Engineered Resilient Systems

Power of Advanced Modeling and Analytics in Support of Acquisition

Computational Engineering Ecosystem
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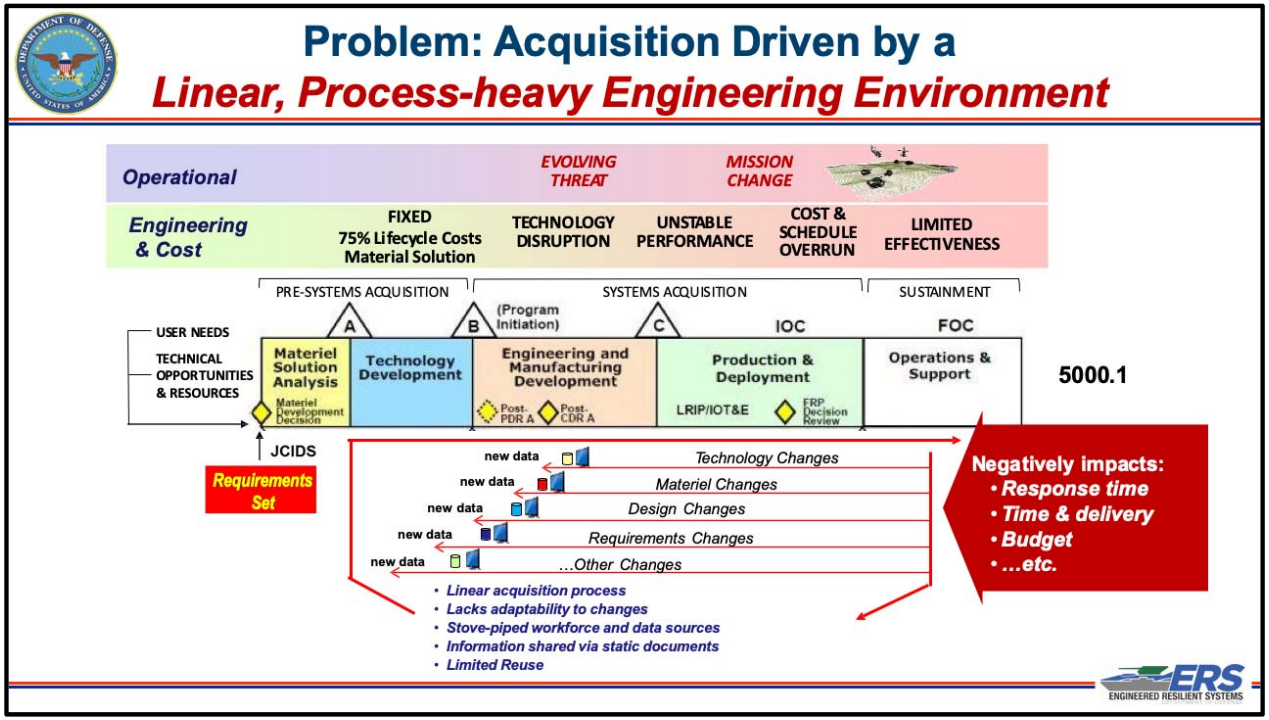
Engineered Resilient Systems LOE (FY16-FY25)

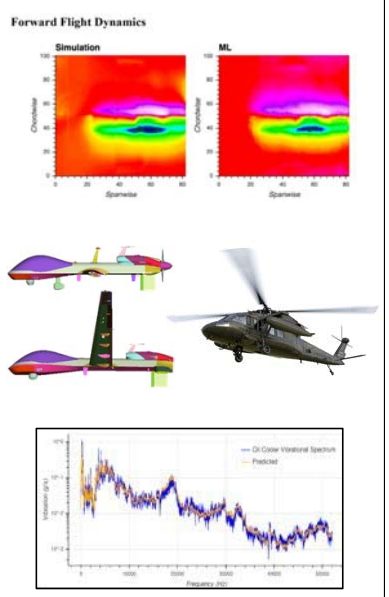
- **ERS Mission**
  - Transform Acquisition Engineering
    - Move engineering rigor to the left
    - Reduce risk through improved simulation
    - Instantiate digital engineering process
    - Increase M&S productivity by 10,000x
  - Tri-Service and Industry Collaboration
    - Facilitate impactful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



