Engineered Resilient Systems Architecture

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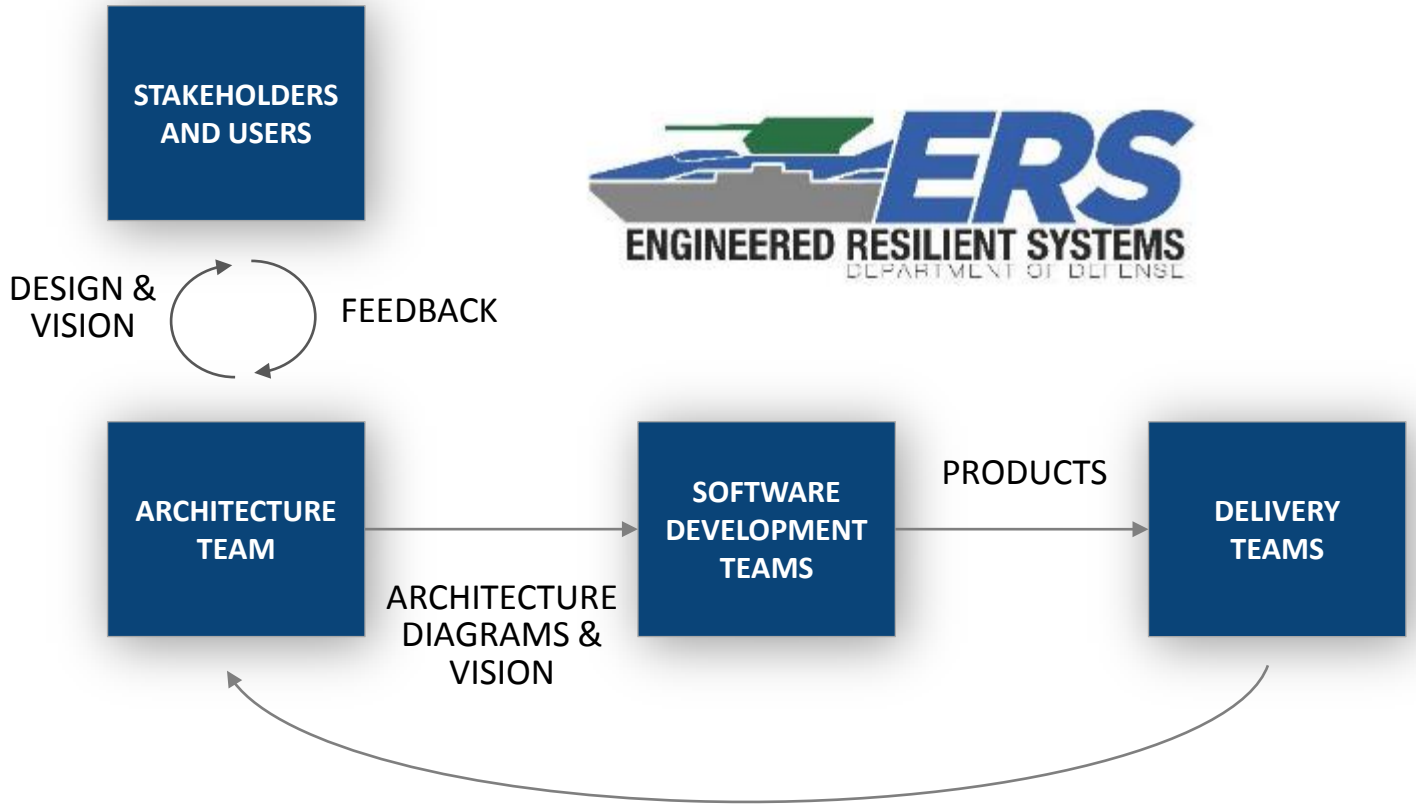
US Army Engineer Research and Development Center (ERDC)

ERS Architecture – Integrating Capabilities

- **Provide a cohesive, integrating capability for ERS tools, technologies and products**
- **Develop reference architecture**
- **Promote reuse and common infrastructure**
- **Develop guidance and standards**
- **Work closely with application and development teams**

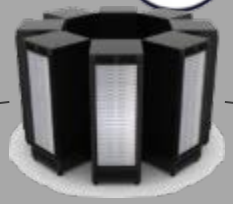


- Architecture artifacts evolve and are refined over time
- Development cycles are aligned with product deliveries

ERS User Groups

STRATEGIC PLANNERS	OPERATING COMMANDS	PROGRAM MANAGEMENT	DOD SYSTEM DESIGNERS	DOD T&E	INDUSTRY
• Satisfy national security objectives	• Analyze operational situation • Identify capability gaps & strengths	• Program Execution • Delivered on time within cost • Meet warfighters' requirements	• Identify designs that meet performance & mission objectives	• Identifies early knowledge of developmental & operational issues	• Identify design alternatives • Proposal devt & production • Better understanding of requirements

