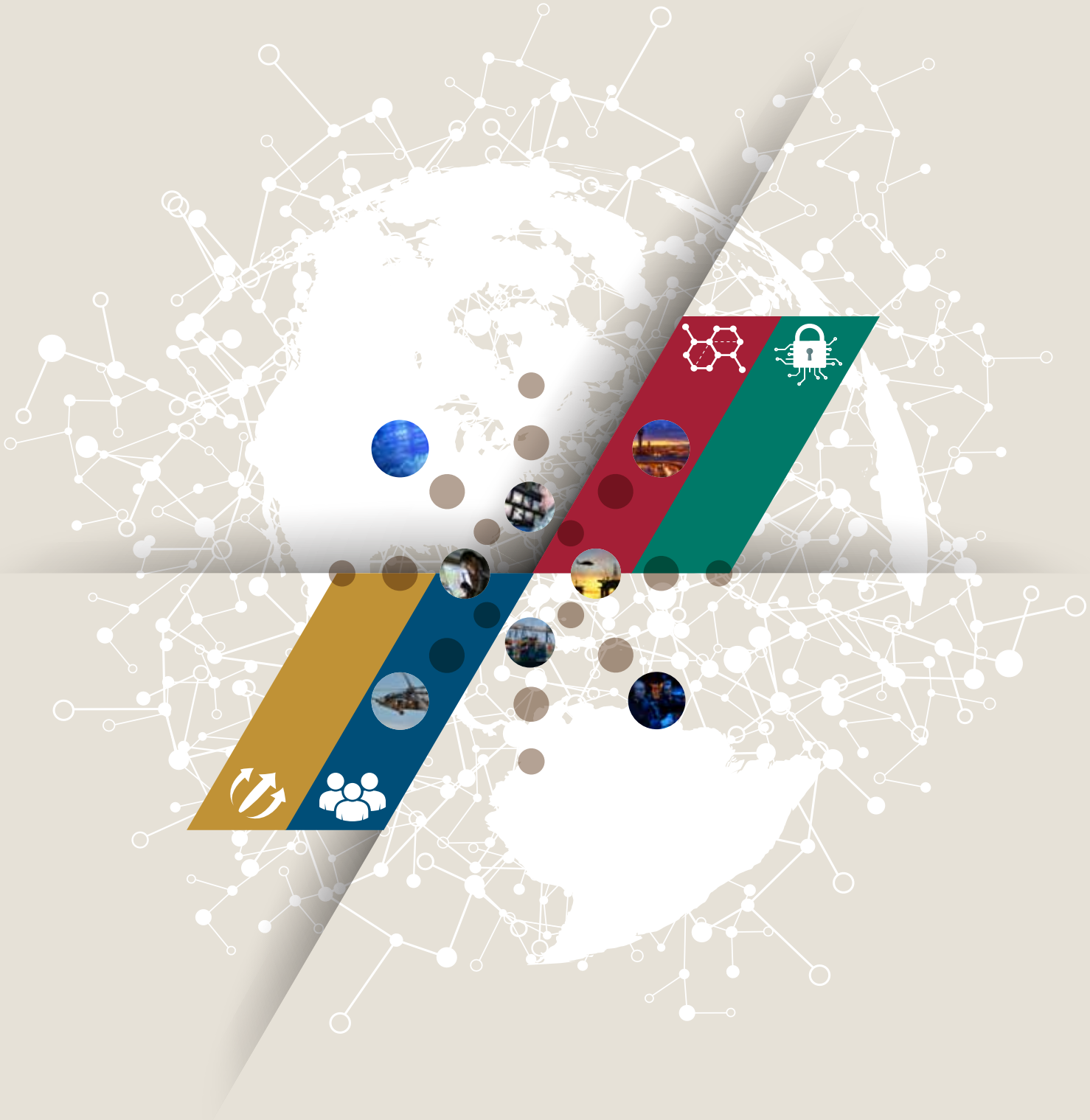
SYSTEMS ENGINEERING RESEARCH CENTER

A US DEPARTMENT OF DEFENSE
UNIVERSITY AFFILIATED RESEARCH CENTER



2017 ANNUAL REPORT

CROSSING BOUNDARIES THROUGH INTEGRATIVE COLLABORATION

2017 ANNUAL REPORT

CONTENTS

"...ARDEC's partnership with the SERC continues to grow. Our latest endeavor has the SERC collaborating with ARDEC to create an integrated Model Based Engineering (iMBE) environment that will reduce product development time. Through basic research in ontology, visualization application, and multi-objective decision analysis, the SERC's efforts have challenged our ideas, strengthened the fundamental principles of our solution, and afforded us the opportunity to partner with other Services, on a similar journey."

- **Jeff Dyer**, *Director, Systems Engineering at US Army ARDEC*

TRANSITIONING RESEARCH INTO PRACTICE – CROSSING BOUNDARIES THROUGH INTEGRATIVE COLLABORATION

GREETINGS FROM THE EXECUTIVE DIRECTOR

Commensurate with our vision to continually focus on the strengthening of the "Systems Research and Impact Network" in support of the priorities of our sponsors within the Department of Defense, it is once again my opportunity to thank members of the SERC Research Council, led by **Dr. Barry Boehm** (USC), our Principal Investigators, and our research sponsors for their unwavering support.

It gives me great pleasure to announce that with the maturing of the research being conducted within the SERC, we are going to focus on the theme of "*Transitioning Research into Practice – Crossing Boundaries through Integrative Collaboration.*" This theme is reflected in this annual report. Examples of research being transitioned into practice via a variety of pathways include:

- **Transforming Systems Enginering through Model-Centric Engineering**

  NAVAIR and ARDEC are both exploring the technical feasibility of a radical change in the way that the government could use digital models, or Model-Centric Engineering (MCE) and/or Digital Engineering (DE), to significantly reduce the time to deliver large-scale systems to the warfighter.

- **Enterprise Transformation**

  Enterprise systems are addressed in this research by the interaction of social, behavioral, and organizational factors through technical solutions that are carefully coordinated with policy and strategy that consider individual, economic, and organizational incentives.

- **Security Engineering**

  The research effort has addressed the use of engineering model-based tools for supporting decisions regarding the design of cyber attack-resilient cyber-physical systems. The issues being addressed are: 1) The design of a tool set that can effectively be used by system designers and decision-makers for identifying and prioritizing potential resiliency solutions, and 2) The scalability of the use of such tools to account for the complex System-of-System (SoS) configurations employed by DoD.

We will continue to build alliances within the National Security ecosystem with the strategic intent of enhancing research transition to practice. It is through integrative collaborations that the best research transition and implementation into practice is realized:

Catalyze community growth among SE researchers and end users by enabling collaboration among many SE research organizations.

Accelerate SE competency development through rapid transfer of its research to educators and practitioners.

Transform SE practice throughout the government by creating innovative methods, processes, and tools that address critical challenges to meet mission outcomes.

I would also like to thank **Dr. Mike Griffin** for his counsel as the Chair of the SERC Advisory Board over the past three years; and to welcome **Dr. Paul Kaminski** as the next chair of the SERC Advisory Board, effective November 10, 2017.

The SERC research network has never been more vibrant, engaged, and energized as we embark upon an update to our technical plan to robustly align with the research priorities within the National Security space in general, and the Department of Defense in particular.

Dinesh Verma, Ph.D., *Executive Director*

SYSTEMS ENGINEERING RESEARCH CENTER

YEAR IN REVIEW

REVIEW OF SERC TALKS - PAST AND FUTURE

SERC TALKS

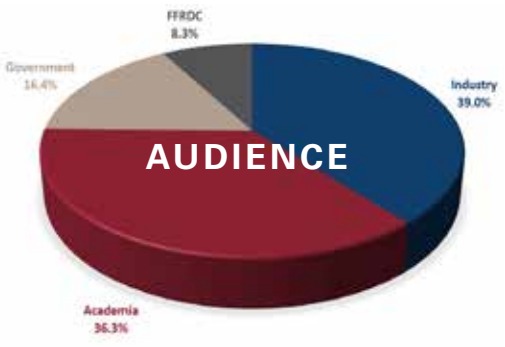
Launched on June 1, 2016, SERC Talks is a bi-monthly, research webinar series featuring researchers from the Systems Engineering community sharing insight on critical systems engineering challenge areas. Aspiring to create an ongoing and more collaborative dialogue between academia, industry, and government sectors, SERC continues to serve as a vehicle to grow Systems Engineering research into areas that can transition into impact, and showed continued growth in 2017 with six well-attended presentations. The SERC Talks in 2017 were split into two series: Cybersecurity and Cyber-Physical Learning Systems.

