Identification of Fields of Action for the Integration and Validation of Future-Oriented Customer-Relevant Product Characteristics During the Product Engineering Process

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Abstract

Products are defined by diverse characteristics that must cater to customer needs for successful marketability and a potential innovation. Foresight methods are used for products with a long-term horizon to anticipate future requirements and product characteristics at the onset of the engineering process. However, the expected future situation and needs can differ from the initial expected environment, necessitating the adaptation of product characteristics to meet the changes. Continuous validation of requirements and product characteristics is imperative, with changes considered accordingly.

This paper aims to identify fields of action for engineering methods and design processes in identifying and validating future-oriented customer-relevant product characteristics in the product engineering process (PEP), and to derive actionable insights and needs for action from this. A systematic literature review was conducted to identify and collate factors influencing the area of investigation consisting of three fundamental domains: product development, customer involvement and foresight. The interrelationships and coherences were evaluated, and the factors synthesized into an Initial Reference Model (IRM). The resultant model revealed five fields of action. Existing potentials and actionable steps were identified and described, especially monitoring and change detection of future development and addressing and validating of customer needs by integrating customers into the PEP.

Keywords
Customer needs, fields of action, foresight, influencing factors and product engineering process (PEP).

1. Introduction
Products are defined by various characteristics (Albers et al. 2021). These must address the requirements and needs of customers so that the product can be successful on the market and thus become an innovation according to Schumpeter's (1939) understanding of innovation. The characteristics are defined at the beginning of the product engineering process (PEP), and later success depends on the decisions made there (Cooper and Kleinschmidt, 1993). For the development of products with a long-term time horizon, needs must be thought ahead, as they may be very different from current needs. For this purpose, methods of foresight are applied (Siebe 2018). However, the expected situation in the future can also vary during the PEP compared to the environment expected at the beginning, which is why the target characteristics can change significantly by the time the product is launched compared to the characteristics defined at the beginning (Albers, Bursac et al. 2018). Changes during the PEP must therefore be considered and implemented.

The requirements and product characteristics must be continuously validated, as this is the only way to ensure "that the product can later be successful on the market" (Albers, Behrendt et al. 2016, p. 2).

1.1 Objectives

The aim of this paper is the identification of improvement potentials and the resulting fields of action in the integration and validation of future-oriented customer-relevant product characteristics in the PEP. The focus is on the possibilities of customer involvement in connection with foresight as well as validation during the current PEP in the case of changes in the expected future. With the help of an Initial Reference Model (IRM), the relationships of previously identified influencing factors are to be established and fields of action for improving the integration of future-oriented customer-relevant product characteristics are to be derived from them.

2. Literature Review

2.1 Understanding of Innovation and Product Engineering Process

Product engineering is to be regarded as part of the product life cycle and comprises all steps from product or business idea to start of production (Albers and Gausemeier 2012). A special role is attributed to the Early Phase, since later success depends heavily on decisions made there (Cooper and Kleinschmidt 1993). The possibilities to influence the process are greatest here and later changes involve comparatively high costs and time (Verganti 1997). Since products are usually developed in generations and based on reference products (Albers, Bursac et al. 2016), Albers et al. (2017) defined the Early Phase of Product Generation Engineering (PGE) in terms of assessing development risk and thinking in terms of product generations. The PGE according to Albers et al. (2015) is an explanatory model for the development of technical products and mechatronic systems. It is based on the assumption that new products are not developed on "white sheet of paper" but always based on references.
Innovations (from Latin "innovatio" = renewal, novelty, change) are of central importance for the success of companies (Schuh 2012). The concept of innovation goes back to Schumpeter, who describes it as the successful implementation of a technical or organizational invention in the market (Schumpeter (1939). Thus, an assessment and classification of an innovation is only possible retrospectively (Albers et al. 2015; Albers et al. 2020). Nevertheless, these must be planned with foresight: "The basis for tomorrow's innovation success is therefore forward-looking and system-oriented product development" (Albers and Gausemeier 2012, p. 17). Albers, Heimicke et al. (2018) take up Schumpeter's description and extend it by the product profile. They describe an innovation as the technical implementation of a product profile through an invention and its successful market introduction (Albers, Heimicke et al. 2018). A product profile is a model of a number of benefits that specifies the solution space for the design of the product and, in particular, makes the benefits accessible for validation by providers, customers, and users (Albers, Heimicke et al. 2018). As understood by Albers, Heimicke et al. (2018), the development and validation of a product profile is a necessary foundation for innovation. It is validated throughout the development, during and after creation, with the stakeholders involved.