DOD M&S



DOD HPC

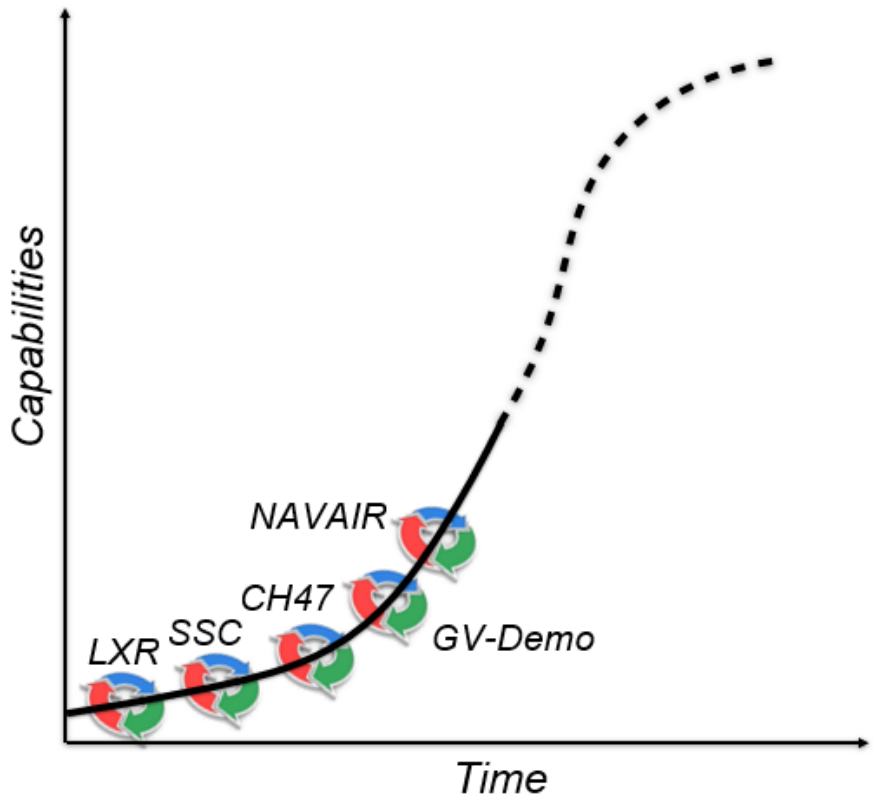
ERS ANALYTICS

Architecture Drivers

- **Improve impact of ERS through early, continuous delivery of products**
- **Focus: Building early user acceptance and adding capabilities as needed/wanted**
- **Enable "Open" computing framework to support cross-community (DoD-Industry)**
- **Apply advanced computing methods to improve accuracy, depth, and breadth of tradespace studies**

Integration with Industry is key to success. Participation in Architecture Working Group kicks off: Nov 2015

Working products are the primary measure of progress.



Represents a cycle in development

Tradespace Analysis

Advanced Tradespace Analysis tools are at the core of the ERS capability.

ERS focuses on improving decision-making by integrating computational resources that increase accuracy and depth of analysis.

Decision-makers refine the system by trading cost, performance, schedule, and risk.

