

# **Technology-Push based Product Engineering based on Future Scenarios: Application for deriving product strategies at BMW AG**

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## **Abstract**

To develop products that achieve high customer satisfaction, product developers have to make decisions during the early phase of product development, regarding the customer and user experienceable properties. Traditional development approaches have to rely on market analysis, but lack a long-term perspective. By integrating forecast methods like scenarios technology, Marthaler developed an approach that allows the development of multiple product generations. This approach currently focuses on market pull strategies. (Marthaler et al., 2019) This article introduces an approach that expands the current approach by focusing on technology push strategies and delivers a method specifically designed for technology push strategies. With this approach innovations can be developed, by utilizing reference systems from other industry sectors. The utilization and subsequent surveys with employees of the BMW AG confirmed the applicability of the approach in their product development process.

## **Keywords**

PGE - Product Generation Engineering, Technology-Push, Future scenarios, Systematic approach, Reference system

## **1. Motivation**

The efficient and effective design of innovation processes is the central task of innovation management. This means that innovations can only be successful if, on the one hand, current and future customer needs are met and, on the other hand, they can be developed and produced in a cost-efficient way (Weissenberger-Eibl & Joachim, 2009). An innovation that targets a specific need that has been identified in the market is referred to as application-oriented innovation or pull innovation. This is a method of positioning the product with a low market acceptance risk. In contrast, technology-oriented innovation or push innovation is used when companies have their own technologies, concepts and ideas and aim at realizing them as products for use cases in new markets. The risk of the market acceptance of the product is higher because the product was not developed based on specific needs. This means that technology push innovations generally have a lower probability of success in the market than pull innovations, as they do not result directly from recognizable market requirements (Hofbauer, Körner, Nikolaus & Poost, 2009). In contrast, however, the degree of innovation is very high since push strategies aim at breakthrough innovations through their massive R&D investments, some of which also flow into basic research (Souder, 1989).

Studies show that decisions made in the early phase of product development determine the success of products on the market (Tobias & Hansgeorg, 2009). In order to increase the probability of success of push innovations, an assessment of potential and future must be made in order to support the early phase with suitable marketing and environment measures.

Technology and market innovations underline that a company can only produce successful product innovations if there is an integration between market and technology opportunities (Hofbauer et al., 2009). There are already numerous methods that can be used to find a technical solution based on a demand. What is currently not addressed is the decision as to whether the new technology can be introduced to the market as products with future thinking, for example scenarios technology.

Numerous ideas or technologies already exist at BMW AG, but it is not always clear which ones will be introduced to the market. It is also a challenge for every large corporation to sit together for certain issues and work more

efficiently. Overall, there are too many voting dates. The information is insufficiently bundled and lacks a method that holds the threads together. Marthaler developed an approach that allows the development of multiple product generations. This systematic approach currently focuses on market pull strategies. (Marthaler et al., 2019) That means that this systematic approach is not suitable for the situation with introduction of new technology at BMW AG. Therefore, a systematic approach for technology push strategy is missing.

## **2. State of research**

### **2.1 Model of PGE-Product Generation Engineering**

The model of PGE-product generation engineering is a description model that describes the majority of development projects in practice and supports them with targeted methods, tools and processes. With the previous theories from construction methodology and innovation management, the wide scope of development projects in companies cannot be completely mapped. Therefore, the model of the PGE extends the existing models through two fundamental hypotheses. The development of products takes place based on references which are summarized in a unique reference system for each product generation. The activities of carryover variation, principle variation and embodiment variation portray the reference system to the product generation. (Albers et al., 2019)

All new products and their technical solutions are thus developed based on references and reference solutions. In some cases, their structure or subsystems are adopted or used as a starting point for variations (Albers, Bursac, Rapp, 2017). Reference solutions do not have to be product-specific; they can also be used by subsystems from other industries or from research. For example, the iPad can be regarded as an element of a reference system for a communication interface in the development of a new generation of vehicles (Albers et al., 2018). The development of the new product generations, related to their subsystems, takes place based on the individual reference system by carryover variation (CV) as well as new development of subsystems in the form of embodiment variation (EV) and principle variation (PV). The product generation in development ( $G_n$ ) consists exclusively and completely of subsystems developed with the three types of variation presented below (Albers, Bursac, Wintergerst, 2015).

- Carryover variation (CV): With this type of variation, the design and solution principle of the subsystems that are transferred from the reference system remain unchanged.
- Embodiment variation (EV): The solution principle of the subsystem is basically retained, but the form is changed.
- Principle variation (PV): If the new development of a subsystem begins with a PV, the solution principle is also changed in relation to the reference product.

### **2.2 Systematic approach for cross-generational product engineering**

For the derivation of future relevant product requirements, methods of foresight are used. Based on the model of PGE there are approaches which aim at closing the gap between strategic product planning and product engineering. One of these approaches is the cross-generational systematic approach proposed by Marthaler et. al. The process model of the systematic approach consists of seven steps which are to be carried out in three different variants depending on the planning horizon (Marthaler et al., 2019).

### **2.4 Technology Push versus Market Pull as innovation drivers**

In science, a basic distinction is made between the two innovation drivers Technology Push and Market Pull. Figure 1 illustrates the relationship between the degree of innovation, R&D applications, time horizon as well as market and technology uncertainty in market pull versus technology push-projects (Gassman, Kobe, 2006).