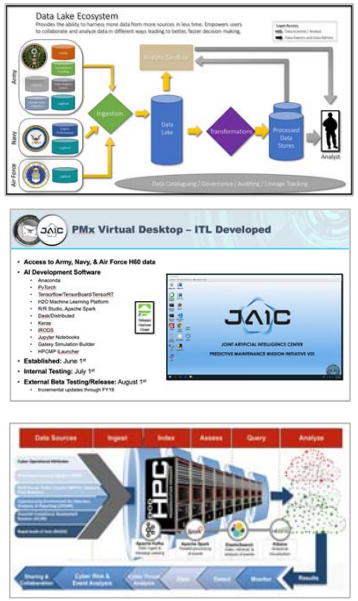
Late discovery of design or requirements changes drive up cost and extend schedules.

ERS Capabilities

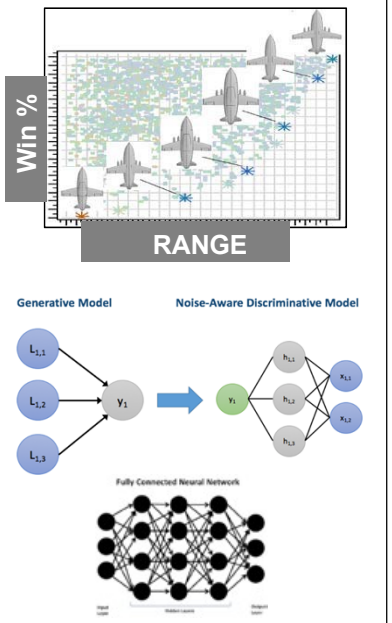
Computational Processes
Speed and Accuracy



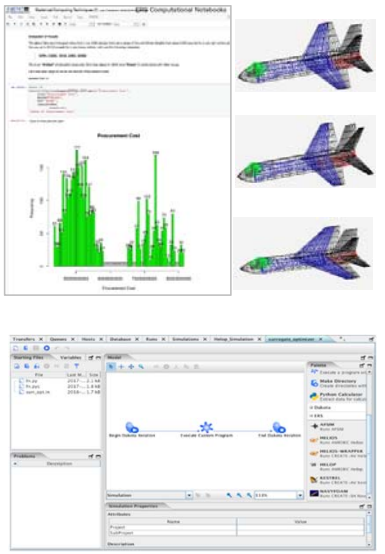
Computational Environments
Shared Tools & Data



