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Design for Value Chain – An Integration of Value Chain Requirements into the Product Development Process

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Abstract
Various factors like an increase of the product variety lead to an increase in complexity both at the level of product and the level of the value chain design. A study has identified the need to integrate the supply chain requirements into the product development process. This paper will describe the Design for Value Chain method as well as the findings by applying the approach at Dräger. From the analysis of the value chain, the identification of complexity and its drivers, individual requirements to the requirements engineering are derived. Those value chain specific requirements are categorised and thematic areas and procedures of Design for Value Chain are explained to support the value chain specific requirements engineering.

Keywords: Design for Value Chain, Product Development, Complexity

Introduction

Companies are facing new and changing challenges caused by globalization of competition, dynamic requirements and shorter product life cycles. These trends are often encountered by the development of customized product variants. The increasing number of customized product variants arouse complexity at the product level and at the level of value chain [1] (Figure 1).

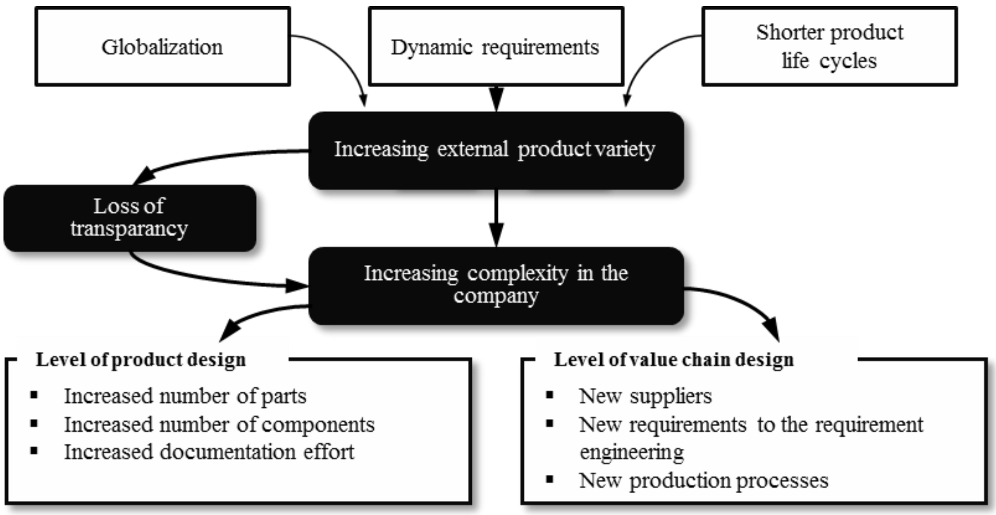

Figure 1 Causes and effects of product variety

To avoid corresponding increase of cost, the complexity in the company's global supply and product distribution has to be reduced by controlling the complexity in the early stages of the product development process. However, an analysis of different complexity management approaches has shown that existing methods either focus on the level of the product design or on the level of the value chain design [2].

The Institute for Product Development and Mechanical Engineering Design (PKT) developed the Integrated PKT-Approach for Developing Modular Product Families (PKT-approach), which adapts the product architecture to offer high external variety without increasing the internal diversity likewise [3]. As product variety also induces complexity at the level of the value chain the PKT-approach was to be expanded by the Design for Value Chain method (DfVC) focusing the simultaneous management of complexity at the value chain as well as at the product level (Figure 2).

