Engineered Resilient Systems LOE (FY16-FY25)

- **ERS Mission**
  - Transform Acquisition Engineering
    - Move engineering rigor to the left
    - Reduce risk through improved simulation
    - Instantiate digital engineering process
    - Increase M&S productivity by 10,000x
  - Tri-Service and Industry Collaboration
    - Facilitate impactful demonstrations
    - Share lessons learned

- **Products Delivered**
  - Computational models and process tools (Galaxy)
  - Conceptual design tools (air, land, sea)
  - High performance data analytic infrastructure
  - Decision dashboards & visualization tools
  - Models for mission effectiveness

- **Lessons Learned**
  - Advanced computing (models, data, and analyses) is required for rigorous systems analysis
  - Computational environments that easily adapt to unique processes, models and tools for each acquisition domain is a must
  - Government/industry collaboration is crucial for success

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Late discovery of design or requirements changes drive up cost and extend schedules.
ERS Capabilities

**Computational Processes**
- Speed and Accuracy

**Computational Environments**
- Shared Tools & Data

**Decision Analytics**
- Deep Insights

**Set-Based Design**
- Risk Reduction & Resilience

**Decision Dashboards**
- Decide Faster

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*Conceptual Design GUI*

*Rotorcraft Sensitivity Studies*
Computational Processes

**Speed and Accuracy**

- **Key Projects**
  - AFRL / Lockheed Hypersonics
  - AFRL Directed Energy
  - Army Future Vertical Lift

- **Required Capabilities**
  - Fast and accurate models – six months to six days to six seconds
  - Model accessibility – production grade
  - Multi-physics, tightly or loosely coupled
  - Temporal and spatial domain scalability – 7 orders magnitude
  - Portability to multiple computing environments
  - Ubiquitous usage

- **Challenges**
  - Solution times
  - Surrogate model training data requirements
  - End-to-end, fully coupled, model execution

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S-76 rotor

AIAA Hover Prediction Workshop 2015
Computational Environments

Shared Tools & Data

- **Key Projects**
  - Hypersonics – AFRL / Lockheed Computational Environment
  - AI/ML – JAIC PMx NMI, JAIC JCF
  - Future Vertical Lift

- **Required Capabilities**
  - Common AI/ML development software
  - Common access to data / models by all partners
  - Must leverage DOD HPCMP and Cloud (JEDI when ready)
  - Portability to future computing platforms

- **Challenges**
  - Continuous funding
  - Computational environments are still in development
  - Cultural acceptance
  - Gov/OEM should utilize same tools
Decision Analytics

Deep Insights

- **Key Projects**
  - Predictive maintenance: (PMx) NMI, UH-60 Black Hawk
  - Cyber analytics
  - Automated labeling of data

- **Required Capabilities**
  - Co-location of data and analytic tools
  - Advanced data wrangling
  - Automated tuning of AI/ML algorithms
  - Computing learning at the edge
  - Physics-informed machine learning

- **Challenges**
  - Tera-, peta-, exabyte data lakes
  - Mixed classification of data
  - Dirty data
Set-Based Design

Risk Reduction & Resilience

• Key Projects (25+ current projects)
  – High-powered microwave effectiveness models (AFSIM)
  – Space-based power, IADS, and LEO satellite studies in AFSIM
  – DARPA HAVOC, DARPA INVEST programs
  – High-energy laser parameter tuning in AFSIM
  – Army Future Vertical Lift conceptual design and assessment
  – Hall Effect thruster parameter tuning

• Required Capabilities
  – Scalability – must execute and analyze $10^N$ simulations
  – Must include legacy tools
  – Machine-driven design
  – Multi-fidelity model coupling

• Challenges
  – Properly sized sets for accurate tradespace exploration
  – Cost modeling
  – Accurate physics
### Decision Dashboards

#### Key Projects
- Trades on ships, AV, missions
- Logbook data (helicopters)
- Environmental factors

#### Required Capabilities
- Ease of use
- Faster execution
- Portability
- Adaptability

#### Challenges
- Portability to environments (classification)
- Disconnected workflows
- Spotty network connectivity
- Unique stakeholder processes
- Mission engineering integration
ERS Partners and Collaborators

Government
- Air Force Research Lab (AFRL)
- Joint AI Center (JAIC)
- Army Research Laboratory (ARL)
- Combat Capabilities Development Command (CCDC)
- Engineer Research and Development Center (ERDC)
- AF Life Cycle Management Center (AFLCMC)
- Arnold Engineering Development Center (AEDC)
- Naval Research Laboratory (NRL)
- Naval Undersea Warfare Center (NUWC)
- Naval Sea Systems Command (NAVSEA)

Industry, & Academia
- Carnegie Mellon University
- Stevens
- Texas
- Georgia Tech
- Pennsylvania State University
- Massachusetts Institute of Technology
- West Point
- NPS

Coalition Partners
- BAE Systems
- Raytheon
- Northrop Grumman
- Dassault Systemes
- Boeing
- Anaconda
- Kitware
- Aqua VEO

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Summary

• The ERS program addresses specific needs as outlined within the 2018 National Defense Strategy.

• ERS is focused on critical OSD priorities (e.g. AI/ML, Hypersonics, Directed Energy).

• Industry interactions are critical in support of priority DoD projects.

• ERS capabilities are adaptable to support the DoD mission engineering process using computational environments, mission modeling software, and advanced visualization.

• ERS ensures ability of services, industry, and coalition partners to fully implement digital engineering strategy.