



# Systems Engineering Research Center Progress and Directions

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[www.sercuarc.org](http://www.sercuarc.org)

**Goal:** Speed the professional development of highly capable systems engineers and technical leaders in DoD and the defense industrial base

1. *Educate and Train Faster:* Develop innovative approaches to educate and train systems engineers at all levels much more rapidly than classical means to address the shortage of qualified systems engineers
2. *Make Effective Technical Leaders:* Develop innovative approaches to educate DoD technical leaders with the right mix of technical, business, and enterprise skills
3. *Improve SE Education:* Develop recommendations on what to teach the next generation of engineers about systems engineering as well as recommendations to educate the next generation of systems engineers. Encourage and enable their wide adoption so DoD and the DIB can hire better educated systems engineers
4. *Access Knowledge Easily:* Make it easy for systems engineers to understand the SE discipline and to access the information needed to perform systems engineering well so the workforce can master the most important competencies
5. *Track Progress:* Track the changes in SE workforce demographics and performance over time to understand how well the workforce is improving and how well improvement programs are working

**Goal:** Develop safe, secure, dependable defense systems that are resilient to cyber & other threats through systemic security approaches that complement current, incomplete perimeter/network

1. *Design for System Security:* Develop design patterns and security architectures, with corresponding systems engineering principles guiding application, that enable security to be based on the specific properties of the system and its implementation rather than on traditional perimeter strategies
2. *Understand the Cost of Security:* Develop MPTs that enable understanding and predicting the cost of implementing specific security policies and requirements, especially on complex systems and complex systems of systems
3. *Tradeoff Security with Other “Ilities”:* Develop MPTs that enable understanding and predicting the relationship between specific security policies/requirements and other “ilities”, such as reliability, safety, and maintainability
4. *Measure System Security:* Develop MPTs that allow measuring “how much” security a system has and that permits comparison of the relative security between two alternative systems