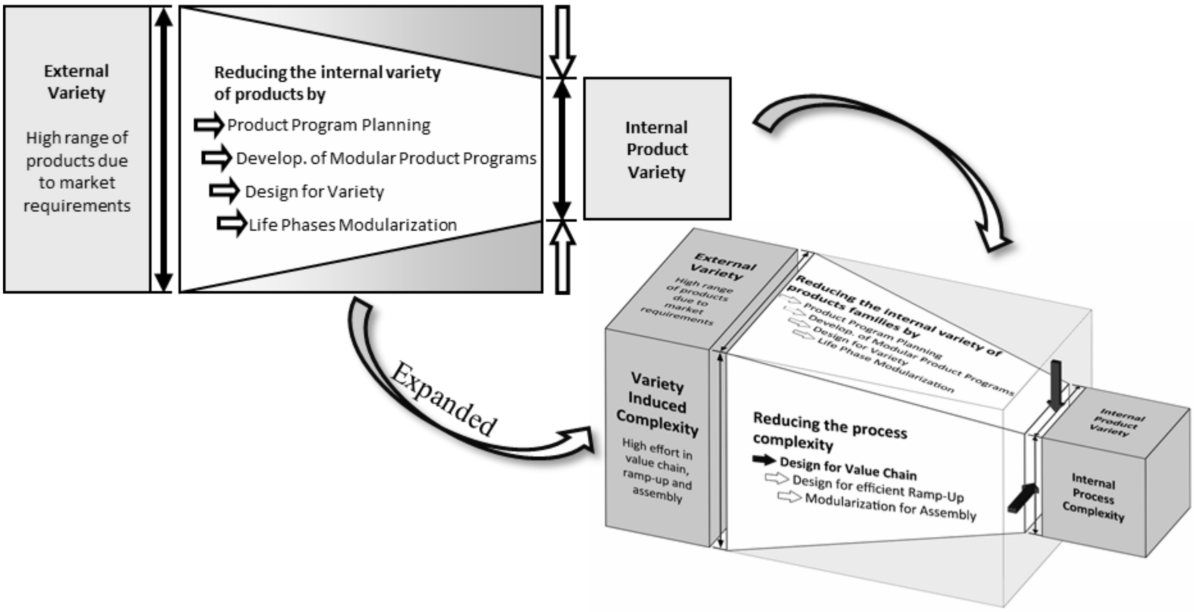

Figure 2 Expanded PKT-approach

DfVC will create product structures optimized to the value chain strategy, learning from the experiences of existing product families and their product variety induced complexity. Therefore requirements of the value chain have to be integrated into the product development process. The method DfVC is described in more detail after the section about the state of the art (categorisation within the requirements engineering in literature). In this paper, the categorization of value chain requirements is described using a case study with Drägerwerk AG & Co. KGaA (Dräger). Hereby, the first three steps of the method DfVC are explained in more detail (see section Design for Value Chain). The first two points were a preliminary study in the context of the case study, whose results will be used in the third step.

Categorisation within the requirements engineering in literature

For the development and planning of products, a systematic requirements engineering is necessary. On the one hand, this includes a systematic collection and on the other hand a systematic structuring of the requirements [4]. According to Ebert, the requirements engineering is divided into the requirements analysis and requirements management. The requirement analysis consists of collecting, documenting, testing and handling requirements.

The requirements management includes describing the processes and entrepreneurial objectives [5].
In practice, the requirements change during the development process, because the understanding of the people is improving and the customer needs are changing. Therefore, requirements engineering is not a linear process but an iterative cycle [6].
The customer and the technical framework conditions usually define product requirements. However, not only the requirements of the customers have to be considered, but also from other stakeholders, such as manufacturing and supply chain [7]. In addition, requirements can be divided into functional and non-functional requirements. Functional requirements describe what a product should do, while the non-functional requirements have no direct impact on product functionality. Non-functional requirements can be divided into product requirements (e.g. reliability), organizational requirements (e.g. manufacturing and supply chain) and external requirements (e.g. laws and standards) [8, 9].
Structuring models provide the possibility to analyse requirements in groups so that they can be considered selectively [10]. In literature there is a wide variety of approaches, which describe how to deal with the issue of structuring in different contexts (e.g. [11–13]). Crostack has summarized these different approaches of structuring [4].
However, the existing structuring approaches do not offer any support of the value chain stakeholder. In addition, the categories are kept very general; therefore a company-specific complexity reduction by these categories is not possible. The DfVC method described in the following helps to fill this gap.