Dr. Barry Boehm, our Editor-in-Chief, has curated the talks to focus on the following themes through 2018:

- Model-Centric Systems Engineering (2016)
- Cyber-Physical-Human Learning Systems (2017)
- Cybersecurity Systems Engineering (2017)
- Successfully Applying Agile Methods for High-Criticality Systems Engineering System Software Qualities (2018)

The series' impact extends beyond the individual participants, as many sites have incorporated SERC Talks into working groups and classrooms, though the chart below shows the audience we see viewing the live event. The sessions are recorded and available for viewing on the SERC website and SERC YouTube channel. Many of the participants have become regular attendees of the talks. For more information, please reach out to **Dr. Barry Boehm (boehm@usc.edu)**.

Dates for future SERC Talks are available at
http://www.sercuarc.org/serc-talks



2017 SERC TALKS

CYBER-PHYSICAL LEARNING SYSTEMS SERIES

What is Self?
Grady Booch, IBM Almaden Laboratory

Can Graphical Models Provide a Sufficient Basis for General Intelligence?
Paul Rosenbloom, University of Southern California

What are Cyber-Social Learning Systems and How Will We Form Them?
Kevin Sullivan, University of Virginia

CYBERSECURITY SERIES

How Do We Prepare the People Who Will Need to Manage the Real-Time Responses to Cyber Attacks on Physical Systems?
Barry Horowitz and Inki Kim, University of Virginia

What are the Top Ten Software Security Flaws?
Gary McGraw, Synopsys

The Dilemmas of Cybersecurity – Why is Everything Broken?
William Scherlis, Institute for Software Research, Carnegie Mellon University

ENHANCING SYSTEMS ENGINEERING RESEARCH IN 2017

SERC Collaborating Universities are leaders in the field of systems engineering research. An example of the robustness would be CSER 2017. Out of the 87 papers accepted at CSER 2017, 30 (34.5%) came from SERC Universities, some of which were directly related to SERC projects. The SERC itself had over 35 journal publications, three of which received Best Paper Awards.

Best Paper Award for Transition in SE Research sponsored by MITRE:

- **Giammarco, K., Giles, K.** "Verification and Validation of Behavior Models using Lightweight Formal Methods." *CSER, Redondo Beach, CA.*

Best Paper Award for SE Training at INCOSE IS 2017:

- **Turner, R.**, et al., "SE Simulation Experience Design: Infrastructure, Process, and Application." *INCOSE International Symposium, Adelaide, Australia.*

Best Paper Award at ESEM:

- **Boehm, B.W., Clark, B., Madachy, R.J., & Rosa, W.** "Early Phase Cost Models for Agile Software Processes in the US DoD." *Empirical Software Engineering and Measurement (ESEM), Toronto, Canada.*

There have also been over 20 courses at SERC Collaborating Universities that have incorporated SERC methods, processes, tools, and research. A few examples are shown below.

PURDUE UNIVERSITY
COURSE NO.: AAE 560
COURSE NAME: System of Systems Modeling and Analysis

STEVENS INSTITUTE OF TECHNOLOGY
COURSE NO.: SYS671- SYS674
COURSE NAME: Systems Engineering of Cyber-Physical Systems

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
COURSE NAMES: Professional Education Digital Programs, Quantitative Methods in Systems Engineering

UNIVERSITY OF SOUTHERN CALIFORNIA
COURSE NO.: SAE 549
COURSE NAME: System Architecting and Engineering

YEAR IN REVIEW

REVIEW OF SERC NAV – TODAY AND FUTURE PLANS

SERC NAV INTRODUCTION

The SERC NAV, short for Network Analysis and Visualization Tool, is a navigation tool that was initially developed to capture and allow users to visually interact with data and relationships that exist within the SERC ecosystem. Those data and relationships include professors, universities, research projects, publications, and metadata about the persons involved. Users interact with the SERC NAV interface, which would visualize the data and relationships within the SERC ecosystem. In this way, users would be able to visually traverse the database and discover the composition of the SERC with regard to research being performed, persons related to the research, universities that collaborate with the SERC, publications related to the research and many other data that exists. The SERC NAV was officially released on November 6, 2017 at the 5th Annual SERC Doctoral Students Forum and 9th Annual SERC Sponsor Research Review and is publically accessible on the Internet by visiting… **http://www.sercnav.org**.

Visualization Perspectives

Since the data that is contained in the SERC NAV database are vast, trying to visualize all the data at one time would not be comprehensible or helpful. The SERC NAV uses Perspectives to define a subset of data to visualize. Each Perspective has a unique characteristic. The People/PI Perspective provides the Collaborating Universities, the researchers within each, and the Research Tasks in which the PI has participated. When you click a Research Task, it shows the people that are involved and also the downloadable Technical Reports. The Projects & Topics Perspective shows the SERC Research Focus Areas, and then further breaks down the projects and Research Tasks within each. As of now, once you click on a Research Task, downloadable Technical Reports are available. In the future, each Research Web Page will contain information about the respective Research Project, artifacts from that Research Project, Simulations, White Papers and Technical Reports. This is helpful for partners in industry and government, sponsors of research, faculty, and students.

SERC Partners in Industry and Government

All research within the SERC is conducted with an objective of having a significant positive impact on the national security of the United States, and the contribution of the SERC continues to grow through our collaboration with a number of FFRDCs, National Laboratories, DoD entities, and Industry partners. There are various ways to get involved with SERC, whether through innovative research, transition of research, or pursuit of academics. The SERC NAV aids in displaying information in an easy and digestible manner to move forward with either transition, initiating innovative research, or finding an academic program that best suits for someone's studies. It helps significantly with visualizing if there is already existing research that aligns with the desired research to be done.

Sponsors of Research

The SERC NAV introduces an easier way to see the progress of the research and the SERC's research focus areas for sponsors of research. It also shows explicitly the researchers involved in the task and where else they have participated in SERC research. The platform can illustrate where there is connectivity between Research Tasks, and meld a collaboration amongst several sponsors.

Faculty

For faculty, the SERC NAV can serve as a way to understand the research being conducted in other projects, and highlight collaborative efforts where research intersects. For faculty who have not yet been involved in a Research Task, it shows which Research Focus Area and which tasks they can best contribute and/or propose new work to be done. This will certainly be helpful for Incubator Projects.

Students and SERC Doctoral Fellows

For students, the SERC NAV helps identify potential contributions to their own research, an avenue to get involved, or help with exploring a potential advisor as a SERC Doctoral Fellow.

SERC NAV Phase II

Having deployed the SERC NAV (Phase I) in November 2017, our SERC engineers are currently determining the future scope of the SERC NAV (Phase II), which we intend to begin to develop in 2018. The SERC NAV Engine was designed in a way such that future enhancements can be added without major architectural changes, however, further improvement on the functionality of SERC NAV is currently being explored. Again, please visit **http://www.sercnav.org** for the currently released version.

REVIEW OF WORKSHOPS AND MAJOR FINDINGS

Ontology Bootcamp

Dr. Barry Smith of University of Buffalo is the creator of Basic Formal Ontology (BFO), which is the most commonly adopted upper-level ontology development framework, now used in over 300 civilian and government ontology initiatives throughout the world. Most recently, he has contributed to the Air Force Research Labs Digital Thread/Digital Twin initiative, whose goal is to develop an ontology-driven analytical framework to allow use and re-use of authoritative data from multiple heterogeneous sources to inform decision-makers throughout a system's lifecycle. Ontologies and Semantic Web Technologies are key enablers for Model Based Engineering. This boot camp, held on December 5, 2017, was organized to provide the attendees with an introduction to the concept of Ontologies in this context. Dr. Smith addressed the ontology timeline from 1980s Artificial Intelligence to 2000s Semantic Web Technologies while also discussing the different suites and principles for building an ontology. Future-proofing ontologies was considered, and an in-depth example was provided through the Gene Ontology. The agenda then transitioned to discuss example ontologies from the systems engineering domain with their respective functions and capabilities, and the day closed with an interactive session on defining "system." The slides are available online, and the recorded session wil also soon be available at **www.sercuarc.org/wp-content/uploads/2014/05/SE-Ontology_Smith_slides.pdf**

