Engineered Resilient Systems (ERS) Architecture
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Cary D. Butler, PhD
Technical Director, ERS Lead Architect
U.S. Army Engineer Research and Development Center (ERDC)
Architecture Approach

- ERDC
- Software Engineering Institute (SEI)
- BAE
- Advanced Coordination Technology (ACT)
- Raytheon
- Lockheed

Software Development Team

1. Architecture Team
   - design & requirements
   - feedback

2. Software products

3. Users

- ERDC
- Kitware
- Georgia Tech Research Institute (GTRI)
- Mississippi State University
1. Apply advanced computing methods as a way to improve accuracy, depth, and breadth of decision making.

2. Improve the impact of ERS through early and continuous delivery of products.

3. Focus on building user acceptance early and adding new capabilities as users become more comfortable with the products (agile approach to development).

4. Enable an “Open” computing framework that supports capabilities spanning DoD and industry.

5. Integration with industry is key to success.

Drive the integration of numerical simulations with the ability to analyze large sets of design alternatives.

11-12 July 2012 - Arlington, VA
Options are organized into a tradespace

Given a set of **design variables**, the tradespace is the space of possible **design options**. - Ross and Hastings

**Data Structure**

**Design Variables**

```
  1  2  3  ...  m

  1  2  3  ...  m

  1  2  3  ...  m

  1  2  3  ...  m
```

**Design Options**

```
  1  2  3  ...  n

  1  2  3  ...  n

  1  2  3  ...  n

  1  2  3  ...  n
```

**Tradespace Complexity**: $O(X^M)$ where $M$ is the number of design variables
Curse of Dimensionality

- **Humans**: 10s of options
- **Excel**: 100s of options
- **Data Analysis Tools**: 1000s of options
- **Supercomputers**: Hyper-dimensional space, millions of options

**Size of tradespace vs. decision complexity**
Workflow View
ERS Workbenches

- Workbenches include preconfigured instantiations of ERS tools
- Simplifies usability – *one-click access* to preconfigured desktops of ERS tools
- Workbenches can be uniquely tailored to a problem domain (e.g., airplanes, ships, ground vehicles, etc.)
- Training is tailored to a specific Workbench
- Workbenches leverage HPC resources
Data Analysis View

High Performance Data Analytics Workbench

- Provides a DoD ecosystem for conducting large-scale data analytics
- Extends existing DoD investments in HPC to include data-intensive computing
- Provides users remote desktop access to Workbench
- Allows for the development of data analytics training curriculum based on Workbench
- Enables the deployment of Workbench on designated HPCMO machines
Topaz is an SGI ICE X System located at the ERDC DSRC. Topaz has 3,456 standard compute nodes each with 36 cores (124,416 total compute cores), 442.37 TBytes of memory, and is rated at 4.62 peak PFLOPS.
Industry Computing View

<table>
<thead>
<tr>
<th>Industry</th>
<th>Amazon Federal Cloud</th>
<th>ers.mil</th>
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</thead>
<tbody>
<tr>
<td>Models</td>
<td>ERS-supported environment for industry partners wanting to participate in ERS</td>
<td></td>
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<tr>
<td></td>
<td>Environment is partitioned into industry spaces</td>
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<td></td>
<td>API standards are defined and used to access models and/or data</td>
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<td></td>
<td>Industry oversees security for their space</td>
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Diagram:
- Amazon Web Services
- TradeStudio
- Model/Data Catalog
- Publish
- Request
- Response
Product View

TRADESTUDIO

1 DEFINE

Define the system & its requirements in SysML

• SysML Authoring Tools

2 BUILD

Construct accurate & complete tradespaces

• Numerical Simulation
• Environmental Simulation
• Data Analytics
• Legacy Models and Data
• M&S Integration
• Industry Models and Data

3 ANALYZE

Visualize & explore the tradespace

• Tradespace Exploration
• Tradespace Reduction
• AoA
• Mission Context Analysis
• Trade-off Analytics
TradeBuilder (Model Integration Framework)

*Models to Tradespace*

- Built using open source Jupyter framework
- Jupyter provides a user-friendly way for stitching codes constructing tradespaces
- Notebooks are developed specific to each acquisition problem
- Notebooks interface with HPC to conduct large-scale calculations
- ERS provides a set of intrinsic functions that speed-up notebook development
- Notebooks are reusable
- Users can easily modify model parameters and rerun tradespace

- Legacy models and data
- OpenVSP (parametric geometry)
- OpenMDAO or HPC Galaxy (model orchestration)
- CREATE (performance models)
- System utilities
- Surrogates (simplified models)
- Jupyter Notebooks (tradespace development environment)
TradeAnalyzer

Tradespace to Insights
Open Architecture

1. TradeBuilder
   • Open development environment for creating tradespaces
   • Bring your own models and data
   • Common set of reusable functions reduce time needed to build tradespaces
   • Designed to leverage CREATE and HPC resources
   • Embed your own R or Python code

2. TradeStudio Modules
   • Modular back-end in Node.js
   • REST services integration through Node modules
   • Project data structures in easy to read MongoDB JSON
   • Front-end tools added through AngularJS directives
   • Client-side services available for most operations

3. Tradespace Data (ERS Data Packaging)
   • Comprehensive REST API for project and tradespace access
   • Low-level API for direct tradespace access for tools needing high performance

4. R Analytics
   • Custom R analysis needed with no web programming necessary

5. Authentication/Authorization
   • Leverages the open SAML standard