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INFLUENCE OF DFX CRITERIA ON THE DESIGN OF THE PRODUCT DEVELOPMENT PROCESS

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1 Introduction

Product development today is affected by a more and more pronounced curtailment of development periods in spite of the products' increasing complexity. That complexity there is primarily arising from the implementation of multi-disciplinary methods of resolution. Just for small and medium-sized enterprises it turns out to be a crucial competitive advantage if they are able to convert innovative ideas quickly and effectively into high-quality products. Along with day-to-day business, this is a great challenge for the enterprises so that not only a support of methods for product development is desirable, but particularly also such methods are in demand, which sustainable support the development process while offering also sufficient potential for its optimization at the same time.

The product development process itself in turn is dependent on the task of design engineering and the industry, within which a product is to be developed. A components supplier to an automotive manufacturer often receives very strict specifications regarding the methods to be applied and the tools to be used, whereas a medium-sized company having its independent product range retains much more scope in the choice of methods. Here, aspects like the experiential horizon of engineers and the handling of know-how in the company rather gain in importance. Such boundary conditions are certainly internalized in the product development process in companies however will need to be explicitly elaborated for general process treatments.

Therefore, the approach for process support in product development to be presented here is to be made on basis of characterizing the development process, but on the other hand it also has to incorporate the respective methods to be applied that are chosen depending on relevant DFX criteria. The objective thereby is to point out to the product developer during the entire development process, which methods are to be applied at what time to achieve an optimum workflow in terms of result and efficiency.

2 Considerations on the product development process with focus on process design

In order to be able to support the product development process, it first needs to be characterized. Initial consideration here is the fact that this process is very creative. The quality and the innovative potential of the product evolving in the course of that process are strongly affected by the experience, the intuition, and the standard of knowledge of the engineer. Therefore in any case, the target must be to provide the engineer with the freedom for thinking, for gathering of information, and for the exchange of knowledge via process design. Process support must not restrict the engineer or burden him or her with routine work but on the contrary, should leave more scope for own thoughts. That for instance could be achieved by making historic processes available in deciding situations or by pointing out suggestions for alternatives.

This is one of the aspects why a classic process support as offered by workflow management systems does not appear to be suggestive in the context with product development. Another important aspect lies founded in the in characteristic of the development process. Workflow management systems are first of all then applicable, when the processes to be represented are clearly structured. In that case, they can be defined and adequately executed in the approach. The product development process in contrast however represents a largely unstructured process. The causes of that are outlined in the following four points [BUJA96], [JOH04]:

- Within product development, the engineer must act on the assumption of **uncertain or incomplete data and/or information**. This is on one hand due to the fact that the requirements and boundary conditions vary, depending on the task of design engineering and are hardly ever completely known in most cases. The developer is often confronted with the situation, where the client revises the requirements during a later phase of development. New boundary conditions are defined or will result not until later in the course of development.

- The information and data basis develops not until later in the course of product development. Redesigns and design adaptations assign the developer with the task of having to find new solution principles for sub-functions. In general, there are several **solution principles** to choose from, which of course again are **connected with different boundary conditions and constraints**. These have respective effect on the course of the process and on the development of necessary subsequent steps.

- The interdisciplinarity of products implicates that development of modules takes place in the individual domains. This postulates **functioning communication structures within development** so that the emerging product data can be made available to all persons involved as quickly as possible.

- Development in the domains furthermore implicates a parallelization of module development, which initially is absolutely desirable for the purpose of **simultaneous engineering**. This however also makes it necessary to know what product data will be needed for the smooth development of a process step to be able to obtain the respective information. Obscurities in this respect delay the progress of the process and hold the risk of starting many steps that will not be completed.