Model Based System Assurance

On December 6-7, 2017, approximately 60 system and software engineers, computer scientists, cybersecurity engineers, and program managers gathered in Washington D.C. for a two-day workshop on "Model-Based System Assurance (MBSA) - Enabled by Digital Engineering" led by Tom McDermott (Georgia Institute of Technology) and Dr. Ye Yang (Stevens Institute of Technology). The MBSA workshop aimed at exploring top-priority research projects for next-generation system assurance design and test, through developing a shared understanding of challenges, opportunities and ideas on this topic, as well as leveraging state-of-art model-based engineering approaches. Through fifteen invited talks and two interactive break-out groups, many ideas emerged as potential areas that we could explore to improve current practices of system assurance design and testing in defense and other adjacent domains. The prioritized research directions include: 1) the need to do an MBSA Pilot with cyber resilience focus, which would be to push the tools and pioneer the processes; 2) the need for a defined spectrum of roles in the system modeling community, particularly with an exploration in the human capital area of modeling roles, including the modelers of the acquisition community, which is much more well defined on the test side, but not on the assurance side; 3) on the basic research side, the need for better leveraging existing formal methods and techniques from the software engineering community, and enabling their integration with functional models, executable models, and simulation models from the system engineering community, in order to achieve the benefits of model reuse and integration to address MBSA challenges. More information can be found at **http://www.sercuarc.org/model-based-system-assurance-workshop/**

Managing Acquisition and Program Risk

The DASD(SE) sponsored workshop on Managing Acquisition and Program Risk was held on December 13, 2017, with Dr. Paul Collopy (University of Alabama Huntsville) as the lead. The workshop brought together representatives of government, industry and academia to explore where research might productively search for ways to improve risk management. Risk Management in the context of systems engineering attempts to address two needs: a) what issues should program managers pay particular attention to? and b) How should engineering and program decisions be made in the face of uncertainty? While the standard risk management process does a fair job at the first need, this is often done at the expense of effectively dealing with uncertainty. The workshop considered which aspects of acquisition and program risk management in the defense domain can benefit from focused research. Speakers presented how risk is managed on Wall Street, oil rigs, in shipbuilding, and in space. Workshop participants, inspired by the wide-ranging discussion, developed over two dozen possible research topics. Top research ideas addressed better communication of risk, better collection and integration of risk across large project organizations, a more standard and rigorous method for estimating risk probabilities, and better use of network analysis and data analytics for risk assessment in complex programs. A workshop report will be published soon to the SERC website identifying top research questions to be addressed for improvement on effective decision-making as the ultimate purpose of risk management.

ANNUAL EVENTS

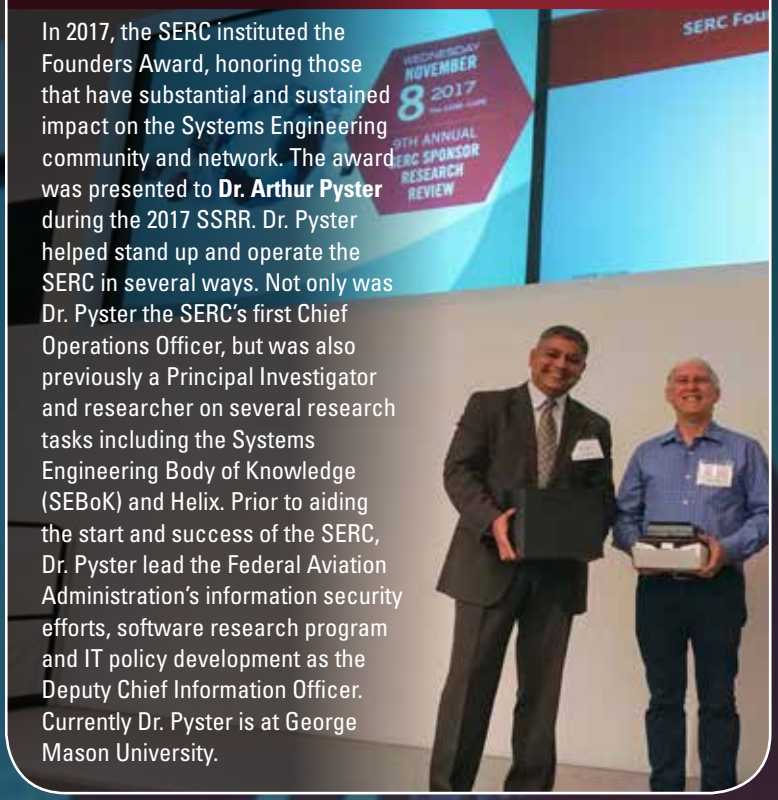
SERC SPONSOR RESEARCH REVIEW

The 2017 SSRR had 160 registrants and 114 attendees where the research showed maturity and readiness transition. **Mary Miller**, Acting Assistant Secretary of Defense for Research and Engineering, was the keynote speaker. The one-day, sponsor-focused event was held in Washington, DC, and united the government, industry, and academic Systems Engineering research community in order to share research progress and discuss the most challenging systems engineering issues facing the Department of Defense. The SSRR program and sessions focused on the research results achieved in each of the four thematic areas. The platform provided exposure to further potential collaboration and refinement of the work being done.

Presentations are available on the website.
Webpage: **http://www.sercuarc.org/research/annual-serc-research-review/ssrr-2017/**

SERC FOUNDERS AWARD

In 2017, the SERC instituted the Founders Award, honoring those that have substantial and sustained impact on the Systems Engineering community and network. The award was presented to **Dr. Arthur Pyster** during the 2017 SSRR. Dr. Pyster helped stand up and operate the SERC in several ways. Not only was Dr. Pyster the SERC's first Chief Operations Officer, but was also previously a Principal Investigator and researcher on several research tasks including the Systems Engineering Body of Knowledge (SEBoK) and Helix. Prior to aiding the start and success of the SERC, Dr. Pyster lead the Federal Aviation Administration's information security efforts, software research program and IT policy development as the Deputy Chief Information Officer. Currently Dr. Pyster is at George Mason University.



SERC DOCTORAL STUDENTS FORUM

The half-day SDSF provides an opportunity for SERC Doctoral Fellows to join with other PhD students doing systems engineering research at the SERC Universities to share their findings with the wider SERC community. In 2017, three Doctoral Fellows and five other students presented to an audience of over a hundred SERC Sponsor Research Review attendees. This half-day event drove high impact by exposing the attendees to the research conducted by students, and also allowed the students to receive feedback and questions from experts outside of academia. **Dr. Jason Providakes**, President and CEO of the MITRE Corporation, gave the keynote address.

Presentations are available on the website.
Webpage: **http://www.sercuarc.org/research/annual-serc-research-review/sdsf-2017/**

BEST STUDENT PAPER AWARD

The 2017 Best Student Paper Award was presented to (now) **Dr. Davinia Rizzo,** for her paper on Bayesian network analysis of vibration testing. Dr. Rizzo is a systems engineer at Sandia National Laboratories who received her doctorate from Stevens Institute of Technology in December 2017. The papers submitted were judged on the basis of potential impact, advancement to Systems Engineering, originality, technical content, and clarity of presentation. As the award winner, Dr. Rizzo was invited to present her paper at the regular SSRR session following the SDSF.

Please note that SERC Doctoral Students Forum allows students who are doing systems engineering research at the SERC Universities to submit papers even if they are not a SERC Doctoral Fellow. We encourage participation, and if there are any questions on process or submissions, please contact **Dr. Wilson Felder** (wfelder@stevens.edu).

TECHNICAL PLAN

TECHNICAL PLAN UPDATE

As originally envisioned, the SERC Technical Plan 2013 – 2018 has served to:

- Provide the vehicle by which to align the SERC Vision and Research Strategy with the Sponsor's Core funding priorities
- Describe the SERC Vision, the Sponsor's needs, and the SERC's response to these needs
- State DoD's SE research grand challenges and how the SERC will apply core and other funding during 2018-2023 to address them
- Provide synergy between SERC research areas, programs and projects to provide mission-level capabilities
- Provide a multi-year roadmap of research programs to support this strategy

