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Using e-mobility as an enabler for a fast and lean product development to optimize the return of engineering with the example of lithium-ion battery

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Abstract

As innovation cycles for new technology products accelerate, markets also demand more complex products with a highly individualized design. Particularly, electric cars represent this case and complexity is not only driven by product variants, but also by an increasing proportion and importance of software applications in value creation. However, the reference processes to develop these automotive products were established two decades ago. The reference process which is used by automotive OEMs is the integrated product and process development which bases on the concept of simultaneous engineering. In contrast to conventional cars with a combustion engine, product architectures for electric vehicles can be planned differently with the lithium-ion battery as the central and most expensive component and can be designed with more degrees of freedom. Such a product architecture can also be simplified that complexity is reduced for both, the product and the development process. Changes in terms of product architecture also imply that there are changes in the technological knowledge of the automotive OEM. It must focus on key technologies. Consequently, suppliers have got the chance to advance from suppliers, who produce products on demand, to technological experts, who provide technology platforms. The development process, moreover, has to evolve from typical stage-gate-concepts to a more agile process tailored to suit continuously changing requirements to fulfil the demand for a fast product qualification for series production. So, even shorter innovation cycles and time-to-market periods can be reached. Certainly, this has an effect on financial aspects with the objective to design the organisational process as lean as possible. Finally, the more agile process design serves an optimised ratio between engineering expenses and customer value – called Return on Engineering. It is the central paradigm to which process design and methods for product development need to adhere.

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1. Introduction

E-Mobility has gained more and more significance over the recent years. This will rise in the future with emission regulations for automotive companies which can only be adhered to if electric vehicles have a certain share in product portfolios. Electric vehicles contain new components and functions. These components do not only concern the drive train (electric engine, battery pack and power electronics), but also other functional elements like electric parts and software applications. Overall, automotive companies (named OEM hereafter) are challenged to industrialize disruptive technologies and to integrate them into the vehicle with a rising significance of e-mobility. [1]

A shift in the customer's expectation can be observed with the mentioned changes in product functions and components.

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Whereas vehicle dynamics and drive train performance have been a major criterion in market differentiation before, nowadays such criteria are range provided by the lithium-ion battery, connected systems and connected services. [2]

Regarding perspectives of future developments for the battery as a key component, automotive companies may need to reorder their key competences. Formerly, those companies had full know-how of performance parts, e.g. combustion engine. Today, performance is mostly defined by the battery and almost every automotive company does not develop and build battery cells by themselves, but buy them from suppliers. And for the future, it is not clear, whether it will stay this way or if know-how of battery cells will be acquired by OEMs.

For these described changes in the electric automotive product and shifting proportions in importance between mechanical and electric parts, it is inevitable to imply adaptions for the development process in the same way.

This paper therefore discusses how the methodic approach of product development can confront the described changes in automotive products and market demand. Upon the background of state-of-the-art product development, three key enablers will be identified to overcome the mentioned challenges.

2. Background

The paper emphasizes three fields of research concerning a fast and lean product development in the context of e-mobility. Firstly, integrated product and process development is examined. This is followed by an encounter of principles of scrum, an agile development method. Additionally, the paradigm of Return on Engineering and its implications are outlined.

2.1. Integrated Product and Process Development

In an effort to fulfill and improve customer satisfaction and meet the competitive global market – the simultaneous product engineering evolved into Integrated Product and Process Development (IPPD). This concept was conceptualized in the 1990s. Since then various industries have had implemented and refined it. Per definition the IPPD is “a management technique that simultaneously integrates all essential acquisition activities through the use of multidisciplinary teams to optimize the design, manufacturing and supportability processes. IPPD facilitates meeting cost and performance objectives from product concept through production” [3].

Within the domain of IPPD, the specialized Integrated Product Team (IPT) is responsible for development and delivery of the product to the market [3]. The time-to-market is very crucial for market domination within the lifecycle of the product. Therefore, the boundaries of design scope are reduced insignificantly at the early stage of product development allowing a significant reduction of the time-to-market. Other than just aiming to capture market domination by achieving reduced time-to-market, IPT has to ensure that the product produced meets the quality standards. For which, the team should be able to develop a sustainable standardized process and product development. This ought to be realized by identifying, quantifying and determining all the relevant restrictions of the product and process [4]. This will lead to the possibilities of process standardizations during the product development process.

One basic concept for process standardization for the IPPD is the Stage Gate Model. Its name derives from the alternation between process phases (stages) and milestones (gates), where deliverables of the previous phase are considered and a decision is made, whether the next stage can begin or work content from the previous stage has to be repeated for better results. The decision is made by a specific committee [5]. The scheme of the Stage-Gate-Process is given in figure 1.

The objective of stage gate model is to eliminate less promising innovations in the development process at an early stage and to minimize financial risk [6].

Today the stage gate model is implemented in various industries involving themselves in product development processes [7]. To fulfil the quality perceptive of product and to eliminate resources being wasted, precise stage wise result oriented definition and monitoring of process specific content is essential. The effectiveness of stage gate model is realized with the aid of various quality decision points, it is determined based on the current status if the process of the project is to be continued, adapted/revised or to be terminated [8]. If the desired quality criteria are not met the development process cannot pass a gate. Quality gates provide a distinct checkpoint where specifically defined requirements are reviewed in a coordinated effort between process customer and process supplier or product customer and product supplier [9].

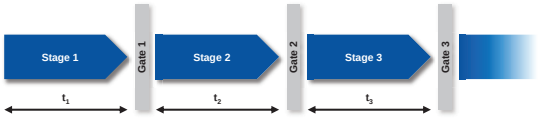

Figure 1 Visualization of a generic Stage-Gate-Process

2.2. Scrum in an Agile Product Development Environment

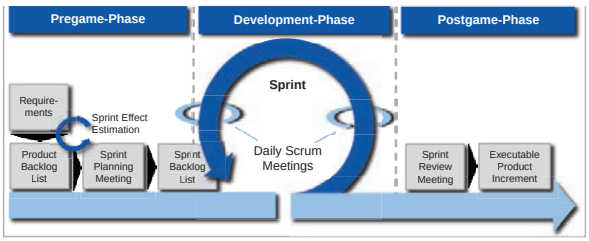

Figure 2 The Scrum Approach [13]

An agile method which is used in industrial planning processes is Scrum [10]. Its basis is the assumption that development processes take place in a volatile environment. This means that the course of the project is not foreseeable with changing variables like availability of qualified personnel or unplanned occurring obstacles. [11] For this, scrum is an empiric approach to handle the complex situation