Setting Strategic Requirements for Tradespace Tools

stract 18845: Tradespace exploration tools support the systems engineering process
ision analysis by identifying compromises, revealing opportunities, and communica
impacts of decisions across a system's development lifecycle. Critical system
isions are made based on the outcome of trades related to technologies, available
ding, processes, time, tools, etc. This presentation will discuss the results of a stud
ducted in support of the Engineered Resilient Systems (ERS) program for developir
despace tools and products to support Department of Defense (DoD) acquisition eff
e study was established to evaluate and identify key tradespace exploration tool
uirements for facilitating the needs of analytical, operational, and science and
nnology (S&T) communities. Initially, stakeholder surveys involving the software
eloper and user communities were conducted to determine if tradespace exploratio
ls under development were fulfilling the tool users' requirements and satisfying
despace exploration. The surveys served to identify a "best common practice" of
abilities for conducting tradespace analysis in support of other government agencie
earch efforts. Additionally, the study facilitated documentation of high-level tradesp
l requirements to support the development and sustainment of a tradespace explora
 analysis software tool. Results will guide future tradespace tool requirements
eration, contribute toward establishing DoD standards for tradespace tools, and
pport the development of tradespace tools for use in system exploration and portfoli
lysis in a wide variety of DoD projects and programs.

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Tradespace Tool Exploration for Engineered Resilient Systems

Dr. Simon R. Goerger (ERDC)
Ms. Drew E. Kelley (ERDC)
Dr. Randy K. Buchanan (ERDC)

NDIA – 19th Annual Systems Engineering Conference

October 2016

Springfield, VA
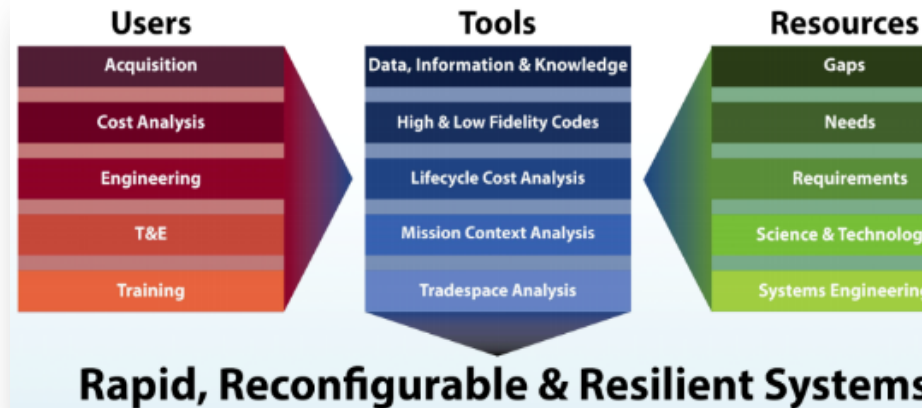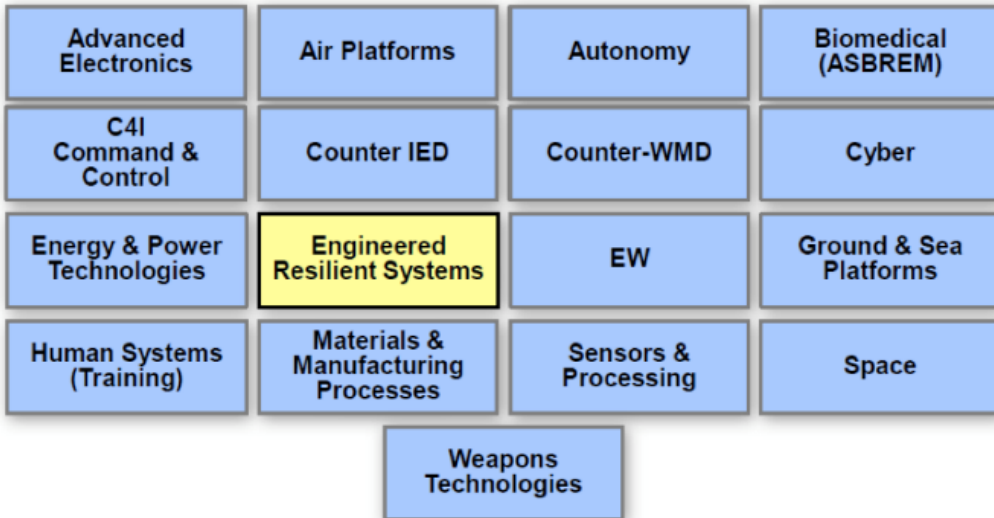
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Outline

Background & Motivation

Survey Objective

Participant Demographics

Sample Study Products

Conclusions and Future Work

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Engineered Resilient Systems (ERS)

One of 17 Department of Defense (DoD) Communities of Interest (COI)

Dedicated to providing the DoD with "Better Buying Power" through o
systems architecture, advanced M&S, tradespace tools and analytics,
virtual prototyping, etc.

