Tradespace: Informed Decision-making for Acquisition

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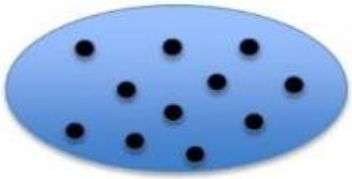
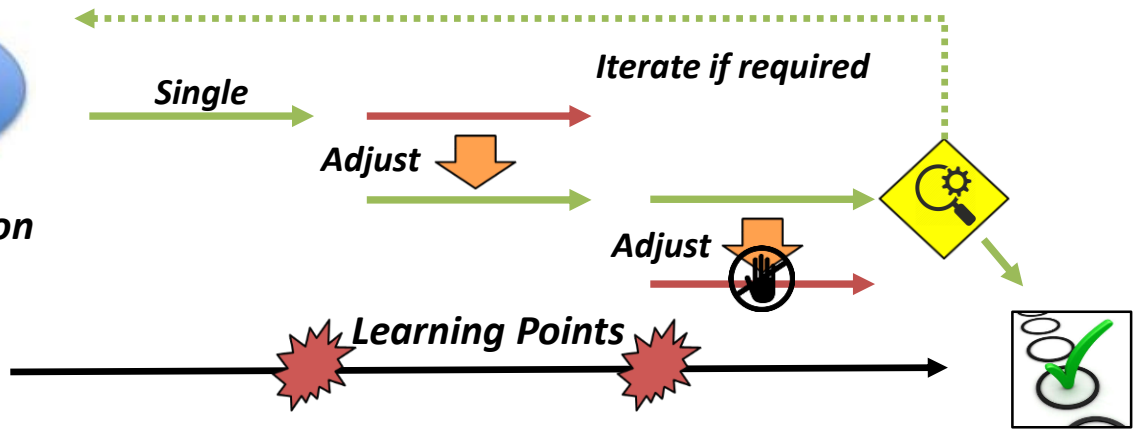
Tradespace Analytics - Set-Based Design

Tradespace - the set of processes, program and system parameters, attributes, and characteristics required to satisfy mission profile

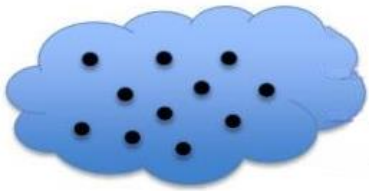
POINT-BASED DESIGN



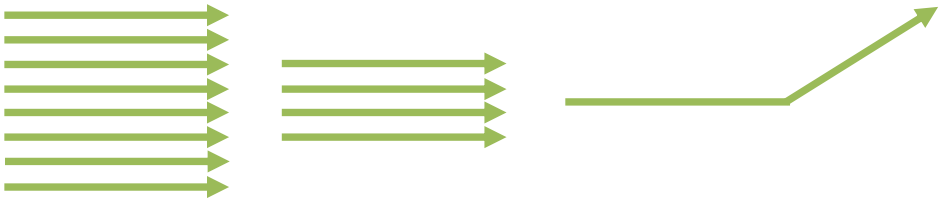
Potential Solution Space



SET-BASED DESIGN



The space spanned by completely enumerated design variables



Advanced analytics allow engineers to investigate more thorough design solutions sets

ERS Tradespace Concept

- Architecture
- Tradespace Analytics
- Advanced Modeling
- Environmental Rep.
- Mission Context

Cost models
-ilities
….other

ERS CLOUD COMPUTING ENVIRONMENT (CCE)

10,000x *Improvement in productivity in Analysis of Alternatives*

Efficiently discover key performance parameters (KPPs)

HPCMP and S&T Resources

Currently Applied ERS Advanced Tradespace Analytics

DEFINE

- Early concept tool
- Functional / component breakdown
- Explore tradespace edges

