Systems Engineering Research Needs and Workforce Development Assessment

Technical Report SERC-2018-TR-102

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Sponsor: DASD (SE) – Deputy Assistant Secretary of Defense (Systems Engineering)

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EXECUTIVE SUMMARY

This research tasks, focused on an assessment of systems engineering research needs and workforce development assessment, involved a data collection exercise resulting from 24 site visits (19) and telephone discussions (5). Additionally, we collaborated with INCOSE to run a supporting survey on this topic to all the INCOSE Fellows – worldwide (approximately 30% of all Fellows responded to the survey). Here is the list of these 24 engagements:

1. Sandia National Laboratories – Engagement 1
2. Sandia National Laboratories – Engagement 2
3. Jet Propulsion Laboratory
4. NSWC – Corona Division
5. NSWC – Philadelphia Division
6. Wright Patterson AFB – AFLCMC
7. Naval Air Weapons Station – China Lake
8. AMSAA – Aberdeen Proving Grounds
9. Embedded Systems Institute – Netherlands
10. The Aerospace Corporation
11. The MITRE Corporation
12. AFOTEC – Kirkland AFB
13. NSWC – Carderock
14. NSWC – NUWC
15. NSWC – Dahlgren
16. NAVSEA Headquarters
17. IC Engagement 1
18. IC Engagement 2
19. INCOSE Fellows – Worldwide Survey
20. ARDEC – Picatinny Arsenal
21. NAVSEA – SPAWAR
22. NAVSEA 05T
23. PEO – Aviation
24. AMRDEC – NASA (Marshall) – Joint Visit

The data collected suggests research priorities that broadly align with the following 4 primary research objectives. Sub-categories within each primary research objective are also highlighted:

1. Knowledge, Data and Machine Learning
   a) AI/Machine Learning;
   b) Data Analytics
   c) Data/Complexity
   d) Knowledge Management and Document/Requirements

2. Systems Engineering MBSE, Decision Making and Integration.
   a) Computational Applications in SE
   b) Decision Making
   c) Model Based SE
   d) System Integration
   e) Systems Engineering Modeling and Measurement

3. Management, Culture and Agility
   a) Mission Engineering
   b) Agile Engineering

4. Security, Trust, Risk and Testing
   a) Cyber-security
   b) Risk and Uncertainty
   c) Security, Reliability and Resilience
   d) System Trust
   e) System Testing

Python scripts using open source packages for Natural Language Processing was the tool chosen for analyzing the data collected. A script that identifies the important concepts (words) of each sentence in the minutes resulting from the engagements allowed us to identify a total of 139 research objectives across the 24 engagements. A sense for the emphasis within these identified research objectives, down to the resolution of the sub-categories identified above are reflected in Figure 1 (A through D). The data collected from the survey of the INCOSE Fellows was analyzed separately and is included in this report also.