Eslinger, O. Engineered Resilient Systems COI Poster [pdf]. Retrieved from http://www.acq.osd.mil/chieftechnologist/COIs.html.

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Tradespace Exploration

The proposed ERS Tradespace is the set of program and system parameters, attributes, and characteristics required to satisfy performance standards. It is the potential solution space.

Development of a large tradespace of viable alternatives is essential for a set-based approach of design.
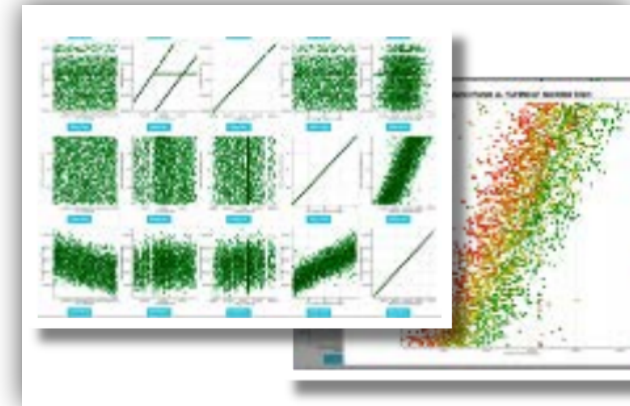
Tradespace exploration supports the systems engineering process for decision analysis by identifying compromises, revealing opportunities and communicating impacts.

Spero, E., Avera, M.P., Valdez P.E., "Tradespace Exploration for the Engineering of Resilient Systems. Army Research Laboratory, January 2014.

