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EXPERIENCE BASED COST MANAGEMENT IN THE EARLY STAGES OF PRODUCT DEVELOPMENT

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1. Introduction

In order to develop successful products, the customer's needs must be identified. For new consumer products this is usually done by surveys or benchmarks. The results of this phase are the basic "needs and wants" of the product to be developed. Out of these needs the requirements are specified and the functions the product should fulfil are derived. Most products however, are based on previous ones and the knowledge of it. Therefore a different approach is used. Well known from the automotive industry and respectively publications, most of the new designs have carry over parts of about two thirds. Therefore the level of experience of product development is very high. A survey of 300 product developers showed clearly that technical problems are not serious; instead the problems are seen in relation with the management of product development.
The attention of the determination of product requirements is not only interesting from a technical perspective, but also for costs visibility reasons. In consequence of product requirements determination costs are also almost fixed. The cost goal itself is one of the most important demands on the product.
In this paper a method will be introduced how to relate costs as well as process steps and components to functions. A tool will be introduced that helps the development team and the sales to estimate costs in early phases of product development based on their experience.

2. The product development process

The standard VDA 4.3 defines the product development process by several phases. These main phases are the *concept phase*, the *product development and verification phase*, the *planning and development of production processes* and the *product acceptance phase*. The p*roviding of production resources* and the *production* are the phases directly related to manufacturing. Continuous *advancement and support process* (e.g. change- and release- or requirements- and cost management) take place in every phase. For the scope of this paper, the development process can be reduced to a model of the information amount in the product development process.
As mentioned in the introduction, the requirements build the basis for product development. Requirements need to be identified, described, analysed, modelled and documented. These documented needs are the origin for the identification of solution patterns which consists of functions, components and processes.
The main goal of product development is to solve a problem and/or to fulfil requirements by developing a product that offers a solution for the initial problem (see figure 1). Start of the problem solution cycle therefore is the definition of the initial problem. Development steps take place and with the help of methods and tools the product evolves. The steps of solution finding, description and rating

are supported by different tools. These tools support the developer in different development stages. Requirements and functional modelling tools for example support the developer during the whole problem solution cycle. Other tools such as CAx systems take place at more specific development steps, depending on the scope of the tool. The jungle of isolated solutions of tools takes over.

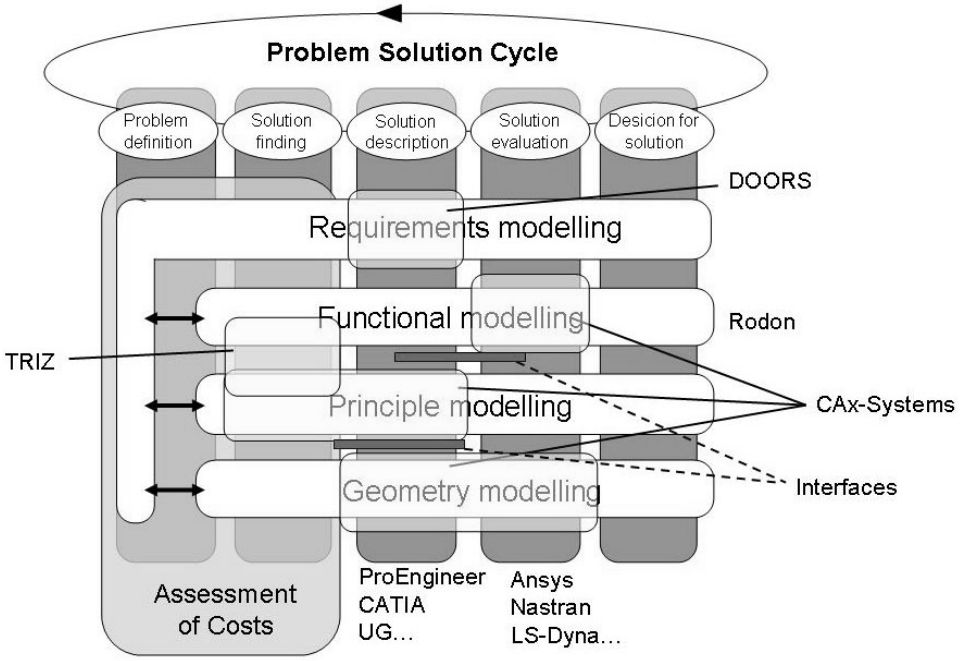

Figure 1. Problem Solution Cycle

These isolated solutions only have one thing in common: they support the developer to achieve his goal which is to develop the best solution to the problem. That states that the problem is well known and understood which only an assumption is in many cases. Globally distributed development teams and a complex supply chain aggravate that. A common understanding of the problem needs to be the basis of the development process in order to counteract to that problem.

