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HOW MISSIONS DETERMINE THE CHARACTERISTICS OF PRODUCT DEVELOPMENT METHODOLOGIES

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1 Introduction

The aim of this paper is to examine the suitability of design methodology to meet today's challenges of product development by looking at the mission behind the evolution of these methodologies. In change management as well as in work psychology having a mission ('Leitbild' in German) is known to be crucial to any change process or work organisation and structuring process. "Mission" will be understood as the idea of a desired, ideal state and the boundary conditions to be considered. The mission determines not only the desired state, the "To-Be" state, but also the view on the current state, the "As-Is" state, and the selected way to get from "As-Is" to "To-Be". This means that to be able to judge the appropriateness of a design methodology for solving particular problems, it is necessary to know the mission underlying this methodology. Furthermore, a reorientation of design methodology to meet today's challenges requires rethinking of the mission of product development rather than trying to adapt existing strategies to today's specific boundary conditions.

This paper is of the 'speculation' category, evolving an idea, not reporting scientific results. It therefore focuses on the introduction of a new approach without strong empirical evidence and shall be seen as a contribution to a hopefully extensive discussion.

2 Challenges of Product Development and the History of Design Methodology

As early as 1972, Beitz listed the following challenges in product development to point out the need for a design methodology ([1], S. 6):

- increased complexity of products to meet increasing requirements regarding technical performance and quality;
- tighter market requirements concerning development time and manufacturing costs;
- shorter innovation time due to rapidly changing technologies;
- increased accountability in product development regarding schedule and cost of the product;
- limited rationalisation in product development compared to other departments;

- required integration of development with manufacturing;
- increased deployment of computers, also in product development;
- shortage of designers.

At first glance little seems to have changed. Due to globalisation and the increasing integration of the customer's viewpoint, some of the issues have become even more challenging and none of these has yet been solved satisfactory. Reality in engineering design departments has changed, but this had had little impact on the formulation of design methodologies.

The following paragraphs apply to a variety of common design methodologies, but refer mainly to the design methodology according to Pahl and Beitz [2], which is very similar to the German guideline VDI 2221 [3].

The haydays of German design methodology can be set around the 1970s. The early approaches mainly aimed at supporting design teaching [4]. Designing was regarded as a process of problem solving during which complex and contradictory requirements had to be met. Psychological findings on problem solving were combined with strategies from systems engineering. These were adapted to the (former) conditions of product development and resulted in a guideline consisting of working steps to be carried out sequentially to obtain certain specified results.

Design methodology today has not changed much since the 1970s. Numerous research projects (some of them can be found for example in [5]) showed that, in general, guideline VDI 2221 is useful for individual design processes, provided it is applied flexibly. Still, in industry design methodology is not widely considered to be helpful in meeting the requirements of product development and often regarded as too time-consuming.

What are the reasons for this obvious lack of practicability of design methodology, even though it is proven to enhance designers' capabilities to find appropriate solutions to design problems?

3 Importance of the Mission

According to work psychology, a problem, as opposed to a task, is characterised by a barrier (e.g. lack of information) between an identified "As-Is" and a desired state "To-Be". Problem solving involves finding a way to get to the "To-Be" state [6]. Design methodologists applied the concept of problem solving to both the design problem and the design process. The psychological concept of "problem solving" has been transferred directly into a practical guideline for solving design problems. In doing so, the fact that the assessment of the "As-Is" state as well as the estimation of the "To-Be " state are highly subjective, has been neglected. Factors that influence problem understanding are ([7], S. 111):

- insight in the problem space and its boundary conditions;
- familiarity with the solution space and its boundary conditions;
- mission behind the "As-Is" analysis.

Particularly the latter has not been considered sufficiently and explicitly in product development methodologies. Problem solutions can be of a completely different nature depending on the discrepancy between the ideal state and the anticipated problems or solutions. For example in the 1980s the very same market situation lead to two opposite concepts for industrial work organisation:

- humanisation of labour through semi-autonomous teams e.g. [8].
- Computer Integrated Manufacturing (CIM) and the unmanned factory e.g. [9].

