

11th CIRP Conference on Intelligent Computation in Manufacturing Engineering, CIRP ICME '17

## Application potentials of systems engineering for small and middle-sized enterprises

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### Abstract

To overcome future product development challenges, the application of Systems Engineering is important for small and middle-sized enterprises. Content of this paper is an analysis of application potentials of Systems Engineering principles for those enterprises especially in comparison to global international companies and organizations which shape Systems Engineering. Furthermore the results are validated by an example enterprise. The aim is to provide a realistic assessment of those potentials and support the use of Systems Engineering.

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Peer-review under responsibility of the scientific committee of the 11th CIRP Conference on Intelligent Computation in Manufacturing Engineering

*Keywords:* Systems Engineering; SME; Potentials for application; Product development.

### 1. Introduction

The increasing globalization leads to an intensive competition and requires that enterprises develop cost and time efficient. Furthermore consumer demand focusses on products, which extensively satisfy individual needs and encompasses present high-tech technologies. These technologies are characterized by rising technological and organizational complexity and multidisciplinary. The development approach Systems Engineering enables to handle these challenges and supports an appropriate development of nowadays systems [1,2,3]. Hence the importance of Systems Engineering rises continuously in several economic sectors. Especially within large, technical orientated enterprises and organizations, Systems Engineering is basis for the development of complex products and services. Although Systems Engineering is a generic approach [3] and theoretically fits to all kinds of systems, services and organizations, small and medium-sized enterprises (SMEs) rarely use it [3,4]. This is a remarkable finding, because studies show that managers of those enterprises are aware of challenges regarding to the development of present and future products and anyhow do not use Systems Engineering [4]

Present Systems Engineering approaches are not appropriate for SMEs, because they have been developed for or by large

enterprises or organizations and are not adapted to the unique characteristics of SMEs, who work in a more informal and less documented manner [5,6].

This is not sufficiently considered by existing approaches. Therefore it is necessary to enhance the actual standards and adapt them to SMEs to make the benefits and advantages of SE useful. The efforts to introduce Systems Engineering to those enterprises should be enlarged, because the number of SME's is significant. In year 2013, 99,8 % of European nonfinancial enterprises we classified as SMEs, employing fewer than 250 persons [7]. This is depicted in Figure 1. Presently the support is limited to the endeavor of INCOSE, the International Council of Systems Engineering.

Type of enterprise	Number of employees	Annual turnover (EURO)	Number of enterprises (% of overall)	Number of enterprises
Micro-enterprises	1 - 9	≤ 2 million	92.2 %	19 968 000
Small enterprises	10 - 49	≤ 10 million	6.5 %	1 358 000
Medium enterprises	50 – 249	≤ 50 million	1.1 %	228 000
SMEs, total	87 100 000		99.8 %	21 544 000*
Large enterprises	> 250	> 50 million		
Large enterprises, Total	42 900 000		0.2 %	43 000

\* Independent companies only, excluding legally independent companies that are part of large enterprises.

Fig. 1. Size of Enterprises in Europe [7].

INCOSE organization published the standard series ISO/IEC/IEEE 29110 to facilitate the application of Systems Engineering for very small and micro enterprises, but there is a lack of detailed research for SMEs.

This paper will analyze application potentials of Systems Engineering for SMEs and validate the result by means of an example enterprise. The consideration of practical aspects shall improve the acceptance of possible users and lift the dissemination of Systems Engineering. To understand the methodology of Systems Engineering and actual research concerning the application for SMEs, the state of art is presented in section 2. Section 3 focusses on Systems Engineering principles and its application potentials for SMEs. Within section 4 these potentials are validated for an example SME enterprise. Section 5 concludes with a discussion of results and an outlook on future research.

## 2. State of the art

### 2.1. Systems Engineering

Systems Engineering is a structured multidisciplinary approach for the development of complex technical systems to achieve a multidisciplinary optimum in specified time frame and budget. For this, the disciplines are structured in technical models and linked together [8]. This definition represents the ideas and principals of the approach. Particularly, emphasizes has to be draws to multidisciplinary, frontloading, which describes the focus on the beginning of development process, and consideration of technical as well as organizational and managerial tasks [9]. Systems Engineering is described as a holistic approach, which deals with all stages of life cycle of the System of Interest (SOI) [1, 10]. It is based on Systems Thinking, which means the clear definition of the system, its elements, its connections and the separation from the environment by definition of boundaries. [1, 3, 10].

INCOSE (International Council on Systems Engineering) describes Systems Engineering in its Handbook by processes, which are detailed in context diagrams. These processes contain Technical-, Technical Management-, Agreement-, Organizational Project-Enabling- and Tailoring Processes [3,11]. An overview is shown in Figure. 2. For application of Systems Engineering it is necessary to configure the process-catalogue according to individual circumstances. This adaption is called tailoring and means to translate a holistic approach into a practical application [3]. The realization of tailoring contains two steps of adaptation:

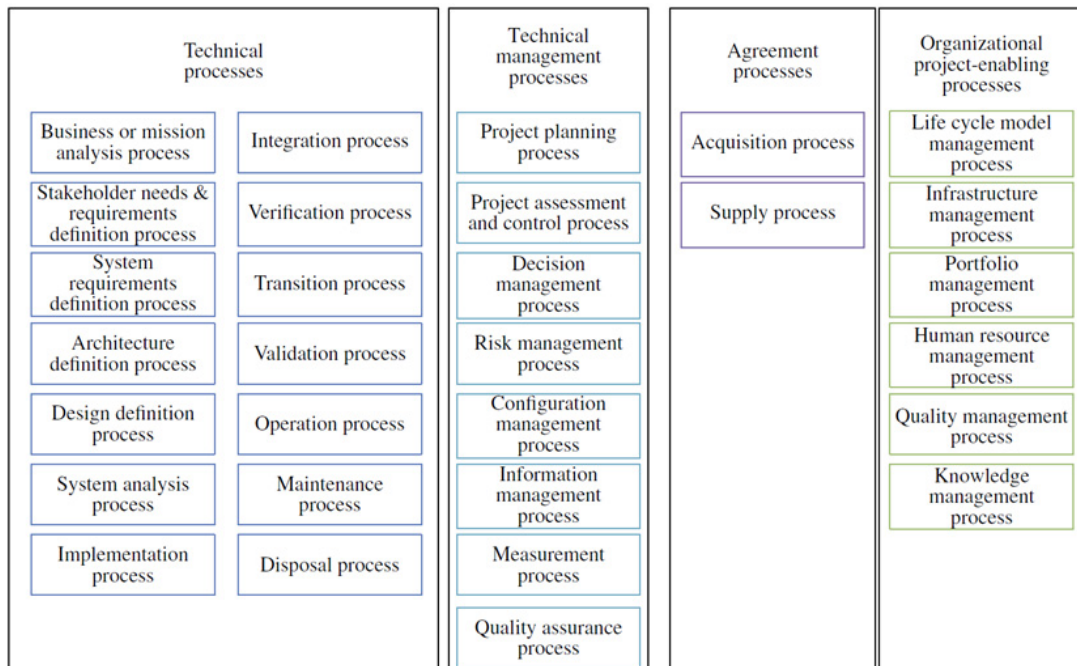


Fig. 2. INCOSE's Systems Engineering processes [3].

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