Existing process models for product development (e.g. VDI 2221, VDI 2206) are based on predefined straight-lined courses of action, which in general are divided into a few manageable phases, leaving a broad room for maneuver to the developer. For a process support, such descriptions are too coarse-granular. Within the phases, an alternative exists to apply a number of different methods to reach the target. Which methods now will actually be applied there depends not only on the product that is to be developed, but also on the marketing strategies of the company and the customers' requirements. Also the sequence of method application is in some way depending on the methods already employed. Characteristic for product development is moreover that the process always must allow for iterations, which primarily may be explained by the uncertain and incomplete data basis [PAE04].

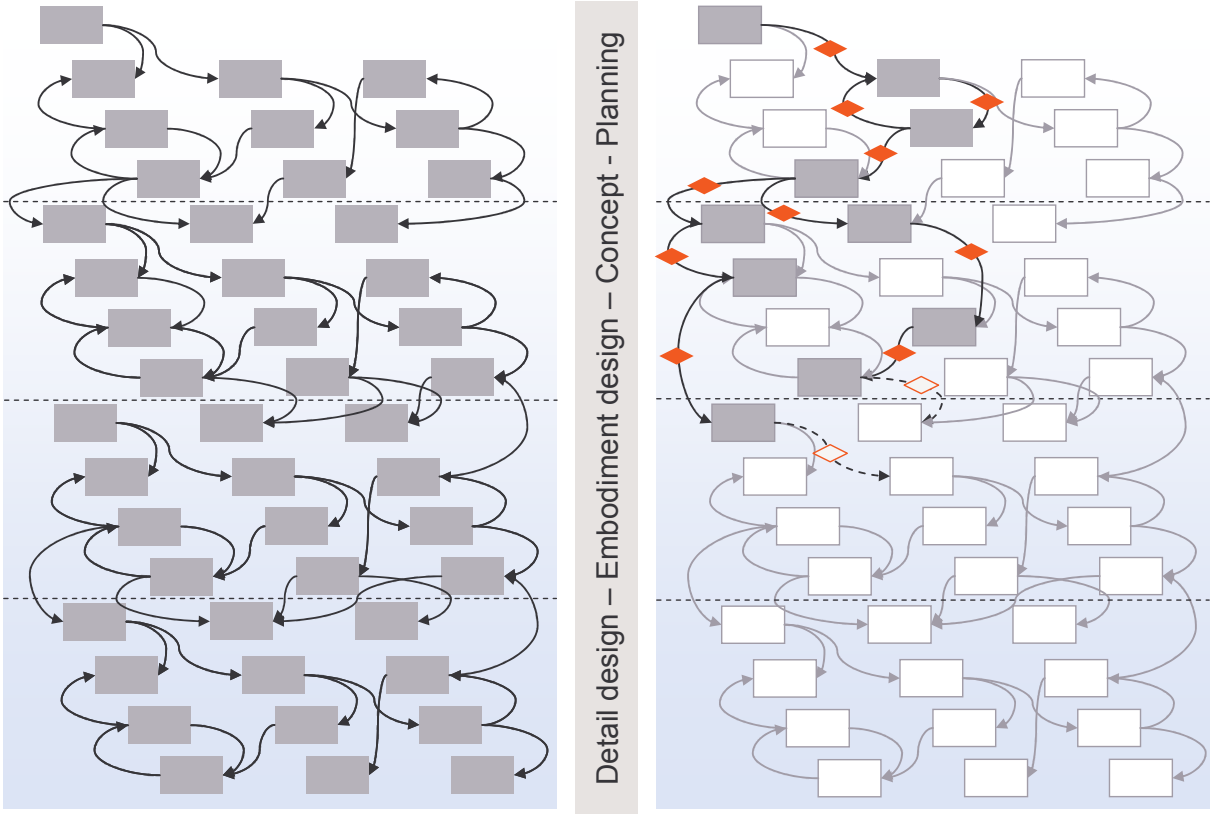

Figure 1. Process-Trait in Product Development

The provision for both of those aspects changes the image of a process model of rather linear character respectively a number of parallel courses of action into a network of possible process steps (figure 1). Thereby the questions comes up of how to interlink these process steps in this network in a target-leading way, or of how to select them, depending on a deciding situation. Due to the characteristic of the development process, the further progress will result not until during the development itself, and it is affected by:

- The boundary conditions given in the deciding situation and the standard of information available
- The complexity of the product itself
- The objectives of product development pursued by the customer and by the manufacturer, which for instance, may be expressed by respective DFX criteria

Therefore, effective approaches towards process support in product development cannot be expressed that way that processes are quasi predetermined, but should support the developer in the deciding situations specific to the progress of the process by targeted provision of information and methods. In order to support decision making, a number of aspects are required that need to be preprocessed accordingly in a process-oriented way: Knowledge of historic processes, methods typical within the company, access to tools and the competences to operate these tools, a suitable provision of product data, but also the knowledge, which methods are most suitable for achieving the respective objectives. In the following, especially the last point shall be treated. On basis of a process-oriented analysis of DFX criteria and the methods interlinked with them shall be demonstrated, how the resulting data are utilizable for process support.

3 Process-oriented structuring of DFX criteria

3.1 Hierarchic structuring

The product development process is affected by the circumstance that the available product and manufacturing process data become more and more precise and extensive with the progress of the process. For that reason, also the entirety of all guidelines, methods, and tools that were created until now for different portions of DFX (particularly for later phases of the development process), is hardly manageable. Therefore, a process-oriented structure of DFX criteria must first of all consider that circumstance, since only then quick access to optimal guidelines, methods, and tools can be assured.

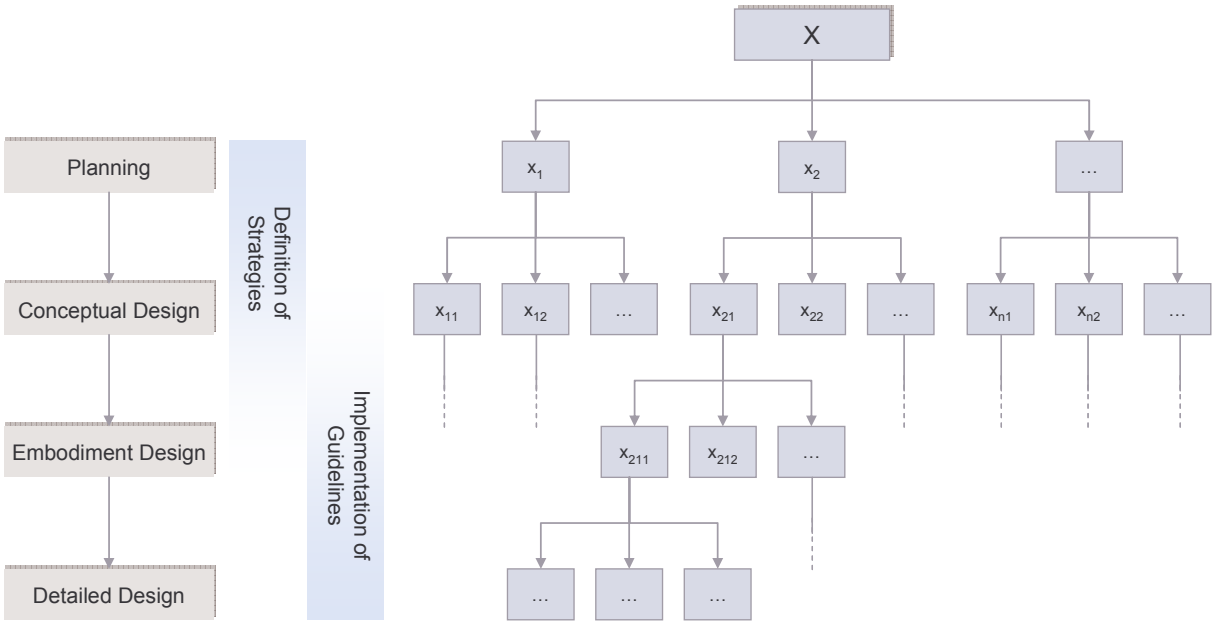

Figure 2. Structure of DFX according to the Stages of the Product Development Process