2.2 Customer Needs and Integration in the Product Engineering Process

Different stakeholders involved in the PEP have different perceptions, with those of customers being the most important (Yang 2018). Lack of customer focus and unmet customer needs are cited as reasons for new product failure (Miller 1977; Scaringella 2017). Therefore, it is important to determine the needs and requirements of customers. Needs and requirements can be captured by specific, required characteristics in the form of development goals to be incorporated into the development of the product (Lindemann 2009; Wiedemann 2014).

During product development, products suitable for the customer must be developed in a timely manner and offered to the customer, whereby it is obvious to involve customers in the design from the beginning (Hofbauer 2013). Market success depends on customer satisfaction, which is why it is important to continuously involve them in product development (Katicic et al. 2015). In the literature, a fundamental distinction is made between two dimensions of customer involvement: customers as a source of information and customers as co-developers (Fang 2008). In the former, the development team gathers information about customer needs and wants through observations or surveys in interviews, focus groups, or polls (Griffin and Hauser 1993). The customer is passively involved and shares his information only when prompted. Customers as co-developers, on the other hand, actively participate in the PEP, develop the product together with the developers, and contribute not only wishes but also possible solutions (Cui and Wu 2016). If innovation processes are initiated by customers and users themselves and only loosely coordinated by the company, the term open innovation or user innovation is often used (Piller 2006). According to Scaringella (2017), despite numerous studies, it is not possible to draw a definite conclusion as to whether customer involvement is more of a stimulus or hindrance to the PEP.

Customers' needs are not constant but change over time. A turbulent, changing environment has an impact on needs and wants. As a result, needs also change, for example, due to changes in customer tastes (Mellahi et al. 2002). Customers do not always know what exactly they want and are often unable to assess what will be important to them in the future (Racela and Thoumrungroje 2019).

2.3 Foresight in the Product Engineering Process

To be successful on the market, products are needed that meet future market requirements (Albers, Dumitrescu et al. 2018). Future management includes all processes, methods, and systems necessary for the early detection of future developments, as well as their design options and implementations in organizations (Micic 2007). Fink and Siebe (2006) divide future management into the three levels prognoses, trends and scenarios, each addressing a different time horizon. In addition to prognoses and trends for short- and medium-term time horizons, scenarios are intended as a tool for long-term foresight (Gausemeier et al. 2016), enabling the derivation of a strategic direction. Several alternative futures are developed to cover the potential future space as broadly and comprehensively as possible, thus supporting open-future thinking. Thus, an exact prediction does not take place. However, partial areas of the possible future space can be focused in order to be able to develop in a future-oriented manner (Thümmel et al. 2022). In monitoring, already focused areas are specifically observed to detect changes in the development. (Siebe 2018)

To make results from foresight methods usable, characteristics for the products to be developed must be derived from them. Building on the PGE model, Marthaler (2021) has developed a systematic approach for identifying future innovation potentials by incorporating foresight tools to enable planning of product developments over several generations (Marthaler, Stahl et al. 2019). A systematic approach by Marthaler, Duehr et al. (2019) for finding relevant product requirements in the short to medium term uses the persona method.

2.4 Influencing Factors

External requirements and constraints, such as the dynamics of requirements, can have a significant impact on the development of the product. These, but also internal influences such as the degree of involvement and collaboration with customers can be mapped by influencing factors. According to Gericke et al. (2013), influencing factors in the context of product development are factors that affect the development project and influence its course. By looking at the influences of these factors, improvement potentials for the integration of product characteristics can be identified to align products with the future needs of customers through improved processes and methods. A large number of influencing factors on the PEP have already been identified in several studies conducted. These cover a wide thematic range, with the topics of foresight and customer involvement being particularly relevant for this work, in addition to general factors of product development. For the area of product development, Wilmsen et al. (2019) compiled 946 possible factors from various fields in a comprehensive literature review. By Marthaler (2021), 328 factors with focus on foresight were compiled in an IRM.