Design for Value Chain

As described in the introduction the DfVC approach will expand the integrated PKT-approach to the level of the value chain. It hereby consists of several blocks that are connected to a common method and have to be integrated into the product development process. Figure 3 shows the different blocks and a possible connection, which are explained in more detail in [14].
In the first step the order fulfilment processes are ascertained, analysed and the complexity within the supply and value chain is identified. On this basis the second step is to identify the complexity drivers. Value chain specific requirements are derived from this analysis. The requirements are needed within the task clarification and the conceptual design phases of the product development process. However, requirement lists should be updated constantly. Therefore, the requirements engineering is also taken into account during the other phases of the product development process. Finally, the product and process concepts that are developed in consideration of the value chain requirements have to be evaluated in terms of their value chain complexity. This happens within the conceptual design phase.
The company-specific complexity drivers can be mapped to generic fields of action within a complexity management system that were previously identified in a comprehensive literature review. The link of identified fields of action to complexity in the company conclusively allows the derivation of a customized package of measurements to reduce, avoid and handle the complexity.

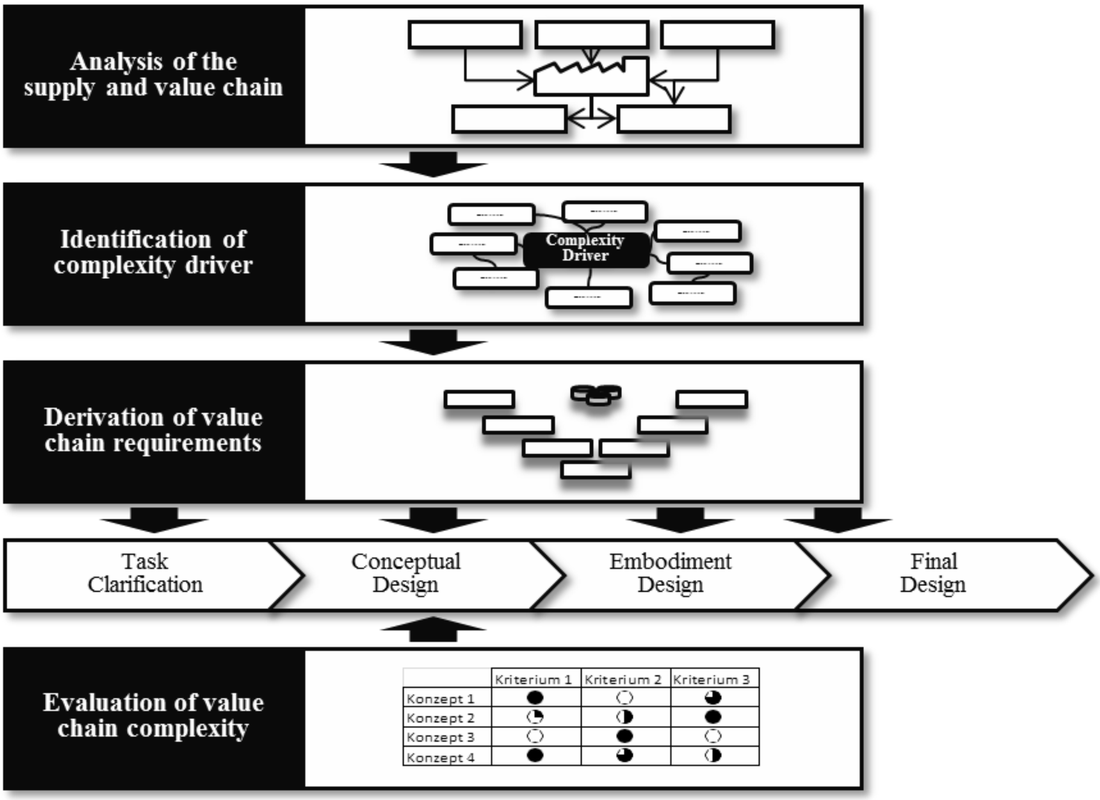

Figure 3 Different steps of Design for Value Chain

In determining the value chain requirements, the value chain specific requirements of the planned markets have to be ascertained and categorised. The various general categories are used in the individual product development projects to ensure completeness of the value chain requirements. First categories are identified from the literature and then supplemented with additional company-specific categories. Company-specific subcategories are associated to each category, which can be derived of the results from the "Analysis of the supply and value chain" and "identification of complexity driver"[2]. Furthermore, the responsibilities have to be identified, that is the question who is responsible for clarifying the requirements (R & D, logistics, sales). These requirement categories are mainly used in the conceptual design phase during the preparation of the technical and requirement specifications. Other important points are the ascertainment of country-specific requirements, respectively the requirements of all relevant scenarios and the adjustment of the product concepts and the process concepts for the implementation of the requirements.

Application of the procedure at Dräger