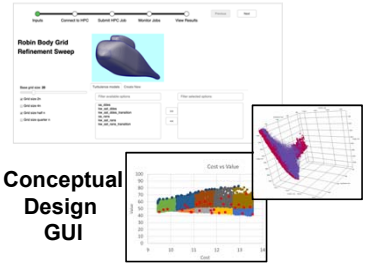
Decision Analytics
Deep Insights

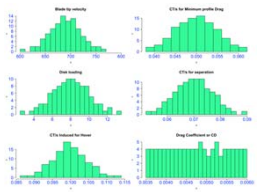


Set-Based Design
Risk Reduction & Resilience



Decision Dashboards
Decide Faster



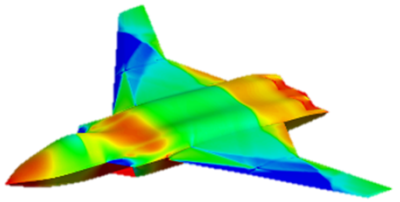


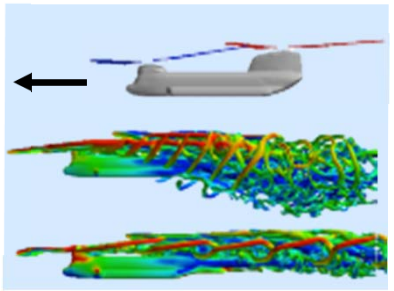
Rotorcraft Sensitivity Studies

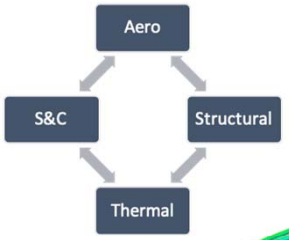
Computational Processes

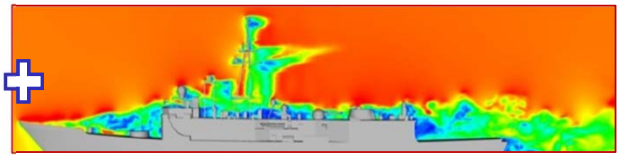
Speed and Accuracy

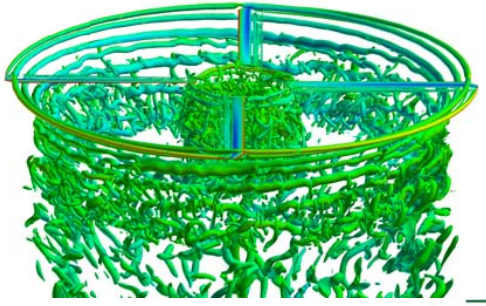
- **Key Projects**
  - AFRL / Lockheed Hypersonics
  - AFRL Directed Energy
  - Army Future Vertical Lift
- **Required Capabilities**
  - Fast and accurate models – six months to six days to six seconds
  - Model accessibility – production grade
  - Multi-physics, tightly or loosely coupled
  - Temporal 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