2.5 Interim Summary

In the PEP, the aim is to develop and launch suitable products that address the future needs and current requirements of customers. For this purpose, potential determination is conducted at the beginning of the process in the Early Phase and the identified potential is recorded in the product profile. To identify current needs, customers can be involved indirectly or directly in the development process, either through observations and surveys or through active participation in the development. For longer-term time horizons, further approaches are required, which is why methods of foresight are used, to show possible future developments, for example, by using scenarios. The factors influencing these areas of product development, customer involvement and foresight are only partially known.

3. Methods

3.1 Need for Action

Many future product characteristics are determined early in the PEP, with subsequent success depending heavily on decisions made there (Cooper and Kleinschmidt 1993). Identifying customer-relevant characteristics for a development with a long-term time horizon is particularly challenging, as the future situation may differ significantly from the current one and is subject to uncertainty, which means that by the time the product is launched, the target characteristics may still change significantly from those defined at the beginning (Albers, Bursac et al. 2018). Therefore, changes must be considered and implemented during the PEP. It is not precisely specified which influencing factors play a role in the integration and validation of customer-relevant characteristics in interaction with foresight - especially after the initial definition of product characteristics in the early phase of the development process and in the case of changes to the expected future. Furthermore, it is not clear to what extent the involvement of customers can be used for this purpose and which improvement potentials for the creation process and their methods result from this. Therefore, the aim is to identify influencing factors and derive fields of action in improving the integration and validation of future-oriented customer-relevant product characteristics based on needs and requirements. Furthermore, for each field of action identified potentials and needs for action to improve.

3.2 Research Design

From the research gap and the need for research, the following research questions can be derived, which are used to structure this work as well as to evaluate the results.

1. Which influencing factors for the integration and validation of future-oriented customer-relevant product characteristics can be identified from the literature?
2. Which needs and potentials can be derived from this for the integration and validation of future-oriented customer-relevant product characteristics?
3. Which fields of action can be derived from the influencing factors, their relationships and potentials for the integration and validation of future-oriented customer-relevant product characteristics?

To answer the research questions and thus to achieve the set research objectives, a systematic approach based on the first two phases of the Design Research Methodology (DRM) of Blessing and Chakrabarti (2009) is chosen. Based on an initial analysis of the research area, a systematic literature review is conducted. Based on the publications identified there, relevant influencing factors are identified and uniformly processed. Then, by transferring the factors into an IRM, fields of action are derived and potentials and needs for action are discussed. The process is shown in Figure 1.

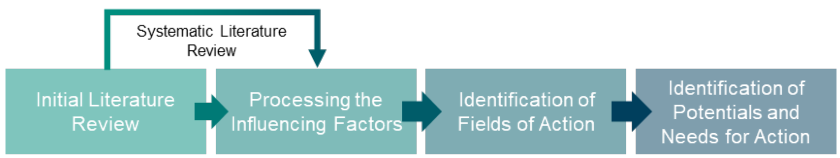
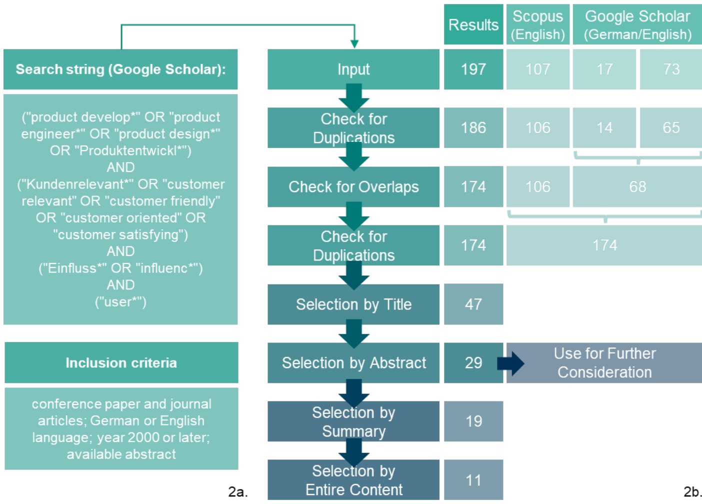