Both positions represent extremes on a continuum and, when applied in this pure form in the practice of innovation, naturally harbor immanent dangers:

- Thus, the technology push approach often leads to a "lab in the woods approach" in which research and development is isolated in terms of space and organization and can therefore lose market relevance. An example of this is the development of touchscreens because the customer only noticed the technology when it came onto the market.
- Market pull strategies often lead to a "face lifting" of existing products without substantially questioning the technological core of the product range regarding new developments. One example of this is the ever-increasing number of images that can be taken with a camera. For years, the customers demand new technologies which are developed accordingly in order to fulfill the requirement (Herstatt, Lettl, 2000). The systematic approach by Marthaler described in Chapter 2.3 is very suited for the market pull strategy.

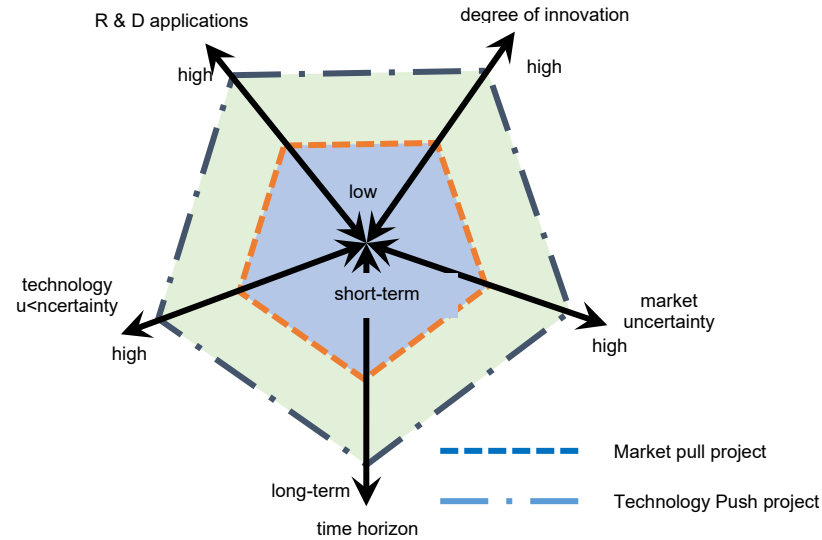


Figure 1: R&D applications, degree of innovation and time horizon of technology push und market pull-projects (Herstatt, Lettl, 2000)

### 3. Research question and research method

The research gap is resulting from the lack of an approach for "technology push" development based on future scenarios.

#### 3.1 Research question

The above-mentioned state of research leads to the following research questions in order to close the discovered gap in research.

1. How to design a suitable approach for technology push product development in order to minimize the market risk?
2. How can the definition of the variants of the approach be justified?
3. What are the interactions between the characteristics that can be experienced by the customer and how are the interactions reflected in the systematic approach?
4. How can the implementation of the systematic approach be simplified?
5. What are the advantages of the systematic approach in terms of reducing risks?

#### 3.2 Research Method

In order to answer research question 1, a systematic approach based on literature research and a expert interviews was developed. The systematic approach is then iteratively adapted and validated. For this purpose, two persons from BMW AG apply the systematic approach to the company's current pre-development strategy. The adjusted systematic approach allows research questions 2, 3 and 4 to be answered. Lastly, a survey based on 20 previously defined success factors (Marthaler et al., 2019) with 5 participants from different specialist departments and research fields is carried out at BMW AG. Within the scope of the survey, the 5th research question is answered.

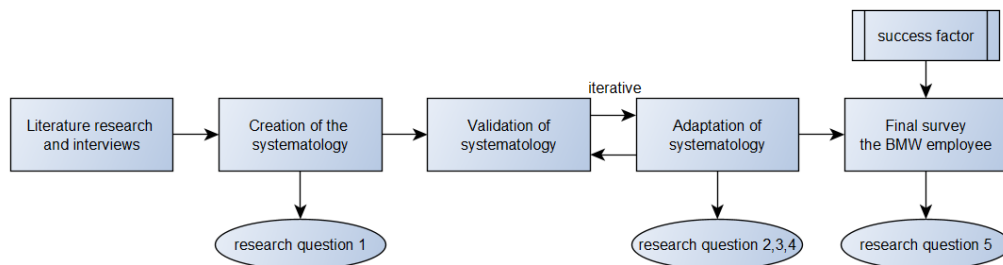


Figure 2: Research procedure of this paper

### 4. Systematic approach for finding implementation potentials in technology push

This chapter starts by describing the systematic approach with which the implementation potential of a technology push can be identified. (see figure 3)