Dräger offers innovative products in the world of medical and safety technology and is already successful in meeting the country-specific market and customer requirements. To be even more effective and efficient in the future, a first preliminary study identified fields of action of a holistic and company-specific complexity management [2]. Dräger will delve into these fields of action in the future. A prioritization of those fields of action has shown that a closer examination of the requirements engineering from the perspective of the value chain needs to be done in order to meet the challenges of globalization more efficiently in the future.

The following is a brief look at the first preliminary study to identify fields of activity of a holistic complexity management. Afterwards, the integration of the value chain requirements into the product development process is explained in more detail.

Preliminary study to identify fields of action of a holistic complexity management

To link the company-specific complexity drivers and the generic fields of action three steps are performed in the case study (Figure 4). In the first step ascertainment and analysis of the order fulfilment processes take place. On this basis the second step is to identify the causes for the complexity, which are further described as complexity drivers. In the third step the identified company-specific complexity drivers are mapped to the generic fields of action of complexity management. The linkage of identified fields of action of the complexity management with the complexity in the company conclusively allows deriving a customized package of measurements to reduce, avoid and handle the complexity. These three steps are explained in more detail in [2]. By analysing the order fulfilment at Dräger, and the identification of complexity and its driver the value chain was identified as an important stakeholder and the need of a value chain specific support of the requirements engineering was revealed.

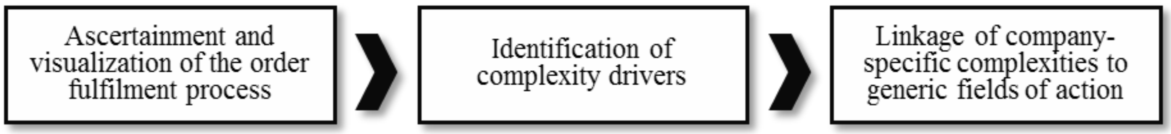

Figure 4 Approach to identify areas of activity [2]

Integration of the value chain requirements into the product development process

The identified driver of complexity were analysed to determine which measures are useful at which point in the product development process to reduce and to avoid complexity in the future. To cope with complexity and to create transparency a grouping and categorisation of the requirements is necessary. At Dräger the identification and grouping of the value chain specific requirements have been performed in the following steps, according to the explained steps of DfVC:

- Identification of relevant stakeholders
- Identification of existing requirement categories in the literature
- Analysis of the complexity drivers using the identified categories
- Expansion of the categories by company specific categories
- Refinement of the categories by using company-specific subcategories

To identify the relevant stakeholders the results of the analysis of the supply and value chain have been analysed to see which stakeholders have effect on the complexity of the value chain. For this, the stakeholders of complexity driver were identified. At Dräger these are the logistics, product planning and marketing.

