Framework to Design the Interface between Technology Development and Product Development

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***Abstract* –In order to stay globally competitive, manufacturing enterprises face an increasing pressure to bring new products and applications to the markets, to enhance existing products technologically and to produce them at a lower price. New technological findings can enable enterprises to meet these challenges. In practice, technology developments with a long-time horizon are given a low priority compared and due to everyday business. Therefore more and more enterprises separate their technology development and product development units to increase innovation focused technology development. Due to this additional interface in the R&D organization new problems appear resulting in technology findings not being implemented in products e.g. due to wrong time for transfer, insufficient technology readiness or technologies that fail to meet product needs. The reasons for these problems often concern different aspects in the organization e.g. culture, communication or strategy. In this paper of ongoing research we introduce a framework to design the interface between technology development and product development.**

I. INTRODUCTION

The perception of technologies as strategically relevant competitiveness factors exists since the mid-80s [6]. In many manufacturing companies technologies have since been perceived as a key competitive advantage [5]. In recent years, the market has steadily changed, because in addition to shorter product life cycles the complexity of developing new technologies and products increases. Causing an increasingly dynamic and complex technological environment, that companies have to face. To remain competitive in such an environment, companies must continually and in ever shorter intervals develop further products and their production technologically as well as realize them at lower costs. In addition, the companies goal is to bring new and innovative products and applications to the market.

To meet these challenges, many companies use to have organizational units that support technology development to meet the above mentioned requirements. In most manufacturing companies, the development of technology is integrated into product development. However, the trend is going to a separation of technology and product development in order to prevent strategically important technology development projects to be neglected in favor of less important but more urgent product development projects. This is a result from empirical studies carried out regularly by the Fraunhofer IPT on selected topics of technology management [7] [8]. In Fig. 1 the trend towards this separation between 2010 and 2012 can be seen.

Often, the decision to separate technology and product development is based on a low number of developed technologies that are suitable for application. As a result a low number of new technologies is implemented in products and decline the company to act more innovatively.

After the decision to separate both units it needs to be regarded that the orientations of technology and of product development are fundamentally different. In addition to partially diverging goals technology development differs in several dimensions from product development regarding prerequisites, technical maturity, time horizon, competence needs, process repeatability and completion point [4]. Concerning a separation of the two organizational units it is particularly important to note these different design aspects. Thus, the technology development is almost always used as a new unit, so that e.g. a long-term focus promotes innovation. In the operative realization it must be regarded that the new technology development department should not be adopted without change from product development, but should be based on own processes, evaluation criteria and organizational structures. COOPER already explained that the technology development requires a separate process [2]. A successful alignment of technology development after its separation from product development succeeds mainly through clear objectives, a defined strategy and a focus on certain topics to be processed.

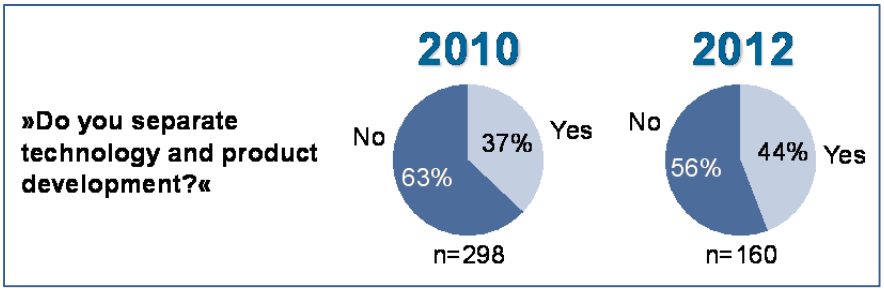

Figure 1: Results regarding the separation of technology and product development from two empirical studies in 2010 and 2012 carried out by Fraunhofer IPT [7] [8]

Besides the strategic and organizational alignment of technology development another issue needs to be considered. By separating the two units, both organizationally and procedurally a new interface is created. Besides the design of the processes a particular challenge for the R&D manager is to design this interface in a goal-oriented way. Although many companies are faced with this problem, there are few guidelines or aids that assist in the orientation and design of the interface to ensure the implementation of technology findings from technology development in the product. The aim of this research approach is to permit a company (e.g. R&D manager) to design their interface between technology and product development ensuring that the (company specific) requirements of product development and technology development are met whilst keeping complexity to a manageable minimum.

