Engineered Resilient Systems (ERS)

Architecture

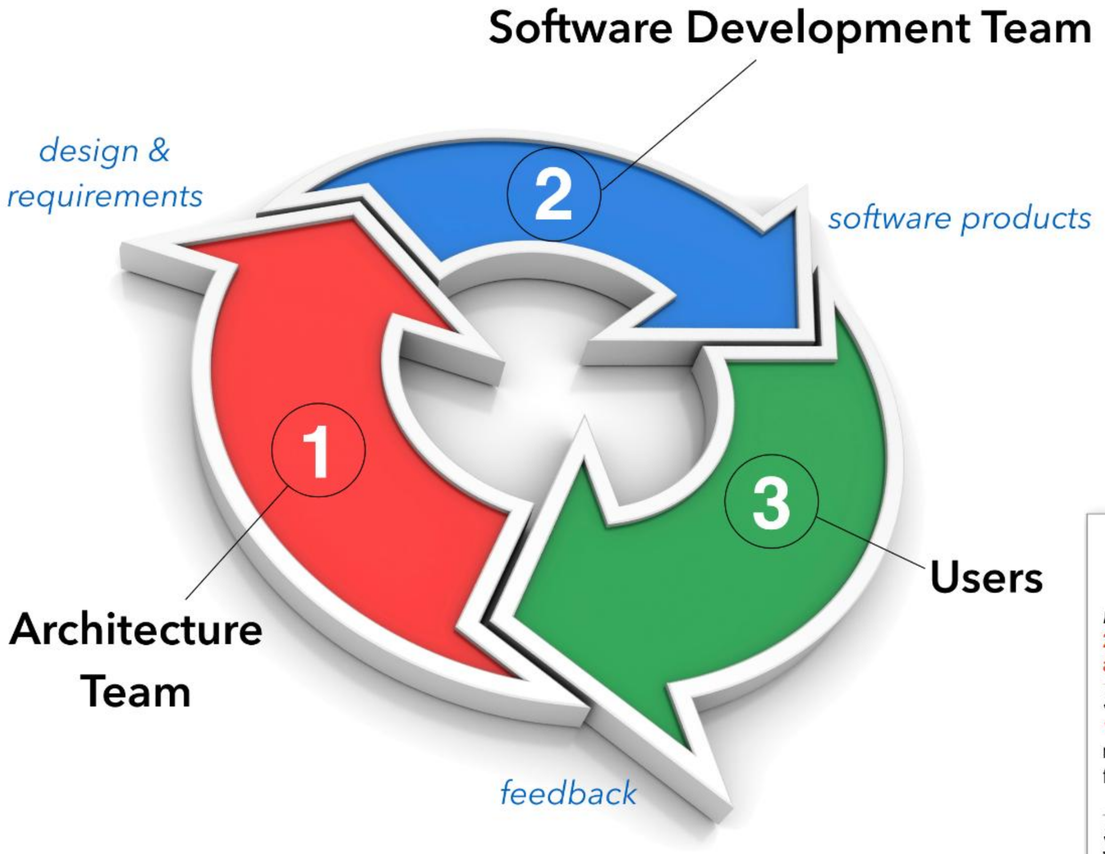
NDIA Conference, November 2016

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

ENGINEERED RESILIENT SYSTEMS

Architecture Approach

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



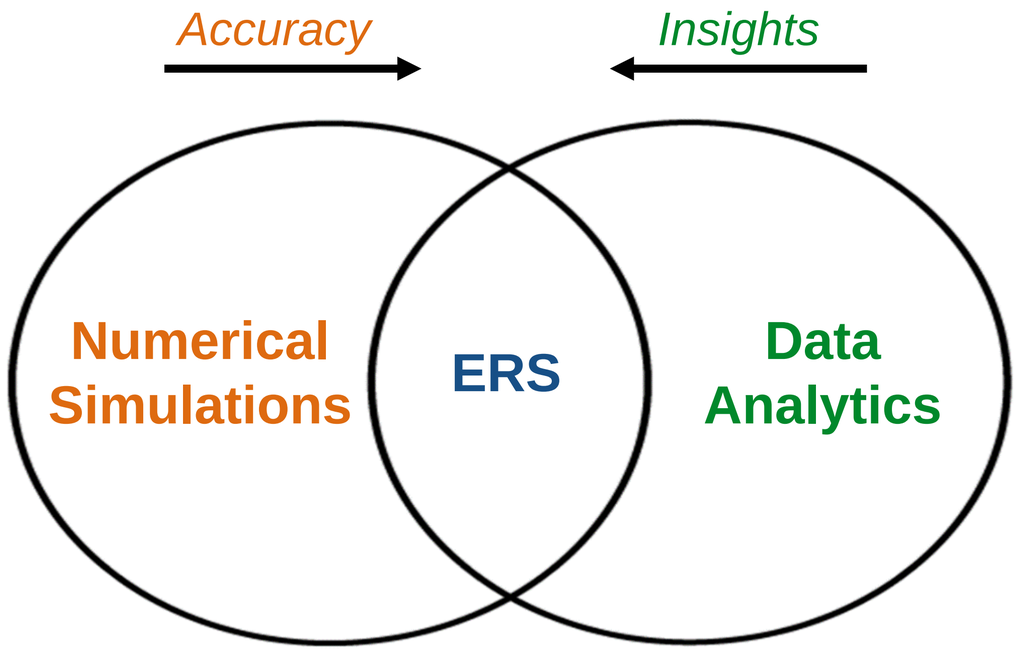
- ERDC
- Kitware
- Georgia Tech Research Institute (GTRI)
- Mississippi State University

Architecture Drivers

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.

