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FIELDS OF ACTION FOR THE REALIZATION OF CONTINUOUS INNOVATIONS

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Abstract: *Due to growing global competition and heterogeneous and short-term changing customer needs, manufacturing companies have to enhance their innovation frequency. In addition, the extension of product life cycles is required to consider the demand of sustainability. In order to face these challenges continuous innovation becomes more important. Although, the importance has already been recognized, challenges for the realization of continuous innovation have not been sufficiently resolved. In this paper the challenges for the realization of continuous innovation are described. Furthermore a systematic and holistic framework including eight fields of actions is derived, which contribute to the realization of continuous innovation.*

Key Words: ***Innovation management, Continuous innovation, Product life cycle***

1. INTRODUCTION

Manufacturing companies are confronted with an increasingly dynamic market environment [1, 2]. Additionally, an increasing competition leads to a shortening of the product life cycles in order to keep pace with competing products [3]. Furthermore the ever faster changes of specific customer demands require also a faster product development to address these requirements repeatedly and promptly in products [4].

Traditional innovation approaches for new product development cannot address these challenges sufficiently, because these are often less flexible with regard to customer-specific short-term adjustments. The consequence of not meeting the described challenges is a reduced customer satisfaction and thus a loss in competitiveness. To address the dynamic market environments and ensure competitiveness, manufacturing companies need to focus on continuous innovation [5].

The realization of continuous innovation leads to the required increase in customer satisfaction through the frequent launch of new customer-centric innovations throughout the product life cycle. It also helps to overcome the increasingly shorter product life cycles and minimizes the need for effort-intensive development for constantly new products. Consequently, it offers the possibility to address the changing customer needs through new and constant innovations

In addition, the realization of continuous innovation helps to extend the product life cycle. This reduces the waste of resources and thus contributes to the important topic of sustainability [6, 7]. Fig. 1 illustrates the potentials of continuous innovations, as customer satisfaction could be increased over time within the life cycle of a product.

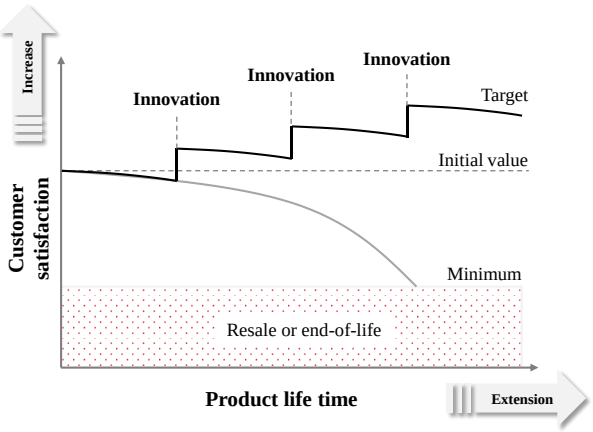

Fig. 1. *Schematic customer satisfaction over time*

In conclusion continuous innovation becomes more important and one of the primary goals for companies [8]. Companies are able to build up competitive advantages and increase customer satisfaction by incorporating and addressing changing market conditions [8]. Furthermore, the realization of continuous innovation addresses the necessity to strengthen the focus on sustainability.

The idea of continuous innovation is not fundamentally new. Successful companies such as Apple, Google, Hewlett-Packard or General Electric have already adopted it for software products [9]. However, the understanding of continuous innovation is not sufficiently embedded in many companies for the innovation of hardware products and currently available approaches do not mention fields of action for its realization [10, 11].

For this reason, the aim of the paper is the development of a holistic framework, in order to systematically derive fields of actions for the realization of continuous innovation. Therefore, the paper is structured as follows. After the motivation, the second chapter focuses on the fundamentals and related work. Within the third chapter, a matrix-framework shown in Fig. 3 is derived and described in detail from the scientific literature. The framework consists of two dimensions from the context of the product life cycle on the one hand and four challenges to be considered in the context of the holistic implementation of continuous innovations on the other hand. Consequently, there will result eight fields of actions, which will be described in detail in chapter four. The paper ends with a summary in chapter five.