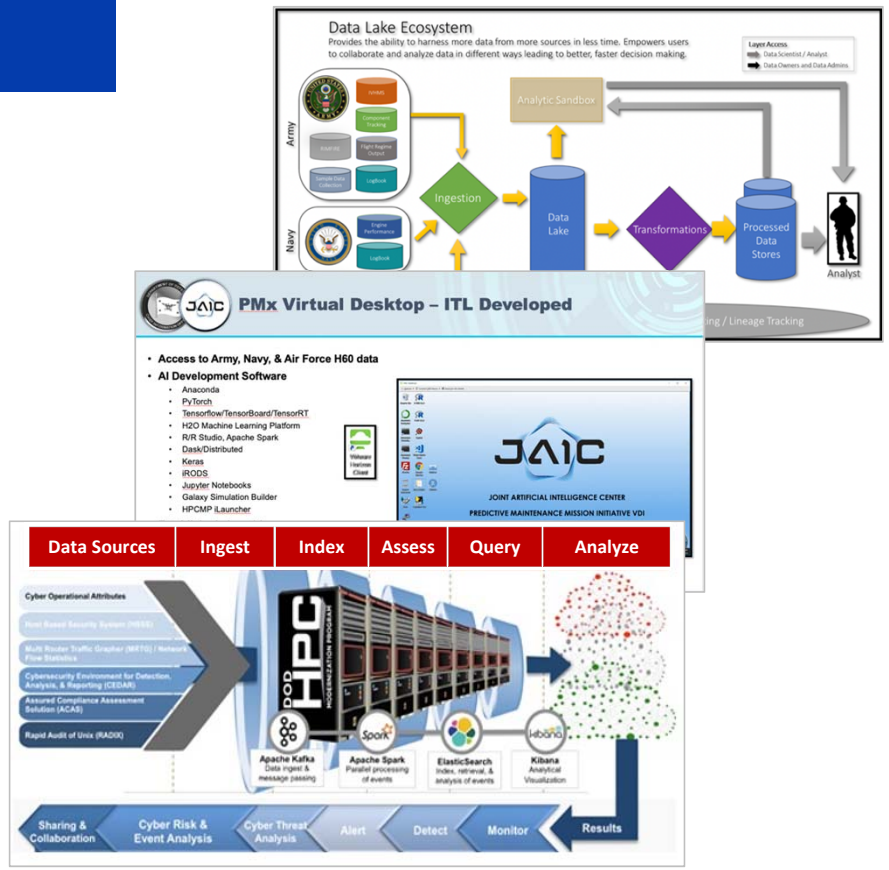
S-76 rotor

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

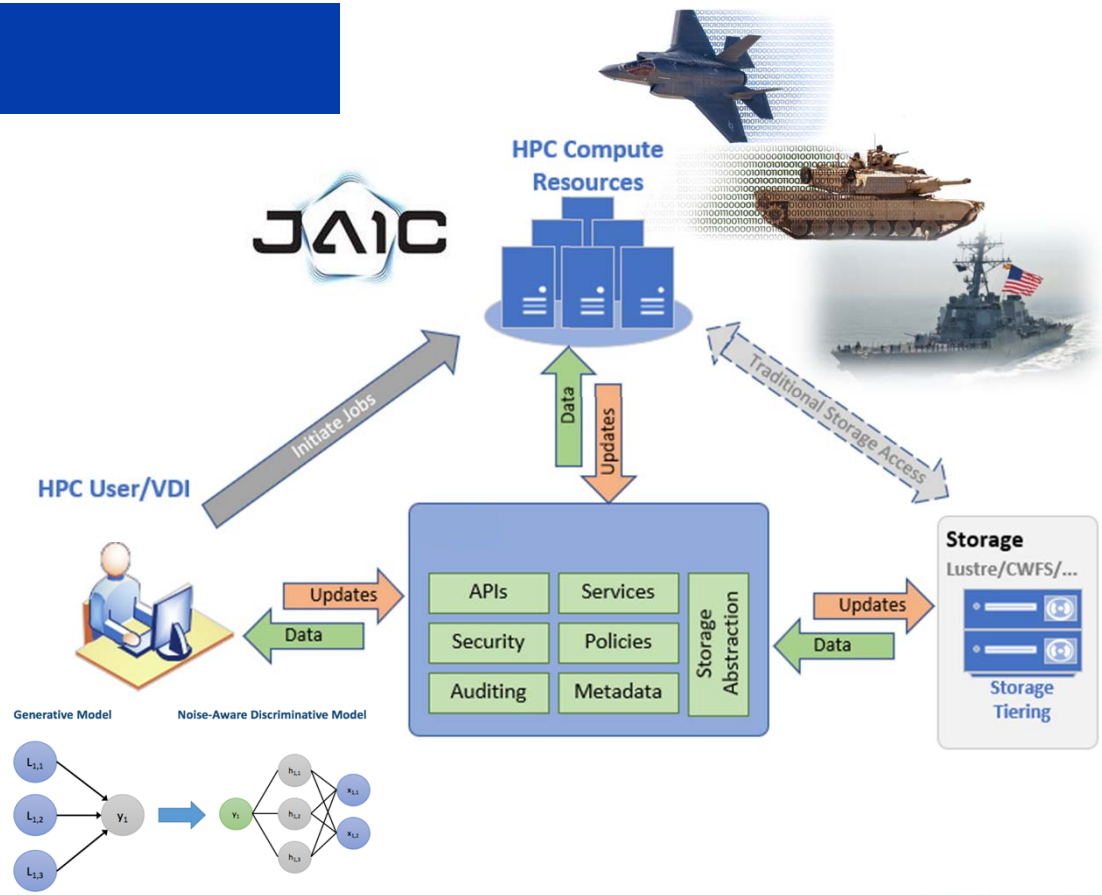


ENGINEERED RESILIENT SYSTEMS

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

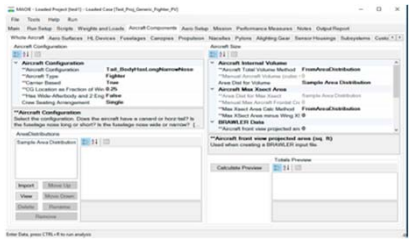


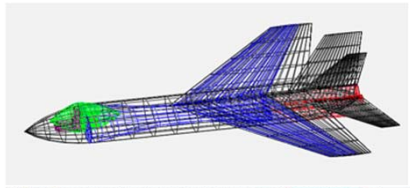
ERS ENGINEERED RESILIENT SYSTEMS

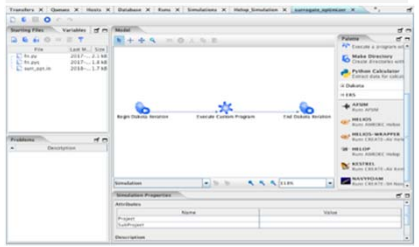
Set-Based Design

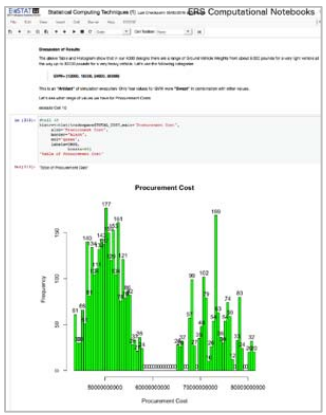
Risk Reduction & Resilience

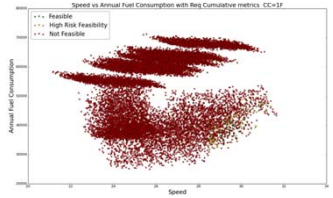
- **Key Projects (25+ current projects)**
  - High-powered microwave effectiveness models (AFSIM)
  - Space-based power, IADS, and LEO satellite studies in AFSIM
  - DARPA HAVOC, DARPA INVEST programs
  - High-energy laser parameter tuning in AFSIM
  - Army Future Vertical Lift conceptual design and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