II. RESEARCH APPROACH

The first step in the process of applied research after ULRICH is to identify and structure issues of practical relevance [10]. In the present case the practical problem is the lack of guidelines for the person in charge of technology and product development (e.g. R&D managers) whose task is to organize the interface between those two departments. R&D managers are faced with the challenge of configuring the interface between technology development and product development in order to meet both needs with the main goal to strengthen the competitiveness of the company. The person in charge must determine who, what, when and how something is done at this interface in order to facilitate a successful transfer of technology knowledge into product development. The practical problem arises from theoretical weaknesses. This is due to a lack of knowledge and understanding on the one hand the factors that influence the configuration of the interface. On the other hand the range of the interfaces' design parameters are not clearly defined. Moreover, there is no systematic approach available for R&D managers to design the interface for their special company's requirements.

After identifying and analyzing the practical problem with the underlying theoretical deficit, relevant theories and methods of existing research are identified, analyzed and interpreted against the problem under consideration.

The next step provides to apply existing approaches and to realize which further development of these approaches is still needed to solve the regarded problem. Having identified the need for a design model at the interface between technology development and product development the next step is to design and detail the design model including its sub models and their compounds, as well as identify appropriate evaluation criteria. Finally the evolved design model will be investigated in a case study to prove the practical applicability/feasibility. In this paper of ongoing research, a framework of the design model to be developed in the future is presented.

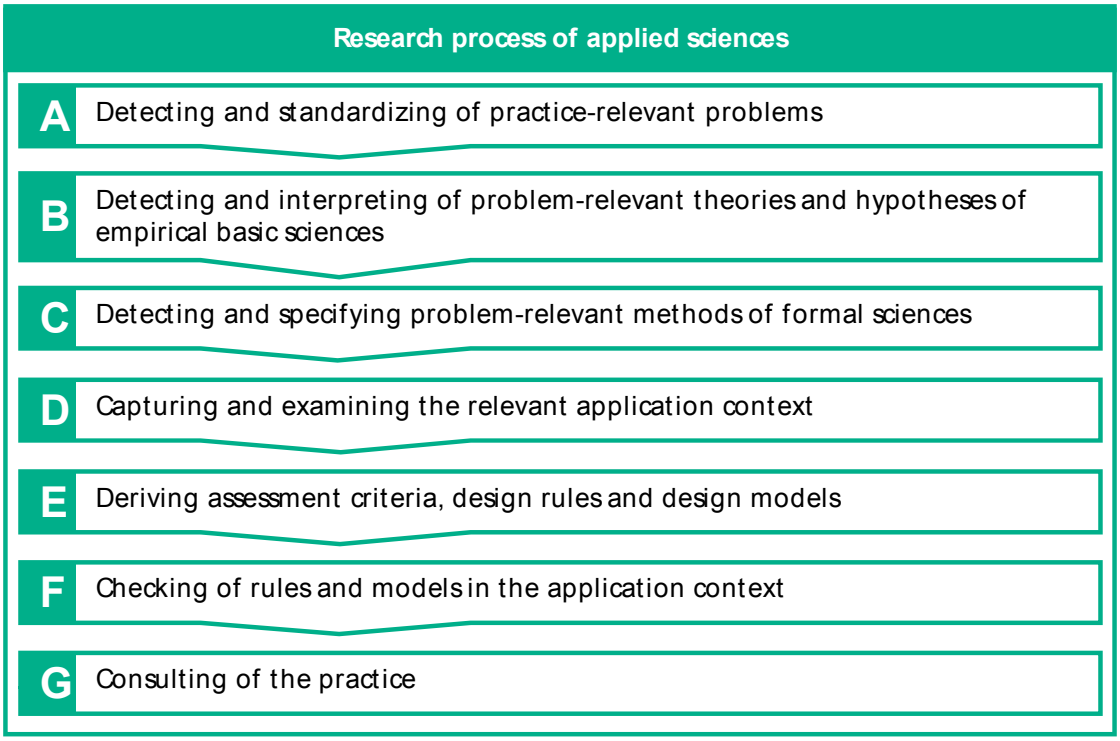

Figure 2: Research process of applied sciences following ULRICH [10]

III. FRAMEWORK DEVELOPMENT

The framework of the design model consists of four sub-models, which are required for a successful configuration of the interface (Fig. 3).

