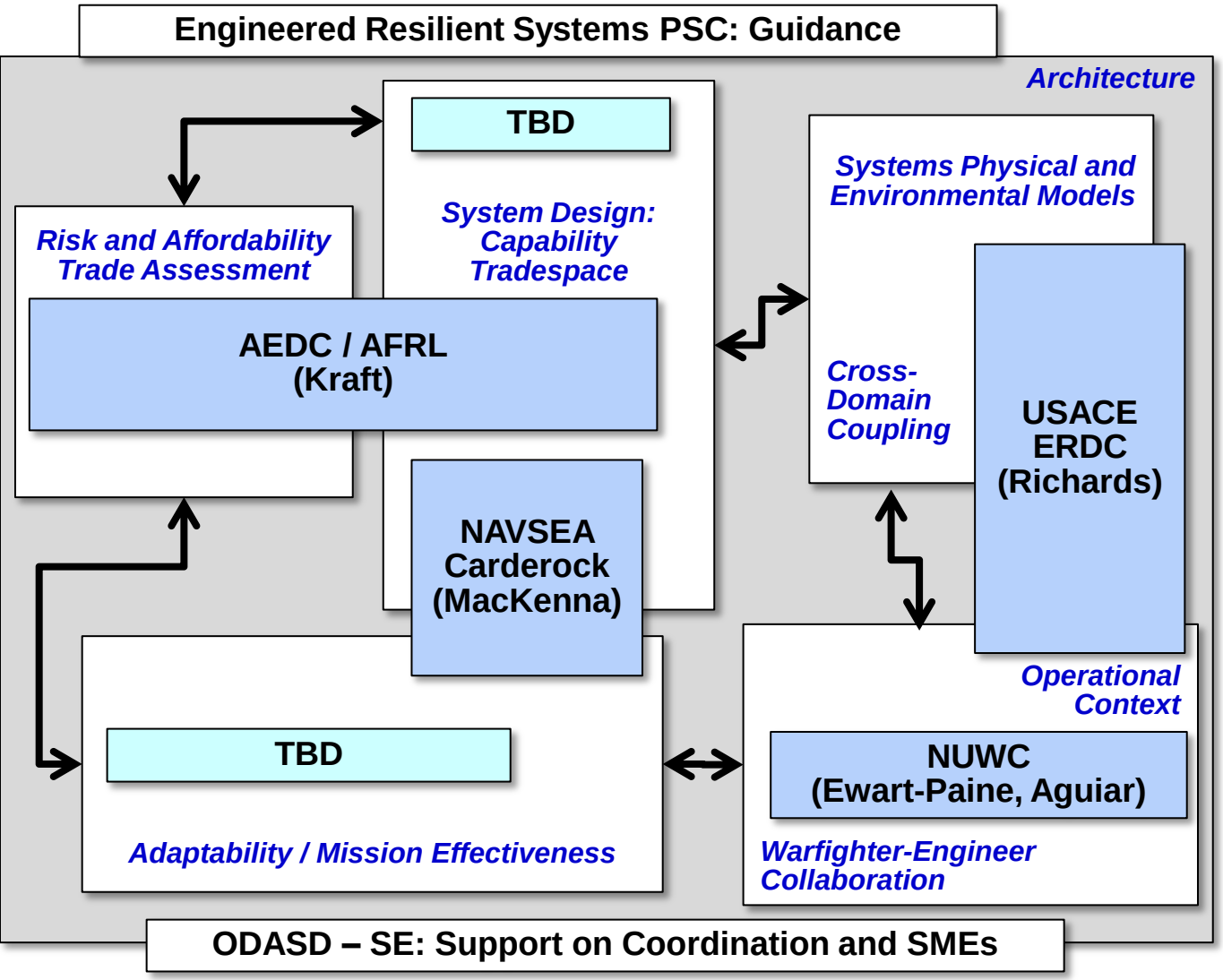
Organizations Collaborating to Illustrate Key ERS Concepts



Outcomes and Deliverables

- **Leave-behind demos**
- **Architecture**
- **"Concept Development with Engineers in the Room" exercise**
- **Compressed time video of demos**
- **Report**
  - Lessons learned
  - Preliminary architecture
  - Future Directions
  - Target Future Demonstrations for the Acquisition community