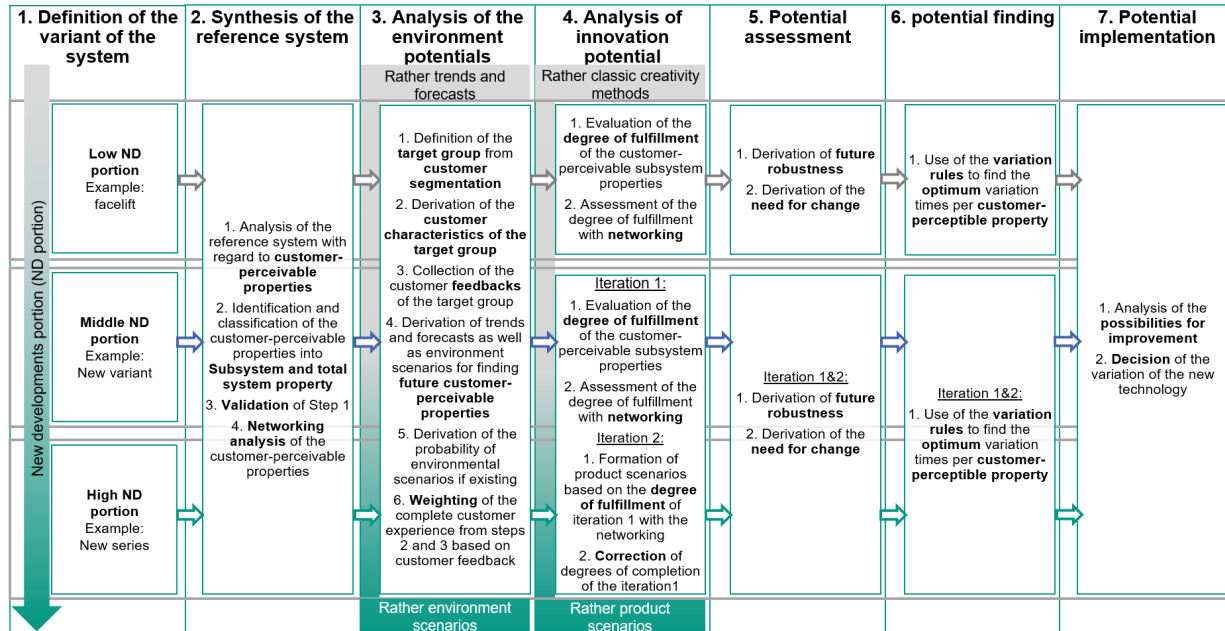


Figure 3: Systematic approach for finding implementation potentials in technology push

#### 4.1 Defining the variant of the systematic approach

The first step is to choose between three different variants which are subdivided according to the share of new development. The selection determines the sequence of the following steps. The correct selection of the variant has the purpose of optimizing the process and thus minimizing the execution time. The higher the share of new development, the higher the effort. In return, however, it can also lead to more benefits.

An example of this is the use of a battery from aerospace for an electric car. From development experience, a new energy storage system is seen as a medium share of new development because some components are to be newly developed, but not a completely new product.

#### 4.2 Synthesis of the reference system

The second step of the systematic is the same for all three variants. The procedure is demonstrated in Figure 4:

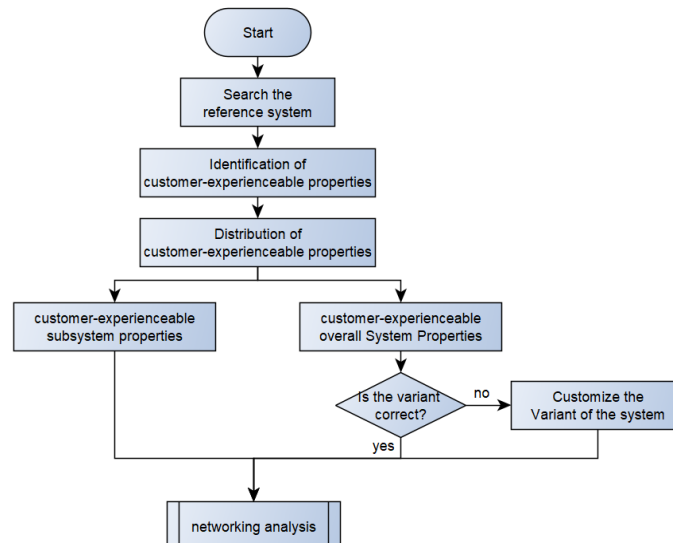


Figure 4: Procedure of synthesis of the reference system

First, a reference system is identified. When a new technology is introduced, the reference system elements from predecessor or competitor products are considered first. Each reference system can contain several reference system

elements. If a technology is new and has never been implemented in the predecessor product, the reference system elements from the predecessor product or competitor product alone are not sufficient. A consideration of a product from other industries and a reference system element, how the technology is implemented in a product from another industry, is required and only used for the technology push strategy. An example is the battery from other industries. In addition to the battery as a reference system element, the subsystems of the predecessor product such as the trunk, heating system, cooling system and crash protection system are also reference system elements:

Products are always developed for customers who do not ask themselves how the product is technologically implemented, but what added value they receive (Marthaler et al. 2019). It is therefore very important for product developers to think in a customer-oriented manner and to improve properties that can be experienced by customers in a targeted manner. Such customer-experienceable properties can be identified from the reference system or via customer surveys for example.

In order to simplify the subsequent steps of the systematic approach and to validate the selection of the variant of the systematic, the properties that can be experienced by the customer are divided. Customer-experienceable subsystem properties are properties that are directly fulfilled by the newly developed subsystem. For example, the physical size of the battery: power density, energy density etc. Customer experienceable properties from the overall system are properties which are fulfilled by the interaction of the newly developed subsystem with the overall system. In the example, these are properties such as crash safety or driving dynamics.

Based on the division, the first step of the system is validated. If the system has few or no overall system properties that can be experienced by the customer, it has a small share of new development since the new system has little or no influence on other subsystems, or can be implemented directly in the product generation to be developed without major changes to the overall system. Depending on the number of overall system properties or changes to other subsystems, the variant with a medium and high share of new development is recommended.