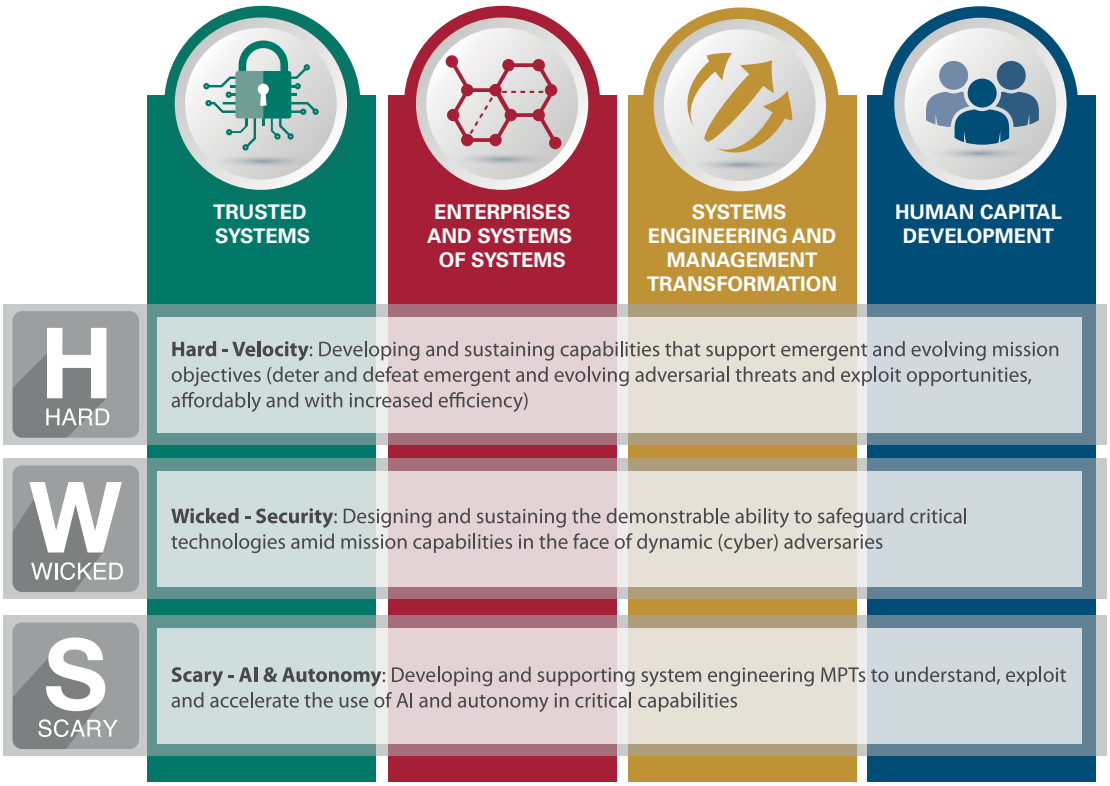
Work has begun in earnest to create a new SERC Technical Plan 2018 – 2022 to provide guidance for the next five years. The current Plan has been quite effective in creating synergy between projects and programs within each research thrust area. In addition, it served well as a framework for resource allocation and the support of evolving programs. The update supported increasing rates of adoption and impact of research results. However, improvements could be made in providing systems between the research thrust areas which are disjointed. Also, the Plan could be improved to support mission-wide capabilities with demonstrable returns. Finally, improvements can be made to continue the broadening of adoption and impact, particularly into the education system.

As a result, our plan is to retain the four research focus areas for continuity as they have been quite successful. However, these focus areas will be augmented with high-level missions with progress objectives to provide synergy and observable mission level capabilities. The three missions following the "hard," "wicked," and "scary" themes are:

- **Hard – Velocity**: Developing and sustaining capabilities that support emergent and evolving mission objectives (deter and defeat emergent and evolving adversarial threats and exploit opportunities, affordably and with increased efficiency)
- **Wicked – Security**: Designing and sustaining the demonstrable ability to safeguard critical technologies and mission capabilities in the face of dynamic (cyber) adversaries
- **Scary – AI & Autonomy**: Developing and supporting system engineering MPTs to understand, exploit and accelerate the use of AI and autonomy in critical capabilities

In addition, transition planning will be continued and strengthened, with upfront commitments and measured progress. The "Grand challenges" in each research focus area will be updated as "Visions," and explicit support of the missions will be noted for each project and program. Finally, the research portfolios will be updated based on the missions, sponsor needs and incubator results.

The plan is for the Research Council to complete a draft of the new Plan by spring 2018 with an approved plan by the end of summer 2018.



REVIEW OF INCUBATOR PROGRAM

INCUBATOR

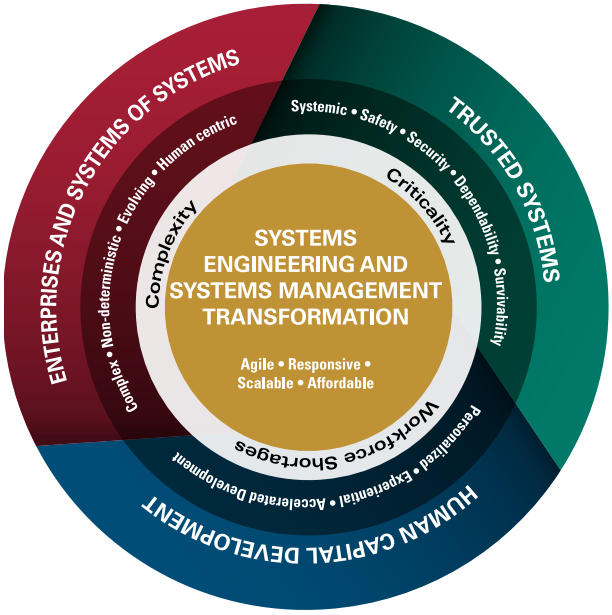
There is a need to support new ideas in their infancy that may become critical research programs for emerging challenges and opportunities. This incubation capability is being supported by a biennial open call to the SERC research collaborating universities to propose early-stage research that can be nurtured through relatively small levels of seed funding.

The initial open call took place on December 19, 2016, with the objective of identifying and developing several short white papers outlining research programs with a significant potential to improve the practice of engineering systems. Over 30 proposals were submitted in January 2017. Each proposal received was reviewed by the Research Council and the Executive Sponsors, and provided a final score based on an equal weighting in each of the following four criteria: intellectual merit, clarity of vision, past performance, and potential strategic impact. Following the evaluations, the following seven proposal topics were selected:

- **David Coe**, University of Alabama-Huntsville, *The Feasibility of Enhancing Security of Complex Systems through Disaggregation of Security Components to Asymmetric Multi-Processors*
- **Paul Grogan**, Stevens Institute of Technology, *Game-theoretic Risk Assessment for Distributed Systems (GRADS)*
- **Azad Madni**, University of Southern California, *Program Protection System Security and Trust Extending Flexible Contracts for Mission Assurance*
- **Karen Marais**, Purdue University, *Data Science Approaches to Prevent Failures in Systems Engineering*
- **Val Sitterle**, Georgia Tech, *Systemic Security and the Role of Heterarchical Design in Cyber-Physical Systems*
- **Gary Witus**, Wayne State, *Trusted Autonomy – Methods for Test and Evaluation*
- **Lu Xiao**, Stevens Institute of Technology, *Identifying and Measuring Modularity Violations in Cyber-Physical Systems*

Preliminary research results were presented by each of the PIs and reviewed by the SERC Research Council and Sponsors at the Incubator Day meeting on September 6, 2017, in Washington, DC. The final research results were presented for review at the annual SERC Sponsor Research Review on November 8, 2017. The final reports of this work have been completed and will be published on the SERC website for public review in 2018. A number of the research projects are being integrated into the SERC Technical Plan to help guide SERC's future research plans.

RESEARCH FOCUS AREAS



The SERC research portfolio is structured into four thematic focus areas:

Enterprises and Systems of Systems: *Providing ways to develop, characterize and evolve very large-scale systems composed of smaller systems, which may be technical, socio-technical, or even natural systems.* These are complex systems in which the human behavioral aspects are often critical, boundaries are often fuzzy, interdependencies are dynamic, and emergent behavior is the norm. Research must enable prediction, conception, design, integration, verification, evolution, and management of such complex systems.

Trusted Systems: *Providing ways to conceive, develop, deploy and sustain systems that are safe, secure, dependable and survivable.* Research must enable prediction, conception, design, integration, verification, evolution and management of these emergent properties of the system as a whole, recognizing these are not just properties of the individual components and that it is essential that the human element be considered.

Systems Engineering and Systems Management Transformation: *Providing ways to acquire complex systems with rapidly changing requirements and technology, which are being deployed into evolving legacy environments.* Decision-making capabilities to manage these systems are critical in order to determine how and when to apply different strategies and approaches, and how enduring architectures may be used to allow an agile response. Research must leverage the capabilities of computation, visualization, and communication so that systems engineering and management can respond quickly and agilely to the characteristics of these new systems and their acquisitions.

Human Capital Development: *Providing ways to ensure that the quality and quantity of systems engineers and technical leaders provide a competitive advantage for the DoD and defense industrial base.* Research must determine the critical knowledge and skills that the DoD and IC workforce require as well as determine the best means to continually impart that knowledge and skills.