To develop the design model, first the requirements for the interface between technology development and product development as well as influencing factors are identified and characterized based on a literature search.

The requirements arise primarily from the objectives of the technology development and product development departments and from the overall goals of the company (act innovatively, etc.). The outcome of this model serves as a target system. The considered influencing factors that have an effect on the interface are represented by the transferred technology (transfer object), the product in which the technology is to be implemented and the company-specific boundary conditions (organizational, procedural ...). The influencing factors are described including their characteristics that are relevant for the transfer. In the next step the interface is described. First of all the design parameters are identified with regard to the results in the target system and in comparison with the influencing factors their possible characteristics are compiled through literature research. Then influencing factors and design parameters are compared and their cause-effect relationships are examined. If cause-effect relationships exist, more detailed cause-effect relationships are formulated considering the individual characteristics of influencing factors and design parameters. Taking into account the company-specific influencing factors and requirements a configuration logic is developed in the final model, which provides the possible configurations of the design parameters. These are evaluated and selected in terms of the limiting factor complexity.

In the following paragraphs the individual sub-models are described in detail by mentioning goal, first solving approaches and the expected results from the sub-models.

A. Requirements model

The aim in this sub-model is to derive and describe requirements for the interface between technology development and product development.

In the first step general goals of technology development and product development are considered. The main goal of technology development is to identify and develop application technologies for the implementation in products. To achieve this goal, the technology development focuses on customer value, the level of innovation and creativity [9]. In product development, however, a product, which fulfills the company-specific quality requirements, must be developed in a short time at the lowest possible cost. With it, the aspects of time, quality and costs have utmost priority [9]. The different goals of technology development and product development are depicted in Fig. 4.