DESIRED PERFORMANCE

PROGRAM CONSTRAINTS

MODELS & DATA

Tradespace Analysis

POSSIBLE ALTERNATIVES

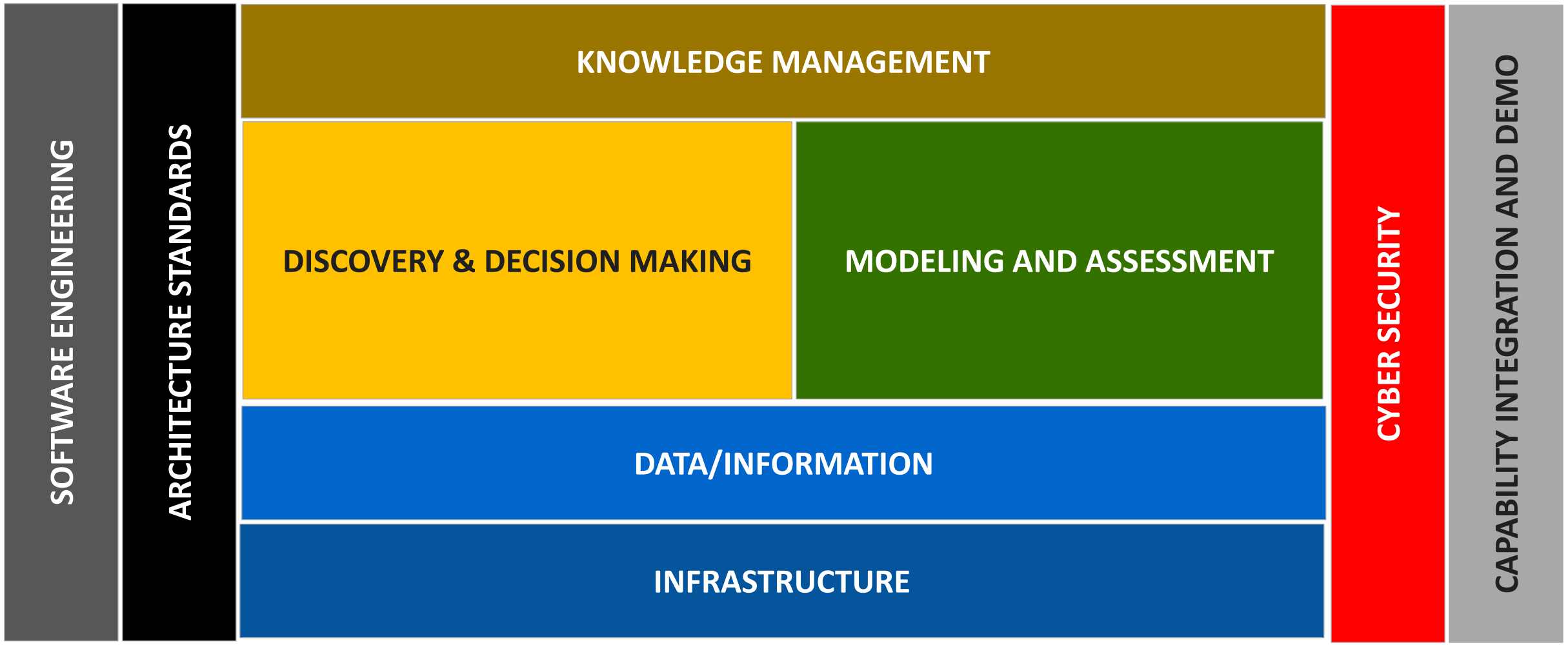
ADVANCED COMPUTING ASSETS

PHYSICS-BASED DESIGNS

MISSION-LEVEL SIMULATIONS

M&S CAPABILITIES

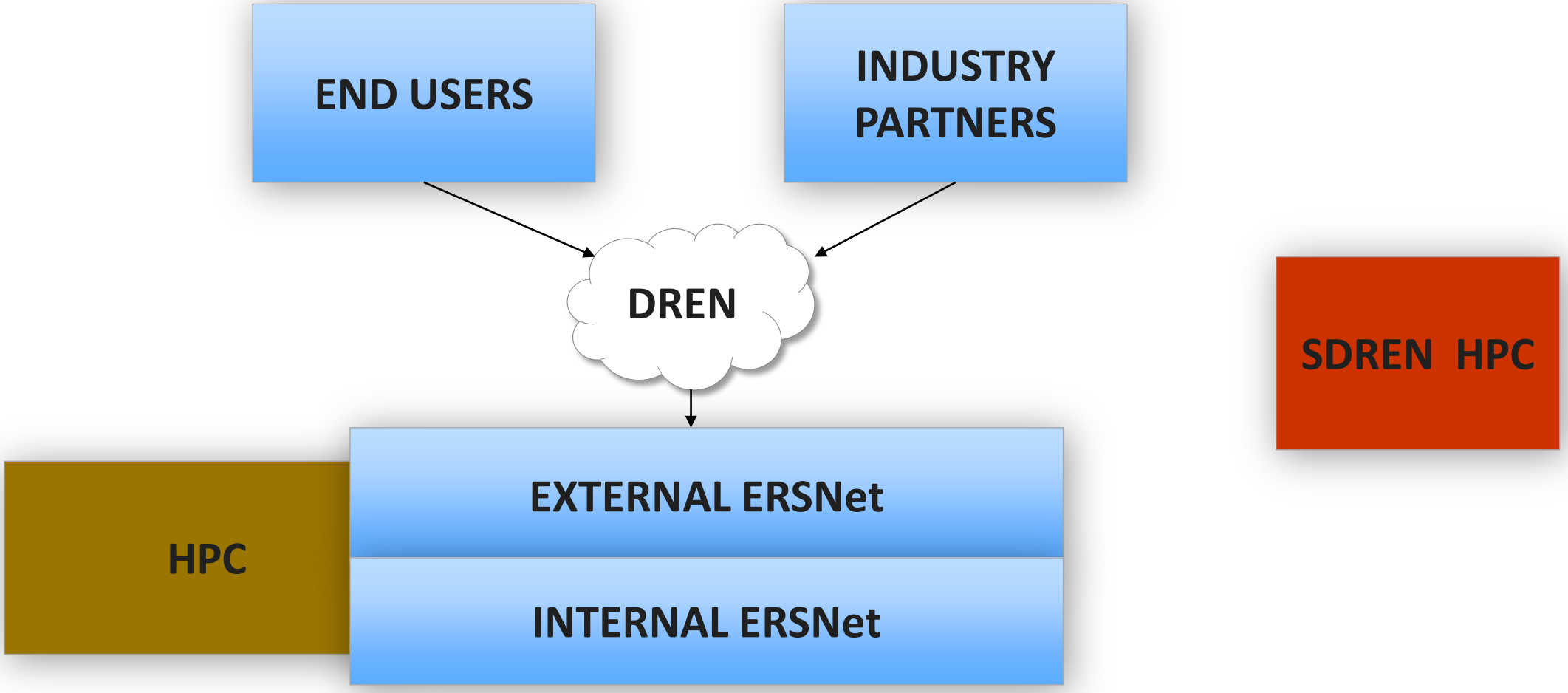
ERS Building Blocks (Reference Architecture)



ERS Open Architecture

- Modular back-end in Node.js using REST services.
- Project data structures in easily read MongoDB JSON.
- Front-end tools added through AngularJS directives.
- Projects and Data accessible through REST API.
- High performance low-level API for tradespaces.
- “R” Analytics tool allows for custom analysis.
- SAML-based 2 factor identity services for federated user management

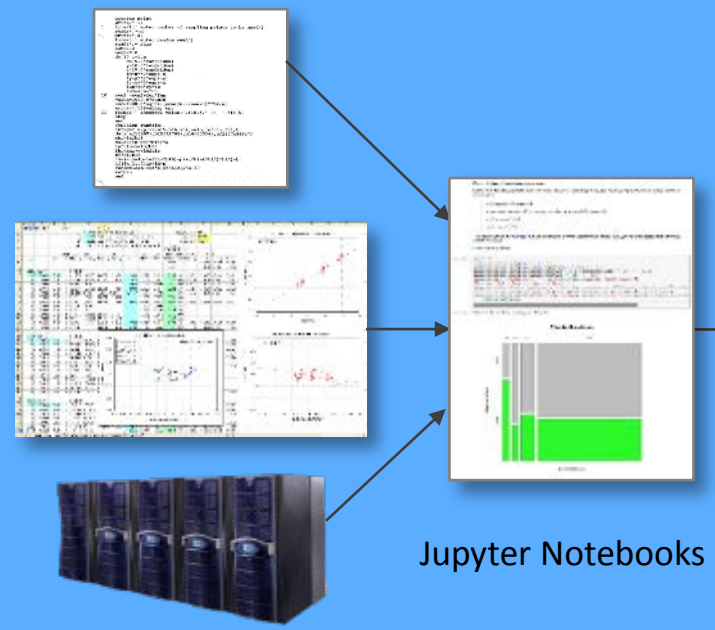
ERS Infrastructure



TradeStudio Processes

MODELING PHASE

TRADESPACE CREATION



Existing Codes
Domain models
Spreadsheet
Python/R Wrappers

Jupyter Notebooks

TRADESPACE

HDFS Format
Metadata included
Stats
Low-level API (c/c++)

ANALYSIS PHASE

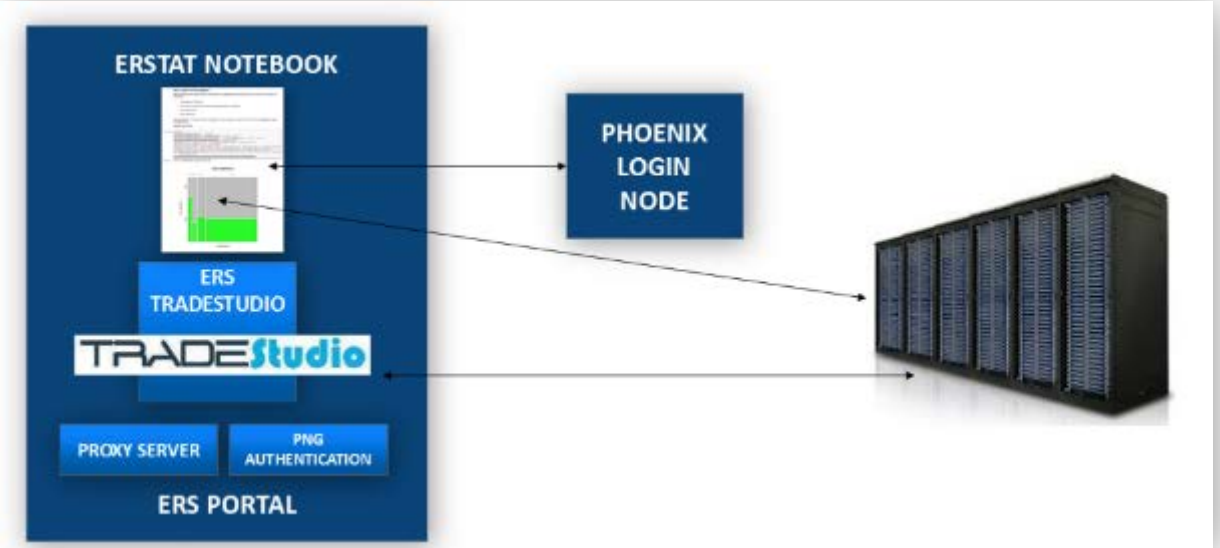
TRADESPACE ANALYSIS

Open Architecture

- **Tradespace API (REST)**
- **GUI Modules**
- **REST Services**
- **R. Modules**

