Systems Engineering Research Needs and Workforce Development Study – Pathfinder Study

Dinesh Verma, Paul Collopy, Spiros Pallas

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SERC Core Competencies

Ability to conduct long-term, comprehensive SE research focused on DoD acquisition, including

- Enable integrated development and management
- New ways to link requirements to design
- Leverage modeling and simulation
- Link technical baselines to architectures
- Apply SE to acquisition of services

Ability to leverage developments in systems architecting, complex systems theory, systems thinking, systems science, knowledge management and SwE to perform research to advance the design and development of complex systems across all DoD domains, including

- System and open systems architecture/analysis
- SE in complex SoS and FoS environments
- Enterprise SE
- SW-unique extensions and modern SW-development technology
- Flexible SE environment
- Knowledge management
- Undergraduate/Graduate SE education needs

Ability to leverage developments in open systems standards, organizational theory, program management, SE management, and IT to provide needed integration of program/technical management MPTs, including

- Integrate TPMs with EVM
- Maturity reviews
- SE team structures, etc. for improvement
- Improved SE information sharing
- Rationale and way ahead for standards
- Toolsets throughout the life cycle
- Analyzing SE costs, accounts, and ROI
- SE metrics and leading indicators
SERC Research Thematic Areas

Enterprises and SoS
- Enterprise Analysis
- System of Systems Modeling and Analysis

Trusted Systems
- Systemic Security
- Systemic Assurance

Human Capital Development
- Evolving Body of Knowledge
- Experience Acceleration
- SE and Technical Leadership Education

SE & Systems Mgmt Transformation
- Affordability and Value in Systems
- Quantitative Risk
- Interactive Model-Centric Systems Engineering
- Agile Systems Engineering
2014-2018 Technical Plan:

- Provided the vehicle by which to align the SERC Vision and Research Strategy with the Sponsor’s Core funding priorities
- Described the SERC Vision, the Sponsor’s needs, and the SERC’s response to these needs
- Stated DoD’s SE research grand challenges and how the SERC will apply core and other funding during 2014-2018 to address them
- Provided a multi-year roadmap of research programs to support this strategy.

We are in the process of developing our next five year Technical Plan
• The foundation for the 2018-2023 SERC Technical plan to include:
  — General Framework: It has been suggested that we retain the four research focus areas for continuity, but add missions that provide connections between these areas
    o “Missions” cut across the four thematic research areas
    o Mission areas might relate to Ms. Baldwin’s famous three:
      — (Hardest) Developing flexible designs that adapt, and are resilient to unknown missions and threats
      — (Wickedest) Security: Safeguarding critical information, Designing systems resilient to a cyber adversary and other advanced threats and technologies
      — (Scary) Designing systems to take advantage of 3rd Offset Technologies, Engineering consideration for AI and Autonomy
  — Critical Research: determination of critical research challenge areas to help realize the stated missions (*These are beginning to be defined*)
  — Technical Plan Roadmap: We hope to go through various iterations of the Technical Plan with the goal of finalizing it by June 2018
• **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

**Significant community consent with these mission areas!**
SERC Research Future Impact Areas: 
Input to the 2018-2023 Technical Plan

• SE and SE Management Transformation
  — Model Centric Engineering
    o linking behavior/system models with performance models;
  — Flexible and Adaptive Systems
    o MOSA – measurement and implications;
    o Multi-Architecture Trade-space Evaluation; Architecture Approaches to allow Rapid/Adaptive Response
    o Architecting and Verification of Cyber-Human Learning Systems
  — Team Effectiveness
    o Architecture of design teams for rapid development
    o Human – Machine Interface Optimization

• Trusted Systems
  — Assurance and Reliability for Mission Critical CPS; Cyber-resilient CPS Systems
  — Cyber-Human Learning Systems -- networks of learning manned and unmanned nodes
  — Systems Approaches to Security:

• Enterprise Systems and SoS
  — Leveraging MOSA to enhance the innovation ecosystem supporting the DoD; Modeling the Defense Innovation System

