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Target-oriented prototyping in highly iterative product development

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Abstract

The realization of radical innovations is a critical success factor in today's markets. When traditional sequential development processes are employed the high degree of uncertainty connected to these innovations results in a long and costly development time, potentially leading to failure of the project. The paper at hand recommends highly iterative prototyping processes based on findings from the software industry where agile processes, mostly Scrum, are widely employed. In the development of physical products, prototyping is often unsystematic which is considered as a major obstacle to an efficient agile development process. This paper presents a systematic method of prototyping in the context of physical product development in order to gradually reduce the high degree of market and technological uncertainty associated with radical innovations. The prioritization of requirements is suggested to be the basis for the design of adequate prototypes. An analytical information-oriented approach is presented that continuously takes into account the amount of uncertainty in the dimensions market, product and process. The evaluation of the specific ratio of benefit and effort connected to the implementation of the requirements leads to their prioritization.

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Keywords: Physical Product Development; Agile Product Development; Highly Iterative Prototyping

1. Introduction

Short product life cycles and continually increasing customer requirements characterize today's markets. The majority of established manufacturing companies have difficulties to launch radically innovative hardware products at high speed - an essential ability to succeed in this dynamic environment [1,2]. The dominant approach in physical product development, the sequential Stage-Gate process model, is overstrained with the realization of radical product innovation [3]. Companies must rethink and restructure their processes to meet the requirements for a successful development of radical products [4]. Based on these thoughts, in this paper, we present a prototyping approach suitable for a highly iterative product development processes.

1.1. The characteristics of radical innovations

Radical innovations are characterized by a high degree of both market and technological uncertainty [5]. This fact makes it harder to control them compared to evolutionary and incremental innovations with their medium and low degree of uncertainties, respectively. The high degree of market uncertainty of radical innovations results from a lack of clarity about the target market and the market potential. Customer requirements are unknown and the willingness to pay cannot be easily estimated [5,6]. Technological uncertainty can be classified in terms of product and process. Concerning the product, a lack of information regarding technical specifications and technical feasibility exists for radical innovations. Furthermore, technical challenges are often unclear and the cost of development is difficult to predict. Regarding the process, a variety of alternative production processes and unknown production costs are characteristic for

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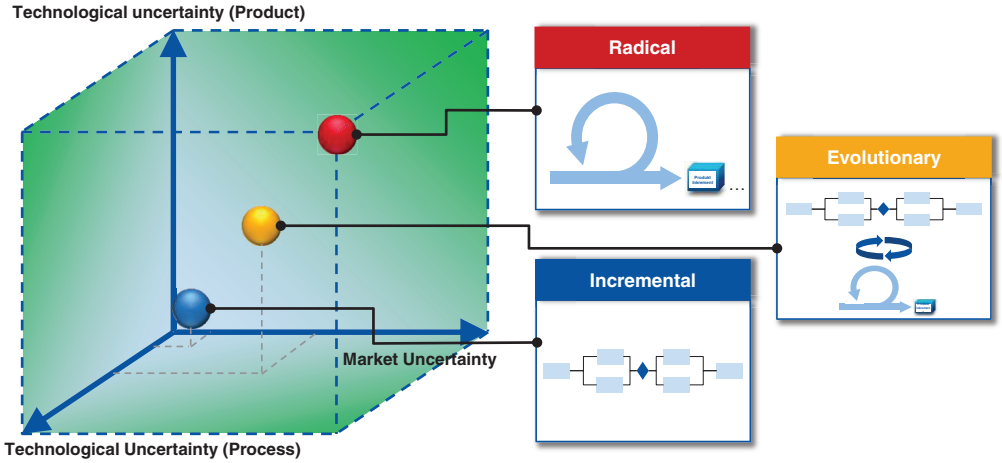

Figure 1 – a) Position of radical, evolutionary and incremental innovations according to their level of uncertainty (left); b) Visualization of the suggested development processes for the three types of innovation (right)

radical innovations [5,7]. In Figure 1 a) the three types of innovations mentioned above are positioned in a graph according to their specific level of uncertainty in the dimensions market, technology (product) and technology (process).

1.2. Development processes as a function of uncertainty

In his article What's Next?: After Stage-Gate Cooper states that "one size should not fit all": The product development process should be adjusted to the specific degree of uncertainty [8]. In the case of incremental innovations which are based on existing market knowledge and technological know-how, it is appropriate to make use of approaches which systemize the process of innovation. Therefore, Cooper developed the Stage-Gate model, which structures the innovation process into separate phases [9]. A further reduction of the time to market and the development costs could achieved by a parallelization and forward displacement of activities, as with Concurrent Engineering and Front-Loading [10,11]. In the case of radical innovations, however, a learning-oriented approach is recommended [12]. Contrary to the clear hierarchical structures that are commonly used to manage daily operations, a high degree of agility and flexibility is necessary to give development teams more creative freedom. Being open to new ideas, as well as working target-oriented rather than process-oriented, are the basic enablers for successful market innovations [4]. Concerning evolutionary innovations a mixture of agile andsequential processes is suggested. Figure 1 b) visualizes the suggested types of development processes for the specific types of innovation.

1.3. Prototyping in agile process structures (Scrum)

In the development of software, sequential approaches have been identified as too bureaucratic and "heavyweight" due to an extensive documentation and strict project role divisions [13]. For this reason, the popularity of agile development processes has increased significantly: A comprehensive assessment of industrial surveys of agile software development shows that the usage of agile methods worldwide is reported at about 55% [14]. Among various agile frameworks, Scrum is the most commonly used one. It structures the work in a development project along so called Sprints. These Sprints are of fixed duration and take place one after the other. Every Sprint starts with a Sprint Planning in which a cross-functional team selects the top-prioritizes items of the Product Backlog. The Product Backlog is a list of items containing short descriptions of all functionalities desired in the final product. The items can range from specifications and requirements, to use cases, epics, user stories, or even bugs and chores. The team commits to complete a specific amount of items by the end of the Sprint. During the Sprint, the chosen items and the overall aim do not change. At the end of it, the Product Increment, the sum of all the Product Backlog items completed, is reviewed with all stakeholder interested in the Sprint Review. The feedback obtained can be incorporated into the next Sprint, again in the form of items. [15]