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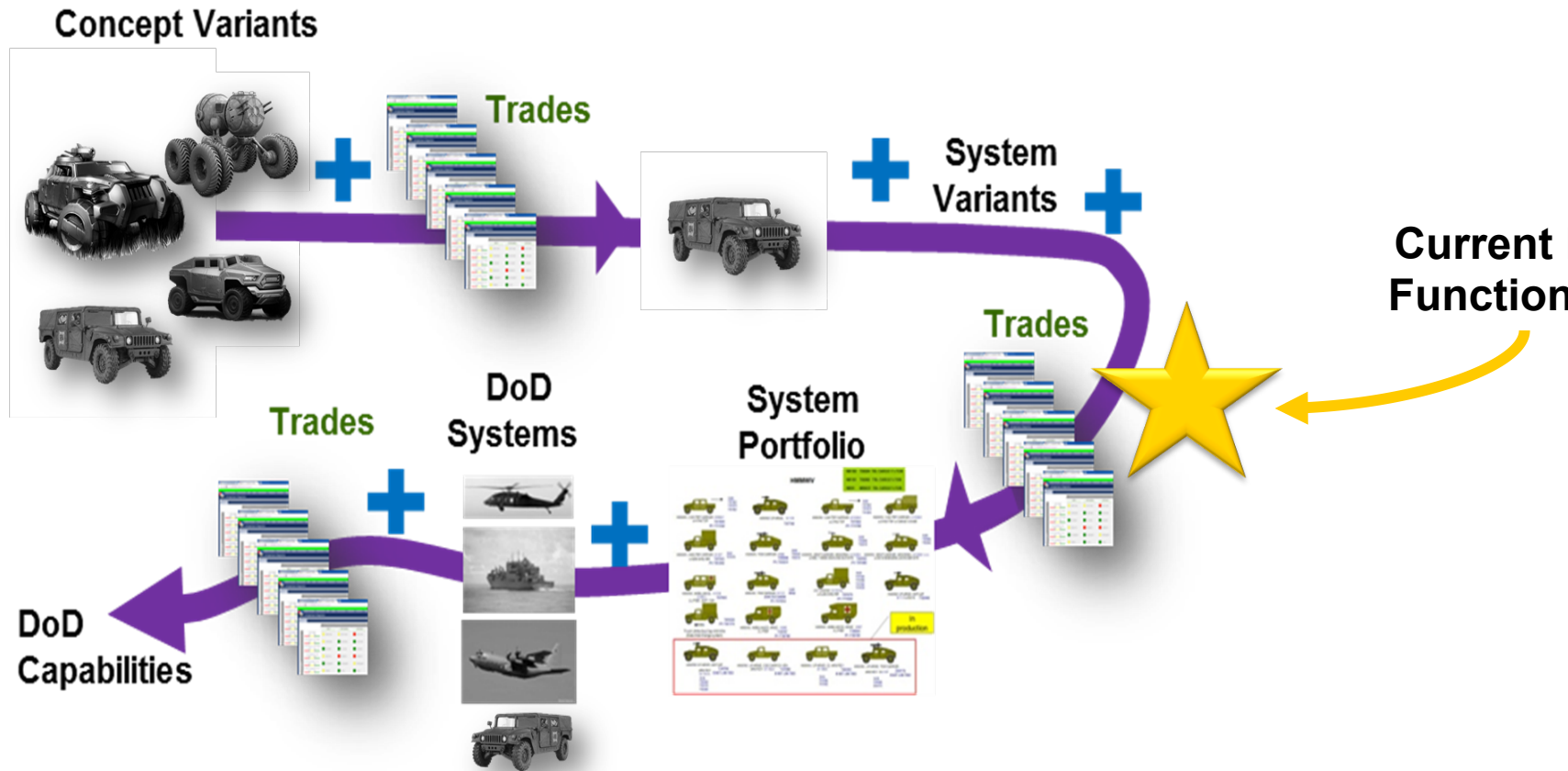
ERS Tradespace Frontier
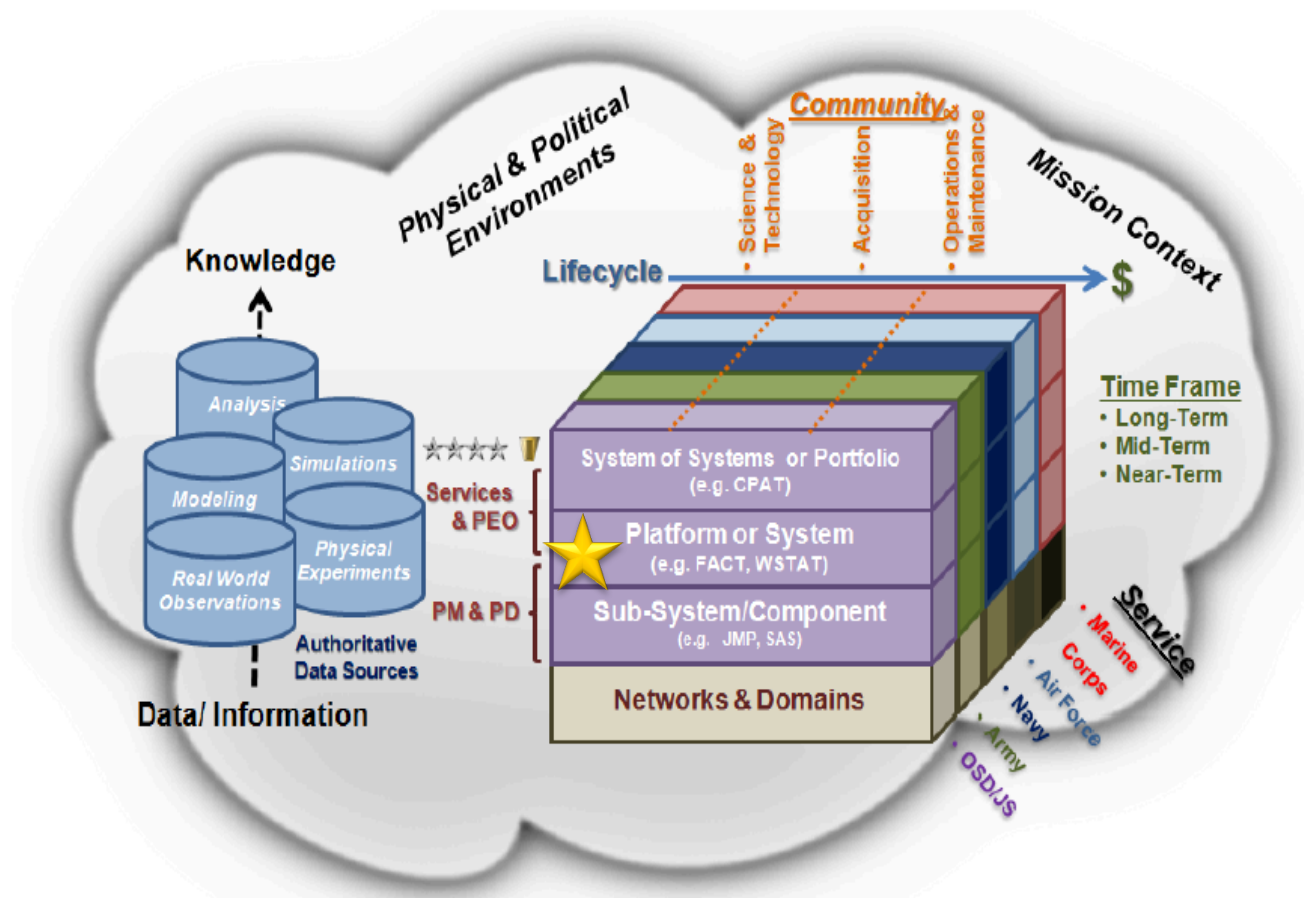
Focus on platform or system portion of the cube, as it applies across timeframes, bodies of knowledge and data, and the system lifecycle

E. Spero, M. P. Avera, P.E. Valdez, S. R. Goerger, " Tradespace Exploration for the Engineering of Resilient Systems", CSER 2014.

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ERS Tradespace Requirements Roadmap

Map represents exemplary method to enable analyzing DoD system, system portfolio, and capability portfolio trades

Kelley, D., Buchanan, R., and Goerger, S., "Tradespace Tool Requirements Exploration for Engineered Resilient Systems", ERDC-ISER 2016.

