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Product Profiles: Modelling customer benefits as a foundation to bring inventions to innovations

Albert Albers, Jonas Heimicke*, Benjamin Walter, Gustav Nils Basedow, Nicolas Reiß, Nicolas Heitger, Sascha Ott, Nikola Bursac

Karlsruhe Institute of Technology (KIT) - IPEK – Institute of Product Engineering, Kaiserstr. 10, 76131 Karlsruhe, Germany

* Corresponding author. Tel.: +49 721 608-47251; fax: +49 721 608-46051. *E-mail address:* Jonas.Heimicke@kit.edu

Abstract

According to recent studies, early and clearly defined customer's demands and provider's demands are necessary elements for the future success of a product. Product profiles within the scope of ASD – Agile Systems Design describe these demands. As product characterizations in the early development phases, product profiles do not anticipate the technical realization of the product, but rather model customer's benefits and provider's benefits as use cases, requirements and boundary conditions and thus include value-added product attributes. By this, product profiles represent the interdisciplinary design objective and form the core of the related generation of business models. However, there is a lack of a suitable methodology to systematize the generation of product profiles. There are no approaches that allow the consideration of corresponding reference products in the context of PGE – Product Generation Engineering when generating product profiles. Starting with a retrospective study, more than 100 product profiles and their development in three Live-Labs with industrial participation as well as three industrial innovation projects are analyzed. Based on this a definition of product profiles is derived and a product profile scheme to model profiles is introduced. Furthermore, the different modules as elements of product profiles are explained.

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Keywords: Invention, Innovation, Product Profile, Agile Systems Design

1. Introduction

History shows, that being successful in the market not only depends on a good idea. Neither does just listing to customer's needs lead to a successful product. A very well-known example of such a failure is the Ford Edsel. In contrast to competing companies such as e.g. GM, Ford did not select the market according to lifestyle, but rather according to income classes [1]. A midsize car was developed for which the customer would be willing to spend more money on. The result was a disaster. The Ford Edsel's complicated design did not address the needs of the masses due to the misunderstanding of customers and caused the company severe losses [2]. The example shows that a holistic understanding of all relevant factors is crucial for the success of the product and various factors have to be taken into account especially at an early stage in the process of product development. In addition to a sufficient differentiation from competitors, high quality of the product and a clear identification of suitable target markets, the early and continued consideration of customer's needs is decisive for the future success of the product [3]. Only if the product satisfies the customer's needs companies can take advantage of the potential to gain new market shares by winning new customers. In addition to the customer's needs and user's needs, an adequate, through implemented products realized provider's benefit is a decisive factor for the economic success of a company [4]. The product profile from Albers follows this idea. Thinking in profiles was shown to be a success factor in an academic research environment: In the Live-Lab IP – Integrated Product development students implement real development tasks together with industry partners. Profiles were shown to be one major success factor for a holistic generation of requirements in past projects [5]. Furthermore, real development projects like the development of the dual-mass flywheel showed the great potential of using

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profiles in early development phases [6]. The claim for the profile of the dual-mass flywheel was: „*We need a system that makes the rotational irregularities caused by the internal combustion engine during operation at low engine speeds (1000-2800 revolutions) in the drive train controllable regarding NVH*." In an increasingly complex product development and a changing development environment the understanding of the product profile needs to be further developed. This paper introduces an appropriate definition of product profiles to create a consistent understanding. In addition, the core elements of product profiles are described on the basis of many years of project experience from practice. This paper is intended to help developers in the process of product development to know and to model the elements they need to identify in order to generate the most complete and robust product profile possible.