2. FUNDAMENTALS AND RELATED WORK

This section outlines the relevant basics, definitions and related work in the context of this paper. For this, the focus is pointed on the following three topics: innovation, product life cycle and in particular the research area of continuous innovation.

2.1. Innovation

Within the scientific literature, various definitions exist for the term innovation. In general, Thushman describes an innovation as a product, which addresses the satisfaction of a market need [12]. According to Schumpeter, the idea can be distinguished to the innovation in terms of the degree of market maturity [13]. Thereby, an idea is only called an innovation when it is successfully launched on the market [14].

In addition, three different types can be recognized mostly in scientific research: Product innovations, process innovations and business model innovation. Within this paper product innovations as well as relevant adaptions regarding the business model and processes are addressed in the context of continuous innovation [15, 16]. Thereby, the transformation from the initial idea to a successful innovation is structured through the innovation process [14]. If the innovation process is described as a phase-oriented process model, it is divided into many different phases in the existing literature [17]. However, the basic phases are idea generation and selection, conceptual design and development, and market launch and dissemination [18]. Thereby, the innovation process can be implement, among other things, according to the classic state-gate concept, more flexible or agile approaches, or according to hybrid approaches which combine these two approaches [19]. In the implementation of continuous innovations, both the early phases of the innovation process and the later dissemination aftermarket lunch as well as the type of implementation must be taken into account.

Furthermore, innovations can be differentiate according to the degree of innovation intensity in incremental and radical innovations [17]. In the context of continuous innovations, the focus is primarily on the further development of existing products and thus rather on incremental innovations [10, 20].

2.2. Product life cycle

Since continuous innovation addresses the linkage of development and usage as also described in context of the innovation process, a brief description of product life cycle is given. Each product of a company passes through different phases in its life cycle. But there are various definitions in the models of product life cycles [21–24]. Continuous innovation focusses mainly on the development and the usage phase as well as the iterative linkage. Within the development phase the generation of an idea as well as the development of the idea into a product concept is conducted. The usage phase starts with the use of the product at customer side and ends before recycling or disposal of the product.

2.3. Continuous innovation

There are different definitions of continuous innovation in the scientific literature, which contain various aspects depending on the focus - process, organizational or product focus [10, 11]. Based on Lianto et al. and White the following definition serves as the basis within this paper: Continuous innovation describes a holistic approach for the continuous identification of customer needs during product usage as well as the development, integration and delivering of new functions, components, technologies or services [10, 25].

In software development, the term continuous innovation is often mentioned in combination with DevOps. The artificial phrase DevOps is made up from the two words "development" and "operations". These represent the organizational departments, which are separated from each other in traditional development processes, but closely interconnected in the context of DevOps. The goal of ongoing new software delivery is pursued, known as continuous delivery. Also frequently used in this context is the term continuous integration, which describes the approach to enable the fastest merging and testing of new software changes [26]. Thereby, DevOps supports the acceleration of the collaboration between the development and operations where further development of products can be implemented during the usage phase [27].

In the approach “Always Beta”, Schuh et al. attempt to transfer the DevOps approach inspired by software to cyber-physical products [27]. The underlying idea of their approach of a continuous evolvable state of a product version, addresses the previously defined understanding of continuous innovation. Thereby, four key phases called monitor, evaluate, adapt and release as well as enabler were derived in order to realize DevOps for cyber physical products. However, the phases are primarily focused on usage data in development and do not focus extensively the other topics in the context of innovations like the business model, product itself, the process or the culture.

Within the approach of Cole the change from continuous improvement to continuous innovation is described in detail [20]. Lianto et al. present a comprehensive definition of continuous innovation, illustrate the need for continuous innovation and describe fundamental elements of continuous innovation capabilities. In addition, six overarching strategies for the

continuous innovation development are described based on the grouped continuous innovation strategies [10].