Expand Tradespace Fully

Performance Assessments
Performance Metrics

High-fidelity Models
Parameter Sweeps:
Design Variations

ANALYZE

- Highly computational
- Sifts through millions of designs
- Refined set of specifications for viable design solutions

Tradespace Exploration Processes

physics-based models analyze new designs

known designs are used in formulating the tradespace

Seeding

High-Fidelity Simulations

Historical Data

evaluated in various performance scenarios

Performance Modeling

analyzed from a systems perspective

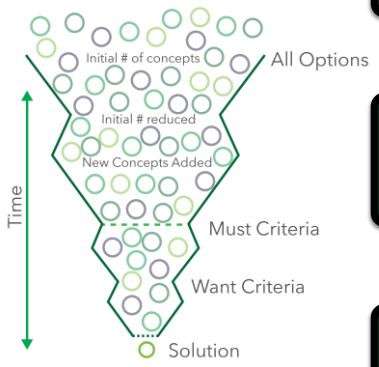
Systems Properties "ilities"

assessed in the context of possible operational missions

Mission Modeling

Tradespace Creation *"Define"*

Tradespace Analysis *"Partition"*



Exclusion

Tradespace is gradually narrowed

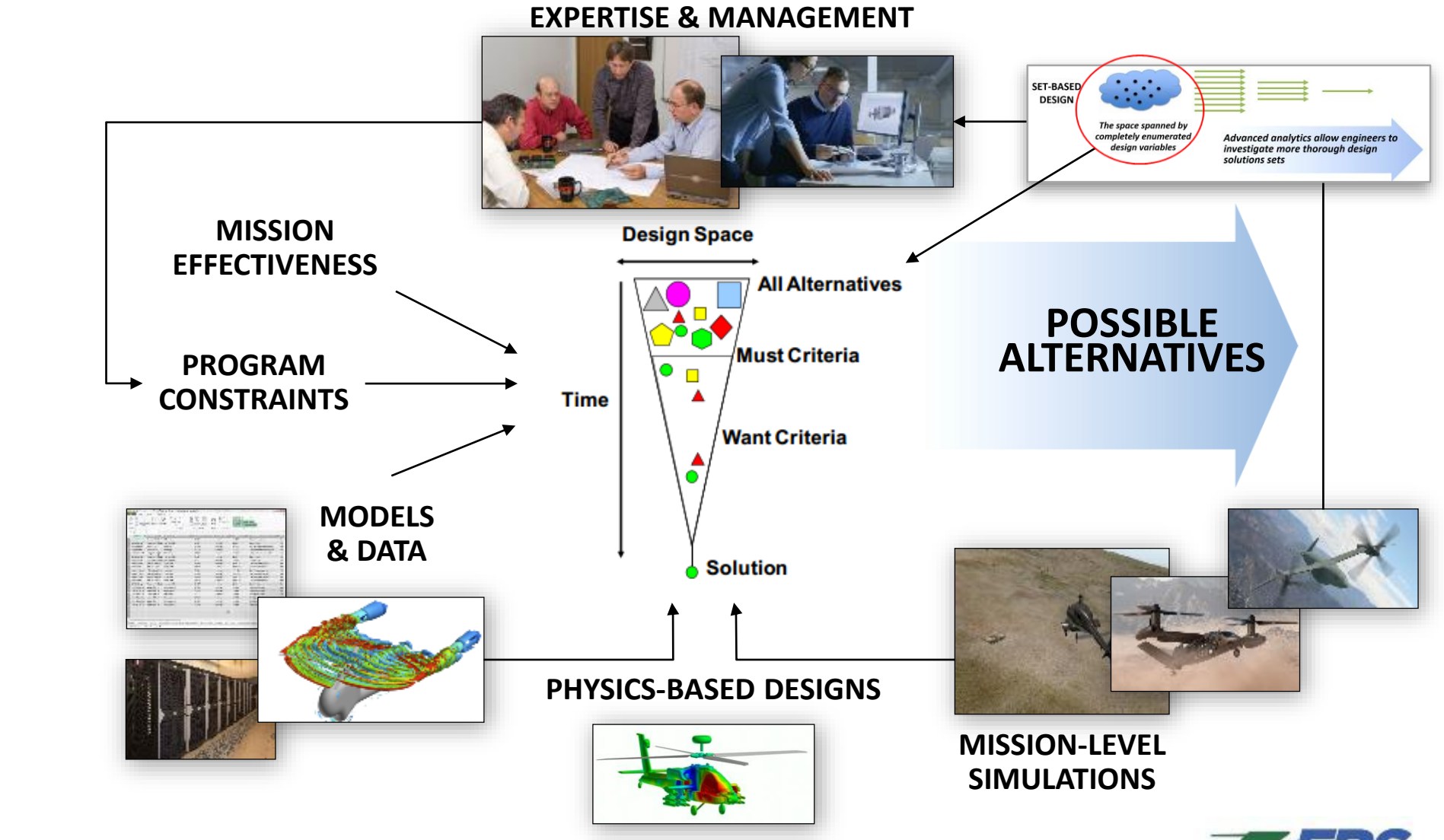
Selection

Globally optimum solutions are revealed

Comparison

Remaining designs are compared and contrasted

Decision Analysis: Integrated Processes with Trade Analytics



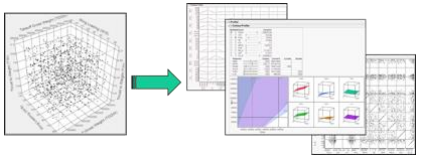
Technical Requirements of Data-Driven Decisions Tools

Trace Requirements and link systems to output

Visualize trades between dominant variables and requirements

Allow novice and advanced data exploration

Quickly find dominant variables



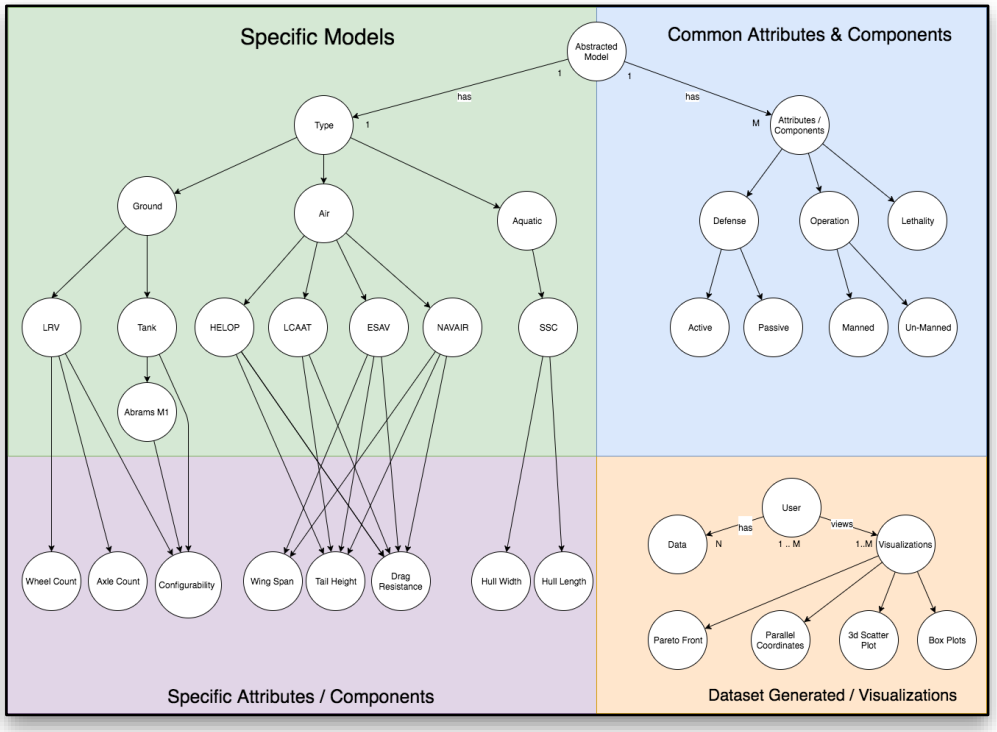
Tradespace tools must:

- Have a traceable history
- Utilize cutting edge search and decision analytics

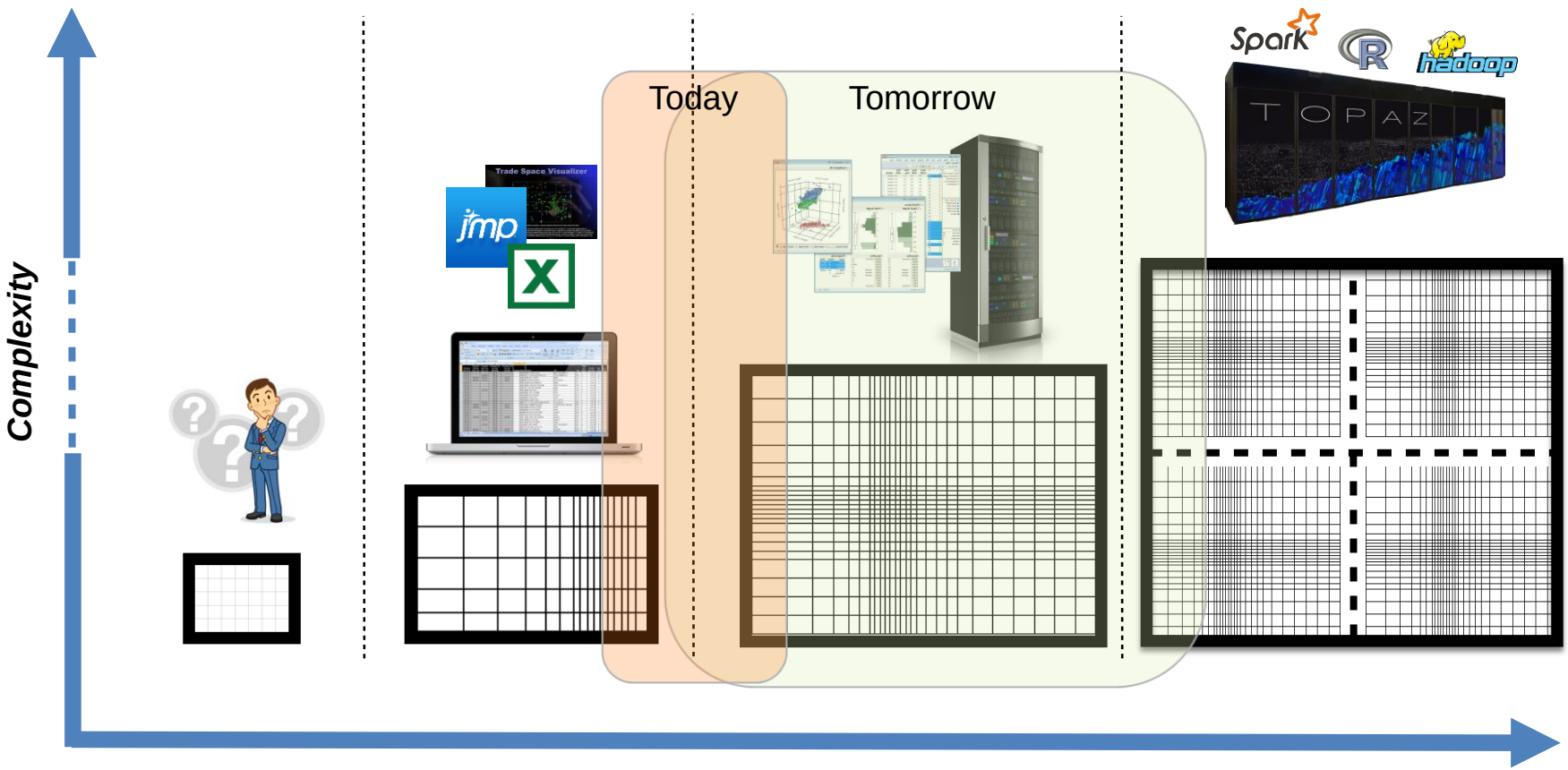
Ontology Models: Consistency in System Communication