NEW RESEARCH TASKS

SUMMARY OF THOSE AWARDED IN 2017

There were **19 awarded Research Tasks in 2017**, some specifically pursuing the Grand Challenges through Core Funding according to the Technical Plan continued in 2016. The graphic at right shows the breakdown of the 19 awarded.

The Incubator Project is considered to be within all of the Research Focus Areas, and had **7** projects. **4** were within Trusted Systems and **3** were Systems Engineering and Systems Management Transformation.

13 Universities participated in the research.

One Research Task had **8** different collaborating universities.

Over **150** faculty and student researchers participated within the SERC in 2017.

15 Technical Reports published.

To see a full list of SERC Research Programs and Projects with their latest publications and Technical Reports, please visit:
www.sercuarc.org/research/research-programs-and-projects/

**1 - Incubator Project is considered to be within all.*

RESEARCH HIGHLIGHTS

In this section, we spotlight several research projects from each of the focus areas that were underway in 2017 and that illustrate the diversity of approaches, strategies, and outcomes of the SERC as a whole.

ENTERPRISES AND SYSTEMS OF SYSTEMS

Approaches to Achieve Benefits of Modularity in Defense Acquisition

PI: Daniel DeLaurentis, Purdue University

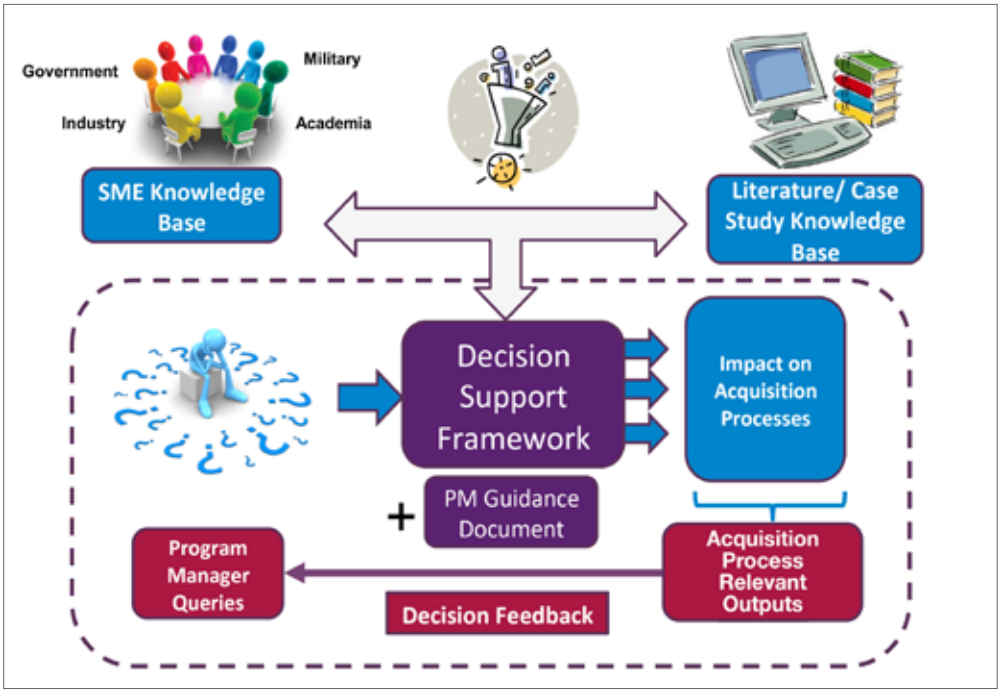
Co-PIs: Gary Witus (Wayne State University), Lu Xiao (Stevens Institute of Technology), Jean (Charles) Domercant (Georgia Tech), Navindran Davendralingam (Purdue University), Cesare Guariniello (Purdue University)

Sponsor: DASD(SE)

Link: www.sercuarc.org/projects/investigating-approaches-to-achieve-modularity-benefits-in-the-acquisition-ecosystem/

The US Department of Defense (DoD) encourages the adoption of modular and open systems architecture solutions, through its acquisition initiative, the Modular Open Systems Approach (MOSA). The initiative is intended to enable rapid development, deployment and evolution of military capabilities, while reducing end costs. However, current high-level guidance lacks sufficient insights on reconciling the technical (associated with modularity) and business (associated with openness) components in the defense acquisition lifecycle. Furthermore, much of the current MOSA efforts are through Open System Architecture (OSA) that focuses on business issues that are necessary but not sufficient to achieve end objectives. The complex interdependencies between business and technical components, and varied incentive structures across multiple stakeholders in the acquisition ecosystem, attenuate MOSA adoption across acquisition programs.

In this research task, we explore modularity and openness in the context of a defense acquisition ecosystem. The research aims to provide actionable knowledge support to program managers and relevant stakeholders on leveraging MOSA benefits towards achieving program goals. Our initial work involved a combination of deep dive knowledge acquisition and collaborative exchanges with key stakeholders from government, industry, military and academia, to extract best practices, perceived risks, key enablers, systemic barriers, and other such practical information associated with MOSA. To date, our work has developed a preliminary canvassing of knowledge artifacts from deep literature reviews, collaborative exchanges with key stakeholders, and outcomes from MOSA workshop, hosted by the SERC. Results thus far include a preliminary version of a Program Manager Guidance Document on MOSA. Our work will continue to expand, and then distill subsequent knowledge into a decision-support framework (figure below). The envisioned framework will be a computational environment that provides feedback to acquisition stakeholders on the impact that certain MOSA decisions can have on an acquisition program. It is through this combination of these feedback elements that we seek to both better incentivize and improve MOSA-related choices in the defense acquisition lifecycle.



Enterprise System-of-Systems Model for Digital-Engineering-Enabled Acquisition

PI: Tom McDermott, Georgia Tech

Co-PIs: Molly Nadolski (Georgia Tech), Chris Paredis (Georgia Tech), Paul Collopy (Univ of Alabama, Huntsville)

Sponsor: DASD(SE)

Digital Engineering is a key enabler for future improvements in acquisition processes and practices. It will allow PMs to reduce both technical and programmatic risk, through better interface management and through better understanding of the impact of design choices on cost and schedule. However, it is expected that this impact could reach much further, not only changing the way information is shared in the acquisitions context but fundamentally changing the business eco-system. The transformation from a primarily paper-based set of decision tools to a digital enterprise will likely make a number of current business processes obsolete, change current relationships between the defense acquisition community and the defense industry, adjust roles and associated jobs, and shift stakeholder perspectives on value in the enterprise. One may expect that the various stakeholders will both embrace and oppose transformative changes in ways that maximize their individual values. But, how exactly these complex interactions among stakeholders will affect the acquisitions eco-system is currently not well understood. The aim of this research project is therefore to address the following questions:

- *What changes are likely to emerge from the transition to digital engineering processes, methods, and tools?*
- *What are the enablers and barriers to such innovation in the DoD acquisition enterprise?*
- *What stakeholders will be affected and how will they likely embrace or oppose change?*
- *How might stakeholders be incentivized to embrace innovation and how will this be measured?*
- *What are the leading and long-term indicators of change?*

To answer these questions, the project will use a qualitative research method. Starting from an enterprise analysis, a Systemigram model will be created that identifies key actors, activities, enablers and barriers to change that drive desired system outcomes. Through semi-structured interviews with stakeholders in DoD and major defense contractors, this model will be developed via a series of narratives generated in the interview process. The resulting conceptual model will capture the impact of digital engineering on the emerging model-centric system acquisition process. It will provide a baseline to identify the consequences of Digital Engineering policies and how they may transform the acquisition eco-system.

Cybersecurity for System of Systems Architectures

PI: David A. Umphress, Auburn University
Co-PIs: Anthony Skjellum and Richard Chapman (Auburn University)
Sponsor: Program Executive Office, Missiles and Space (PEO-MS)
Link: Information available by request

The Cybersecurity for System of Systems Architectures research project focused on determining the systemic cybersecurity posture of an air-missile defense (AMD) battle command center by analyzing vulnerability information collected from its constituent parts. The research team mimicked a malicious actor by constructing a block diagram of the system based solely from open sources; identifying potentially exploitable vulnerabilities; and developing the mechanisms for collecting and analyzing vulnerability data from an actual system.

The Technical Report is marked for limited distribution, and is available from the Defense Technical Information Center.