Figure 1. Overview of the process

3.3 Preparing and Conducting the Systematic Literature Review

An initial literature review is conducted to identify influencing factors. Based on the state of research, the research topic is divided into three basic areas: product development, customer involvement and foresight. Comprehensive collections of influencing factors on the topics of product development by Wilmsen et al. (2019) and foresight by Marthaler (2021) are already available from previously conducted research projects. Therefore, these are not explicitly searched for again, but prepared accordingly from the existing ones. The systematic literature search therefore focuses on the topic area of customer involvement in the PEP.

Using the findings from the initial literature review, search strings are formed and search criteria defined based on Kitchenham's (2007) inclusion criteria: publications in form of conference papers or journal articles in German or English starting from 2000 or later with available abstract. Scopus and Google Scholar are used as search engines. Since they have different requirements and limitations for entering search strings, individual search strings are formed for each. For example, the search string for Google Scholar and the inclusion criteria are shown in Figure 2a.



No.	Source	No.	Source
1	Loureiro et al. 2020	16	Stock 2014
2	Racela and Thoumrungroje 2019	17	Lin et al. 2013
3	Madzík 2019	18	Tajeddini et al. 2013
4	Nguyen and Harrison 2019	19	Lin and Huang 2013
5	Syahrial et al. 2019	20	Coviello and Joseph 2012
6	Yang 2018	21	Chan and Ip 2011
7	Louw et al. 2018	22	Fuchs and Schreier 2011
8	Khanagha et al. 2017	23	Öberg 2010
9	Dong and Sivakumar 2017	24	Luo et al. 2010
10	Scaringella 2017	25	Matt 2009
11	Cui and Wu 2016	26	Füller et al. 2004
12	Abrell and Durstewitz 2016	27	Fang 2008
13	Katicic et al. 2015	28	Bonner and Walker 2004
14	Li et al. 2015	29	Salomo et al. 2003
15	Zhao et al. 2014		

2c.

Figure 2a. Search string for Google Scholar / Figure 2b. Selection process of the publications / Figure 2c. Identified publications for further consideration

A total of 197 publications were identified by the two search engines, which are systematically analyzed in the following steps. First, a check is made for duplications in the two search engines. Then, the results are analyzed step by step for relevance in terms of content and sorted out after checking the title, abstract, summary, and entire content. This process is illustrated in Figure 2b. Based on the systematic literature search, 11 relevant publications were identified. However, relevant sub-aspects are included in supposedly non-relevant papers, which is why a total of 29 publications are included in further consideration. These are shown in Figure 2c.

3.4 Identifying and Processing the Influencing Factors

Relevant influencing factors regarding the involvement of customers in the PEP are identified from the selected publications. Some of these are already available in the form of a tabular list or figure or are extracted from the full text. The influencing factors identified in this way represent a raw format from which unified influencing factors are subsequently selected and formulated. In this way, 34 influencing factors were identified for the area of customer involvement and reduced to 16 different factors after duplications and content selection.

For the area of product development, a systematic evaluation in two stages was carried out for the collection of influencing factors of Wilmsen et al. (2019). In the first step, a distinction is made in 4 levels between no, low, medium and strong influence on the area under investigation in this paper. In a second step, the factors with medium and strong influence are reviewed and the evaluation is adjusted. This results in 31 relevant factors for the product development area.

Marthaler (2021) presents a collection of a total of 328 factors in 14 thematic areas on the interaction between PGE and foresight. From this collection, the relevant areas are examined and relevant factors from these and neighboring areas are selected by the situation understanding generated on the basis of the current state of research. This results in 35 influencing factors for the area of foresight.