But, the strategies derived from the literature from Lianto et al. do also not fully address the relevant topics product, process, business model and culture defined above to realize continuous innovation and the current challenges. Rather, they focus on organizational aspects mainly. Other approaches, like Saunila or Lianto et al. focus primarily on the performance measurement of continuous innovation [28, 29]. Specifically, Lianto et al. provide numerous criteria and indicators in their model for measuring continuous innovation capabilities of manufacturing companies [28]. However, there is no overarching presentation of relevant fields of action or similar from the practical and scientific context.

Schuh et al. describe interdependencies between customer-centric continuous innovation in subscription business [30]. Thereby, continuous innovation needs to be included in the business model in order to be successful. Within the approach, a management model is presented that represents continuous innovation as the interface between the subscription business model and the organization to deliver continuous customer value. This demonstrates the relevance of the right business model in connection with continuous innovations but the object area in this management model is only on the organization and the associated organizational enablers.

In addition, the google model approach is often mentioned in the context of continuous innovation. Steiber compares findings from empirical studies of Google Inc. with further organizational characteristics for continuous innovation. In the publication "The Google Model", Steiber derives six management principles for continuous innovation. The focus lies on organizational perspectives, company culture, management guidelines and the capabilities that a company or an organization must have in order to be able to implement continuous innovation. The (cyber-physical) product itself and its technical implementation are not the focus. [11].

In conclusion, none of the described approaches provide a systematic and holistic overview of fields of action for the successful realization of continuous innovation. Although individual capabilities and enablers are presented and challenges outlined, it is not always referred to all topics for the realization of continuous innovation with regard to products, business models, processes and culture. Moreover, the approaches do not sufficiently focus on the necessary objectives of increasing innovation frequency and the design of sustainable product life cycles. For this reason, it is necessary to derive a holistic research framework and identify fields of action for the realization of continuous innovation.

3. DERIVATION OF THE RESEARCH FRAMEWORK

The aim of this paper is to present a framework that describes fields of action for the realization of continuous innovation in the manufacturing industry. The research framework is based on two dimensions.

The first dimension of the research framework is derived from the product life cycle. The decisions that are relevant for the usage phase and the product's life cycle are made often during development. Therefore, development has a major impact on the design of product life cycles and though also sustainable product life cycles [31]. In contrast to traditional innovation approaches, continuous innovation does not focus exclusively on the development phase. It also focuses on the usage phase and, in particular, on a targeted link between the usage and development phases [32]. Hence, the development and usage of products represent the two overriding phases of a product life cycle in context of continuous innovations and thus represent the first dimension of the research framework.

The second dimension of the research framework is derived from the design thinking approach. In general, there are various approaches to successfully create and implement innovations. The design thinking approach developed at Stanford University is an established and well-known innovation management method which is both recognized in science and successfully applied in practice. The approach required the consideration of the three elements: Technical feasibility, economic viability and human desirability [33]. In addition, the consideration of people and organization is a key for the success of continuous innovation [34]. The integrated consideration of these aspects support the success of an innovation within the market [35]. Based on these four elements four main challenges for the realization of continuous innovation could be described.

The first challenge is derived from the dimension human desirability. Customers usually do not require a product, but rather want to have its functionality. Due to the high level of differentiation and individualization of the "jobs to be done", the realization of these by physical products is challenging [36–38]. To address the challenge the research question must be answered as to how products have to be designed in the context of continuous innovation?

The second challenge arises from the technical feasibility and thus aims at the process to generate (continuous) innovations. Thereby, companies are confronted with the challenge to identify the right potentials for the further development of their products and to transfer the potentials into new product features [43]. Consequently, it is necessary to analyze how the required processes have to be structured in the context of continuous innovation.

The third challenge is derived from the economic viability and targets the required business models. The actual challenge is to operate the approach continuous innovation economically. 61% of the companies cited an incompatible business model as one of the biggest reasons why continuous innovation cannot be implemented [39]. In particular, the accounting and payment for continuous deliverables within existing transactional business models constitute major problems [36]. In addition, companies are no longer able to deliver all relevant values in a business model independently. It is therefore necessary to establish new forms of collaboration within ecosystems [40, 41]. Consequently, it is necessary to address the question: How

does the supporting business model need to be designed in the context of continuous innovation?