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Tradespace Tool and Exploration Research Background

Tool Sources and Surveys

- Army Research Laboratory ARL-TR-7288
- Operations Research and the Management Sciences (OR/MS) Today Decision Analysis Software (DAS) Survey
- Rexer Analytics Data Miner Survey
- ERS Demonstration Projects
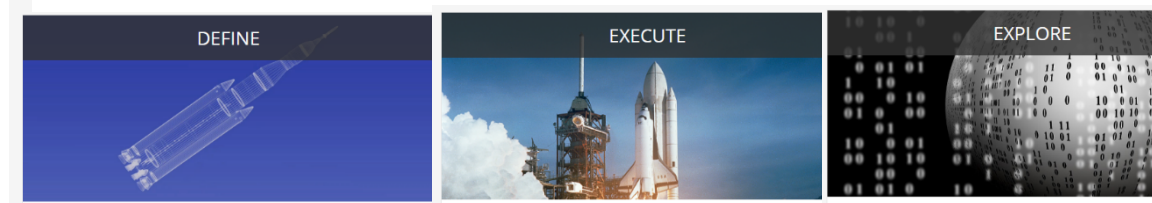- Internal organization research and experience

## Tool Reduction

Tool Attributes

Process Steps

Motivation

Develop an understanding of how tradespace exploration (TSE) tools are used to support the decision analysis process

Leverage the paradigm shift towards common tradespace methods, tools, and steps

Enable the ERS Community of Interest (COI) Tradespace Requirements Working Group (WG) to better assess tools for their ability to accomplish TSE efforts

Inform stakeholders of existing functionality and tradespace tools enhancements under development to meet stakeholder TSE needs
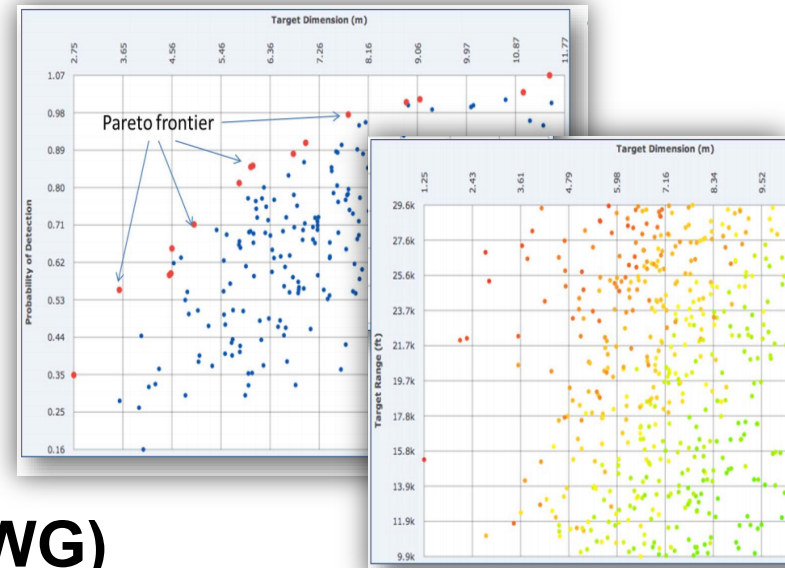
Ender, T. R., et al. Engineered Resilient Systems Tradespace Tools Research RT-120. 6th Annual SERC Sponsor Research Review, 04 December 2014.

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Survey Objective & Analysis

Provides a deeper understanding of how a specific selection of tools is used when performing TSE in support of the systems engineering decision analysis process.

Enables users and developers to better assess if they possess the appropriate tools and capabilities for tradespace exploration and analysis (E&A).

Responses collected from a representative sample of both the software developer and user communities.

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Conference on Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

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Survey Results: Participant Demographics