Original system breakdowns by ontologies or SysML, along with requirements, are tied to the tradespace

- **Inserts greater accuracy and verification into the analytic processes**
- **Passing the metadata gives us insight into how to analyze the data**
- ***Direct mapping via SysML → WBS → MILSTD-881C (soon 881D) is an OSD-CAPE requirement***



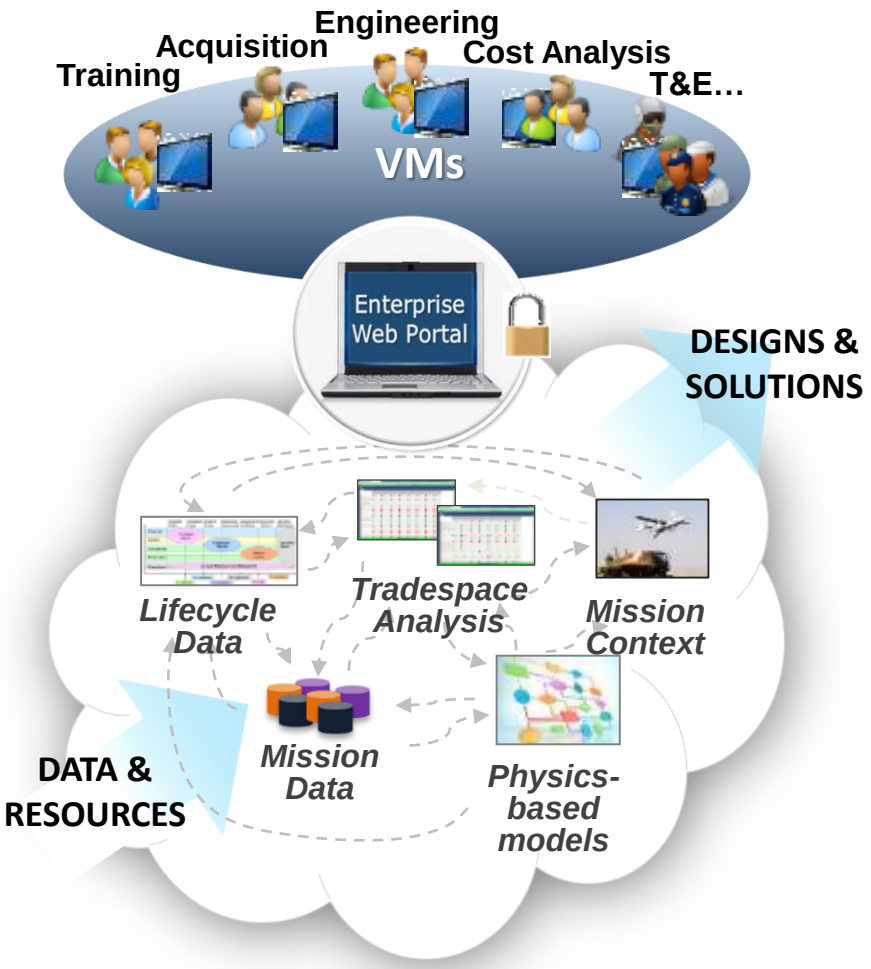
Data Metrics



Tradespace Analytics – Data Analysis and Visualization Tool

Beta-Release Status:

- **Supplied acquisition community a web-based environment for storing, visualizing and analyzing data**
- **Allowed for access and annotation by multiple parties for any given location;**
- **Provided the base for a collaborative decision support environment.**
  - Gaps in previous environments forced point-based design methodology.
- **Successfully supported MBSE and data filtering**
  - Previously available MBSE were expensive and resource heavy – requiring local resources and administrative personnel, required expensive licensing agreements.



