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Agile predevelopment of production technologies for electric energy storage systems– a case study in the automotive industry

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Abstract

Curtailing development periods in the automotive industry require concurrent predevelopment of new products and production technologies. Volatile requirements and complex interdependencies are the main challenges which agile methods originating from software development are designed for. To examine transferability of several agile methods to the predevelopment of hardware, the authors first theoretically analysed existing methods regarding their potential. While adopting the most promising methods, a case study regarding the production technology for electrical energy storage systems was conducted. It showed that many agile aspects and tools are easily adoptable and help developers in the early stage depending on group size and complexity. They contribute by ensuring that complexity remains manageable, encouraging close teamwork, improving information circulation and supporting transparency. Thus agile methods supplement concurrent predevelopment.

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Keywords: Agile methods; production technology; predevelopment; hardware Scrum; e-mobility; technology transfer; product generation development

1. Introduction

One crucial factor to success in industries with quickly developing technologies lies in a permanent generation of technology innovations with a rapid transfer to series production. Companies pay attention to effective and efficient predevelopment activities for production technologies affecting both future product design and suitable manufacturing systems. Challenges in the predevelopment derive from high complexity, high level of novelty and variability and relatively low structure [1]. In the field of disruptive technology (such as in the electric car industry) requirements quickly change as products are altered radically during the development process. Thus concurrent predevelopment in the early stages is important for the handling of complexity and an efficient industrialisation of innovations.

In earlier studies the authors identified communication barriers regarding requirements, necessary tasks and project's progress as major obstacles for an efficient predevelopment [2]. Changing requirements lead to problems in deadline compliance for technology transfer.

Agile methods originating from the software industry were designed for similar purposes. They help in managing complexity and can increase the efficiency under open requirements. They been transferred for different non-IT purposes and validated successfully. Based on similar circumstances an application for the predevelopment of production technologies seems feasible.

This paper first presents an overview about agile methods and the state of the art regarding usage of agile methods in non-IT-applications. The focus lies on the adaptation of agile methods including a case study conducted in a predevelopment project regarding production technology for battery module assembly at a German car manufacturer. We validated the method's usability including expert's feedback. The article's purpose is to present the methods and their adaptations, the observations we made in practical use and the expert's assessment on how much these methods can contribute to a successful industrialization of predeveloped technologies. The major contribution of this article to the current state of research is a validation of agile methods in industry adding the perspective of early development stages.

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2. Research Question and Methodology

2.1 Research Question

This paper investigates the research questions: “Are agile principles and methods applicable in the predevelopment of production technologies?” and “are these methods useful to support technology transfer to the series development?”

We accompanied a running project to evaluate the hypothesis: “Using agile methods in predevelopment projects helps transfer barriers such as open and changing requirements, inefficient communication and a lack of transparency with relation to the necessary activities and project progress”.

2.2 Research Methodology

We analysed the main challenges attached to different predevelopment arrangements in literature matching them with our experience in practice. In the next step an analysis of the state of the art describing agile methods (especially Scrum and extreme programming) in non-IT applications was conducted. We identified the most promising approaches for the application in predevelopment that can help to overcome the obstacles described. We adopted them to fit with a running project concerning a new production technology at a car manufacturer. In the role of Scrum masters, we trained the project team and accompanied the project for three months testing. We identified advantages and disadvantages by participatory observation during project meetings and took interviews with experts after each project iteration. Finally, a feedback meeting with an evaluation of the method’s benefit was carried out. We used a questionnaire asking the project team members about their estimation of the extent to which each agile method can help overcoming the barriers in technology transfer. We asked “Can the method contribute to overcome the obstacles described?” referring to the aspects outlined in the introduction of this paper. We provided an end-named scale reaching from “very low contribution” to “very high contribution” for the evaluation.

3. State of the Art

3.1 Process in predevelopment of production technologies

The main objective of predevelopment activities is the generation of new concepts, including a proof of feasibility i.e. a reduction of risk for series development projects. Predevelopment is commonly arranged in stand-alone projects with separate funding carried out by separate departments. If feasible technologies have to be taken into account by both product development and process planning from series development projects for implementation into new production systems. Generally, there are two major ways of arrangement: Separated from series development or integrated. The separated approach leaves more room for innovation and has the advantage of higher innovation rates but commonly faces the problem of transfer over department interfaces [1]. Integrated predevelopment provides easier prioritization of objectives and tasks and easier transfer. On the other hand, it involves risks of low prioritization of predevelopment in times of capacity shortages and lower chance for “think out of the box”-solutions [3]. For these reasons large companies often have separated organizations [1]. Especially for projects which are driven by technological potential for improvements in production rather than necessity for product realization problems in transfer to series development occur: Lack of flexibility for quick adoption to changes, obstacles in the communication and coordination over department interfaces and disregard of other department’s needs [3, 1].

3.2 Agile Methods

Augustin [4] defines agility as “the ability to deliver customer value while dealing with inherent project unpredictability and dynamism by recognizing and adapting to change“. Highsmith [5] summarizes “agile” by five major objectives: continuous innovation, product adaptability to future requirements, reduced delivery schedules, people and process adaptability and reliable results.

The main principles of agile software development were published in the “agile manifesto” by Beck et al. [6] in 2001. Twelve principles describe the basic rules of agility. Characteristics differing from a traditional approach common to all agile methods include an active user involvement into the project, a self-deciding interdisciplinary team, an iterative procedure with a fixed time scale, development in small incremental releases and a permanent testing of results.

Agile project management provides a large set of specific methods for the implementation of these principles. Many of them are described in the framework Scrum, which is the most commonly used method [7]. Another widely spread similar framework is “extreme programming”. Agile methods have been detailed in the IT-sector and are now spreading over different non-IT areas. The most common methods that were identified in the analysis of literature are illustrated by table 1 [8, 9].

There is no distinct line between “agile” and “non-agile” and many agile aspects can already be found in the predevelopment of production technologies (see table 1). Serrador [10] published a survey showing that 65 % of the identified projects had some agile component. The author found that the greater the agile/iterative way the higher the project success. For this reason, many researchers have worked on approaches for agile transfer into different areas (often called agile tailoring) over the past years. Campanelli [11] recently presented a wide ranging literature review on 56 studies with around two thirds of the papers using empirical research methods.

3.3 Transfer to the predevelopment of non IT-Projects

The only approach for agile predevelopment was published by Gonzales [12]. The author introduced a conceptual model on how agile principles can be applied in the predevelopment stage of innovation. Gonzales proposes an increase in speed and effectiveness as a result. The paper does not present any validation or detailed explanation for specific implementation in practise. Lima et al. [13] developed a model for the co-development of software and hardware based on Scrum on a solely theoretical basis. Hardware development is divided into short phases linked to software design using agile principles. The authors do not show a validation of practical benefit. The project “Wikispeed” developed an entire car prototype using Scrum. It works in self-organizing teams with 44 members using one-week iterations. The team re-evaluates each part of