The fourth challenge is derived from the consideration of people and the organization itself and addresses the required cultural change of a company. The challenge is to build and anchor a new mindset in the organization. Actual customer needs and expectations are often still not used as initial criteria for the derivation of innovations by manufacturing companies [42]. Rather, companies are more likely to trust in their experience and intuition in order to implement innovations in product development [43]. This leads to unfulfilled potential in satisfying customer needs. It is therefore necessary to analyze how existing culture need to be transformed in the context of continuous innovation.

In summary, four challenges regarding product, process, business model as well as culture for the realization of continuous innovation are identified, which are summarized in Fig. 2.

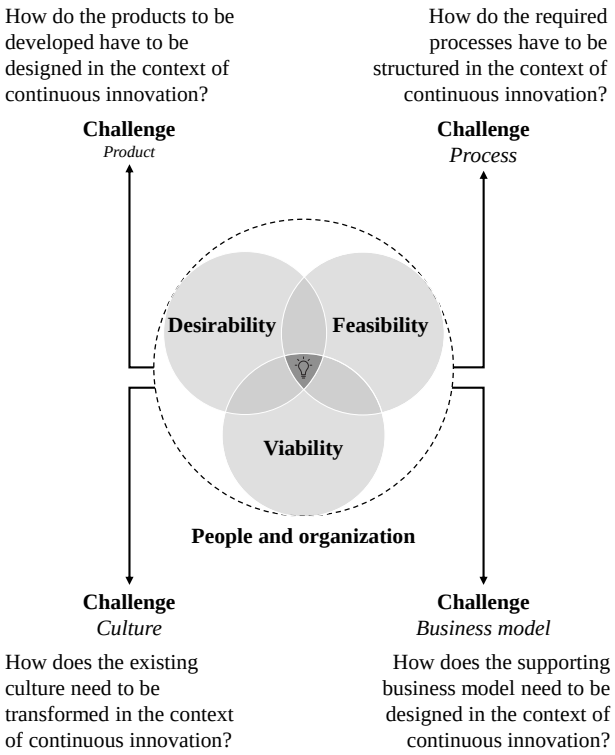

Fig. 2. *Challenges in the realization of continuous innovation*

The above-mentioned challenges, together with the product life cycle phases “development” and “usage”, result in a matrix of eight fields of action. These fields provide the research framework for this paper and are described in detail in the following chapter.

4. FIELDS OF ACTION FOR THE REALIZATION OF CONTINUOUS INNOVATION

The following section is structured according to the framework derived previously. Thus, fields of action for the realization of continuous innovation are derived as shown in Fig. 3.

	Development	Usage
Product	Establish an **integrated hardware and software architecture** as basis for the design of products	Implement **products as intermediaries** between the customer and service offers
Process	Define different development paths within an **iterative development and optimization process**	Define the concept **“Proof-of-Value”** as standard for **continuous learning** in the usage phase
Business-model	Realize the **monetarization** of continuous innovation by **subscription business models**	Anchor a **„win-win-win“** guiding principle **for business models in ecosystems**
Culture	Promote the **culture change** towards a **consistent customer focus** by a central organization unit	Implement an **“always better” mindset** through **transparent communication**

Fig. 3. *Research framework*

4.1. Product

In the section 4.1, the two fields of action regarding the product are elaborated. In the development phase, it means for the product that an integrated focus on hardware and software architecture is nessessary. The transformation of today's products from purely mechanical to mechatronic products as a combination of software, electrical and hardware modules to in some cases cyber-physical systems enables new possibilities to realize functions [44]. On the one hand, new software functions can be implemented into the product, and on the other hand, functions realized by mechanical components and modules can be extended by software components. This trend of digitalization can already be seen in many industries [45–47]. However, many companies still focus on the development of physical products and do not consider the use of digital innovations [39, 48]. This results in a lack of opportunities for the realization of functions in order to address dynamic, individual customer demands, faster innovation cycles as well as a greater differentiation from the competition. This is particularly evident in the fact that the adaptation of hardware components to rapidly changing customer requirements cannot always be implemented without major effort while functional enhancements through software updates can, in some cases, be implemented with less effort. [44]. This may be due to high scaling potentials with software. Consequently, the predominant physical product focus can create a delay in the implementation of continuous innovations. Nonetheless, mechatronic products also offer huge possibilities of achieving a repetitive increase in customer value through the continuous introduction of hardware upgrades even with potential higher efforts beside shorter-cycle software updates [44, 49]. Thus, an integration of hardware and

software architectures needs to be focused as a central basis for the design of products in the context of continuous innovation.