The study of the complexity drivers of these three stakeholders has resulted in the thematic areas shown in Figure 5, to integrate the value chain requirements into the product development process. The three thematic areas are the determination of the value chain requirements, the examination of the maturity of market specific requirements and the definition of a product specific order fulfilment process through outbound logistics.

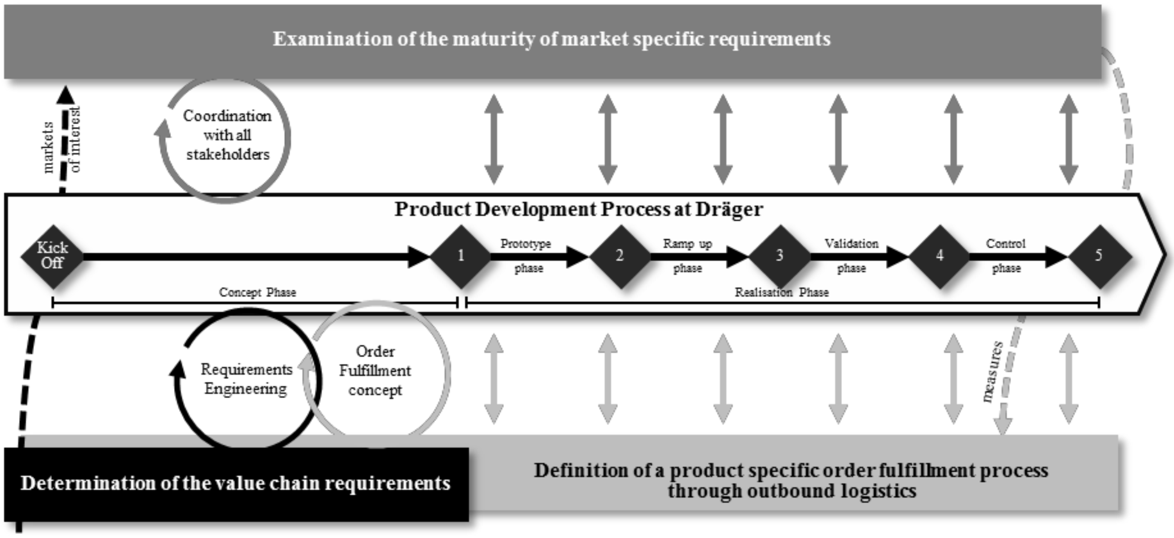

Figure 5 Thematic areas and procedures of Design for Value Chain

In the middle of the figure is a rough overview of the Product Development Process at Dräger is shown, in which the requirements are to be integrated. Dräger adapted the stage gate process by Cooper [15]. Between the kick-off and the first gate the concept phase is located in which both product concepts as well as production and distribution concepts are developed. The realisation phase is located after Gate 1. In the realization phase no new requirement will be added. Thus, the iterative requirements engineering is placed exclusively in the concept phase. For this purpose, first the requirements of the value chain are determined and the markets are defined. The examination of the country-specific maturity verifies if all relevant requirement scenarios are identified, in consultation with the stakeholders.

After the concept phase, the value chain requirements need to be validated and verified. In addition, countermeasures must be identified in case that requirements cannot be fulfilled exclusively by the product.

In the definition of a product-specific order fulfilment process through outbound logistics, a concept is developed to fulfil orders. This is done using different approaches to reduce the internal complexity.

Because a large amount of requirements needs to be handled in the determination of value chain requirements and not to forget any requirements, the requirements are grouped and categorised. Here the focus is on the non-functional requirements. Figure 6 shows the identified categories. Furthermore, these were detailed by company-specific subcategories.