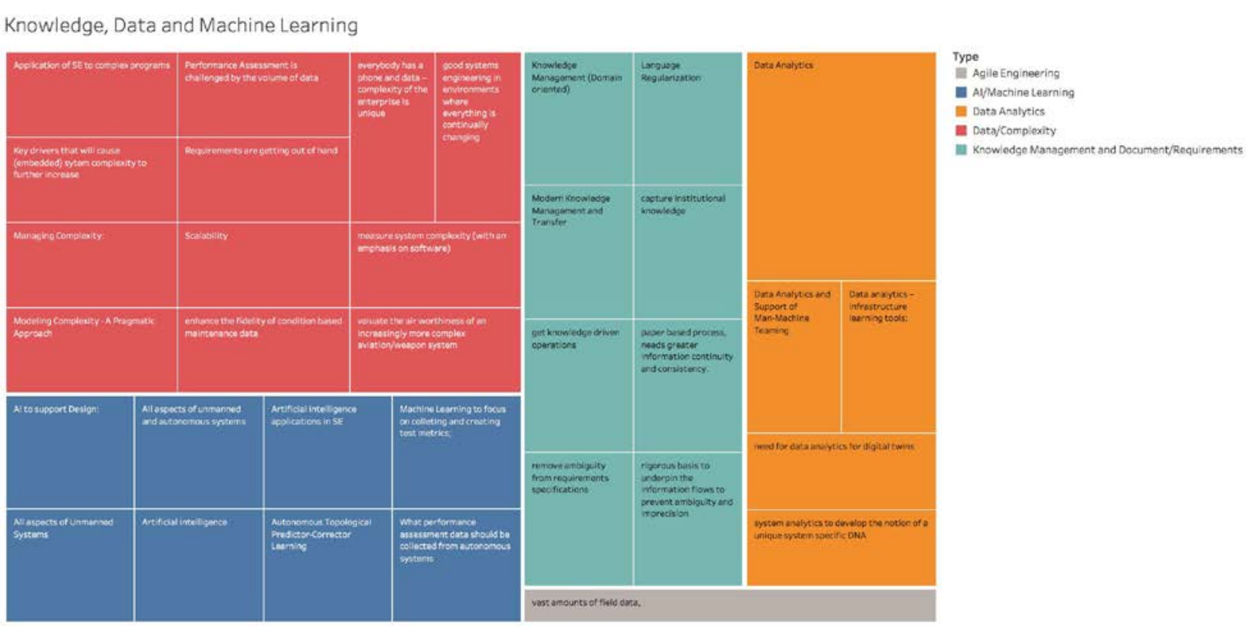

Figure 1A. Breakout of Cluster 1

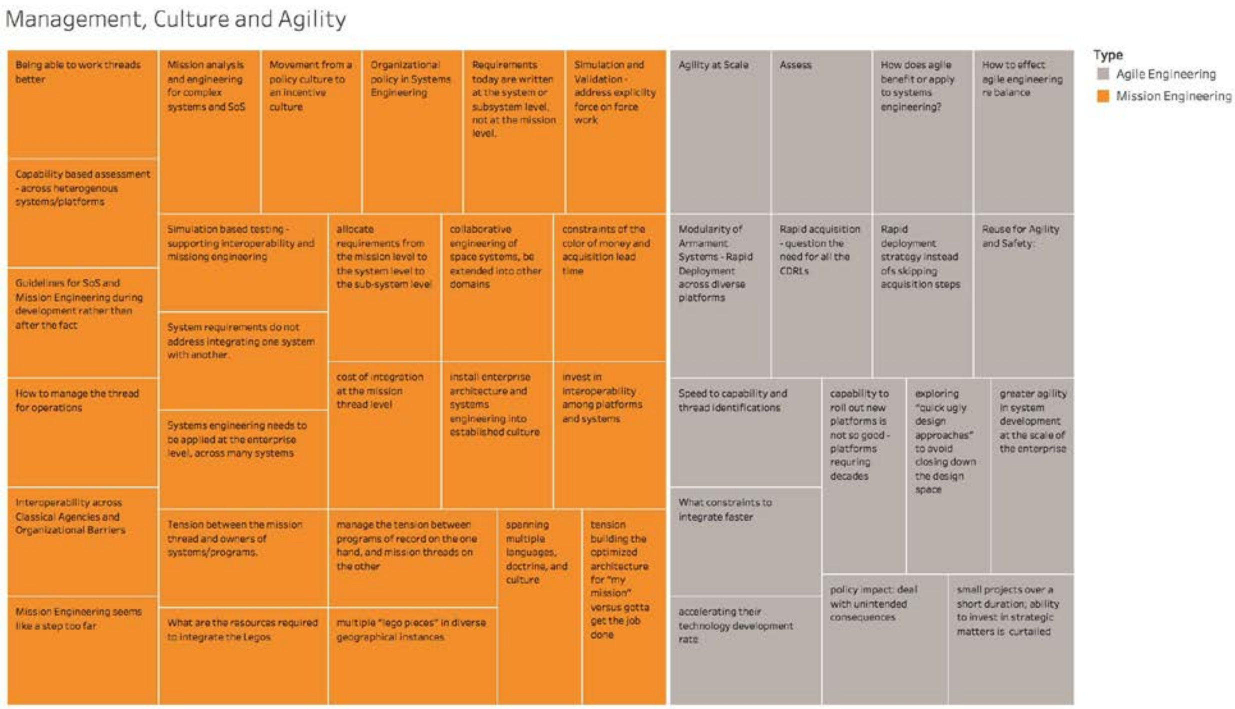

Figure 1B. Breakout of Cluster 2

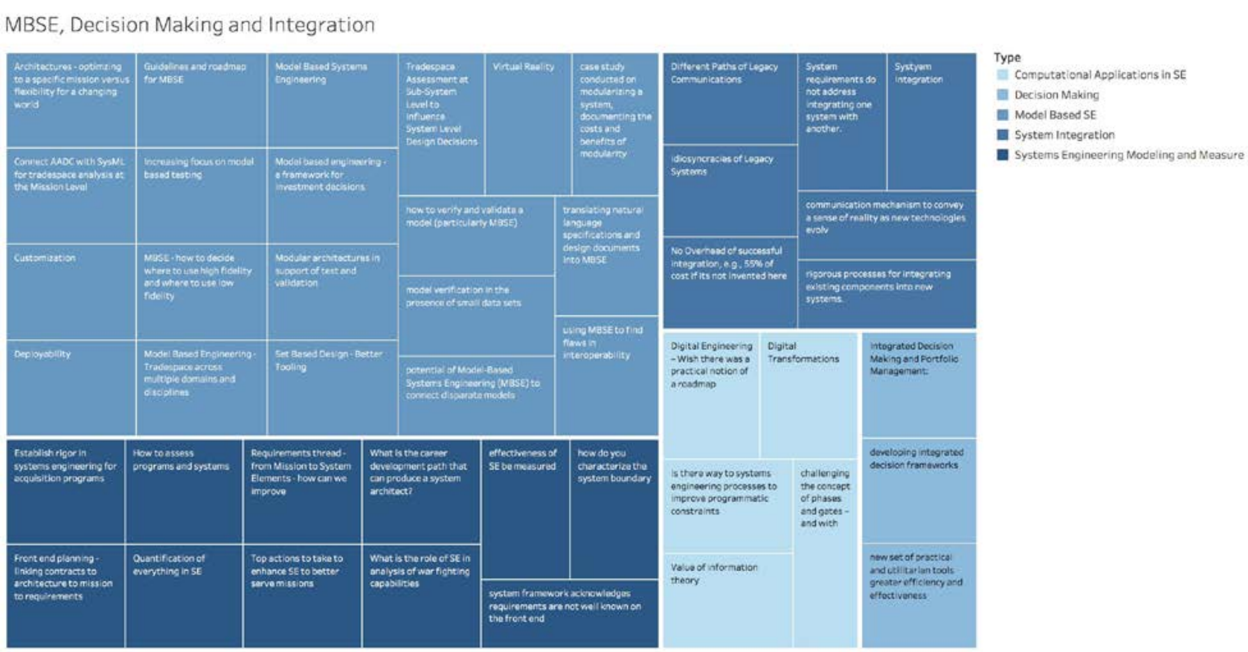

Figure 1C. Breakout of Cluster 3

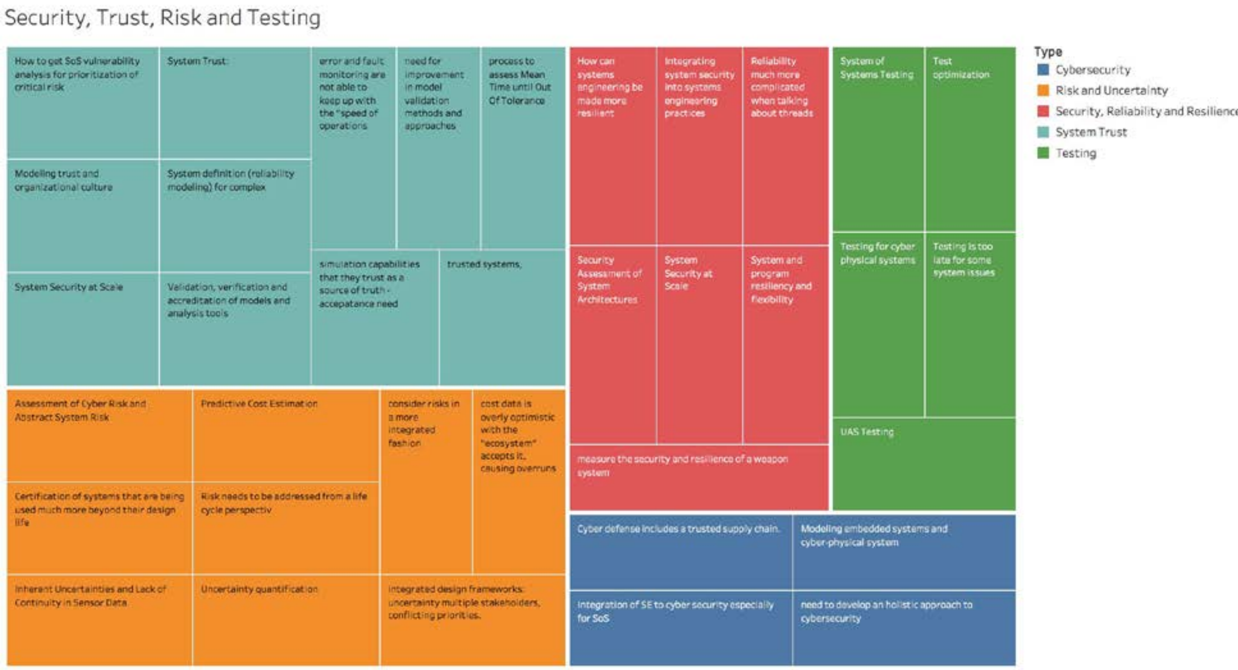

Figure 1D. Breakout of Cluster 4

Research Task Context and Preparation

Research Task Background

The Department of Defense (DoD) determines its research needs for the SERC in a variety of ways. The SERC executes the core-funded research outlined in the SERC Technical Plan, which was developed based on inputs from the Government's Executive Advisory Board and the SERC's Research Council. DoD organizations sponsor their own tasks within the SERC. Finally, the SERC periodically puts out a call for incubator tasks, where principal investigators put together a short research proposal which receives a modest amount of funding to develop a set of research findings and challenges, which may receive substantial funding on subsequent task orders. Although these avenues and this information is helpful in shaping DoD's SE research priorities, this particular research task was focused on engaging with S&T and Engineering leaders across the DoD's laboratories and engineering centers to understand if it was possible to identify discernable patterns across the board with regard to research priorities and opportunities for impact. This information would be useful in the ongoing initiative to update the SERC Technical Plan for the next five years.

Research Task Approach

This research task was established to identify patterns of research that are of the greatest relevance to the engineering and technical leaders at warfare centers in the Army, Navy and Air Force. Researchers engaged other Defense communities, such as the Intelligence Community with the same objective. The research patterns identified in this task will help guide SE research priorities over the next two to five years and increase the return on investment of future RTs. The SERC researchers assessed the research needs through visits and discussions with technical leaders at the various warfare centers, with a focus on the leveraging the three core competencies of the SERC:

1. Long-term, comprehensive systems engineering focused on DoD acquisition,
2. Leverage developments in systems architecting, complex systems theory, systems thinking, systems science, knowledge management and software engineering to perform research to advance the design and development of complex systems across all DoD and Intelligence Community domains.
3. Leverage developments in open systems standards, organizational theory, program management, SE management, and information technology to provide needed integration of program/technical management MPTs.

The research team also collected and assessed any development issues related to the engineering workforce.

The data collection exercise consisted of 24 site visits and telephone discussions. Additionally, we collaborated with INCOSE to run a supporting survey on this topic to all the INCOSE Fellows – worldwide (approximately 30% of all Fellows responded to the survey). Here is the list of these 24 engagements:

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24. AMRDEC – NASA (Marshall) – Joint Visit

The site visits got triggered by a visit request and an attached Terms of Reference for the visit. An exemplar visit request letter and the attached Terms of Reference are included in Appendix A of this report. A set of the minutes resulting from these visits is included in Appendix B of this report. The names of the individuals who hosted the study team and were engaged in discussions during the visit have been removed.

OVERVIEW AND ANALYSIS OF THE DATA COLLECTED

The data collection exercise consisted of 24 site visits and telephone discussions. Additionally, we collaborated with INCOSE to run a supporting survey on this topic to all the INCOSE Fellows – worldwide (approximately 30% of all Fellows responded to the survey).

Python scripts using open source packages for Natural Language Processing was the tool chosen for analyzing the data collected. A script that identifies the important concepts (words) of each sentence in the interviews allowed us to identified 139 total research objectives across the 24 engagements. The number of objectives for each research center identified can be seen in Figure 2. It is important to note that the numbers disparity is a reflection of the nature (sometimes unique, such as in test organizations) of the organization as well as whether or not they need to or are already covering the research topic.

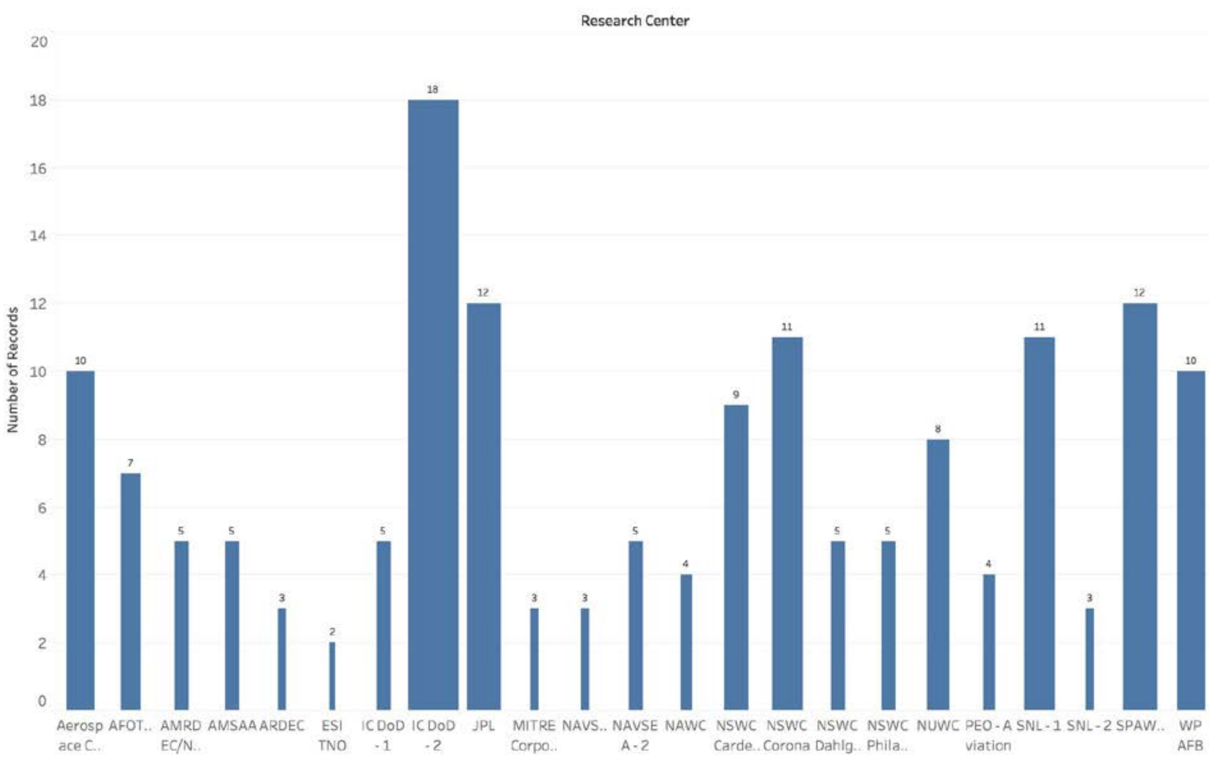


Figure 2. Snapshot of Data Collected across the various Engagements

Thereafter a secondary script was developed to order the objectives identified based on their similarity, creating clusters of closely related objectives. After this automated identification of clusters, we manually identified whether the clusters did identify human interpretable concepts and found clear patterns in the results. The objectives were then divided into 4 main groups of research objectives, and these 4 groups were then sub-divided into lower level objectives that are very closely related to each other.

The 4 primary research objectives are:

5. Knowledge, Data and Machine Learning
6. Systems Engineering MBSE, Decision Making and Integration.
7. Management, Culture and Agility
8. Security, Trust, Risk and Testing

The distribution of the research objectives identified in this study across the 4 primary clusters/groups can be seen in Figure 3.

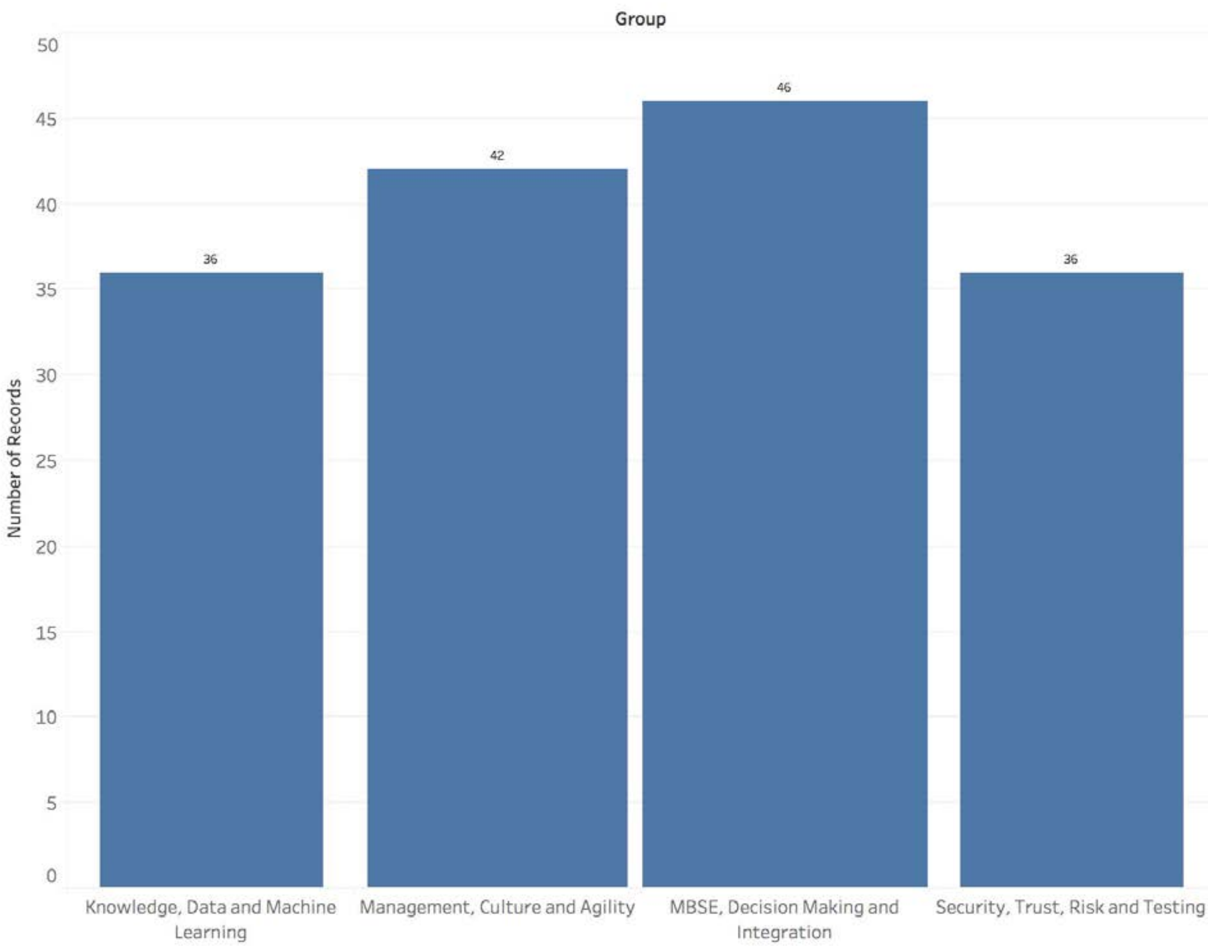


Figure 3. Distribution of Research Objectives across the 4 Primary Clusters

The types of research objectives that these groups were divided in are described in the sections that correspond to each group. An important part of the data is that the interest of the research centers varies significantly between groups of research objectives. The only research center that approached a uniform distribution of interests was Aerospace Corp, while other research centers such as AFOTEC and ESI TNO had only interests in one or two of the groups. The distribution of interests of the across the engagement sources is shown in Figure 4.