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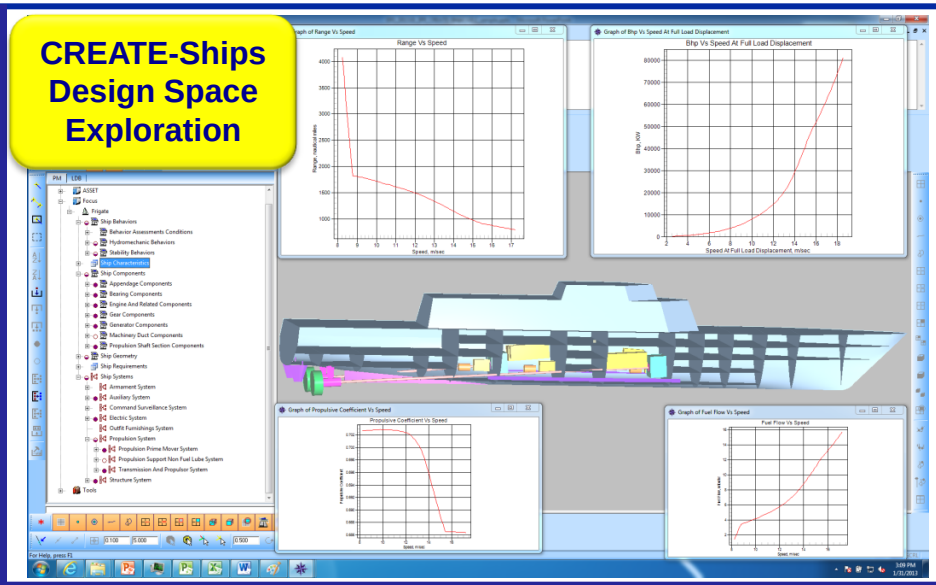
Example ERS Effort
Ships Demo

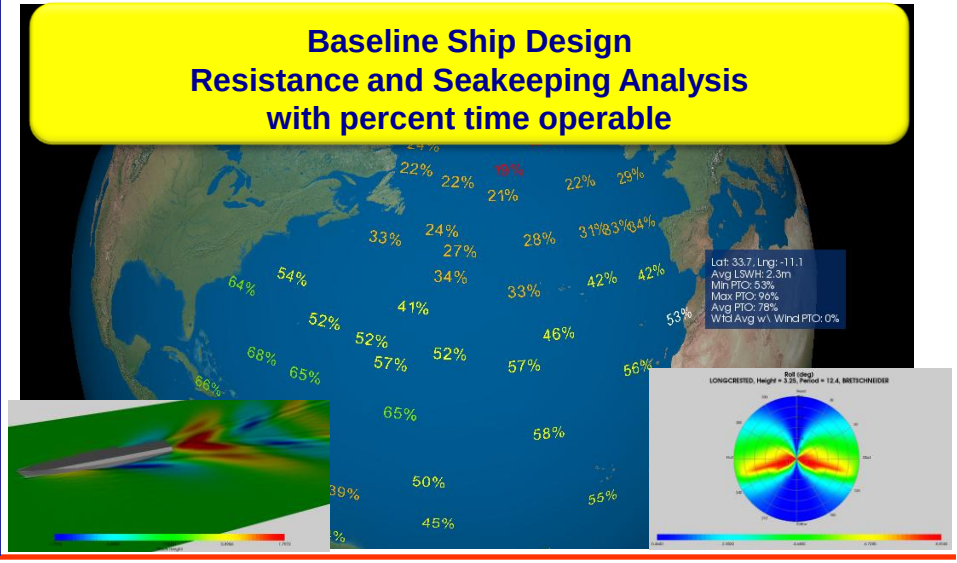
Products

- Demonstration of Set-Based Design Methodology
- Ships designed under changing requirements
- Exercise of CREATE – Ships toolset



Partner Organizations

- NSWC – Carderock Division
- NAVSEA Headquarters
- NAVSEA CPSD
- Navy CONFORM
- HPCMO CREATE – Ships



