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Systems Engineering Management Based on a Discipline-Spanning System Model

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Abstract

In many current development projects targets concerning time, cost and quality are often not achieved. This is due to the complexity of the product and its engineering processes. The conceivable development of information and communication technology will enable advanced mechatronic systems. Their manifold system functions, the cross-linking of elements within the system and their hardly manageable interactions induce a much higher complexity in the development process and make it much more challenging than today. As approaches of Model Based Systems Engineering (MBSE) get more and more accepted within industry, they can be the foundation for a better management of the product development process. Due to this, we state that model based systems engineering forms the basis for systems engineering management to ensure, that project targets are achieved. In this contribution we point out, how a discipline-spanning system model can be used as the core of system engineering management: We introduce a modelling technique and its utilization for project planning as well as assessment and control. We present approaches for planning operational structures as well as technical reviews and further for measuring development progress and product maturity on different system hierarchy levels, using the information modeled within the system model.

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1. Challenges within the Development of Complex Systems

The products of mechanical engineering and related industrial sectors, such as the automobile industry, are often based on the close interaction of mechanics, electrics/electronics and software engineering, which is aptly expressed by the term mechatronics. The conceivable development of communication and information technology opens up more and more fascinating perspectives, which move far beyond current standards of mechatronics: mechatronic systems having an inherent partial intelligence. These intelligent systems have the ability to react autonomously and flexibly on changing operation conditions. Further they are able to communicate and cooperate. The result is a network of intelligent systems.

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This opens up fascinating perspectives for the development of future mechanical engineering products. Besides these perspectives the development of intelligent systems also implicates some challenges. The noticeable increasing functionality of intelligent products, the cross-linking of elements within systems and their hardly manageable interactions induce a high complexity in the development process and make it challenging. Many engineering projects run into deep trouble, because they cannot manage these product and process complexity. As a consequence cost, time or quality targets fail. To challenge these increased complexity an effective cooperation and communication of the developers from different disciplines during the whole development process is required. An approach to manage these challenges is Systems Engineering and especially Systems Engineering Management.

2. Systems Engineering as a powerful Approach to Manage Product Development

Systems Engineering (SE) is a holistic and interdisciplinary approach to enable the realization of successful systems. It integrates systems thinking, discipline specific engineering approaches (methods, tools, and procedure models), human sciences, and management aspects [1], [2]. Systems Engineering's mission is to ensure 1) effectivity ("do the right things") and 2) efficiency ("do the things right") of product development. That means, that the task of systems engineering is to make sure that the right product is developed, with the aim to reach high quality at the first go with low costs. This is why there is not only a technical but a management component of systems engineering. Accordingly Systems Engineering is about looking at the "big picture" of product development [3].

Figure 1 illustrates the components of the system engineering approach according to HABERFELLNER et al. [4]. The approach describes product development as problem solving process. That can be distinguished into two components: system design and project management. **System design** addresses the basis design work. Core task is the creative development of the solution. This is where techniques like Model Based Systems Engineering (MBSE) are used. **Project management** dedicates to the organization and coordination of the problem solving process.

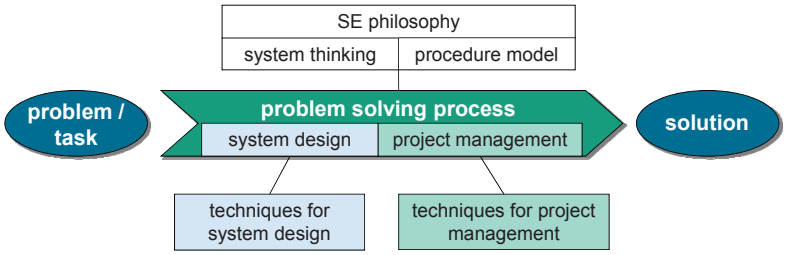

Fig. 1. Systems Engineering Approach according to HABERFELLNER et al. [4]

Product development can only be successful, if technical and organizational issues are considered. **System Engineering Management** brings both, system design and project management, together. It focuses on the engineering aspects of a project and addresses the following aspects: planning, assessment and control, risk management, measurement, decision management, configuration management, information management, and quality management. At this systems design provides the technical aspects respectively inputs; whereas project management provides the cost and time inputs [2], [3], [5].

According to the **5-layer model** the techniques and concepts of Systems Engineering (SE) and Systems Engineering Management can be used on different levels: product SE, project SE, enterprise SE, industrial SE, and socio-economic SE [6]. At his, each layer is an integrative part of the superordinated layer. As a consequence the product layer forms the basis for a holistic SE. As a consequence a lot of information for the other layers, have specified already at the product layer respectively in an overall product/system model. One example is, that project SE requires information about the technical and organizational interfaces for planning the development process.

Hence **Model Based Systems Engineering** (MBSE) becomes the basis for a successful system engineering management. It provides techniques for the holistic specification of a system model and can deliver all information, which are necessary to manage product development on the different layers. MBSE addresses the formalization of almost all models beginning in the conceptual design phase and continuing throughout development and later life