

# ERS Tradespace Toolset

**19<sup>th</sup> Annual NDIA Systems Engineering Conference**  
**26 October 2016**

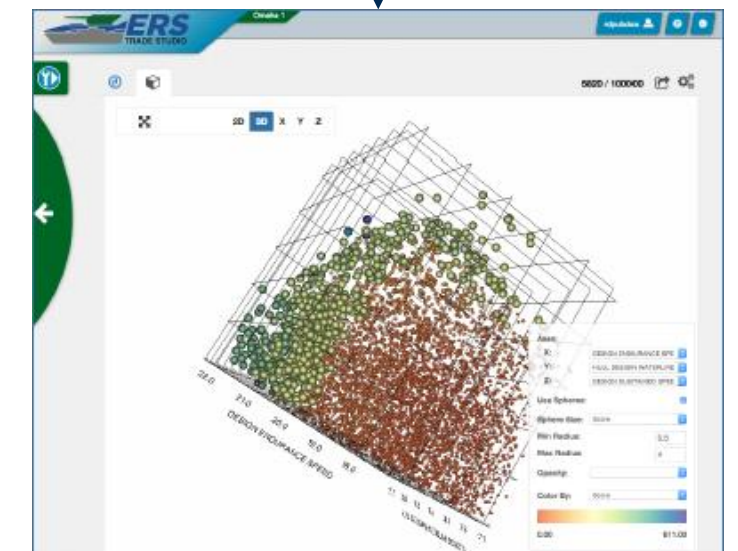
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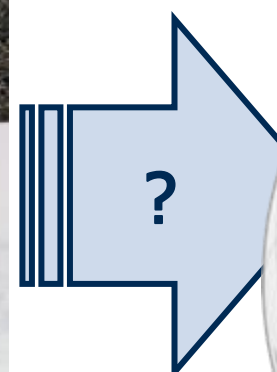
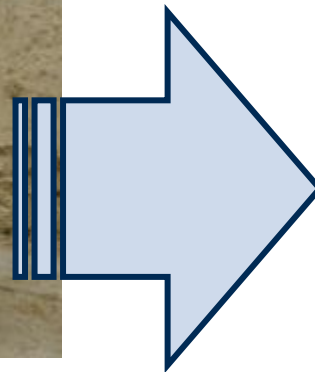
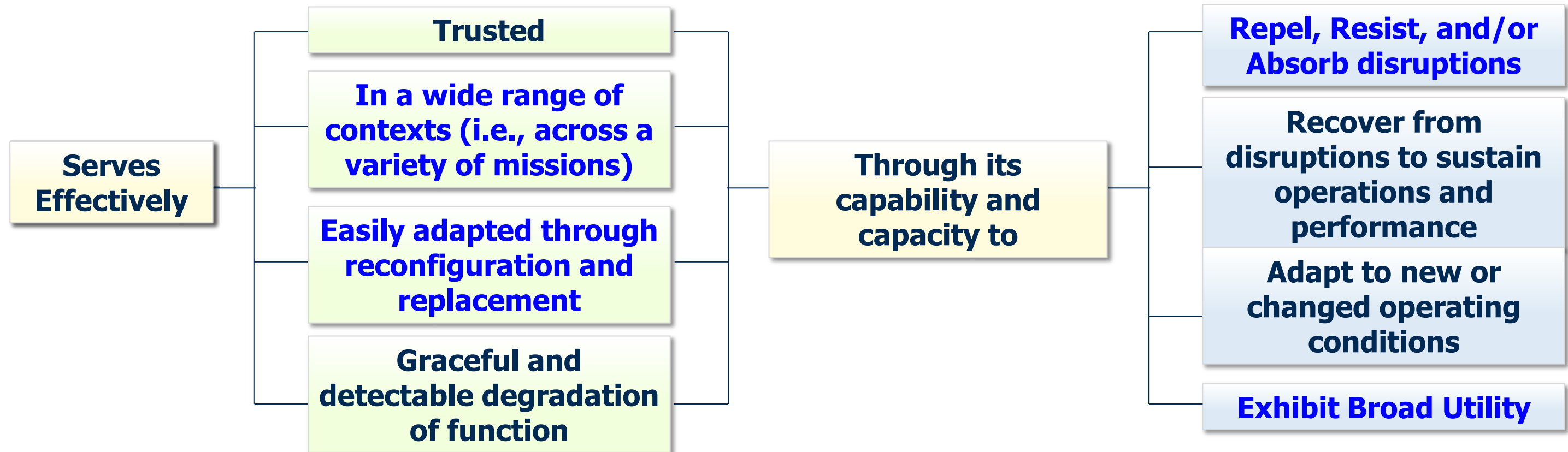


# Summary of Topic

- Analytical building blocks
- Systems Engineering processes
- High Performance Computing
- ERS TradeBuilder walkthrough