2. State of the Art

2.1. The Innovation Process

According to SCHUMPETER, innovation is the basis for entrepreneurial success on the market. In contrast to an invention, he links great economic importance to innovation [7]. For this purpose, it is necessary that the invention satisfies a demand situation in the market, to lead to successful market penetration and to become an innovation. Innovations differ in their degree of inventiveness, which means the share of new developed components [8]. The description of broad shares of new development of real entrepreneurial product development projects is achieved by the approach of the PGE – Product Generation Engineering according to ALBERS. The two basic elements of this approach are on the one hand the understanding that new products are always developed on the basis of existing reference products or solutions, and on the other hand that when developing new product generations, the activities of *Carryover Variation* (CV), *Embodiment Variation* (EV) and *Principle Variation* (PV) are systematically combined. The synthesis of subsystems of the new product generation based on subsystems of reference products can be described by these types of variation. EV and PV jointly represent the respective parts, which are newly developed in a product generation. Case studies have shown that possible motives for the use of different types of variation have direct effects on the design of validation systems, production systems as well as on the resulting development risks and costs. This approach can also be applied to individual product development processes in which different degrees of maturity of prototypes are interpreted as generations of development [6]. Particularly in the synthesis of systems of objectives as well as in validation of systems of objects, PGE's way of thinking can reveal potential for optimization in a more focused way [9]. The product development can be understood abstractly as the continuous interaction of three systems within the system triple of product engineering (cf. Fig. 1.) [10]. Accordingly, the operation system, which includes developers, development resources as well as processes, methods and organizational knowledge, continuously synthesizes two different systems - the system of objectives and the system of objects

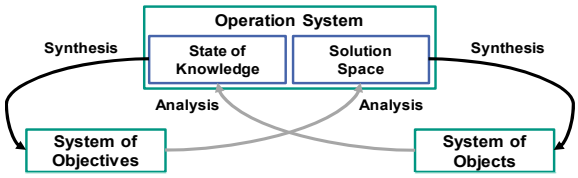

Figure 1: System Triple of Product Engineering Describing the Continuous Mitigation of Uncertainty by Information Gaining and Decision Making [11]

- throughout the entire development process. In addition to the final product, new information is constantly generated during the development process, which is the basis for new objectives. Additionally, throughout the process a large number of objects is produced continuously, which in turn leads to further information. Objectives and various design objects cannot be defined in their entirety in the development process. The three systems and their interaction are therefore subject to constant uncertainty, which means that processes have to be iterative, flexible and agile. Uncertainty results on the one hand from a lack of knowledge and on the other hand from a lack of definition as well as the necessity for a rational completion of the system architecture. Accordingly, uncertainty is to be counteracted by obtaining the necessary information (Fig. 1. State of Knowledge) and by making the necessary decisions to reify the solution space (Fig. 1. Solution Space). Based on the state of knowledge of the operation system, an initial system of objectives can be synthesized which contains a first vague description of the product. At the beginning of the product development process, the initial system of objectives provides the first basic objectives and the foundations for the development of the right product. By analyzing the system of objectives, a solution space can be defined, which represents the basis for a syntheses of objects. In the course of the development process, synthesized objects are continuously analyzed, thereby enriching the state of knowledge and the system of objectives is steadily specified. The continuous analysis of the system of objectives leads to a successive concretization of the solution space [11]. In this model, the validation can be understood as the analysis of the system of objects with regard to the fulfilment of the system of objectives. This analysis leads to a further gain of knowledge, which leads to an expansion of the state of knowledge and a further concretization of the system of objectives. According to ALBERS, validation is the central activity in product development in addition to the creation, which leads to a targeted evolution of the system of objectives [11]. In dynamic markets, the innovation process is subject to many uncertainties [12]. An approach for an adequate handling of these uncertainties is the ASD – Agile Systems Design (see Fig. 2.). Due to an increased agility in the process, the organization is able to react. ASD supports the developer during the innovation process as a holistic, structuring approach for the agile development of mechatronic systems, the associated product strategy, validation systems and production systems, consisting of principles, methods and processes of PGE. ASD is human-centred and supports the developer by means of methods and processes of the PGE in a situation-based and needs-based manner, by conducting activities of product development simultaneously and iteratively. The focus of this contribution is on the

phase of Identifying Potentials, as the result of this phase is a validated product profile. [13]

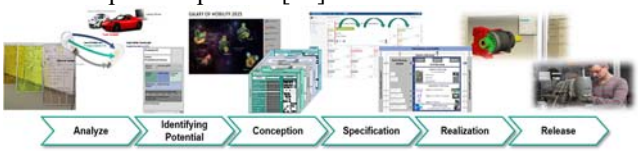

Figure 2: The ASD – Agile Systems Design– Elements and Phases [13]