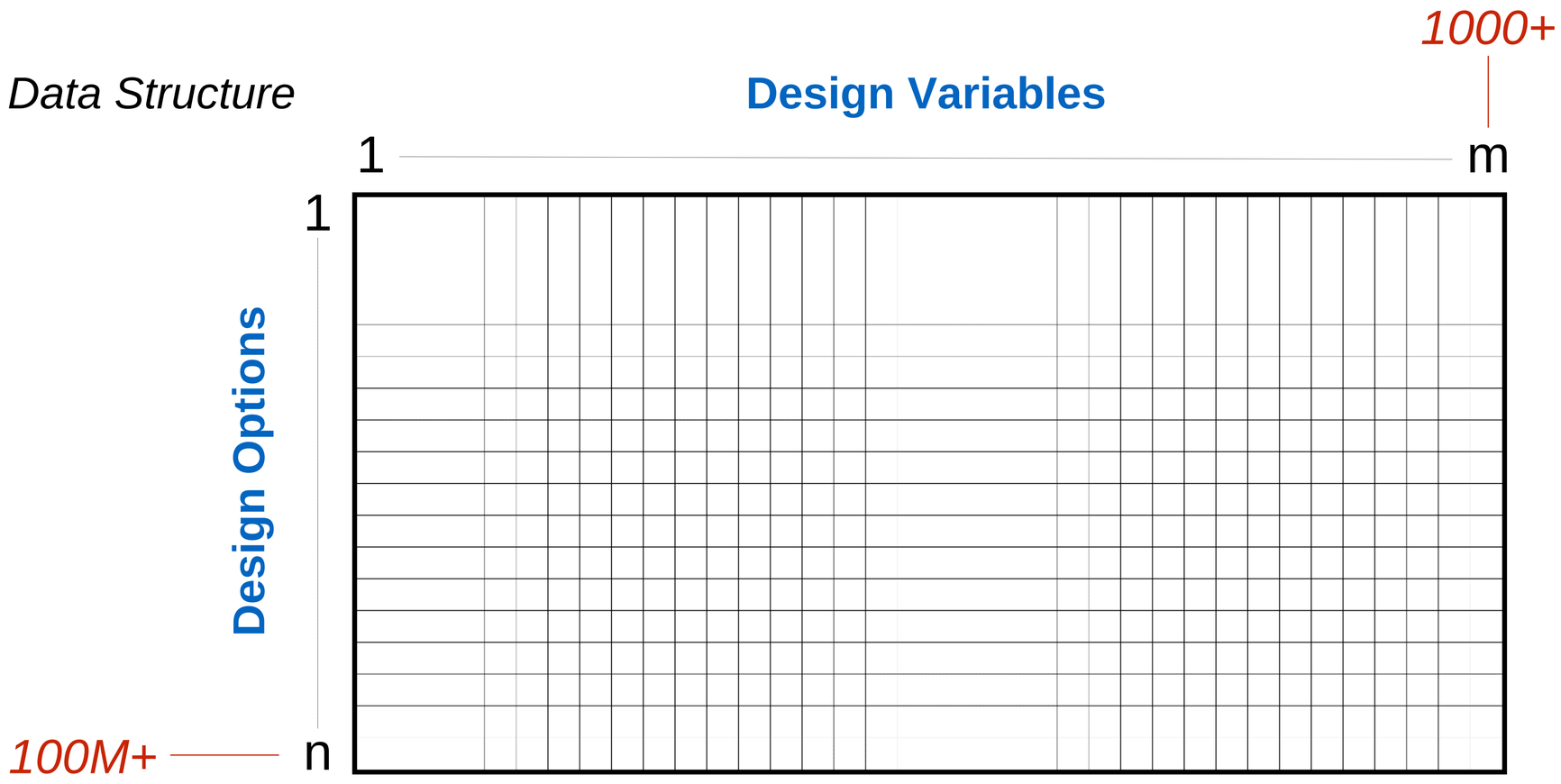
11-12 July 2012 - Arlington, VA

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



Options are organized into a tradespace

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



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

Curse of Dimensionality

Humans

10s of options

Excel

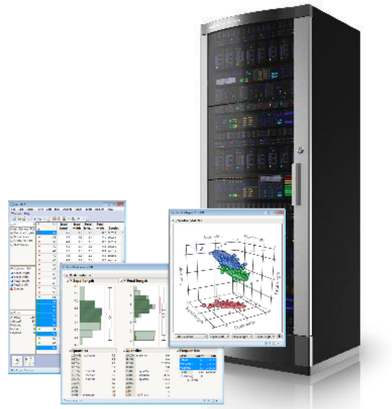
100s of options

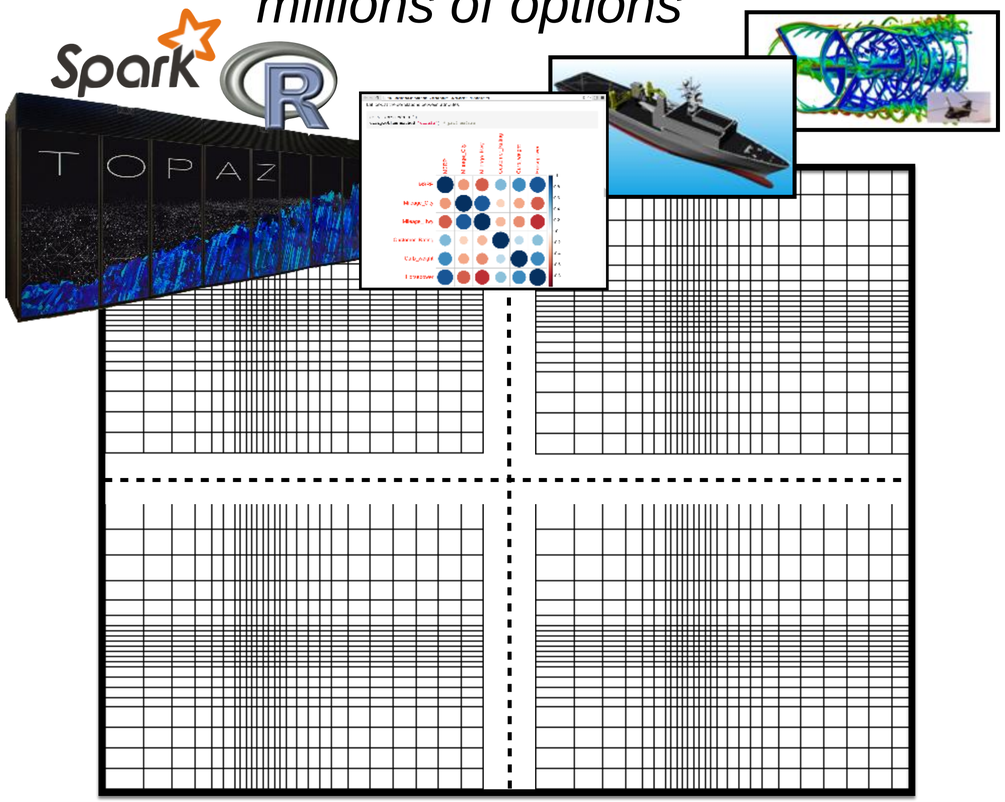
Data Analysis Tools

1000s of options

Supercomputers

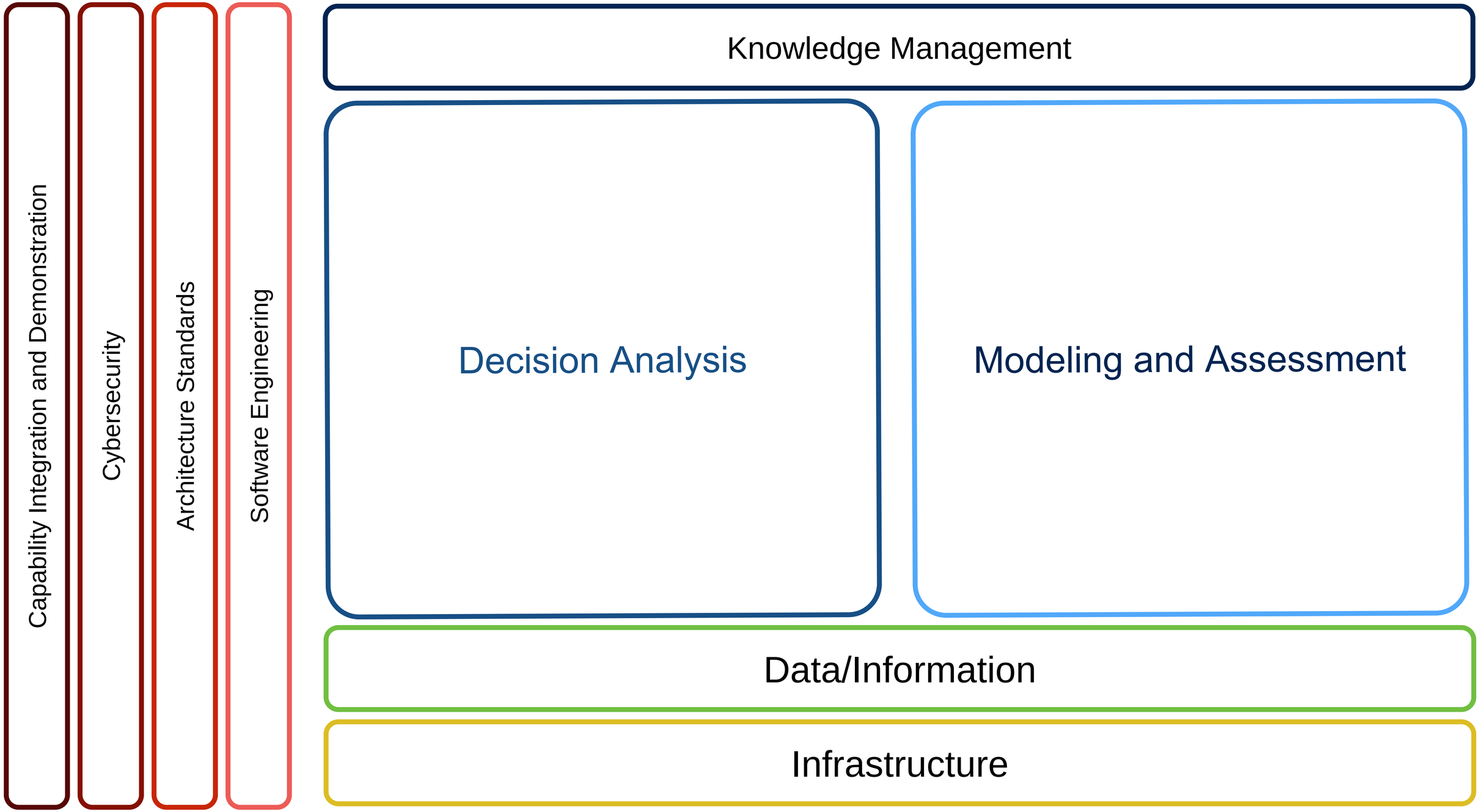
Hyper-dimensional space millions of options