Thereafter, the following sections show the distribution of identified research interests and research centers in each of the four groups. First, each section presents the objectives organized in the identified cluster. Afterwards for each section the following things are presented:

- A first bar or pie chart describing the amount of research interests that each research center has in that group.
- A packed bubble chart describing the amount of research interests in each research type (the sub clusters that each research group is contained). This chart also describes the amount of research interests that each research center identified in each type.
- A tree-map analyzing the patterns of the interests and the related distribution among the research centers.

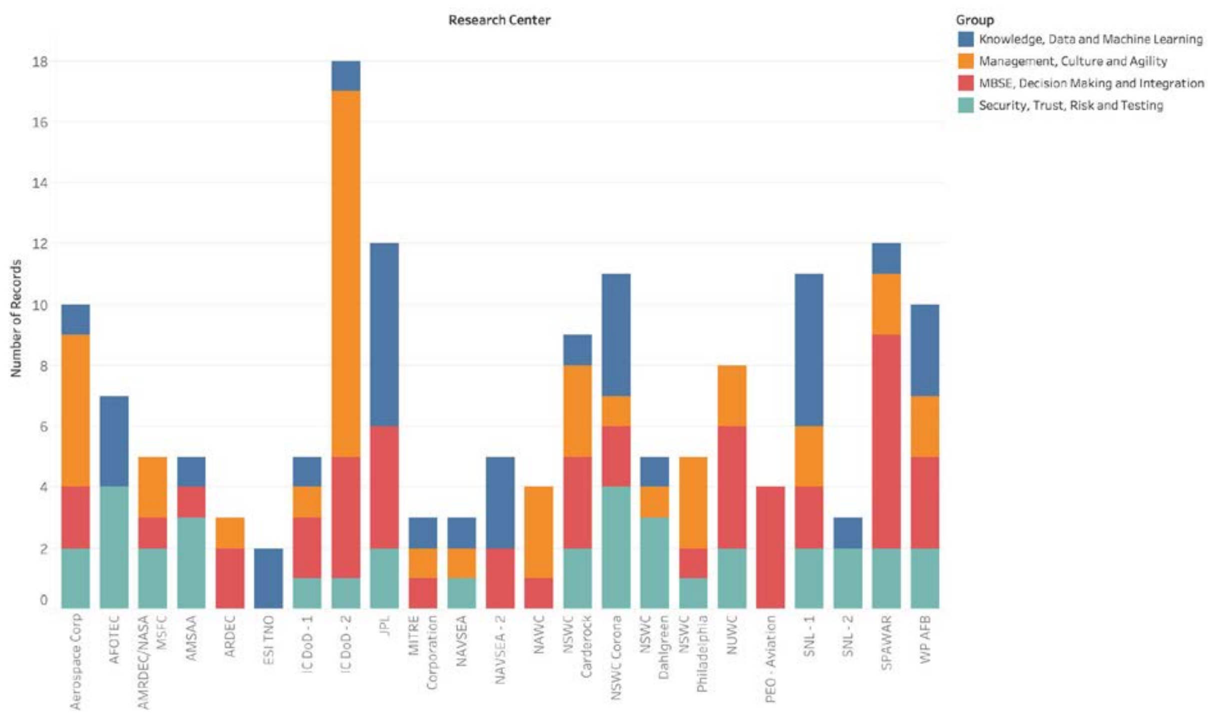


Figure 4. Distribution of Research Interests across the Data Sources

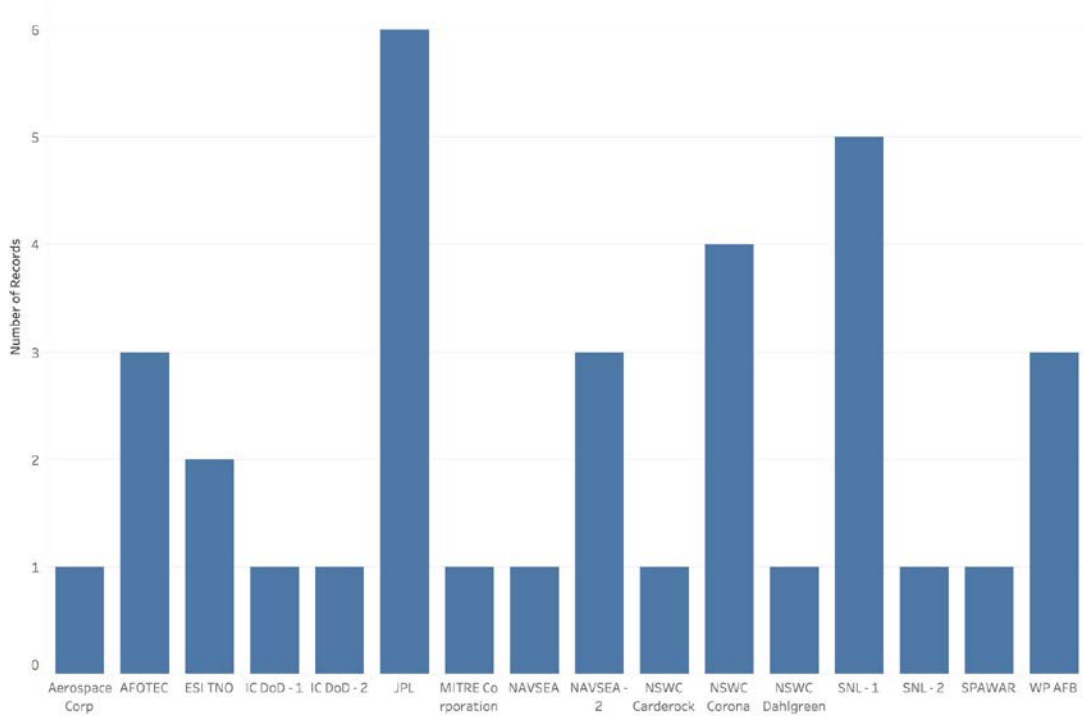
CLUSTER 1: KNOWLEDGE, DATA AND MACHINE LEARNING

The first cluster identified was called *Knowledge, Data and Machine Learning.* It contains all the identified research interests that are data centric, either dealing with the management and complexity of the data or the application of data manipulation techniques such as *AI/Machine Learning* and *Data Analytics.* The primary sub-categories in this cluster area include the following:

- AI/Machine Learning
- Data Analytics
- Data/Complexity
- Knowledge Management and Document/Requirements

The two centers with the biggest amount of discussed research interests in this area were Sandia National Laboratory and JPL. Particularly important patterns identified include:

- JPL discussed the widest interest in knowledge, document and requirement management. They showed a significant interest in concepts such as language regularization and ambiguity minimization.
- The other types of research projects had a very diverse and uniform distribution of research centers interested, showing the prevalence of data size, availability and complexity issues that have arisen. This is perfectly coherent with the big surge of the interest in the (arguably) buzzword *big data,* which mainly deals with the massive amounts of information being produced.
- The *Data/Complexity* type of research interest was of greatest interest among all the types of research types in all the research groups, once again reinforcing the importance of dealing with big amounts of data and showing this as one of the main areas of research identified in the set of interviews.
- Even though smaller in the amount of research objectives contained, if we combine *AI/Machine Learning* and *Data Analytics*, which are disciplines with a big intersection, they also represent an important area of research identified. AFOTEC (test focus organization) was the main research center interested, but overall these research areas had a big uniformity and number of research centers with interests in them.
- The overall uniformity in the distribution of the research types *Data/Complexity, AI/Machine Learning* and *Data Analytics* show that projects in these areas have a very big potential of collaborating and/or impacting multiple research centers at the same time.