Requirements build the basis for that. Every following development step is based on the initial requirements. I.e. functions and solution principles are derived from requirements which build the basis for the geometric design and the methods used to ensure that the product fulfils what it originally was designed for. That is where the problem solution cycle closes itself after a certain number of iterations and improvements. In theory this is well understood but the reality is not always satisfactory.

The assessment of the costs also plays a major role. The decisions made at the beginning of the development process influence the total costs of the product. The further the development progresses, the less influence one has on the costs. Most costs are established with the determination of product requirements and the related functions and later on with components and processes.

3. Function and process oriented product development

Nowadays it is important to determine costs quickly and early in the development process although the requirements specification documents (Lasten-/ Plichtenheft) are not yet complete, and the product does not exist in detail. At the beginning of the development process it does not depend on the exactness of the cost data, but rather that nothing is forgotten and deviations of the usual are recognized and considered. So the question is: How can we manage to get the right solution pattern for the identified and documented requirements? Function and process orientation helps!

Functions are derived from requirements without knowing details of internal or external factors. It is important that everybody involved in the development is part of this process since the actions that are defined here influence the whole product life cycle. Numbers of items, quality and costs as well as many more characteristics are defined here. All these characteristics influence each other as well as the development process. Higher numbers of items, for example, influence the costs; compromises regarding product functions might need to be undertaken in order to reduce costs etc. A poor understanding of product properties and the related functions, as well as profit losses and wrong price estimations might be the result of that. Therefore process steps also need to be taking into consideration for the cost estimation.
The demand is to have something that helps to perform these tasks and gives the engineer the opportunity to estimate what results his actions have. He needs to know, in these early phases as well as during the whole development process, what is influenced by what and how it affects the development process.
The CHAOS report lists a number of factors for project failures. Two out of the first three reasons are directly related to requirements. Since the functions of products are directly derived from the requirements, this part deserves special attention. That also states that the functions oriented approach needs a computer supported method in order to e.g. manage requirements & functions or estimate costs.

3.1 The function oriented approach

In times of technical and social changes and ever changing environment, function orientation provides the necessary flexibility for a company. Functions which fulfil requirements are long term profitable and stay received as opposed to products which change quickly.
For cost oriented development of technical products it appears that function costs are useful additives. Target costing and value analysis use function costs for the development of successful products. After the clarification of tasks in product development, used for pick up information about product requirements which are placed to the solution, there are many arguments for a function orientation:

- Identification and understanding of the coherences and complexity of functions among each other
- Illustration of efforts and benefits of product according the product functions
- Identification of parts with no functions
- Identification, definition and enabling of function objectives
- Verification and fulfilment of requirements
- Realisation of components with the same functions

3.2 Target Costing

Target costing is a cost management concept that has been developed and practised in Japanese companies since the 1970s. The basic idea of target costing is simple. “What are the allowable costs of a product?” The allowable product costs were deduced from the market by estimating the price a customer is willing to pay for the product (Target Price). After a yield (Target Profit) one arrives at the allowable costs (Target Costs). Target Costing should be performed at the very beginning of the product creation process. That is when it is most important to get the product and its functional architecture right the first time.

3.3 Process management and activity based costing

Process management means to organize a company with process focus. Therefore the process organisation, the operation of activities, and also time and topology aspects are in the centre of consideration. Process management is the planning and controlling in plant and industry wide processes, whereas both core-processes and support-processes are elements of process management. Core processes are deduced from core capabilities of an organisation. Support processes are activities which supports core processes.

Activity based costing is an instrument of controlling and allocating indirect costs - process oriented to projects or products. The main advantages of R&D activity based costing is the improvement of exactness for cost estimation for projects and products in the early phases of product development and the improvement of R&D controlling based on transparent indirect costs.