2.2. Identifying Potentials in early Stages of Product Engineering

The phase *Identifying Potentials* is a key phase in ASD. Based on a broad understanding (result in the *Analyze* phase) of the system to be developed and its entire environment, the systematic identification of product profiles takes place in the phase *Identifying Potentials*. The product profiles are generated iteratively, are methodically validated (e.g. by a sounding board with potential users) and are extended. At the end of the phase, one product profile is selected together with the project customer, which is then technically implemented in the subsequent phases. This is also done iteratively by systematically using knowledge from previous generations in the sense of the PGE. The aim of the ASD is to build prototypes early on and validate them together with customers. In this way, further goals and wishes are derived, which are then integrated into the prototype in the subsequent process. As a result, the prototypes gradually gain maturity and functionality. ASD supports the developer with development methods that are tailored to the situation and requirements and generates a process that is robust against a high level of environmental dynamics. [13]

The product requirements defined at this time form the system of objectives of the product to be developed. Accordingly, the totality of the requirements already represents an abstract description of the solution [14]. LINDEMANN also names target planning as the starting point for successful work in product development [15]. In order to answer the crucial question of "what should be developed", precise and comprehensive knowledge of the current development situation is essential. The prerequisite for this is a situation-specific analysis of customers, markets, competitors and products at the present time and for the future [16]. In order to systematically plan goals, it is necessary to deal with the development of alternative, possible, future models in order to be able to offer products and services in line with the market in the future. The sales market, the own products, as well as those of the competition, the technological development and the wishes of the customers are therefore of upmost importance. According to PAHL and BEITZ, product planning is also of central importance for the degree of innovation of new products [17]. They highlight the fact that in this phase, the success of the subsequent product depends above all on the wishes and needs of the customers. The first step in product planning is the analysis of the situation, whereby impulses from the market, from other environments and from the company itself provide a first basis for a potential search for product ideas. Impulses from the market mainly refer to the economic position of the own product on the market, as well as technical advantages of direct competitor products and changed market needs or suggestions of the customers directly. Factors influencing the company's environment include economic policies, the substitution of old technologies and new environmental requirements for existing products or processes. The impulses from the own company include aspects such as the use and introduction of our own research results and new production processes, various types of function expansions and a higher degree of diversification [18]. In summary, this phase includes the consideration of the provider's benefit as well as a precise analysis of customer needs and the market situation as well as an analysis of new potential technologies [19, 20].

3. Need for Research, Research Questions and Approach

The initially presented example of Ford Edsel is not an isolated case. The problem of modeling costumer, user and provider benefits and continuously validating product ideas, concepts and prototypes in relation to them, poses a challenge to the developer. This article will outline a way to condense and model different benefits in an artifact. For this purpose, a uniform understanding of the product profile is to be developed. Therefore, the following research questions are to be answered:

- How are product profiles understood in the context of ASD - Agile Systems Designs?
- Which elements are part of product profiles?
- How can a product profile be modeled?

In order to answer the research questions, insights of product profiles from innovation projects that have been carried out at the Karlsruhe Institute of Technology (KIT) over the last 20 years is applied [5]. The documentation covers 304 product profiles that were successfully presented to 12 project partners. An expert workshop with researchers from the field of innovation management was held in order to generate a uniform definition of the term *product profile*. In the next step, case studies were conducted as part of the Live-Labs ProVIL - Product Development in the Virtual Idea Laboratory, IP - Integrated Product Development and AIL - Agile Innovation Lab [13] to identify and cluster the elements contained in product profiles. From this a product profile scheme is derived, which represents the basis for a standardized modeling of product profiles.