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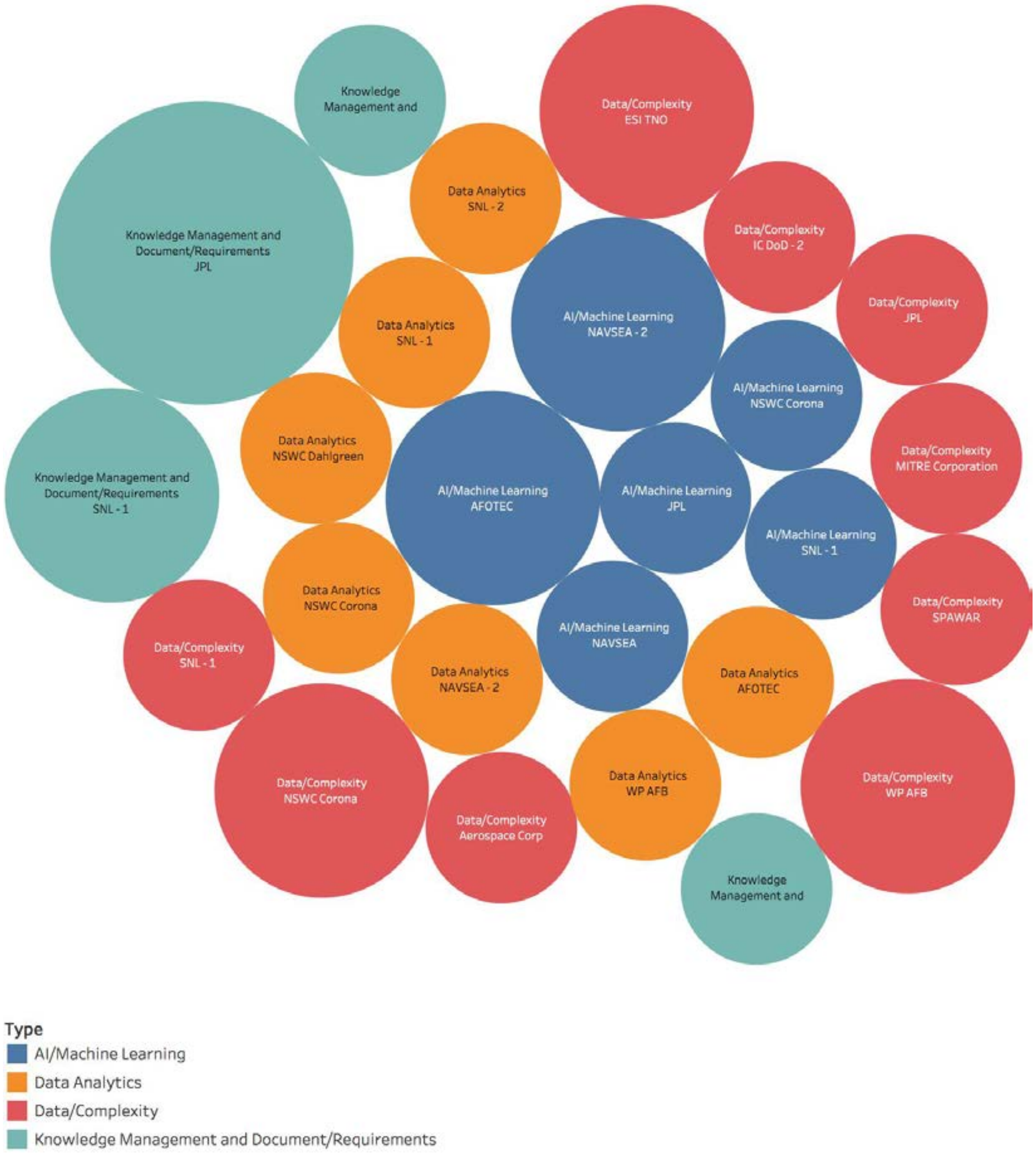
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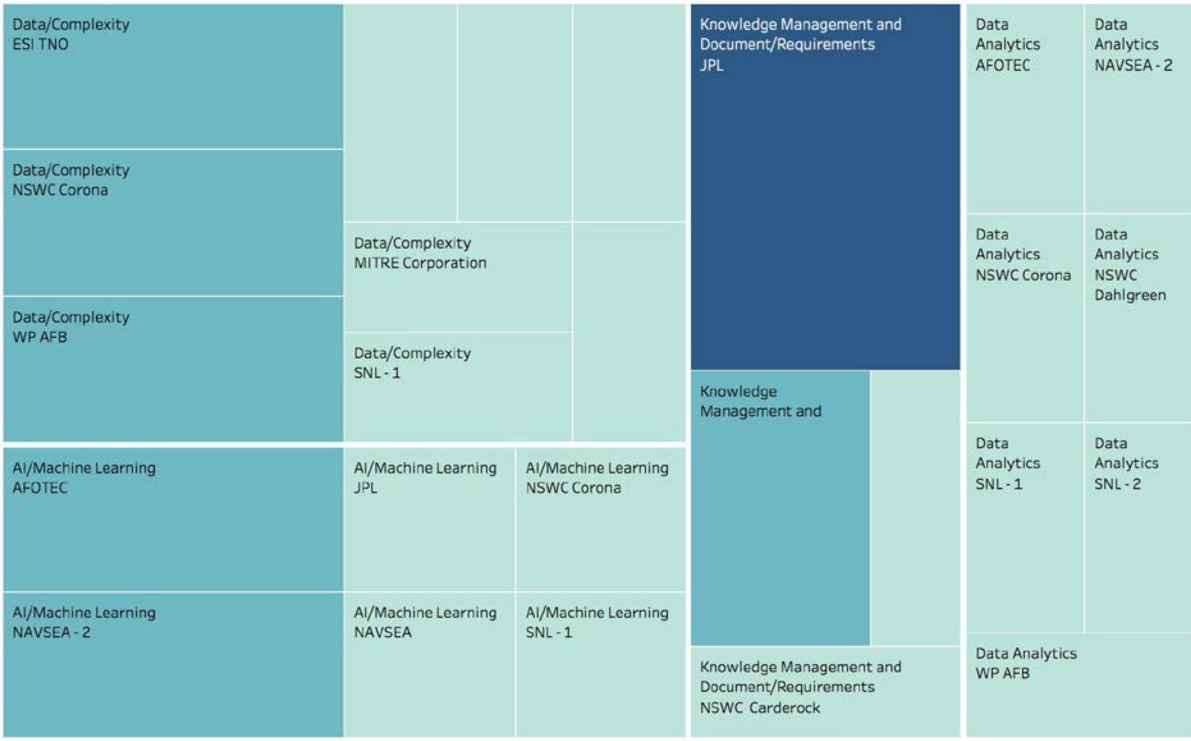


CLUSTER 2: MBSE, DECISION MAKING AND INTEGRATION

The second cluster of research interest identified was identified as *Systems Engineering: MBSE, Decision Making and Integration.* Most research topics identified came from SPAWAR and DoD IC. Even though these were clearly the leading centers for number of identified research interests, there was still a big number of other research centers and uniformity in this cluster. The primary sub-categories in this cluster include:

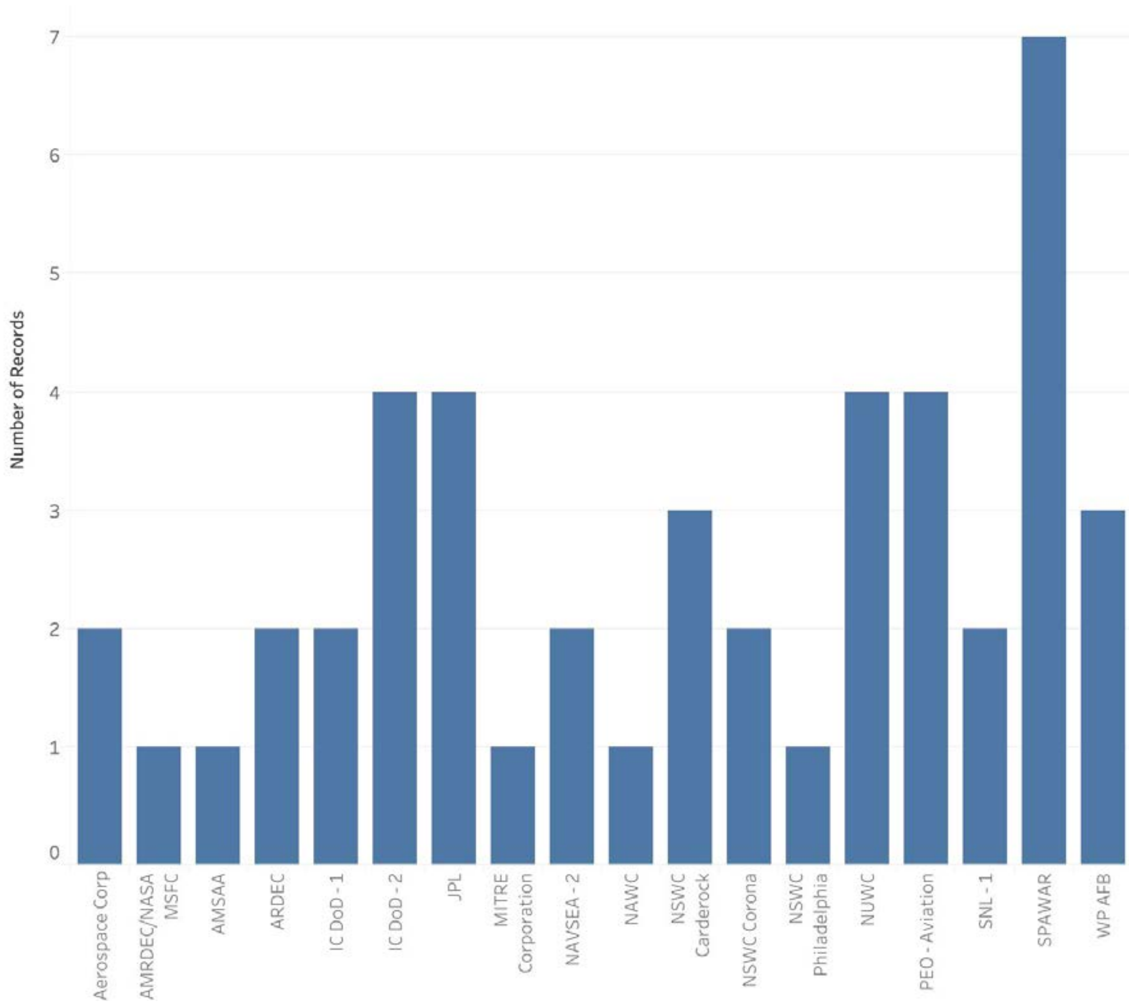
- Computational Applications in SE
- Decision Making
- Model Based SE
- System Integration
- Systems Engineering Modeling and Measurement

Particularly important patterns identified include:

- *System Integration* was the type of research that had the biggest amount of research interests in it. IC DoD, SPAWAR and Aerospace Corp were the research centers that identified the most interested in it, but overall it contained a big number of research centers with interest in it. Particularly notable is that, even though this type of research is identified in this second cluster of interest related to *Systems Engineering*, it arguably is closely related to the research type of *Data/Complexity* in the first cluster (*Knowledge, Data and Machine Learning).* This is coherent with the analysis presented in that section, since it is not hard to argue that at least theoretically an increase in *Data/Complexity* would have a positive feedback loop with an interest in

System Integration type of research.