4. Macro model for cost estimation

The developed approach of the macro model for cost estimation puts the product functions into the centre of cost management (cost estimation) in early developing phases. The amount of requirements on the product and their transformation into functions should be noted as given and is not commended in this model. The model itself consists of the elements *Product Functions*, *Components*, *Target Costs* and *Processes* as well as connections between these elements as shown in figure 2.

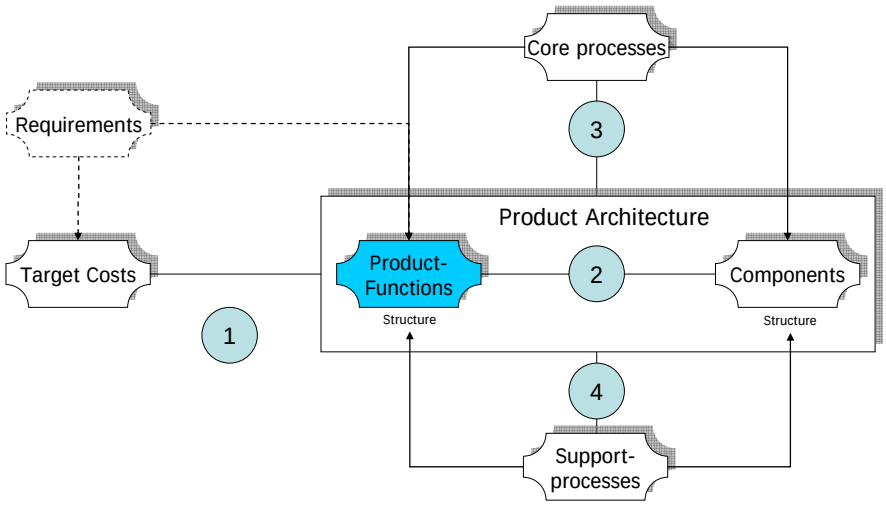

Figure 2. Macro Model for Cost Estimation

1. *Connection between Target Costs and Product Functions*
   The inquiry of the target costs is done by calculation based from the market. In case of complex products the target costs of the product can first be split up into target costs for modules. In this model the main goal is the achievement of target costs for functions which are the basis for cost tracking for following product development phases. E.g. target costs of a cockpit could be split up into function costs such as “heating”, “windscreen de-icing” etc. The function orientation simplifies the subjective estimation of complex products for customers. Estimation of components values for customers is not obvious and comparable, but the estimation of values for functions is rather easy.
2. *Connection between Product Functions and Components*
   As already mentioned, we describe the functions and the components with their connections between each other: the product architecture. The function structure is basis for the functional composition and their connections among each other and the components structure is basis for the physical composition of the product. Functions are arranged to main functions and components are merged to sub modules and module (see Figure 3).

3. & 4. *Connection between Processes and Functions or Components*
   In order to increase the transparency of the indirect costs in the existing approach, the core and support processes necessary for the function fulfilment are connected. The connections with the product functions are direct or indirect via the components. In this approach the core processes are the equivalent of development and testing processes of a product. The support processes are processes such as project management, purchasing processes, logistic processes, risk management etc. Behind the core and support processes are process cost rates and therefore cost.