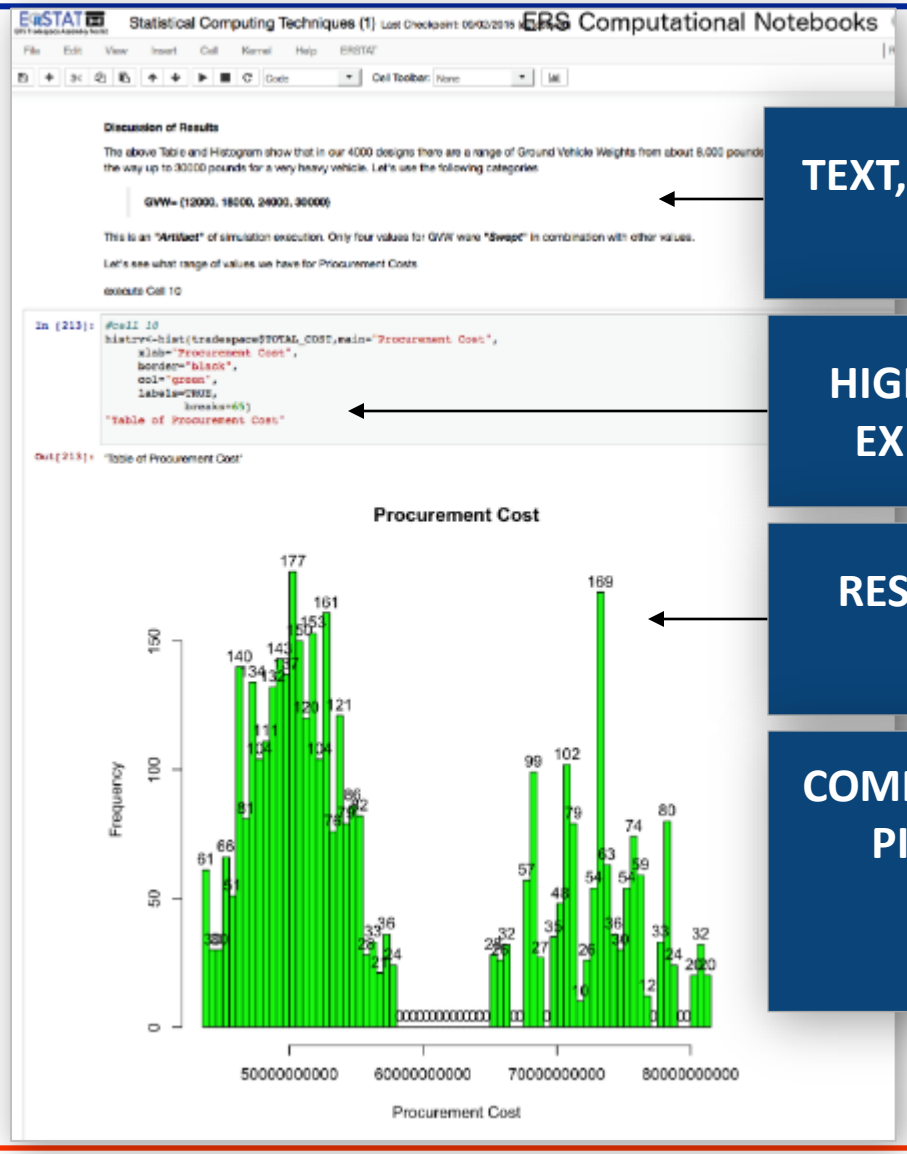
ERS Tradespace Assembly Toolkit (ERSTAT)

- Introduce DoD Conceptual Design Teams to the Cloud Computing Environment (CCE)/HC
- Introduce DoD Conceptual Design Teams to R Language
- Enhance Collaboration
- Gather and distribute cross-cutting functionality
- Examine, profile and improve model assembly pipelines



ERSTAT is a computational environment that connects legacy M&S to the ERS Workflow