# Resiliency Characteristics in an ERS Context

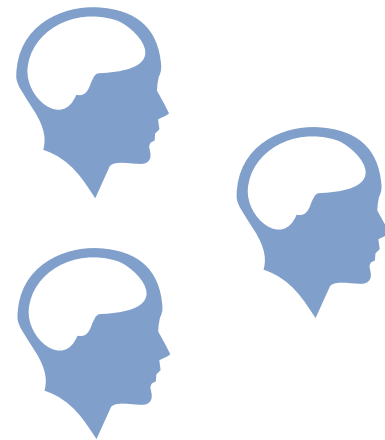




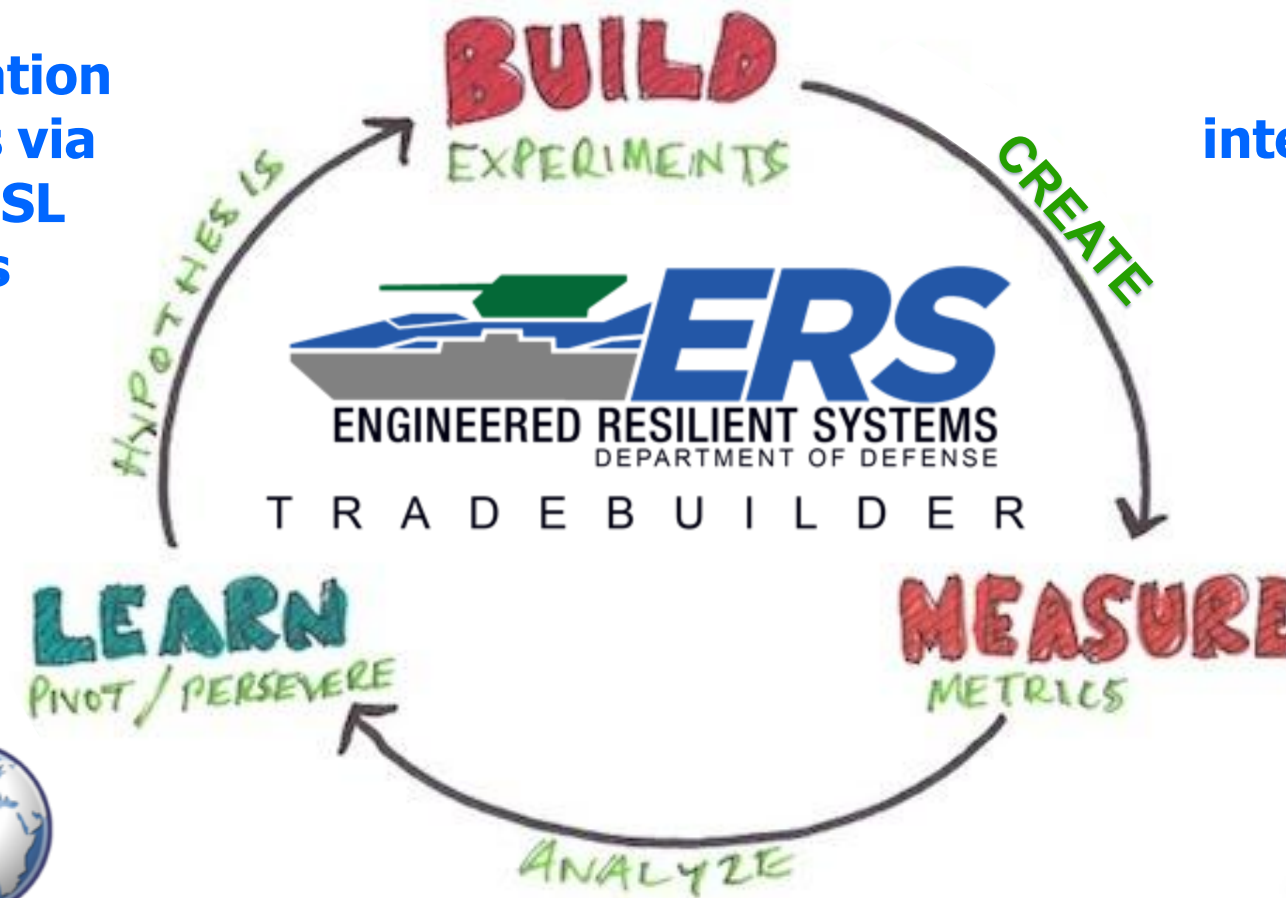
# Guiding Concepts

Create open SW architecture and integrated toolset

Support exploration of SE questions via higher-level DSL abstractions



Promote interoperability and extensibility



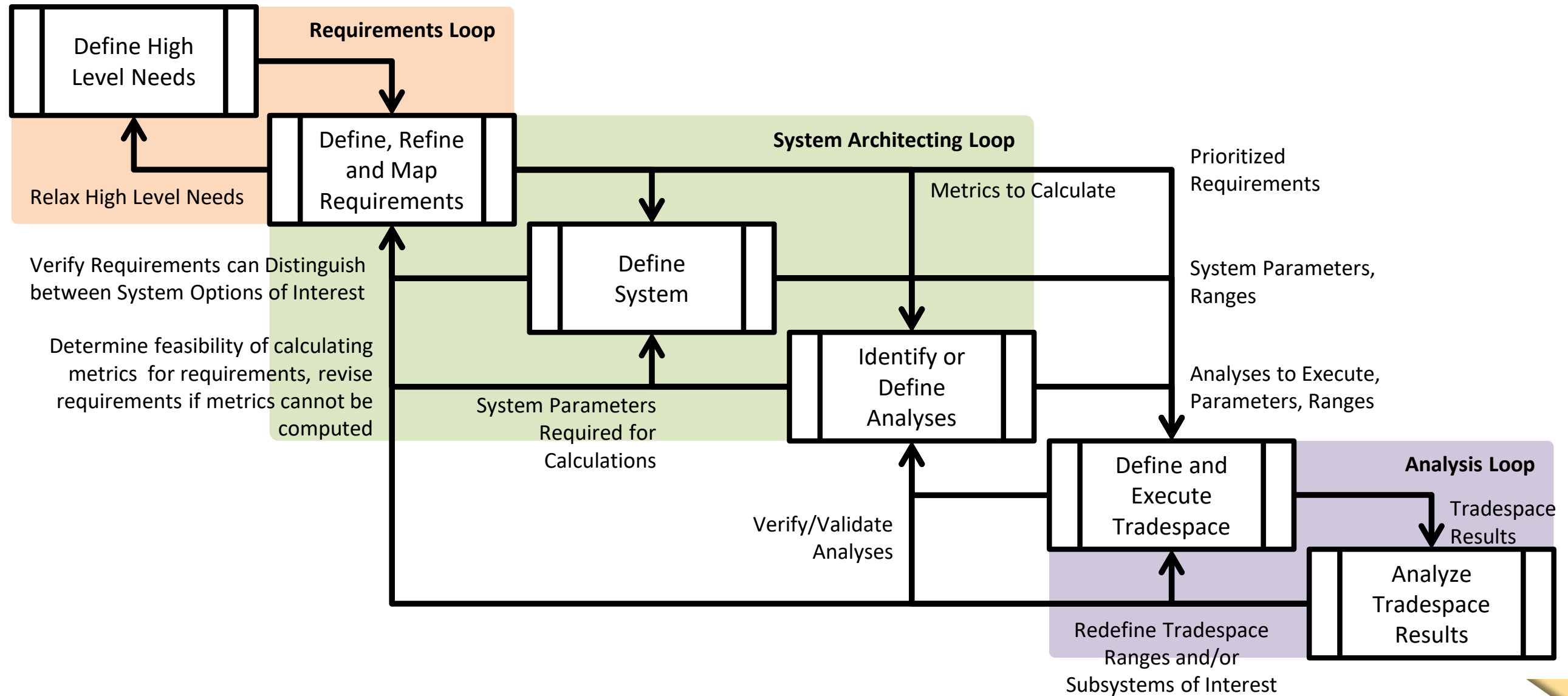
Promote collaborative design and analysis in an executable environment