In addition, a cross-linking analysis is necessary since the properties that can be experienced by the customer can interact with each other. With the target relationships according to Vahs (Vahs, Schäfer-Kunz, July 2015), the cross-linking analysis subdivides and supplements the customer-experienceable properties in cases with different relations:

Table 1: Networking option

	Influence of E1 on E2:	Influence of E2 on E1:	Results:
1	positive	positive	complementary goals (synergy)
2	negative	Negative	competing goals (conflict of goals)
3	Positive/Negative	Negative/Positive	Unstable connection
4	negative	no influence	Improvement / requirement
5	positive	no influence	Deterioration / side effect

The example of the electric car battery shows that an increase in range due to an increase in the number of batteries leads to a reduction in storage space. The two properties have thus competing objectives.

### 4.3 Analysis of the environment potentials

The process to be performed in the third step is shown in Figure 5. The environment is divided into macro and micro environments. Therefore, the analysis of the environment potential is carried out in two different ways.

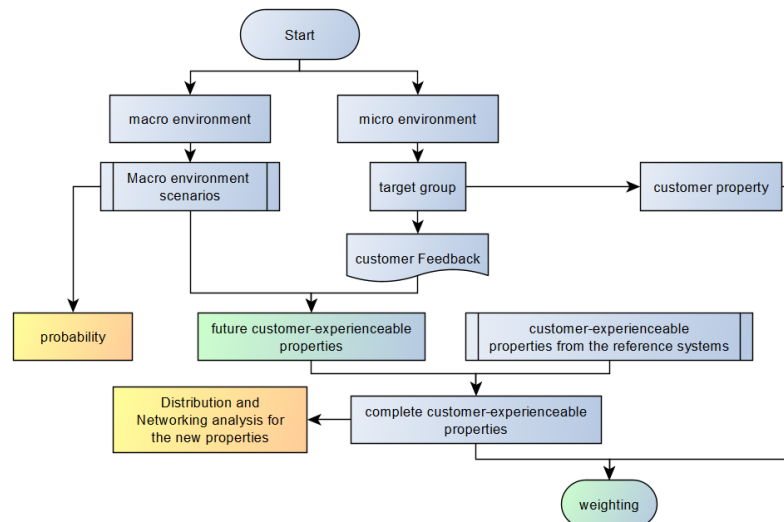


Figure 5: Procedure of analysis of the environment potentials

In order to derive and weight further future, yet unknown, customer-experienceable properties, the macro and micro environment must be considered. However, this derivation and weighting cannot be based exclusively on today's reference systems, as the future must be analyzed for this purpose. Only by using future knowledge, which is generated from prognoses and trends as well as from environment scenarios, the properties can be generated and evaluated for their future relevance. Experience has shown that the larger the share of new developments, the more relevant new and changed customer-experienceable properties exist. This results in a more complicated and uncertain future. If the trends or prognoses from the macro environment are not sufficient to predict the significance of the individual methods, macro environment scenarios are necessary.

The scenarios describe alternative future situations, but not the probability of them. In order to derive the probability, a three-point estimate for a consistency analysis or a probability tree diagram in addition to a morphological box is recommended. The example of the battery has used the probability tree diagram shown in Figure 6 to derive the probability of the scenarios.

The tree diagram consists of paths with associated probabilities. The probabilities of the individual events are determined by the experts by using a Delphi survey, for example. To calculate the scenario probability, all probabilities are multiplied along the path. This way, the probability of macro scenario 2 is calculated by multiplying the probabilities of the path by  $50\% \times 30\% \times 100\% = 15\%$  for example (see Figure 6).

In addition to deriving the macro-environment potential, the micro-environment potential is also determined. An A-B-C method can be used to perform customer segmentation and to derive the customer characteristics of the target segment, such as the gender or age of the customers. Customer feedback from the target group is collected via surveys and research. With the environment trends, prognoses or scenarios and the customer feedback, the gaps in law, environment potentials and future customer requirements are known and serve as a basis for further future customer-experienceable properties.

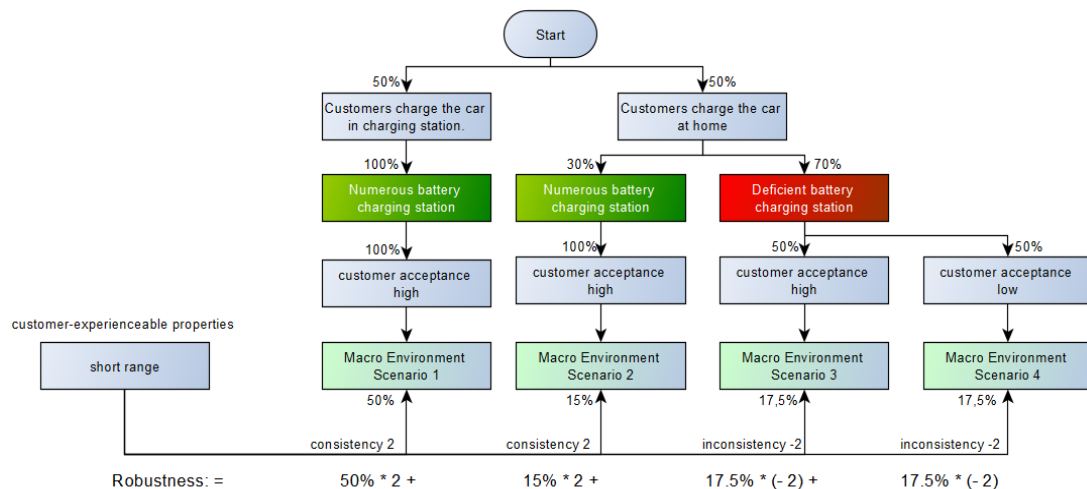


Figure 6: Probability tree diagram charging behavior and consistency assessment and robustness calculation of an electric vehicle

After deriving complete customer-experienceable properties identified from the environment potential (see Chapter 4.3) and from the reference system (see Chapter 4.2), the experts weight the characteristics based on the customer characteristics on a scale of 1 (irrelevant) to 10 (very important). In the case of the battery example, the characteristic "range" (customer-experienceable property) for men (customer characteristic of the target group) would be weighted 8 (important).