Tradespace Analytics Beta Release Lessons Learned

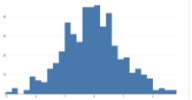
The FY17 Beta Release of TradeAnalyzer to a number of DoD Users resulted in important lessons and changes

- **Use of ParaView Web - generating interactive visualizations of large data-sets and annotation capabilities**
- **Role Based Access Control (RBAC) needed to execute R-Scripts in a secured environment; implementation in a complex collaborative environment is challenging.**
- **Working on secure authentication mechanisms that couple with customers local access control policies is an ongoing and important DoD issue.**

ERS Tradespace development is now focusing on the user-oriented approach in preparation for DoD-wide implementation and adoption

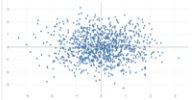
Tradespace Analytics and Visualizations

Available Plotting Options



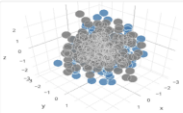
Histogram

A diagram consisting of rectangles whose area is proportional to the frequency of a variable and whose width is equal to the class interval



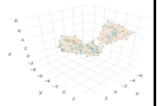
Scatter Plot 2d

A graph in which the values of two variables are plotted along two axes, the pattern of the resulting points revealing any correlation present



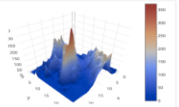
Scatter Plot 3d

A graph in which the values of three variables are plotted along three axes, the pattern of the resulting points revealing any correlation present



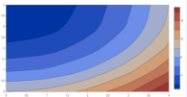
Clustering 3d

A graph in which the values of three variables are plotted alon three axes, with a mesh alpha clustering overlay



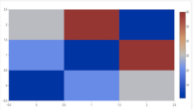
Surface Plot 3d

Surface plots are diagrams of three-dimensional data. Rather than showing the individual data points, surface plots show a functional relationship between a designated dependent variable (Y), and two independent variables (X and Z).



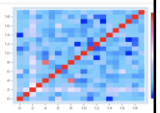
Contour

A contour plot is a graphical technique for representing a 3-dimensional surface by plotting constant z slices, called contours, on a 2-dimensional format.



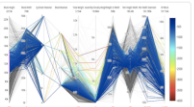
Heatmap

Graphical representation of data where the individual values contained in a matrix are represented as colors.



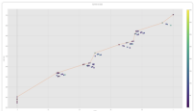
Correlation Matrix

Graphical representation showing the correlation coefficients betweensets of variables.