# Systems Engineering and Management Transformation Research Strategy

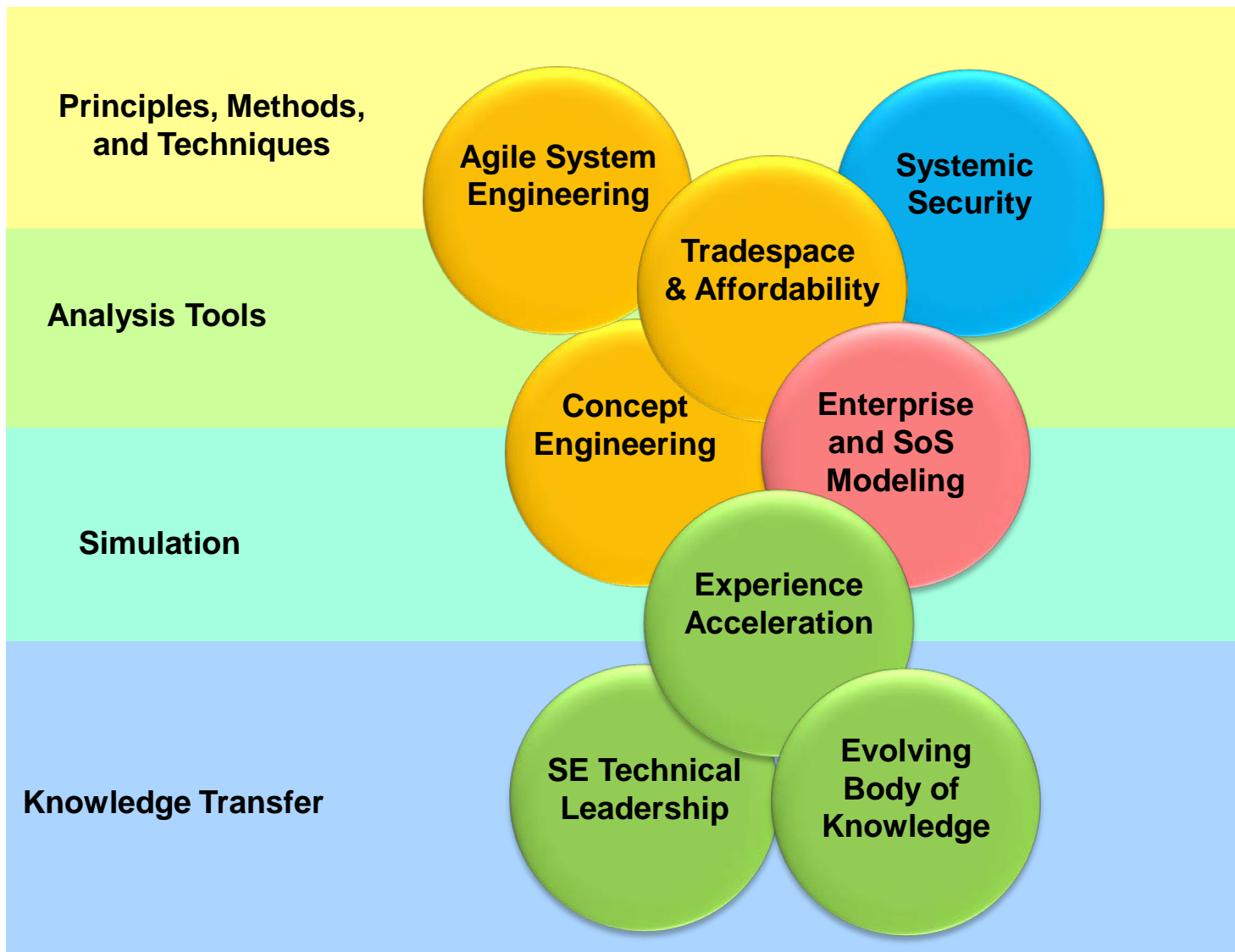
**Goal:** Move from engineering approaches for systems designed for optimal performance against a static set of requirements over long procurement cycles to approaches that enhance the productivity of engineers to rapidly develop cost effective, flexible, agile systems that can respond to evolving threats and mission needs

1. *Make Smart Trades Quickly:* Develop MPTs to enable stakeholders to be able to understand and visualize the tradespace and make smart decisions quickly that take into account how the many characteristics and functions of systems impact each other
2. *Rapidly Conceive of Systems:* Develop MPTs that allow stakeholders to quickly develop alternative system concepts and evaluate them for their effectiveness and practicality
3. *Be Agile:* Develop SE MPTs that work well in the face of high uncertainty and rapid change in mission, requirements, technology, and other factors to allow a system to be rapidly acquired and responsive to both anticipated and unanticipated changes in the field
4. *Align with Engineered Resilient Systems:* Align research to leverage ERS and contribute to it; e.g., ERS efforts to define new approaches to tradespace

**Goal:** Improved engineering to develop and deliver end-to-end defense capability to the warfighter for operation in complex organizational and operational environments, with fewer unintended consequences and unforeseen risks

1. *Model:* Develop MPTs that allow quick and insightful modeling of enterprises/SoSs so that the effects of changes in policies, practices, components, interfaces, and technologies can be anticipated and understood in advance of their implementation
2. *Acquire:* Develop MPTs that allow insight into enterprise/SoS acquisition approaches in the face of significant uncertainty and change to minimize unintended consequences and unforeseen risks
3. *Evolve:* Develop MPTs that facilitate evolving and growing an enterprise/SoS, including insight into different architectural and integration approaches that facilitate evolution in the face of uncertainty and change in how an enterprise/SoS is used, the technologies available to implement it, and the environment in which it exists
4. *Verify:* Develop MPTs that allow the properties of an enterprise/SoS to be confirmed during development and evolution, including for an enterprise/SoS which includes legacy systems that are in operation while development and evolution are underway

# SERC Research Programs and Outcomes



# Current SERC Research Portfolio

## Enterprise Systems and System of Systems

Program	Project
Enterprise/SOS Modeling	SoS Analytic Workbench
	SoS Agent-Based Models
	Multi-Level Socio-Technical System Modeling