Support higher-level decision making goals quantifiably and traceably

Evolve how SEs more effectively represent and express their problems

# An Executable Systems Engineering Process



# Promote Collaborative Systems Engineering for the Masses

## Collaboration

- Facilitate the integration of expertise
- Decide together

## Interactivity

- Help understand
- Expedite the hypothesis-test-learn cycle

## Better Systems Engineering

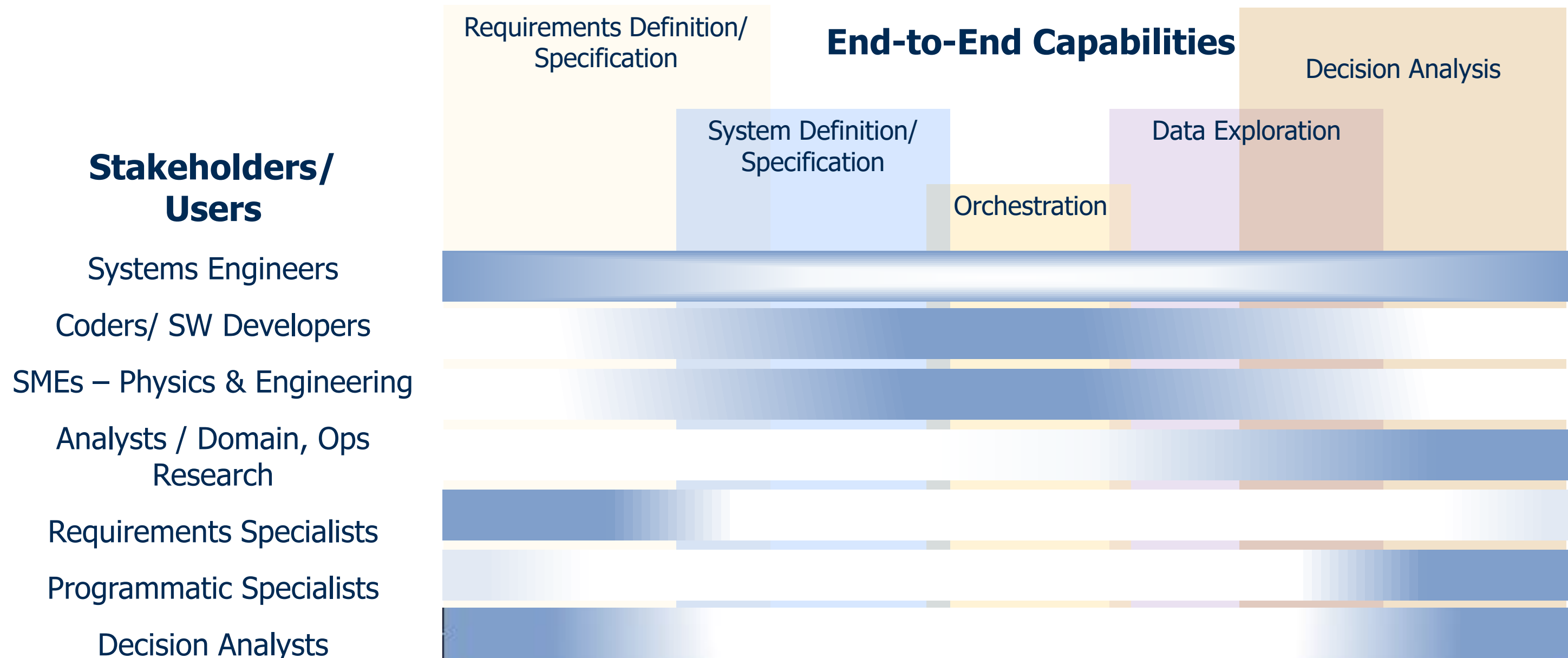
## Iteration

- Lessen the effort in repeating the process
- Encourage review of knowledge

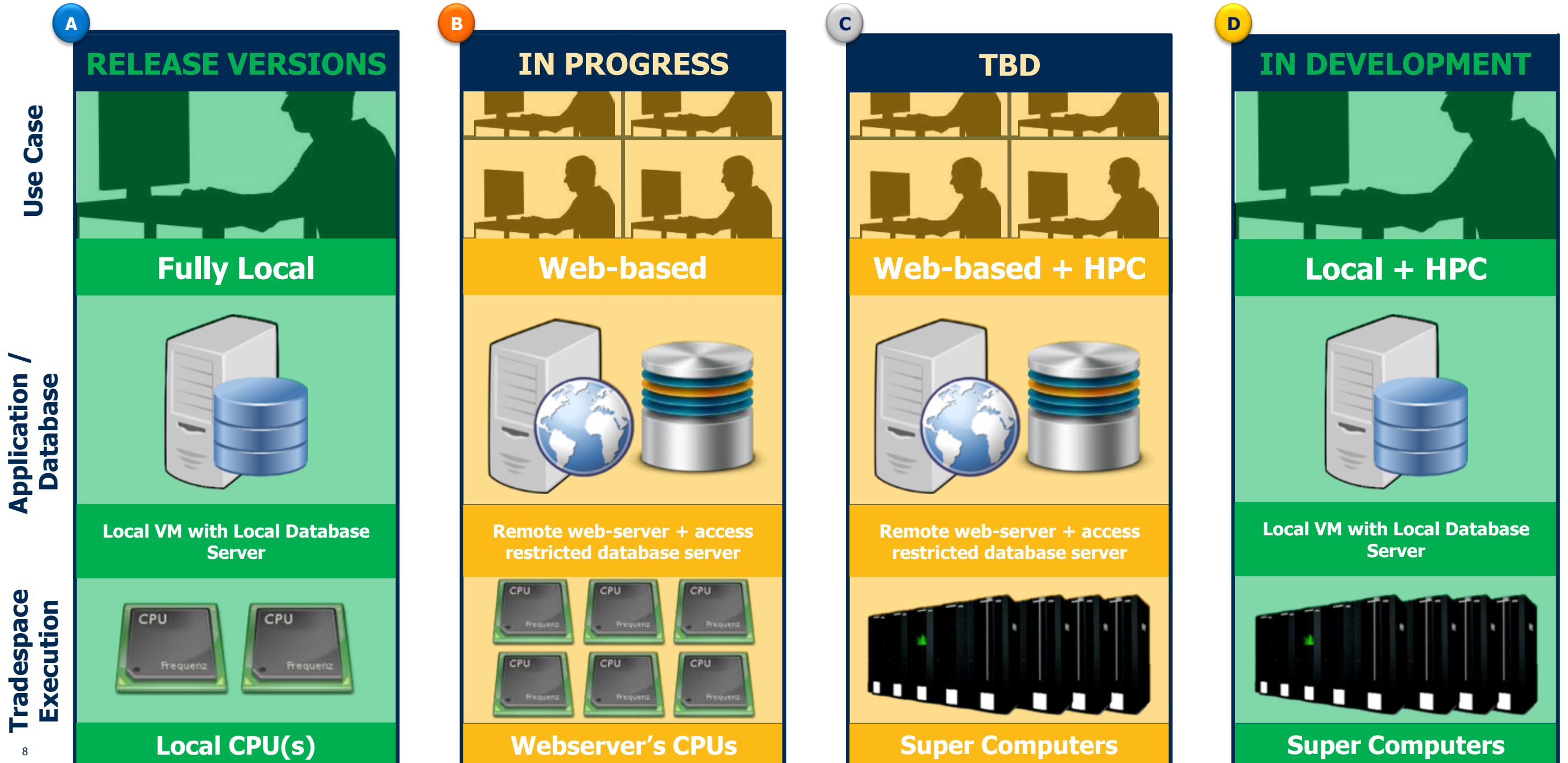
## High Performance Computing

- Reduce time to obtain insight
- Explore the option space more fully