Computational Notebooks



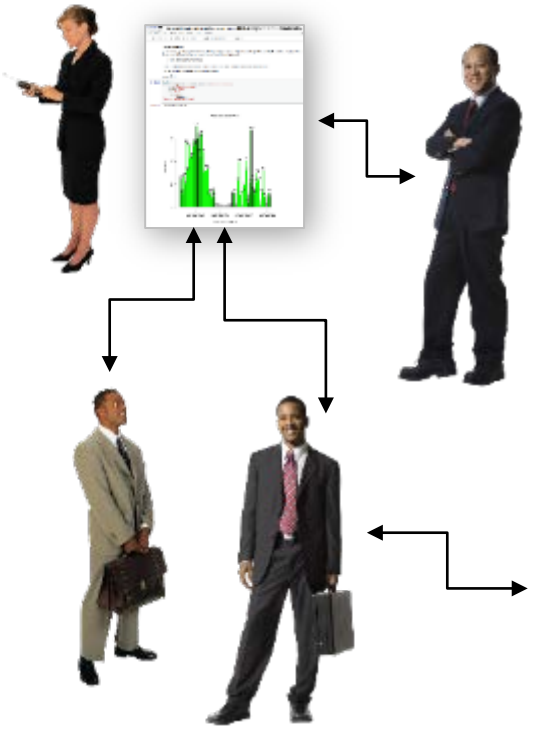
TEXT, DIAGRAMS, EQUATIONS EXPLANATIONS

HIGH-LEVEL CODE DIRECTLY EXECUTABLE ON ERS HPC

RESULTS, TABLES, GRAPHS, STATISTICS

COMPUTATIONAL NOTEBOOK:
PIPELINE OF ACTIVITIES
EASE OF USE
EASILY SHARED

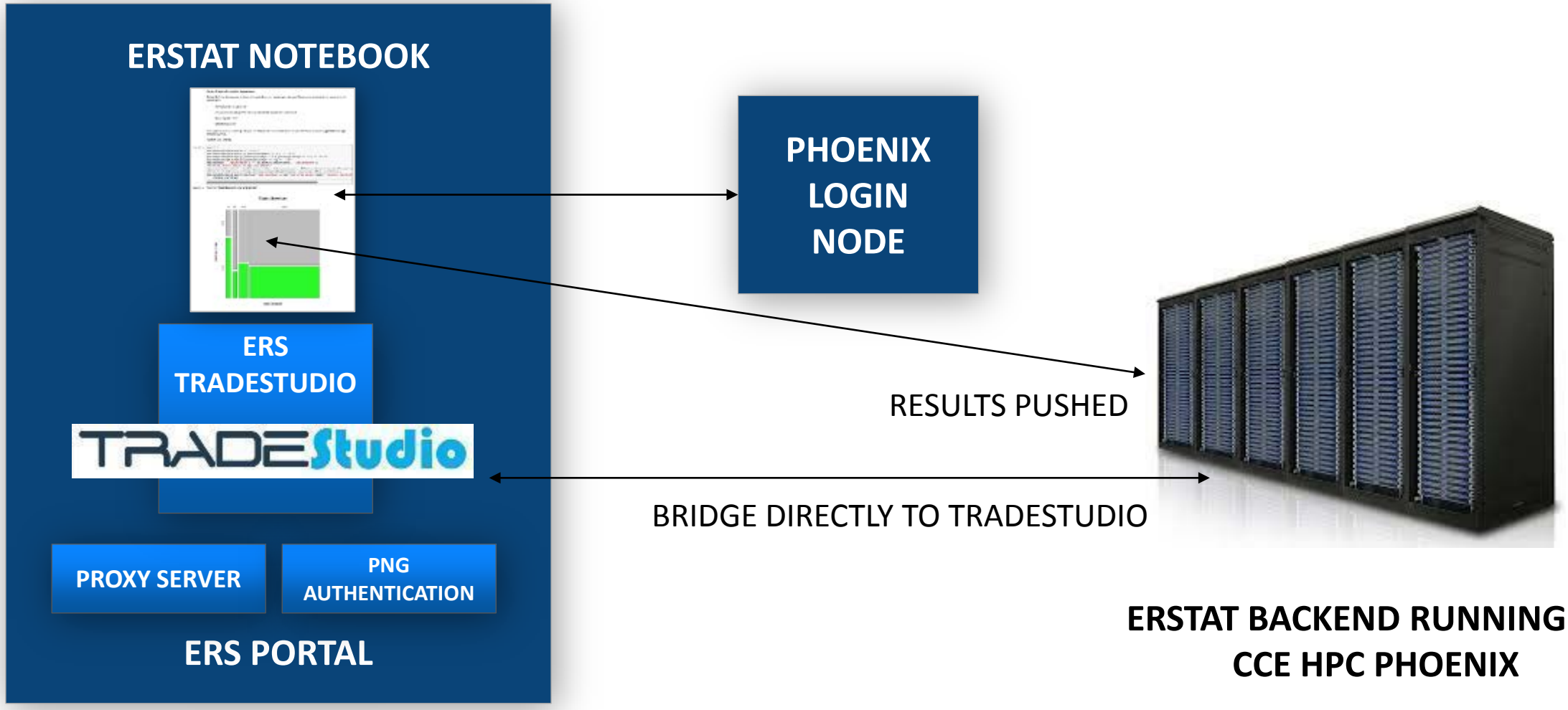
NOTEBOOKS ARE DESIGNED TO BE SHARED



ERS Common Computing Environment (CCE)

