Research Priorities for Systems of Systems Engineering

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INCOSE President
Research Priorities for SoSE

• Several sources contribute to the potential list of priorities and research agenda
  – Transatlantic AREA SoS
  – Systems Engineering Research Center (SERC) research agenda
  – SE of the Future Initiative
  – INCOSE SoS Working Group Research Roundtable
• INCOSE has been collaborating with all of these sources
### Table 1: Priority research themes

<table>
<thead>
<tr>
<th>Rank</th>
<th>Research Area</th>
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<tbody>
<tr>
<td>1.</td>
<td>Engineering for emergence</td>
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<td>2.</td>
<td>Architecture patterns for SoS</td>
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<td>3.</td>
<td>Multi-heterogeneous modelling and multi-notation approaches</td>
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<td>4.</td>
<td>Enterprise SoS, governance and policy</td>
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<td>5.</td>
<td>Trade-off techniques for integration of legacy and managing evolution</td>
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<td>6.</td>
<td>Metric identification/validation</td>
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<td>7.</td>
<td>How to prototype SoS?</td>
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<td>8.</td>
<td>Scenario-based simulation and analysis</td>
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<td>9.</td>
<td>Dynamic SoS</td>
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<td>10.</td>
<td>Security of SoS implementation</td>
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<td>11.</td>
<td>Capabilities, processes and competencies</td>
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<td>12.</td>
<td>Techniques for validation of interoperability</td>
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<td>13.</td>
<td>Qualification of safety or security critical SoS</td>
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<td>14.</td>
<td>Multi-level infrastructure consistency</td>
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<td>15.</td>
<td>Technological issues</td>
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<td>16.</td>
<td>Economic effects</td>
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<td>17.</td>
<td>Political and social user acceptance and legal: mixing criticality – security and safety</td>
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<td>18.</td>
<td>Need for case studies and identification of commonalities across case studies</td>
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<td>19.</td>
<td>Identify and build the constituency and stakeholders in a SoS</td>
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Systems Engineering Research Center (SERC)

**Systems Engineering Research Center (SERC)**

**System of Systems Modeling and Analysis:**

- Create, validate, and transition methods, processes, and tools (MPTs) for analyzing and evolving systems of systems and provide support for their technical assessment, including through a “workbench” of analytic tools
  - Flexible Intelligent Learning Architectures for Systems of Systems (FILA-SoS)
  - Assessing System of Systems Architecture and Acquisition Evolution
  - An Advanced Computations Approach to SoS Analysis
  - Assessing System of Systems Architecture and Acquisition Evolution
SE of the Future Initiative

• Largely in its initial stages
• However, highly recognizes the importance to SoS in the future of systems and SE
• Looking at the need to establish and use systems that are highly interconnected with dynamic changes
  – Dealing with high levels of unplanned changes
• High priority will be the effect of advanced technology application on the SoS and system
• Building in cyber resiliency across the constituent systems and their interfaces
• ...
INCOSE SoS Working Group Research Roundtable

- Many of the challenges facing SoS are the topic of ongoing research
- SoS WG sponsored “SoS Research Roundtables”
  - IS 2012, IS 2014, IW 2016, and IW 2018
  - Presentations are on the INCOSE SoS WG Connect Site
- SoS Webinars regularly feature presentation on SoS research initiatives and results
• Bridging the Performance Gap: Model-Based SoS Engineering and the Learning Digital Twin
• Agent-based simulation framework and decentralized planning algorithm for opportunistic coalition formation in Earth observing systems of systems
• Mission Engineering Competencies
• A Cyber-Physical Systems Approach to Optimizing Internet of Vehicles Architecture with Rapidly Evolving Technology
  – Complex System Governance Research: Advancing System of Systems Engineering
• SoS Analytic Workbench – Reflections on a Successful SERC Project and Directions for Future Projects
• SoS Solutions in Driverless Vehicles
• Lessons Learned from Engineering Emergence Research
Summary of Priorities (Personal View)

- SoS Analysis (e.g., trade-offs)
- SoS Emergence and Dynamics - highly interconnected systems with dynamic changes
- SoS Architecture
- SoS Governance and Policy
- SoS Cybersecurity, Cyber Resilience, and Security Engineering
Path Forward

• Engage INCOSE SoS WG (and others) as key stakeholders working with research programs and academia
  – Stakeholders roles
    • Help shape priorities and definition of research projects
    • Engage experts to work with academia in technical advisory role across life of project
    • Provision of data, as possible
    • Pilot results of research
    • Transition into practice and documentation