#### 4.4 Analysis of Innovation Potentials (1st iteration)

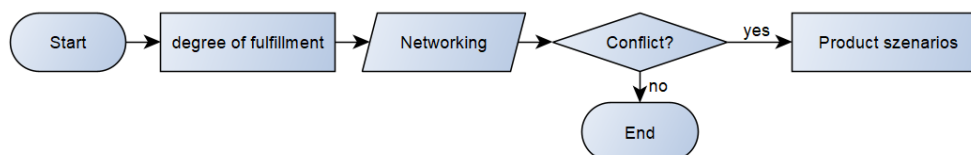


Figure 7: Procedure of the analysis of the innovation potential

In order to analyze the innovation potential, as shown in Figure 7, it is necessary to find out in what extend the new technology fulfils the characteristics that can be experienced by the customer. Furthermore, it is important to consider



which subsystems need to be adapted in order to ensure that the product continues to function when the new technology interacts with other subsystems.

The "technology push" is a new technology from another industry or from research, in short from another area of application, used in a product. However, the properties of the technology from the other application area are already known. For example, a battery from research achieves a higher energy and power density.

The properties of push technology are regarded as unchangeable **input variables**. For this reason, it is relevant to clarify in advance whether the existing properties of the battery fulfil the properties that can be experienced by the customer, or whether they fit into the future environment. If the properties do not fit, step 5 potential evaluation is carried out directly and the systematic approach is thus shortened. If the properties are worse than those from the predecessor technology or inconsistent with the macro environment.

The degree to which the customer can experience the properties is described on a scale whose values range from 4 to -4. The value 4 stands for maximum satisfaction, the value -4 for the lowest and the value 0 indicates that the new technology has an identical degree of fulfillment to the predecessor product. There are also the following hypotheses to simplify the degree of fulfillment:

1. If a new customer-experienceable property is added, or if there is no reference from a predecessor product, the property is automatically regarded as improved. At this point, the customer-experienceable property is rated at least 0.
2. If a property is ideal, e.g. the colors of an LED lamp, then this property has no potential for improvement and the new technology cannot further increase the customer requirement. At this point, the customer experienceable property is rated as 0 at the most.

Product scenarios are only necessary if there are overall system properties or competing subsystem properties because the overall system properties are variable and the competing subsystem properties could have a conflict of objectives. Both cases could lead to an increased uncertainty.

#### 4.5 Potential assessment (1st iteration)

The fifth step of the systematic approach is the potential assessment. In this step, the two parameters of future robustness and need for change are defined as in Figure 8.

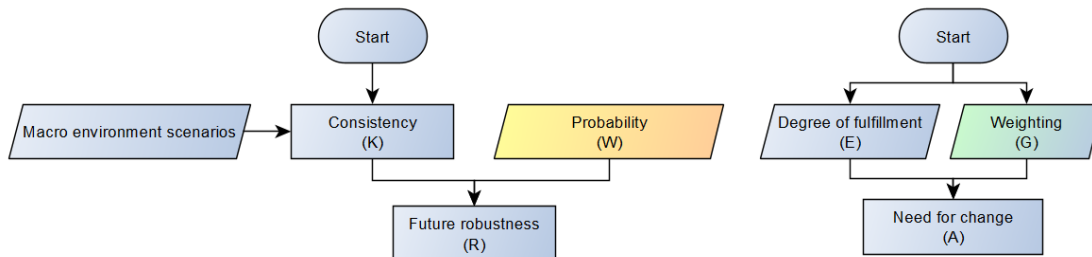


Figure 8: Procedure of the potential assessment

The future robustness describes how suitable the customer-experienceable properties are in consideration of all environment scenarios. In order to calculate the future robustness, the consistency of the environment scenarios regarding the customer-experienceable property  $K_j$  is first evaluated with a value between -2 and 2. In the battery example, the customer-experienceable property "short range" is compared with each macro-environment scenario and its consistency is evaluated. Since a low range is more consistent with a high number of charging stations than with a small number of charging stations, scenarios 1 and 2 are assessed positively (see figure 6).

The equation for calculating robustness is shown in formula (1).  $R$  corresponds to the future robustness of a customer-experienceable property which results from the individual consistencies  $K_j$  and the probabilities  $W_j$  derived in Chapter 4.3. Here,  $j$  indicates the respective macro-environment scenario. Future robustness applies to all variants of the systematic and is evaluated between -2 and 2.

$$R = \sum_{j=1}^n (W_j * K_j) \quad (1)$$

The larger the value, the more robust the customer's experience of the environment will be in the future. High positive robustness means that all requirements are met and that the property can be implemented. A high negative robustness means that there are problems with the property because it is e.g. not admissible, or no longer of relevance and that it will rather not be implemented in the future. If the robustness is rated 0, the property is uncertain in the future. This value is to be determined for each customer-experienceable property.

