Chapter 3.22
Capacity for Engineering Systems Thinking (CEST):
Literature Review, Principles for Assessing and the Reliability and Validity of an Assessing Tool

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ABSTRACT

To successfully perform systems engineering and/or designing IT architecture roles, the systems engineers and IT architects need a systems view or a high capacity for engineering system thinking (CEST). This paper discusses the essence of this capacity, presents principles for developing a tool for assessing the CEST and presents a tool developed for use in selecting engineers for jobs that require CEST. A tool for CEST assessment may be useful for several purposes, one of which is the effective selection of candidates for engineering positions that require high CEST. The tool was tested and implemented in a pilot study aimed at examining its reliability and validity. Two types of reliability and four types of validity were checked. Then, a second study aimed at strengthening the results of the pilot study was conducted. The findings of the two studies indicate that the tool may prove to be a validated instrument.

INTRODUCTION: SYSTEMS ENGINEERING, IT ARCHITECTURE AND ENGINEERING SYSTEMS THINKING

Systems thinking, according to Senge (1994), is a discipline for seeing wholes. *Engineering Systems Thinking* is a major high-order thinking skill that enables individuals to successfully perform systems engineering tasks (Frank, 2002). To successfully perform systems engineering and/or designing IT architecture roles, both systems engineers and IT architects need a systems view or

a high capacity for engineering systems thinking (CEST). Despite its importance, no high-quality tool exists as yet for CEST assessment, which may be useful, for example, in enabling a more effective selection of candidates for engineering positions that require high CEST. The current paper discusses the essence of this capacity, presents principles for developing a CEST assessment tool, and presents a tool developed for assessing the interest for job positions requiring high CEST and in selecting engineers for jobs that require CEST. The paper presents the results of two studies aimed at validating the tool.

As modern technological projects have increasingly become larger, more complex and interdisciplinary, systems engineering and designing Information Technology (IT) architecture have come to play an ever-increasing a major role in projects. In the IT sector, IT architects play the same role that system engineers play in engineering organizations, which is being responsible of seeing the whole picture of the system.

The main functions of systems engineering in technology-based and projects are: requirements analysis, functional analysis, architecture synthesis, systems analyses, verification and validation and optimally integrating individual components into a whole system that meets specific systems-level requirements (INCOSE, 2004). According to Sheard (1996), the twelve systems engineering roles are requirements owner, system designer, system analyst, validation and verification, logistics and operations, "glue", customer interface, technical manager, information manager, process engineer, coordinator and "others".

According to Frank and Waks (2001), *Engineering systems thinking* is the ability to:

1. **See the big picture:** the ability to: grasp and understand the whole system and the big picture, conceptually and functionally, without understanding all its minutiae and all of the system's details; understand the interconnections and the mutual influences and interrelations among system elements/sub-systems/assemblies/components/parts; describe a system from all relevant perspectives (a well-known approach for categorizing the required views distinguishes between operational views, system views, and technological views); derive the synergy of a system from the very integration of the subsystems; identify the synergy and emergent properties of combined systems; understand the system as a whole and anticipate all the implications (including side effects) of changes in the system, engineering and non-engineering alike; understand and describe the operation, purposes, applications, advantages, and limitations of a new system/sub-system/idea/concept immediately after receiving an initial explanation, and remedy system failures and problems.
2. **Implement managerial considerations:** the ability to grasp and implement managerial, organizational and broad-perspective considerations.
3. **Acquire and use interdisciplinary knowledge:** the ability to: deal with multi-tasking and interdisciplinary knowledge; use this knowledge for developing the concepts of operation, logical solutions (functional analysis), and physical solutions (architecture synthesis); make analogies and parallelisms between systems; implement systems design considerations; conduct –ilities analyses (availability, maintainability, etc.), and run simulations and optimization analyses (Frank, 2002).
4. **Analyze the needs/requirements:** the ability to capture, understand and analyze the customer/market requirements/needs and future technological developments.
5. **Be a systems thinker:** the ability to be curious and innovative, to be an initiator and independent learner, and to have the ability to develop and ask good questions**.** CEST is also required in designing and managing information systems.