- *Model Based SE* was one of the main identified interests of NUWC, being responsible of a considerable percentage of the research interests in this area. Some of the research interests contained in it were closely related with other areas, including concepts such as *model testing* and *model verification.*
- There was a big interest in the area of general *Systems Engineering Modeling and Measure*, which includes overall quantification and effectiveness measures of *Systems Engineering* concepts. The center with the highest discussed interest in this area was SPAWAR.
- There is a wide interest in research on Verification and Validation. NUWC Newport mentioned model validation in general and MBSE validation in particular. NSWC Corona asked for help with model verification in the presence of small data sets, and AMSAA asked about better understanding of V&V and accreditation of models and analysis tools. JPL mentioned V&V for learning systems, Sandia brought up V&V for additive manufacturing, and AMRDEC emphasized the issue of validation within systems engineering in general.
- One interesting area identified was the *Applications of Computer Science Concepts.* Even though small, the research interests identified represented a different combination of disciplines than most of the research interests identified. Discussed mainly by IC DoD, it consisted of trying to apply *Computer Science* concepts and disciplines to *Systems Engineering.*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NSWC Corona
NSWC Philadelphia
NUWC
PEO - Aviation
SNL - 1
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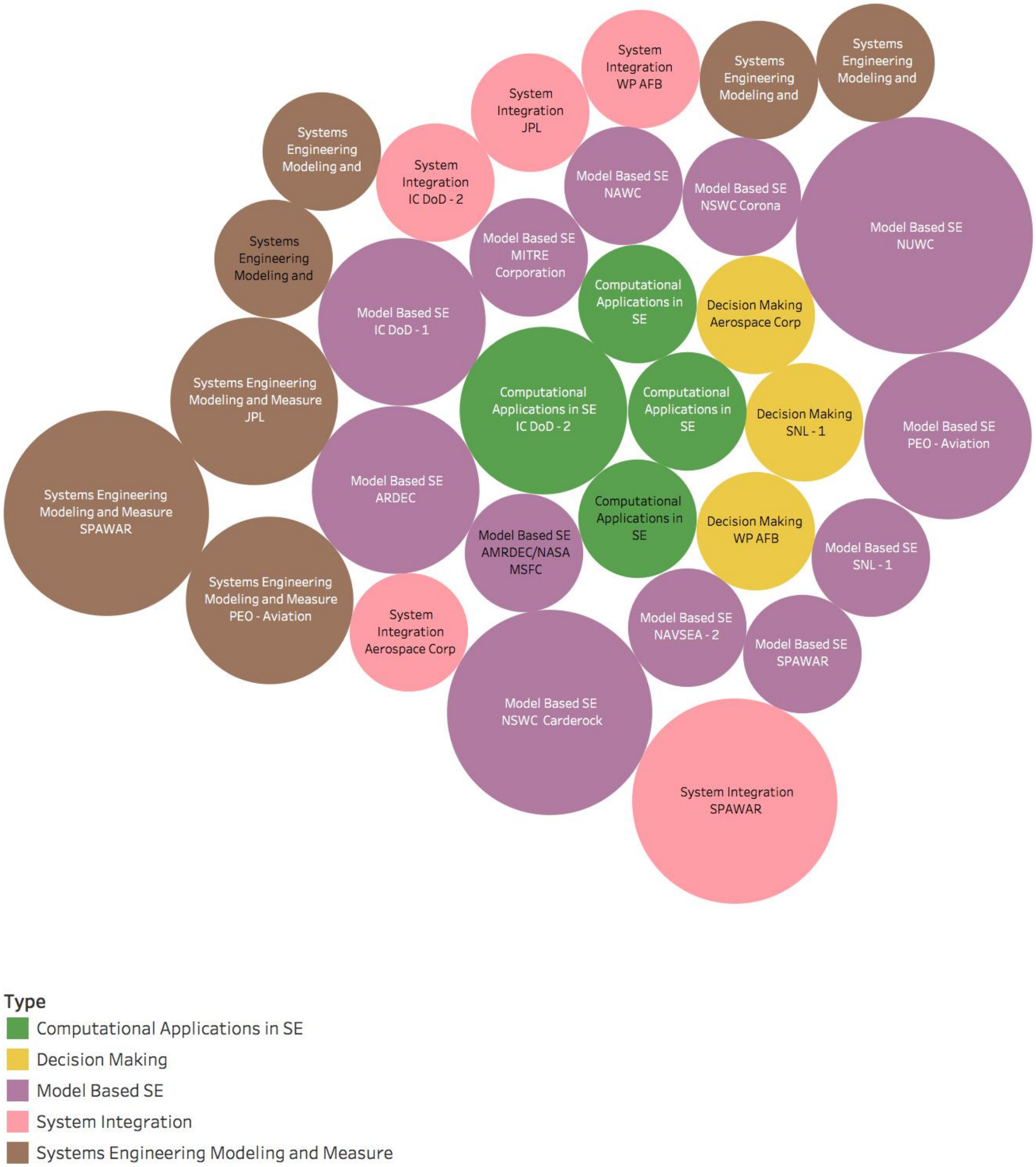
WP AFB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Computational Applications in SE
Decision Making Aerospace Corp
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Systems Engineering Modeling and Measure JPL
Computational Applications in SE IC DoD - 2
Computational Applications in SE
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Model Based SE PEO - Aviation
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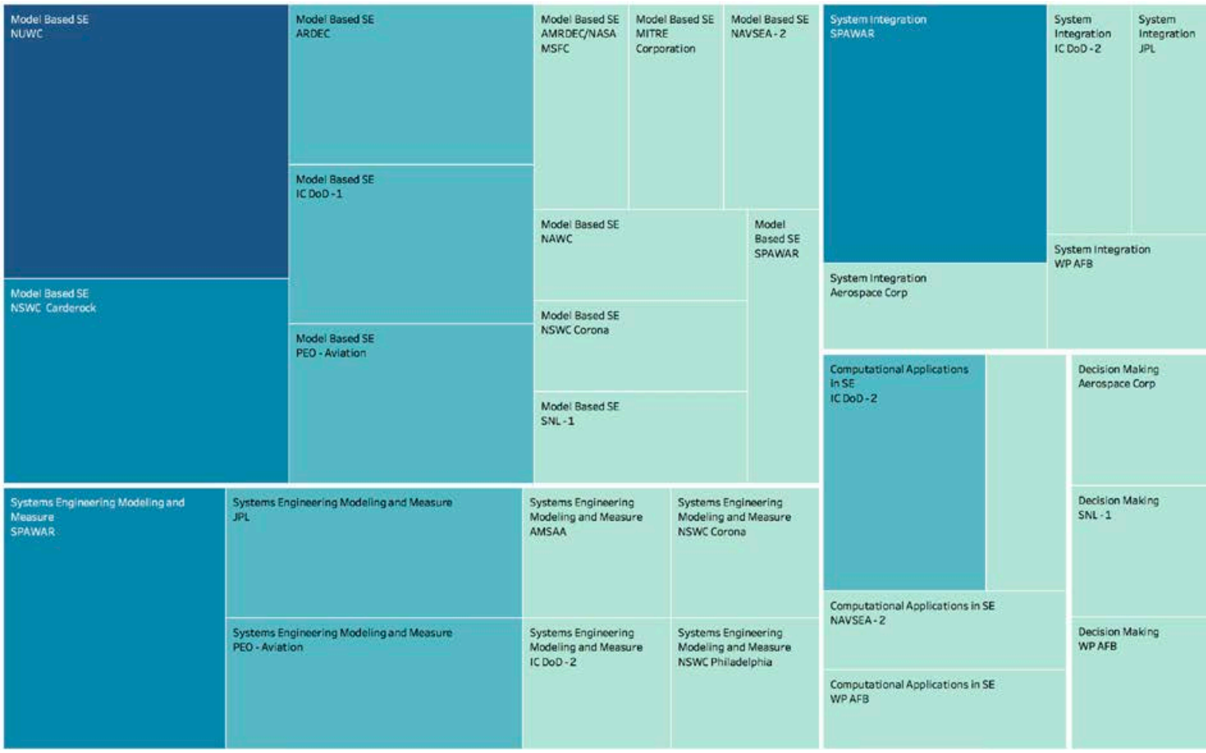


CLUSTER 3: MISSION ENGINEERING AND AGILITY

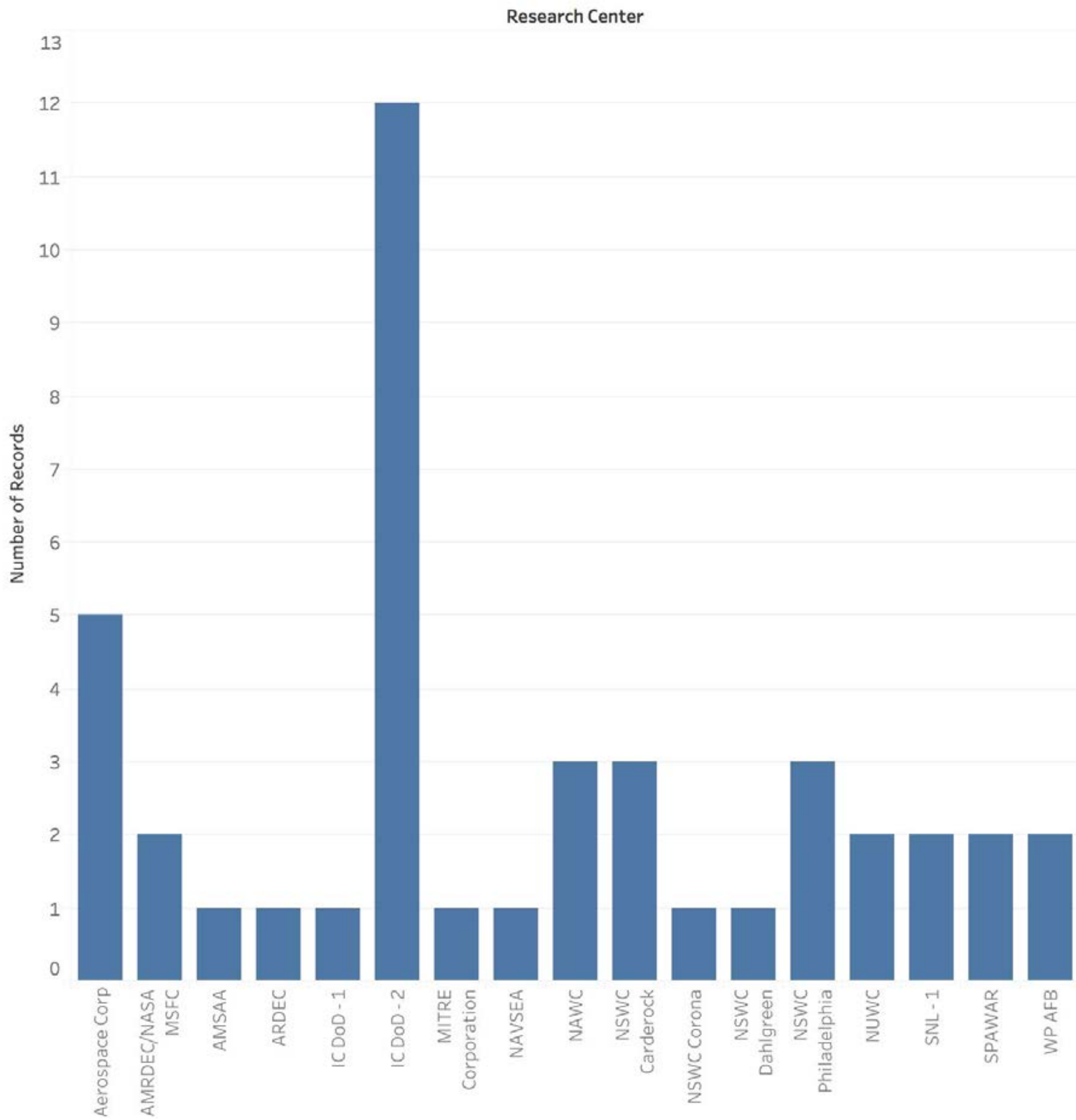
The third cluster of research interests identified was called *Mission Engineering and Agility*. Not only is this research cluster different in its nature that the others, it is also significantly different in its distribution:

- Unlike all the other clusters, one research center identified the greater amount of research interests identified in this cluster: DoD IC. Combining the interests in both of its engagements, DoD IC is source for over identification of half of the research interests in this cluster.

Overall the "dominance" of one research center makes this cluster of research interests significantly different than the others, and is a clear consequence of the focus of IC DoD of dealing with training Systems Engineers. Overall, pursuing a research interest in this area would be highly conductive with collaboration and/or impact with IC DoD mainly, with some secondary research centers like Aerospace Corp.

The primary sub-categories in this cluster include:

- Mission Engineering
- Agile Engineering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IC DoD - 1
IC DoD - 2
MITRE Corporation
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NSWC Philadelphia
NUWC
SNL - 1
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Agile Engineering SPAWAR
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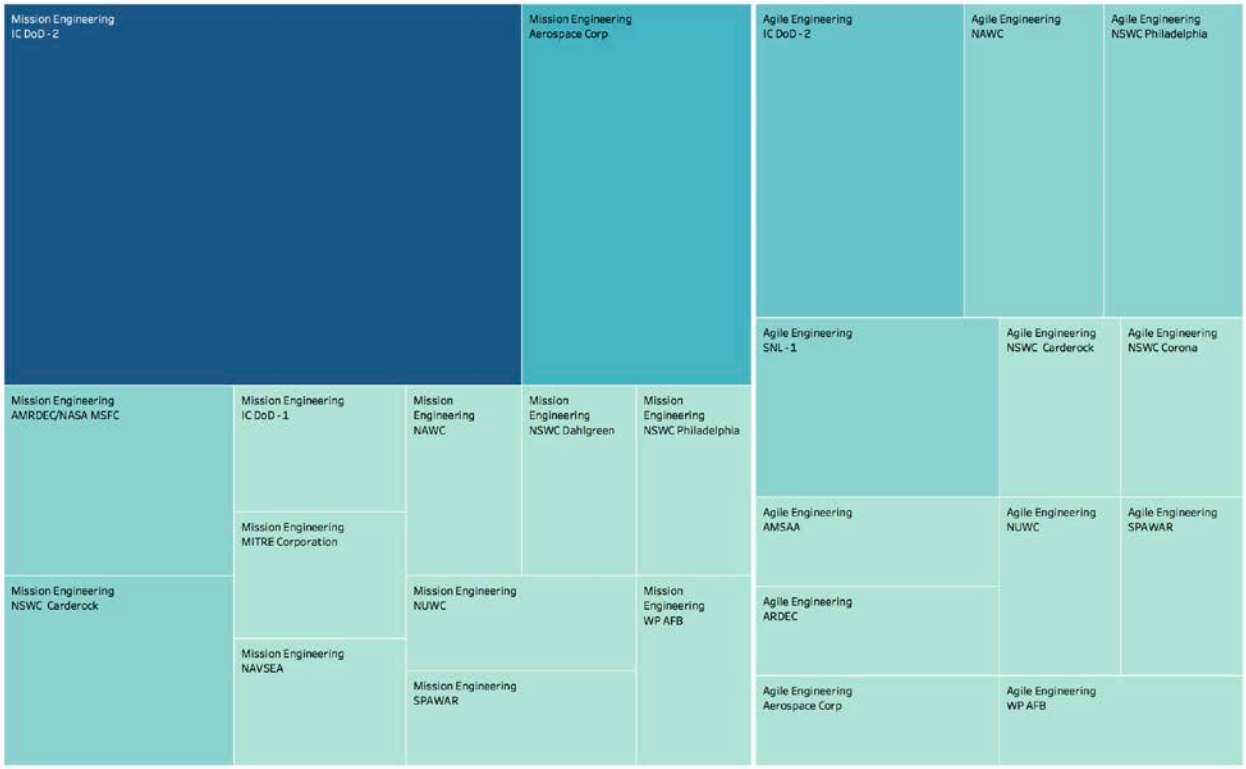
Mission Engineering



CLUSTER 4: SECURITY, TRUST, RISK AND TESTING

The last research interest cluster identified was called *Security, Trust, Risk and Testing.* Given its nature it is related in a considerable manner to the second cluster, though given the clear distinction and amount of research interests it was deemed appropriate to create the fourth cluster separated from the second one.