System Aware Cybersecurity

PI: Barry Horowitz, University of Virginia
Co-PIs: Peter Beling and Cody Flemming (University of Virginia)
Sponsor: DASD(SE)
Link: www.sercuarc.org/projects/security-engineering/

Weapons are typically part of a System of Systems (SoS) configuration that integrates a diverse set of warfighting-related capabilities such as: target detection, tracking and identification, command and control, communications, fire control, and mission planning. Advancements in automation and system integration result in a set of increased cyber attack risks that can potentially impact the performance of weapon systems. In addition to denial of weapon system operation impacts, cyber attacks could create such serious consequences as fratricide, undesired collateral damage, weapon accuracy reductions, and important delays in achieving specific operational outcomes. Cyber attack-related causes of these warfighting-related consequences could be difficult to discover and respond to during operation, especially when adversaries design their attacks in a manner that attempts to avoid detection. This SERC research activity has been exploring potential system resilience opportunities for SoS-based weapon systems. In order to autonomously provide cyber attack-related resilience, an SoS-based weapon system must be designed to detect anomalous behaviors that would be the consequence of a cyber attack, and to support related SoS reconfigurations that would permit continued operations in a viable manner. Research efforts over the past year have focused on developing system engineering model-based solutions that would support system planners and decision-makers in prioritizing resiliency solutions for possible implementation. The Army's Armaments Research, Development and Engineering Center has been collaborating with a University of Virginia-led team including the Software Engineering Institute and Virginia Commonwealth University. Based upon the research team's progress in the development of an initial version of cyber attack resiliency decision support tools, and in defining a process for users to effectively and productively employ the tools, an activity has been started to engage with Army staff members in an experiment that employs the tools for prioritizing solutions for an Army designated hypothetical weapon system application. The Army user group will provide evaluations of the tools that will support a parallel ongoing SERC research activity that is advancing the tools for use in analyzing more complex SoS configurations in a process that employs higher levels of automation.

Transforming Systems Engineering through Model-Centric Engineering

PI: Mark Blackburn, Stevens Institute of Technology

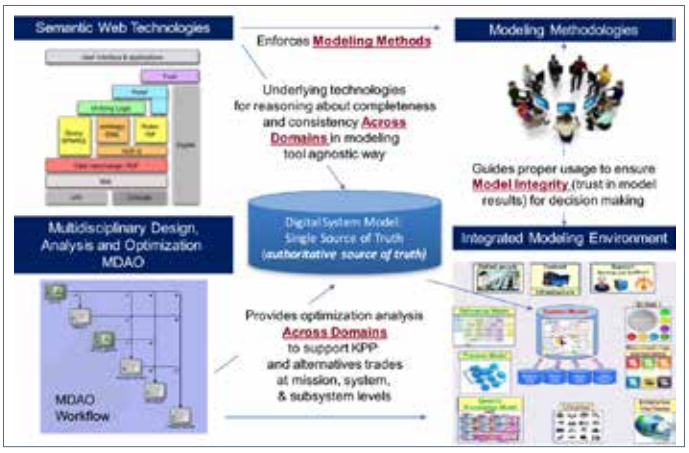
Sponsor: NAVAIR and US Army RDECOM

Link: www.sercuarc.org/projects/transforming-systems-engineering-through-model-based-systems-engineering/

In 2013, the Naval Air Systems Command (NAVAIR) initiated an effort through the Department of Defense (DoD) Systems Engineering Research Center (SERC) to explore the technical feasibility of a radical transformation of NAVAIR systems engineering and acquisition practices to use more advanced and holistic approaches to model-based systems engineering. A global scan of industry, government and academia facilitated a common understanding of the most advanced and overarching digital approaches for integrating different model types with simulations, surrogates, systems, software, hardware and components at different levels of abstraction and fidelity across disciplines throughout the lifecycle, which was characterized as "model-centric engineering" (MCE).

By 2015, NAVAIR's leadership concluded that they must move quickly to adopt MCE, and thus, in 2016, NAVAIR made the decision to accelerate a Systems Engineering Transformation (SET). Further, in 2017 the research needs were aligned with a new and evolving concept for the SET Framework to investigate a new operational paradigm between industry and government. The latest and ongoing efforts involve a NAVAIR Surrogate Pilot for executing the SET Framework to assess, refine, and understand this new paradigm for collaboration in Authoritative Source of Truth (AST).

Also in 2016, the US Army Research, Development and Engineering Command (RDECOM) Armament Research, Development and Engineering Center (ARDEC) started a complementary and collaborative SERC research in Semantic Web Technologies and ontologies, visualization application, and multi-objective decision analysis to inform ARDEC about enabling technologies and methods for their integrated Model Based Environment (iMBE) concept. Finally, these research tasks have generated awareness and mutual comprehension for a Digital Engineering concept defined by the DoD as: An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal.



System Qualities Ontology, Tradespace, and Affordability (SQOTA)

PI: Barry Boehm, University of Southern California

Co-PIs: David Jacques (Air Force Institute of Technology), Valerie Sitterle (Georgia Institute of Technology), Donna Rhodes (Massachusetts Institute of Technology), Ray Madachy (Naval Postgraduate School), Michael Yukish (Pennsylvania State University), Kevin Sullivan (University of Virginia), Gary Witus (Wayne State University)

Sponsor: DASD(SE)

Link: www.sercuarc.org/projects/tradespace-and-affordability/

The eight-university System Qualities Ontology, Tradespace, and Affordability (SQOTA) project entered its fourth year with several new, expanding, or transitioning research results. The ontology foundations researched and developed in the first three years have been strengthened and applied to DoD and other tradespace analyses. For example, the ontology identified the key role of Maintainability not only in improving Life Cycle Efficiency (most key DoD and other complex systems have 75-90% of their functionality expressed in software, and spend 75-90% of their life cycle costs after initial fielding), but also in Changeability and Dependability. USC (Barry Boehm, Pooyan Behnamghader, Celia Chen) has developed large-scale data analytics tools to track sources and costs (technical debt) incurred during development, but most often having to be paid during maintenance. A recent use of the tools was to quickly analyze some NASA mission problem identification software for use in a Navy mission problem avoidance training class. U. Virginia (Kevin Sullivan) is experimenting with a complementary software data analytics approach. MIT (Donna Rhodes, Adam Ross) has similar results with their Changeability analysis toolset and its use in their Epoch-Era analyses.

Other SQOTA team members are developing and applying methods and models enabling the use of set-based design and model-driven development to support particular DoD organizations, but also applicable for other DoD organizations. Wayne State (Gary Witus) is creating such capabilities with TARDEC; Penn State (Mike Yukish) is creating similar capabilities with NAVSEA. AFIT (Dave Jacques) and NPS (Ray Madachy, Kristin Giammarco) are developing similar capabilities in the modeling of swarms of Air Force and Navy drones, collaborating with USC and GTRI to add cost analyses, and collaborating with USC (Azad Madni) in exploring learning algorithms for swarm situation assessments. GTRI (Valerie Sitterle, Tommer Ender) is also building on the use of their cost-effectiveness analysis tools by USMC, Army, and Navy to create, evaluate, and evolve a Pipeline Analysis and Workflow (PAW) framework for rapid tailoring and composability of future cost-performance tradespace tool configurations. In the area of next-generation cost models, a collaborative-effort paper on the first use of a domain-specific cost model approach by Wilson Rosa (Naval Center for Cost Analysis), Ray Madachy (NPS), and USC (Brad Clark, Barry Boehm) received a Best Paper award at the 2017 Empirical Software Engineering and Measurement conference.