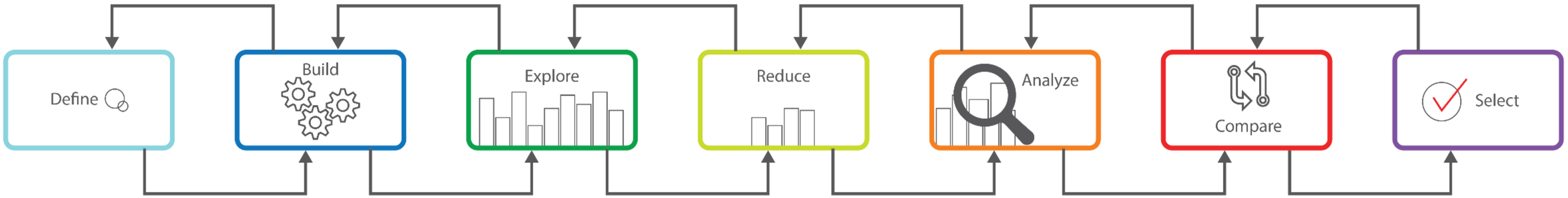


decision complexity

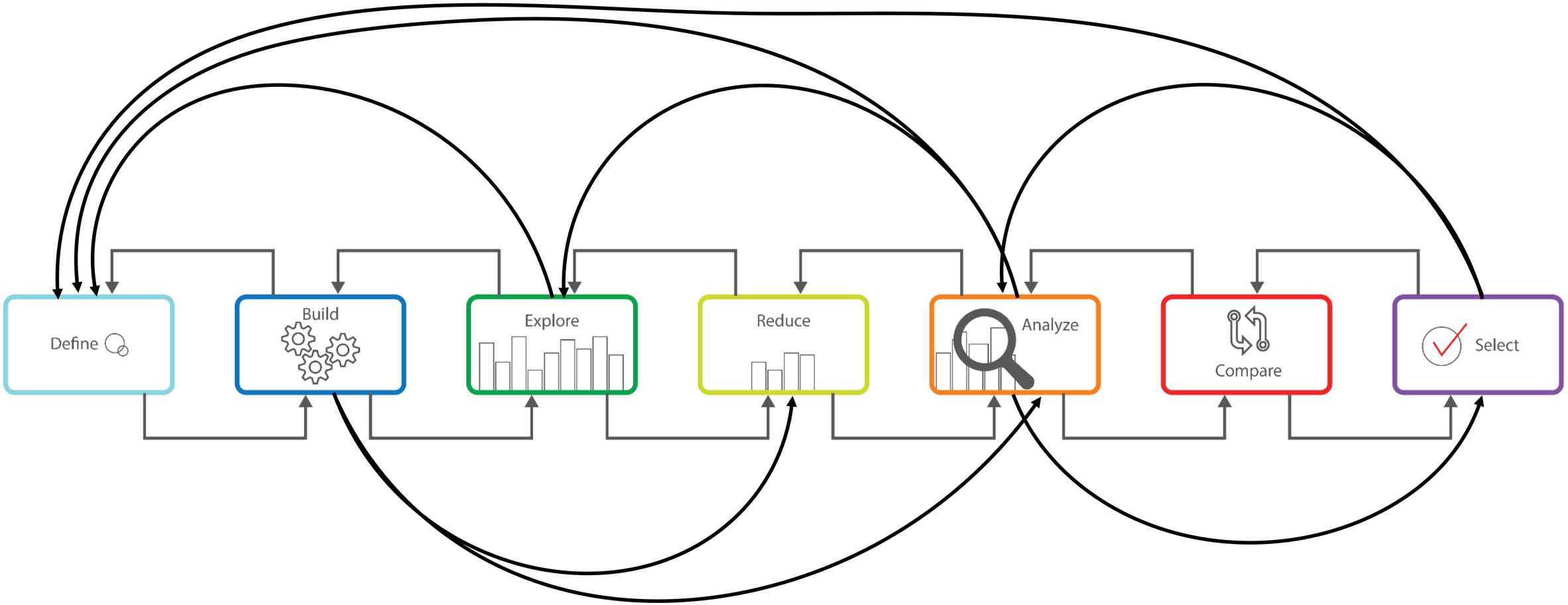
size of tradespace


Capability Integration and Demonstration
Cybersecurity
Architecture Standards
Software Engineering
Knowledge Management
Decision Analysis
Modeling and Assessment
Data/Information
Infrastructure