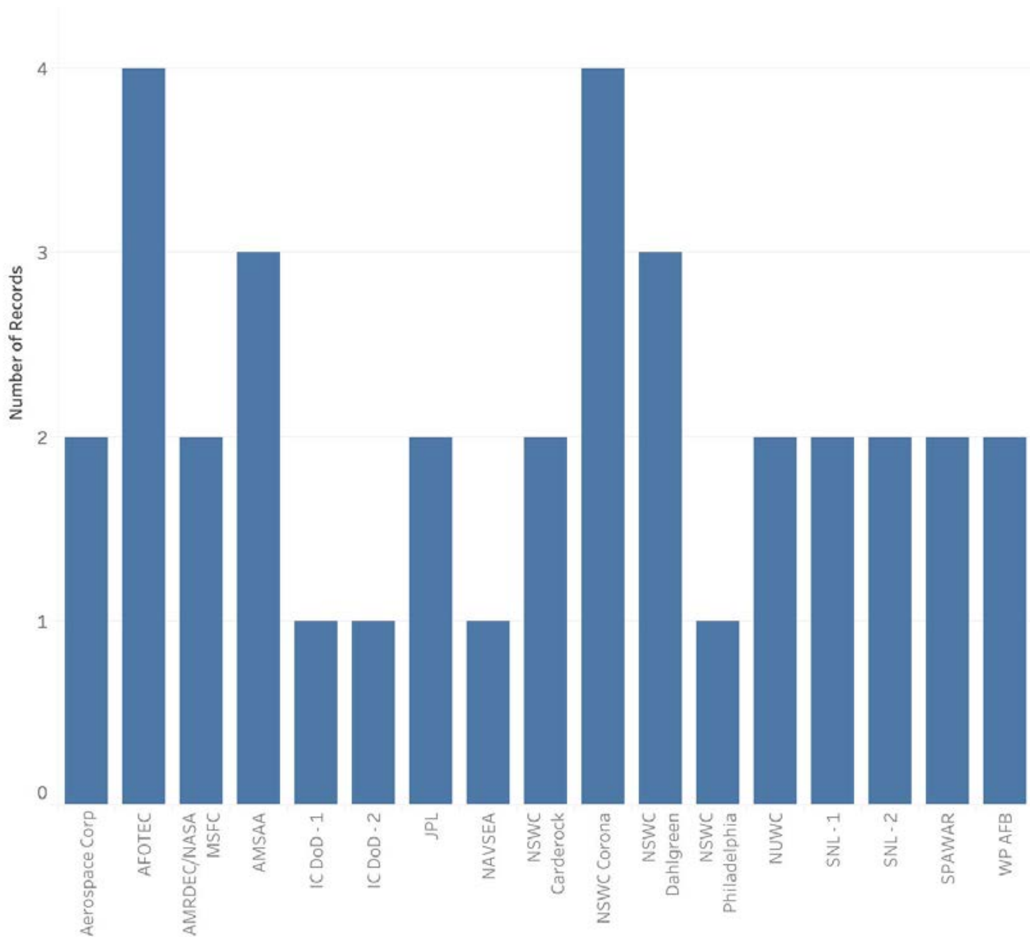
This research cluster had no single research center as the most interested in it, but had a high uniformity in the distribution of research centers interested. The primary sub-categories in this cluster include:

- Cyber-security
- Risk and Uncertainty
- Security, Reliability and Resilience
- System Trust
- System Testing

Particularly important patterns identified include:

- *System Trust* was the biggest research type identified, with almost 40% of the research interests in the cluster. This type of research contained interest of a large number of research centers, which mainly dealt with the difficulty of achieving concepts such as: *system trust, source of truth, system definition* and *validation.* It is very closely related to the *Risk and Uncertainty* and the *Security, Reliability and Resilience* types of research, and if those three are counted together they represent over 66% of the interests in this cluster, with 11 research centers interested in this areas.

- The *Testing* area was a big priority for AFOTEC (as would be expected), with this research center accounting for all minus one of the research interests in this group.
- Cyber security was mainly identified interests of NSWC Corona, with NAVSEA and NSWC Dahlgren also expressing explicit interest in this type of research. it could be an area that rises as sub interests of some of the *System Security* interests in *System Trust*, so it could be deceptively small. Overall there was a big number of research centers interested in this area, similar to the first cluster projects in this areas have a very big potential of collaborating and/or impacting multiple research centers at the same time.



Security, Reliability and Resilience WP AFB
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Security, Reliability and Resilience
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Risk and Uncertainty JPL
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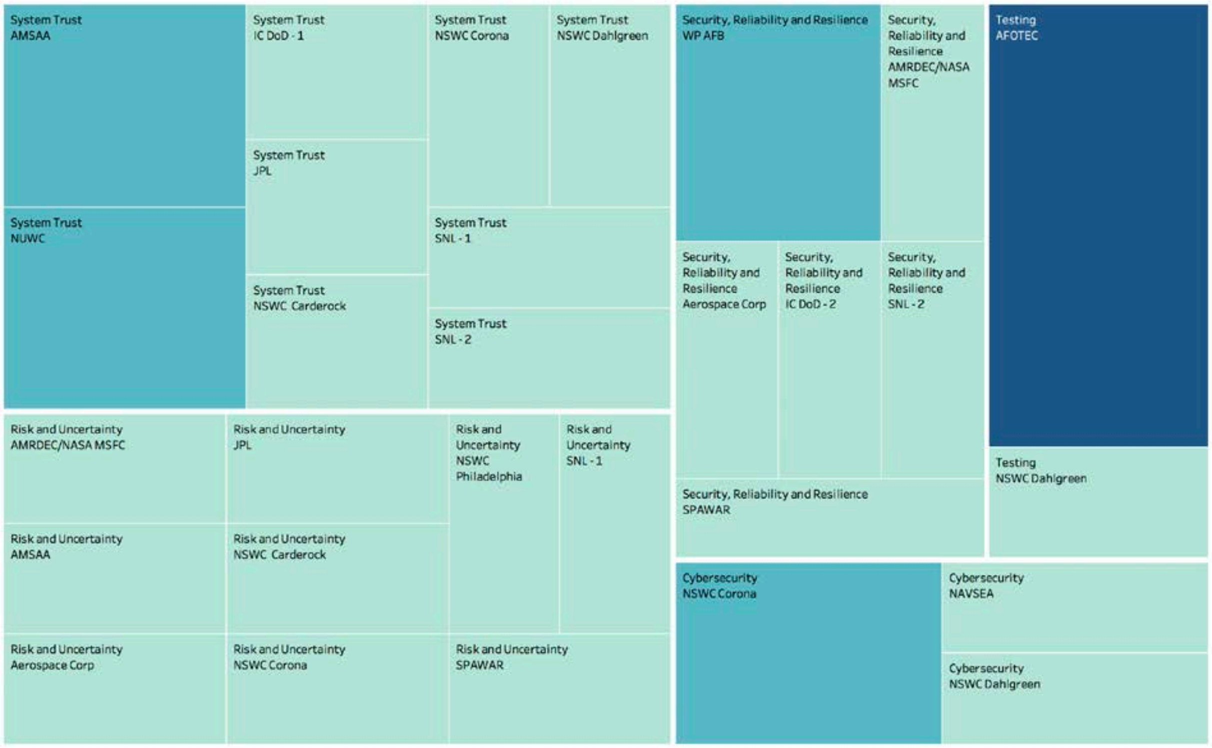


WORKFORCE ISSUES

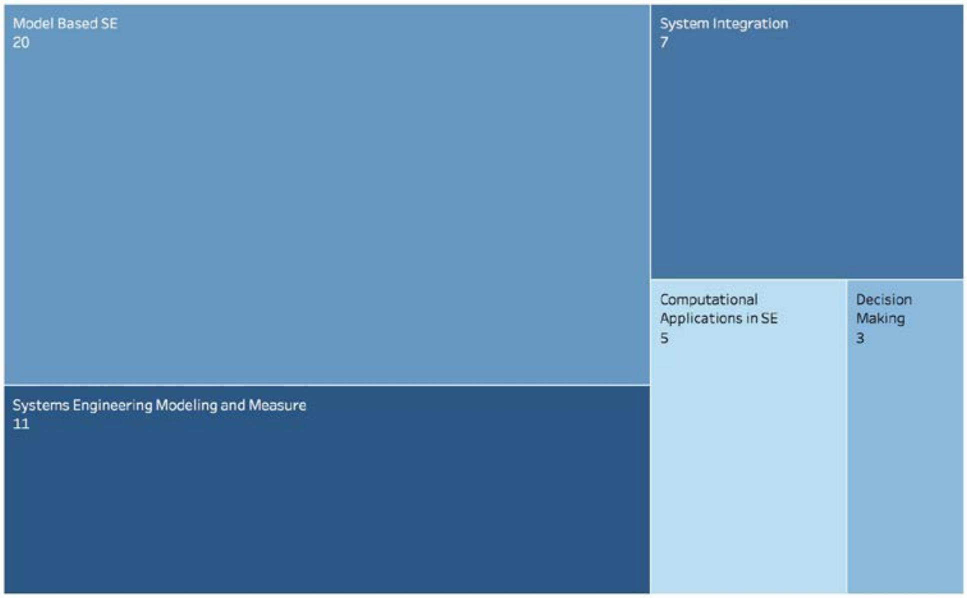
Workforce issues were discussed explicitly in most of the 24 engagements. Some of the significant concerns included the following:

- It is often hard to compete against industry for talent, particularly IT/Software developers.
- In the current environment of competition for cybersecurity talent, some organizations are falling back on training to develop cybersecurity expertise, as opposed to hiring experts. There is a perceived need for DoD coursework to support this strategy. This need was mentioned by NSWC Dahlgren and NUWC Newport.
- Upcoming retirement of a significant portion of the workforce and the commensurate loss of domain knowledge and experience. This notion of loss of domain knowledge was brought up during almost all our engagements.
- Lack of trust among major organizations, particularly between acquisition and contractors, inhibits capability.
- Concern about transitioning to digital engineering due to a lack of talent and capability at all levels of seniority.
- Concern about skills relating to software and systems engineering and architecting; system security; analytics and machine learning. This is particularly true when hiring individuals who have the ability to go through the clearance process.

The topic of replacement of lost expertise due to retirement or other attrition led to some discussion pertaining to mentoring needs and enhanced training of the entry level workforce.

Survey Results: INCOSE Fellows

This section reflects the input received from the survey of the INCOSE Fellows, worldwide.

