

Chapter 1.26

The Role of Systems Engineering in the Development of Information Systems

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ABSTRACT

In this article, the inter-relationship between information systems (IS), systems engineering (SE), and information system development (ISD) is discussed from past, present, and future perspectives. While SE is relatively a well-established discipline based upon an interdisciplinary approach to enable the realization of successful systems, ISD has evolved to a variant of SE applied mainly for the development of IS. Given the growth in complexity and cost and schedule over-runs associated with software centric systems, well-established methodologies are needed for the development of good IS. Similarities and differences of methodology as well as their evolution and perspectives are also presented herein. We found a positive trend in the evolution of research methodology in SE

and its use in IS towards a system's approach as a holistic methodology.

INTRODUCTION

The title of this article seems like tautology or at least a redundancy, but was conceived to support the vision of the new *International Journal of Information Technologies and the Systems Approach*. Applying a system approach (SA) and its interaction with systems engineering (SE) for a better understanding and development of the information systems (IS) disciplines is one of main goals of the new journal and also this article. Our task is twofold: to analyze the significance of IS for SE and its methods as well as the relevance of SA and SE for the development of IS. Both of

them are important and distinct. It is impossible to utilize SE and SA methods without proper IS, and conversely you cannot develop cost effective and efficient IS without disciplined SE or SA approaches. However, there has historically been a difference in the methods used for the IS development and other sociotechnical systems using SE. These differences in methods were caused by user experience and established practices although economic and technical developments will lead to their convergence. Our aim in this article is to generalize and highlight these different methodologies and their relevance for research of the vast variety of processes where IS and system's methodologies are essential conditions.

The word "system" can broadly be defined as an integrated set of elements that accomplish a defined objective (INCOSE, 2004). Simply put, a system is a whole consisting of parts and is more than sum of its parts. That was an axiom of ancient philosophers, which accurately anticipated the contemporary definition of systems. Only order, structure, and behavior were added to the meaning of systems in cybernetics and general systems theory. Complex systems are usually understood intuitively, as a phenomena consisting of a large number of elements organized in a multilevel hierarchical structure where elements themselves could represent systems (Mesarović & Takahara, 1989). The word "complex" is used only to indicate that the problem treated here cannot be expressed only in hard (quantitative) relations, and those many relevant characteristics are qualitative. With a conception of complex systems, we think about a system within which a main role is played by a complexity of control and information processes. Undoubtedly, existing SE methodology is applied to small, medium, large scale, and complex process but with complex systems, SE moves to a SA methodology. Fortunately, these same SE techniques that have been successfully applied to complex systems are also being applied to systems of systems (SoS) and large enterprises.

A paradigm of SE has played important roles in the dealing with different aspects of human activity. In the beginning, it was based on empirical knowledge and heuristics in the building of human-made objects like pyramids, fortifications, tools, and so forth. Industrial production and scientific organization began with Ford Motor and F.W. Taylor who contributed to work specialization, planning, and control. The result was mass production, standardization, and higher productivity at defined quality levels. This period of worldview in science and production was known as the Machine Age and was marked by its use of classical analysis for problem solving (Ackoff, 1999). Systems engineering was subsequently born in the telecommunications industry of the 1940s and nurtured by the challenges of World War II (WWII), when project managers and chief engineers with the assistance of key subsystem leads oversaw the development of aircraft, ships, and so forth. The post-WWII creation of more complex systems, mainly in defense and communication systems, led to the formalization of SE as an engineering discipline. Its relevance became indispensable after WWII, when systems—technical, production, and organizational—became highly complex. A landmark for systems philosophy was founded in General Systems Theory (Bertalanffy, 1968) and Cybernetics (Wiener, 1948) and continued to be adapted to the different contexts and tools, taking new meaning and significance with successive ages as indicated by Ackoff (1999). The history of civilization development and growth is closely related to the history of working methodology and organization.

Although modern definitions of SE are of a later date, there are several books and papers on this topic, which discuss SE and the system engineer in great detail (e.g., Martin, 1996; Sage, 2000; Thomé, 1993). Some examples of modern SE definitions are shown in Table 1. This explanation is derived from the root of two words: "engine" and "systems." An engine is a device consisting of different parts. Engineers are those who construct

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