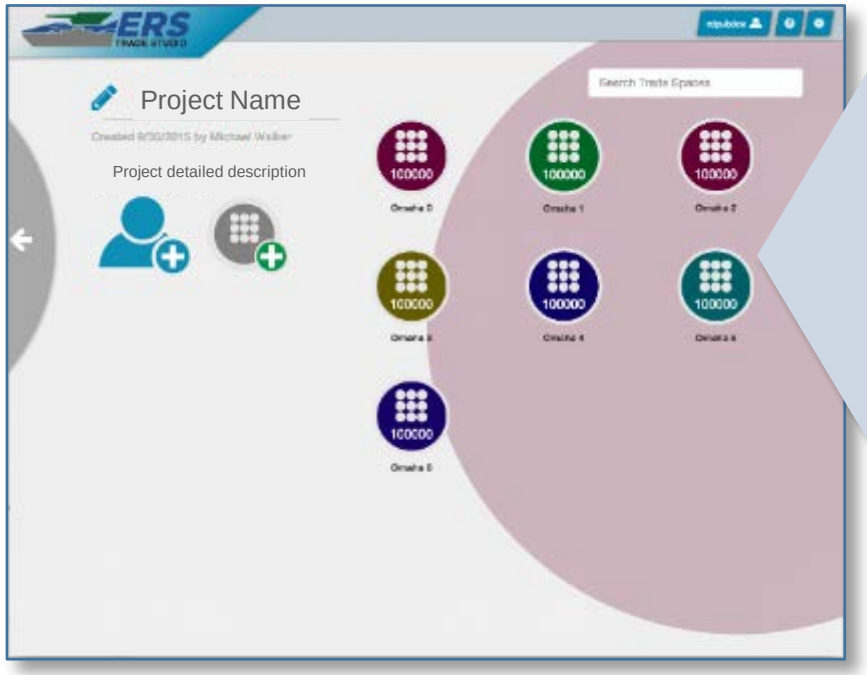
NOTEBOOKS CAN RUN ON ANY ERS PLATFORM

ERSTAT Architecture



ERSTAT BACKEND RUNNING ON CCE HPC PHOENIX

Data Management and Transformation Tools



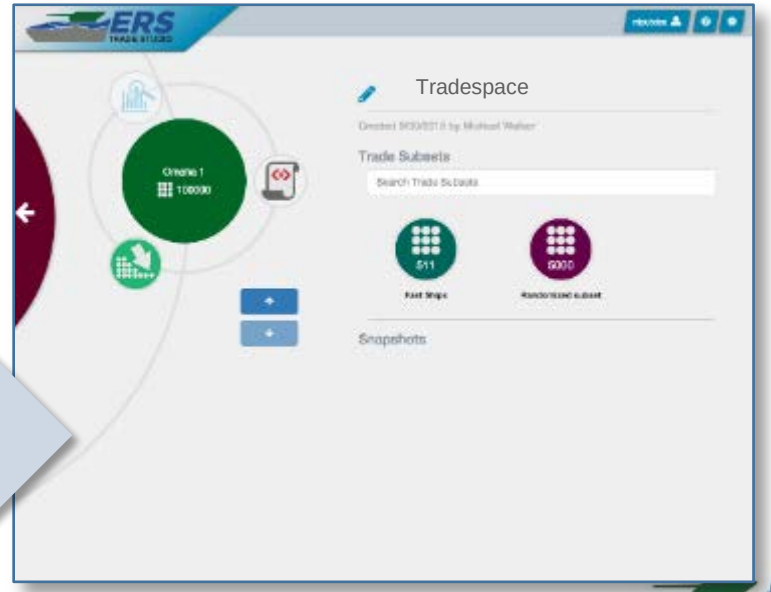
Managing data: Projects and Tradespace

Projects:
- Top-level data container
- Full security through permissions
- Shared Workspace

Tradespace:
- Standalone – immutable dataset
- HDF5 format
- Metadata
- Statistics

Transforming data: Tools

- Appropriate tools surround the tradespace
- Tools can create subsets

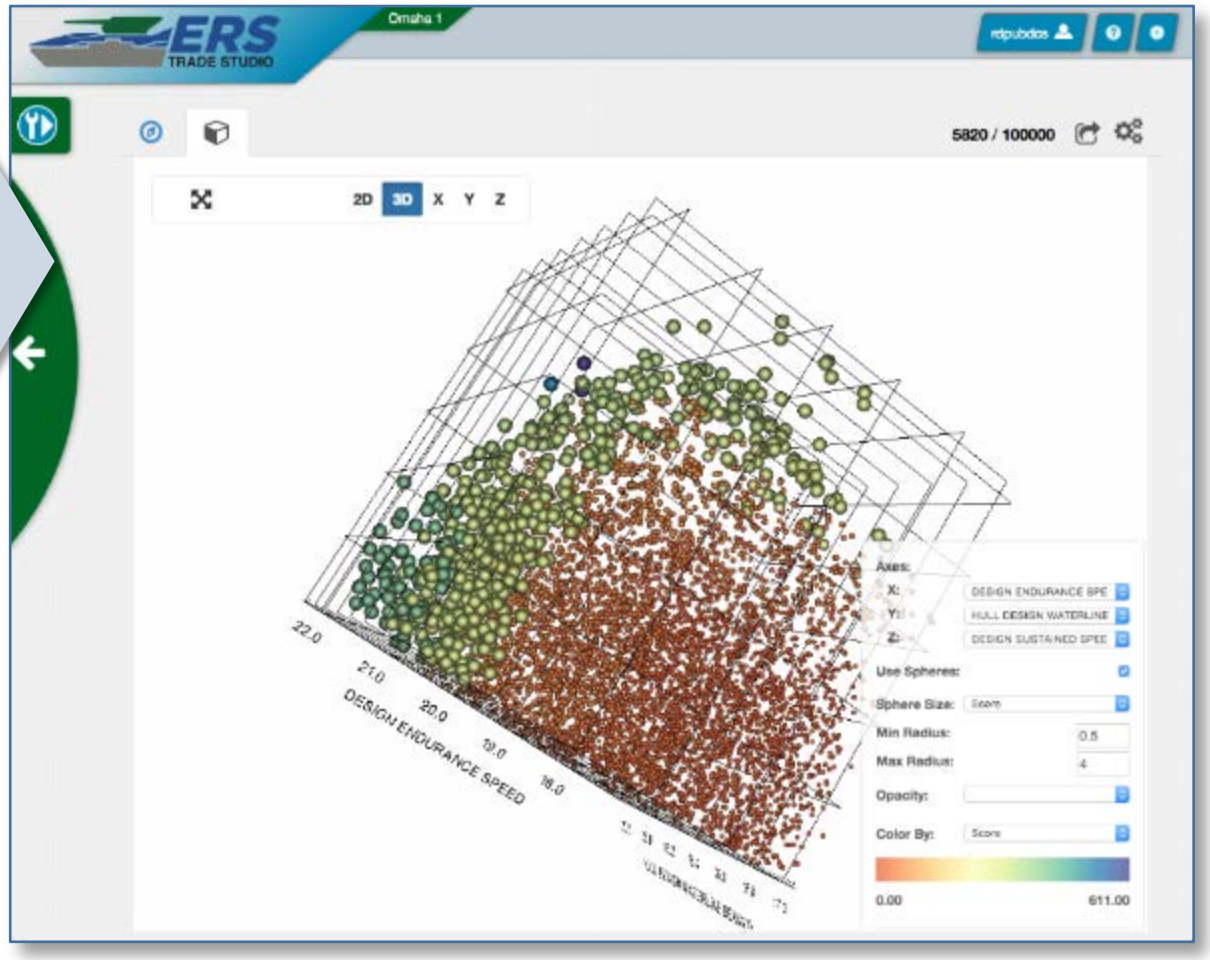


Data Reduction Tools

- Operates on very large tradespaces (up to 10 million designs)
- User selects attributes of interest, conducts scoring process that allows exclusion of designs by attribute value
- Each attribute assigned a weight
- Cumulative score is displayed in real time
- Results saved as a new sub-tradeset with added “score” attribute

