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Title: 19th IFSR Conversation – Conversation Topic Application

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Data Driven Systems Engineering Approaches

The Relationship between Systems Engineering and Systems Sciences: Systems Sciences can be described as the application of a systematic approach (systems thinking) that includes tools and techniques from systems analysis, data analysis, computer science, efficiency/ecology, human factors, systems dynamics, and complexity theory towards topics in nature, society, health, and engineering. My interest and research is in the application of systems science toward engineering the total system (Systems Engineering), particularly the analysis of high fidelity data to drive engineering decisions in complex systems, systems of systems, and massively complicated systems. Research shows that many of the systems we take for granted, such as automobiles and airplanes, and the infrastructures that support these systems (system of systems) are becoming increasingly more complicated. The automobile of today contains over a million lines of code; an airplane can contain over 10 million LOC. At the same time, economic and political pressures are being applied to drive down cost and reduce schedules. Systems analysis and data analytic methods are being used effectively in many business use cases. Systems Engineering is responsible for the understanding and control of complex systems. I would like to explore the application of analytic techniques to the Systems Engineering problem space.

Systems Engineering as an engineering discipline is based on assumptions from supporting disciplines such as systems analysis, systems science, and systems think. Therefore, it should be natural to think of Systems Engineering as being data driven. However, my experience finds the contrary. Engineering programs (Products, technology, processes, and people organization) are often based on the processes, organization, technology and product plans of previous programs, whether (or not) those past programs were successful. And little consideration is given to whether those past program processes, tools, technology, people, or organizations are optimally suited for the new product or processes. If Systems Engineering is a true engineering discipline, then I assert that we should use our Systems Engineering methods to design our engineering programs. That is, to use systems analysis methods to systematically model and optimize the program approach. At Sandia, my colleagues and I have a theory that engineering programs should be dictated by the processes and products being developed. This theory is being developed upon progressive data to determine an optimal engineering initiative impact assessment approach for new program selection.

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Contributions to the field of systems science and systems engineering might include:

- Broadening systems engineering to include a holistic view of not just the system, but the system within the supporting system ecosystem and throughout the system lifecycle
- The socio-technical aspects of transition methods, procedures, and tools for complex enterprise systems
- Targeting the application of systems dynamics, discrete, and agent based simulation for the most appropriate situations, component, part, and product sets
- Multivariate modeling of cyber threat potential in a modular bus-based architecture
- Application of game theory to improve complex system development lifecycles
- Using conceptual (UML or SysML) models to describe the competing engineering processes, product evolution, business interactions, and technical interactions of complex, massively complicated, system of systems, or autonomous systems
- Applying big data techniques to mine historical data (such as cost, schedule, or communication data) from multiple massive and independent programs, in order to understand the interdependencies, common threads, and calculate uncertainties
- Apply uncertainty algorithms to predict cost factors for massive programs, using parametric parameters
- Model the social interactions of complex engineering program team members for programs with thousands of team members, in order to understand optimal organization structures, leadership constructs, and decision making approaches

Therefore, I would like to propose a conversation with my international colleagues on what data, processes, and systematic approaches we have collectively experienced to drive engineering program transformation. In particular, I am interested in a conversation about what data, processes and systematic approaches have been successful to transform an engineering program toward a fully digital engineering environment. For example, what data can we show and discuss deeply that documents the justification to transform an engineering program to a model-based engineering approach? As we all know, transformation is often difficult. There are organizational culture issues to resolve, effective and timely training required, expensive tools to support both the engineering and the change processes. As another example, in the transformation toward a fully digital engineering environment (approach and tools) many will start by choosing an engineering tool. However, the process to transform the modeling standards and software applications that will support the engineering processes are often much more complex to define and implement. And as implied above, doing so without also engineering the organization has often resulted in either transformation delay or even outright failure.

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Conversation Team Leadership Interest

I would like to express my interest in being a conversation team leader and participant.

BIOGRAPHY and QUALIFICATIONS:

Edward R. Carroll is a Principal R&D Systems Research Analyst at Sandia National Laboratories with a primary research interest in engineering methodologies and effective transformation. In the past 2 years, he has focused on understanding the optimal application of model-based systems engineering (MBSE), modular architecture, and agile hardware approaches toward meeting Sandia's strategic nuclear weapons engineering objectives. He has over 30 years of experience leading the development of data-intensive solutions to automate engineering programs and business decisions through analytic models. Ed directed his own consultancy for 14 years, and provided leadership in executive roles in business development and technology, including roles as vice president of engineering for Egghead.com, director of technology at Nike, and director of software engineering at Boeing, and is a retired Naval Aviator. Ed received a BA in Liberal Art from Arizona State University, a MS in Systems Management from the University of Southern California, and a Graduate Certificate in BioMedical Informatics from Oregon Health Sciences University.

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