4. The Product Profile

4.1. Definition of a Product Profile

A product profile is a model of a number of benefits that makes the intended provider, customer and user benefits accessible for validation and explicitly specifies the solution space for the design of a product generation. The number of benefits will be understood as a set of products and services, which are offered with the purpose of being sold to a customer and to provide benefits for him directly or indirectly - e.g. for users taken into account by him or for his customers. By describing the actual, with the respective product development status achieved intended provider, customer and user benefits, the product profile can be validated by applying suitable methods against the

actual provider, customer and user benefits. In addition, any conflicts of interest and potential for synergies between provider, customer and user benefits can be identified. Moreover, a product profile is the starting point for the development of a product generation as well as the basis for validation against which product ideas, product concepts, product models and the final product can be verified. Besides describing provider, customer and user benefits, product profiles roughly outline the product; e.g. essential product attributes, which can be experienced by the customer and functions of the future product, without completely anticipating its shape. Furthermore, the product profile also contains information on the essential boundary conditions of the product, such as existing reference systems or existing modular systems, which have to be consistent with the product in development. In order to communicate the product profile to internal and external stakeholders in the best possible way, its core contents are used as a product claim summarized in one sentence. As an essential element of innovation processes consistent with ASD, product profiles are a central factor of success in PGE. While they support companies in answering the question of which provider, customer and user benefits are to be realized by the future product, the subsequent development of the product, which in a broad sense can also include accessories and service components, answers the question of how provider, customer and user benefits are to be technically realized. This essentially includes the definition or modeling of operating principles, (partial) functions and embodiment of design and can be considered as the actual technical invention in its entirety. Subsequently, appropriate marketing and sales strategies ensure that the product is optimally positioned on the market. Although there can be no guarantee of a product's success on the market, the use of validated product profiles in combination with appropriate inventions and marketing and sales strategies increases the probability of market success, since this enables the early and continuous involvement of the perspective of the customer and the user in development projects [3]. In the development process, product profiles should usually be developed before the actual search for technical solutions. Ideally, in a specific development project a certain variety of alternative product profiles is generated in order to identify the best possible product profile in the current situation. For the development, different starting points are possible. It can be based on the analysis of existing reference products, on an existing business model or on a rather vague development theme. In addition, the development of product profiles can be systematically supported by various development methods. Dependent on the development goal and the initial situation of the development project, the describing elements contained in the product profile in the categories product description, providers', users' and customers' benefit and boundary conditions have to be adapted to the specific situation and standardized for the current development process. This makes it possible in particular to weight the benefits of providers, customers and users on a project-specific basis. The product profiles are validated during and after their development, with the help of the corresponding stakeholders. In particular, it is ensured that the descriptions of the benefits of provider, customer and user are accurate, whether or to what extent the expected market potential exists and whether the desired product is in theory technically feasible, or which parts have to be newly developed in terms of the PGE. The latter can be used as basic information for assessing development risks. After the decision-making process, a product profile is usually selected and used as the basis for the further development process. By taking technical and economic perspectives into account, the product profile provides a systemic basis for arguments and discussion for all stakeholders involved in a development project. As such, a product profile helps to establish a common understanding of the relevance and direction of a development project between different divisions such as strategy, development, sales or production within the company. In this context product profiles bring added value by supporting the identification of missing or contradictory information and ambiguities. On this basis, appropriate research can be conducted or suitable experts can be integrated. Product profiles are used in the same way as product requirement documents and functional specifications in early phases of development. In contrast to product requirement documents and functional specifications, however, product profiles focus primarily on prospects for use. This has several advantages. On the one hand, product profiles can be used at an earlier stage than product requirement documents and functional specifications. On the other hand, product profiles, in contrast to product requirement documents and functional specifications, provide detailed information on the provider's benefit (e.g. the use of existing reference systems to realize the desired product) and thus enable the early identification of potentials for synergies and target conflicts between provider, customer and user benefits. In addition, the use of product profiles promotes a deeper understanding of customers on the part of design engineers, as they have to deal with specific customer needs rather than formalized requirements. This is especially true in the area of B2C customer relations, as design engineers are otherwise rarely in direct contact with end customers. As business models, product profiles strongly focus on customer benefits. While, however, business models make statements on the cost structure, revenue streams and the companies value network, product profiles concentrate on the implications of customer benefits for the product to be developed and on the integration of provider benefits, such as the use of reference systems, existing know-how or the increased use of existing production systems. In particular, provider benefits are not generally explained in detail when modeling business models, for example when using the Business Model Canvas - apart from financial flows.