# End-to-End Capability Supporting Diverse Stakeholders

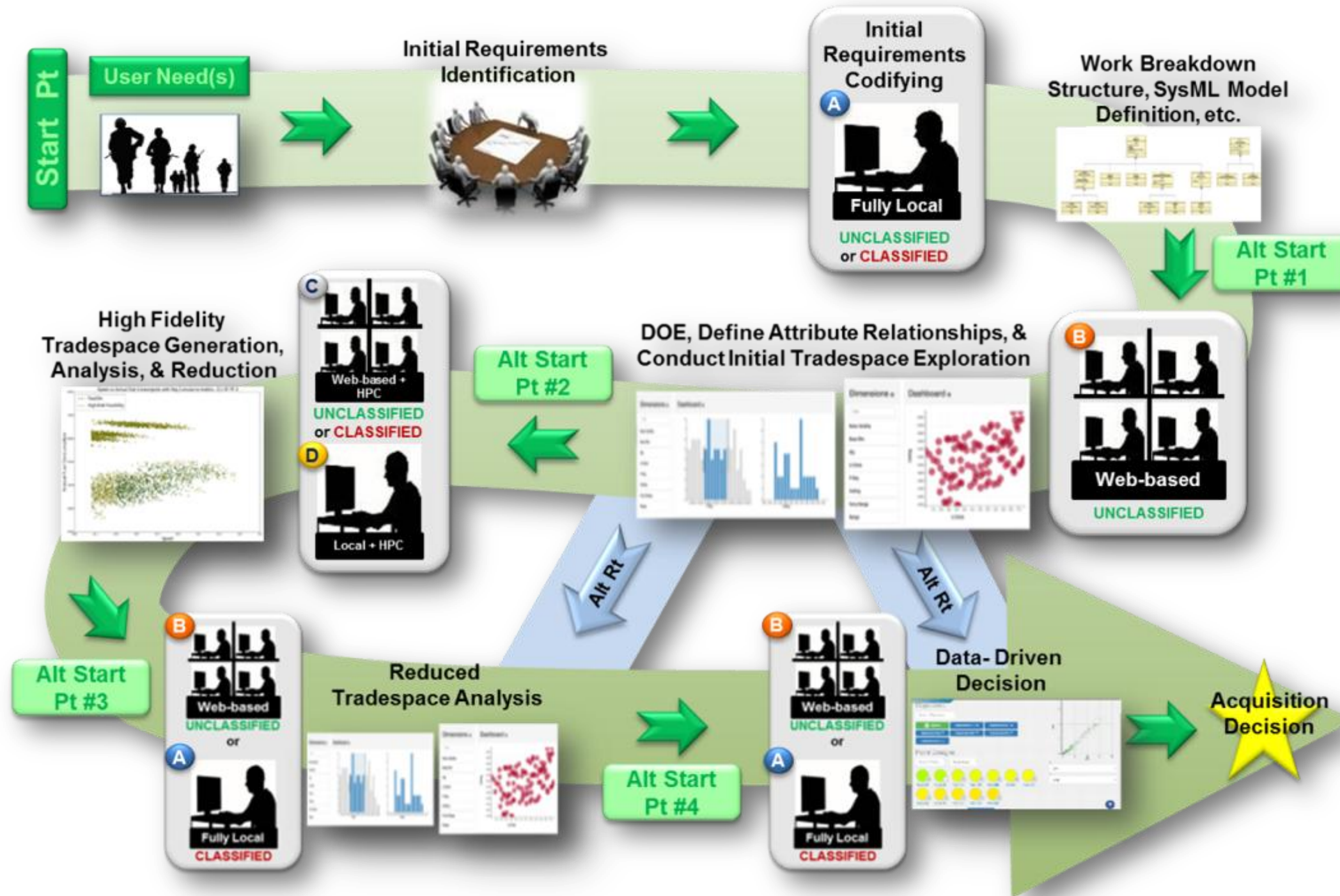


# Deployment Use Cases



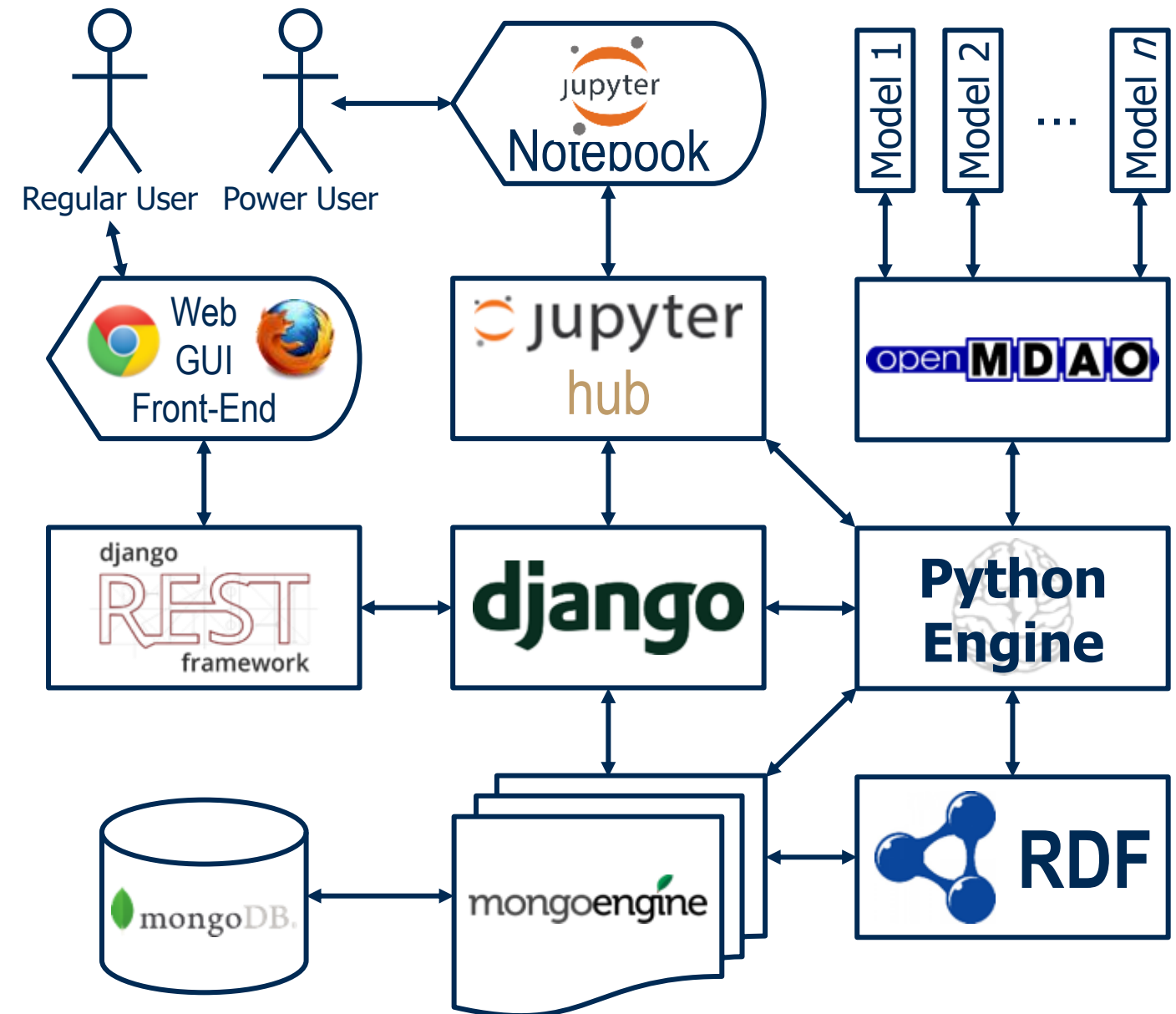


# Example Deployment Use Cases

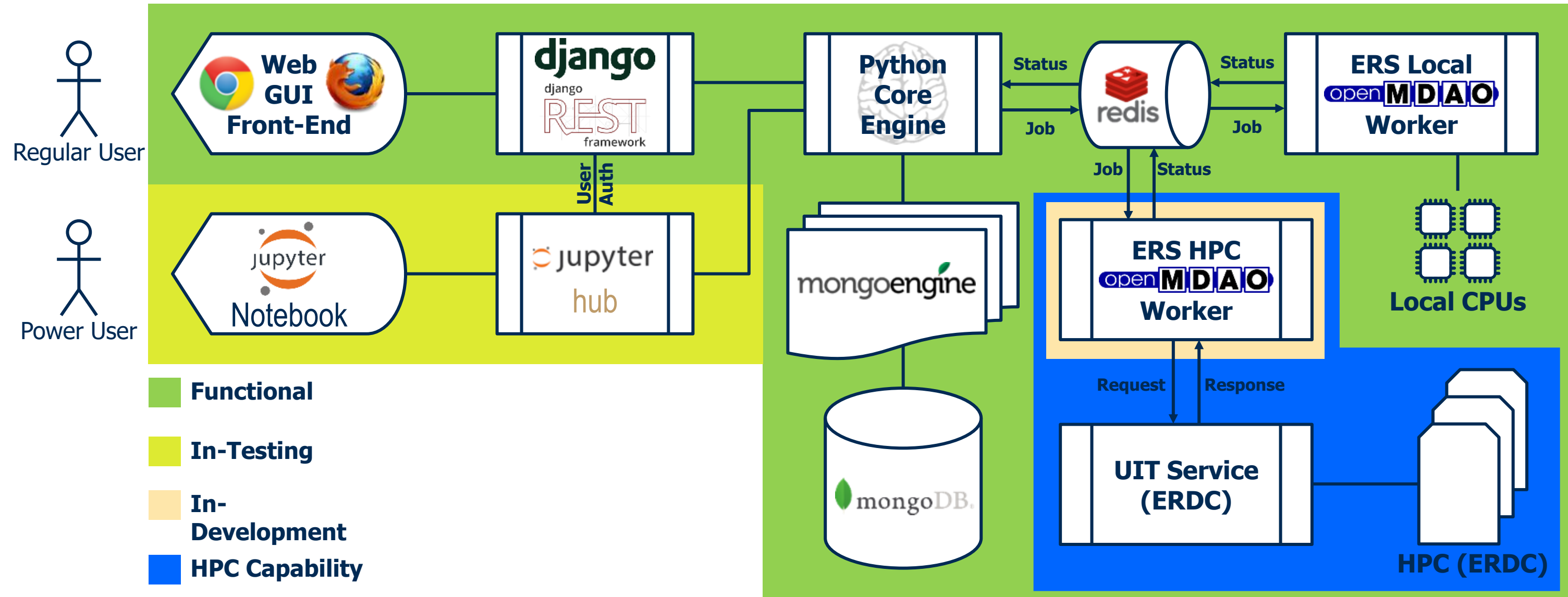


# Software Architecture

- **Support both regular and power users**
  - Regular users employ the more visual interface
  - Power users employ an extensible programming interface
- **Relies on permissive open source technologies**
  - Software used does not require release of own code
- **Extensible and scalable**
  - Modular architecture intended to facilitate the integration of new technologies

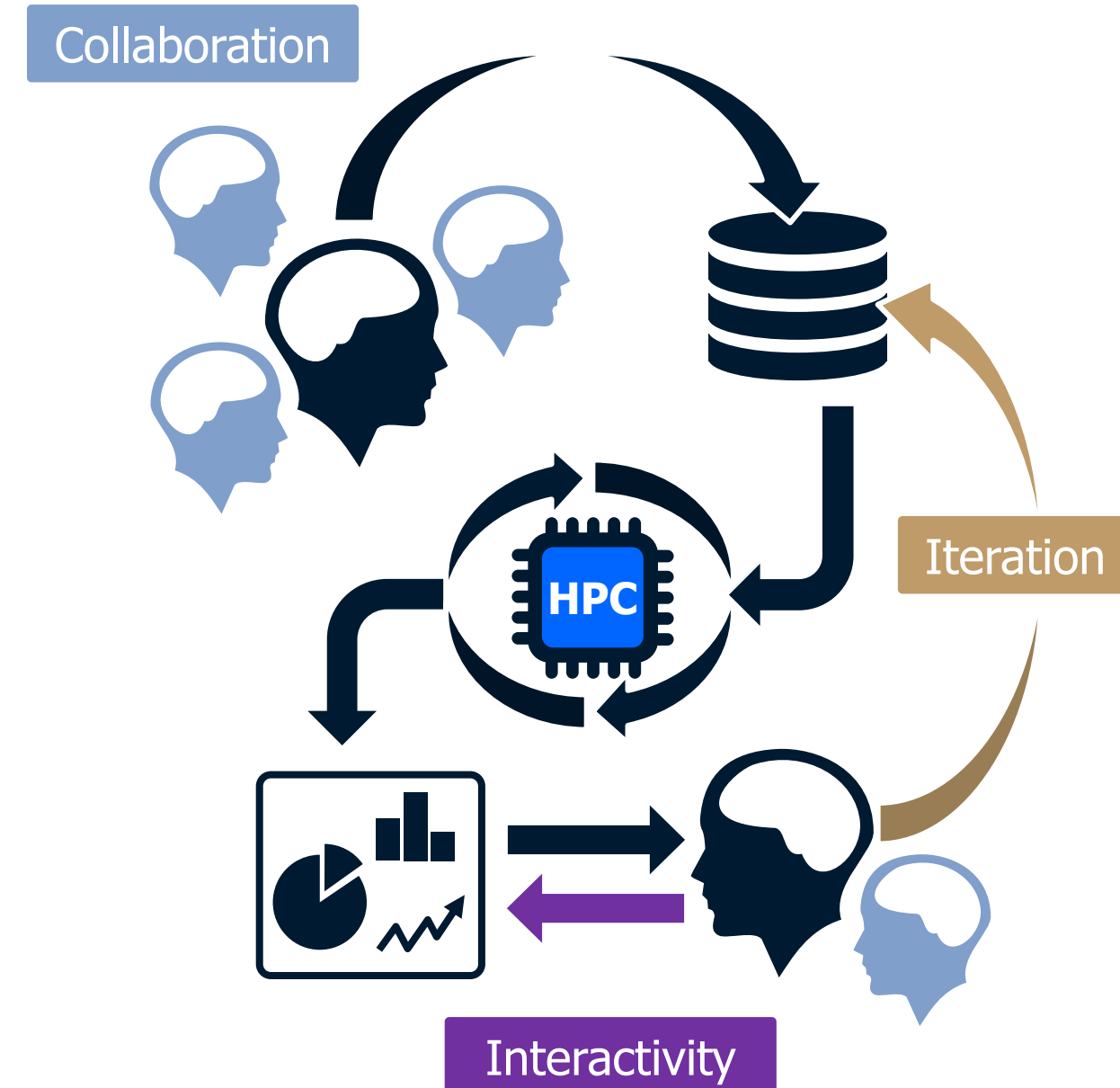


# Execution with HPC



# Pillars of Complex Decision Making

- **Define**  
users describe the needs, the analyses to assess whether or not the needs are met, and the system (or systems) being designed to satisfy said needs
- **Execute**  
users set conditions for and manage/monitor the execution of the integrated engineering models
- **Explore**  
users assess the information generated by the execution of the models to improve their mental models of the problem and the system of interest



# Supporting Disciplines

- **Define**  
users describe the needs, the analyses to assess whether or not the needs are met, and the system (or systems) being designed to satisfy said needs
- **Execute**  
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**MBSE**