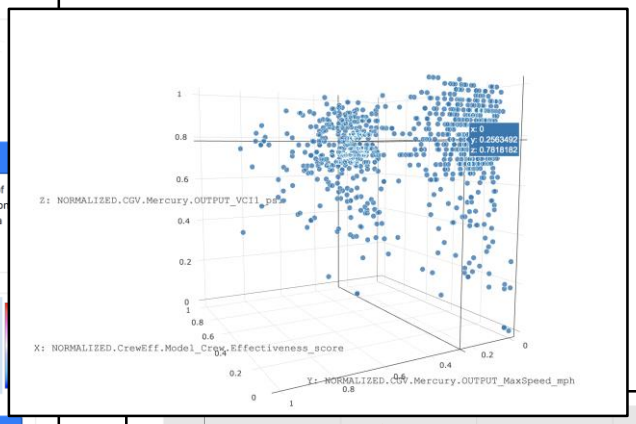
Parallel Coordinates

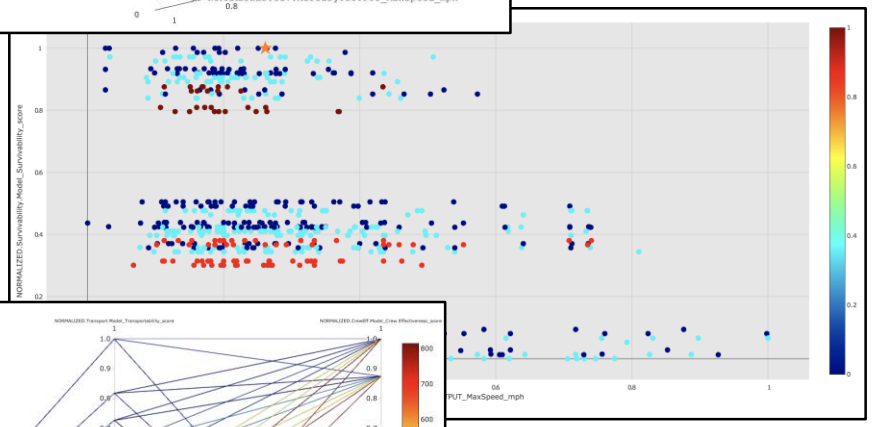
A common way of visualizing high-dimensional geometry and analyzing multivariate data.

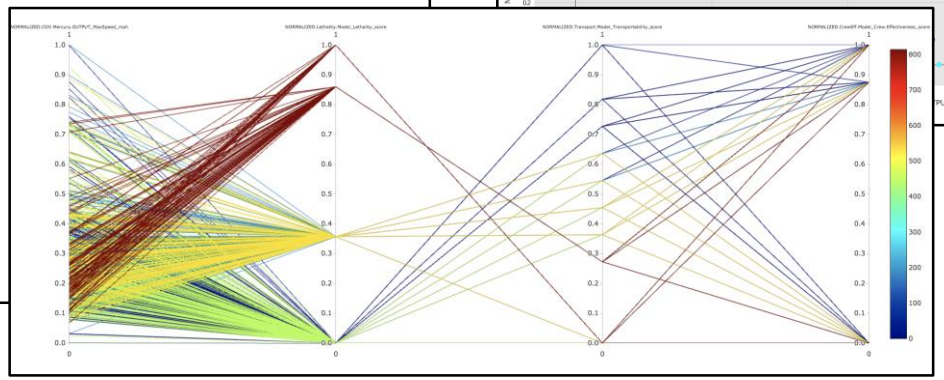


Pareto Front

A framework for partially evaluating a set of "actions" with multi-dimensional outputs assuming a very weak "desirability" partial ordering which only applies only when one processes is better (or at least as good) for all the outputs. It is useful for reducing a set of candidates prior to further analysis.