• Human Capital Development
  — Mission Engineering
  — System Safety
Research workshops that we held last year...
May 26, 2016
WASHINGTON, DC

Creating a New Culture and Ecosystem for Coordination and Collaboration with Model-Centric Design and Acquisition

INTRODUCTION, BACKGROUND, AND CONTEXT:
Model-centric engineering can be characterized as an overarching digital and visual approach to engineering. It also involves integrating different model types with simulations, surrogates, systems and components at different levels of abstraction and fidelity across disciplines throughout the system or solution lifecycle. The use of such digital engineering technologies and model-centric engineering practices are advancing, and adoption is accelerating. While this is happening, a number of technical and business/acquisition model challenges remain. The current business models may not be appropriately aligned for acquisition in such a model-centric ecosystem. We as a community must discuss approaches to allow better collaboration, while nurturing competition with appropriate approaches to address Intellectual Property Protection, Government Data Rights, and a Collaborative Environment.

These digital technologies are changing how organizations are conceptualizing, architecting, designing, developing, producing, and sustaining. Some use model-centric environments for customer engagements, as well as design engineering analyses and review sessions. Some are integrating mission and system-level modeling and simulations originally created for design and development and expanding them into new cloud-like services enabled by the industrial Internet. Most organizations today have a unique capability realized by integrating commercial technologies and tools with their own innovations.

We need insights from key stakeholders in the “user community” on how to transform our engineering and acquisition culture in light of these advancements, how to align engineering and business/acquisition
September 26, 2016; Invitation only attendance, limited to 35

TRUSTWORTHY CYBER-SOCIAL LEARNING SYSTEMS

DATE
September 26, 2016

LOCATION
Washington, DC

ABSTRACT
The looming integration of data-driven, artificially intelligent, semi-autonomous cyber-physical systems with people and social phenomena at scale presents new challenges and opportunities in systems engineering. The overall opportunity is to transform societal systems into cyber-social learning systems (CSLS): systems that integrate machine, human, and institutional perception, learning, reasoning, and acting to produce major improvements in socio-technical system function, performance, and fitness in complex, evolving, competitive, and hostile environments. Progress in CSLS science, engineering, and design will drive advances in all sectors, from defense to healthcare, education, and beyond. At the same time, CSLS present significant unresolved challenges in systems engineering. This workshop will focus on CSLS, in general, and on the need for advances to underpin the trustworthiness of mission- and safety-critical CSLS, in particular. Issues include but are not limited to allocation of responsibilities across human/social-machine boundaries; test and evaluation, accountable AI; system monitoring and control; systems safety for AI-infused cyber-social learning systems; and use of CSLS concepts, methods, and tools to improve the safety and trustworthiness of existing systems.
MODULAR OPEN SYSTEMS APPROACH

MOSA:
TOWARDS COST EFFECTIVE ACQUISITION STRATEGIES

ABSTRACT:

As the DoD strives to affordably address emerging threats, it is challenged by issues such as component obsolescence, loss of critical suppliers, and planning technology insertion and upgrades for tightly coupled, highly integrated systems. The Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD-CSSE) Modular Open Systems Approach (MOSA) initiative seeks to balance the business objectives with the technical means to meet these challenges through a modularization approach under the auspices of open systems architecture (OSA). In this context, a critical set of new questions arise, at the holistic and localized levels that involve a diverse set of stakeholders across the acquisition life cycle.

Example questions include how to: 1) define modularity and openness contexts (technical and programmatic) in an ecosystem; 2) quantify the costs, benefits, and risks of modularization across multiple dimensions through trade space exploration; and 3) identify compatible policies that can be used to capitalize on the positive aspects of modularization. Progress on these questions will ultimately provide decision-makers within the defense acquisition system to clearly identify opportunities for modularization, identify compatible architectural alternatives, promote system-level innovations, reduce costs, and, most importantly, execute these within a decision-maker friendly framework that does not encumber the overall acquisition process with undue complexity.