ectors include:
ce and Technology (S&T)
motive – Research and
opment (R&D)
ry Intelligence
ce and Investment
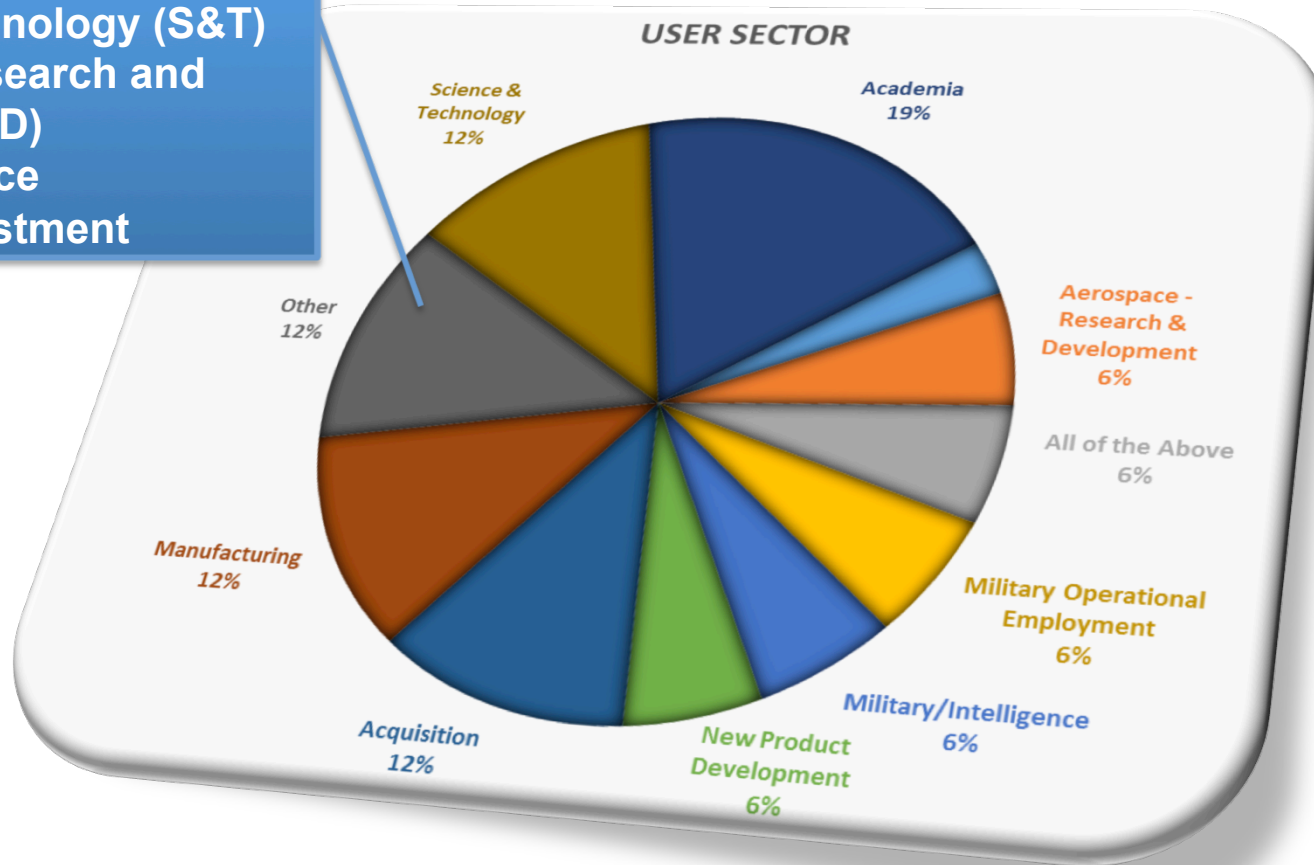
USER SECTOR

**Top four User Sec
represented 55%
participants:**

- **Academia**
- **Acquisition**
- **Manufacturing**
- **Science and Techn**

Survey results indicate that TSE is applied across DoD analytical efforts

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer
Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

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Survey Results: Tradespace Tools

Tools in development:

- ATSV
- ERS Tradespace Tool
- IVTea Suite
- JMP Statistical Package
- MAT/Mercury
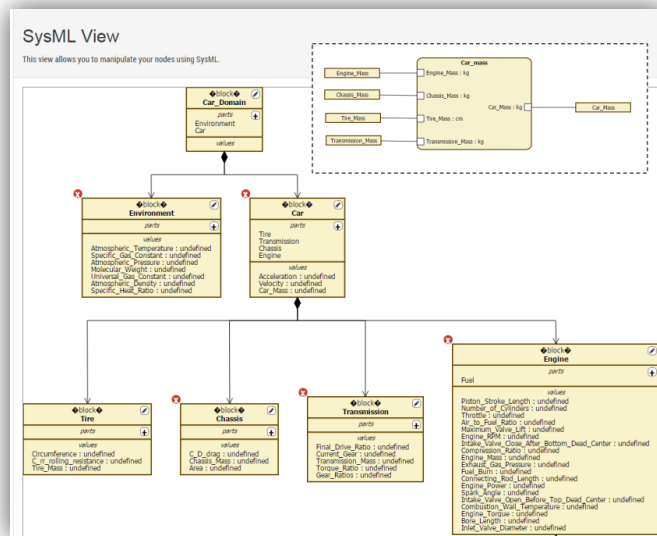
Tools in use:

- **Any SysML Authoring Tool**
- **ATSV**
- **CPAT**
- **Excel**
- **FACT**
- **IVTea Suite (internal usage)**
- **JPAT**
- **JMP**
- **Matlab**
- **Mathematica**
- **ModelCenter**
- **OpenMDAO**
- **R**
- **WSTAT**

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

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Survey Results: Decision Analysis Efforts

our Tool Applications were 70%
tradespace tool use cases:
ysis of Alternatives
ems Design
Benefit Analysis
folio Optimization/Management