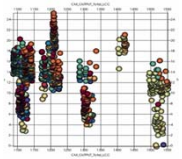




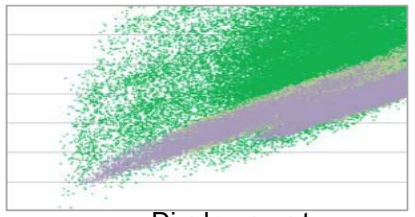








Cluster analysis - GV

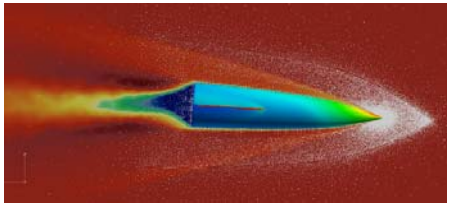


ENGINEERED RESILIENT SYSTEMS

Decision Dashboards

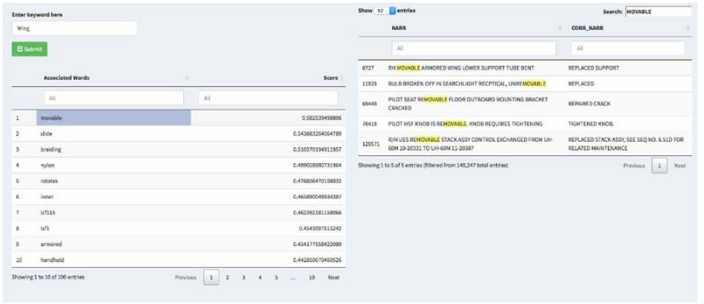
Decide Faster

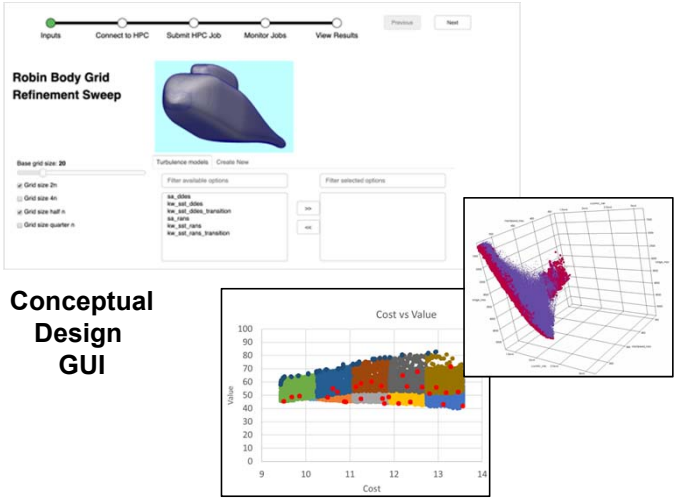
- **Key Projects**
  - Trades on ships, AV, missions
  - Logbook data (helicopters)
  - Environmental factors
- **Required Capabilities**
  - Ease of use
  - Faster execution
  - Portability
  - Adaptability
- **Challenges**
  - Portability to environments (classification)
  - Disconnected workflows
  - Spotty network connectivity
  - Unique stakeholder processes
  - Mission engineering integration