A hierarchic structure seem to be suggestive in this respect, in which hierarchy levels of the DFX structure can be interlinked with the adequate phases of the product development process (Figure 2). Important is here that DFX guidelines, methods, tools, and finally criteria can be derived from those structures, which are adapted to the information content of the product model in the current development phase.

While in earlier phases rather strategic decisions are made and need to be supported by adequate guidelines, in later phases predominantly concrete guidelines are concerned (e.g. design notes) for a successful accomplishment of the processes chosen for product development. Thereby is also becomes apparent that the number of potentially relevant guidelines in creases in the course of the product development process.

3.2 Structuring of DFX criteria according to their derivation in the product development process

In [RUDE98], a classification of DFX partial aspects is made according to their derivation in the product life cycle (schematically demonstrated in Figure 3) in which practically all equitabilities are arising from design engineering while being widely influenced and accounted for by it.

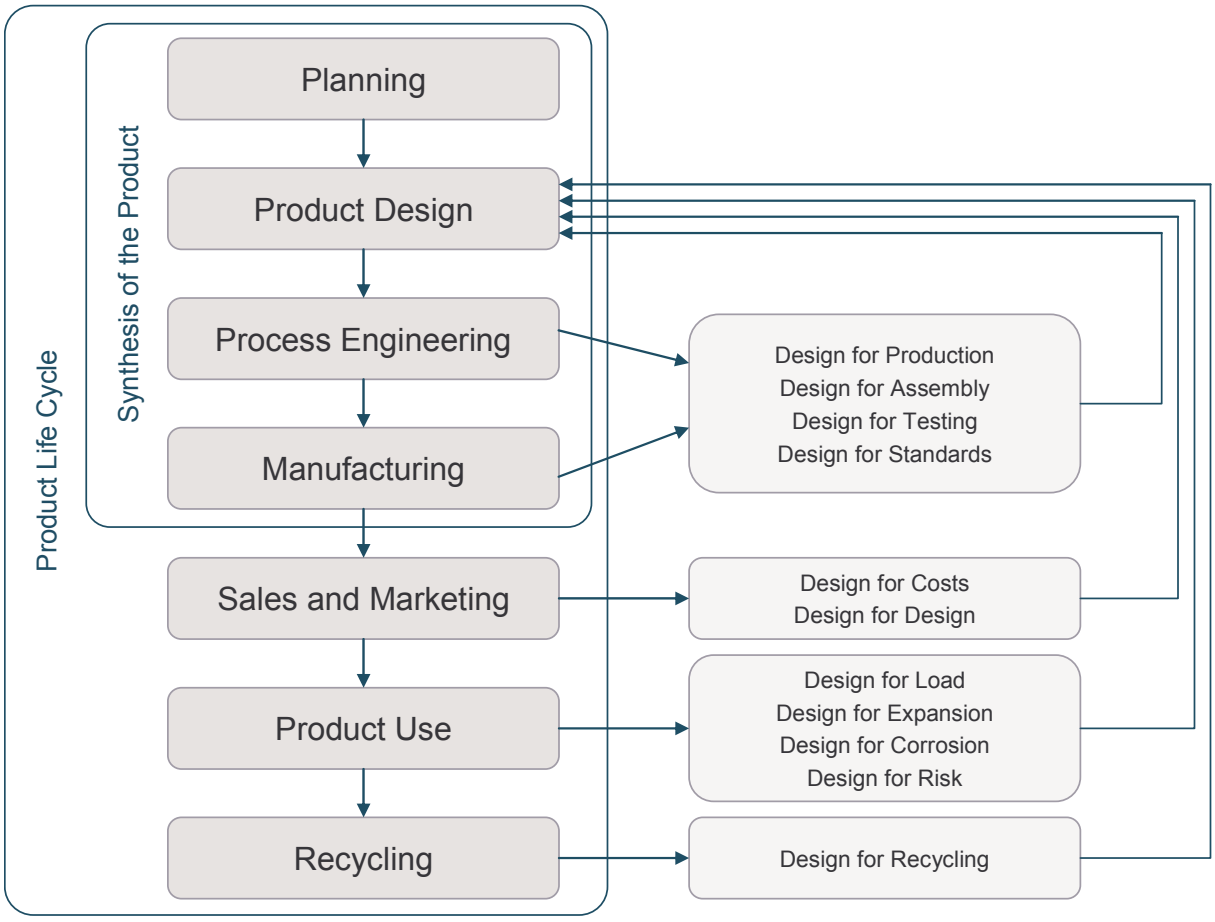

Figure 3. Structure of DFX according to their derivation in the Product Life Cycle

Advantageous with this type of structuring is its orientation on ways of thinking in practice. It can be applied without problem to the in many enterprises existing division structures (production division, assembly division, sales & marketing division, etc.). Derivation-oriented structuring of DFX criteria can easily be interlinked with the hierarchic approach by identifying the primary objectives (which ideally are to be defined during the planning phase) with respective derivation-oriented aspects. In this way, a reasonable structure of DFX criteria can be created, which takes the domains necessary for the specific type of development task

into consideration as well as the observation of different detailing steps resulting form the progress of the process.

4 Conditioning of DFX methods to process components

Considerations on a suitable granularity of process steps have shown that the method can be regarded as the smallest process component. A finer dissection is not suggestive since on the one hand, the engineer would then be highly restricted in his or her freedom of action and on the other hand, it is simply pointless to stop within a method to start other steps when results are not yet completely on hand. In the style of a behavior description, the method is now regarded as a black box in which not the contents, thus the activity stands in the foreground. The procedure for the individual methods is assumed to be known. Rather it is essential to consider input and output parameters as well as disturbances and boundary parameters more closely to enable in this way a derivation of conclusions on the progress of the process (Figure 4).

Input parameters are usually provided via the product model by the PDM system, output parameters are returned to it. Thus, data in the product model reflect the development status of the product and also allow drawing conclusions on the process status by stage-of-maturation considerations. An analysis of methods analogous to the process idea differentiates at first roughly between process-promoting and product-describing parameters. To enable making a categorization, all parameters, which are directly derived from the product (geometry, combinational logic, software, structures) are classified as product-describing. Information and data, which directly or indirectly contribute to the progress of the method, are process-promoting parameters.