TOOL APPLICATIONS

Cost Benefit Analysis
13%

Portfolio Optimization or Management
13%

Strategic Planning
9%

Prospecting
5%

Vendor Selection/Analysis
4%

Risk Assessment
4%

Budget Resourcing
4%

All of the Above
4%

Analysis of Alternatives
22%

System Design
22%

Survey results indicate that TSE is used most often in: System Design, AoA, Cost Benefit Analysis, and Portfolio Management
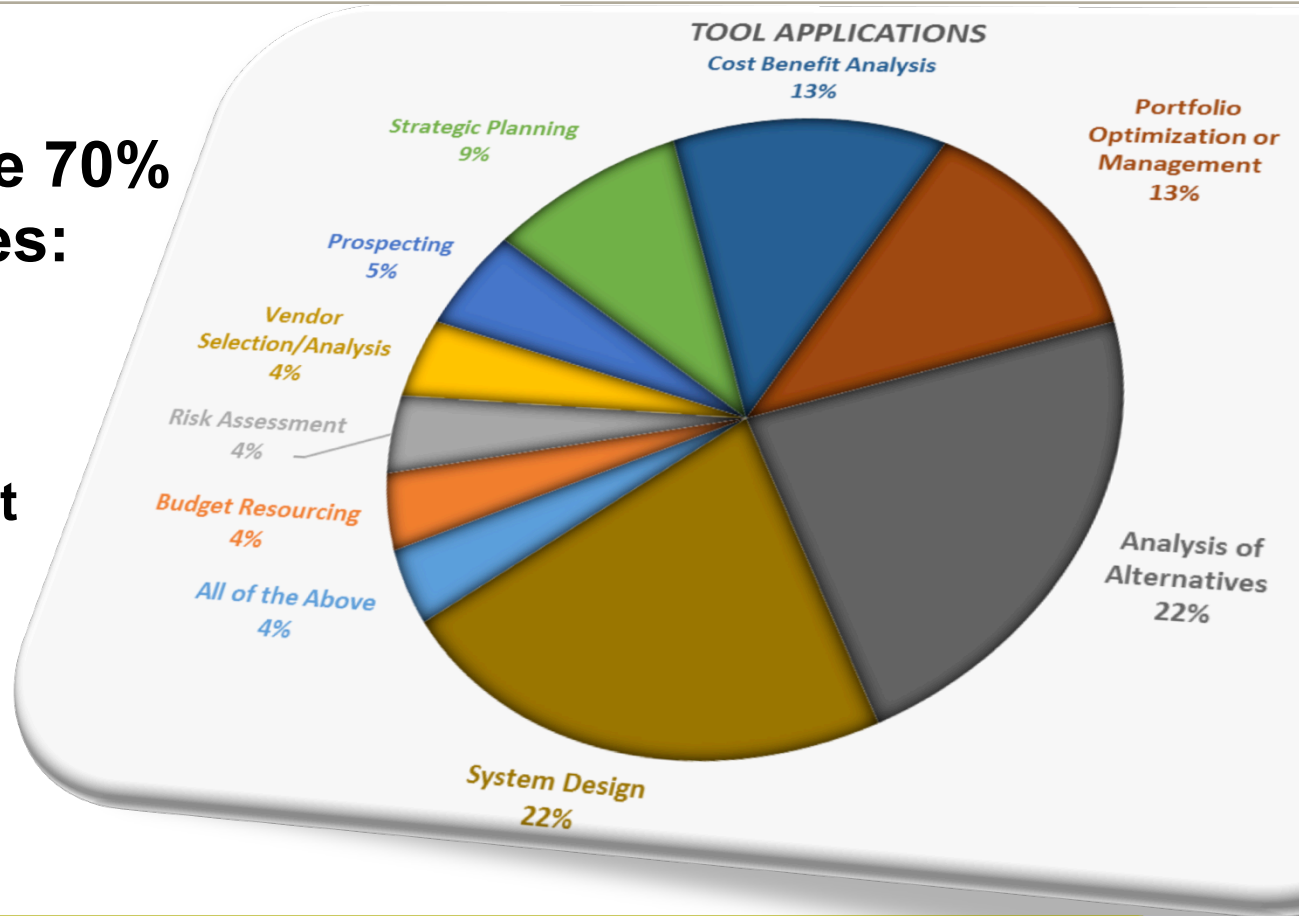
Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

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Requirements Breakdown Summary

Total Requirements (96)

Capability Categories (17)

- **Analysis of Alternatives**
- **Modeling and Simulation**
- **Decision Support**
- **Etc.**

Roles (3)

- **User**
- **Developer**
- **Systems Administration**

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer
Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

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Survey Results: Desired and Developed

Software Capabilities Gaps

...d with ...for ...cements:

...ssment ...rtainty ...ysis ...metric ...Sharing ...ession ...ng

Limited ... at this ti...
• Portfoli...
  Manage...
• Decisio...
  Designe...

