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## Engineering product and process design changes: A literature overview

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### Abstract

Engineering product/process design changes are unavoidable and necessary for improvement & innovation. To capture the maximum market shares, manufacturers have to effectively and efficiently manage engineering changes throughout the entire product life. In this paper a comprehensive literature review on engineering change management in product/process perspective is presented. Engineering design changes can be taken in both aspects, such as an opportunity or as a burden. Different methods have been proposed by the researchers for better understanding of engineering change phenomenon. The insight regarding the changes propagation during the engineering design is crucial because a large number of artifacts are results of the predecessors. This article discusses the significant aspects of engineering changes, product architecture, propagation paths and highlighted the methods and tools that are proposed by the researchers. This paper will help researchers and managerial staff to get an idea and awareness about the change propagation and its impact. The review shows the prominence of engineering change management and concluded that the interest in the research field is escalating gradually.

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### 1. Introduction

Engineering design change is one of the most influential factor for product innovation. In recent years, engineering change and its management has gained popularity in academic research and as well as in industry. First literature review on engineering change was published in 1997 by Wright [1]. He reviewed literature between 1980-1995 and found few publications on this topic. Due to its popularity overtime, different literature reviews have been conducted by the researchers [2,3]. Most recent literature review has been conducted by Hamraz et al. [3], which reviewed the literature published till September 2011. One of the main purpose of this article is to give an overview of engineering product / process design change management. In this paper, publications after September 2011, are reviewed.

Increasing competitiveness in the market due to fast growing change environment, forces the industrialists to pursuit ways to manufacture a high quality product at a minimal cost with least possible time. To reduce the risk, manufacturing cost and time, companies have promoted focus

on the incremental products. Thus, the aim of the designers is to change as little as possible. Most of the new designs are refined versions of the existing designs developed through alterations and changes to the current design [4]. These products have new characteristics, functions and performances that depends on the current product design. To satisfy the customer's requirements, these products are usually available in different kinds, which can require considerable changes to the initial design. Consumers are anxious about the product trustworthiness and thus they are hesitant to use too many unverified components [5]. The information regarding product parameters increases in quantity and also in quality as the design proceeds and provides a better insight of the design issues. In order to avoid undesired change propagation, designers may restrict propagation by freezing product components or their interfaces. Freezing the component design in early stage can restrain novelty, product improvement. On the other hand unfreezing the product elements can trigger the design iterations and increase the cost of redesign. In such cases the optimal freeze order has to be determined.

The phrase “do it right the first time” is far from reality and very difficult to be applicable [6]. Engineering design changes have been recognized as unavoidable in the development of complex engineering product [5,7]. Engineering design changes have huge influences on production activities and hence making the activity of product development very pricey and prolong [7]. In the early decades the engineering changes were predominantly seen as a problem. People were reluctant to implement the change management system. From the past few decades it has been seen that industrialist take it as an opportunity and source of innovation and creativity [8]. Engineering design changes can facilitate to perform modification and error elimination in existing products. As a result, the product manufacturing cycle time decreases and manufacturers can launch new products to the market in least possible time. Engineering design changes can be taken into account as a driving force for incremental product improvement as customers are interested in more customized products. Keeping in view the above, knowledge attained from engineering changes is very helpful and useful for the design and development of the product. In the field of manufacturing, today’s markets and consumers demand changes so quickly. Engineering design changes arises frequently for continual improvement of system or artifact.

The methodology to carry out the literature review is given in Section 2. Section 3 describes the definition and categorization of ECs and objective of ECM. In Section 4, product architecture has been elaborated. Section 5 gives an idea about the change propagation. Section 6 discusses the engineering change process. In Section 7, tools and methods to support ECM have been presented. Finally, Section 8 summarizes the paper.

## 2. Methodology

The research commenced with a rigorous literature review on current engineering change management practices. To conduct the literature review on engineering change management, different journals and conferences were focused for the review process and procedure.

### 2.1. Literature selection

In order to carry out the review on selected topic, a systematic collection of articles is carried out. It consists of following four phases.

**Phase-1:** In the first phase, the literature review conducted by Hamraz et al. [4] is accessed thoroughly. Some of the references mentioned in that article are relevant to other research areas, thus the paper which are related to the core field of engineering change management are selected. This article covers the literature review till September 2011.

**Phase-2:** In the second phase, collection of publications from October 2011 to August 2015 has been done by consulting multitude of journals and conference proceedings related to engineering change management and design. The main journals which are used as a source for the related

papers/articles are: Journal of Engineering Design, Computers in Industry, Computer Aided Design and Applications, Design Studies, IEEE Transaction on Engineering Management, Research in Engineering Design, International Journal of Design Engineering, International Journal of Computer Integrated Manufacturing, Computer and Industrial Engineering, Knowledge Based System, Journal of Computing and Information Science in Engineering, Systems Engineering, Artificial Intelligence for Engineering Design. Conferences proceedings which were included in the literature review are: International Design Conference (IDC), ASME International Design Engineering Technical Conference, International Council of Aeronautical Sciences, CIRP International Conference on Life Cycle Engineering, Conference on System Engineering Research, International Conference on Engineering Design (ICED) and International Design Structure Matrix Conference (IDSM).

This phase started with listing down the publications which include the term “change” in the title, abstract and in keywords. Then the selected articles are thoroughly checked to shortlist the publications regarding engineering product and process design change.

**Phase 3:** In the third phase, the citation record of the core publications in the field of engineering change management maintained by Scopus were accessed thoroughly and the related publications are shortlisted.

**Phase 4:** In the fourth phase, an open search for the word “engineering change” was carried out with the help of search engines “Google Scholar”, “Scopus” & “SpringerLink” and the related papers are downloaded.

### 2.2. Publication’s distribution over year

The final list of publications including journal articles and conference papers selected through the aforementioned approach contains 366 publications. 247 publications out of 366 were selected from the literature review conducted by Hamraz et al. [4]. These articles are related to the core field of engineering change management, published till September 2011. The remaining 119 articles are collected for a period from October 2011 to August 2015 through systematic approach. The publications distribution over year is presented in Figure 1. From this graph it has been concluded that interest in the field of engineering change management steadily increased till 2007 where it get its first peak. From 2008 onwards up to 2012 there is a decrease but still remains at the higher level than the period before 2006. From 2013 onward there is again increase in the number of publications. 182 (49.73%) of the publications are journal articles and 184 (50.27%) are conference papers.

### 2.3. Citation analysis

To view the relation between the research articles, citation analysis has been carried out. Database maintained by Scopus has been used for this analysis. The most cited paper is written by Eckert et al. [8]. It is also mentioned by Hamraz et

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