



Systems Science:

Tuesday, March 22, 2016

Meeting Room 1

Towards a theoretical foundation of systems engineering

Raman Kumar Agrawalla

God created system engineering and engineers to solve problems, to solve practical and complex problems; and help create useful, robust, resilient and agile systems (physical and cyber-physical, technical and socio-technical, socio-digital and socio-cultural systems; business systems) for the benefit of the mankind and the society at large. And it is said that system engineering gets its sustenance from the body of knowledge emerging out of the systems movement comprising ideas as assimilated in the systems theory and cybernetics, especially from the tradition of the general systems theory and systems science. However, of late there is a realization that the science of system engineering has lagged behind and the field of system engineering is in the dire need of a theoretical foundation for its continuing sustenance and success. The dreams of Ludwig von Bertalanffy to have a 'general system theory' in the real sense of the term and a 'general science of wholeness' and that of Norbert Wiener to have a 'unified science of control and communication', yet not fulfilled. However, the good news is that now there is a silent movement undergoing to unearth and unravel a systematic and systemic theoretical foundation for system engineering. The present paper is an effort towards this direction and it holds the view that the systemic theoretical foundation of system engineering can be created within a decade given the concerted and collaborative individual and institutional efforts by the researchers, scientists and the system engineers.

In the present paper, a theoretical foundation of system engineering is propounded in terms of what I call 'a positive sum value theory' of systems engineering. We can state that the systems engineering of the value-co-creating system is conducted in such a way that it creates and delivers a *positive-sum value* and it ensures a *positive value for all* the stakeholders of the system; that can be explained creating cases of the 'input-transformation process-output' system in systems engineering. Our theoretical foundation of system engineering is based on our analytical framework that derives its basis from the synthesis of some 'dualities' namely means and ends, known and unknown, thinking and doing, shallow and deep learning, effortful and autonomic systems, bounded and unbounded rationality. In fact, our analytical framework builds on both analytics and systemic at the same time.

The palm: a systems generational evolution story

Katherine Burris and Dr. L. Dale Thomas

The objective of this survey paper is to investigate the new idea of systems generational evolution. This concept examines how a system evolves and how one generation of the system differs from another. Looking to biology as a basis for this preliminary research, the process of technological evolution has noticeable similarities. An exploration of Palm's personal data assistant (PDA) life cycle provides a good framework of the idea that is systems generational evolution and how man has yet to harness the wisdom of nature in the ongoing evolutionary cycle. Items beneficial in exploring the context of this new idea are mathematical evolutionary models, understanding how non-natural elements affect systems generational evolution and having a concrete classification system of systems. The balance that nature achieves between adaptation and the chaos of evolution equates to a balance of knowing what and when to evolve.

Integrating Systems Engineering Knowledge into the Education of ALL Engineers, Research Challenges

Richard Adcock

The International Council on Systems Engineering (INCOSE) have an interest in the role of Systems Engineering (SE) knowledge in all types of education. This paper discussed work to explore ways of understanding, promoting and enhancing the value of Systems Engineering Knowledge in the university education of all Engineers. This aim was identified through a series of workshops and discussions. This topic provides INCOSE with an opportunity to promote the wider value of SE within engineering and to collaborate with other international education organizations.

A forum was held in May 2015 to discuss these ideas with the aims of bringing together a community of interest in SE education, including people outside of the existing INCOSE academic community and creating useful information and outputs, which can be used to support this transformation. This paper will discuss the results of this forum and how it is shaping the authors own research agenda.

The scope of SE Knowledge used in this work is based on the scope of the SE Body of Knowledge (SEBoK) and includes relevant systems thinking and systems practice knowledge; knowledge on how individuals and organizations do SE; relationships between SE and other disciplines and the application of SE across a broad range of application types and domains. This paper will look in particular at the research challenges raised by this initiative and discuss some of the activities planned for 2016 and beyond.

Ensuring Continued Enterprise Resilience: Developing a Method for Monitoring Health

David Lowe and Mike Yearworth

In January 2015, the British Secretary of State for Defense stated that his department “*must not merely be match-fit, it must be permanently fit*” in order to be ready to meet the full range of operational tasks. This paper describes research that is being conducted in response to this challenge and that, once complete, will address key shortfalls in the evidence base required to support executive decision-making. The aim of the research is to investigate how large and complex enterprises can be engineered to ensure continued resilience - i.e. that they will always be able to perform in the future environment. This paper also describes the development of a systems engineering approach (using hierarchical process modelling) for monitoring the health of the enterprise as an enabler for this continued resilience.