In the following, the field of action regarding the product in the context of the usage phase is described. Successful corporate strategies are no longer focused on selling pure products [50], but rather on meeting customer needs [51] and forming lasting customer relationships [52]. Thus, additional services are offered to the customer to increase customer satisfaction [53]. The combination of products and services is referred to “benefit-focused product ecosystem” based on Belz et al. and describes a central physical product that can be supplemented by various services and utilities [54]. A long-term customer relationship can be created by the high comfort for the customer due to the additional and temporally introduced benefit-oriented service offers.

Nevertheless, the physical product represents the central interface to the customer. Consequently, products should be interpreted and used as intermediaries between the customer and the service offerings in order to realize a lock-in effect in the sense of customer loyalty.

4.2. Process

In the next section 4.2 the fields of action are derived from a process perspective. Due to the dynamic and rapidly changing market, customers and their product requirements must be constantly reviewed and, if necessary, updated through product updates [19, 55]. In this context, a regular market feedback requires a short-cycle iterative development process that translates the requirements into new product features. Thereby, not all requirements can be addressed to the same extent and at the same speed. Here, it is necessary to strive for parallelized development paths in order to integrate for example possible low-effort module or software upgrades into the product on a short-cycle basis in the sense of a "fast-track idea". More complex adaptations needs to be implemented on the basis of a longer development cycle. In this context, product features should not only be tested in the development phase, but also evaluated after the market launch in order to enable continuous feedback and integration of new insights into the development process to get future product requirements. Here, a cyclical approach as known from “Lean Startup” or an agile way of working can be seen as helpful to be able to implement the parallelized development paths and the continuous testing into the process [56]. Similar approaches are already known from software development in the context of DevOps. The aim should be to transfer the DevOps approach, as already carried out by Schuh et al., to cyber physical products, whereby the respective development cycles should be parallelized and timed differently [27]. This is particularly important against the background of the most diverse regulations in various industries, since homologation processes in the automotive industry, for example, are bound by specifications and times. Accordingly as a recommendation for action in context of the product development phase, a definition of differently timed development paths in an iterative development process on the development side and a targeted optimization process on the market side can help to control the continuous delivery of new hardware and software releases.

The following section focuses on the field of action regarding processes in the context of the usage phase. The optimization process on the market side in particular offers the opportunity to validate the assumptions made during development with regard to customer wishes during the usage phase. One promising way for that in line with design thinking is to collect and to analyze product usage data [57]. The application of usage data in the development process helps to narrow the information gap regarding the actual utilization of the product [48]. This is possible because hypotheses about the use of the product and the value of product functions for the customer are made in the development phase. Not all these assumptions can be extensively validated in the development phase. By collecting usage data in the usage phase, these existing hypotheses about the value of product features can be validated after the market launch and served as a basis for new product updates [58, 59]. By means of the actual usage and usage characteristics of the product, unused or over-engineered functions could be identified and adapted to optimize products [60–62]. A study of the WZL Aachen on market intelligence shows that 84% of the examined companies do not systematically include usage data in the development process [43]. As a result, a proof-of-value of product features should be established. Thereby, the testing of hypotheses made in the development phase about the value of product features must be validated in the usage phase by means of usage data. This proof-of-value as a central benchmark for continuous learning in the usage phase.