plotly JS

python

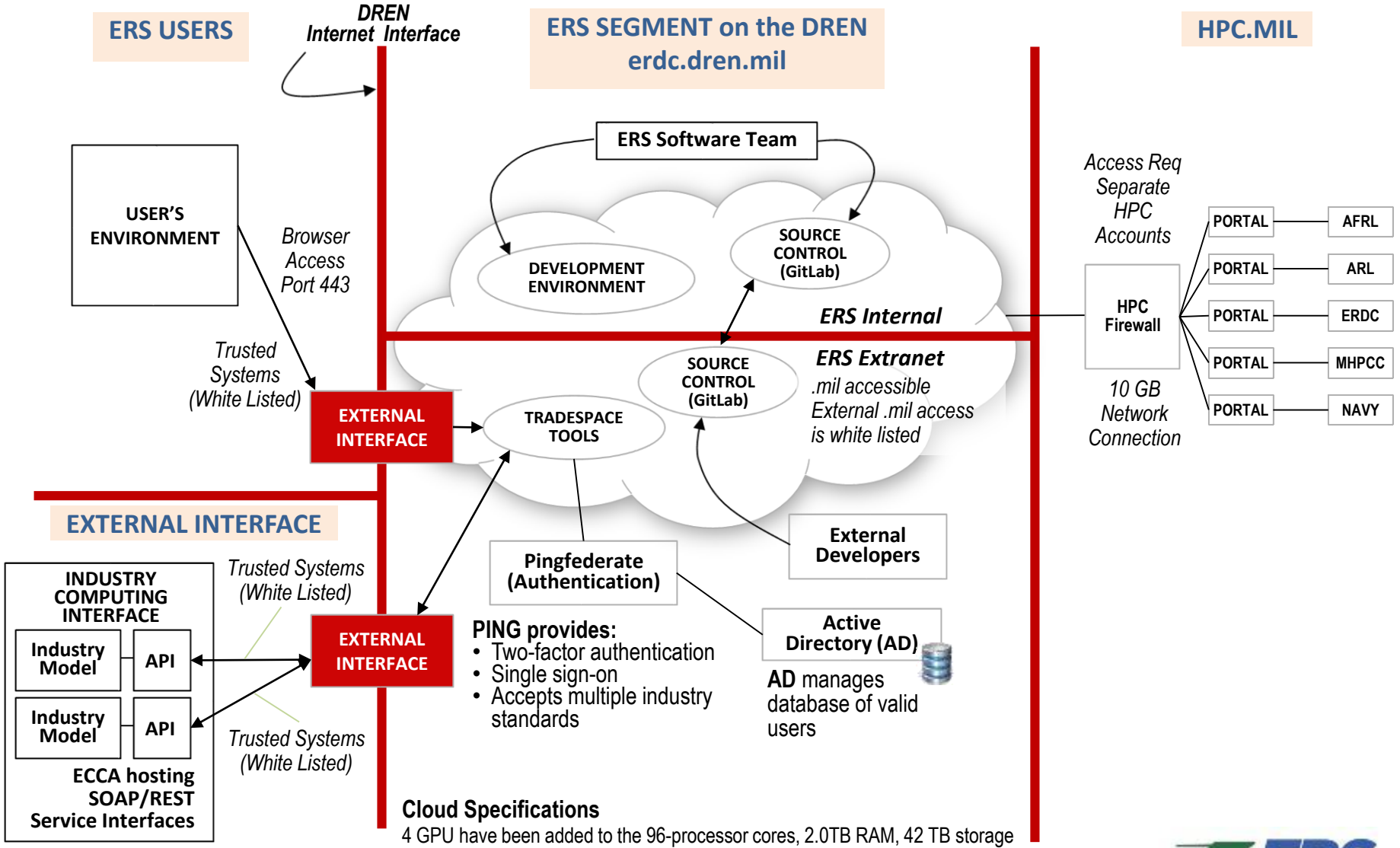
Updates to Architecture

- ***Web Hosted***
- ***Access Control***
- ***Collaboration***
  - ***Shared Notebooks***
  - ***Shared Data***
- ***Versioning***
- ***Analytic Packages***
- ***Scalable***
- ***Portable***
- ***Reproducible***
- ***Distributed***
  - ***Spark***
  - ***Hadoop***

Relevant ERS NDIA Talk

10:40 - Resilient Tools: Building an Agile Framework for the Analysis of Environmental Impacts on Military Systems
Dharhas Pothina, PhD - ERDC

Network Access



Questions

ERS NDIA
FUELING INNOVATION & COLLABORATION

Backup Slides

What is a Tradespace

- **Tradespace is the space spanned by completely enumerated design variables. It is the potential solution space.**
- **Tradespace can also be defined as the set of processes, program and system parameters, attributes, and characteristics required to satisfy mission profile.**
- **The enumeration of a large tradespace helps prevent designers from starting with point designs while allowing them to investigate more thorough design solutions sets.**

System-Supported Collaboration Supports Data-Driven Decision-Making

ERS Tradespace Analytics support Collaborative Processes