Model-Based Systems Engineering

**MDAO**

Multi-Disciplinary Analysis and Optimization

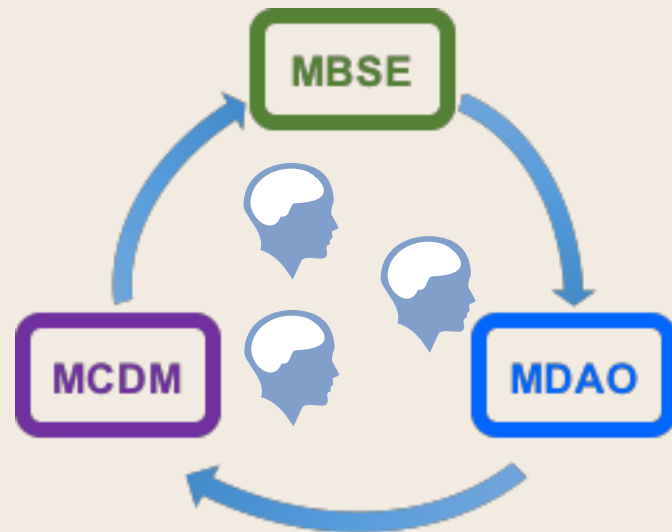
**MCDM**

Multi-Criteria Decision Making



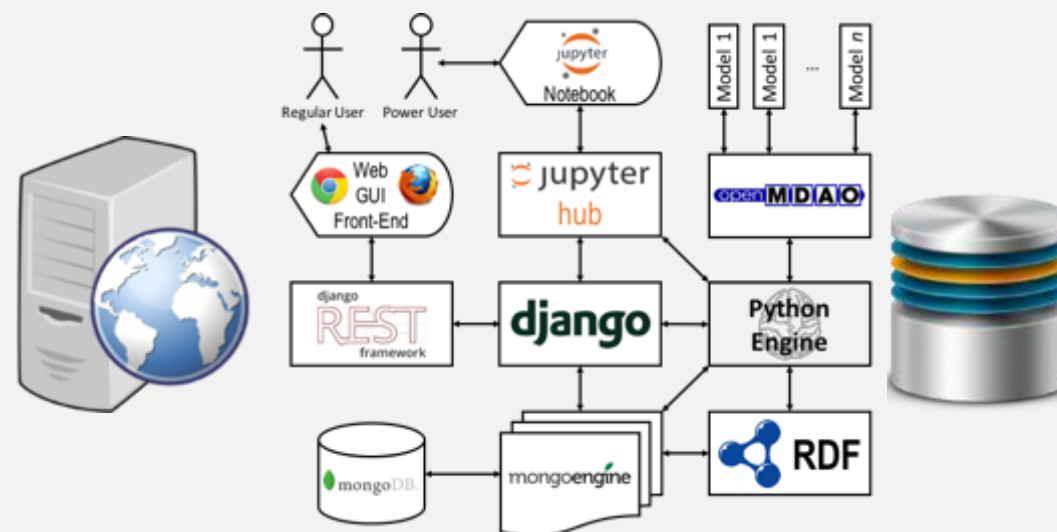
# Integrate Requirements, Design, and Knowledge Generation

## Collaborative SE



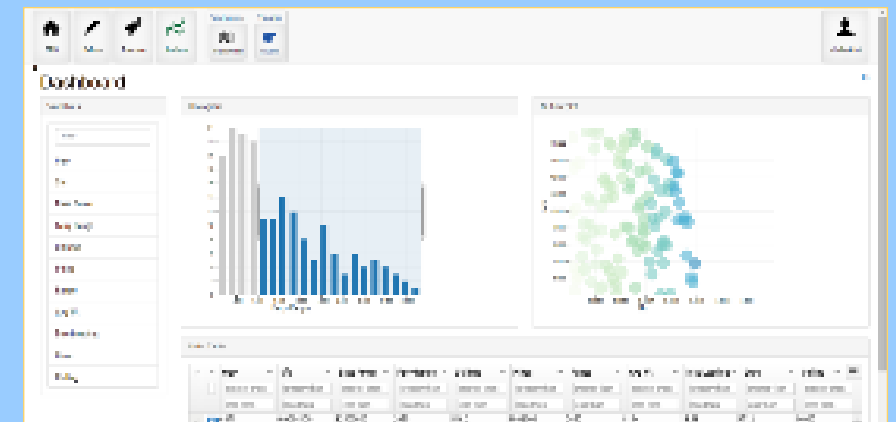
*End-to-End Capability*

## Scalable Framework



*Server or Stand-Alone Execution*

## Dynamic, Customizable, and Visually Interactive



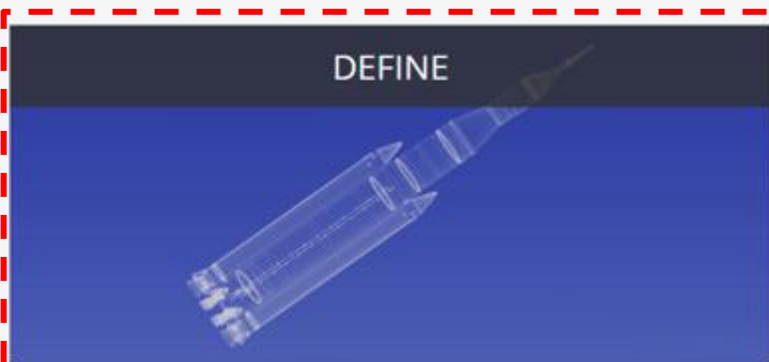
*Method and Stakeholder Fluid*



Log In



# T R A D E B U I L D E R



## DEFINE

Define your system of interest by collaboratively authoring *SysML* Block Definition and Parametric Diagrams. Set your system KPPs and KSAs as requirements. Navigate the project tree to view the [details](#).



