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Development of optimized test planning procedures for stabilizing ramp-up processes by means of design science research

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Abstract

Unplanned engineering changes represent a major field of disturbance during production ramp-up. They require time-consuming qualification and approval procedures for product- or process-related redesign. Numerous engineering changes during production ramp-up can be traced back to lack of product maturity, not sufficiently increased during the precedent stage of product development. By applying effective and efficient product testing processes, product maturity can be measured and enhanced at an early stage. As a consequence, unplanned engineering changes can be avoided. Nevertheless, contemporary test management procedures lack of methodological support, especially in the field of test planning. To date, the successful evaluation of testing demand and selection of necessary test specifications mainly depends on the expert knowledge of the test management team. The present paper focuses on the development of optimized test planning procedures in order to accelerate early product maturity enhancement for stabilizing production ramp-up processes. Following design science research methodology, the relevance of the problem statement in the application environment of production ramp-up will be assessed. Furthermore, approaches of the knowledge base related to test management will be analyzed in order to constitute rigor of the applied research approach. Based on the evaluation of business needs from the relevant environment as well as the investigation of application knowledge, a research framework for deriving optimized test planning procedures is presented.

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Keywords: Quality assurance; Test; Planning;

1. Introduction

1.1. Motivation for research in test management within ramp-up management

Production ramp-up can be considered as the final stage of product development. [1] It links finishing activities of product and process design with the stage of volume production and consequently plays an important role within the product life cycle. During production ramp-up, numerous disturbances occur impacting the performance of the production system related to target levels of volume, cost and quality. A major field of disturbance is represented by unplanned engineering changes which can be traced back to insufficient product maturity during the precedent stage of product development [2]. Consequently, the reduction of unplanned engineering changes caused by lack of product maturity is a major goal for both producing companies as well as research activities in ramp-up management.

An important field of action for the above named challenges is represented by the area of test management. By planning and conducting engineering tests during product development, confidence in the proper fulfilment of product requirements can be gained at an early stage of the product life cycle [3]. Furthermore, testing activities are able to uncover product-inherent defects [4]. The knowledge about requirement fulfilment and defects offers the opportunity to increase product maturity during early stages of product development.

As production ramp-up is frequently characterized by lack of product maturity, the present paper is based on the hypothesis that activities of test management during product development are performed insufficiently. Hence, product-inherent

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defects remain concealed until production ramp-up and lead to engineering changes at a late stage of product life cycle. Consequently, further research in test planning is required in order to enhance product maturity at an early stage of the product life cycle and hence to stabilize ramp-up procedures due to decreased occurrence of engineering changes.

1.2. Objective and structure of the paper

According to the methodology of design science research, the paper presents the results of the investigation of business environment as well as the relevant knowledge base. Current business needs are stressed and the deficits of existing knowledge and approaches are elaborated. Based on the results, a research concept for the improvement of test planning procedures is presented. The concepts aims at optimizing test planning procedures for early product maturity enhancement. This is expected to stabilize ramp-up processes by less unplanned engineering changes.

The paper is structured according to the methodology of design science research. Chapter 2 provides an overview of research methodologies applied in ramp-up management and gives a short introduction to design science research. Chapter 3 focuses the relevant business environment in order to analyze business needs. In chapter 4, the related knowledge base in terms of techniques, models and methods from different fields of research is elaborated. Based on the results both analyses, a research concept for the optimization of test planning procedures is presented in chapter 5.

2. Design science research

2.1. Research methodologies within ramp-up management

Research methodologies represent a systematic approach to the effective exploitation of scientific knowledge [5]. By applying established research methodologies, a comprehensible line of arguments and thus profound research results can be achieved [6].

The field of ramp-up management is especially investigated by the research disciplines of engineering science and management science [7]. Both disciplines have their well-established research methodologies. Table 1 provides an overview of applied research methodologies in doctoral thesis of recent ramp-up research, which has been institutionalized in the Research Training Group "Ramp-Up Management" by the German Research Foundation (DFG).

Table 1. Research methodologies applied in ramp-up management research.

Lemma of ramp-up research work	Author	Year	Research methodology
Quality inspections within the ramp-up of assembly systems	Basse	2015	Ulrich 1984
Efficient commissioning within end-of-line assembly	Janßen	2015	Ulrich 1984
Control of product realization processes	Stiller	2015	Ulrich 1984
Evaluation of substitutional risks of manufacturing processes	Buchholz	2014	Ulrich 1984
Cybernetic planning of production programs	Schürmeyer	2014	Ulrich 1984
Mechanisms for synchronized production plant design	Wesch-Potente	2014	Ulrich 1984
Discrete migration strategy for ramp-up of assembly systems	Gartzen	2012	Ulrich 1984
Ramp-up-based technology planning	Nau	2012	Ulrich 1984
Performance management of ramp-up processes	Renner	2012	Hevner 2004
Quality-oriented management of ramp-up processes	Schmitt	2012	Ulrich 1984

According to table 1, the most common research methodologies applied in research of ramp-up management relate to economic sciences as application-related social sciences introduced by Ulrich in 1984 [8]. However, the research methodology of design science (DS) research, as summarized by Hevner et al. [9] or Peffers et al. [10] shows great promise of applicability within other design-oriented communities, such as engineering fields [11] or the area of ramp-up management [12]. Fundamentals of DS research and its applicability for research work in the field of ramp-up management will be stated and discussed in the following sections.

2.2. Fundamentals of design science research

The methodology of design science research has been created in order to provide a reference process for conducting design science research based on existing approaches in literature and to provide researchers a mental framework for research approaches and outputs [10]. Basically, DS research has its roots in engineering and artificial sciences and is based on a problem solving paradigm [9]. Figure 1 provides a visualization of the framework for information systems research, combining approaches from behavioral-sciences and design science paradigms. On the left side, the environment constitutes the problem statement research activities intend to address. In the context of research for information systems, the environment can be modeled by the application domain, represented by involved people, related business organizations, technologies and technical systems as well as occurring problems and opportunities. The investigation of these areas enables a carved-out problem statement with requirements from the business perspective that need to be addressed.

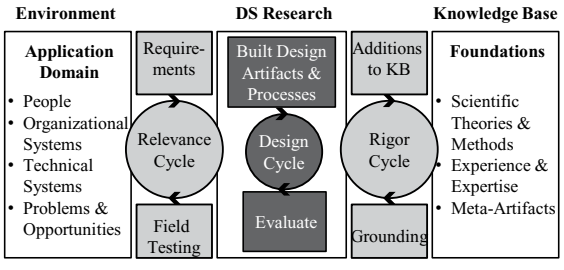

Fig. 1. Framework for Design Science Research [11]