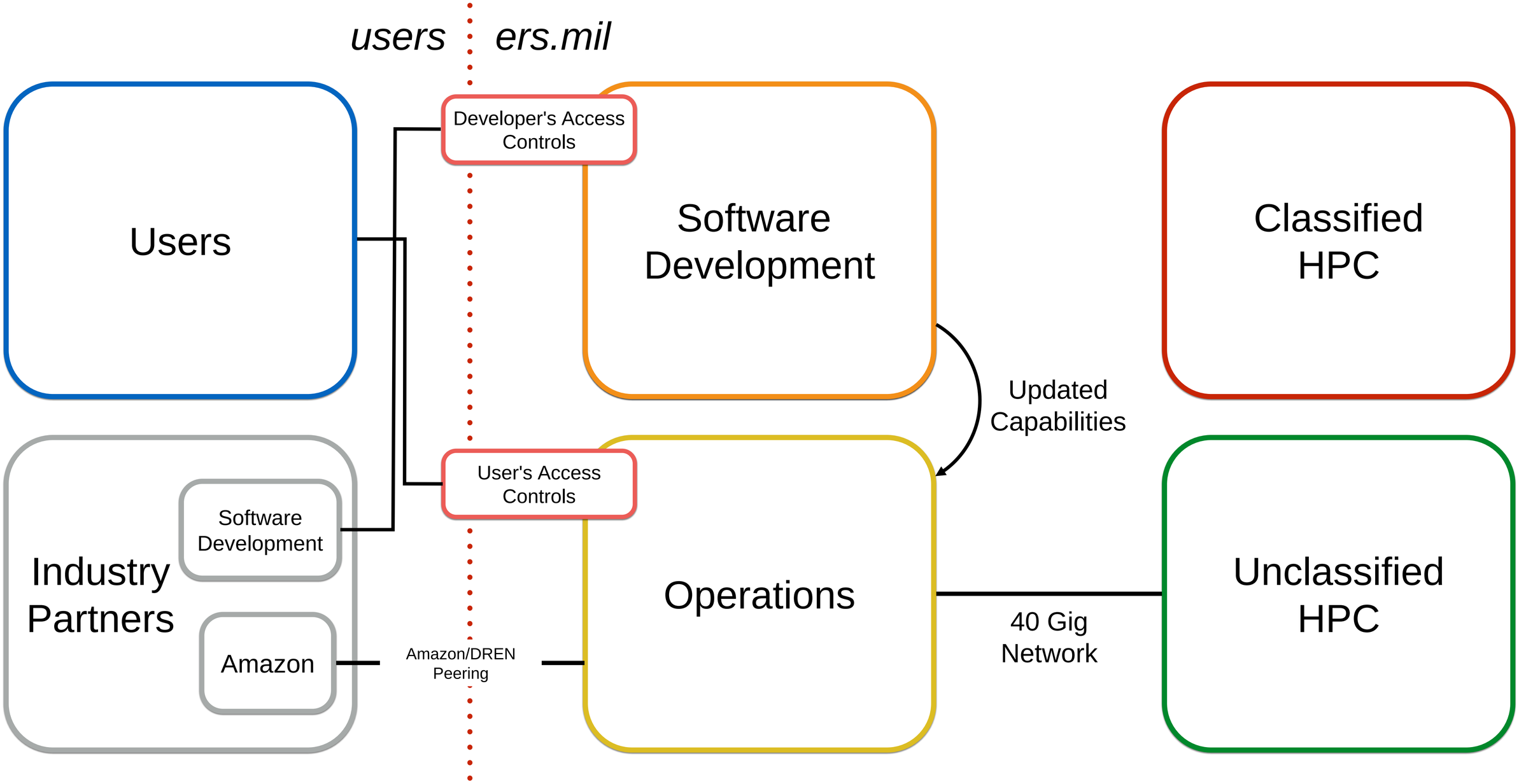
Workflow View



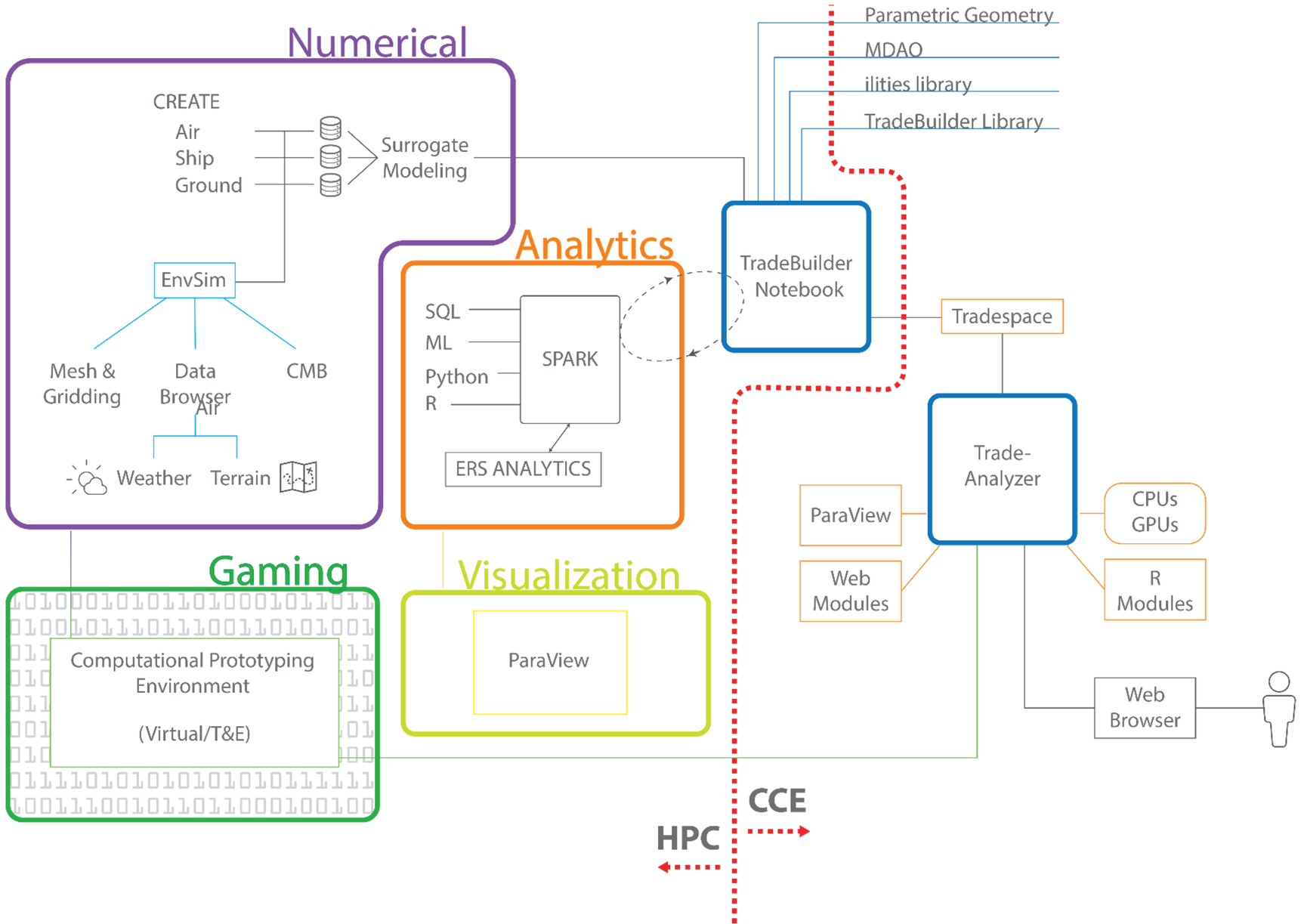
Workflow View



Infrastructure View

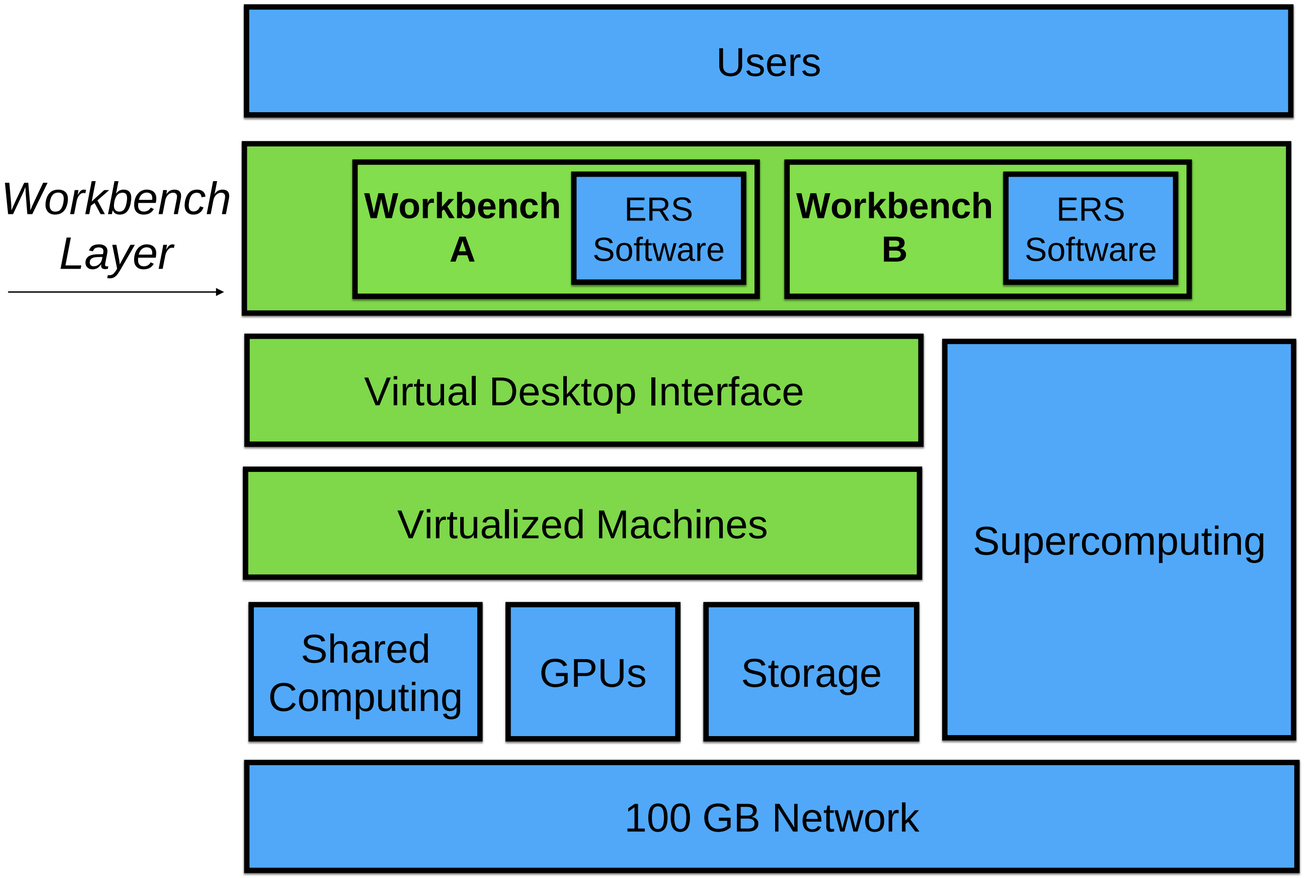


System View


Numerical
CREATE
Air
Ship
Ground
Surrogate Modeling
EnvSim
Mesh & Gridding
Data Browser
CMB
Air
Weather
Terrain
Analytics
SQL
ML
Python
R
SPARK
ERS ANALYTICS
Parametric Geometry
MDAO
ilities library
TradeBuilder Library
TradeBuilder Notebook
Tradespace
Trade-Analyzer
ParaView
Web Modules
CPUs GPUs
R Modules
Web Browser
Gaming
Computational Prototyping Environment
(Virtual/T&E)
Visualization
ParaView
CCE
HPC