## EXECUTE

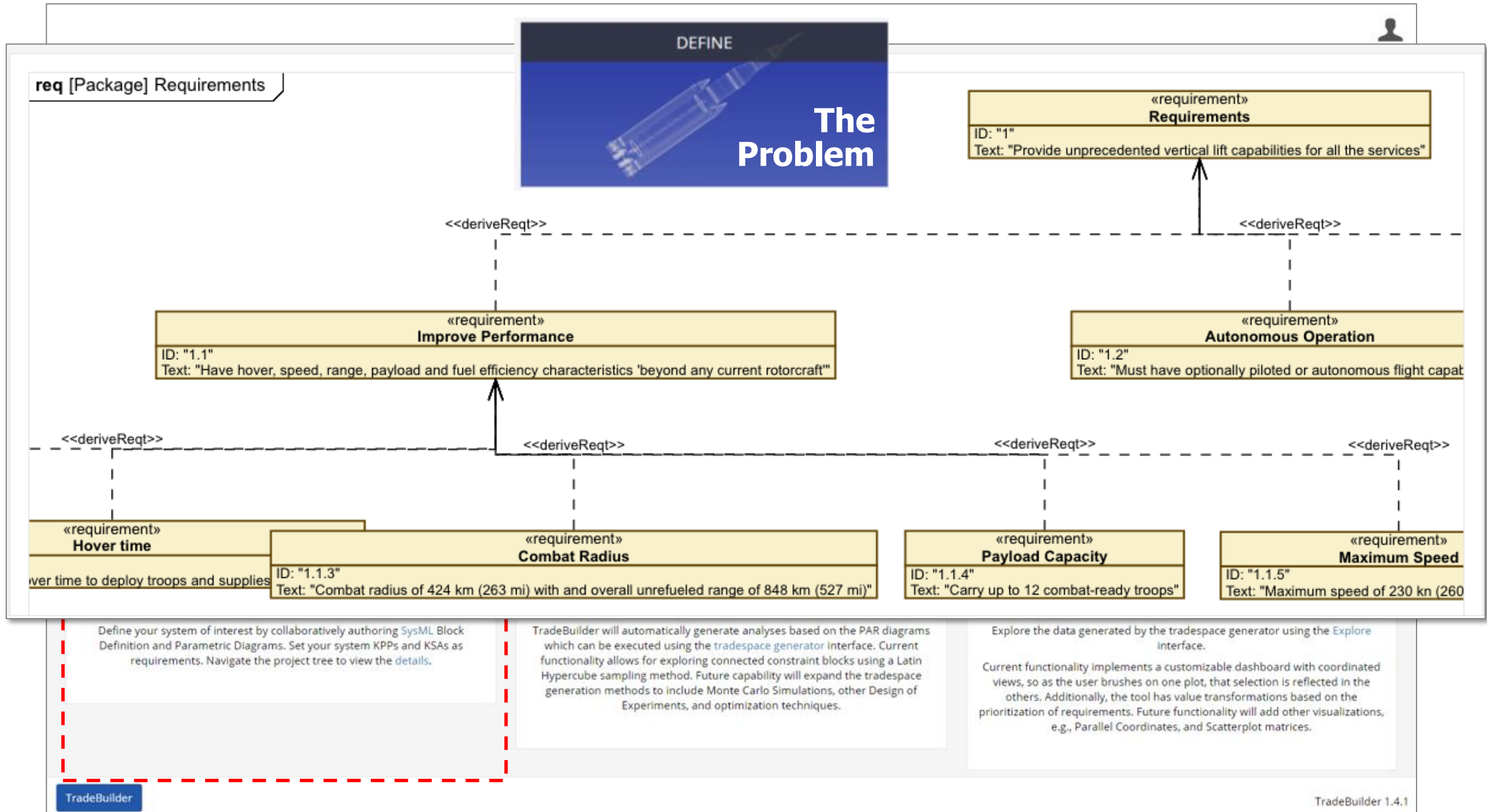
TradeBuilder will automatically generate analyses based on the PAR diagrams which can be executed using the [tradespace generator](#) interface. Current functionality allows for exploring connected constraint blocks using a Latin Hypercube sampling method. Future capability will expand the tradespace generation methods to include Monte Carlo Simulations, other Design of Experiments, and optimization techniques.

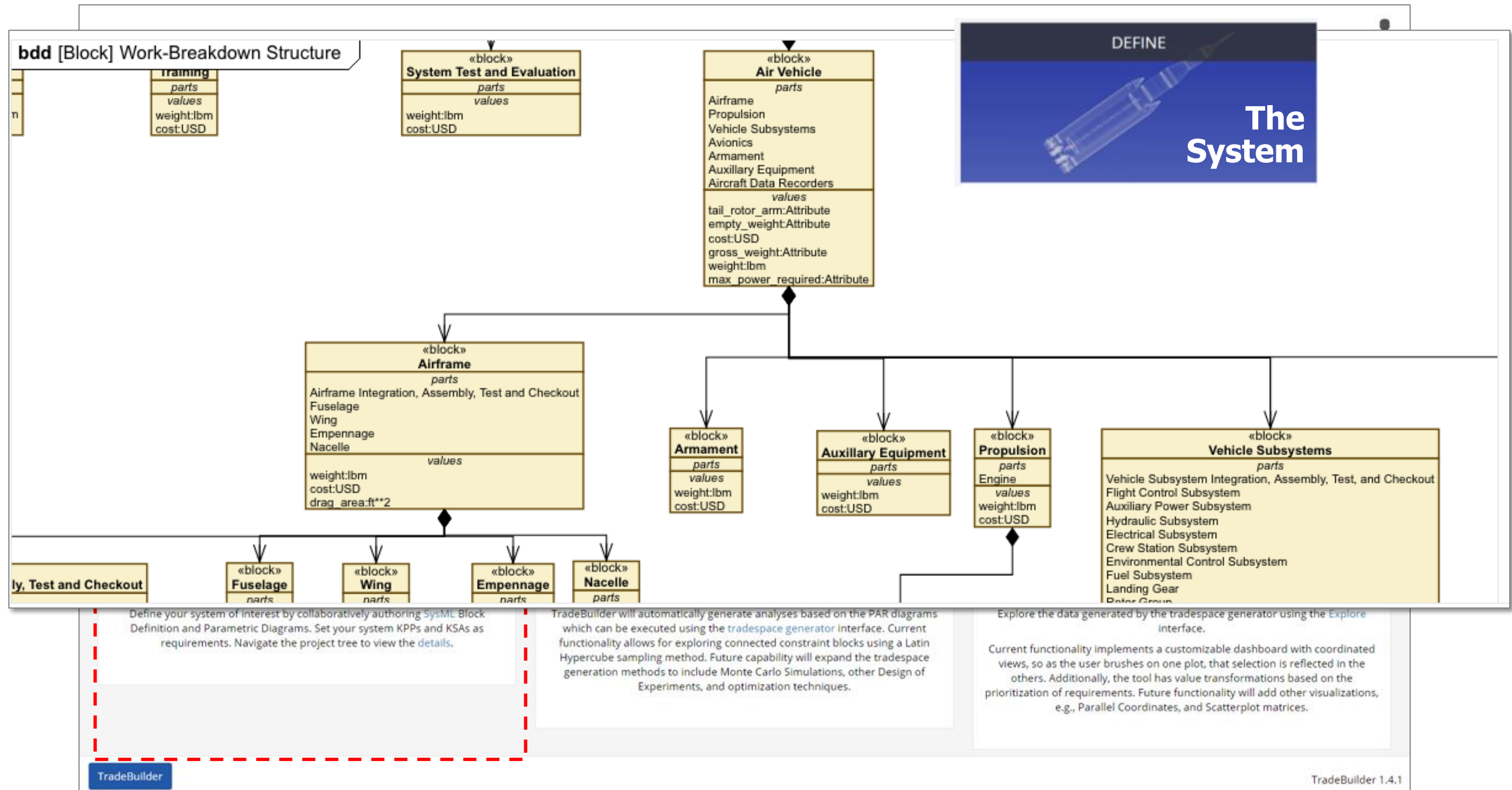


## EXPLORE

Explore the data generated by the tradespace generator using the [Explore](#) interface.