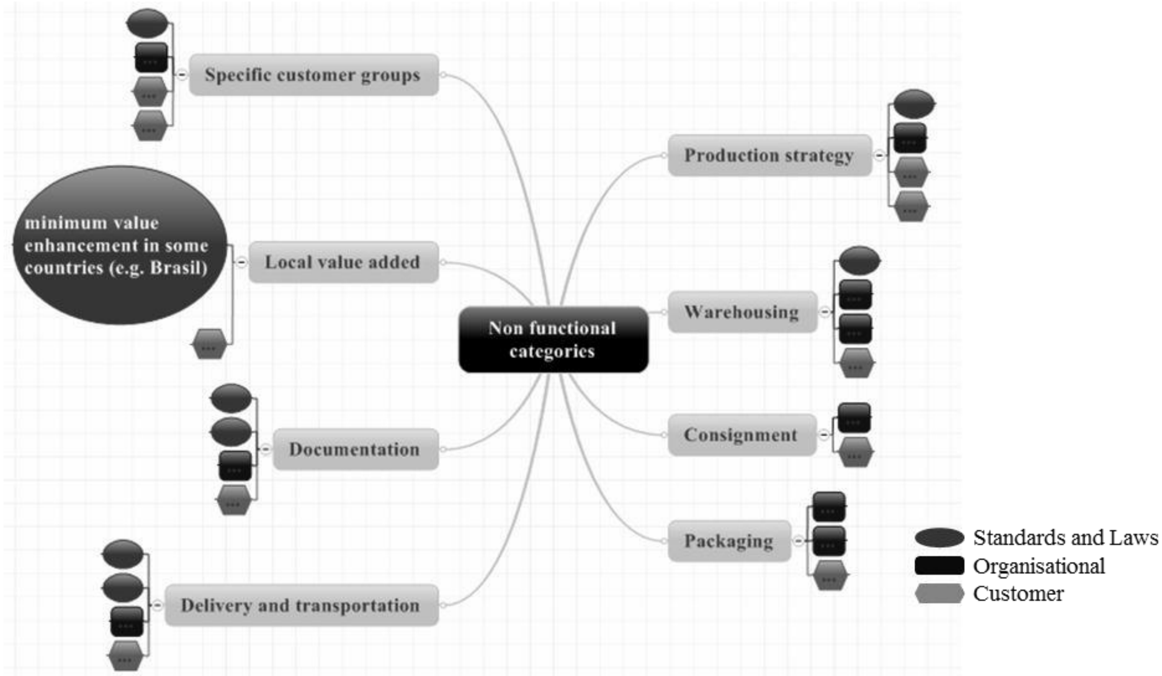

Figure 6 Requirement categories and examples of different groups of subcategories

Thereby, the subcategories were divided further according to their origin. The origin can be the customer or the organization or the standards and laws. One example is shown in Figure 6; the subcategory "minimum value enhancement in some countries (e.g. Brazil)" is a subcategory of the local value added. This involves the question: Is a minimum value enhancement required in any country to avoid high taxes? This subcategory is associated, to the group of standards and laws.
In the implementation of DfVC at Dräger company specific categories and subcategories were found which foster the support of the value chain specific requirements engineering in the future. Solutions have been developed which are closely related to the existing structures at Dräger. The operative implementation is currently being tested in some pilot projects.

Conclusion and Prospect

The analysis of the supply chain and the identification of complexity drivers identify individual engineering and product requirements. Those are needed within the clarification phase of the product development process.
Industrial projects and case studies show that reduction of internal complexity urgently needs the integration of value chain requirements into the product development process. However, a holistic, systematic and methodical support does not exist yet. Therefore DfVC extends the PKT-approach.
As part of the case study at Dräger, the value chain specific stakeholders and their requirements were identified and categorised. These categories and their company-specific subcategories were integrated into the process of the DfVC. Thus, an integration of the value chain requirements into the product development process was achieved and Dräger will be able to implement market and country-specific customer requirements more effectively and more efficiently in the future.
The evaluation of value chain complexity is another important step of the DfVC, which was not yet implemented in a case study.
Detailing the DfVC and further implementations into industry are topics of future research work.

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