Applied to design methodologies two important statements can be derived:

- The mission from the 1970s, representing the image of the ideal design process and the problems to be solved, has to be clarified. A mission for today's product development processes has to be formulated. These missions must then be compared to find elements of design methodology that are still relevant and those that might have become redundant.
- To be of practical use, a design methodology must reveal its underlying mission to enable potential users to judge the suitability of the mission, and thereby the particular methodology, for their specific problem.

3.1 Optimisation of Product Development in the 1970s and Today

The aim of rationalisation in product development in the 1970s was the "taylorisation" of the process through standardisation and optimisation, analogous to the strategies in manufacturing. With this aim in mind the overall task of product development was divided in partial tasks to be executed by single persons or within particular departments within the company. The use of computers aimed mainly at the automation and substitution of human workforce rather then its support. The integration of the results of partial tasks took place higher up the hierarchy, requiring equally specialised knowledge in these positions. Planning and control was based on the elaboration of rather detailed results at long term and also took place in higher levels of hierarchy. Due to the kind of problems to be solved as well as the corporate structures in the 1970s, product development could mainly take place within one single unit of organisation or domain. The number of disciplines and groups involved was low compared to today. The integration of product development activities in the company's organisation structure and workflow usually resulted in clear areas of (managerial) authorities for everybody involved in the product development process.

The strategies of design methodology match the boundary conditions from the 1970s named above. To be able to estimate the use of these strategies to meet today's challenges the former boundary conditions have to be examined and compared to today's aims and strategies.

Due to the current market situation, globalisation as well as the need for multidisciplinary problem solutions and the parallelisation of product development processes today's aims and strategies are integration, cooperation and coordination of various disciplines and institutions in product development projects. The importance of information exchange as well as effective and efficient communication and cooperation processes within and between (units of) organisations increases strongly. Today, self-organisation, self-management, short feed back circles and flexible target planning replace detailed top-down planning of working steps and the resulting long iteration loops.

What conclusions have so far been drawn from these changes to find approaches to optimise product development processes? Current efforts can be distinguished in two main lines: technology oriented or human oriented strategies.

Technology oriented optimisation of product development

The availability of information and the consistent and general management of data are considered to be the main problems to be solved throughout the product development process, which leads to the development of specialized hard- and software to support designers in fulfilling their tasks. The aim is to store and process the designers' expert knowledge in information systems and in the long run to increase automation of (partial) product development tasks.

Human oriented optimisation of product development

Coordination and cooperation processes are considered crucial for the success of product development, which leads to new concepts for management processes that are based on motivation, goal analysis and review. Therefore not only domain-specific competencies but, methodical as well as social competencies of designers play an increasingly important role. The acquisition of these competencies takes place in an organisational and personal learning process which has to be integrated into corporate structures.

Table 1. Technology and human oriented strategies for the optimisation of product development processes

	technology oriented	**human oriented**
goals	• subdivision of the overall process in partial processes • automation of as many partial processes as possible • high availability of information through universal data concepts (process chain)	• optimisation of cooperation and coordination performance • motivation and integration of the collaborators • high availability of information through organisational integration (shallow organisation)
management model and principles	• management process partially automated by supporting software • workflow determined by software	• target planning • delegation of management functions to lower levels of hierarchy • self management in teams
organisation structure and workflow	• determination according to supporting software • cross functional • parallel-hierarchical approach	• determination by all collaborators via targets • cross functional • integrated approach
managerial authority	• overlapping authorities in matrix structures • clear authorities required for data management in process chains	• overlapping authorities in matrix structures
feedback, iteration loops	• depend on the use of supporting software	• short loops because of regular information exchange in teams
information flow	• independent from the individual • individual is responsible for collecting relevant information	• related to the individual • individual is responsible for providing and requesting information

In table 1, characteristics of technology oriented and human oriented strategies to optimise product development processes are compared. To discover the mission behind each approach ideal types are described what means that each strategy *focuses* on the elements listed above but does of course not totally neglect elements of the opposite strategy. In reality elements of both strategies often occur as a mix, but mostly with an emphasize on one of the approaches mentioned above.

3.2 Missions related to these Strategies

The comparison of the technology oriented and human oriented strategy shows that these are based on fundamentally different missions about aims and problems in product development processes.