From the three areas of product development, customer involvement and foresight, the selected 82 influencing factors are now combined into a unified overall list. Since the influencing factors from the various sources, but also within the sources, are available in different levels of detail and language, they must be standardized for further use. The influencing factors will be formulated for later consideration of influence in such a way that control levers can be plotted as a dimension on a uniform scale from low to high: e.g., change of demand, time horizon. In conclusion, there is a unified list of 71 influencing factors for the integration and validation of future-oriented customer-relevant product characteristics that represent the answer to research question 1. These are listed in Figure 4.

3.5 Identifying the Fields of Action and their Potentials and Need for Action

To define fields of action, the selected and prepared influencing factors are set in relation to each other. The levers can be used to describe the influence of one factor on another based on literature, own knowledge or assumptions. The pattern and an example are shown in Figure 3a and 3b. This can be done systematically using an IRM.

Figure 3a. Relationship between two influencing factors / Figure 3b. Example for the connection of two factors

By delineating sub-areas within the IRM, areas for action as well as potentials and needs for action can be derived. In some cases, influencing factors of these fields overlap, as they are directly relevant for several areas. The fields also influence each other, so it is not possible to make a clear distinction between the various fields of action, nor is it expedient to do so. Rather, the fields of action are intended to describe areas in which more intensive research will be conducted in future research projects and approaches to solutions for improving the respective field will be found and elaborated. The action map in Figure 5 shows the fields of action as islands inspired by those often used in the scenario method to give an overview.

4. Results – Influencing Factors and Fields of Action

A total of 71 relevant influencing factors were identified and standardized from the existing lists of influencing factors in the areas of product development and foresight as well as a systematic literature research on customer involvement. Those are listed in Figure 4 categorized by the area of origin. Due to the focus on the future, the majority comes from the area of foresight. Based on the factors, the following five fields of action were identified by considering the relationships in an IRM: "Changes of Plans for Future Products in the Product Engineering Process", "Recognizing Changes in the Future Development", "Integrating Customer, User & Supplier Utilization in Demand and Product Validation", "Improving Targeted Customer, User and Supplier Orientation in the Product Engineering Process" and "Future Personas for Early Anticipation of Customer & User Benefits". Each of these will be briefly described below and their potential and need for action highlighted. This provides the answer to research questions 2 and 3.

The fields of action are interrelated, complement each other in part or are interdependent. The representation in Figure 5 shows the fields of action in the form of a map - based on the representation of scenarios of the future space from the scenario technique. The individual fields of action are represented stylized by islands and roughly described by supplementary, characteristic details. The distances between the islands represent the thematic interrelationships. Fields of action that are characterized by strong customer involvement are located in the lower part. Fields of action with a strong connection to foresight tend to be located on the right of the map.