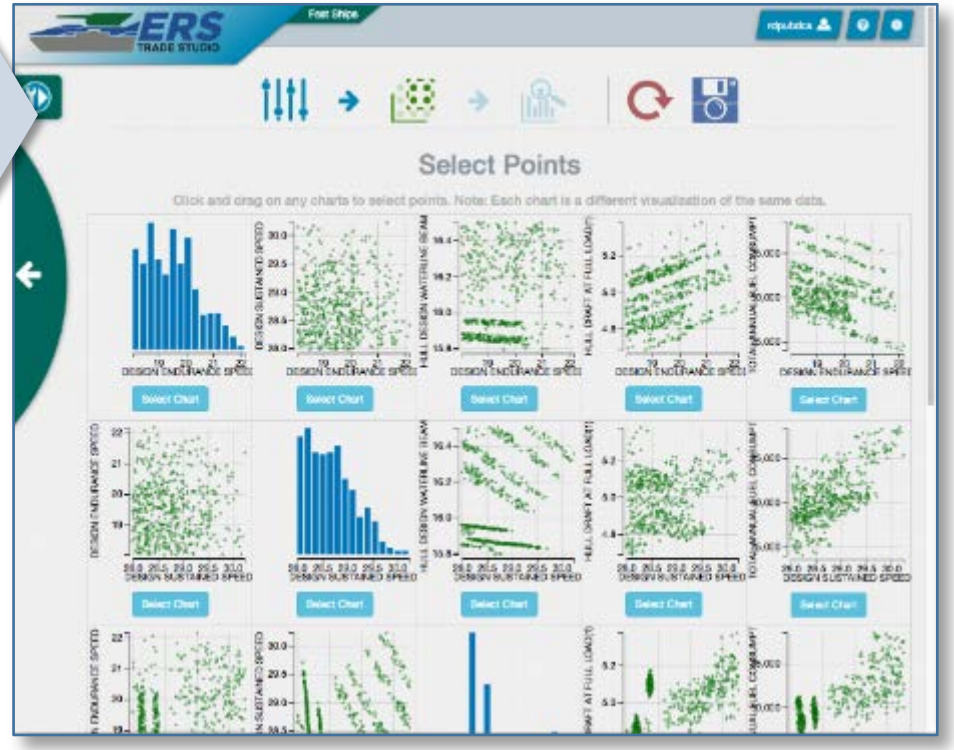
Data Visualization Tool

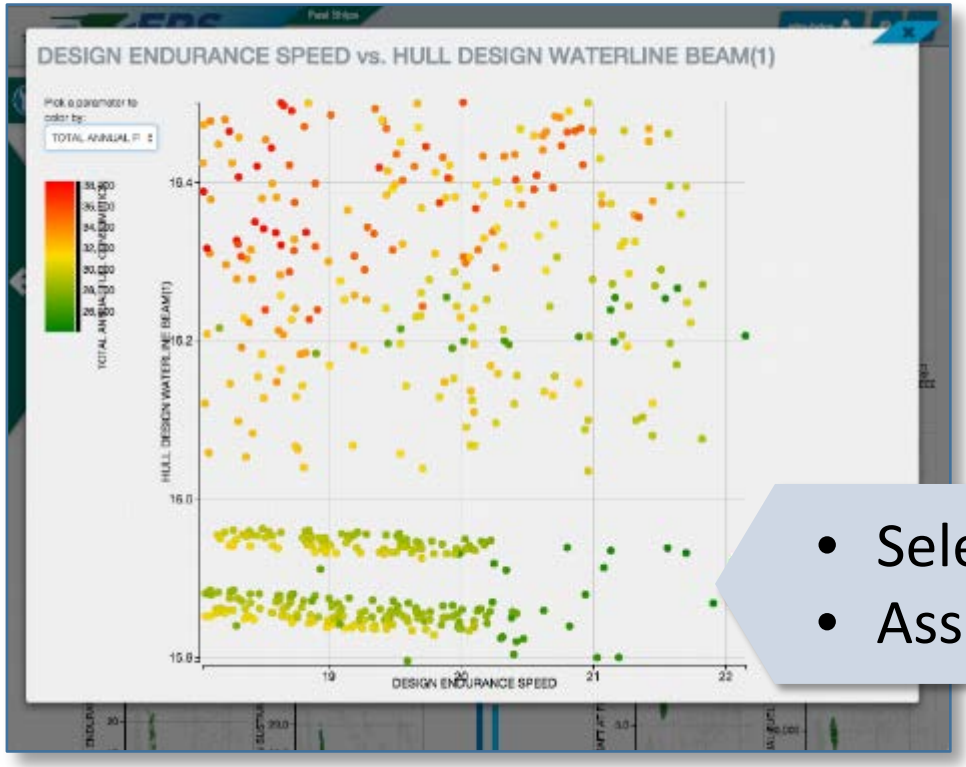
- 2D/3D visualizer
- Use color, size and opacity or a fourth attribute