ERS Workbenches

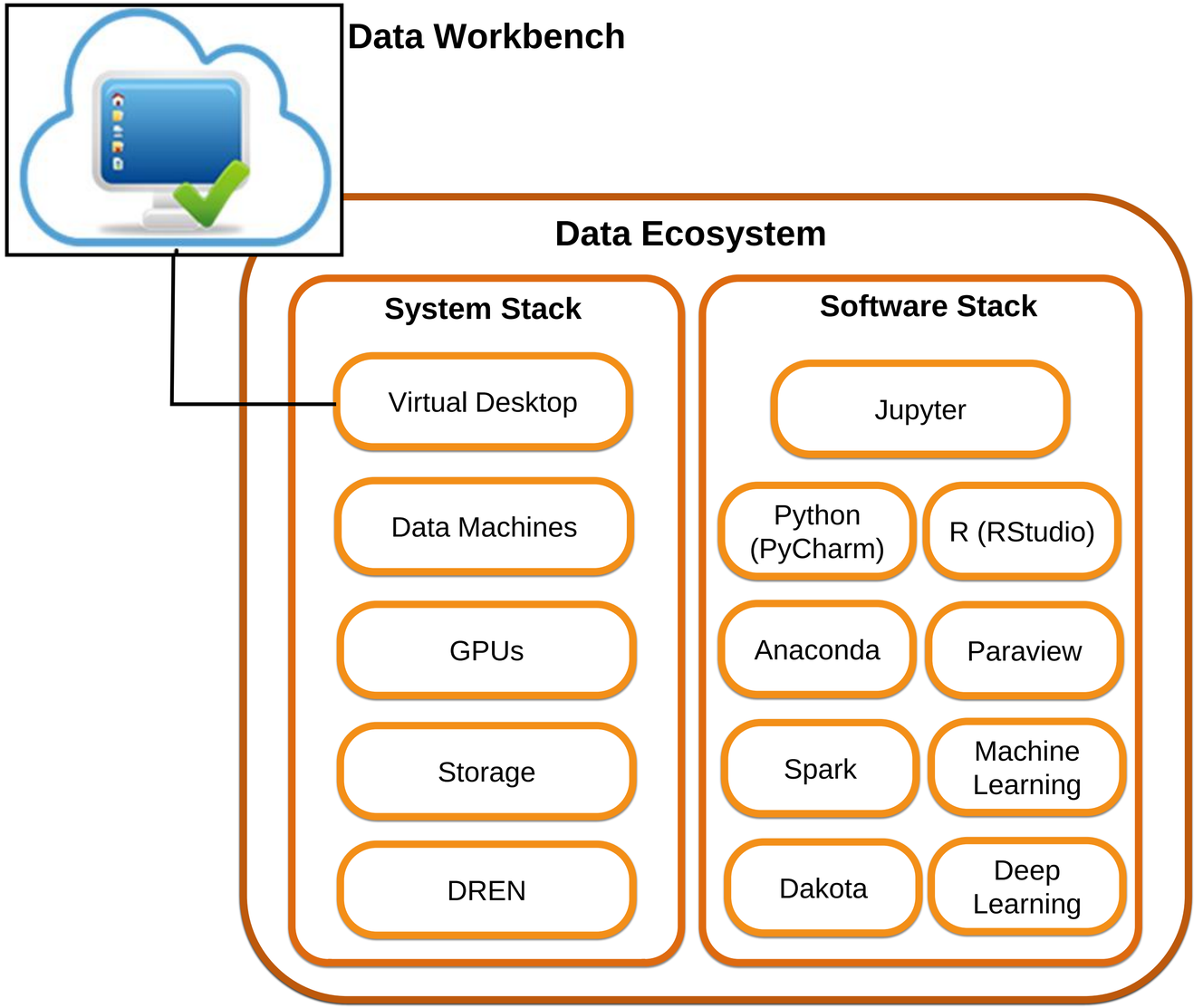
- Workbenches include preconfigured instantiations of ERS tools
- Simplifies usability – *one-click access* to preconfigured desktops of ERS tools
- Workbenches can be uniquely tailored to a problem domain (e.g., airplanes, ships, ground vehicles, etc.)
- Training is tailored to a specific Workbench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