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer... Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.
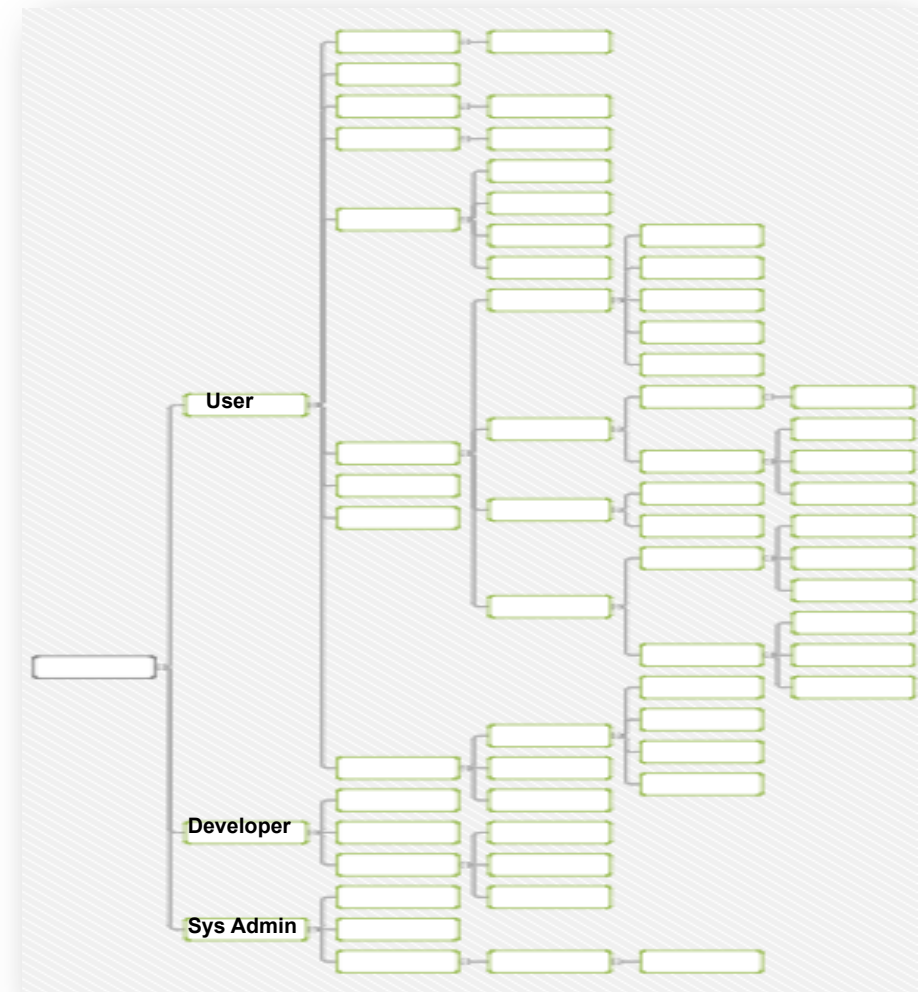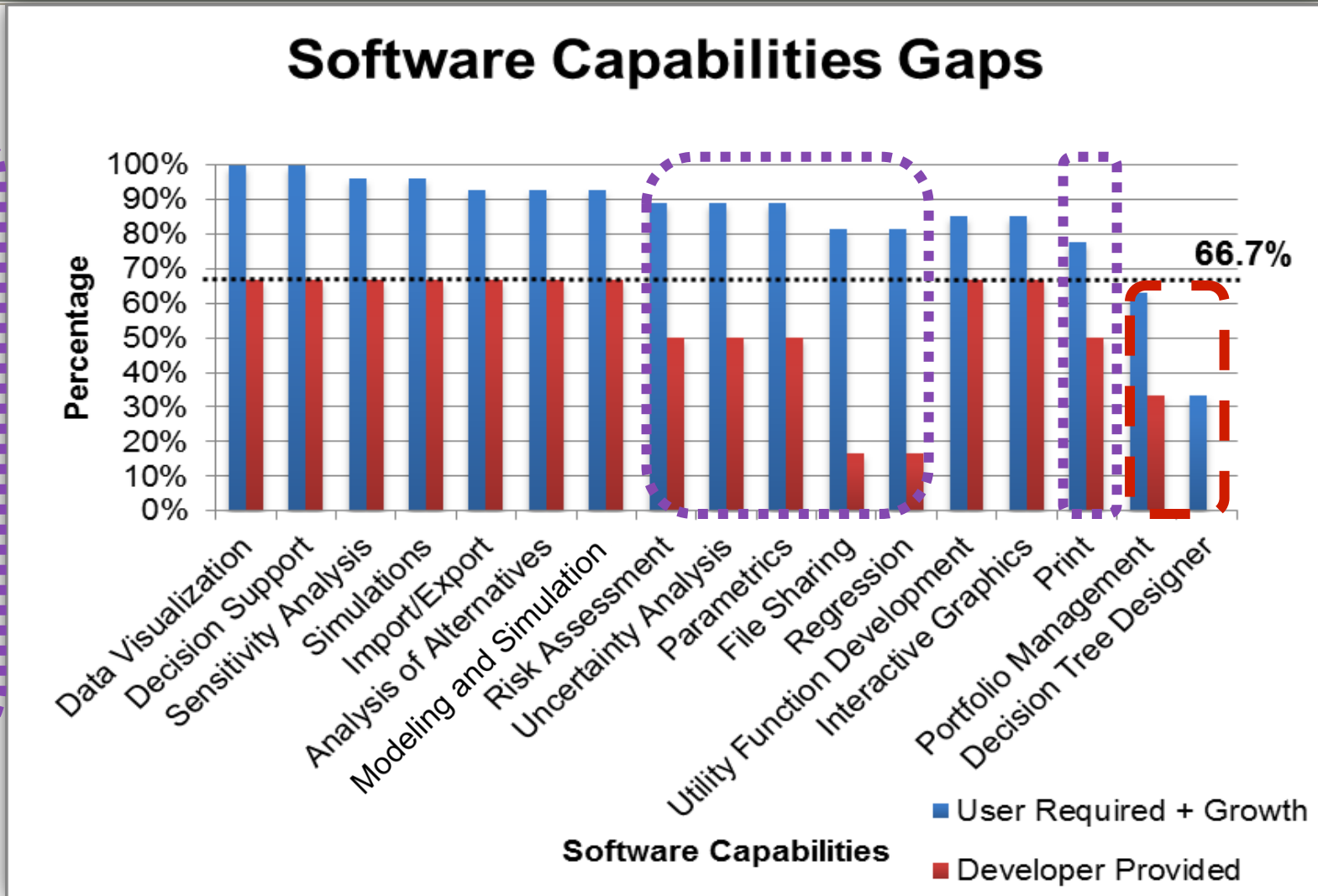
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Survey Results: Expanding Capabilities
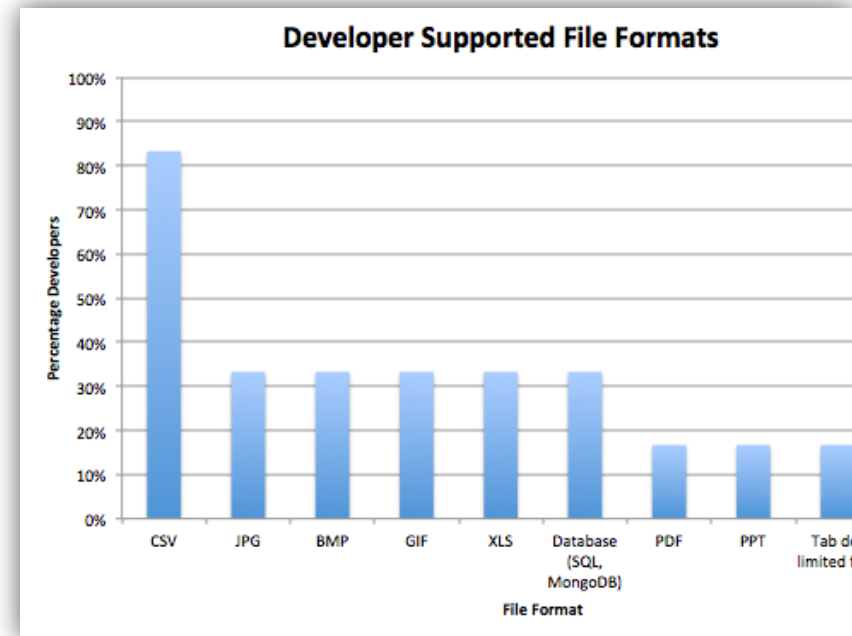
Uncertainty Analysis:

– **Type A and Type B**

– **Propagation of Error**

– **Uncertainty Budgets**

– **Sensitivity Coefficients**

– **Standard and Expanded Uncertainties**

Cost Estimating Resources:

– **Excel Cost Models**

– **Automated Cost Estimation Integrated Tools (ACEIT)**

– **Planned for next version of software**

• **Supported Programming Langua**

– **C**   **- HTML**

– **Java**   **- Java Script**

– **JMP Script**   **- Python**

– **R**

Kelley, D., Goerger, S.R., and Buchanan, R.K., "2015 ERS Tradespace Tool Survey – Evaluating Tradespace Exploration for Engineered Resilient Systems," 2016 Confer Systems Engineering Research (CSER16), Huntsville, AL, 22-24 March 2016.

Conclusion and Next Steps

entified, evaluated, and proposed 96 strategic and sub-level requireme the ERS COI

tablished better understanding of tradespace exploration & analysis t

ovided insight into the development of a standardized process to iden despace tools and tool requirements

orm stakeholders (including industry partners) of existing capabilities tial strategic tradespace tool requirements in support of DoD tradespa orts

ntinued investigation to identify additional enhancements to tradespa ols in support of ERS and industry partner requirements to include:

Supported Programming Languages (for integration of new/enhanced models)

Uncertainty Analysis

Cost Estimating Resources

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Acknowledgements

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adespace Tool Surveys whose participation and support allowed fo
ccessful survey analysis and tradespace evaluation. Finally, we wo
e to acknowledge all ERS COI Tradespace Tool Requirements Worl
up members for their willingness to supposed and participate
fining, identifying, and discussing tool gaps and developing in
quirements for future ERS tradespace E&A tool development
ssessment efforts.

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Questions?

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