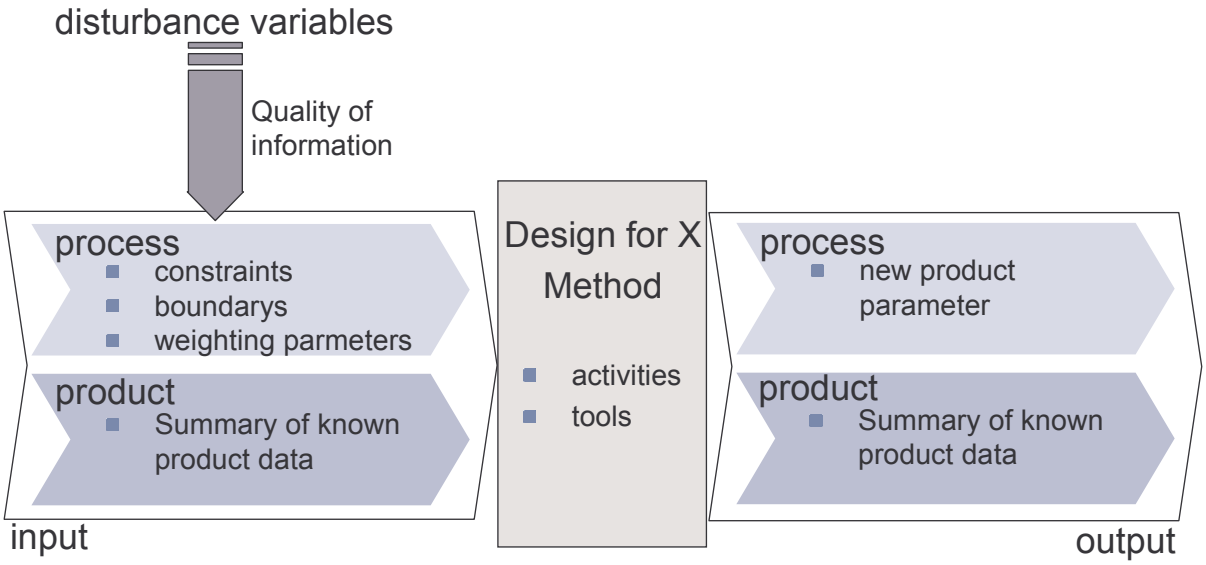

Figure 4. Black-Box-Model to characterise methods

Now when considering the black box representation, it becomes apparent that classical input parameters are always product-describing. A new significance however is gained by boundary conditions and disturbances, which result from the requirements list. They need to be considered as input parameters, but having process-promoting character. Their value does not only decide about the choice of the methods, but also about the course within the application

of the method. Output parameters indeed will contribute to the specification of the product description, however have process-promoting character, because in matching with the requirements list it either becomes apparent that iterations will be necessary, which will result in a repetition of process steps, or however, boundary conditions are rendered more precisely, which condition the implementation of further steps respectively allow the progress in the process.

The displayed approach features a number of advantages for the support of the engineer in deciding situations. This approach can be very well used to support a simultaneous engineering, since on basis of the data in the PDM system, it is possible to permanently verify, which product data were already compiled. Those can be compared to the data that are required for the application of relevant methods. In this way, process steps can also be initiated parallel respectively considered for the planning and reservation of resources (employees and tools).

On the one hand, iterations are indispensable in the product development process for abovementioned reasons, on the other hand, they often become necessary to increase the quality of results in the product. Individual or several process steps are then run through several times to find optimum solutions. When quality factors for product functionality are determined in the requirements list, it becomes feasible via a detailed description of methods and the quality of output parameters to be expected, to check whether another iteration loop will be effective or whether the product improvements to be expected would rather be marginal. Process optimization is guaranteed alone by the fact that methods can be planned purposefully, and the employment of tools involved in it can be coordinated.

5 Summary and outlook

A target-leading support of the workflow in the development process must not dictate method of working, sequence of process steps, and methods and tools to be applied, but has to take the specific methods of working and challenges in the product development processes sensitively into account. As it is shown, those challenges in product development are primarily in the distinct dissimilarity of arising tasks, in the lack of manageability of the number of available DFX methods and tools for the support in most diverse subproblems, and in the permanent necessity of having to run through iteration loops.

The potential of efficient workflow support is here mainly in pointing out to product developers, which DFX methods and tools should be applied at what time and in which sequence or combination for the purpose of optimum quality and efficiency in the result of the development processes.

The presented approach there is always only to be valued as a step towards purposeful process support in product development. In addition to the consideration of DFX criteria and their process-oriented processing, other aspects are to be clarified like, for example, the possibility of documenting historic or current processes and conditioning and providing them for later processes. Important appears to be also to strengthen the product data management to such extend that in addition to classical product data, further information on product behavior and on the process can be filed. These approaches have to exceed by far the workflow functionalities often provided by PDM systems today. Furthermore, high-capacity knowledge databases are needed and in connection with it, also the facility to search in them context-based respectively by similarity criteria in former products and processes.

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