This workshop will focus on exploring these questions. Participants will actively contribute to in-depth discussions on 1) defining, quantifying and assessing modularity and openness; 2) generating candidate strategies, cognizant of current barriers and potentially useful incentives; 3) synthesizing a key list of stakeholder needs and/or concerns across a MOSA ecosystem; and 4) mapping beneficial elements of modularization strategies to appropriate acquisition processes that encourage adoption. Participants will also assist in developing a useful repository of case studies (government/industry), including anecdotal evidence and lessons learned in the implementation of modular strategies.

WORKSHOP - OCTOBER 5, 2016
8am – 5pm • Stevens Institute of Technology, Ronald Reagan Building, Washington, D.C.
Workshop attendance is by invitation only.

LEADS:
Dr. Daniel DeLaurentis
Purdue University
Dr. Mitchell Kerman
Stevens Institute of Technology
SERC Executive Director:
Dr. Dinesh Verma, Stevens
SERC Chief Scientist:
Dr. Barry Boehm, USC

For SERC Use Only
Research workshops that we are holding this year...
TENTATIVE
AGENDA

Wednesday, December 6, 2017

8:30 Welcome

8:45 Introductory Remarks: Priorities with Regard to System Assurance (Security, Safety, Reliability) within a Digital Engineering/Acquisition Environment (Ms. Kristen Baldwin, DASD-Systems Engineering)

9:15 Featured Talk: Model-Based Development: What’s New? What’s Needed? (Professor Nancy Leveson, MIT)

10:00 Coffee Break

Government Perspective — Challenges and Opportunities with Enhancing System Assurance in a Digital Engineering Environment:

10:15 Challenges with Realizing Robust System Security in Complex Systems (Ms. Melinda Reed, Deputy Director, ODASD — Systems Engineering)

10:45 Challenges and Research Priorities with Digital Engineering as an Enabler for Trade Space Exploration/Systems Analysis (Ms. Philomena Zimmermann, Deputy Director, ODASD — Systems Engineering)

Industry Perspective — Challenges and Opportunities:

11:15 Hardening Legacy Systems and Cyber Resilient System Architectures (Ivy Thompson, Star Labs)
MANAGING ACQUISITION AND PROGRAM RISK

WORKSHOP
for GOVERNMENT, INDUSTRY & ACADEMIA

December 13, 2017

TENTATIVE AGENDA

Wednesday, December 13, 2017
8:00  Welcome (K. Darlington)
8:15  Scope, Background, and Process for the Workshop (P. Colloy)
8:30  A position statement and a set of challenges on enhancing our ability to assess risks and make informed decisions in the face of risk (J. Thompson)
9:00  Finding, and assessing risk – an insurance industry perspective (David Carl, formerly of Def Horizons Ventures)
9:30  Coffee Break
9:45  Breakout Sessions on Assessing and Communicating Risk
10:45  Debrief by Scribes
11:00  Balancing risk and execution: a view from the investment community (Lou Sherrerg, former CTO, TD Ameritrade)
11:30  Working Lunch in Breakout Sessions on Balancing Risk and Opportunity
1:00  Debrief by Scribes
1:15  Confronting Risks with Flaws and Decisions (Industrial speakers)
1:45  Breakout Sessions on Risk Planning and Investment
2:45  Coffee Break
3:00  Debrief by Scribes
3:15  Plenary Discussion on a path to the future in Risk Management
4:00  Collection of Research Topics
4:30  Rating Research Topics
4:55  Wrap-Up (Dinesh Verman)

ABSTRACT

Risk Management is the context of systems engineering attempts to address two needs:

a) What issues should program managers pay particular attention to?

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. This workshop will explore how the risk process might manage uncertainty better without compromising focus on the primary aspects of a program.

Risk management is an active area of research and practice in numerous domains outside of systems engineering. Whole industries, such as insurance, petroleum exploration and pharmaceuticals, critically depend on effectively managing risk, and they invest in research on making strategic decisions in the face of uncertainty.