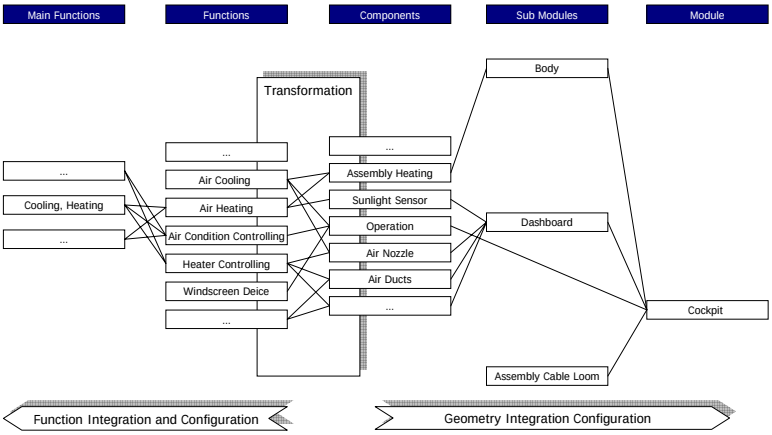

Figure 3. Product Architecture e.g. cockpit

5. Validation of model with solution pattern on the example "Vehicle Door"

The solution pattern for enabling the assembly of a door to the vehicle is shown in figure 4:
Step 1 is to select one main function. One of the main functions out of the reference functions structure based on experience of a door is to enable the assembly to the vehicle. Step 2 is to split up the main function into sub functions. The main function mentioned before can be split up into three functions: getting in and out of the vehicle, enable to hook the door in and out and the positioning of the door. Step 3 is to relate the functions to the necessary components. The functions are related to components, carry over parts (COP) and new parts (NP), out of the reference components structure which is based on experience and guidelines of the development engineer. E.g. for the function "enable to hook the door in and out" the components hinge, hinge pin, support hinge and fasteners are related.
Step 4 is to relate the processes to the functions. This can be done directly or indirectly over the components through the product architecture. The processes *clarification of task* (used for pick information about product requirements which are linked to the solution) and *conceptual design* (part of design that clarifies the way of the solution by the use of functional structure and suitable principles) is also related to the functions. The process *designing* (part of design that defines the shape of the product based on functional structure) is related to the new parts and via the relations between functions and components. The process *finishing* (part of design that finalizes the shape of the product by the use of concretises specifications for the shape, configuration, surface, material, verification of producibility etc.) is related similar like the design process. The simulation processes such as *operational stability* or *stiffness* are assigned to the functions directly. Prototype tests need components, but could also be assigned to the functions directly.
Step 5 is to estimate the cost blocks shown in the figure. According to connections mentioned before we accumulate the costs to get a cost estimation of the main door function "enable assembly to the vehicle" based on essential inputs of the model: estimated hours, number of processes and estimated components costs.

6. Summary and outlook

Function orientation and process cost management allows a transparent and complete estimation of costs in the early phases of product development based on developer's experience. The present approach utilises the experience of developers and shows the relationship between the functions, components and processes of a product with specific requirements.
PDM/PLM-systems build the backbone for data based engineering and could be expanded with cost management features. The next step is to integrate the described model in PDM/PLM systems for cost estimation on the basis of functions and requirements in early stages of product development.

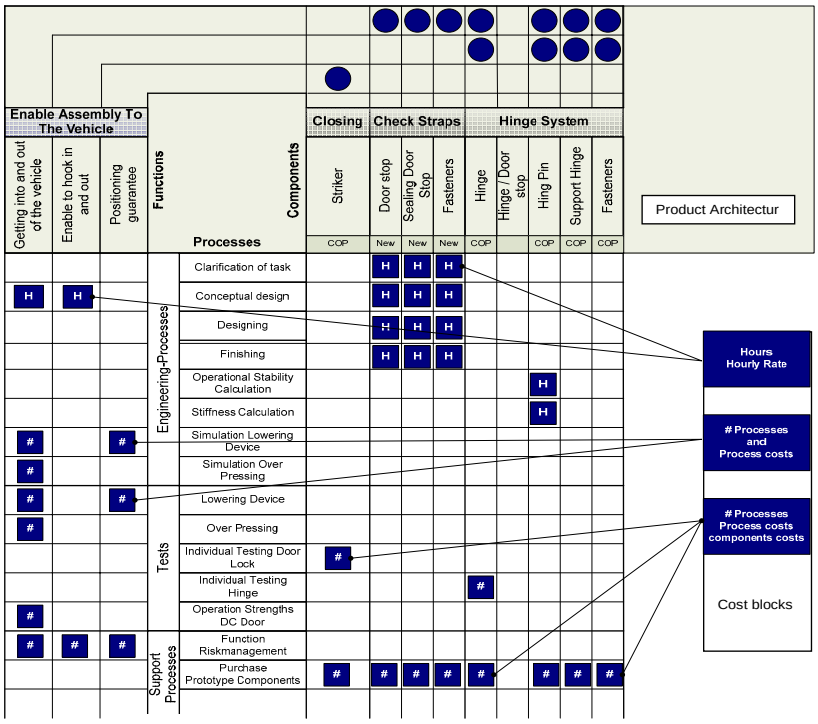

Figure 4. Solution pattern for enabling the connections to the vehicle

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