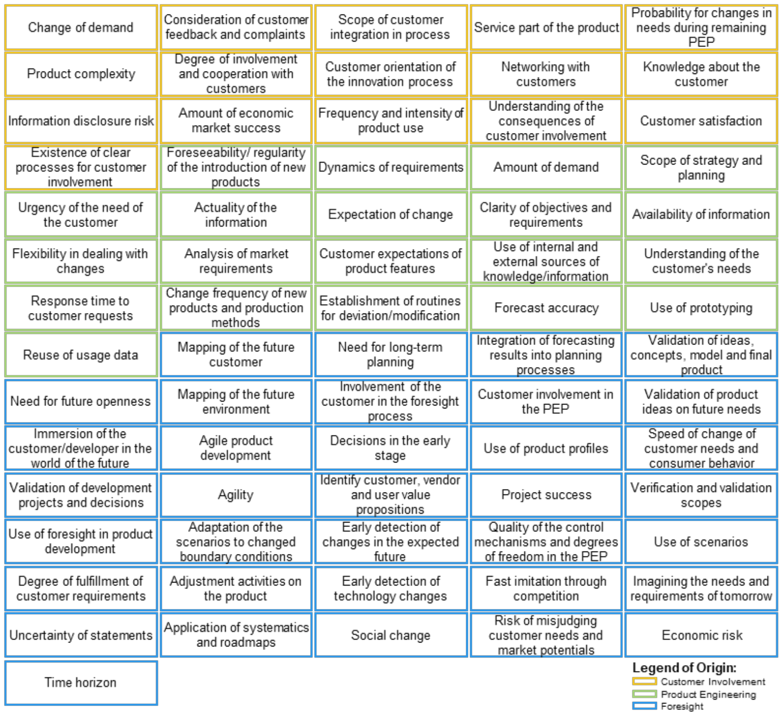


Figure 4. Overview of the identified influencing factors

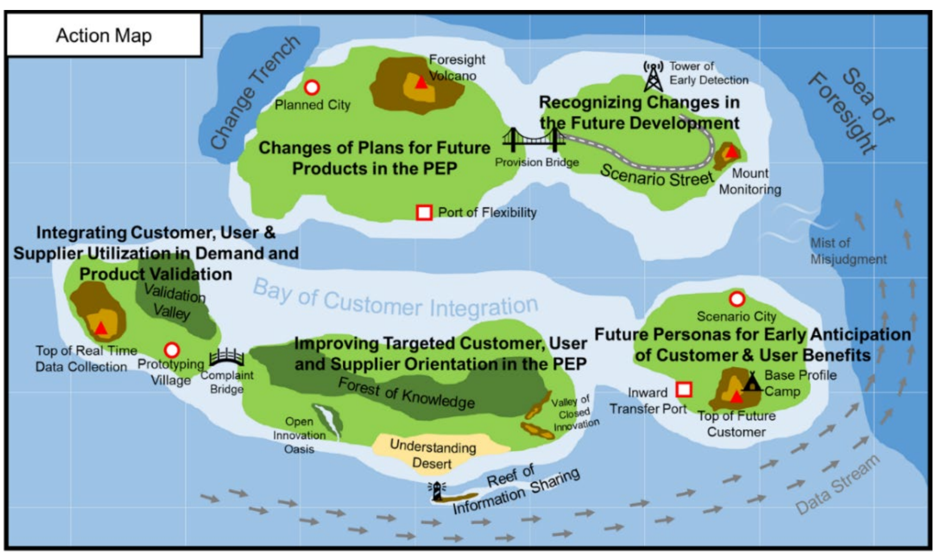


Figure 5. Action Map of the five derived Fields of Action

4.1 Field of Action 1 – Changes of Plans for Future Products in the Product Engineering Process

Changes in requirements occur during the PEP. These must be considered in order to address the needs of customers when they enter the market. The probability of changes occurring depends on the time horizon and the complexity of the product. Depending on the dynamics of the requirements and the maturity of the product under development, there are different scopes and efforts for changes to be made with regard to the product characteristics. These are greater the later the changes are to be implemented.

Validation is a continuous process in the PEP, which is why there are no discrete points in time for validation. The field of action aims at the validation of requirements and product characteristics derived from foresight methods. It is assumed here that the future product characteristics are identified at the beginning of the PEP in the early phase, for example with the aid of scenarios. A later check and comparison with the future development once the PEP has begun has not yet been carried out. Changes in the environment, for example because of newly established technologies and changes in social views, can change the expected future, the needs of customers and, as a result, the characteristics required in the future.

Depending on the time horizon of the development and the complexity of the product, the required product characteristics will change to varying degrees. Therefore, at certain points in time, these should again be derived from or compared with updated results using methods of foresight. Depending on the deviation between the originally expected future and the updated future, measures may be required to adjust the product characteristics, which can then be defined and implemented. It must be clarified whether a continuous reconciliation is possible due to the effort and the available information or at which point in time such a review and reconciliation should be carried out. The point in time could, for example, be made dependent on the maturity level of the product or subsystem to be developed. One approach would be to determine or define a critical point in time after which a change is no longer possible and at which a critical review and final decision must be made. The more advanced the development process, the more complex changes are, which is why it must be decided whether a change can be implemented with reasonable effort and whether the adaptation is worthwhile. Even an implementation of changes after the launch on the market can be considered and realized by updates for software and upgrades for hardware. If the product is on the market and the requirements change, its features and functions can be supplemented and exchanged. The reference for this is the software industry, which regularly adds new functions to products on the market. Therefore, the development of mechatronic systems needs to adapt on the hardware side.