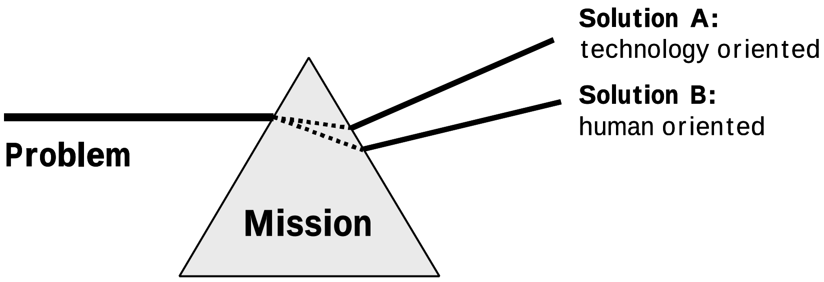

Figure 1. Different solutions to the same problem depending on the underlying mission of product development

The technology oriented mission says that

- In theory the process of product development can be fully automated, in practice this is hindered by problems resulting from the transfer from knowledge of designers to computer data and the performance of current hard- and software.

- Available information will be searched and retrieved by designers and interpreted correctly according to the actual problem to be solved. Therefore large amounts of data have to be made accessible for as many collaborators as possible.

The human oriented mission says that

- The key factor for the success of product development is the human being. Therefore appropriate strategies have to be found to identify and clarify the aims of product development from the viewpoints of the collaborators. Simultaneously the integration of individual and organisational goals has to be aimed for.

- Information does not make sense by itself but becomes useful within a particular situation or context of cooperation and communication. Therefore in product development (cooperation) situations have to be created that enhance the effective and efficient exchange of information of the collaborators. Information technology is needed to support – as opposed to replace – human design activity.

When examining current approaches for optimising product development it becomes clear that these are based, to varying degrees, depending on the particular approach, on one of the missions (or parts of these) described above. The missions behind the approaches are rarely made explicit: looking at their specific characteristics facilitates only an implicit conclusion on the underlying mission. Knowing this, it is easy to explain why there is no such thing as the “right” design methodology. Different strategies can be valid in different coordinate systems, analogous to mechanics. But revealing the mission - the coordinate system - enables on the one hand the transfer of universal elements into other applications. On the other hand this allows a focused discussion on missions in product development, without getting lost in argumentations about details of characteristics of specific approaches.

3.3 A new Design Methodology based on Human Oriented Strategies

In this paragraph a new approach to design methodology will be presented. Starting point is the design methodology according to Pahl and Beitz [2]. This methodology was chosen because numerous research projects over the last decade in Germany dealt with its suitability to enhance effective and efficient product development processes. In addition, the authors of this paper have experience with the application of this design methodology in teaching and practice.

The mission of the following strategy is human oriented and says in particular that:

- *Cooperation is a key factor for successful product development.*
  The increasing need for multidisciplinary problem solutions, increasing complexity of products to be developed, and the globalisation of markets, lead to problems that cannot be solved by single designers or within single domains. Therefore engineering design management must match these conditions and is of increasing importance.

- *The quality of cooperation processes depends not only on social skills of the individual but also on other boundary conditions.*
  The individual designer cannot be the only party to be held responsible for successful cooperation. For example corporate culture, organisation structures, workflow, the leadership attitude, or the kind of task to be fulfilled equally influence the quality of cooperation processes.

- *Managing effective and efficient cooperation processes can be learnt and must be learnt.*
  Cooperation and communication can be enhanced by specific boundary conditions and supported by specific methods. Therefore an appropriate training and the reflection of cooperation situations within the design process improve cooperation performance. Finally, the success of this process of 'life-long-learning' very much depends on the formulation of an explicit mission.

The proposed strategy aims at the optimisation of product development through implementing a corporate culture of individual and organisational learning and the optimisation of cooperation and communication processes. A detailed description of the strategy, called Goal Oriented Cooperation Management in Product Development, can be found in [10]. Basic elements of this strategy are (see figure 2):

- A model of analysis providing parameters that determine cooperation processes. These apply to entire product development projects as well as to single team meetings. The parameters are: personal boundary conditions, institutional boundary conditions, goals/objectives, contents/subject, methods applied, and the media used [11].