4.2. Modeling Product Profiles

Based on a literature review, internal expertise and the identification of best practices generated from 304 product profiles developed in 12 joint projects with well-known partners (see Table 1), different modules for product profiles have been identified and clustered (see Figure 3). Particularly, 12 modules have been identified. Each module can be interpreted as an analytical perspective and contains several sub-elements.

Table 1 Year, project partner and number of analyzed profiles

Year - Partner	Number of analyzed Profiles
2005/06 - Freudenberg Group	19
2006/07 - Kärcher GmbH & Co. KG	21
2007/08 - Blanco Group	17
2008/09 - Stihl Holding AG & Co. KG	21
2009/10 - BSH Hausgeräte GmbH	21
2010/11 - Voith Paper	28
2011/12 - TRUMPF Group	30
2012/13 - Wittenstein SE	28
2013/14 - Daimler Trucks	30
2014/15 - Schaeffler Group	30
2015/16 - AVL List GmbH	27
2016/17 - DIEHL Metering	32

It needs to be considered that the sub-elements of the modules may vary depending on e.g. the development task, type of relation with the customer or the company's sector. Additionally, the sub-elements possess different level of validation. Following the strong empirical character of this study, a reconstructed product profile from engineering practice (dual-mass flywheel of the first generation G_1 1984) is shown in Fig. 3. Detailed and precise knowledge of this subject is available in particular because the main author was personally involved in the developments. [6]

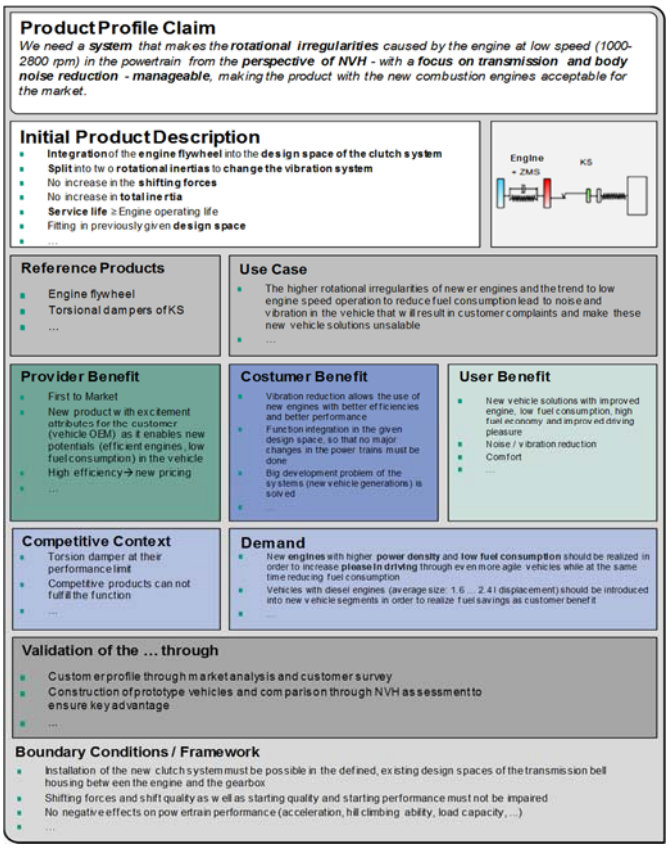

Figure 3: Product profile scheme (dual mass flywheel Generation G_1 1984)

Product profile claim - The product profile claim states the main goal in a short form and provides a brief overview of the product. "*We need a product, which < solution statement>*."

Picture - The picture shows a brief sketch or icon to improve communication. Like the product profile in general, the visualization does not explicate a technical solution. It may also contain a *QR-Code* and a *link* to link the product profile to other visualization methods, e.g. video clips.

Initial product description - The description of the potential product provides a more detailed overview of the potential product. Usually it contains information as e.g. the *product properties*, the *main functions* of the product or the *unique selling proposition (USP)*.

Reference products - Reference products are key factors to increase development success. Potential reference products therefore are crucial for the product profile. Therefore, it may contain *previous product generations*, *internal/external reference products*, independent from their degree of maturity.