Current functionality implements a customizable dashboard with coordinated views, so as the user brushes on one plot, that selection is reflected in the others. Additionally, the tool has value transformations based on the prioritization of requirements. Future functionality will add other visualizations, e.g., Parallel Coordinates, and Scatterplot matrices.







par [ConstraintBlock] Performance

Main Rotor

cd0

ki

solidity

tip\_speed

diameter

Tail Rotor

cd0

solidity

tip\_speed

diameter

Air Vehicle

empty\_weight

gross\_weight

tail\_rotor\_arm

«constraint»

Performance

- main\_rotor\_cd0 : undefined
- main\_rotor\_ki : undefined
- main\_rotor\_solidity : undefined
- main\_rotor\_tip\_speed : ft/s
- main\_rotor\_diameter : ft
- tail\_rotor\_cd0 : undefined
- tail\_rotor\_solidity : undefined
- tail\_rotor\_tip\_speed : ft/s
- tail\_rotor\_diameter : ft
- weight\_empty : lb
- weight\_gross : lb
- tail\_rotor\_arm : ft
- sfc : lb/hp/h
- installed\_power : hp
- drag\_area : ft\*\*2
- max\_mission\_range : nm
- hover\_ceiling : ft
- ferry\_range : nm
- flight\_ceiling : ft
- max\_rate\_of\_climb : ft/min
- mission\_loiter\_time : h

Design Requirements

combat\_radius

ceiling



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Log In



**ENGINEERED RESILIENT SYSTEMS**  
DEPARTMENT OF DEFENSE

T R A D E B U I L D E R



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TradeBuilder Define Execute Explore Tradespace Manage Run

ERS ENGINEERED RESILIENT SYSTEMS DEPARTMENT OF DEFENSE TRADEBUILDER

Notebook demo Manage

Parameters Run

weight	
Empty Weight Ratio	0.7
Weight Crew	500

Hover Time

Low: 32.30 High: 60.00

Weight Payload

Low: 1,000.00 High: 4,500.00

TradeBuilder TradeBuilder 1.5.1

ERS ENGINEERED RESILIENT SYSTEMS DEPARTMENT OF DEFENSE TRADEBUILDER

Notebook demo Manage

Tradespace Manage Run

Run

hpc

### Login

with DoD HPC OpenID's Kerberos using Yubikey

Principal  @

Kerberos Password

Token Code

- HPCMP.HPC.MIL
- MHPCC.HPC.MIL
- CMF.NRL.NAVY.MIL

TradeBuilder TradeBuilder 1.5.1



Log In



ERS  
ENGINEERED RESILIENT SYSTEMS  
DEPARTMENT OF DEFENSE

# TRADEBUILDER



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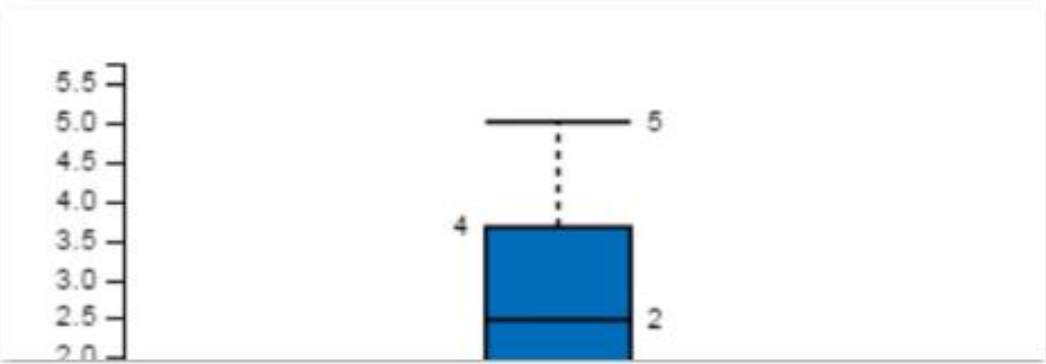
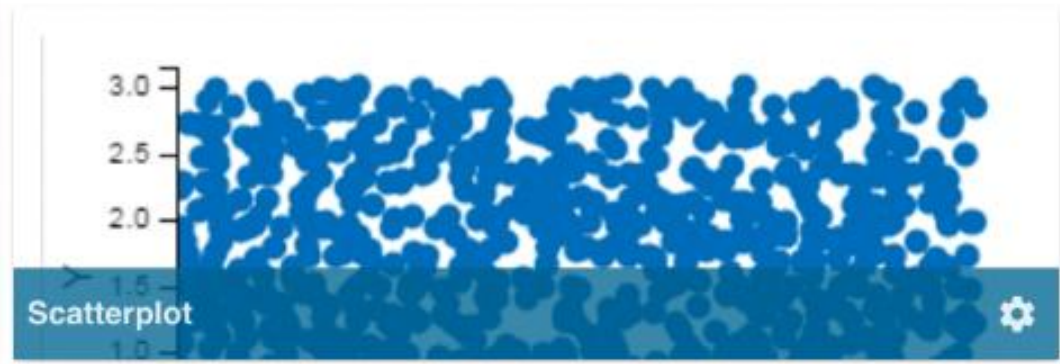
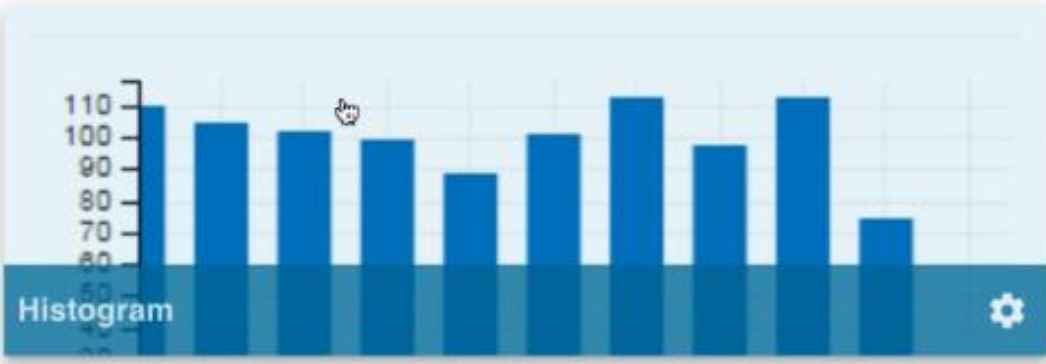
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# Empty workspace

To get started, select a tool to add to the workspace.



**Table**

F1	Y	X
132.34739...	2.8446840...	4.9994621...
105.61238...	1.2059478...	4.9948758...

**Stoplight**

Item	1.1 Internal Performance	1.1.1 Mean Time (hr)	1.1.2 High Mission Operations (HMO)	1.1.3 Control Factors (hr)	1.1.4 Cost
0	Yellow	Red	Green	Yellow	Yellow
1	Yellow	Red	Green	Yellow	Green
2	Green	Red	Green	Red	Yellow
3	Red	Yellow	Green	Red	Yellow
4	Green	Yellow	Green	Red	Green
5	Red	Green	Red	Red	Yellow







# Applications: USAF Development Planning



- Integration with **AFSIM** simulation framework
- Immediate application to USAF **experimentation campaign** in Defeating Agile Intelligent Targets

**Informs USAF planning and technology investment**

# Applications: Next Generation Air Dominance



## The U.S. Navy's Plan to Dominate the Sky in the 2030s (And Beyond)



- “More than just the design of a 6<sup>th</sup> generation fighter” – impact on the full Family of Systems
- Stated need to appreciate the entire life cycle up front

Topics: SECURITY  
 Regions:  
 More stories by: Dave Majumdar

Dave Majumdar  
 June 6, 2016



The United States Navy has officially kicked off its analysis of alternatives (AoA) for a future replacement for the Boeing F/A-18E/F Super Hornet strike fighter and its EA-18G Growler electronic attack derivative.

The Next Generation Air Dominance (NGAD) effort—which until recently used to be called the F/A-XX—will study a range of options to replace the service’s aging strike fighter fleet in an era of renewed great power contest where the threat environment promises to grow evermore challenging. But unlike previous Pentagon programs, the NGAD may not be a single new airframe—rather it might be a family of systems.





# Acknowledgements



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- Mr. Daniel Chausse
- Mr. David Stuart
- Dr. Andrew Strelzoff

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