Subsequently, the need for change of the properties of the current product generation ( $A$ ) is calculated. In this case, the weighting of the customer-experienceable properties of a specific customer segment ( $G$ ) derived from Chapter

4.3 and the technical degrees of fulfillment of the customer-experienceable properties of the product (E) are reused. The corresponding formula is shown in equation (2) below.

$$A = G * E \quad (2)$$

The need for change receives values between -40 and 40. The greater the need for change, the more urgently the new technology must be implemented. The weighting shows the priority of the need for change. A high, positive need for change describes the probability of a company to become a pioneer since the property that is important to the customer is fulfilled much better than with the competitor or the predecessor product. If the degree of fulfillment is high and negative, the technology is not yet mature. If the technology were to be implemented, the properties would be worse than those of the predecessor product or the competition. This can again be explained with the battery example: The long range is not so relevant for a 60-year-old man who drives to work by car every day and has at least 2 cars. The weighting of the property from step three of the systematic approach is therefore 2. One product scenario shows that with the new technology, the car has a lower range than the predecessor model. The degree of fulfillment is -1. From this, the need for change is calculated with the value -2.

#### 4.6 Identification of potential (1st iteration)

In the sixth step, the different combinations of future robustness and needs for change are subdivided into different types of variation. These are shown in Figure 9.

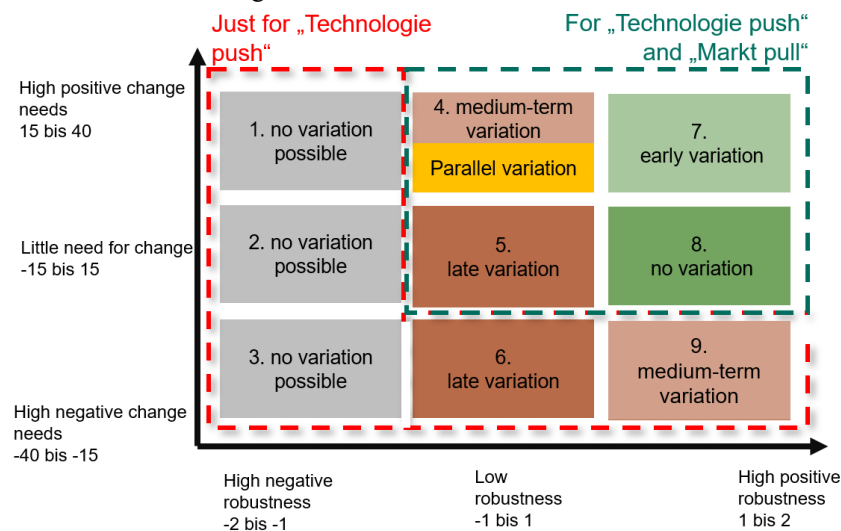


Figure 9: Potential evaluation: determination of search fields

If the robustness deviates into the negative as in fields 1, 2 and 3, this means that the property is not admissible in the future or is no longer relevant. As a result, the need for change is irrelevant. If this is not permitted by law, the customer request or the availability of the technology is irrelevant and the implementation of this property is not possible.

The low robustness as in fields 5 and 6 leads to uncertainty. The variation should take place in a later product generation until the environment is secure and the technology is further developed. If there is a high positive need for change, the variation is either a medium-term or a parallel variation. A parallel variation is when two variants are offered at the same time. A company can wait until its environment is safe for this property and decide whether to implement it or not.

However, if a company decides to shift the variation time due to uncertainties, it misses the chance of being a “first mover”. Therefore, it is recommended to develop several variations (parallel variation). The company decides whether it would make sense to develop two options, each suitable for the uncertain one.

In Chapter 4.2, all customer experienceable-properties were linked and evaluated. There are properties that are to be considered together due to networking. The following section explains how the interconnected customer-experienceable properties are considered. All directly or indirectly linked properties are referred to as a networked property group.

The following cases exist to determine the need for change in the networked property group:

1. If all properties from the group have a need for change that is positive, the need for change of the group is also positive, the value is the same as the highest need for change of the property from this group. For example, the range and the weight are networked properties. If the need for change of the weight is 0, it means that the weight of the vehicle is not improved. However, if the need for change of the range is rated



10, this means that the range is improved. The need for change of the property group "weight and range" is positive and rated 10.

2. If at least one property from the group has a need for change which is high and negative, the need for change of the group is also high and negative and the value is the same as the highest negative need for change of the property from that group. If the need for change of the design is rated 40 and the need for change of the safety is rated -20, the need for change of the property group "design and safety" is negative and rated -20. Customers do not buy a car that is beautiful but not safe.
3. If at least one property in the group has a need for change that is low and negative, the need for change in the group is difficult to determine. For example, the storage space with the range is a group. A high range leads to a slight reduction of the storage space. Whether the reduction of the storage space can be compensated by the enthusiasm about the high range is to be analyzed by means of the Kano model.

### **Kano model comparison**

1. All properties from the networked group are identified according to the Kano model regarding the competitive product. The requirement can be grouped by using the Kano model: The basic, performance and enthusiasm requirements.
2. With the weightings and degrees of fulfillment of all properties, an approximate value is calculated after identification.