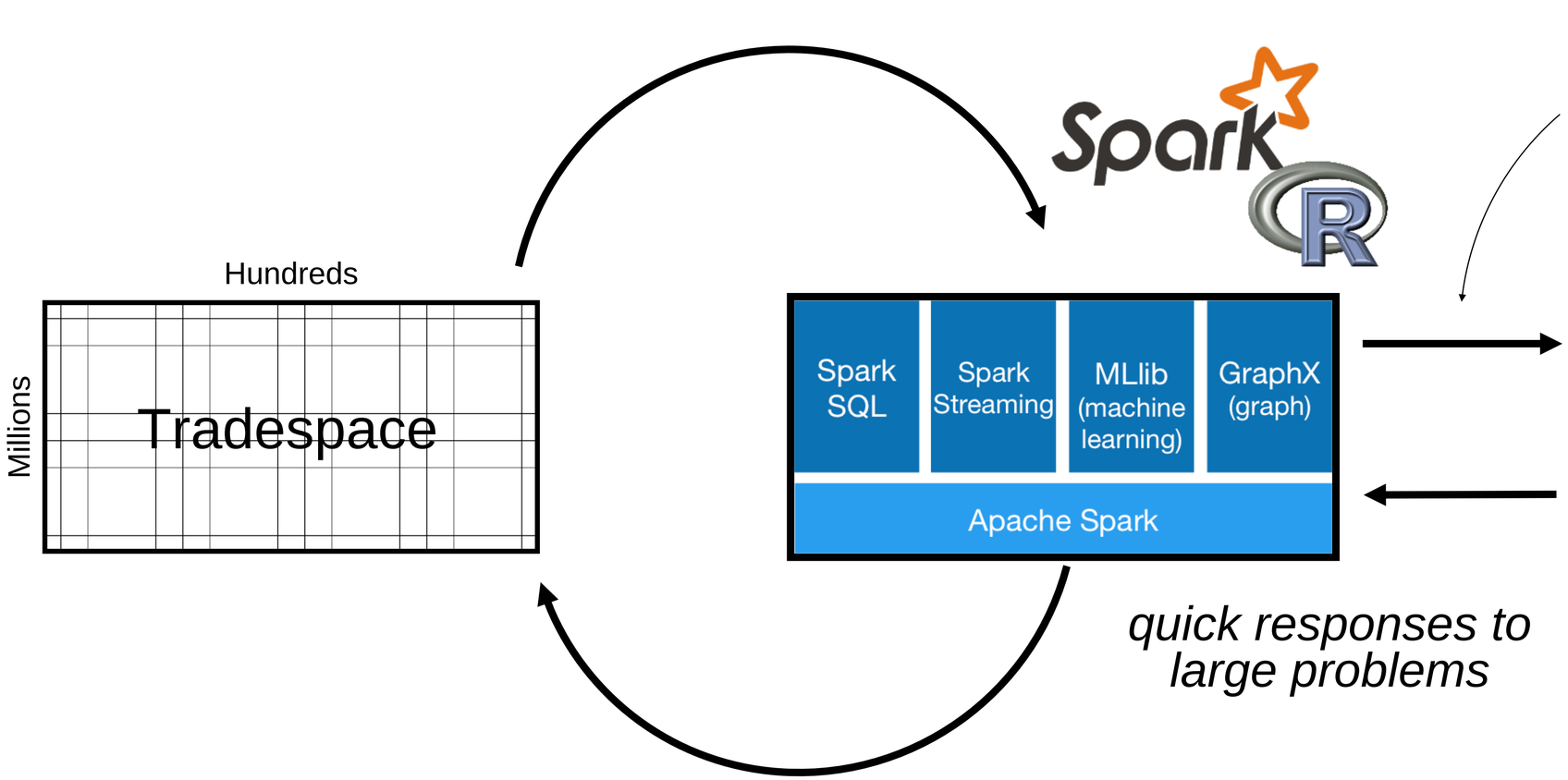
Data Analysis View

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



High-Performance Data Analytics

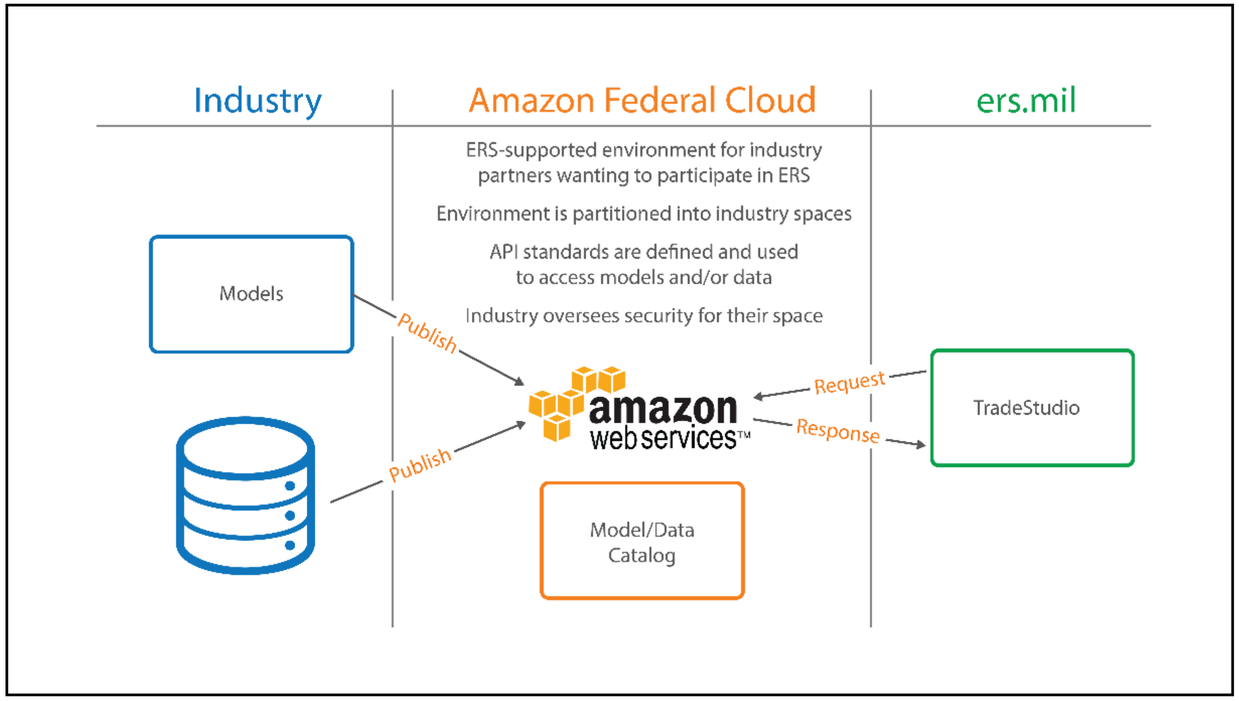


subdivides the problem across multiple cores

quick responses to large problems

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

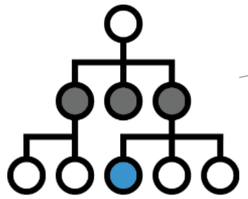


Product View

TRADESTUDIO

1 DEFINE

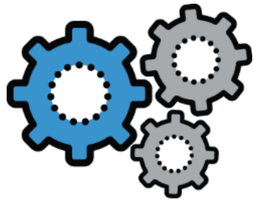
Define the system & its requirements in SysML



- 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

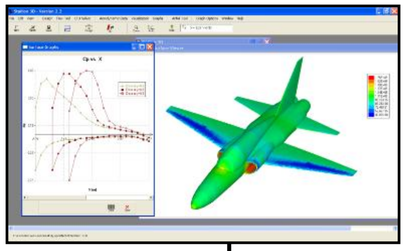
- Tradespace Exploration
- Tradespace Reduction
- AoA
- Mission Context Analysis
- Trade-off Analytics

TradeBuilder (Model Integration Framework)