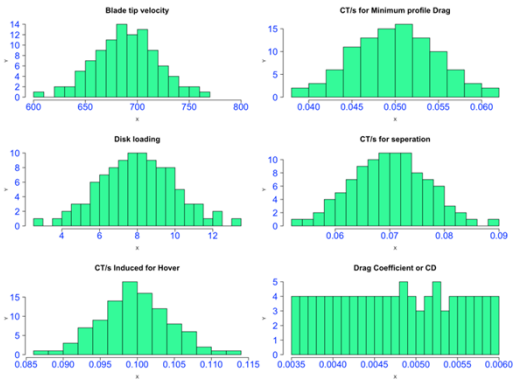
Scientific Visualizations

Maintenance Dashboards





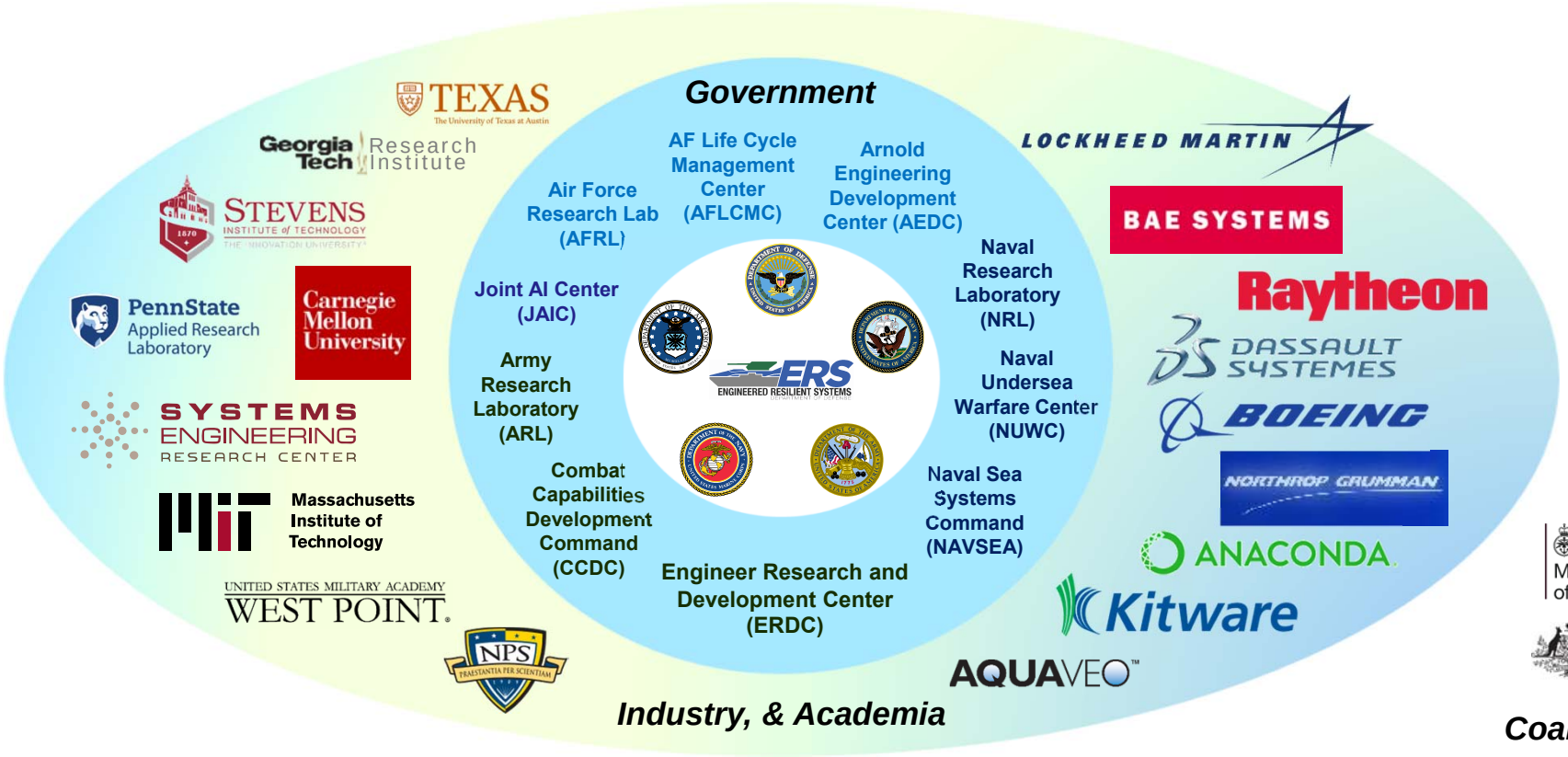
Conceptual Design GUI



Rotorcraft Sensitivity Studies

ENGINEERED RESILIENT SYSTEMS

ERS Partners and Collaborators



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.