The different customer requirement variants:

- Basic requirement:  $-\left(\frac{E^2}{4} - \frac{E}{2} + 1\right) \times G$  für  $E < 0$ ;  $-\frac{1}{E+1} \times G$  für  $E > 0$
- Performance requirement:  $E \times G$
- Enthusiasm requirement:  $\left(\frac{E^2}{4} + \frac{E}{2} + 1\right) \times G$  für  $E > 0$ ;  $-\frac{1}{E-1} \times G$  für  $E < 0$

3. All values are added and compared with the maximum indifference zone. The indifference zone is a zone of possible performance perception, due to which a consumer reacts neither positively nor negatively. In the calculation, the maximum indifference zone has the same value as the maximum weighting of the properties under consideration.
4. If the total value is greater than the positive maximum indifference zone, the need for change of the property group is described as positive and high.  
If the total value lies within the maximum indifference zone, the need for change of the property group is described as low.  
If the total value is smaller than the maximum negative indifference zone, the need for change of the property group is described as negative and high.

Table 2: Evaluation of future robustness of networked properties

	If the robustness of one of the properties from the networked property group is high and negative:	If the robustness of one of the properties from the networked property group is low:	When all the robustness of the properties from the networked property group is high and positive:
Robustness of the property group	High and negative	determined by the least amount of robustness of their properties	determined by the least amount of robustness of their properties
Reason	If a property is not admissible or no longer relevant, the networked property group is also not admissible or no longer relevant.	The most uncertain property makes the networked property group also uncertain. The amount is identical.	The most uncertain property makes the networked property group also uncertain. The amount is identical

After determining the robustness and the need for change of the customer-experienceable property groups, the whole group is regarded as a property and further evaluated.

### **4.7 Analysis of Innovation Potentials (2nd iteration)**

After the first iteration of the potential evaluation, the possible input variables (see chapter 4.4) are generated. These are used to further evaluate the overall system properties that can be experienced by the customer.

The networking is directly observed as shown in Figure 10.

In order to evaluate the influence of the subsystem property on the overall system property, the passive influences of the customer-experienceable overall system properties (area 1) are considered first. Then, the active influences of the overall system properties that can be experienced by the customer are further evaluated in the evaluation of the degree of fulfillment (area 2). After considering all active influences as a whole, the different combinations of all fulfillment levels are formed as product scenarios.

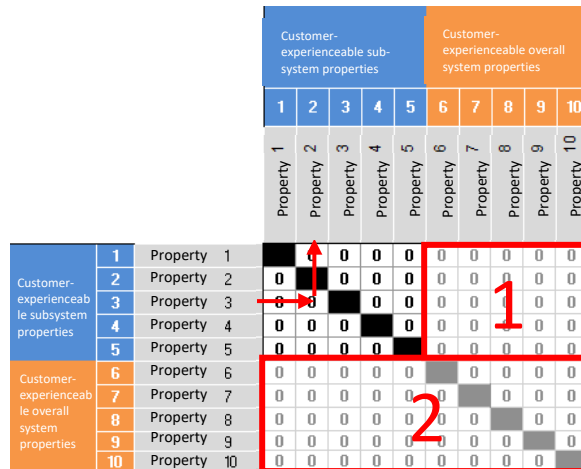


Figure 10: Analysis of interconnection

#### 4.8 Evaluation of potential (2nd iteration)

In the same way as in Chapter 4.5, the second iteration potential assessment first assesses the consistency of the customer-experienceable properties regarding the environment scenarios. Then the need for change and the robustness are calculated by using the two formulas from Chapter 4.5.

#### 4.9 Identification of potential (2nd iteration)

The definition of the variation is also the same as the process described in Chapter 4.6 and is derived from it. The networking of customer-experienceable properties is only considered if a property from the property group exhibits late, medium-term or improbable variations.

#### 4.10 Implementation of potential

The next step is to implement the identified potentials. Since the subsystem properties that can be experienced by the customer are the existing properties from the technology and the overall system properties are the properties that result from the implementation of the subsystem properties, all properties must be considered together in the "technology push".

"Technology push" means that the technology already exists. If the decisive variation is an early variation, the technology should be implemented immediately.

In the case of a medium and late variation, it is analyzed why the introduction time is postponed. There are several possibilities for this (M):

- M1: If the technology is still immature, the cooperation with the supplier who has a superior technology is a good solution.
- M2: If the weighting of the customer experience is low, the company can establish a trend by considering the risk. Or it can follow the customer requirement and adapt the product. The systematic approach is carried out again very quickly after the adjustment, since only limited numbers of the customer-experienceable properties must be adapted and the other evaluations can be taken over.
- M3: If the legislation or the environment is not certain, the company can consider the profitability of the subsystem and decide whether it is worth developing a subsystem with two additional variants for the uncertain scenario. (parallel variation)

The decision on the variation of the new technology is derived from the variation of individual customer-experienceable properties:

1. When all variations of the customer-experienceable properties are either early or no variations. There are noticeable improvements of the important customer-experienceable properties without worsening the other properties. The new technology is implemented immediately, but it is recommended to evaluate all customer-experienceable properties with "no variation" while implementing M1 and M2 in order to optimize the performance of the product.
2. If all customer-experienceable properties are rated as "no variation" only, the reason will be identified. The property with the low weight is tested with M2 and the property with the low degree of fulfillment is carried out via M1. If the execution does not work, the implementation of the new technology is called no variation. The new technology is not implemented.