SE Research Needs and Workforce Development Assessment

PI: Dinesh Verma, Stevens Institute of Technology

Co-PIs: Paul Collopy (University of Alabama, Huntsville), Spiros Pallas (Stevens Institute of Technology)

Sponsor: DASD(SE)

Link: www.sercuarc.org/projects/

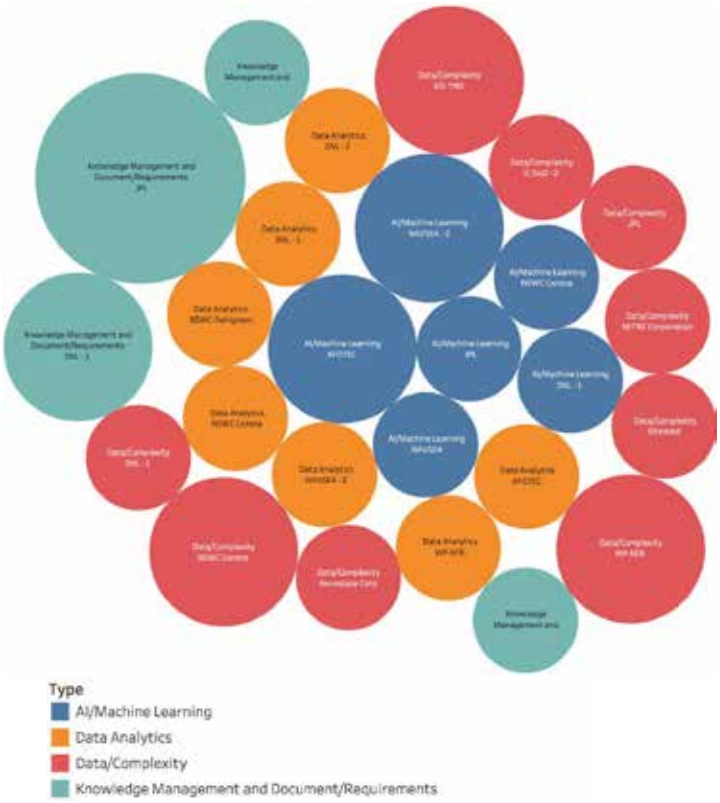
This particular research task was focused on engaging with Department of Defense Science and Technology (DoD(S&T)) and Engineering leaders across the DoD's laboratories and engineering centers to understand if it was possible to identify inclusive discernable patterns with regard to long-term, comprehensive research priorities and opportunities for impact. The information will also inform the 2018 update to the SERC Technical Plan, helping to guide research priorities over the next two to five years and increase the return on investment of future research tasks. Centering on an assessment of systems engineering research needs and the workforce development, this Research Task involved a data collection exercise resulting from 24 site visits and telephone discussions. Additionally, in collaboration with INCOSE, a survey supporting this topic was sent to all the INCOSE Fellows worldwide, with approximately 30% of all Fellows responding. The data collection suggests research priorities that broadly align with the following four primary themes, along with relevant sub-categories.

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



Mission Engineering Competencies

PI: Gregg Vesonder, Stevens Institute of Technology

Sponsor: DASD(SE)

Link: www.sercuarc.org/projects/

This Research Task focuses on the exploration of the current state of mission engineering and developing the foundations for a mission engineering competency model. Though this RT is designed for and focused on the DoD, the team also collected data from non-DoD government organizations as well as private and commercial organizations. This research task will provide several critical insights on mission engineering:

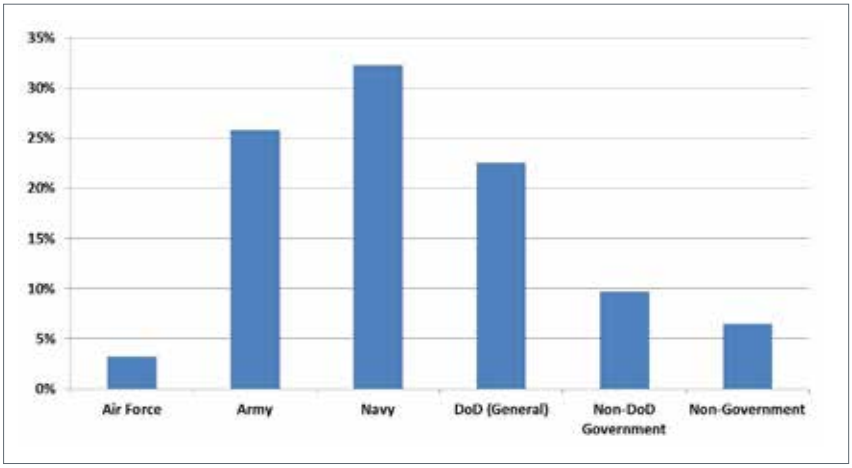
- How mission engineering is currently defined in practice, including discussions of overlap with other disciplines such as systems engineering and system of systems engineering;
- Key challenges identified for mission engineering;
- The skills cited as "most critical" for the effective practice of mission engineering in the current dataset – these can provide a foundation for a future competency model around mission engineering;
- The overlap of these skills with existing competency models for related disciplines; and
- A future vision for mission engineering.

The team has developed the findings and conclusions around these topics using a two-pronged, mixed-methods approach. The first is an extensive literature review of related fields such as systems engineering, systems of systems, force design, etc. The second is based on SERC's Helix project methodology – a grounded theory approach based on qualitative analysis of in-depth interviews with practicing mission engineers as well as thought leaders in the field.

The current dataset consisted of in-depth interviews with 26 individuals as well as over 100 sources on systems of systems, mission engineering, systems engineering, and force design. The 26 interviewees come from a variety of organizations, as shown in the figure below.

The technical competencies gleaned from analysis of the interviews – reflecting what practitioners believe are critical skills for successful mission engineering – include:

- Technical Competencies, specifically competencies that revolve around the design and management of capabilities that cross multiple systems and platforms;
- Systems Mindset, specifically competencies that deal with systems thinking and holism; and
- Team-Based Competencies, specifically those required to not only work within a team (e.g., a group of mission engineers) but also to influence across a diverse set of teams, each with their own goals and objectives.



IMPACT AND TRANSITIONS

HIGHLIGHTED IMPACT THROUGH COLLABORATIONS AND TRANSITIONS OF 2017

SERC HIGHLIGHTED IN INCOSE INSIGHT

*- **William Miller,** Editor-in-Chief, insight@INCOSE.org*

INSIGHT, the practitioner magazine for the systems engineering community published by the International Council on Systems Engineering (INCOSE) and Wiley, devoted the September 2017 issue to transitioning SERC research into practice. INSIGHT's mission is to provide informative articles on advancing the state of the practice of systems engineering. The purpose is to accelerate the dissemination of knowledge to close the gap between the state of practice and the state of the art. The articles span the diversity of SERC contributions to advancing the practice of systems sciences and systems engineering. Articles address the following topics: systems thinking skills, ontology for system qualities, semantically enabled model-based systems engineering of safety-critical networks of systems, human model interactive model-centric systems engineering, operational perspectives into the analysis of engineered resilient systems, systems engineering simulation experience design, system-aware cyber security, and a system-of-systems analytical workbench for architectural analysis and evolution. The last-named article was the recipient of a best article award presented at the 2017 INCOSE International Symposium. Issues of INSIGHT are available to INCOSE individual members and employees of the Corporate Advisory Board (CAB), including DoD, at **www.incose.org/ProductsPublications/periodicals/insight**. Individual articles are accessible through the INCOSE website's link to the Wiley online library. All others can access articles through the Wiley online library at **onlinelibrary.wiley.com/journal/10.1002/(ISSN)2156-4868**.

USC PARTNERSHIP LEADING TO ADVANCED SOFTWARE SAFETY ENGINEERING COURSE

*- **Archibald McKinlay,** Deputy Assistant Program Manager for Transformation at National Geo-Spatial Intelligence Agency (NGA)*

USC partnered two USC Schools to give the US Navy at China Lake, CA, an Advanced Software Safety Engineering Course with Security and Anti-Counterfeiting highlights in September 2017, with the next being in 2018. Combining teams from Dr. Barry Boehm's Center for Software Engineering with School of Engineering Aviation Safety and Security, advanced tool assessments tutorials were delivered to a dozen Naval Aviation Ordnance engineers with other Weapons Acquisition centers now interested. Following USD(R&E) and SERC's vectors, Dr. Boehm helped connect his team's tool to implement a continuing education course where the processes and tools help frontline acquisition programs meet the requirements. With an integrated tool-based approach, it allows engineers to perform real-time lifecycle assessments of software, systems, and systems of systems across several version iterations. This allowed for an SoS view across time and the actual content of changes to visualize trends, emphasis, and value of changes.

TRANSITIONING RESEARCH INTO PRACTICE WITH MITRE

*- **Dr. Rob Pitsko**, Department Head, End to End Systems Engineering and **Laura Ricci,** Deputy Director, Systems Engineering Practice Office at MITRE*

The SERC MITRE partnership presents a strong platform to transition research into practice and to inform future systems engineering research. While operating several FFRDCs, MITRE has a unique vantage point to scout and assess transition opportunities while collaborating with federal agencies to enable transitions and optimize impact from the developed SERC research. One SERC-MITRE partnership example in 2017 has been the adoption and implementation of the Helix research, Atlas, by the MITRE corporate Systems Engineering Technical Center (SETC). In early to mid-fiscal year 2017, MITRE transitioned the Atlas framework's Proficiency Model into practice through an initial pilot of supervisor-staff developmental discussions. Feedback indicated that incorporation of the tailored Helix artifacts enabled discussion and shared understanding of staff interests, technical proficiency areas and technical career paths. Further development intends to broaden the SETC Helix pilot for additional SETC perspective, refine the systems engineering proficiency profile and assessment guide, share across other MITRE Technical Centers, and refine SETC organizational development initiative goals and metrics.