## SE and Management Transformation

Program	Project
Tradespace & Affordability	Software-Intensive Systems Cost Estimation
	Quantitative Risk Management
	Tradespace and Affordability
Concept Engineering	Graphical CONOPs
Agile Systems Engineering	Kanban for Agile/Lean SE
	Expedited SE

## Human Capital Development

Program	Project
Evolving Body of Knowledge	Body of Knowledge and Curriculum to Advance SE
SETL Education	Technical Leadership
	Workforce Evolution
	SE Capstone Registry
Experience Acceleration	Experience Accelerator

## Trusted Systems

Program	Project
Systemic Security	System-Aware Security

The current 15 projects build on research from concluded projects

# Annual Sponsor Award Summary (\$000)

	2008	2009	2010	2011	2012
IC	\$346	\$1,478	\$1,017	\$1,117	\$869
ASD(R&E)	\$494	\$1,146	\$4,291	\$4,578	\$3,205*
DAU		\$430	\$800	\$1,239	\$1,268
Air Force		\$180	\$218	\$690	\$48
Army			\$910	\$720	\$175
Navy		\$250			
Other		\$78			
<b>TOTAL</b>	<b>\$840</b>	<b>\$3,562</b>	<b>\$7,236</b>	<b>\$8,344</b>	<b>\$5,565</b>
	<b>\$25,547</b>				

\*Includes \$750K expected to be awarded before December 31, 2012



SERC Strategy Element	Metric	Examples
<p><b>Create Research Ecosystem</b></p> <p><i>Create and strengthen vibrant relationships between the SERC and other organizations, between SERC research projects and non-SERC projects, and among SERC researchers</i></p>	<p>Conduct research which builds on work being funded by others, creating larger more impactful projects</p>	<ul style="list-style-type: none"> <li>• BKCASE (RT-1) to be co-funded by INCOSE and IEEE-CS</li> <li>• Quantitative Risk Management (RT-40) builds on DARPA F6 project</li> <li>• Tradespace and Affordability (RT-46) will build on several non-SERC funded Collaborator efforts such as MIT's Epoch-Era Analysis in SEArI and work with DoD Engineered Resilient Systems Program</li> </ul>
<p><b>Conduct Transformational Research</b></p> <p><i>Conduct longer-term research recognized by the community as high quality with the potential to be transformational</i></p>	<p>Extend research projects by continuing to fund additional research stages or spinning off new projects</p>	<ul style="list-style-type: none"> <li>• In 2012, more than \$4M in additional funding applied to existing projects or to start "spin-off" projects</li> </ul>
	<p>Peer-reviewed papers published in journals, conferences, and books</p>	<ul style="list-style-type: none"> <li>• "A System-Aware Cyber Security Architecture" (RT-28) published in Systems Engineering Journal</li> <li>• "Developing a Stakeholder-Assisted Agile CONOPS Development Process" (RT-30) published in Systems Engineering Journal</li> </ul>
<p><b>Transition Results into Impact</b></p> <p><i>Create the next generation research community; get research results into use in academia, government, and industry</i></p>	<p>Integrate research results into Collaborator courses</p>	<ul style="list-style-type: none"> <li>• Numerous courses that integrate SE Capstone (RT-19)</li> <li>• Purdue AAE560 "System of Systems Modeling and Analysis" use RT36 – SoS Analytic Workbench</li> <li>• Stevens SYS750 "Advanced System and Software Architecture Modeling and Assessment" use RT-30 – Rapid CONOPS</li> </ul>
	<p>Validate, pilot, or adopt research results into DoD and IC programs and organizations</p>	<ul style="list-style-type: none"> <li>• TARDEC using flexible requirements methods developed in RT-26</li> <li>• DAU transitioning Technical Leadership (RT-4) and Experience Accelerator (RT-16) research into their curriculum</li> </ul>