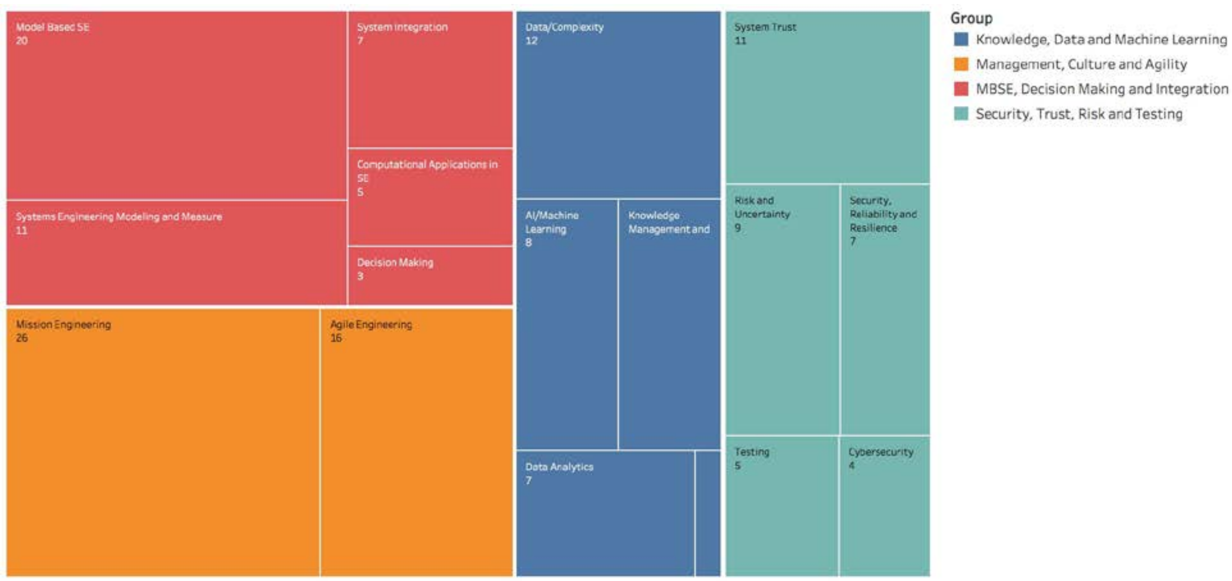


The general Systems Engineering Modeling and Measures along with research priorities in Model Based SE were by far the most common ones for the fellows, occupying 75% of the interests of Systems Engineering.

CONCLUSION

This project has provided a strong demand signal with regard to the research priorities in the DoD ecosystem, from the perspective of technical leaders. The five broad areas of research emphasis, based on the data collected area:

1. Multiple topics relating to Mission Engineering
2. Multiple topics relating to Agile Development and Engineering at the Scale of the Enterprise
3. Model Based Systems Engineering
4. Modeling and assessing System Trust, Security, and Resilience
5. Development of Pragmatic Methods to deal with and to leverage increasing Complexity and Analytics, and leveraging machine learning for this purpose.



APPENDIX A: EXAMPLE VISIT REQUEST AND THE ATTACHED TERMS OF REFERENCE

Name and Title
Organization
Address 1
Address 2

Subject: Systems Engineering Research Needs and Workforce Development Study

Dear XYZ:

The DASD, Systems Engineering, within the Office of the Secretary of Defense has created and funded a University Affiliated Research Center (UARC) to focus on systems engineering: the Systems Engineering Research Center (SERC). It is critical to supplement SERC research priorities with input from technical leaders at the various warfare centers within the Army, Navy, Air Force, and Marine Corps, given the SERC charter to conduct research leading to improved methods, tools, and processes to improve the practice of systems engineering on complex, complicated programs within the Department of Defense. This research task is focused on understanding the current state of engineering practice and the potential gaps that should be addressed by research.

This study will systemically address the following questions:

1. How do you apply systems engineering to complex programs? How do you address system and program resiliency and flexibility? What is the role of SE in analyzing needs and war-fighting capabilities, simulations/gaming, concept analyses, forming of CONOPS, program formulation and execution, test and integration, sustainment and capability evolution, and training?
2. What is your organizational policy on systems engineering? How do you assess program and system quality attributes? Are your workforce needs being met? Can you share with us your current state of practice with regard to engineering tools and environments?
3. From your point of view, what are the shortfalls, and key engineering and systems engineering challenges that should be addressed through focused research, leading to the development of new enabling methods, tools, and capabilities?

Our approach to these discussions will be very broad based to understand all engineering, technology, and workforce related matters of concern to the technical leaders at visited centers. Focus will be on support of the warfighter, particularly through rapid delivery of effective technology.

We would like to have several members, potentially including Ms. Baldwin (DASD (SE) – Acting), of our study group visit NAVSEA sometime during the week of October 16, subject to personnel availability.

During our visit we would like to be briefed on the overall NAVSEA mission, along with your current capabilities in engineering and systems engineering as discussed above. As part of this briefing, we would welcome your thoughts on engineering and systems engineering capability gaps that should be addressed via research, together with your thoughts on the development of the engineering workforce today and into the future. We would be able to provide you with a briefing on the Systems Engineering Research Center and its current research portfolio. Please suggest potential dates for our visit and provide a draft agenda at your earliest convenience. Supporting descriptive material that you might choose to provide in advance would be helpful.

Thank you for your assistance in this important endeavor. We look forward to our visit and to learning about the comprehensive range of NAVSEA activities.

Sincerely,

Dinesh Verma, Ph.D.
Executive Director, SERC

Copy:
Ms. Kristen Baldwin, DASD (Systems Engineering), Acting
Mr. Scott Lucero, Deputy Director, Strategic Initiatives, ODASD (Systems Engineering)

Attachment:
Systems Engineering Research Needs and Workforce Development Assessment Study TOR

Terms of Reference: Systems Engineering Research Needs and Workforce Development Assessment Study (SERC RT-174)

Background

The DoD makes a significant investment in research intended to improve systems engineering. The direction for this research is determined by responsible OSD personnel advised by an executive advisory board government experts, as well as industry experts, and active systems engineering researchers. This approach has been productive, but to develop a research agenda that directly addresses critical future warfighter needs, systems engineering shortfalls and opportunities and also future engineering workforce needs, research priorities must be understood from the point of view of DoD's laboratories and engineering centers.

Context and Rationale

The DASD for Systems Engineering, within the Office of the Secretary of Defense, has created and funded a University Affiliated Research Center (UARC) to focus on systems engineering research: the Systems Engineering Research Center (SERC). It is critical to supplement SERC research priorities with input from technical leaders at the various warfare centers within the Army, Navy, Air Force, and Marine Corps, given the SERC charter to conduct research leading to improved methods, tools, and processes to improve engineering on complex and complicated programs in the Department of Defense. This research task will be focused on reducing the air gap between such programs and the research being conducted by the faculty at the various SERC collaborator universities. The objective of this study will be to understand the specific systems engineering research and workforce needs at the various warfare centers, and to identify the common themes that extend across different DoD organizations.

Approach and Objectives

In close coordination with the DASD (SE), the research team will schedule visits to the various Army, Navy, Air Force, and Marine Corps warfare centers. They will also plan visits to MDA and selected IC organizations. Illustrative centers include:

- NSWC, NUWC and NAVAIR – Various divisions
- SPAWAR
- SMC
- Army RDECs
- Army COE ERDC
- Army TRADOC, especially ARCIC
- AF SMC, ACC, and AFLCMC
- AFRL, NRL, ARL
- Representative PEOs
- Joint organizations such as MDA and USSOCOM
- Relevant FFRDCs and UARCs

The approach to these discussions will be broad-based to understand all engineering, technology, and workforce related matters of concern to the technical leaders at these centers. Focus will be on support of the warfighter, particularly through rapid delivery of effective technology.

Each visit will be memorialized with a visit report and white paper outlining the attendees, the agenda, any tours or lab visits, and key takeaways from the discussions regarding the pain points with regard to workforce related matters, research and development related matters, and related risks.

The various visit reports and white papers will then be consolidated into a final report and an executive presentation, identifying SE shortfalls and opportunities for research across the DoD engineering and warfare centers. The research patterns identified in this task will help guide systems engineering research priorities over the next two to five years and increase the return on investment of future SERC research tasks.

Deliverables

A008 Status report (bi-monthly)

A009 Technical and Management Work-plan (due at the start of the project)

A013 Final Technical Report (due at the completion date)

Stakeholders, Roles and Responsibilities, and the Format of the Study

The study will be conducted by the Core Study Team, with guidance and review by the Study Steering Team. Team members are delineated in Table 1.

Table 1: Study Team

Core Study Team:	*Dr. Dinesh Verma*, SERC (Stevens Institute of Technology) – Chair of the Core Study Team *Dr. Paul Collopy,* SERC (University of Alabama – Huntsville) *Dr. Spiros Pallas,* SERC (Stevens Institute of Technology)
Study Steering Team:	*Ms. Kristen Baldwin*, DASD (Systems Engineering), Acting *Mr. D. Scott Lucero,* Deputy Director, Strategic Initiatives, ODASD (Systems Engineering)

APPENDIX B: LISTING OF ALL RESEARCH INTERESTS FROM ENGAGEMENT MINUTES

Research Objective	Type	Group	Research Center
Knowledge Management	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	JPL
capture institutional knowledge	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	SNL - 1
paper based process, need consistent in information continuity and consistency.	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	SNL - 1
rigorous basis to underpin the information flows to prevent ambiguity and imprecision	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	JPL
System requirements do not address integrating one system with another.	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	Aerospace Corp
get knowledge driven operations	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	IC DoD - 1
Requirements today are written at the system or subsystem level, not at the mission level.	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	NUWC
Language Regularization	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	JPL
remove ambiguity from requirements specifications	Knowledge Management and Document/Requirements	Knowledge, Data and Machine Learning	JPL
good systems engineering in environments where everything is continually changing	Data/Complexity	Knowledge, Data and Machine Learning	Aerospace Corp
System Security at Scale	Data/Complexity	Knowledge, Data and Machine Learning	SNL - 2

What performance assessment data should be collected from autonomous systems	Data/Complexity	Knowledge, Data and Machine Learning	NSWC Corona
enhance the fidelity of condition based maintenance data	Data/Complexity	Knowledge, Data and Machine Learning	NSWC Corona
vast amounts of field data,	Data/Complexity	Knowledge, Data and Machine Learning	AMSAA
valuate the air worthiness of an increasingly more complex aviation/weapon system	Data/Complexity	Knowledge, Data and Machine Learning	WP AFB
Managing Complexity:	Data/Complexity	Knowledge, Data and Machine Learning	SNL - 1
measure system complexity (with an emphasis on software)	Data/Complexity	Knowledge, Data and Machine Learning	WP AFB
Agility at Scale	Data/Complexity	Knowledge, Data and Machine Learning	SNL - 1
Scalability	Data/Complexity	Knowledge, Data and Machine Learning	ESI TNO
Performance Assessment is challenged by the volume of data	Data/Complexity	Knowledge, Data and Machine Learning	NSWC Corona
Requirements are getting out of hand	Data/Complexity	Knowledge, Data and Machine Learning	JPL
everybody has a phone and data – complexity of the enterprise is unique	Data/Complexity	Knowledge, Data and Machine Learning	IC DoD - 2
Key drivers that will cause (embedded) sytem complexity to further increase	Data/Complexity	Knowledge, Data and Machine Learning	ESI TNO