4.2 Field of Action 2 – Recognizing Changes in the Future Development

To obtain an overview of the expected environment of the future and to be able to derive strategies, options for action and ultimately product characteristics from this, methods of foresight are applied. One possibility is the scenario technique, in which the relevant factors are selected and projected into the future. Different characteristics are combined into bundles and ultimately into scenarios, which are then interpreted and used to derive measures in the form of visions and strategies and in the end roadmaps and plans. The scenarios are evaluated in terms of probability of occurrence to narrow down the expected future space. By mapping and visualizing the future space, developers are able to immerse themselves in the future world.

Changes can be detected early by scanning and observing the future development using scenario monitoring. In particular, the factors used to create the scenarios are monitored and compared with prognoses and trends. Depending on the extent of the changes, the scenarios are reinterpreted, adapted or completely redeveloped, resulting in an updated picture of the future for deriving requirements. By using available information that is as current as possible, forecast accuracy can be improved. This reduces the risk for misperceptions of future needs and more comprehensively meets needs and customers.

Foresight monitoring processes offer potential for improvement to detect changes earlier and more accurately. Improved and earlier detection of changes in the environment and needs can be achieved, for example, through increased monitoring of the development of current trends or through improved forecasting from more up-to-date information. Better, preferably continuous, availability of foresight for product development to match the originally expected future and the product characteristics derived from it at the beginning of the PEP with updated insights would improve the addressing of customer needs. For example, existing systems for deriving characteristics could be extended to include the possibility of subsequent validation. In this process, derived needs and characteristics could be checked against the revised scenarios and updated future world, the deviation and need for change identified, and eventually adjusted accordingly.

4.3 Field of Action 3 – Integrating Customer, User & Supplier Utilization in Demand and Product Validation

Improved feedback from customers, users and operators is achieved through close networking with vendors. The provider can more effectively gather feedback efficiently and analyze it with regard to current market requirements. In addition to simple surveys, this networking can also take place through practical tests based on prototypes with selected stakeholders and use of modeling of the demand situation based on the product profile, which can increase accessibility to needs and benefits. The usage data that emerges in the process is improved if the determination can be captured and analyzed in real time. The more frequently and intensively the product is used, the more data can be collected and used for further analysis. This data can be reused for further development activities to make development decisions more valid. On the one hand, usage data can be increasingly used for validation and to identify current usage trends. Through stronger networking with customers and users, for example, information on usage type, duration and intensity can be collected to better assess needs or to retain or discard functions. In this way, not only can the product itself be validated with its functions, features and requirements, but also foresight tools such as prognoses or trends can be validated.

If, for example, current trends go towards the use of touch screens instead of physical buttons, this development can be examined by analyzing the usage data of corresponding machines with touch screens and physical controls. On the one hand, this can be used to investigate which technical invention is predominant on the market and better meets the current need or whether the need is there at all. On the other hand, the trends regarding the interaction and operation of machines can be analyzed and which counter-trends currently exist and how these are to be evaluated. Otherwise, different prototypes could be tested in real use at the customer's site and usage data could be recorded in real time. In this way, knowledge could be fed back to the developers as to which features and functions are valid, which still need to be worked out, and which have not yet been considered. In addition, the application can also validate the need and utility of the product. For example, customer use of touch screens can identify whether the control concept is valid, still needs improvement, or new elements such as additional physical controls need to be added. In addition, the need for new controls and the benefits of a touch screen can be assessed during use.