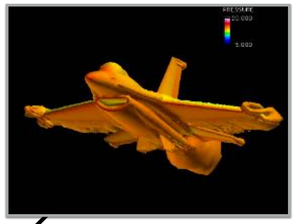
Models to Tradespace

- 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

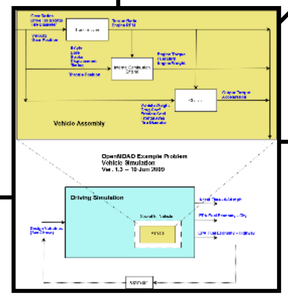
Parametric Modeling



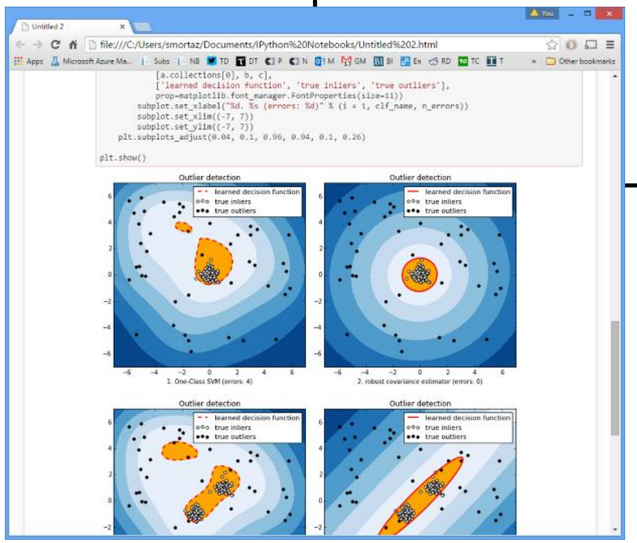
CREATE



HPC



Galaxy

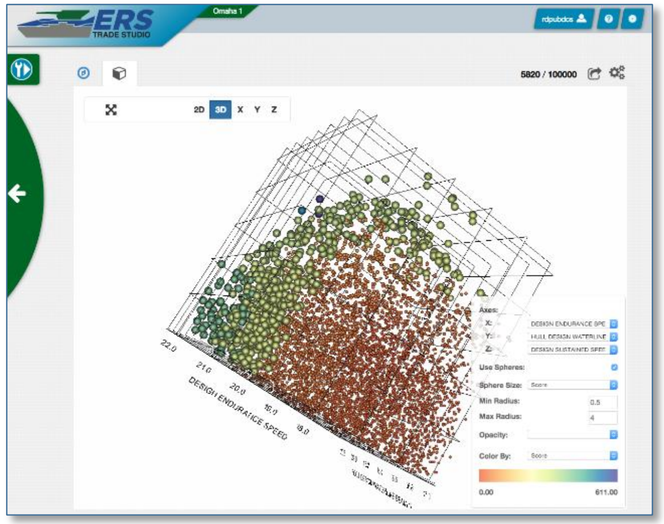


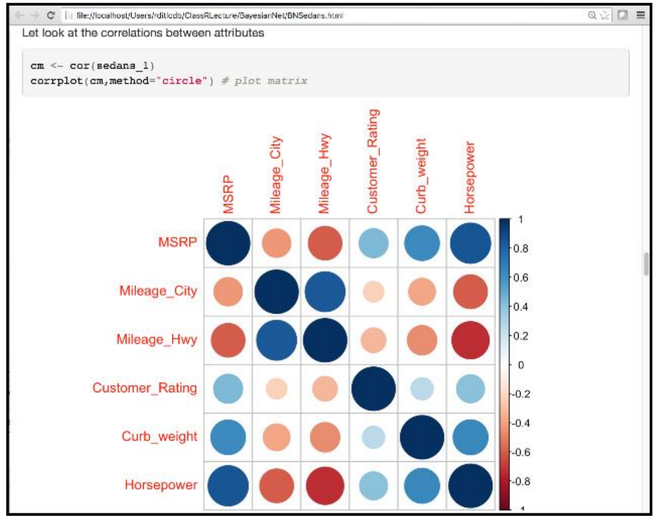
Notebook

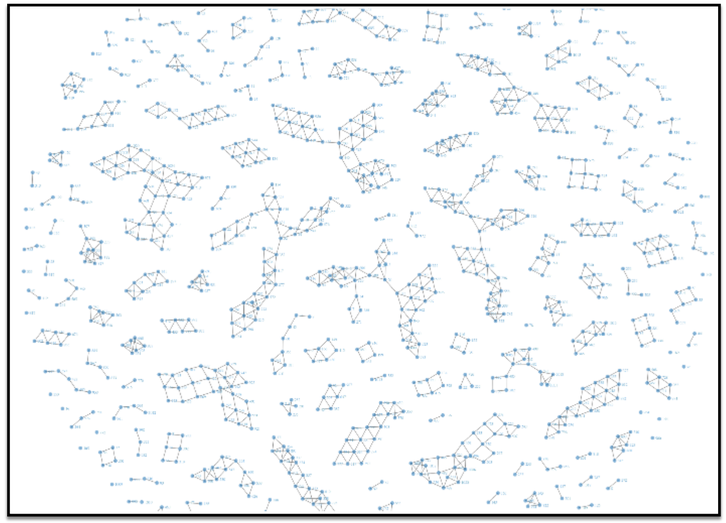
- *Legacy models and data*
- *OpenVSP (parametric geometry)*
- *OpenMDAO or HPC Galaxy (model orchestration)*
- *CREATE (performance models)*
- *System ilities*
- *Surrogates (simplified models)*
- *Jupyter Notebooks (tradespace development environment)*

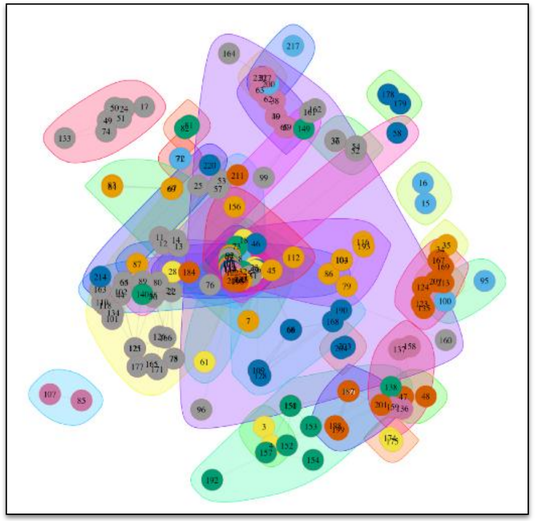
TradeAnalyzer

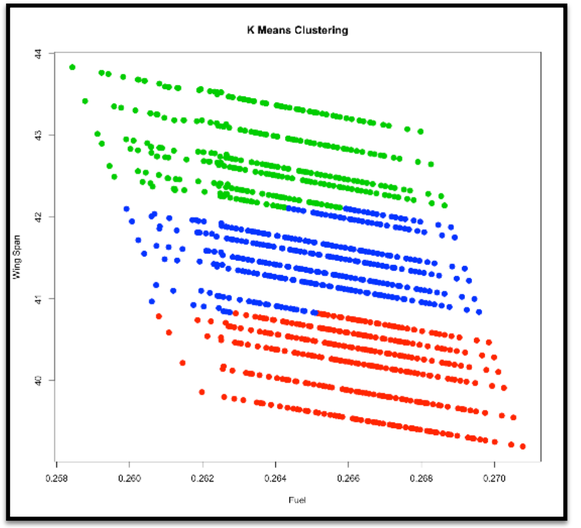
Tradespace to Insights











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)

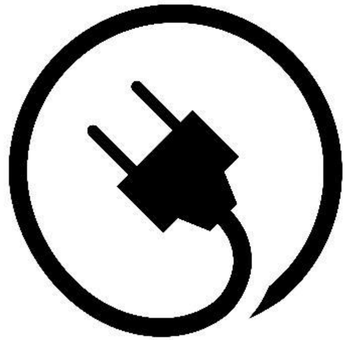
- Comprehensive REST API for project and tradespace access
- Low-level API for direct tradespace access for tools needing high performance

4. R Analytics

- Custom R analysis needed with no web programming necessary

5. Authentication/Authorization

- Leverages the open SAML standard



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Cary D. Butler, PhD
cary.d.butler@erdc.dren.mil