The purpose of the workshop will be to consider which aspects of acquisition and program risk management in the defense domain can benefit from focused research. Drawing on the rigorous probabilistic tools, and focusing on effective decision-making as the ultimate purpose of risk management, this workshop will map out a direction for improvement and attempt to articulate three to five research questions that should be addressed.

RESEARCH WORKSHOP LEADER:

Dr. Paul Colloy
- Professor, University of Alabama (Huntsville)

SERC Executive Director:
Dr. Dinesh Verman
- Stevens Institute of Technology

SERC Chief Scientist:
Dr. Barry Boehm
- University of Southern California

To register, please visit: http://www.sercuarc.org/events/serc-workshop-managing-acquisition-and-risk/

PARTICIPATION IS LIMITED — REGISTER NOW!
This is the context of the Pathfinder Project

Visit a number of warfare centers, R&D centers, National Laboratories, and FFRDCs, with the objective of talking to senior technical leaders – with a view to identify systems engineering “pain points”, research priorities, and any strategic workforce considerations

- 12 visits have been completed...
- Another 10 have been scheduled or are currently being scheduled...
1. Sandia National Laboratories
2. Jet Propulsion Laboratory
3. NSWC – Corona Division
4. NSWC – Philadelphia Division
5. Wright Patterson AFB – AFLCMC
6. Naval Air Weapons Station – China Lake
7. AMSAA – Aberdeen Proving Grounds
8. Embedded Systems Institute – Netherlands
9. The Aerospace Corporation
10. The MITRE Corporation
11. AFOTEC – Kirkland AFB
12. Components of the IC
What is driving complexity increase in High Tech Industry?

- **Continuously Evolving Systems**
  The system has both the capability and the need to evolve over time

- **Series-of-one Systems**
  High level of customization of each system delivered, no two systems alike

- **Autonomous Systems**
  System operates without human in the loop, human interaction moves to higher level

- **Systems of Systems**
  The system is an integral part of a larger system without any control of that system

- **X-as-a-Service Systems**
  Not the machine, but the service it provides is the manufacturer’s value proposition

- **Parameters-times-10 Systems**
  All current design parameters (e.g. interfaces, LoC) get one (or more) orders more demanding
## ESI-TNO: Research Roadmap Structure

<table>
<thead>
<tr>
<th>Drivers</th>
<th>now</th>
<th>2 years</th>
<th>5 years</th>
<th>10 years</th>
<th>Vision</th>
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<td>Continuously Evolving Systems</td>
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### ESI-TNO: Research Roadmap Structure, with evolving details

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<td>From preconceived layout to configuring at point of use</td>
<td>Unique products on standard platforms</td>
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<td>Series-of-1 Systems</td>
<td>From happy flow to “all wheather” autonomous operation</td>
<td>Embedded decision making</td>
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<td>Autonomous Systems</td>
<td>From stand-alone to ubiquitously connected SoS</td>
<td>Open systems coalitions</td>
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<td>Systems of Systems</td>
<td>Single feature aaS</td>
<td>Combined features aaS</td>
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<td>X-as-a-Service Systems</td>
<td>Physical features aaS</td>
<td>Large feature sets</td>
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<td>Parameters-times-10 Systems</td>
<td>Lines of code, interfaces, computational nodes grow order of magnitude</td>
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Primary themes during the visits...

- Model Based Engineering – Digital Engineering
  - Various sub-themes
- Tension – System and System Elements on the one hand; and Mission Threads on the other
  - Collaboration and Competition – Computational Policy Framework
- System Security/Reliability/Resilience
  - Particular reference to Distributed Systems (IoT; Cyber-Physical Systems; Mission Threads)
- Analytics and Enhanced Quantification to all aspects of Systems Engineering
- Knowledge Management
  - Legacy and into the future with changing demographics
- Systems Engineering Aspects of Autonomy, AI, and ML, especially V&V
- Agility at the scale of the Enterprise
- Understanding and managing complexity – and its impact on Acquisition Risk
Questions?