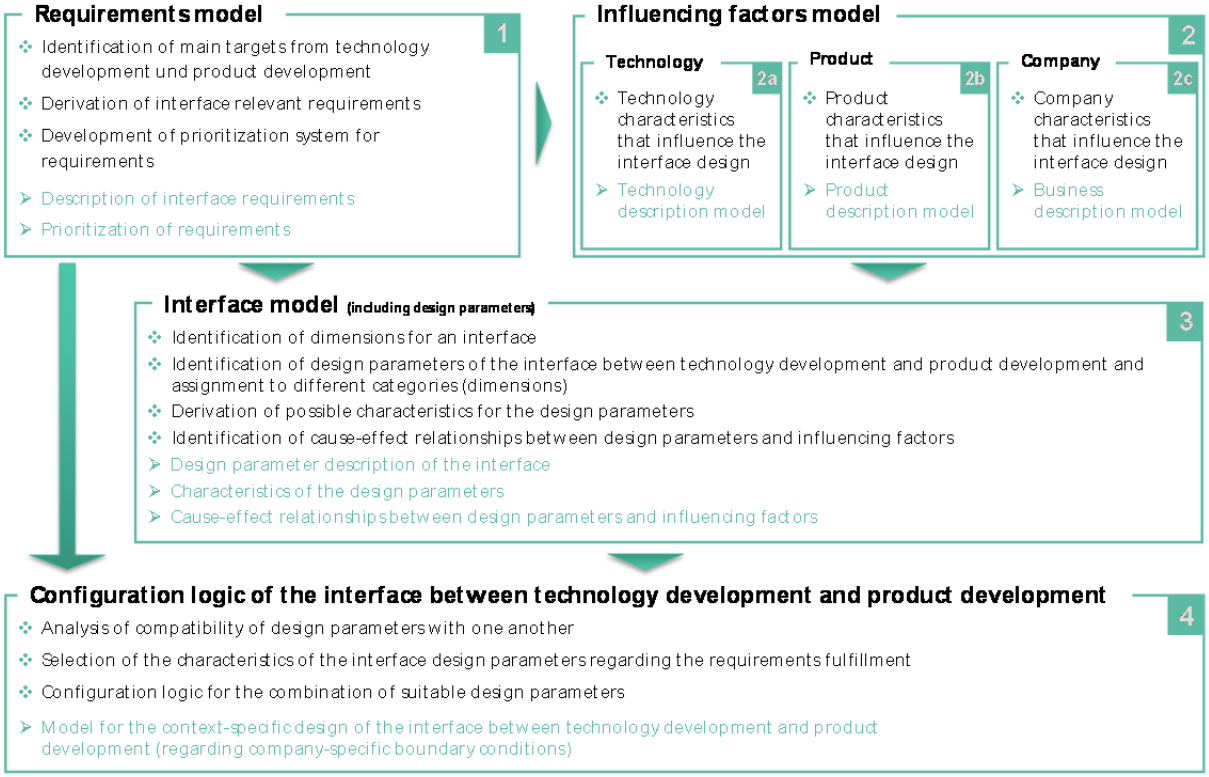

Figure 3: Framework for the design model

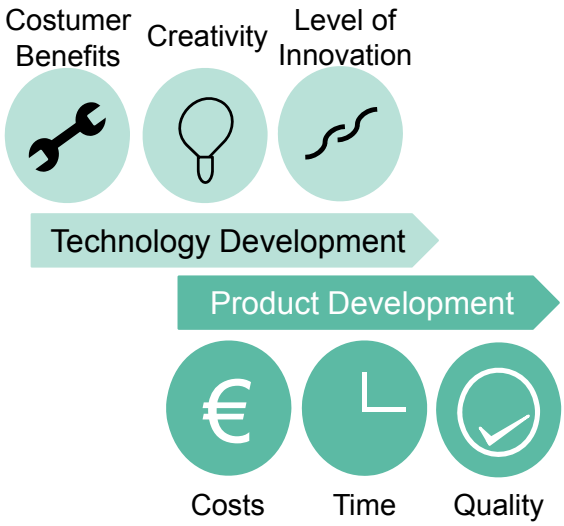

Figure 4: Main goals of technology and product development [9]

From the general objectives of the two organizational units requirements to the interface are derived. These partly conflicting requirements (e.g. lowest possible cost vs. room for creativity) are prioritized. In order to ensure a company-specifically designed interface, in the subsequent application of the model, the user must assess at this point the requirements according to the importance for his company. This ensures that only reasonable design parameters are later used in the configuration model, so that out of them a meaningful combination can be selected.

The outcome of the sub-model is a (company specific) target system containing the relevant framework for the interface model as well as evaluation criteria as input for the configuration model. The requirements permit to identify design parameter and select influencing factors and act as a target system for the configuration logic.

B. Influencing factors model

The aim in this sub-model is to provide a description of influencing elements at the interface. The influencing factors can be categorized in three categories: technology, product and company. In order to characterize the influencing factors in a meaningful way, factors that are relevant to the interface are first identified and as a next step their possible characteristics are researched. To be able to decide which influencing factors are relevant to the interface, the requirements defined in the requirements model need to be included in the selection of the influencing factors.

At the interface between technology development and product development, **technology** is the transfer object, which must be transferred from the development (technology development) into the implementation (product development). This for the type of technology has a great importance in the design of the interface. Hence, a description model has to be developed for the transferred technology, which includes the relevant influencing factors for the interface. For the individual influencing factors the relevant characteristics are identified. One possible representation for this descriptive model is a morphological box, in which in a left column (transfer-relevant) influencing factors of the technology are registered and in the remaining columns, the possible values are specified. Exemplary, such a box is shown in Fig. 5.

In addition to the technology also the **product** plays an important role for the interface, as it is the target object, in which the technology is to be implemented. Equally as the technology, the product must therefore be described in all its influencing factors and their characteristics, which are relevant to the interface. Also in this case, the specifications from the requirements model are included in the description.

If the transfer object (technology) and the target object for the implementation (product) are described, it is moreover necessary to have a description of handover relevant influencing factors of the **company**, that affect the interface. This includes aspects of the organization of the company, the strategic orientation (also in the market), the communication culture, certain skills and resources to name only a few. The description of the company is important, because the orientation of an interface (as well as so far without a systematic approach) should be a very company-specific solution.

Influencing factor	Characteristics			
Degree of technological maturity	TRL 1 (technology readiness level)	TRL 2	TRL 3	…
Implementation effort (costs)	Low (e.g. software)	Medium	High (e.g. material testing)	…
Transferability	Easy	Difficult		…
Technology type	Producttechnology	Processtechnology	Materialtechnology	…

Figure 5: Exemplary visualization for the results of the influencing model for technology

The outcomes of this sub-model are descriptions of the influencing factors and their characteristics, relevant to the interface design. The influencing factors are structured according to technology, product and business characteristics. In order to identify cause-effect relationships among the design parameters of the interface, the influencing factors are used as input parameters for the interface model.