3. If at least one property is rated "late variation", the reason is identified. Since all "late variations" have a low robustness, the critical property is performed with M1. If it works, it could lead to a parallel variation. If it does not work, it is checked with the consideration of the interconnection whether it would be possible to omit the corresponding critical property. If the critical property still exists after all treatments, the new technology is called late variation or medium-term variation and is not implemented immediately.
4. If at least one property is evaluated as "medium-term variation", it is necessary to identify the reason. If the need for change is negative, an important customer experience is greatly impaired, the technology is referred to as medium-term variation and is not implemented immediately. If the need for change is positive, only the robustness is low. Therefore, M3 is carried out. If it is not economical to implement both variants, the technology is not implemented immediately.
5. If there is "no variation possible", it is considered whether the critical property could be omitted. If not, the new technology is also described as impossible.

## 5 Evaluation of the systematic approach

The central measure for evaluating the systematic approach is the degree to which the 20 success factors have been met, which are evaluated with the help of a two-stage Delphi survey of different stakeholders. The survey with a project manager who pursues the pre-development strategy is of particular interest. The result was collected from all stakeholders and the mean values were calculated as shown in Figure 11.

The mean values were shown to the project manager and he completed the survey a second time. Since the other stakeholders are employees from different departments and were only partially introduced by the systematic only the result of the project manager of the pre-development strategy in the second survey was considered. His final opinion was expressed as a corrective to his own judgements after the results of the first survey.

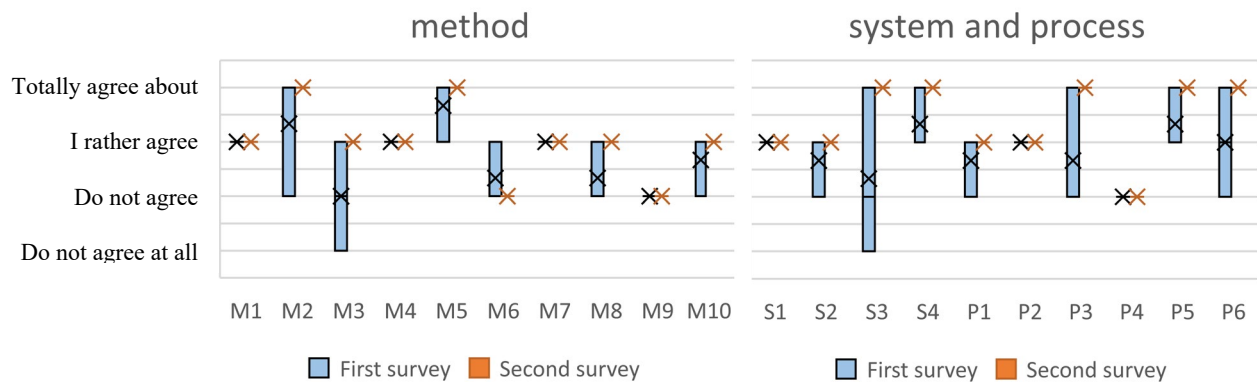


Figure 11: Result of the first and second survey about method (M), system (S) and process (P) factors

When considering the method factors, it was observed that the stakeholders from different departments were rather critical of many factors. In addition, the evaluation for M2 and M3 shows a large deviation.

- M2: The systematic must demonstrate the advantages of using foresight over non-application despite high initial effort.
- M3: The systematic must be intuitively applicable for the product developer.

In the second survey, the project manager always gave a better rating than the other participants. Except for M6 and all participants for M9 who received a poor rating.

- M6: The systematic must enable the conscious handling of opportunities and risks of development scopes and thus ensure the correct prioritization of individual development scopes in different products and product generations.
- M9: The systematic must ensure the comparison with the development history or the completed development projects.

The evaluation of the system factors and process factors is similar to that of the method factors. There are large deviations with S3 and P3.

- S3: The systematic must ensure a high quality of the input and output information in the context of the system in development.
- P3: The systematic must stimulate the discussion of the product developers about current and future needs.

According to the results of the first survey, the project manager did not change his opinion much and evaluated the systematic approach in terms of system and process as good.  
All participants gave a negative assessment for P4.

- P4: The systematic can be integrated into existing product development processes.

## **6 Interpretation and outlook**

The results of the Delphi survey show concrete possibilities to make the systematic approach applicable with the "technology push" strategy. Most of the success factors are assessed positively by the project manager, but there are still a few factors like M2, M3, S3 and P3 that were assessed with a large deviation.

It is due to the fact that the systematic approach is very complicated, and very quickly presented. In principle, employees from different departments only get a glimpse of the systematic's sub-steps. In order to create a holistic view, the entire systematic approach was presented in 15 minutes so that they could also participate in the survey. The sub-step that is relevant to the corresponding employee was presented intensively and in detail. However, not every sub-step includes foresight or future thinking, so it is difficult for some employees to judge whether they have fully understood the entire process and it is not intuitive for them to apply the systematic approach. If this is the case, the deviation from the success factor M3 is also explained.

In addition, there is the problem that the systematic approach is very difficult to master in a short time. In order to carry out the systematic, the project manager must fully understand it. In order to deliver efficient work, the other participants must not know what is behind a sub-step, which is why there are sometimes employees who only give simple input information and are not allowed to expect or receive any output information. For this reason, success factor S3 has a large deviation.

In addition to the large deviation, the systematic approach also has negative success factors like M6, M9 and P4.

The project manager of the pre-development strategy expressed that he could hardly perceive any chances or risks from the systematic approach. The development history and the completed development projects were also not compared since the technology is completely new. The systematic approach has made a leap from maturity level 0 to maturity level 3 in the BMW Maturity Process.

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