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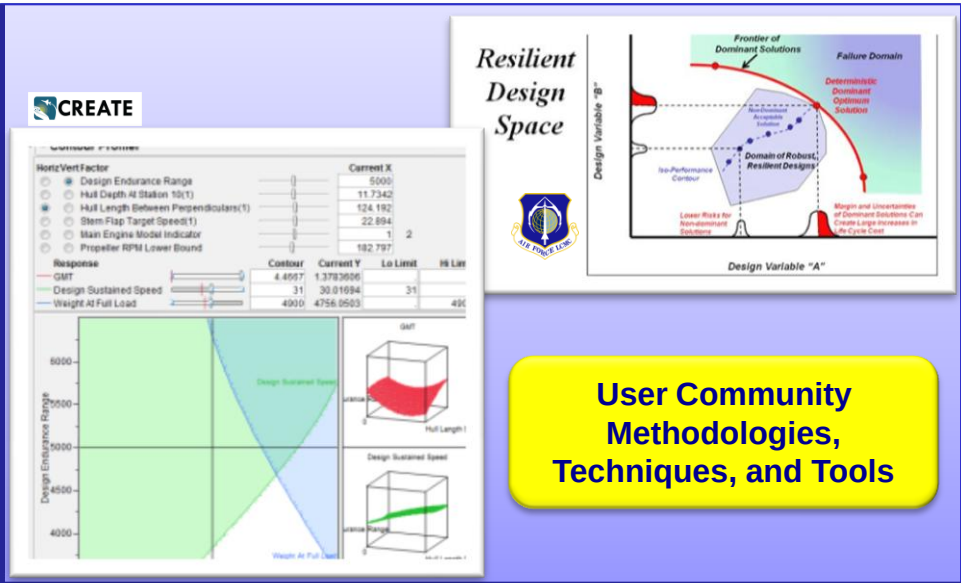
Example ERS Effort Tradespace Analysis

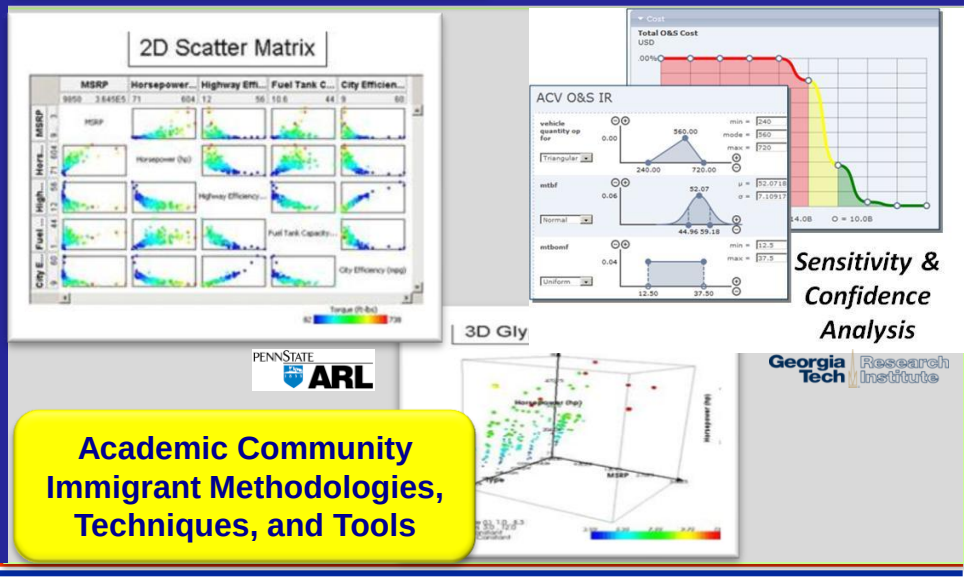
Products

- ERS Tradespace Methodology, Technique and Tool Survey
- Initiated Draft Requirements Document (CDD) for Portfolio Analysis Tool
- Develop a Tradespace Analysis Tool Kit for Acquisition Activities



Partner Organizations

- US Army ERDC
- ARL
- PSU – ARL
- USMA
- GTRI



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Summary

- **ERS potential is enormous**
  - Requirements generation
  - Operational analysis
  - Reset support
- **Current ERS investments highly focused**
  - DARPA, Services
  - Working to “put Humpty-Dumpty” together
- **Requirement – working gap closure**
  - Integration chief among these gaps
  - Essential to gain industry, academia, Department engagement
- **Team is ready, concepts are fully developed**
  - We know what to do

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