- A process model for product development focusing on the integration of management functions into the product development process. The model consists of elements of design methodology according to VDI 2221 (workflow and design methods), elements of Project Management (management and phase concept), and the management attitude as well as cooperation methods, e.g. the concept of semi-autonomous teams well known from manufacturing.

- A strategy for the implementation of Goal Oriented Cooperation Management in Product Development in practice. The implementation strategy consists of a combination of elements from organisational development and experiential learning (the latter according to Kolb [12]). The reasons are that the workflow in product development has to be changed, and the collaborators have to learn how to manage efficient and effective cooperation processes based on the above described model.

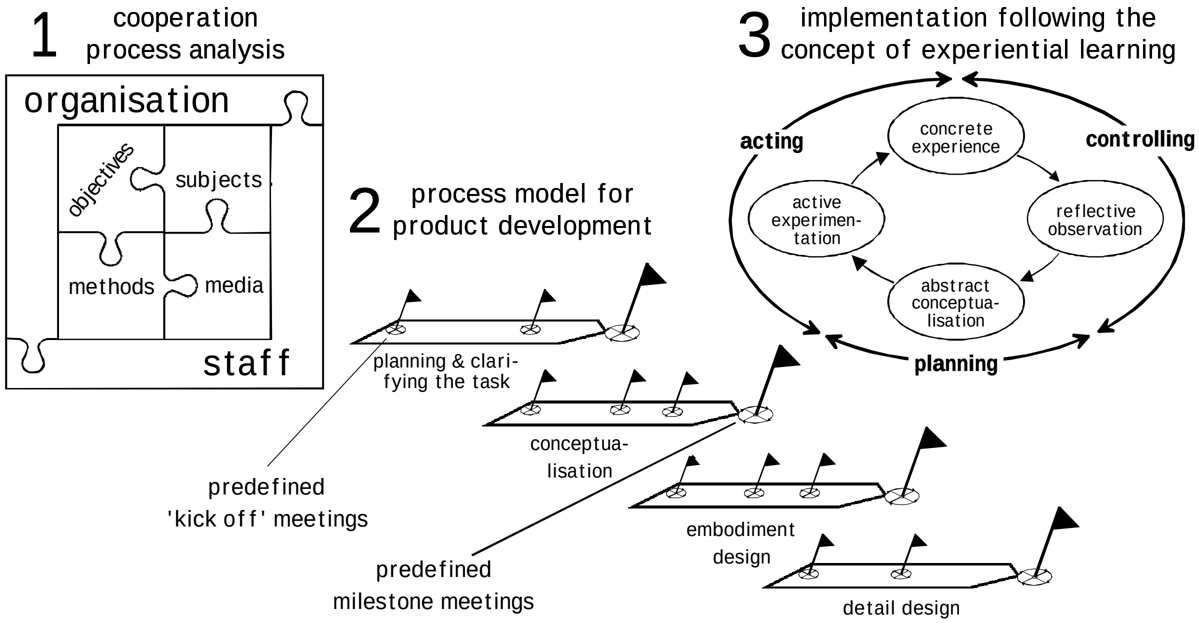

Figure 2. Characteristics of Goal Oriented Cooperation Management in Product Development

4 Conclusion

This paper highlighted the importance of the underlying mission for understanding characteristics of strategies for the optimisation of product development processes in general and design methodologies in particular. Based on theoretical findings on factors influencing the idea of a current state and the desired state, we showed that completely different ways of dealing with the very same problems can be found. To clarify this, two different views about the current problems in product development were presented: the technology oriented and the human oriented approach. It is obvious that the fundamental differences between the underlying missions prevent the development of a universal design methodology.

Still, there is a need for new strategies in product development since the boundary conditions and thus the missions fundamentally changed since the 1970s. So far, attempts to adapt the VDI 2221 design methodology only went as far as changing isolated details (for example its flexible application in iteration loops as opposed to sequential workflow, or computer support for particular design tasks). As long as there is no common understanding about missions in product development, a discussion about a universal design methodology is not fruitful. We have tried to start this discussion by introducing our human oriented mission and the core elements of an approach to a new - in the sense of adapted to today's challenges - design methodology that were derived from this mission.

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