ENTERPRISE ANALYSIS, TRANSITIONING RESEARCH WITHIN ACADEMIA

*- **William B. Rouse,** Stevens Institute of Technology*

The multi-level modeling framework and methodology developed via SERC support (Rouse, 2015) has been extensively applied to healthcare and more recently research universities. The resulting Economic Model of Research Universities has been transitioned to over 10 universities in the US who are in the process of evaluating its usefulness for addressing key tradeoffs such as brand value versus tuition levels, tenure track versus non-tenure track faculty, and approaches to addressing risks such as declining foreign student applications and increasing quality of lower-priced online offerings. On December 4, 2017, Dr. William Rouse gave the National Academy Sackler Talk on the topic, which is available at: **youtu.be/DQscynSFbqo**

STUDENT ENGAGEMENT

THE AEROSPACE CORPORATION JOINS SERC DOCTORAL FELLOWS PROGRAM IN 2017

In 2017, The Aerospace Corporation joined the SERC Doctoral Fellows Program, and quickly provided their first Fellow who is studying at University of Southern California. With The Aerospace Corporation joining in 2017 and Raytheon Company – Missile Systems in 2016, there are now five participating organizations since the program's inception. Also included are The MITRE Corporation, ARDEC-Picatinny Arsenal, and The Boeing Company. The SERC Doctoral Fellows Program leverages an exceptional foundation of education through the selected SERC Collaborator Universities where participating U.S.-based organizations are able to nominate and select employees to become Ph.D. students concentrating on systems-related research consistent with both the SERC's charter and their own research priorities. The SERC Doctoral Fellows Program is not a scholarship program, but rather, participating organizations sponsor a specific number of Doctoral Fellows each year. Fellows receive tuition reimbursement form their sponsoring organizations and are allocated one day per week to dedicate toward their doctoral studies and research. **For more information about the SERC Doctoral Fellows Program, please contact Wilson Felder (wfelder@stevens.edu).**

CAPSTONE MARKETPLACE

In December 2017, SERC hosted a workshop with key personnel to discuss the goals and challenges of the Capstone Marketplace (CM). The vision is to have sustained growth, spanning multiple universities and sponsoring organizations. In the workshop, critical use cases were discussed and developed while testimonials from sponsors and faculty members underlined the importance of the CM mission. The CM addresses the critical challenge of developing the next generation of systems engineering talent for future Department of Defense and industry needs. Great engineers require technical depth, breadth, and leadership skills to deal with today's complex systems. Most engineers, however, graduate with depth in one discipline, but with limited breadth and leadership skills. The lack thereof impacts the students as they are immersed in industry, hindering systems engineering, systems thinking, and design. Creating multidisciplinary student teams and pairing them with challenging engineering projects from industry helps students gain better insight into systems engineering, systems thinking, and leadership qualities, while enabling a better appreciation of the varying methods and tools of different engineering disciplines. The project sponsors provide domain expertise and advice, while faculty supervisors help guide the teams and grade their work. The Capstone Marketplace website (**www.capstonemarketplace.org**) makes it easy for sponsors to reach out to potential students, and it helps the students find projects best matched to their interests. It also showcases some of the great ingenuity that has come from engagement with the Capstone Marketplace. Faculty and students are also able to propose projects that may be of interest to the sponsors. **For more information, please contact Michael DeLorme (mdelorme@stevens.edu).**

SERC LEADERSHIP

LEADERSHIP TEAM

For full bios visit ***http://www.sercuarc.org/serc-leadership/***

Dinesh Verma
Executive Director, SERC

Jon Wade
Chief Technology Officer, SERC

Barry Boehm
Chief Scientist, Chair of the SERC Research Council, SERC

Megan M. Clifford
Chief of Staff to Executive Director/ Manager Program Operations, SERC

Roger Blake
Chief Software Engineer, SERC

SERC ADVISORY BOARD

For full bios visit ***http://www.sercuarc.org/serc-advisory-board/***

Paul Kaminski
President and CEO, Technovation, Chairman, SERC Advisory Board

Major General Curtis M. Bedke
US Air Force (Retired)

Lieutenant General Ted Bowlds
US Air Force (Retired)

Victoria Cox
Assistant Administrator for NextGen at the Federal Aviation Administration (Retired)

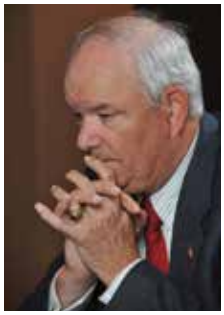
Dr. Ruth David
President and CEO of Analytic Services Inc. (Retired)

Major General Nick Justice
US Army (Retired) Executive Director of PowerAmerica

David Long
Liaison with INCOSE, President (2014-2015), Founder and CEO of Vitech Corporation

Dr. Steve Rottler
Senior VP, Sandia National Laboratories (Retired)

Capt. William M. Shepherd
US Navy (Retired), NASA Astronaut (Retired), Science Advisor, US Special Operations Command (Former)



The Honorable Michael Wynne
21st Secretary of the Air Force (Retired), Emeritus member and former Chairman of the SERC Advisory Board

RESEARCH COUNCIL

For full bios visit ***http://www.sercuarc.org/serc-research-council/***

SE AND SM TRANSFORMATION

Barry Boehm

Chair of the SERC Research Council

See previous page in SERC Leadership team; SERC Chief Scientist

Mark R. Blackburn

Associate Professor, Stevens Institute of Technology

Paul Collopy

Chair, Industrial and Systems Engineering and Engineering Management,University of Alabama in Huntsville

ENTERPRISES AND SYSTEMS OF SYSTEMS

Daniel A. DeLaurentis

Professor, School of Aeronautics & Astronautics, Purdue University

William B. Rouse

Alexander Crombie Humphreys Chair in Economics of Engineering, Stevens Institute of Technology

TRUSTED SYSTEMS

Barry Horowitz

Munster Professor of Systems and Information Engineering and Chair, University of Virginia

Kevin Sullivan

Associate Professor in Computer Science, University of Virginia

HUMAN CAPITAL DEVELOPMENT

Tom McDermott

Director of Technology Policy Initiative, Sam Nunn School of International Affairs, Georgia Institute of Technology

Jon Wade

Distinguished Research Professor, Stevens Institute of Technology

ABOUT THE SERC

The Systems Engineering Research Center (SERC), a University-Affiliated Research Center of the US Department of Defense, leverages the research and expertise of senior lead researchers from 22 collaborator universities throughout the United States. The SERC is unprecedented in the depth and breadth of its reach, leadership, and citizenship in systems engineering through its conduct of vitally important research and the education of future systems engineering leaders.

Begun in 2008 and led by Stevens Institute of Technology and principal collaborator, the University of Southern California (USC), the SERC is a national resource providing a critical mass of systems engineering researchers – a community of broad experience, deep knowledge, and diverse interests. SERC researchers have worked across a wide variety of domains and industries, and bring that wide-ranging wealth of experience and expertise to their research. Establishing such a community of focused SE researchers, while difficult, delivers impact well beyond what any one university could accomplish.

BECOMING A SPONSOR

Since 2008, SERC research sponsors have benefited from research performed by nearly 500 faculty, staff, and students across the SERC Collaborator Universities. Any US Government organization can benefit from the SERC by sponsoring systems research or by adopting the results of research sponsored by others.

Interested government organizations should contact the SERC's primary sponsor, the Deputy Assistant Secretary of Defense for Systems Engineering (DASD(SE)), to discuss their needs and determine if addressing them is within the scope of the SERC's mission at osd.atl.asd-re.se@mail.mil. If you have a specific Principal Investigator or university in mind, be sure to discuss your requirements with DASD(SE). If feasible, a Statement of Work (SoW) will be developed and the SERC will respond with its technical approach, cost estimate, and deliverables.

University or Research Organization

1. Stevens Institute of Technology
2. University of Southern California
3. Air Force Institute of Technology
4. Auburn University
5. Carnegie Mellon University
6. Georgetown University
7. Georgia Institute of Technology
8. Massachusetts Institute of Technology
9. Missouri University of Science and Technology
10. Naval Postgraduate School
11. North Carolina Agricultural & Technical State University
12. Pennsylvania State University
13. Purdue University
14. Southern Methodist University
15. Texas A&M University
16. Texas Tech University
17. University of Alabama in Huntsville
18. University of California - San Diego
19. University of Maryland
20. University of Massachusetts Amherst
21. University of Virginia
22. Wayne State University

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