4.4 Field of Action 4 – Improving Targeted Customer, User and Supplier Orientation in the Product Engineering Process

During the development of products with high innovation potential, the needs and benefits of customers, users and suppliers must be taken into account. In this context, the integration of these stakeholders into the PEP is important. In addition to proximity to the customer through good networking, the customer, user and supplier orientation of the innovation and PEP in the company also plays a role. Improved alignment and involvement result in improved knowledge of the stakeholders, improved recognition of the need and benefit of the product. However, uncertainties exist here such as information disclosure to competing competitors and uncertain stakeholder statements. The opportunities and risks have already been investigated in various research projects, but an approach for evaluating and weighing opportunities and risks for the decision on direct involvement as well as at which points in time involvement should take place is missing. To this end, investigations must be carried out to determine in which development activities and phases direct stakeholder involvement makes sense. Based on this, customers could be involved in the PEP at defined points in time to a certain extent and in an appropriate manner. Depending on the phase, the customer can serve as a source of information, for example by means of observations and surveys, be actively involved as a developer and idea provider, derived from the concept of open innovation, or act as a decision-maker. The critical point here is that customers, users and providers are often unable to define their needs precisely, which is why development teams must proactively generate needs, ideas and concepts in order to be able to narrow down and express the needs and wishes.

4.5 Field of Action 5 – Future Personas for Early Anticipation of Customer & User Benefits

In addition to integrating customers, users, and providers into the PEP, understanding these stakeholders is important for needs derivation and validation, and their future needs in particular must also be taken into account. By using the scenario technique, various alternative futures are developed and mapped as the future environment. This allows future needs to be derived by integrating the customer, user and supplier into the foresight process during the PEP. Currently, however, future needs are not derived, described, and validated with the customer, user, and provider of the future because personas describing stakeholders are mostly based on today's experiences and do not map future characteristics. Therefore, methods of foresight must be integrated into the creation of personas for deriving future needs. Here, customers of the future could be derived from scenarios to validate product needs in the early phase. Likewise, these future personas could be used to derive further requirements. One solution approach is to develop an AI-based support for generating future customers from prognoses, trends and scenarios. A basic principle for a corresponding algorithm has already been designed. The concept could be validated by looking retrospectively at past forecasting results and comparing them with the current environment.

5. Conclusion and Outlook

To identify fields of action in the integration and validation of future-oriented customer-relevant product characteristics during the PEP, a literature analysis was first conducted to identify the most important areas. Based on this, a total of 71 factors were identified in the three fields of product development, customer involvement and foresight. To this end, existing collections from the literature were analyzed and a systematic literature search was conducted on the area of customer involvement. The factors were systematically selected step by step, processed and unified into an overall list. Based on the relationships, an IRM was created and five fields of action were derived and described on the basis of their corresponding potential and need for action. An action map in Figure 5 illustrates the fields of action as islands to get an overview. These will be analyzed and addressed in more detail in further research projects. In particular, with regard to the improvement of the foresight or the monitoring of this as well as properties derived from it and the implementation of subsequent changes in the PEP. A research project therefore deals with the description of changes in the foresight and a procedure for the improved recognition of changes. With updates and upgrades, there is the possibility for changes beyond the classical development period of a product. Therefore, one research topic deals with modularization in combination with foresight as a basis for updates and upgrades. There is also potential for improving the addressing of customer needs by integrating customers into the product development process. Future personas and the early involvement of customers in the validation process could make it easier to narrow down future customers, check their needs and thus develop customer-oriented products. Initial concepts have already been developed for this which still need to be elaborated and tested.

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Albert Albers has been full professor for product development and head of IPEK - Institute of Product Engineering at the Karlsruhe Institute of Technology (KIT) since 1996. He received his doctorate in 1987 under Prof. Palandan of the University of Hannover. Before his appointment to Karlsruhe, Prof. Albers worked for LuK GmbH & Co. OHG, most recently as head of development and deputy member of the management board. He is a founding and former board member of the scientific society for product development WiGeP, a member of the German Academy of Science and Engineering (acatech) and a member of the Advisory Board of the Design Society. Since 2008, he has been President of the Allgemeiner Fakultätentag (AFT e. V.). In addition, Prof. Albers engages in the VDI and serves on the advisory boards of several companies. In 2016, he and the IPEK team were awarded the Honorary Award of the Schaeffler FAG Foundation for excellent achievements and competencies in science, research and teaching in the technical-scientific field.