Mission analysis and engineering for complex systems and SoS	Data/Complexity	Knowledge, Data and Machine Learning	NSWC Dahlgreen
Autonomous Topological Predictor-Corrector Learning	AI/Machine Learning	Knowledge, Data and Machine Learning	AFOTEC
Artificial intelligence	AI/Machine Learning	Knowledge, Data and Machine Learning	JPL
Machine Learning to focus on colleting and creating test metrics;	AI/Machine Learning	Knowledge, Data and Machine Learning	AFOTEC
AI to support Design:	AI/Machine Learning	Knowledge, Data and Machine Learning	SNL - 1
need for data analytics for digital twins	Data Analytics	Knowledge, Data and Machine Learning	NSWC Corona
Data analytics – infrastructure learning tools;	Data Analytics	Knowledge, Data and Machine Learning	AFOTEC
Data Analytics and Support of Man-Machine Teaming	Data Analytics	Knowledge, Data and Machine Learning	SNL - 2
Data Analytics	Data Analytics	Knowledge, Data and Machine Learning	SNL - 1
Data Analytics	Data Analytics	Knowledge, Data and Machine Learning	NSWC Dahlgreen
system analytics to develop the notion of a unique system specific DNA	Data Analytics	Knowledge, Data and Machine Learning	WP AFB
Increasing focus on model based testing	Model Based SE	MBSE, Decision Making and Integration	SNL - 1
model verification in the presence of small data sets	Model Based SE	MBSE, Decision Making and Integration	NSWC Corona

how to verify and validate a model (particularly MBSE)	Model Based SE	MBSE, Decision Making and Integration	NUWC
translating natural language specifications and design documents into MBSE	Model Based SE	MBSE, Decision Making and Integration	NUWC
using MBSE to find flaws in interoperability	Model Based SE	MBSE, Decision Making and Integration	NUWC
potential of Model-Based Systems Engineering (MBSE) to connect disparate models	Model Based SE	MBSE, Decision Making and Integration	NAWC
System requirements do not address integrating one system with another.	System Integration	MBSE, Decision Making and Integration	Aerospace Corp
No Overhead of successful integration, e.g., 55% of cost if its not invented here	System Integration	MBSE, Decision Making and Integration	IC DoD - 2
rigorous processes for integrating existing components into new systems.	System Integration	MBSE, Decision Making and Integration	JPL
case study conducted on modularizing a system, documenting the costs and benefits of modularity	System Integration	MBSE, Decision Making and Integration	NUWC
Certification of systems that are being used much more beyond their design life	System Integration	MBSE, Decision Making and Integration	SNL - 1
Systems engineering needs to be applied at the enterprise level, across many systems	System Integration	MBSE, Decision Making and Integration	Aerospace Corp
cost of integration at the mission thread level	System Integration	MBSE, Decision Making and Integration	IC DoD - 2
invest in interoperability among platforms and systems	System Integration	MBSE, Decision Making and Integration	NAWC
What constraints to integrate faster	System Integration	MBSE, Decision Making and Integration	IC DoD - 2
communication mechanism to convey a sense of reality as new technologies evolv	System Integration	MBSE, Decision Making and Integration	WP AFB
What is the career development path that can produce a system architect?	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	AMSAA
system framework acknowledges requirements are not well known on the front end	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	NSWC Philadelphia

Mission Engineering seems like a step too far	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	WP AFB
Quantification of anything in SE	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	JPL
effectiveness of SE be measured	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	JPL
how do you characterize the system boundary	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	IC DoD - 2
Establish rigor in systems engineering for acquisition programs	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	NSWC Corona
allocate requirements from the mission level to the system level to the sub-system level	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	NSWC Philadelphia
new set of practical and utilitarian tools greater efficiency and effectiveness	Decision Making	MBSE, Decision Making and Integration	WP AFB
developing integrated decision frameworks	Decision Making	MBSE, Decision Making and Integration	Aerospace Corp
Integrated Decision Making and Portfolio Management:	Decision Making	MBSE, Decision Making and Integration	SNL - 1
Digital Engineering – Wish there was a practical notion of a roadmap	Computer Science Concepts Applications	MBSE, Decision Making and Integration	WP AFB
Value of information theory	Computer Science Concepts Applications	MBSE, Decision Making and Integration	IC DoD - 2
Is there way to systems engineering processes to improve programmatic constraints	Computer Science Concepts Applications	MBSE, Decision Making and Integration	IC DoD - 2
challenging the concept of phases and gates – and with computational design techniques	Computer Science Concepts Applications	MBSE, Decision Making and Integration	JPL
Testing for cyber physical systems	Testing	Security, Trust, Risk and Testing	AFOTEC

UAS Testing	Testing	Security, Trust, Risk and Testing	AFOTEC
System of Systems Testing	Testing	Security, Trust, Risk and Testing	AFOTEC
Testing is too late for some system issues	Testing	Security, Trust, Risk and Testing	AFOTEC
Test optimization	Testing	Security, Trust, Risk and Testing	NSWC Dahlgreen
Integrating system security into systems engineering practices	Security, Reliability and Resilience	Security, Trust, Risk and Testing	WP AFB
measure the security and resilience of a weapon system	Security, Reliability and Resilience	Security, Trust, Risk and Testing	WP AFB
How can systems engineering be made more resilient	Security, Reliability and Resilience	Security, Trust, Risk and Testing	Aerospace Corp
Reliability much more complicated when talking about threads	Security, Reliability and Resilience	Security, Trust, Risk and Testing	IC DoD - 2
need to develop an holistic approach to cybersecurity	Cybersecurity	Security, Trust, Risk and Testing	NSWC Corona
Cyber defense includes a trusted supply chain.	Cybersecurity	Security, Trust, Risk and Testing	NSWC Corona
Integration of SE to cyber security especially for SoS	Cybersecurity	Security, Trust, Risk and Testing	NSWC Dahlgreen
Modeling embedded systems and cyber-physical system	Cybersecurity	Security, Trust, Risk and Testing	NAVSEA
need for improvement in model validation methods and approaches	System Trust	Security, Trust, Risk and Testing	NUWC
trusted systems,	System Trust	Security, Trust, Risk and Testing	JPL
How to get SoS vulnerability analysis for prioritization of critical risk	System Trust	Security, Trust, Risk and Testing	NSWC Dahlgreen
System Security at Scale	System Trust	Security, Trust, Risk and Testing	SNL - 2
System Trust:	System Trust	Security, Trust, Risk and Testing	SNL - 1
simulation capabilities that they trust as a source of truth - accepatance need	System Trust	Security, Trust, Risk and Testing	NUWC
Validation, verification and accreditation of models and analysis tools	System Trust	Security, Trust, Risk and Testing	AMSAA
System definition (reliability modeling) for complex	System Trust	Security, Trust, Risk and Testing	AMSAA
process to assess Mean Time until Out Of Tolerance	System Trust	Security, Trust, Risk and Testing	NSWC Corona
error and fault monitoring are not able to keep up with the “speed of operations	System Trust	Security, Trust, Risk and Testing	IC DoD - 1
Uncertainty quantification	Risk and Uncertainty	Security, Trust, Risk and Testing	AMSAA

integrated design frameworks: uncertainty multiple stakeholders, conflicting priorities.	Risk and Uncertainty	Security, Trust, Risk and Testing	Aerospace Corp
Risk needs to be addressed from a life cycle perspectiv	Risk and Uncertainty	Security, Trust, Risk and Testing	NSWC Corona
consider risks in a more integrated fashion	Risk and Uncertainty	Security, Trust, Risk and Testing	JPL
Movement from a policy culture to an incentive culture	Mission Engineering	Management, Culture and Agility	IC DoD - 2
tension building the optimized architecture for “my mission” versus gotta get the job done	Mission Engineering	Management, Culture and Agility	IC DoD - 2
constraints of the color of money and acquisition lead time	Mission Engineering	Management, Culture and Agility	IC DoD - 2
install enterprise architecture and systems engineering into established culture	Mission Engineering	Management, Culture and Agility	IC DoD - 2
Tension between the mission thread and owners of systems/programs.	Mission Engineering	Management, Culture and Agility	IC DoD - 2
collaborative engineering of space systems, be extended into other domains	Mission Engineering	Management, Culture and Agility	Aerospace Corp
spanning multiple languages, doctrine, and culture	Mission Engineering	Management, Culture and Agility	Aerospace Corp
How does agile benefit or apply to systems engineering?	Agile Engineering	Management, Culture and Agility	Aerospace Corp
exploring “quick ugly design approaches” to avoid closing down the design space	Agile Engineering	Management, Culture and Agility	NUWC
How to effect agile engineering re balance	Agile Engineering	Management, Culture and Agility	IC DoD - 2
capability to roll out new platforms is not so good - platforms requring decades	Development and Deployment Rapidity	Management, Culture and Agility	NAWC
Rapid deployment strategy instead ofs skipping acquisition steps	Development and Deployment Rapidity	Management, Culture and Agility	NSWC Corona
accelerating their technology development rate	Development and Deployment Rapidity	Management, Culture and Agility	NAWC
greater agility in system development at the scale of the enterprise	Development and Deployment Rapidity	Management, Culture and Agility	WP AFB

Reuse for Agility and Safety:	Development and Deployment Rapidity	Management, Culture and Agility	SNL - 1
manage the tension between programs of record on the one hand, and mission threads on the other	Project “Lego” Management	Management, Culture and Agility	NAVSEA
Being able to work threads better	Project “Lego” Management	Management, Culture and Agility	IC DoD - 2
How to manage the thread for operations	Project “Lego” Management	Management, Culture and Agility	IC DoD - 2
What are the resources required to integrate the Legos	Project “Lego” Management	Management, Culture and Agility	IC DoD - 2
multiple “lego pieces” in diverse geographical instances	Project “Lego” Management	Management, Culture and Agility	IC DoD - 1
small projects over a short duration; ability to invest in strategic matters is curtailed	Project “Lego” Management	Management, Culture and Agility	NSWC Philadelphia
cost data is overly optimistic with the “ecosystem” accepts it, causing overruns	Other	Other	NSWC Philadelphia
Customization	Other	Other	IC DoD - 1
Deployability	Other	Other	IC DoD - 1
All aspects of unmanned and autonomous systems	Other	Other	NAVSEA
install policies re admin policies	Other	Other	IC DoD - 2
policy impact: deal with unintended consequences	Other	Other	NSWC Philadelphia
Systyem Integration	System Integration	MBSE, Decision Making and Integration	SPAWAR
Model Based Systems Engineering	Model Based SE	MBSE, Decision Making and Integration	SPAWAR
Inherent Uncertainties and Lack of Continuity in Sensor Data	Risk and Uncertainty	Security, Trust, Risk and Testing	SPAWAR
Idiosyncracies of Legacy Systems	System Integration	MBSE, Decision Making and Integration	SPAWAR
Different Paths of Legacy Communications	System Integration	MBSE, Decision Making and Integration	SPAWAR

Application of SE to complex programs	Data/Complexity	Knowledge, Data and Machine Learning	SPAWAR
Top actions to take to enhance SE to better serve missions	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	SPAWAR
What is the role of SE in analysis of war fighting capabilities	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	SPAWAR
System and program resiliency and flexibility	Security, Reliability and Resilience	Security, Trust, Risk and Testing	SPAWAR
Organizational policy in Systems Engineering	Mission Engineering	Management, Culture and Agility	SPAWAR
How to assess programs and systems	Systems Engineering Modeling and Measure	MBSE, Decision Making and Integration	SPAWAR
Speed to capability and thread identifications	Agile Engineering	Management, Culture and Agility	SPAWAR
Military Hardware and Equipment	Other	Other	NAVSEA - 2
Digital Transformations	Computer Science Concepts Applications	MBSE, Decision Making and Integration	NAVSEA - 2
Data Analytics	Data Analytics	Knowledge, Data and Machine Learning	NAVSEA - 2
Unmanned Systems	Other	Other	NAVSEA - 2
Artificial intelligence	AI/Machine Learning	Knowledge, Data and Machine Learning	NAVSEA - 2
Virtual Reality	Other	Other	NAVSEA - 2
Advanced Materials	Other	Other	NAVSEA - 2
Energy Harvesting	Other	Other	NAVSEA - 2