Use case - The use case describes specific situations where the product provides a solution. It therefore e.g. may refer to the *context in which the product is used* or to the specific situation *how the customer/user interacts with the product.*

Provider benefit -The provider benefit shows how the provider could profit from the development of the product. Thus, the provider benefit addresses factors e.g. the *strategic benefits*, *fit to company's culture or brand*, *addition to product portfolio*, *business models* (incl. estimated revenues, costs and prices) and *resources* or leveraged *core competencies*.

Customer benefit - The customer benefit defines the *target group* and *market segment*. The customer benefit describes the *problem to be solved from the customer's perspective*. Additionally, the customers benefit therefore shows *how the customer would benefit* from the potential product.

User benefit - Especially in B2B customer relations customer and user may differ. While the customer decides whether a product should be ordered or not, users mainly interact with the product on an operational level. Since between customer and user often conflicting objectives exist, a separation into these different dimensions is key to target and solve these issues. A brief example is the development of a truck seat. If only the customer's perspective is considered, the development process may focus on reducing the engineering and production effort. The resulting seat may not be ergonomic (user perspective) and thus lead to an increased illness rate of the user and consequently lead to negative results also for the customer as well. Thus, the user benefit describes the *target group* and the *problems to be solved from the user's perspective*. Additionally, the user's benefit shows how the user would *benefit from the potential product*.

Competitive context - The competitive context provides a brief overview of the competition landscape. Therefore, it contains elements e.g. *competitors*, *the market share distribution*, the *patent situation* and *competing products* (incl. prices).

Demand - The demand provides a brief overview of the demand situation. Therefore, it contains elements e.g. the *customer and user description*, their respective *markets*, the *market potential* and *market sizes*, *trends* and *scenarios*.

Validation of the… through - Each sub-element of the other modules (e.g. Customer benefit) has a specific level and type of validation. While the lowest level of validation has the character of a hypothesis, the highest validation level could be interpreted as empirically proven. Sub-elements of the product profile validation are e.g. conducted *market studies* with *related methodologies*, e.g. expert interviews.

Boundary conditions / framework - The boundary conditions describe general constraints which cannot be directly influenced by the product developer. Thus, it may e.g. contain *legal restrictions*, *standards* or *strategic relationships*, which need to be considered.

Product profiles and their elements are developed methodically following two approaches. In the top-down approach, a multitude of claims is generated using creativity methods. These are evaluated and summarized and then enriched with data. The bottom-up approach involves a thorough investigation of the various elements. These are then summarized by a fitting claim.

5. Findings

In this contribution, a basic definition of a product profile has been introduced, which can be transferred to various projects. In the context of PGE and ASD in particular, a product profile is a powerful artefact for the early and consistent integration of the customer into the development process. In addition, a product profile provides two views of the validation. On the one hand, it is possible to validate various identified customer's, user's and provider's benefits regarding their relevance. On the other hand, the product profile makes it possible to validate (subsystem-) solutions, ideas and prototypes against the modelled number of benefits. During the validation, it is possible to verify to what extent the product satisfies the actual needs of customers, users and providers. In addition, it was shown how a product profile can be modelled by the interaction of different elements. With the findings of this paper Schumpeter's description of innovation can now be amplified with product profiles. According to this, an innovation is based on a product profile that is technically implemented by the invention and completed by successful market launch.

6. Future Works

Even though the resulting framework for the modeling of product profiles is based on vast empirical data and widely accepted literature, it must be further validated in industrial projects. Additionally, approaches for product profile modelling as a key activity of ASD need to be developed to guide the developer through a well-structured but agile process and by this enhancing the development success. Different channels to generate product profiles have to be considered. In addition, it must be understood how a systematic approach for the technical implementation of product profiles in ASD by Intentional Forgetting of irrelevant objectives can be defined. Particular importance is attached to looking ahead with the help of future scenarios. These describe consistent future worlds by linking future developments with particularly influential factors. However, there is a lack of mature and validated methods that make it possible to use scenarios to determine profiles in the long term. These potentials need to be further enhanced. Furthermore, methods for the selection of the most promising product profiles as well as the selection of the proper validation methods, the consequence analysis and relation to the context of System of Systems need to be addressed.

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