C. Interface model (design parameters of the interface)

The goal of this sub-model is to derive and describe relevant design parameters for the configuration model, with whom the interface between technology development and product development can be described. In addition to that it links the results of the influencing factors with these design parameters.

This is achieved in a first step by identifying existing models to describe interfaces. Outcome of this literature research is a catalogue of relevant categories (in the following named as dimensions) that need to be taken into account to describe interfaces in general.

Aligning these findings with the requirements from the requirements model a description model for the special interface between technology development and product development is developed. In the next step design parameters in the different dimensions are identified. These design parameters are further detailed by identifying possible characteristics.

To have a rough idea about a possible outcome of this model, as an example in Fig. 6 a general description model of KOSIOL is used to categorize relevant design parameters in dimensions such as "who" or "how" [3]. The model of KOSIOL is usually used for task descriptions – in this case it provides with possible dimensions for the interface. Different design parameters are assigned to the dimensions and the morphologic box is completed by enclosing the possible characteristics of the design parameters. This part of the interface model can be named "interface description model" and represents the first part of the interface model.

The second part of the interface model consists of a coherence model. Taking the influencing factors into account a matrix is generated in which cause-effect relationships between influencing factors and design parameters are identified and documented. This matrix' goal is to filter out the relevant characteristics of the design parameters so that they can enter in the next step, the configuration model. The other characteristics of the design parameters that are sorted out due to company-specific boundary conditions (through the influencing factors) are not supposed to be available for the configuration model. In Fig. 7 an example is shown of how the characteristics of influencing factors and design parameters are compared with each other.

Dimension	Design parameter	Characteristics			
Who (responsibilities)	Responsibility TRL 1-3	technology development		product development	
	…	…	…	…	…
How (methods/ tools)	Knowledge transfer	Handover meeting	Mailing	Job Rotation	…
	Communication of demands	Requirements workshop		…	…
…	…	…	…	…	…

Figure 6: Exemplary visualization for the interface description model (part one of the interface model – dimensions after [3])

	Influencing factors	Transferability		…	
Design parameters	Characteristics	Easy	Difficult	…	…
Knowledge transfer	Handover Meeting	-	+	…	…
	Mailing	-	+	…	…
	Job Rotation	+	-	…	…
	…	…	…	…	…
	…	…	…	…	…

Figure 7: Cause-effect relationships matrix (part two of the interface model)

The outcomes of this sub-model are the relevant design parameters for the configuration logic.

D. Configuration logic

The configuration logic links the results of the requirement model with the design parameters entering from the interface model.

The main function of this sub-model is to develop a method of configuring the design parameters of the interface model so that the requirements of the requirements model are met whilst ensuring a level of complexity as low as possible for the interface.

In a first step the different design parameters need to be analyzed about their compatibility with one another. This is achieved by using a combination matrix to test which design parameters can be combined. In a second step the design parameters are compared with the requirements coming from the requirements model and the degree to which the requirements can be met, is rated.

The configuration logic must ensure that the defined requirements are met to a highest degree whilst remaining within complexity targets. Complexity in this context still needs to be defined. In particular, it will be important to avoid exceeding or falling below of the requirements since this would lead to either unsatisfied or too many characteristics chosen and therefor inefficiency. On this basis, a selection will be made.

The outcome of this model is a configuration of the interface (suitable characteristics of design parameters) that considers company-specific requirements and influencing factors.

IV. CONCLUSION AND FUTURE RESEARCH

In this paper we introduced the framework of a design model for the interface between technology development and product development, i.e. an interface meeting the needs and requirements that arise from company-specific boundary conditions. The boundary conditions comprise the requirements towards such an interface and the characteristics of elements that influence the interface design.

As a first step, relevant contents of the design model were identified and sketched in sub-models. The inputs and outputs of each sub-model were specified and interconnections were described. In future research, the drafted sub-models have to be further detailed and explained. Interconnections between the sub-modeled have to be specified and detailed.

Having elaborated the detailed design model, it should be applied to a practical case. The case should apply the model from an industry point of view and will be dealing with an enterprise, that is characterized by a separation of technology development and product development.

Finally, after having shown its applicability in the case study, the design model could be actively used in companies and trough the experience gained there be further developed to offer an audit of the interface as a service in the future.

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