4.3. Business Model

The third dimension addresses the challenge to redesign or adapt the existing business model. The business model must be designed to increase customer value and the manufacturer's profit growth. Therefore, within the context of the development phase, the successful and transformation towards subscription-based business models is in focus. Subscription-based business models are currently established on the market. Thereby customers continuously pay for services. Subscription-based business models can be used to offer customers individual service packages. The services used are therefore to be charged according to the extent of use of the product. [63]. Thus, customers pay only for the services they need. This leads to a unique understanding of the customer, as subscription providers need to focus in particular on customer value as a value proposition. [64, 65]. However, the basis of such a business model is a constant contact to the customer and the necessity of tracking the usage of the product functionalities in order to charge for the services the customer received. These include the product and product-accompanying services. The intense orientation towards the customer and usage enables that continuous innovations can be aligned in the most effective way to the fulfillment of customer needs. Thus, subscription models can form the basis for monetizing continuous innovation in the product life cycle since new innovations introduced into the product also have to be billed. At the same time, the strong customer focus can accelerate the innovation frequency, as no

superfluous product features are developed. In order to meet the comprehensive value propositions for customers within the usage phase, additional competencies from other companies or even industries are often necessary, which can be obtained through partnerships [66]. This aspect regarding business model in the context of usage phase is described within the following. A targeted selection of cooperation partners in an ecosystem can generate additional value for customers and companies as well as for partners [67] The benefits for the customer are the new value proposition, whereby payment is only made for the services that the customer actually uses like descripted in context of subscription models The company has the benefit of being able to gain access to required competencies they need to offer a “benefit-focused product ecosystem” to the customer, while the partners can access new business areas.

As a result, the "win-win-win" principle in an ecosystem in accordance to Gassmann and Ferrandina should be anchored as a maxim for action in the context of continuous innovation. Latter defined the second field of action from the business model perspective [67].

4.4. Culture

The fourth dimension addresses customer’s and company´s culture. First, the field of action regarding the development phase is described. The idea of customer-focused development has not yet been sufficiently integrated into working methods, ways of thinking and current routines. End-to-end customer centricity and the associated focus on the customer experience is key to a long-term corporate success. Therefore, customer centricity should be established as a principle not only for development but for the entire company [68, 69]. In this way, customer wishes, and requirements should become an integral part in the innovation process [70]. For the long-term implementation of this approach, it is crucial to anchor the desired focus on the customer experience in the existing organizational structure. For this purpose, as recommendation for action in context to the development phase, a corresponding organizational structure should be established with a central unit coordinating and controlling the recording and analysis of market requirements and customer wishes. This ensures that the organization does not fall back into less customer-oriented patterns [71].

In addition to the organizational restructuring, it is highly relevant to communicate the concept of continuous innovation within the organization and to the customers. Therefore, the second field of action in the context of culture regarding the usage phase is described. On the one hand a comprehensible communication about product changes or improvements can increase customer satisfaction [72]. On the other hand, a lack of information about changes and modifications to the product can lead to a loss of control and uncertainty, which has a negative impact on customer satisfaction. A well-known example in this context is the not always transparent communication of customer data usage [73, 74]. Consequently, there should be continuous communication about functional enhancements and improvements. At the same time, it must be ensured that the customer does not get the impression of buying a still unfinished product that is being tested within the customer usage. Instead, it must be made clear that this 100% functional product is being continuously improved through continuous enhancements in order to achieve even higher productivity and fulfillments of customer needs.

Accordingly, an "always better" mindset in the sense of an ever-improving product should be implemented with through transparent communication to the customer and integrated into the corporate culture.

5. SUMMARY

Due to changing conditions like the increase of global competitiveness as well as short-term changing customer needs even within the product lifecycle, manufacturing companies have to increase their focus on continuous innovation. Therefore, this paper presents a framework based on the identification of four main callenges with regard to the product, the processes, the business model as well as the culture both in the context of the product development as well as product usage phase. Eight fields of action for the successful realization of continuous innovations were presented. With the help of the presented field of actions, the research questions posed could be adressed. The framework derived in this thesis can serve as a guide for future research. In the future, it is important to detail and methodically prepare the derived contents to support the operational realization of continuous innovation. For example the design of an appropriate business model and its dimensions for the realization of continuous innovation should be addressed in more detail. Furthermore it is necessary to develop a process for the operative implementation of continuous innovation for manufacturing companies.

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