

## System of Systems Engineering Collaborators Information Exchange (SoSECIE)

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### What Systems Engineers Should Know About Emergence

*Presenter: Prof. Jakob Axelsson  
Mälardalen University and RISE Research Institutes of Sweden*

#### Abstract

The concept of emergence refers to phenomena that occur on a system level without being present at the level of elements in the system. Since a system is created to achieve certain emergent system-level behavior, while avoiding other emergent properties, a deeper understanding of emergence is crucial to further the field of systems engineering. It has also been identified as one of the key aspects of systems-of-systems. However, the concept has been the topic of much debate in philosophy, systems science, and complexity science for a long time, and there is yet no precise characterization on which there is general agreement. In this paper, a selection of the literature on emergence is reviewed to identify some key characteristics and disputes. The various philosophical points of view are analyzed from the perspective of systems engineering, to sort out what characteristics have practical implications, and which philosophical quiddities are merely of theoretical interest. The paper also relates emergence to systems engineering practices and suggests some tactics for dealing with emergence. Key results are that the inclusion of an explicit observer is essential for understanding and handling emergence, and that emergence is closely related to the amount of information required to describe the system which is also a defining characteristic of complexity.

#### Biography

**Jakob Axelsson** received an MSc in computer science in 1993, followed by a Ph.D. in computer systems in 1997, both from Linköping University, Sweden. He was in the automotive industry with Volvo Group and Volvo Cars 1997-2010. He is now a full professor of computer science at Mälardalen University, Sweden, and a senior research leader in systems-of-systems at RISE Research Institutes of Sweden. His research interests include all aspects of systems-of-systems engineering. Prof. Axelsson is a member of INCOSE and has served as chairman of the Swedish chapter.