Data Analysis Tools

- Select attributes to show plot matrix with histograms





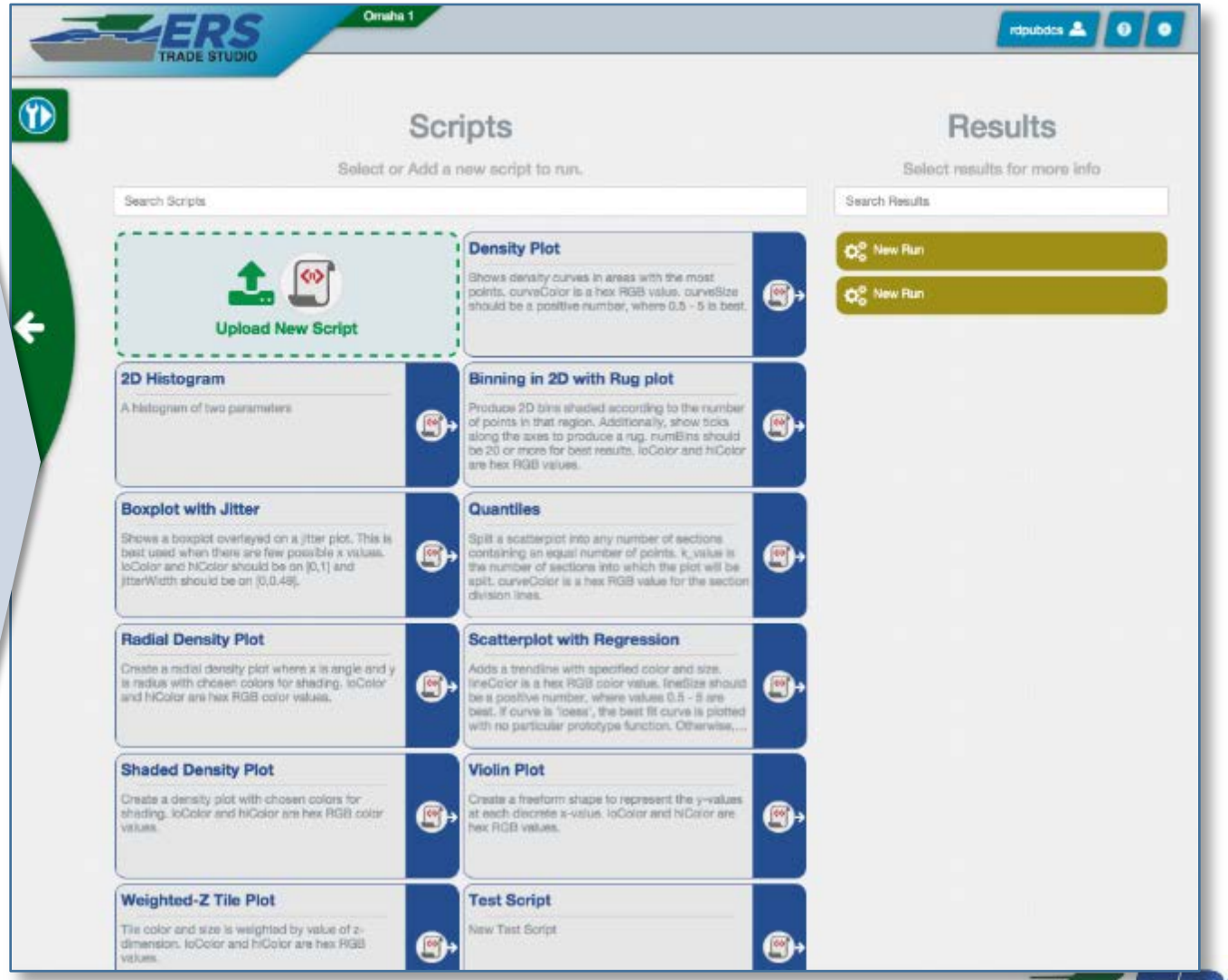
- Select any graph for close-up
- Assign parameter colors

Data Analysis Tools

- Select “Analyze Points” to run analysis tool
- Select objective attributes
- Change objective values
- Tool calculates score for each design

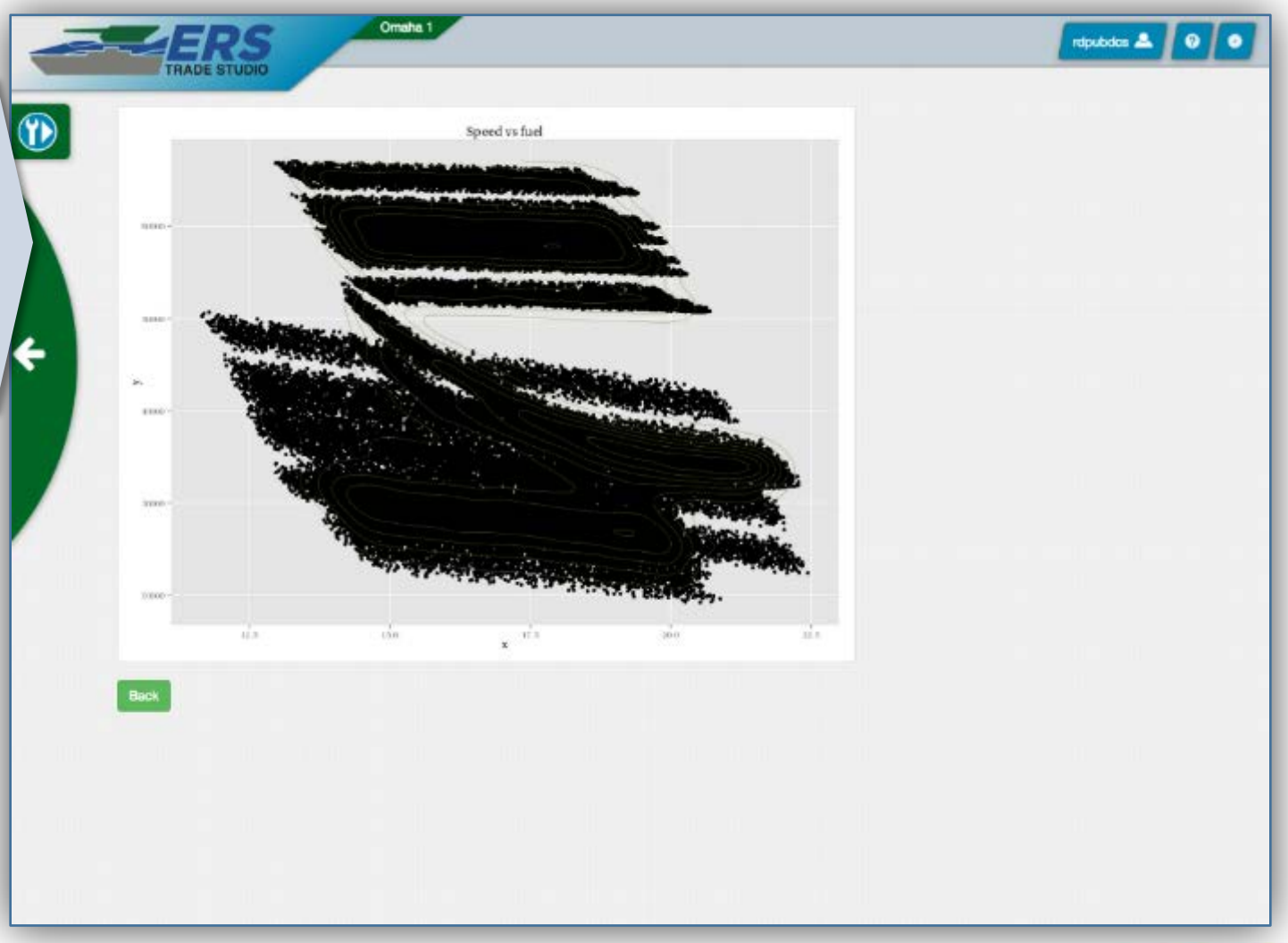
“R” Analytics

- **“R”** script tool allows upload of new, custom analytics
- ERS **“R”** packages inform what GUI inputs should be
- **“R”** scripts output plots or new subsets



“R” Analytics

“R” script output is stored in the project relative to the tradeset used to generate it.



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Questions & Answers